ASSESSMENT OF POTENTIAL HEALTH BENEFITS OF NOISE ABATEMENT MEASURES IN THE EU

Phenomena project

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The information and views set out in this study are those of the authors and do not necessarily reflect the official opinion of the European Commission.

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List of acronyms

AGC	European Agreement on Main International Railway Lines
AIRS	Annual Indicator Report Series
ANIMA	Aviation Noise Impact Management through Novel Approaches
BAR	Balanced Approach Regulation
CAEP	Committee on Aviation Environmental Protection
CBA	Cost-benefit analysis
CDO	Continuous Descent Operations
CEDR	Conference of European Directors of Roads
CER	Community of European Railway and Infrastructure Companies
CIT	International Rail Transport Committee
CNOSSOS-EU	Common Noise Assessment Methods in Europe
DAC	Dense asphalt concrete
DALY	Disability Adjusted Life Years
dB	Decibel
DPSEEA	Driving forces – Pressures – State – Exposure – Effect - Action
EAP	Environmental Action Programme
EEA	European Environment Agency
END	Environmental Noise Directive
EPA	Environment Protection Agency
ERF	Exposure-response functions
EU	European Union
GDP	Gross Domestic Product
GTR	Global Technical Regulation
ICAO	International Civil Aviation Organization
Lden	Day–evening–night noise level

Lmax	Maximum sound level
Lnight	Night-time noise level
MS	Member State
NAP	Noise Action Plan
NDTAC	Noise Differentiated Track Access Charges
NEG	Noise Expert Group
NNV	Network on Noise and Vibrations
OECD	Organisation for Economic Co-operation and Development
OSJD	Organization for Cooperation of Railways
OTIF	Intergovernmental Organisation for International Carriage by Rail
REFIT	Regulatory Fitness and Performance initiative
SDG	Sustainable Development Goals
TER	Transport Express Regional
TER	Development of a trans-European railway network
TSI	Technical Specification for Interoperability
UIC	International Union of Railways
UN	United Nations
UNECE	United Nations Economic Commission for Europe
WHO	World Health Organization
YLD	Years lost due to disability
YLL	Years of life lost

1 Introduction

1.1 Background and objectives

Long-term exposure to environmental noise from road traffic, railways and aircraft can lead to serious health effects, such as sleep disturbance, cardiovascular diseases, annoyance, cognitive impairment and mental health problems. The European Environment Agency (EEA)[1] estimates (2017-19 data) that 109 million people in the EU-28 are exposed to road traffic noise levels of 55 dB Lden and higher. In the case of railways, the number is estimated to be 21 million, while for aircraft 4 million. The World Health Organization (WHO) has classified traffic noise from roads, railways and aircraft as the second most important environmental source of ill health in Europe[2]. It also recommends much lower exposure levels than that currently set by Member State legislation.

Given the number of exposed citizens in the EU, and taking into consideration the growth of traffic, infrastructure and adjacent dwellings, further intervention is required to mitigate the impacts of environmental noise in the short and medium term. Increased implementation of noise abatement solutions is required, which could be driven by EU and national legislation. The Phenomena study aims to identify how this can be achieved.

The objective of the Phenomena study was to support the European Commission in defining the potential of measures capable of delivering significant reductions (20%-50%) of health burden due to environmental noise from roads, railways and aircraft by 2030, and to assess how relevant noise-related legislation could enhance the implementation of measures, while considering the constraints and specificities of each transport mode.

The project collected and analysed data from geographic areas with the following limitations:

- Roads and railways inside agglomerations of more than 100,000 inhabitants;
- Major roads of more than 3 million vehicles a year;
- Major railway lines of more than 30,000 trains a year; and
- Major airports of more than 50,000 movements a year.

The focus was on areas in agglomerations and along major roads with noise levels above 53 dB Lden, railways with noise levels above 54 dB Lden and airports with noise levels above 45 dB Lden. Peak noise from occasional sources, which do not affect the Lden levels, are not in the scope of this study, although they can be relevant for perceived noise. Health impacts are primarily associated with the year-averaged L_{den} and L_{night} levels.

The study ensured that results are representative at EU level by analysing a wide range of literature sources and assessing a balanced selection of Member State noise solution practices.

The following was undertaken to achieve the above objectives:

- Review of international and EU literature as well as EU and Member State legislation;
- Broad stakeholder consultation and two stakeholder workshops;
- Assessment of noise action plans, their implementation and enforcement;
- Identification and assessment of legislative drivers of noise abatement solutions;

[1] EEA "Environmental noise in Europe – 2020", Figure 2.18. See Environmental noise in Europe — 2020 — European Environment Agency (europa.eu)

[2] "Environmental Noise Guidelines for the European Region", World Health Organization 2018.

- Revision of the intervention logic;
- Listing of good practices;
- Health impact assessment and cost-benefit analysis;
- Assessment of available noise abatement solutions;
- Scenario analysis of noise abatement solutions; and
- Proposals for EU and Member State policies to reduce the health burden.

Key points from the primary data collection exercises including desk-research, consultations and test site analysis, are summarised in the subsequent sections.

1.1.1 Literature and legislation review

A comprehensive desk-based and legislative research was carried out to assess the current policy and technical environment related to environmental noise and noise abatement solutions. This is set out in chapter 2.

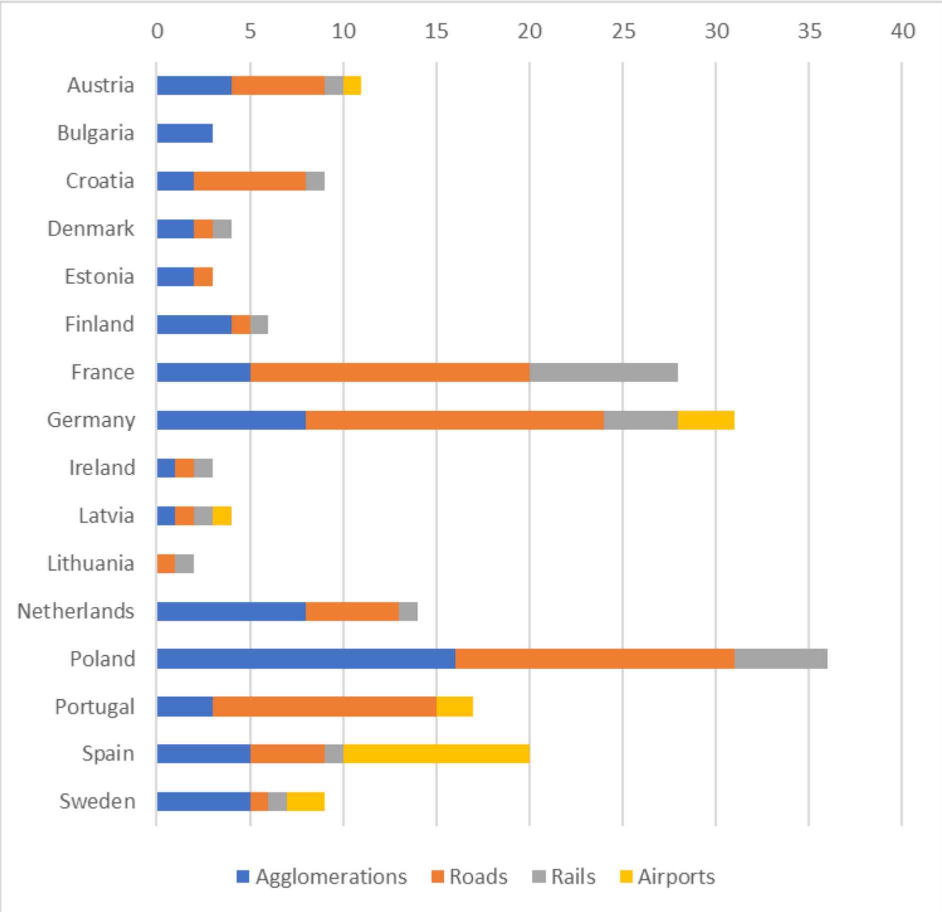
The aim of the desk-based research was to provide information on the current level of progress, ambitions and challenges regarding the implementation of noise abatement measures in Member States. It consists of the following main elements:

- Overview of relevant Member State and EU level legislations (including action plans and legislation on noise at source and receiver);
- Assessment of the level of implementation (compliance and benefits) of relevant Member States and EU level policies; and
- Identification and analysis of noise abatement solutions.

During the course of the study we carried out the overarching analysis of 200 noise action plan (NAP) summaries[3] covering agglomerations, roads, railways and airports from 16 Member States: Austria, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and Sweden. The aim of this analysis was to identify whether there were any interventions resulting from the noise action plans and if so, what type of interventions these were. An overview of the action plan analysis per type of transport mode and country is shown in the following graph.

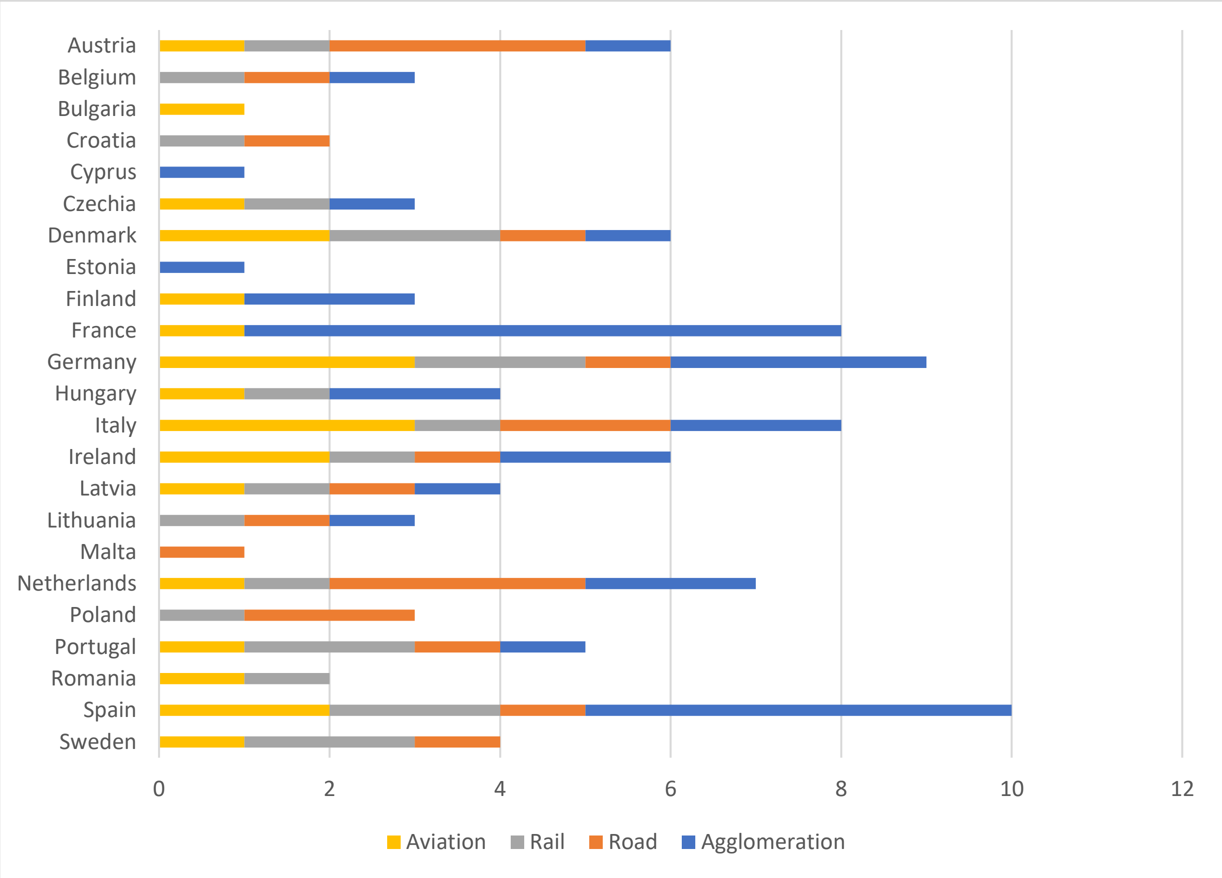
[3] Delivered in Reportnet, which is Eionet's infrastructure for supporting and improving data and information flows. https://www.eionet.europa.eu/reportnet

Figure 1.1 Selected NAPs for general review by country and noise source



Additionally, an in-depth analysis of 100 noise action plans was also carried out from Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Ireland, Malta, Netherlands, Latvia, Lithuania, Poland, Portugal, Romania, Spain and Sweden.

Figure 1.2 Selected NAPs for in-depth review by country and noise source



The aim of the in-depth analysis was to gather more detailed information on the implemented interventions and to ascertain the extent to which national and EU legislations drive the implementation of noise abatement measures. The aim was to identify good practices as well as challenges that may restrict the roll-out of certain measures. Information from the analyses of the action plans was also fed into the drafting of a revised intervention logic illustrating the wide-reaching impacts of relevant policy measures described in Chapter 4. Furthermore, the result of the action plan review provided information for the identification of possible new policies that can strengthen and facilitate the effective implementation of noise solutions. This process allowed for the identification of workable and sustainable noise solutions, strategies and corresponding legislative procedures that can facilitate 20%-50% reduction of related health burden and increase compliance with WHO thresholds. A detailed analysis of our findings can be found in the following chapters.

1.1.2 Stakeholder consultations

Information gathered through desk-based research was complemented with stakeholder interviews, which continued until the drafting of the final report thus allowing ample time for interested parties to provide feedback, share good practices and further information pertaining to national or EU level implementation of noise abatement solutions.

The purpose of these interviews was manifold. On the one hand we gathered information relating to national or EU level implementation, while on the other hand we sought the opinion of stakeholders on the effectiveness of noise abatement measures as well as their suggestions on potential improvements. Additionally, heath experts with knowledge on noise induced health impacts were also consulted. Stakeholders were asked to propose action plans that they would find useful to be reviewed within the context of this study. Allowing stakeholders to contribute to the selection of the NAPs helped to create an analytical baseline that directly responds to stakeholder concerns regarding current noise abatement strategies and implementation measures. Findings of the interviews can be found in chapter 4 and Annex 2. Reference is also made to stakeholder inputs in chapters 6 and 8, where relevant.

Stakeholders of the European Commission's Noise Expert Group (NEG) were informed about the study at the start and were kept informed on its progress during two dedicated interactive workshops. The study also gathered and took into account feedback from NEG members.

The reports of the two workshops are available in Annexes 8 and 9. Relevant stakeholders were identified during the literature review phase and were contacted via email. A balanced set of stakeholder opinions were gathered from the three transport modes and agglomeration representatives from various countries. Altogether 64 stakeholder interviews were carried out with the representatives of national authorities, transport providers, businesses, researchers and citizens. Representatives from EU Commission Directorates were regularly consulted, including DG Environment, DG GROW and DG MOVE, both at the start of the study and during subsequent progress meetings and the workshops.

1.1.3 Health impact assessment, noise solutions, and cost-benefit analysis

A methodology and calculation model for health impact assessment of road traffic noise, railway noise, and aircraft noise are set out in chapter 5. The model allows a full-chain analysis of environmental noise. The analysis starts from the noise sources, and results in estimates of the health impact on people in the EU. The model is applied to the baseline scenario and alternative scenarios including noise abatement solutions and legislative solutions for each transport mode. The model ensures representativeness at EU level by using the EU noise exposure distributions as provided by the EEA. The effect of noise solutions is determined by calculating changes of noise levels for a set of characteristic situations, such as residential streets, main roads, and motorways for road traffic noise. The corresponding changes in the EU noise exposure distribution are used to calculate health benefits.

Health effects are expressed in three ways:

- i) Numbers of people with the following negative health effects:
  - a. annoyance,
  - b. sleep disturbance,
  - c. myocardial infarction,
- ii) Healthy life years lost (DALYs),
- iii) Monetised health effects in euros.

For the monetised health effects, two different calculation methods are used to account for uncertainty.

The model also includes a cost-benefit analysis (CBA) procedure that is applied for each individual noise abatement solution and potential combined solutions. The CBA covers the period 2020-2030 and also looks forward to 2035, as some measures take longer to render their full benefits. The calculation model for health impact assessment and the CBA approach are described in chapter 5.

Test site analysis

In order to analyse and validate elements of the calculation model, detailed noise-mapping calculations for 'test sites'[4] were performed in this study, set out in chapter 5 and Annexes 4, 5, and 6. The test site calculations focused on the shape of exposure distributions, which could be compared with EU exposure distributions. These calculations also provide insight into the relative noise contributions of minor roads and major roads in cities.

Noise abatement solutions

Potential noise abatement solutions are described in chapter 6 for each transport mode. These include only existing and broadly available measures such as those applied in the scope of noise action plans. For each noise solution a general description is given with an overview of aspects relevant for this study, such as general principle, potential noise reduction, implementation level, triggers and obstacles and how they are linked with legislation.

Scenario analysis and CBA

Analysis of single and combined scenarios for each transport mode is presented in chapter 7, also explaining the basis for combined scenarios and the outcomes found. The benefits calculated for the scenarios depend on the definition of the baseline scenario, which includes growth and expected fleet evolution.

Potential to deliver higher implementation of noise abatement solutions

Suggestions for policy options to achieve the required higher health benefits by higher implementation of noise abatement solutions are set out in chapter 8. These are both at EU and national level, based on the findings of the previous chapters. These policy options consist of both general options applicable to all three transport modes and options specific to each mode separately.

The overall conclusions are set out in chapter 9.

Covid-19 impacts

Notably, this study was performed during the Covid-19 pandemic, which has had a major effect on transportation worldwide, and having an audible effect on environmental noise. Shifts in traffic rates have occurred, most strongly in the aviation sector, but also for railways and road transport, where a shift from public transport to individual transport was observed. These effects are in part considered in this study, although it is envisaged that growth will continue after recovery, resulting in similar noise impacts as before.

Consortium and EU contract

This report was prepared by VVA Brussels and TNO together with Tecnalia, ANOTEC and Universitat Autònoma de Barcelona (UAB) under EU contract No. 07.0203/2019/ETU815591 ENV.A.3 on the Assessment of the Health Benefit Impacts of Noise Related Measures. The study started in December 2020 and was completed in March 2021.

[4] Test sites are not measurement sites, but parts of noise maps evaluated for the purposes of this study

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Chapter 9: E. Kantor, M. Dittrich

Test site analysis: E. Salomons, I. Aspuru, P. Fernandez

2 Literature Review: assessing existing international, EU and national legislation

2.1 Overview

An extensive literature review was carried out examining all relevant international, EU and Member State level legislations that could, directly or indirectly, impact on the reduction of noise source and consequently on the reduction of the associated health burden. The main goal of this literature review is to identify and analyse all relevant regulatory measures, technical, environmental and health assessments that could indicate the level of effectiveness of noise abatement solutions and regulatory compliance in Europe as well as internationally.

In addition to the review of relevant legislations, the general assessment of 200 and the in-depth assessment of 100 noise action plans was carried out, specifically looking at their level of implementation of noise abatement solutions. The findings of the analysis aim to feed into the selection and analysis of noise solutions. In addition to the legislations, the literature overview also extends to cover the following:

- Studies, including END assessment, evaluations of noise source and reception limits for road/railways/aircraft;
- Noise valuation, data and information on solution effectiveness, cost and LCC, benefit analyses including monetisation of health benefits, hospitalisation and change in real estate value;
- National and international research projects, noise abatement measures and health effects;
- Relevant publications from EEA, CEDR, FEHRL, ERA, Shift2Rail, EASA, Eurocontrol etc.; and
- Test and validation reports on noise control measures for road, rail and air.

2.2 Findings of the literature review

The literature review aims to provide the thematic and chronological approach to the subject of the present study. It first develops an overview of the international drivers and rationales for the causes of environmental noise pollution. Secondly, it critically reviews the Environmental Noise Directive and established EU noise management. Finally, it reviews a complementary EU legislation on noise emission limits in the area of road traffic noise, railways, aviation and agglomerations.

Environmental noise is an increasingly important health issue, placed among the key environmental risks to health.[5] According to the findings of the WHO, there is sufficient evidence underlining the connection between the population's exposure to environmental noise and adverse health effects. At a 2010 meeting, traffic noise was identified as the second most significant environmental stressor in terms of its public health impact in six European countries.[6] The negative impacts of noise on human health have become a cause of growing concern not only in the international arena (e.g. WHO, ICAO etc.) but also at the EU and national level.

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[5] WHO (2018) Environmental Noise Guidelines for the European Region. Regional Office for Europe. Available at: http://www.euro.who.int/__data/assets/pdf_file/0008/383921/noise-guidelines-eng.pdf

[6] WHO (2011) Burden of disease from environmental noise http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf

Early work on noise undertaken by Ward and Fricke[7] as well as Kryter[8] in the late 1960s and at the beginning of 70s tended to demonstrate techniques for the evaluation of environmental noise in terms of its specific effects on humans (e.g. psychological, physiological, effect on speech etc.). In response to the growing issues of the noise pollution and community noise annoyance, in 1999 the WHO adopted Guidelines for Community Noise. The Guidelines identified several health disturbances linked to environmental noise such as hearing impairment, speech perception, reading, sleep disturbance, physiological functions, mental illness, social behaviour, annoyance and provided guideline values for setting community noise thresholds in specific environments (indoor, outdoor) as recommended values for the adoption at the national level. At the international level, this document became an important point of reference for the development of new regulatory frameworks and for addressing noise pollution as a public health problem.

Research documents[9] exploring the public health implication of environmental factors distinguish 'sound' from 'noise'. While the notion of 'sound' is perceived as "a sensory perception and the complex pattern of sound waves" such as music, speech and others, 'noise' could be defined as unwanted sound[10]. Following Murphy and King, environmental noise represents an unwanted sound caused by human activities, which is harmful or detrimental to human health as well as quality of life.[11] A recent joint publication from the WHO Regional Office for Europe and the Joint Research Centre further explored the burden of disease arising from environmental noise, such as cardiovascular ailment, cognitive impairment, especially in terms of quantification of healthy years lost in Europe.[12] The study found that approximatively one million years of healthy life are lost every year from traffic related noise in western Europe.[13] Among the main impacts of environmental noise sleep disturbance and annoyance are counted, mostly due to road traffic noise, which is likely to be the main source of community noise pollution.[14] In addition, an increase in the migration of population from rural to urban areas in the past 50 years from 33.6% to 54.3% resulted in the rapid development of cities.[15] Europe is one of the most urbanised regions of the world, with urban areas accounting for 74% its territory.[16] According to the UN, this trend is set to grow over the coming years, with 68% of the world's population living in urban areas by 2050.[17] However, Morillas and al. note that urban spatial planning has not taken account of this trend, leading to growing noise pollution in these high population density areas.[18] The detrimental effect of human exposure to noise could be reduced by efficient noise management schemes. Noise can be managed through technical interventions in relevant areas of noise pollution. According to Brown and Kamp, this involves not only "reduction of source emissions but also alteration of the transmission path, for example by the positioning of outdoor barriers between source and receivers, and changes in the acoustic properties

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[7] Ward, W. D. and Fricke, J. E. (1968). Proceedings of the American Speech and Hearing Association Conference on: Noise as a Public Health Hazard. Washington, D.C.

[8] Kryter, K. D. (1970). The effects of noise on man. Academic Press. https://www.sciencedirect.com/book/9780124274501/the-effects-of-noise-on-man?via=ihub=

[9] Murphy E. and King E. A. (2016) Principles of Environmental Noise in. Environmental Noise Pollution. Elsevier.

[10] Berglund B., et al. (1999). Guidelines for community noise, World Health Organization http://apps.who.int/iris/handle/10665/66217.

[11] Ibid.

[12] WHO Regional Office for Europe and JRC (2011). Burden of disease from environmental noise. http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf.

[13] Ibid.

[14] Rey Gozalo G., Morillas J. (2016). Analysis of Sampling Methodologies for Noise Pollution Assessment and the Impact on the Population. International Journal of Environmental Research and Public Health. Available at: https://www.researchgate.net/publication/302969166_Analysis_of_Sampling_Methodologies_for_Noise_Pollution_Assessment_and_the_Impact_on_the_Population#pff.

[15] The World Bank (2017) Urban population (% of total). The United Nations Population Division's. Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS.

[16] United Nations (2018), World Urbanized Prospects: the 2018 Revision. Available at: https://population.un.org/wup/Publications/Files/WUP2018-KeyFacts.pdf

[17] Ibid.

[18] Morillas J.M.B., Gozalo G.R., González D.M. et al. (2018). Noise Pollution and Urban Planning. Curr Pollution Rep 4. Available at: https://doi.org/10.1007/s40726-018-0095-7

of building envelopes to reduce levels at receivers".[19] This may also involve additional source-related modification such as time restrictions on operations of sources as well as changes in infrastructure among others.[20]

Given the above, regulating the impacts of noise emission is a rather complex process. Identifying minimum tolerable limits can be a subjective task, which also need to reflect a range of strategic and cost-effective technical objectives. Additional complications may arise from the topic being at the crossroads of different policy areas (environment, health, transport, urban planning, road safety, construction and product life cycle etc.) and its efficient management requires broad coordination of policies at the national, local, regional and EU level. The adopted policy and legislative measures, as well as guidelines, rely on a wide range of options provided in a conceptual framework for noise intervention developed by Brown and Kamp that classifies noise intervention and their health effects.[21] Hence, options for improved EU and national noise legislation and selection of adequate noise abatement measures to underpin these regulatory efforts must also consider systemic challenges. For the purpose of this study, it is important to emphasise how different categories of interventions fit along the system pathway between noise sources and human outcomes.[22]

2.2.1 Approach towards legislating noise emission limits and control

Since the 1990s, the EU's noise policy acknowledged the nexus that exists between the noise receiver and health care burden. The Fifth EU Environmental Action Programme (1993-2000) established an objective that "no person should be exposed to noise levels which endanger health and quality of life", but it left it up to the Member States to determine its most appropriate implementation at a national level. Building on the Action Programme, the Green Paper on 'Future Noise Policy' (1996) offered an impetus for creating a comprehensive EU noise regulatory framework with the focus on noise exposure coming from road, rail, air transport and outdoor equipment. At the same time ,on the international level the WHO's Guidelines for Community Noise stated that more than half of EU citizens were exposed to significant acoustic pollution coming from all means of transport. This document has greatly influenced future EU policy and legislative developments in the area of noise pollution.

2.2.1.1 International drivers and underlying rationale

In 1999 the WHO, which was concerned by adverse health effects of noise and based on the best available science as well as studies carried out up to 1995, published its first Guidelines for Community Noise. The document recognised noise as a serious public health issue. It indicated that 40% of the EU's population was exposed to road traffic noise with a sound pressure level exceeding 55 dB(A) during daytime and 30% to the same level during the night.[23] According to the WHO, nearly 50% of EU citizens suffered from exposure to acoustical discomfort in the area they lived.[24] In 2009 WHO Regional Office for Europe complemented its previously released document with Night Noise Guidelines for Europe (NNGL). Based on the important research advancement on normal and disturbed sleep, the NNGL significantly complemented and updated the 1999 guidelines.[25] Finally, incorporating new scientific evidence, WHO published an updated Environmental Noise Guidelines

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[19] Brown A. L. and van Kamp I. (2017), WHO Environmental Noise Guidelines for the European Region: A Systematic Review of Transport Noise Interventions and Their Impacts on Health. Int J Environ Res Public Health. Available at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5580577/

[20] Ibid.

[21] Ibid.

[22] Ibid.

[23] *Op.cit.* Berglund B., et al.

[24] Ibid.

[25] Kim R. and van den Berg M. (2010). Summary of night noise guidelines for Europe. Noise and Health. Available at: http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2010;volume=12;issue=47;spage=61;epage=63;aulast=Kim.

for the European region in 2018 that provides an important linkage between environmental noise and its effect on human health.[26] The document proposes a new set of guidelines of public health recommendations on exposure to environmental noise. It aims to protect human health "from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise".[27]

The current recommendation establishing the exposure level above which the impact on health is rated negative is presented in the table below and are indicated in terms of L_{den} and L_{night} values relevant for the annual average of outdoor noise. The guidelines are specific to the sources of noise and recommend values for exposure to road traffic, railway, aircraft and wind turbine noise and in- and outdoor levels for exposure to leisure noise.

Table 2.1 Recommendations from the WHO environmental noise guidelines

Reducing noise below these levels is strongly recommended			
Noise indicator	Road	Rail	Air
L_{den}	53 dB	54 dB	45 dB
L_{night}	45 dB	44 dB	40 dB

Source: European Environmental Agency

The WHO strongly recommends that policy-makers find measures that reduce noise exposure below these levels. However, according to the recent European Environmental Agency (EEA) publication, most European countries have set national limit values at a relatively higher level than the noise levels recommended by the WHO.[28] Furthermore, the EEA points out that the WHO limit values emphasise that humans tend to be more annoyed and disturbed by aircraft noise rather than road or railway noise at the same decibel level.[29] In fact, a relatively high number of countries allow the equivalent or even higher levels of aircraft than road traffic noise, while "a smaller percentage of countries apply higher railway noise limits than those for road traffic noise".[30]

The objective of the abovementioned guidelines is to support the legislation and policy-making process on local, national, regional and international level. The WHO guideline values should be seen as public health-oriented recommendations, based on scientific evidence of the health effects and on an assessment of achievable noise levels.

Further, the WHO developed an approach to quantify the burden of disease from environmental noise using DALYs. The method developed jointly by WHO and JRC combines years of life lost due to premature mortality and years of life lost due to time lived in states of less than full health.[31] This approach allows for quantifying the burden of disease as a result of annoyance, sleep disturbance and reading impairment, using exposure-response relationships as well as the population-attributable fraction for ischaemic heart disease.

In addition, according to the most recent global trends the noise pollution fits into the 2030 Agenda for Sustainable Development. Hence, tackling noise pollution and disturbance could take a more

[26] WHO (2018). Environmental noise guidelines for the European region, WHO Regional Office for Europe. Available at: http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelinesforthe-european-region-2018.

[27] Ibid.

[28] EEA. (2020). Environmental Noise in Europe – 2020. Available at: https://www.bruitparif.fr/pages/Autres%20actualites/2020-03-06%20Le%20bruit%20en%20Europe%202020,%20dernier%20rapport%20de%20l'AEE/Environment%20noise%20in%20europe%202020.pdf.

[29] Ibid.

[30] Ibid.

[31] *Op.cit.* WHO Regional Office for Europe and JRC.

holistic approach and could underpin achieving UN Sustainable Development Goals (SDGs).[32] The literature notably shows that there is a strong relationship between two out of the 17 SDGs targets with regards to noise pollution: SDG 3 (Good Health and Well-being), SDG 11 (Sustainable Cities and Communities). Given that SDG 3 aims to ensure healthy life and promote well-being for all at all ages, its objective is aligned with reducing extreme adverse health effects and reduction of noise exposure as understood by the WHO.[33] Also, given the increasing noise pollution distribution in the cities, SDG 11 is of relevance as it aspires to make cities and human settlements inclusive, safe, resilient and sustainable. This includes a reduction of the adverse per capita environmental impact on cities.[34] For instance, the United Nations Economic Commission for Europe (UNECE) examined challenges and opportunities of working together globally to achieve the transition towards sustainable mobility for inland modes of transport i.e. road, railways, inland waterways and intermodal transport.[35]

In addition to the UN framework, the OECD (2020) has also issued recommendations regarding improved legal implementation of noise legislation, financing innovation and the use of 'quieter' products, land-use planning and traffic management.[36]

Since international drivers on noise abatement come both from non-binding recommendations (WHO, OECD, SDGs etc.) and binding international standards, it is important to acknowledge compliance with international standards on noise under organisations such as the European Committee for Standardisation (CEN) and the International Organization for Standardization (ISO). The CEN Technical Committee (TC) 211 (Acoustics) and ISO Technical Subcommittee (SC) 43 (Noise) provide more than 80 noise abatement standards for businesses, institutions, academia etc.[37] The ISO 43 has two secretariats that provide standards on active noise solutions (SC 1: Noise) and passive noise solutions (SC 2: Buildings).[38]

2.2.1.2 International research and literature

Corresponding to international policy measures, and often serving as valuable background, joint technical research projects have been conducted, engaging universities, research centres and enterprises from around the world. The results of international research can drive and facilitate regional and local transport and infrastructure development.

Research efforts targeting noise mitigation of aviation and specifically aeroplane noise technologies are driven in part by the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP).

In its independent expert review of 2016-2019 CAEP found that for single and twin aisle modern jet aircraft fan noise is the dominating noise source followed by jet noise. For smaller aircraft jet noise may still be the dominating factor but further noise reduction due to reduced velocity is not expected. Instead, literary sources suggest that more attention is now being paid to the reduction of fan noise via modifications to fan pressure. For incoming aircraft, the largest source is airframe

[32] Unites Nations. Transforming our world: the 2030 Agenda for Sustainable Development. Available at: https://sustainabledevelopment.un.org/post2015/transformingourworld

[33] Ibid.

[34] Ibid.

[35] UNECE. Transport and the Sustainable Development Goals. Available at: http://www.unece.org/trans/transport-and-the-sustainable-development-goals.html.

36 OECD (2020), Recommendation of the Council on Strengthening Noise Abatement Policies, OECD, available at: https://legalinstruments.oecd.org/public/doc/35/35.en.pdf

37 CEN (2020), Mechanical engineering – General, CEN, available at: https://www.cen.eu/work/sectors/mechanical_machines/pages/mechanicalengineeringgeneral.aspx

38 ISO (2020), ISO, available at: https://www.iso.org/committee/48558/x/catalogue/ (ISO Building acoustic standards), ISO/TC 43/SC - Noise (road vehicles, railway) https://www.iso.org/committee/48474/x/catalogue/

noise resulting from the landing gear. Potential noise solutions for fan noise include noise barriers while for landing gear noise, modifications to operational procedures may be more relevant[39].

Recent international research into the impacts of aviation noise also draws attention to the possible reinvigoration of supersonic jets and the sonic boom that accompanies such aircraft. Should innovation bring forth a new age of supersonic air travel, revisiting regulatory measures may be necessary (ICAO's Assembly Resolution A38-17 Appendix G).[40]

Regarding mitigation efforts for road transport noise, the World Road Association (PIARC) suggests closer collaboration between road managing agencies (companies) and competent authorities as well as a range of noise solutions such as buffer zones, quieter pavements and the use of ITS technology for smoother traffic flow management[41]. While these are some of the most referred to and used noise solutions, other innovative approaches are also being explored. A recently published paper in Nature looks at possible ways that buildings (residential, commercial or industrial) can control road noise without compromising ventilation. The research describes an active sound control system made up of a 'reference' sensor which provides advance information of the primary noise to be attenuated, an actuator driven by an adaptive circuit which produces the anti-noise, and an 'error' sensor which provides feedback to the adaptive circuit to adapt to changes in the primary noise. The system relies on mini loudspeakers, which are fitted in window openings and a single reference microphone which provides advance information for the controller to compute the anti-noise signal input to the loudspeakers in real time. During a mock-up testing up to 10 dB reduction in energy-averaged sound pressure level was achieved at the receiver.[42]

An alternative line of research is that of sound-absorbing construction material. Some of these sound-absorbing porous materials are often harmful for human health, and therefore their use must follow strict guidelines. However, natural materials can also be used for acoustical applications such as hemp, coconut and mineralised wood fibres. Further research into the possible application and combination of these materials can deliver benefits for mitigating noise levels at the receivers.[43]

Predictive mapping provides interesting opportunities for the reduction of rail traffic noise. This software-based technology works by collating information on rail types, rolling stock, frequency of railway use, size and speed. The software then generates a map using colours to represent the different levels of noise over the tracks. These maps can help railway managers and engineers work out the most suitable noise solutions for a given area as well as have a better overview of their associated costs and benefits.[44]

Some examples on the management of rail noise can also be drawn from Japan. While rolling stock noise have been mitigated by the use of noise barriers and rail grinding, the mitigation of the aerodynamic noise of Shinkansen trains remains a challenge. The use of surface smoothing, low-noise pantographs and insulator covers have all been tried to address the problem.[45] The

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[39] ICAO Doc 10127 (2019) https://www.icao.int/environmental-protection/Pages/Noise-Reduction-Technology.aspx

[40] Basner M, Clark C, Hansell A, et al. Aviation Noise Impacts: State of the Science. Noise Health. 2017;19(87):41-50. doi:10.4103/nah.NAH_104_16 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5437751/

[41] PIARC: Let's Act on Road Traffic Noise https://www.piarc.org/en/PIARC-knowledge-base-Roads-and-Road-Transportation/Road-Administration/Environment/Act-on-Road-Traffic-Noise

[42] Lam, B., Shi, D., Gan, W. et al. Active control of broadband sound through the open aperture of a full-sized domestic window. Sci Rep 10, 10021 (2020). https://doi.org/10.1038/s41598-020-66563-z

[43] Azimi M (2017) Noise Reduction in Buildings Using Sound Absorbing Materials. J Archit Eng Tech 6: 198. Doi: 10.4172/2168-9717.1000198

[44] Varsa Saraogi (2017): How predictive mapping can help railways cut noise pollution, Railway Technology, https://www.railway-technology.com/features/how-predictive-mapping-can-help-railways-cut-noise-pollution/

[45] International Railway Journal (2015): Combating noise from the Shinkansen https://www.railjournal.com/in_depth/combating-noise-from-the-shinkansen

applicability of these and other similar technologies on European railway lines have been investigated and a significant noise reduction potential of 3-10 dBA was found.[46]

In addition to noise from road, rail and aviation, the additional sound burden from maritime transport is also a factor in port cities. While maritime transport noise is outside the scope of this study, it is worth noting its impact. In one interview with local authorities drafting NAPs, the stakeholder highlighted a legislative gap on noise from ports and ships, and suggested that port authorities should draft NAPs and noise annoyance plan such as airports.[47]

2.2.2 Environmental Noise Directive and noise management in the EU

2.2.2.1 Noise legislation at the EU level

Since the 1990s, the EU has adopted laws on regulating noise at source for aircraft (Directive 89/629/EEC), automobiles (Directive 92/23/EEC; 97/24/EC) and outdoor equipment (Directive 2000/14/EC). Following the WHO's Guidelines (1999), the 6th EU Environmental Action Programme (2002 - 2012) announced the plan to draw up a European Noise Directive that aims to reduce the number of EU citizens exposed to traffic noise levels that are deleterious to health (Art. 7.1.). Other measures from the Environmental Action Programme included expanding the regulation on noise sources (in particular, the interaction between tyre and road surface, motor vehicles, transport demand reduction, shifts to less noisy modes of transport and sustainable transport planning). At the EU level, a great segmentation of regulation required the development of a comprehensive instrument on the environmental noise health impact.

2.2.2.2 END in a nutshell

In response to greater knowledge of the adverse effects of noise and to the increasing need for integrated management across the EU, the European Commission adopted the Environmental Noise Directive (END) in June 2002. END aims to "define a common approach intended to avoid, prevent or reduce the harmful effects due to exposure to environmental noise". The definition of 'environmental noise' under END is more detailed than the one provided by the WHO. Article 3(a) of the Directive specifies that 'environmental noise' is to be understood as "unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport, road traffic, rail traffic, air traffic, and from sites of industrial activity".[48] Hence, this literature review does not cover noise disturbance originating from workplaces, domestic activities, neighbours, recreational venues, inside means of transport or due to military activities in military areas. To achieve its objectives the END targets three mains fields of action:

i. The determination of exposure to environmental noise;

ii. Ensuring that information on environmental noise and its effects is made available to the public; and

iii. Preventing and reducing environmental noise where necessary as well as preserving environmental noise quality where it is good.[49]

In its legislative framework for the management of environmental noise in the EU, the European Commission opted for a two-fold approach, by limiting noise source levels of (new) vehicles, and by not reducing the noise levels at the receiver (dwelling façade). To achieve the overall objective, END

[46] Ivanov N.I., Boiko I.S., Shashurin A.E. (2017) The problem of high-speed railway noise prediction and reduction, Transportation Geotechnics and Geoecology, TGG 2017, 17-19 May 2017

[47] Interview with a stakeholder from a French agglomeration on 02/09/2020.

[48] more detailed that the one

[49] European Commission. (2020). Environmental Noise Directive (END). Available at: https://ec.europa.eu/environment/noise/directive_en.htm.

establishes a number of actions that need to be implemented by its Members States. Among which the most relevant are:

- Monitoring of environmental noise via establishment of strategic noise mapping at the national level (Art.7 of END);
- Managing environmental noise issues by drawing up national action plans (Art. 8 of END);
- Public information and consultation of strategic noise-related documents (Art. 9 of END); and
- Development of a long-term EU strategy towards noise (Art.10 and 11 of END).

The Directive provides two key instruments for the achievement of its goal: noise maps (Art.7 of END) and action plans (Art.8 of END). Following Murphy and King, noise maps should be understood as visualisation of "data on an existing or predicted noise situation in terms of a noise indicator, indicating breaches of any relevant limit value in force, the number of people affected in a certain area, or the number of dwellings exposed to certain values of a noise indicator".[50] Strategic noise maps aim to assess the level of population exposed to noise pollution in a given geographic area and estimate their exposure to various noise categories separately for different modes of transport.[51] The reference values for which strategic maps were to be drawn up have changed over the years as shown by the following table.

Table 2.2 Thresholds between first and second reporting period of the END

	By 2007	By 2012
Agglomerations	>250.000 inhabitants	>100.000 inhabitants
Major roads	>six million vehicle passages per year	>three million vehicle passages per year
Railways	>60 thousand train passages per year	>30 thousand train passages per year
Civil airports	>50.000 take-offs or landings per year	Unchanged (Article 7(2))

Source: European Commission

Based on noise mapping results, Member States are required to develop action plans for the largest urban areas (agglomerations)[52] and major transport sources[53]. According to Art. 8 of the END, action plans are "designed to manage, within their territories, noise issues and effects, including noise reduction". Hence, these plans should contain noise abatement measures to tackle the identified noise issues together with their effect and to protect quiet areas against a potential increase in noise pollution.[54] Action plans are established for areas where the specific END indicators[55] have been surpassed. The current noise levels in the EU are defined in the 7th Environment Action Programme (EAP) for Lden above 55 dB and for Lnight above 50 dB. However, according to the WHO guideline the night-time noise level is stricter than the L threshold of 50 dB under the END.[56]

Finally, the END aims to ensure a long-term EU strategy towards noise solution, by specifying that both strategic mapping and national action plans should be reviewed every five years. In addition, it requires Member States to establish competent authorities responsible for making, approving and

[50] Murphy, E., King, E.A.. (2010). Strategic environmental noise mapping: methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications. Available at: https://www.sciencedirect.com/science/article/pii/S0160412009002360

[51] Fathy F. and Rau H. (2013). Methods of Sustainability Research in the Social Sciences. SAGE, available at: https://books.google.pl/books?hl=pl&lr=&id=SdOCAgAAQBAJ&oi=fnd&pg=PA133&ots=LylYld6Aag&sig=dvvI7kLmWyhPD9lznDwDLyvuYUA&redir_esc=y#v=onepage&q&f=false

[52] Agglomerations with more than 100,000 inhabitants.

[53] Major roads (more than 3 million vehicles a year); major railways (more than 30.000 trains a year); major airports (more than 50.000 movements a year, including small aircraft and helicopters).

[54] *Op.cit.* END - Art.8.

[55] 55 dB averaged across the day, evening and night periods (L) and 50 dB averaged across the night period (L).

[56] EEA (2016), Annual Indicator Report Series (AIRS): Environmental Noise.

collecting noise maps. Noise maps and noise action plans are submitted to the European Commission and are publicly available at the EEA's Eionet portal and the Reportnet website[57]. Every five years, the European Commission publishes assessment reports on the implementation of the END, including the state of noise reporting from Member States and the implementation level (the first report: 2011; the second report 2016; the third report: 2021 – to be expected).

Following the END's entry into force, the first strategic reporting period occurred in 2007, followed by a second in 2012 and a third in 2017. However, between the first and the second reporting periods the reporting threshold was lowered as presented in the table above. During the first period Member States were required to report noise maps for agglomerations of more than 250,000 inhabitants, roads with more than 6 million annual vehicles passages, railways with more than 60,000 annual train passages and airports with more than 50,000 annual movements. However, since 2012 the Member States were allowed to report noise maps for agglomerations with more than 100,000 inhabitants, roads with more than 3 million annual vehicles passages, railways with more than 30,000 annual train passages and no additional requirements for civil airports. The application of these different reporting thresholds makes it difficult to compare data for the two periods.

The EEA also reported comparability issues, based on two rounds of reporting of noise mapping assessment in 2007 and 2012, in its Annual Indicator Report Series on Environmental Noise.[58] The agency identified the main factors as the lack of a common assessment method and the incompleteness of submitted data which ranged between 40-70% of expected inputs. According to a 2014 report[59], the main difficulties in comparing results relate to the (i) incompleteness of the reporting of strategic noise maps by MS; (ii) the different quality and format of data reported at EU level; (iii) the different assessment methods used; (iv) the different strategies adopted concerning the selection of roads to be mapped for example; (v) the distribution of the populations and dwellings within buildings; and (vi) the unavailability or reliable dose–response curves required for health impact assessment. Moreover, Murphy and Douglas assessed methods for estimating population exposure to road traffic based on the results of different exposure estimations.[60] The research revealed that "the exposure estimation method rather than the noise calculation method …has the greatest effect on population exposure estimation". Therefore, the exposure method should be considered when seeking to understand health impacts and achieve consistent results.

Given the identified shortcomings related to the END, Annex II of the Directive was revised in 2015 to establish a common EU method for calculating exposure to different noise levels. Annex II was revisited with Directive 2015/996[61] on establishing common noise assessment methods and introducing the Common Noise Assessment Methods in Europe (CNOSSOS-EU) framework for strategic environmental noise mapping. Member States were required to comply with the new rules by 31 December 2018 – i.e. after the third round of reporting under END. Nevertheless, it has been recommended that Member States apply CNOSSOS-EU provisions to the extent possible also for this third noise mapping round.

In addition, a recently adopted Directive 2020/367 has replaced Annex III of the END, ensuring its full compliance with the CNOSSOS-EU framework on dose-effect relations, on harmful effects of environmental noise and on the establishment of assessment methods. The timeframe for the transposition of this complementing 2020 Directive falls at end of 2021, just before the fourth round

[57] https://www.eionet.europa.eu/

[58] Ibid.

[59] Kephalopoulos S., Paviotti M., Anfosso-Lédée F., Van Maercke D., Shilton S., Jones N. (2014), Advances in the development of common noise assessment methods in Europe: The CNOSSOS-EU framework for strategic environmental noise mapping. Science of the Total Environment. Available at: https://www.sciencedirect.com/science/article/pii/S0048969714001934.

[60] Murphy E. and Douglas O. (2018). Population exposure to road traffic noise: Experimental results from varying exposure estimation approaches. Transportation Research Part D: Transport and Environment. Available at: https://www.sciencedirect.com/science/article/pii/S1361920917302237.

[61] Directive 2015/996 http://publications.europa.eu/resource/cellar/a2af495c-1fe0-11e5-a342-01aa75ed71a1.0006.02/DOC_1

of strategic noise mapping. Nevertheless, the CNOSSOS calculation method still has room for further improvement, according to a recent EEA report[62]. It says that it is uncertain how Member States will interpret the CNOSSOS-EU method.[63] Murphy and King point out that in the literature "several aspects of the method have already been questioned and some experts appear reluctant to embrace it".[64] Recently Kok and van Beek has prepared a proposal for the improvement of the calculation method itself.[65]

2.2.2.3 Review of END

Since its adoption, the END has encountered various reviews and evaluations. According to Eurocities. the first implementation report emphasised that END brought real benefit, leading to the development of the first coherent management system of environmental noise in all Member States.[66] Nevertheless, some shortcomings were also noted, such as insufficient comparability of data due to different data collection, quality and availability and assessment methods used. It also found room for different interpretation and implementation across the EU, a lack of co-ordination with air quality issues and the need to simplify the reporting timetables.[67]

The second implementation report from 2017 took stock of the actions already taken and noted additional areas where further improvements would need to be made to meet the objectives of the END and WHO limit values. The number of submitted strategic noise maps and action plans has increased and reached 80% and 50% respectively. Likewise, 13 Member States have designated quiet areas (in agglomerations and open countries), which represents a slight increase compared to previous reporting periods. Among others, the report identified considerable delay as well as inconsistency in the implementation of the END and its interpretation across Member States.[68] It also pointed out the need to adjust the Directive to recent scientific findings (e.g. evidence that harmful health effects that could occur at lower levels than those addressed by END) and regulatory developments that have taken place at EU level since the END adoption.[69] In addition, the report emphasised that tackling noise issues could also be done or complemented via urban planning. Finally, this report also noted that data collected from different Member States between first two rounds (2007, 2012) are not comparable due to different threshold parameters for agglomerations, roads, rails, airports and the use of national methods for assessing the noise and thus pointed out the need for the common method (CNOSSOS-EU).

During the last 10 years, the EU has adopted several policies relevant to reducing noise pollution at source from roads, railway and airports. These include:

1) Sound level of motor vehicles (Regulation 540/2014);
2) EU airports within a Balanced Approach (Regulation 598/2014);
3) Approval and market surveillance of two- or three-wheel vehicles and quadricycles (Regulation 168/2013);
4) Technical specification for interoperability on "rolling stock - noise" (Regulation 1304/2014)
5) Connecting Europe Facility (Regulation 1316/2013);

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[62] EEA. (2020). Environmental Noise in Europe – 2020. Available at: https://www.eea.europa.eu/publications/environmental-noise-in-europe

[63] Murphy E. and King A.E (2014). Environmental Noise Pollution: Noise Mapping, Public Health, and Policy. Elsevier.

[64] Ibid.

[65] Kok, A. and van Beek, A., (2019). Amendments for CnossosEU, description of issues and proposed solutions, RIVM Letter Report, National Institute for Public Health and the Environment.

[66] European Commission. (2011). Report On the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0321&from=EN.

[67] Ibid.

[68] European Commission. (2017). Report on the Implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=COM:2017:151:FIN&from=EN

[69] Ibid.

6) Single European railway area (Directive 2012/34);
7) Staff Working Document on 'Rail freight noise reduction'; and
8) Regulation on tyre safety including noise limits and labelling (Regulation 2020/740).

The implementation report states that EU 'noise-at-source' legislation provides the most effective combination of measures for reducing noise impact. For roads, this would refer to noise levels of vehicles and tyres. For railway, it would decrease the rolling stock noise, particularly from rail freight, and for airport it is associated with aircraft approach and departure. However, noise levels depend also on infrastructure condition, driver behaviour and vehicle condition. Among the recommendations is extension of EU support in financing noise mitigation activities relevant to urban policy at the Member State level (via instruments such as the Cohesion Fund, European Regional Development Fund and Connecting Europe Facility).

Given the rapidly evolving context, the European Commission proposed carrying out an evaluation of END in 2013 to determine whether the directive remains relevant to tackling the issue it addresses, while providing EU added value in relation to Member State acting alone.[70] The evaluation took a form of the Regulatory Fitness and Performance initiative (REFIT) 10 years after adoption of END between 2015 and 2016.

This evaluation procedure emphasised that the directive has not fully met is objectives given the long period required for adopting common methodology assessments and for enforcing active implementation. The implementation of the directive has not been carried out across all Member States, with long delays in drawing up and adopting action plans for noise management experienced.[71] Consequently, the European Commission has started official enquiries for non-compliance (8) and infringement cases with Member States (7).[72] Additionally, Member States requested a longer than one-year time period between the reporting on strategic noise maps and noise action plans.

In parallel to the abovementioned implementation report and REFIT, the EEA has published two reports on the status of noise pollution in Europe. The main findings from the first report in 2014 have already been covered in the END evaluation documents from the same period. The second EEA report highlighted that most European citizens (113 million) suffer from road traffic noise above 55db(A), while railway noise affects 22 million, aircraft noise 4 million and industrial noise 1 million. The report is based on data from the third reporting round for which Member States have submitted around 70% of required reporting data. Compared to the previous round (2012) figures relating to the number of people impacted remained the same. However, due to increasing mobility demand and growing populations, an increasing number of people will be impacted. The report calls for a more accurate designation and increased protection of quiet areas in and around cities. The EEA concluded that the EU has not yet reached recommended WHO noise levels. Using Dublin as an example, Murphy and King investigated various scenarios of noise action plans and the impact of mitigation measures on population exposure.[73] The research demonstrated that the level of population exposure during night-time is unexpectedly high in comparison to the limits established within WHO guidelines.[74] It would appear that the WHO guidelines are considered a long-term ambition rather than a concrete policy objective. In addition, according to the Annual Indicator Report Series (AIRS) released by EEA on Environmental noise, "efforts to reduce environmental noise

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[70] Ibid.

[71] European Commission (2016). REFIT Evaluation of the Directive 2002/49/EC relating to the assessment and management of environmental noise. Available at: https://ec.europa.eu/environment/noise/pdf/staff_working_doc_refit_evaluation_environmental_noise.pdf.

[72] Ibid.

[73] Murphy, E. and King, E.A. (2011). Scenario analysis and noise action planning: modelling the impact of mitigation measures on population exposure. Available at: https://www.sciencedirect.com/science/article/abs/pii/S0003682X10002343.

[74] Ibid.

tend to be offset by an increase in the number of people being exposed to high noise levels, in particular due to increasing road and aviation traffic and an increase in the number of city inhabitants”.[75]

2.2.3 EU complementary legislation on noise emission limits

The EU response on reducing environmental noise pollution, according to END, focused on legislation targeting ‘noise-at-source’ (road, rail, aircraft, infrastructure, outdoor, industrial equipment, mobile machinery), which complements noise reduction efforts at local and national level. To efficiently tackle noise pollution, both exposure-related and non-exposure related interventions should be considered. Brown and van Kamp define a exposure-related measure as one that aims to “change the level of noise exposure of people” while non-exposure-related are intended to change health outcomes but do not include changing people’s exposure” (e.g. education and communication).[76] Noise is a local problem, therefore according to the subsidiarity principle, local and regional authorities are responsible for measuring and proposing effective noise solutions. Consequently, local, regional and national levels tend to have more knowledge and competences on regulating noise reduction. Noise management activities such as urban and land planning, traffic regulation, building noise barriers and infrastructure, regulating noise limits nearby schools and hospitals are Member State competences. However, EU-level policies do impact on the formulation and thresholds imposed by national and local legislation concerning planning and infrastructure activities (‘noise management’).

The END directives focus on reducing the ‘noise at sources’, acknowledging also other minor noise sources (industry, machinery and outdoor noise). However, its nexus with other EU policies could mean that it impacts on other activities as well. The EEA 2020 report notes that air and noise mitigation measures jointly would give better cost-benefit results than each of these areas treated separately.[77] Therefore, this approach requires a more efficient horizontal coordination between different policy areas and alignment with the Green Deal ambitions in pursuing sustainable development goals (SDGs). In doing so, the EU would put more emphasis on the focal point of its environmental policy: the principle of integration of environmental policy in other sectors.

For instance, the EU is currently pursuing ambitious 2030 the Energy and Climate Framework that obliges Member States to adopt national energy and climate plans (NECPs) for the period 2021 – 2030 that take into consideration environmental and health benefits (i.e. reducing the air pollution etc.). Also, a correlation can be drawn between the noise abatement measures and the field of the building renovations regulated under the Energy Efficiency Directive and Energy Performance of Buildings Directive (e.g. insulation in buildings according to the latest innovations). Furthermore, the policy coordination between “quiet areas” and “protected areas” according to Natura 2000 (Birds 79/409/EEC and Habitats 92/43/EEC Directives), could be sought to foster another joint cost-benefit initiative. As well as interlinkages between relevant policy EU areas, further coordination between EU and international standards could be developed through different noise-related policies.

2.2.3.1 Road traffic noise

International level

The United Nations Economic Commission for Europe (UNECE) and its Transport Division on World Forum on Harmonisation of Vehicle Regulations (WP.29) played a key role in shaping legislative

[75] EEA. (2016). Annual Indicator Report Series (AIRS): Environmental noise.

[76] *Op.cit.* Brown and van Kamp 2017.

[77] *Op.cit.* EEA 2020.

frameworks and guidelines at international level. There are three main agreements that underpin the work of WP.29:

- The 1958 Agreement: the legal basis for international UN Regulations on vehicle type approval; the regulations are updated according to technological and scientific progress, but the adoption of UN Regulations is not binding and each contracting party may decide on including it to its own legal system;
- The 1997 Agreement: the legal basis for UN Rules on periodical inspections of vehicles in use; and
- The 1998 Agreement: the legal basis for the establishment of United Nations Global Technical Regulations (UN GTRs) as the part of UN Global Registry; the UN GTRs explain technical references and regulations rationale for the transposition in national legislation.[78]

The UNECE (WP.29) has a Working Party on Noise and Tyres (GRBP).[79] The Informal Working Groups under GRBP actively assist GRBP on the development of UNECE regulations related to sound emissions from vehicles and tyre's performance, in addition to the direct discussions in GRBP (Additional Sound Emission Provisions, Tyre GTR, Worn Tyres Wet Grip, Task Force on Measurement Uncertainties, Task Force Tyre Pressure Monitoring System and Tyre Installation, Task Force on studded tyres, Task Force on Reverse Warning System).[80]

On behalf of the EU (understood as Regional and International Organisation – REIO) and all EU Member States, the European Commission is negotiating and adopting legislation inspired by UN Regulations and UN GTRs.[81]The European Commission has been organising stakeholders' consultations within CARS 21 group (Competitive Automotive Regulatory System for the 21st Century)82 and regularly publishing:

- Status of EU accession to UNECE regulations for vehicle approval; and
- Progress report on activities of the world forum for harmonisation of vehicle regulations.[83]

In 2002, the UNCE and the WHO created a common platform on the Transport, Health and Environment Pan-European Programme (THE PEP) with a focus on sustainable urban transport and policy integration.[84] Similar to the END reporting on noise action plans, the PEP and the WHO have developed together a manual (2014) for national transport, health and environment action plan (NTHEAP) that "provide a comprehensive and intersectoral way of planning and implementing transport, environment and health action at the national level."[85] In 2019, the PEP has published the

[78] UNECE (2012), World Forum for Harmonisation of Vehicles Regulation (WP.29) How it works? How to join it? Third edition, available at: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29pub/WP29_Blue_Book_2012_ENG.pdf

[79] UNECE (2020), World Forum for Harmonisation of Vehicle Regulations (WP.29) Working Party on Noise and Tyres (GRBP), available at: https://www.unece.org/trans/main/wp29/meeting_docs_grb.html

[80] UNECE (2019), Working Party on Noise and Tyres (GRBP) (Former GRB) Informal Working Groups (IWGs) under GRBP, available at: https://wiki.unece.org/pages/viewpage.action?pageId=917781

[81] UNECE (2019), World Forum For Harmonisation of Vehicle Regulations (WP.29) How it works – How to join it? Fourth Edition, available at: http://www.unece.org/fileadmin/DAM/trans/main/wp29/wp29wgs/wp29gen/wp29pub/WP29-BlueBook-4thEdition2019-Web.pdf

[82] European Commission (2012), Informal document WP.29-157-23 (157th WP.29, 26-29 June 2012, agenda item 6), available at: https://www.unece.org/fileadmin/DAM/trans/doc/2012/wp29/WP29-157-23.pdf

[83] European Commission (2020), UNECE: Progress report and status report, available at: https://ec.europa.eu/growth/sectors/automotive/legislation/unece_en

[84] WHO Regional Office for Europe (2014), From Amsterdam to Paris and beyond: the Transport, Health and Environment Pan-European Programme (PEP) 2009-2020, available at: https://thepep.unece.org/sites/default/files/2017-05/From-Amsterdam-to-Paris-and-beyond-Eng.pdf

[85] WHO Regional Office for Europe (2014), *Developing national action plans on transport, health and environment*, available at: http://www.euro.who.int/__data/assets/pdf_file/0010/247168/Developing-national-action-plans-on-transport,-health-and-environment.pdf?ua=1

results of present partnerships on Health Economic Assessment Tools (HEAT), Cycling Promotion, Eco-Driving, Jobs in Green and Healthy Transport, Integration of Transport, Health and Environmental Objectives into Urban and Spatial Planning, and environmentally healthy mobility in leisure and tourism.[86] After one decade (2019), the PEP has involved through its partnerships around 30 countries, international organisations (e.g. ILO, UNEP, OECD etc.), NGOs (e.g. Polis, European Cyclist Federation etc.) emphasising the importance of the provision of public bicycles and walking in urban sustainable transport strategies, as it appears to be a neglected topic in transport discussions.[87]

EU level

According to 2018[88] reporting by the EEA, road traffic is the most widespread noise source and is responsible for a large majority of exposure to road traffic noise above 55dB every day. In fact, according to a 2020 publication[89] by the EEA, at least 113 million people are affected by exposure to long-term traffic noise above 55dB despite longstanding EU legislation establishing noise standards for vehicles.

The most significant sources of noise from road transport are powertrain noise and rolling noise. Other sources such as car horns, door slamming and squeaking brakes can cause disturbance but tend not to affect the average noise levels and are not included in noise mapping. Powertrain noise is known to be the dominant source at low speeds, at junctions and on gradients whereas tyre noise is predominant at higher speeds depending on the road surface and vehicle type. In urban situations, there is therefore always a mix of powertrain and rolling noise. On roads with higher speeds, such as arterial roads and motorways, tyre noise tend to be dominant.

A range of solutions can be found for reducing noise at source, in the propagation path and at the receiver, which are selected in relation to noise exposure related health impacts. Relevant literature on the topic indicates that measures implemented, which can include physical barriers, financial incentives as well as landscaping and other alternatives, need to be monitored in terms of their effectiveness and efficiency (including cost-efficiency) in order to adapt these noise solutions to the changing needs of the population – i.e. increasing population density, revitalisation of specific urban areas etc.

Noise solutions implemented at the source, such as the reduction of tyre noise and quieter road surfaces, are more effective if they involve all relevant industry stakeholders.[90] In addition to the implementation of legal requirements, international standards and voluntary industry initiatives are also an important part of wide-scale implementation of innovative noise solutions.

A methodology developed by the International Standards Organisation (ISO) for the measurement of influence of road surfaces on traffic noise (ISO 2017) identifies a method for evaluating different road surfaces with respect to their influence on traffic noise, under conditions when tyre/road traffic noise dominates[91]. While the standard does not establish minimum criteria for road surfaces, it does provide an overarching methodology for measuring and comparing the noise generated by different compositions of road surface noise in a free-flowing traffic.

A 2012 study from the European Network of the Heads of Environment Protection Agencies (EPA Network) confirmed that mitigation efforts to reduce noise are more cost efficient if taken 'at source'

[86] UNCE (2019), The PEP Partnerships, available at: https://thepep.unece.org/sites/default/files/2019-07/1822582E_interactive.pdf

[87] Ibid.

[88] EEA (2018) https://www.eea.europa.eu/airs/2018/environment-and-health/environmental-noise

[89] EEA (2020) Environment noise in Europe https://www.eea.europa.eu/publications/environmental-noise-in-europe

[90] European Commission (2009). Accompanying the document Proposal for a Regulation of the European Parliament and of the Council on the labelling of tyres with respect to fuel efficiency and other essential parameters and repealing Regulation (EC) No 1222/2009. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018SC0189

[91] ISO 11819-2:2017 https://www.iso.org/standard/39675.html

than if implemented 'at the receiver'.[92] Noise 'at source' measures for road transport relate primarily to vehicle and tyre characteristics, but can include low noise surfaces and driving conditions.[93]

Given that tyre noise becomes the dominant rolling noise source at higher speeds (30-40 km/h), the acoustic optimisation of tyres can be an important element of road noise reduction. A recent study, based on the comparative analysis of 14 different tyres on 14 different road surfaces, showed a 4-5dB difference between the specific tyres. The study calls on policy-makers to dedicate more resources to the proliferation of 'silent tyres' as a way to reduce road traffic noise.[94] Another recent research conducted in the Nordics confirmed the difference between measured noise levels at ISO surfaces and labelled values for both commercial and passenger vehicle tyres. This study identified an 11dB difference between the noisiest and quietest tyres and pavements, while emphasising the combined benefits of tyre and road surface noise reduction.[95]

To align regulatory provisions with technological developments, relevant EU policies are regularly reviewed and amended as necessary. The EU recently adopted[96] a new regulation for the labelling of tyres, aimed at increasing consumer awareness (via labels on tyre characteristics), improving market surveillance and enforcement. The new regulation aims to update the current label from May 2021 onwards. The new labels are expected to bring savings for consumers by lowering fuel consumption, increase road safety by highlighting information on tyre characteristics and lower CO_2 and noise emissions.[97] This legislation is addressing concerns by reducing both noise at source and increasing awareness among buyers of tyres.

The implementation of noise solutions at source can bring additional costs for the manufacturers in terms of innovations, labelling requirements and bringing new products to the market. In a 2008 report[98] the International Road Transport Union (IRU) criticised the European Commission's assessment of the internalisation of external costs in the transport sector highlighting uncertainties in EU studies and stating that noise costs are partly borne by motorists who co-finance noise protection measures (via taxes, charges and other instruments). The IRU argues that external costs relate solely to residents living in the vicinity of the road. The report calls for those paying the lowest cost for avoiding the noise pollution to reduce the external cost. In practice this may mean those who have purchased properties in the vicinity of high noise pollution areas should co-finance noise solution measures, although the extent of the burden sharing is not detailed in the paper. While this concept of burden sharing takes a rather limited approach without considering the wider socio-economic issues that may have led to a segment of the population to live near congested and noisy areas, the idea of taking a wider look and considering solutions in addition to those targeting the source is a valid one. In fact, urban planning, landscaping and similar initiatives could very well complement receiver-based solutions. In a follow-up study of 2012[99], IRU argues that transport noise can only be efficiently reduced if certain issues, such as providing investment guarantees and incentives to operators and creating more low noise infrastructure, are taken into account.

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[92] Van Blokland G., (2012), Progress report on measures on road traffic noise in the EU, EPA Network, available at: https://epanet.eea.europa.eu/reports-letters/reports-and-letters/ig-noise_measures-on-road-traffic-noise.pdf/@@download/file/IG%20Noise_Measures%20on%20Road%20Traffic%20Noise.pdf

[93] Ibid.

[94] Hammer, Buhlman (2018) The noise reduction potential of "silent tyres" on common road surfaces https://www.euronoise2018.eu/docs/papers/453_Euronoise2018.pdf

[95] NordFoU (2018) Potential society effects of regulation tyre/road noise–Summary report of the NordTyre projects http://www.nordfou.org/knowledge/Documents/NordTyre%203%20-%203.pdf

[96] EC (2018) Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the labelling of tyres with respect to fuel efficiency and other essential parameters and repealing Regulation (EC) No 1222/2009 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018PC0296

[97] EP (2020), Tyres Labelling, available at: https://www.europarl.europa.eu/news/en/headlines/society/20200423STO77731/tyre-pollution-lowering-car-emissions-with-new-eu-tyre-labels

[98] IRU (2008) https://www.iru.org/sites/default/files/2016-01/en-acea-critical-review.pdf

[99] IRU (2012) Position paper on noise https://www.iru.org/sites/default/files/2016-01/en-anex-b100870-vehicle-noise-2012.pdf

The externalisation of internal transport costs was further studied by the Commission in 2019[100] in a report prepared with CE Delft. The study took into consideration a range of external costs including accidents, air pollution, climate change, noise, congestion, well-to-tank emissions, and habitat damage and concluded that on average motorcycles cause the highest external costs due to their relatively high noise and accident costs. In addition, the average external costs of buses/coaches are lower than those of passenger cars, pertaining to their higher occupancy rates. The paper identifies several measures that could improve internalisation of external costs including wider use of distance-based road charges differentiated to vehicle characteristics.

These reports highlight the complexity of choosing the fit-for-purpose noise solution measures that are effective in protecting the population from noise pollution – i.e. those that are adapted to the specific conditions of the area (urban, rural) while being cost effective and allowing a large number of businesses to adopt them.

A 2017 study by the Conference of European Directors of Roads (CEDR) on the monetisation of road traffic noise provides guidance and examples regarding the selection of the most suitable noise solutions, taking into consideration their effectiveness and cost efficiency. The report proposed that national road authorities invest in the development and dissemination of cost-benefit and cost effectiveness analyses tools and use them to define the right type of noise solutions.[101] It also provides a guide supporting the selection of the most suitable cost-analysis tool and identifies several good practices (e.g. speed limit reduction, quiet asphalt, road planning projects).

Overall, research on road traffic noise solutions indicates that there is still room for improvement in terms of coordination of innovation and dissemination of knowledge regarding the best available technologies, as well as the cost effectiveness of measures.

2.2.3.2 Railway

International level

The UNECE Working Party on Railway Transport (SC2) brings together various stakeholders (countries, the European Commission, OSJD, OTIF, TER, CIT, CER, UIC etc.) and provides continuous work on topics such as:

- Pan-European rail infrastructure standards (AGC Agreement)
- Development of a trans-European railway network (TER Project)
- Facilitation of border crossing in international rail transport
- Operational aspects of international rail transport (capacity, productivity, interoperability, new technologies)
- Facilitation of container train traffic on Euro-Asian routes
- Rail tunnel safety
- Rail transport security
- Passenger accessibility of rail transport
- Environmental questions related to railways.[102]

[100] EC (2019) Sustainable Transport Infrastructure Charging and Internalisation of Transport Externalities https://ec.europa.eu/transport/sites/transport/files/studies/internalisation-study-exec-summary-isbn-978-92-76-03080-5.pdf

[101] Fryd J., Axelsson H., Lükk V., Bellucci P., Izquierdo López M., Dahlbom L., (2017), Technical Report 2017-03: State of the art in managing road traffic noise: cost-benefit analysis and cost-effectiveness analysis, CEDR, available at: https://www.cedr.eu/download/Publications/2017/CEDR-TR2017-03-Noise-CBA-CEA.pdf

[102] UNCE (2020), About the UNECE Working Party on Rail Transport (SC.2), available at: http://www.unece.org/trans/main/sc2/sc2_about.html

The UNCE Railway basic legal documents are European Agreement on Main International Railway Lines – AGC (1985) and UN Resolution No. 66 on marshalling yards on the AGC network.[103]The UNCE Railway has also dedicated group for Unified Railway between pan-European and Euro-Asian transport corridors. [104]

The International Union of Railways (UIC) oversees the work of its Network on Noise and Vibrations (NNV) which functions as a centre of excellence for collating and disseminating information, organising events and leading research.[105] In its 2016 report[106], it points out the complexities of reducing noise and maintaining rail freight traffic between EU countries. Rail is consider to be a more environmentally friendly transport mode than road, and its development aligns with the EU's sustainability agenda. It also serves to link the most densely populated industrial and commercial areas of Europe. In this context, innovation and its cost-effective application play an essential role in the development and implementation of adaptable noise solutions.

EU level

The railway system is much more interdependent than road and aviation. Cross-country railway infrastructure must be developed according to the same standards to allow for international transport to operate. In Europe it is the Technical Specifications for Interoperability (TSIs)[107] that define the technical and operational standards which must be met by each subsystem or part of subsystem to fulfil the essential requirements and ensure interoperability across the EU. Directive 2016/797 defines the systems and subsystems that must apply TSIs, stating that:

> "The design and operation of the rail system must not lead to an inadmissible level of noise generated by it:
> - in areas close to railway infrastructure, as defined in point (3) of Article 3 of Directive 2012/34/EU, and
> - in the driver's cab[108].
>
> Operation of the rail system must not give rise to an inadmissible level of ground vibrations for the activities and areas close to the infrastructure and in a normal state of maintenance."

EU legislation on the reduction on noise from railway noise at source, TSI Noise[109], is part of a high-level legislation on interoperability of the EU railway system. Similar to road transport, in order to advance EU legislation in this field, technical and scientific updates must be closely followed.

The main element of TSI Noise is the specification of noise limits for newly approved rolling stock allowed to run in the European rail network. Type approval noise limits are specified for pass-by noise at constant speed, at acceleration and at standstill/idling, under controlled and well-defined conditions. The limits are given for passenger vehicles, locomotives, high-speed trains and freight vehicles, including retrofitted freight wagons with quieter (composite) blocks. A 2019 amendment[110] to the TSI adds the requirements for 'quieter routes' with more than 12 freight trains per night on average, to stimulate the use of silent wagons on these lines, which are in fact the busiest and have

[103] UNECE (2020), Rail transport Legal Instruments, available at: http://www.unece.org/trans/main/sc2/sc2.html

[104] UNECE (2013), Joint Declaration on the promotion of Euro-Asian rail transport and activities towards unified railway law, available at: http://www.unece.org/fileadmin/DAM/trans/doc/2013/itc/Joint_Declaration_on_URL.pdf

[105] UIC Noise and Vibrations https://uic.org/sustainable-development/noise-and-vibration/

[106] UIC (2016) Railway noise in Europe https://uic.org/IMG/pdf/railway_noise_in_europe_2016_final.pdf

[107] TSI definition by the European Railway Agency at https://www.era.europa.eu/activities/technical-specifications-interoperability_en

[108] Directive 2016/797 on the interoperability of the rail system within the European Union https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1519999459620&uri=CELEX:32016L0797

[109] Commission Regulation (EU) No 1304/2014 of 26 November 2014 on the technical specification for interoperability relating to the subsystem rolling stock — noise amending Decision 2008/232/EC and repealing Decision 2011/229/EU https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02014R1304-20190616

[110] EU 2019/774 https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0774&from=DE

the most impact on adjacent dwellings. The European Union Agency for the European Railway Area (ERA) developed a guide[111] in 2012 containing references, procedures and technical solutions for the assessment of subsystems.

Retrofitting of wagons is financially supported by some Member States as well as through EU instruments such as the Connecting Europe Facility (CEF)[112] which has been providing funding for the retrofitting of wagons since 2014, and in the most recent financing period allocated a further €20.1 million for this purpose.

Noise reduction efforts can also be implemented through Noise Differentiated Track Access Charges (NDTAC) that are implemented and managed by infrastructure managers to incentivise further circulation of quieter wagons. According to UIC[113] NDTAC schemes are likely to be introduced by Member States while those existing schemes that had already been in place prior to the regulation must be harmonised to ensure compliance with the current rules. These schemes exist in Austria, the Czech Republic, Germany, Netherlands and Switzerland, where the high volume of traffic on Rhine-Alp corridor makes the scheme very efficient.

On the national level, the German Environmental Agency published a report on Strategies for Effective Reduction of Railway Freight Noise in 2017[114] (UBA 2017) in which the substitution of cast-iron brake blocks by composite brake blocks is one of the proposed noise reduction solutions that is expected to be fully implemented by the end of 2020. The UBA's study analyses a range of measures to reduce freight railway noise. It focuses on solutions for freight wagons, but it also surveys measures for infrastructure and locomotives. The expected future growth of rail freight and the complex organisation of freight wagons pose significant challenges for noise reductions. It notes that wheel roughness is the most important cause for noise emissions; most wagons have traditional block brakes and use cast-iron brake blocks that increase wheel roughness.

The report also notes that noise levels can drastically exceed regulatory thresholds on some parts of the network, especially at night. The replacement of cast iron brake blocks with composite brake systems is seen as an effective solution and a key priority. Further reductions of 10 to 15dB(A) are necessary. Reducing wheel roughness will result in a lower noise level and other sources of noise will then become more important for the perception of noise.

One aspect of noise solutions that has been relatively absent from the relevant literature is urban planning including the acquisition of dwellings and even relocation of rail tracks etc. While relocation of rail tracks is a rather complex long-term and high-cost infrastructural investment, examples do exist. New high-speed lines and tunnelled lines under urban areas are commonplace in Europe and elsewhere. In Canada, for example, government funding is available to co-finance rail relocation or rerouting if the upgrade or expansion of the current system is not feasible.[115]

2.2.3.3 Airports and aircraft

International level

The International Civil Aviation Organisation (ICAO) has been the key initiator behind the global harmonisation of aviation rules. In terms of noise, the most relevant aspect of policy is ICAO's Annex 16 to the Chicago Convention, which was adopted in 1971. Annex 16 is composed of four volumes which focus on aircraft noise, engine emissions, CO_2 emissions and carbon offset scheme (CORSIA). The document also contains technical manuals dedicated to each of the four volumes which describe

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[111] ERA (2012) TSI application guide https://www.era.europa.eu/activities/technical-specifications-interoperability_en

[112] Connecting Europe Facility https://ec.europa.eu/inea/en/connecting-europe-facility

[113] UIC (2016) Railway noise in Europe https://uic.org/IMG/pdf/railway_noise_in_europe_2016_final.pdf

[114] Umweltbundesamt (2017) Strategien zur effektiven Minderung des Schienengüterverkehrslärms https://www.umweltbundesamt.de/publikationen/strategien-zur-effektiven-minderung-des

[115] Rail Canada (2017) Rail relocation https://www.railcan.ca/wp-content/uploads/2017/08/Rail_relocation_factsheet_EN.pdf

procedures for the certification of aircraft related to the aforementioned emission types.[116] The scope of Annex 16 has significantly expanded in the past 50 years to include various new kinds of aircraft (e.g. light propellers and helicopters) and introduce more stringent emission limit requirements.[117]

Another important ICAO policy is the development and dissemination of the 'Balanced Approach'[118] to Aircraft Noise Management which promotes the combination of various noise solution measures (at source, at the receiver, procedures and operating restrictions) to achieve maximum noise level reduction and efficiency. In addition to Annex 16 and the Balanced Approach, the ICAO has a number of further guidelines and publications on community engagement, operational procedures, land use planning and community engagement which can all contribute to lower noise emission levels. These include:

- Community Engagement for Aviation Environmental Management;
- ICAO Doc 9184: Airport Planning Manual (Land Use and Environmental Control);
- ICAO Doc 9888: Noise Abatement Procedures (2007) (2010);
- ICAO Doc 9911: Recommended Method for Computing Noise Contours around Airports;
- ICAO Doc 9931: Continuous Descent Operations (CDO) Manual; and
- ICAO Doc 8168: Procedures for Air Navigation Services — Aircraft Operations.[119]

In line with ICAO 'balanced approach', experts found that the reduction of 'noise at source' and improving the aircraft operational procedures (departure and landing) are the most efficient noise mitigation strategies.[120]

More recently, within its 2019 Environmental report[121] the ICAO published a white paper[122] on noise which stated that annoyance-related aircraft noise has increased in recent years, although a set of acoustic and non-acoustic factors may impact the level of annoyance. These may include the rate of change or the number of movements at the airport. The paper acknowledges the strong link between aviation noise and health outcomes, specifically its association with heart disease, with the caveat that the exact magnitude of exposure-response estimates remains uncertain. At the same time, the lack of studies related to the mental health impact of noise is also noted.

EU level

The EU legislation related to the reduction of aircraft noise is strongly aligned with relevant ICAO decisions. The ICAO's Balanced Approach (2011), was transformed into EU legislation via the adoption of Regulation 598/2014[123] which established rules and procedures on the introduction of noise-related operating restrictions at airports in the EU within a Balanced Approach. It is the main EU legal and policy reference for air traffic noise. Technical procedures and standards from the ICAO

[116] ICAO, The Postal History of ICAO, available at: https://applications.icao.int/postalhistory/annex_16_environmental_protection.htm

[117] ICAO, 2019 Environmental Report: Aviation and Environment

[118] ICAO, Balanced Approach to Aircraft Noise Management, available at: https://www.icao.int/environmental-protection/Pages/noise.aspx

[119] ICAO, Environment Publications, available at: https://www.icao.int/environmental-protection/Pages/environment-publications.aspx

[120] ICAO (2019), 2019 Environmental Report: Aviation and Environment, available at: https://www.icao.int/environmental-protection/Documents/ICAO-ENV-Report2019-F1-WEB%20(1).pdf

[121] ICAO (2019), 2019 Environmental Report: Aviation and Environment, available at: https://www.icao.int/environmental-protection/Documents/ICAO-ENV-Report2019-F1-WEB%20(1).pdf

[122] ICAO (2019) Aviation noise white paper, available at https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg44-61.pdf

[123] European Commission on the establishment of rules and procedures with regards to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach https://op.europa.eu/en/publication-detail/-/publication/b6947ca7-f1f6-11e3-8cd4-01aa75ed71a1

can also be transposed via rules, guidelines and certification requirements of the European Aviation Safety Agency (EASA). [124]

The EU's Balanced Approach adopts the ICAO principle four pillars and notes that the decision on noise mitigation measures should be based on cost assessment principles. According to the Balanced Approach, each airport should decide on noise mitigation measure based on the relevant noise exposure limits, geographic locations and other key characteristics. If noise pollution cannot be mitigated with measures under first three pillars (reduction of noise at source, land-use planning, noise abatement operational procedures) than the fourth pillar on noise operating restrictions can be put in place. This 'flexible' approach allows each airport to find the relevant solution for its own context.[125]

The effectiveness of operational restrictions including night-time curfews has been studied extensively over the past two decades. Research shows that noise reduction is achieved through operational restrictions, although these may not apply to all aircrafts (such as military planes) and some noise disturbance during the night time can still remain.[126] Additionally, community engagement and communication with citizens was found to be essential for identifying the most effective noise reduction measures for specific locations.[127]

Airport Council International is the main industry association representing airport owners. Its European branch, ACI Europe, published a study in 2018 emphasising the importance of distinguishing between acoustic and non-acoustic factors:

- Acoustic factors focus on the reduction of noise at source (e.g. quieter aircraft etc.) and traffic management (e.g. avoiding flying over residential areas); and
- Non-acoustic factors rely on people's attitudes and perception of noise.[128]

This is a relevant topic as the airports may frequently encounter a situation where noise levels decrease while noise complaints and annoyance increase.[129] In order to gather scientific evidence related to noise effects, the German non-profit institute Gemeinnützige Umwelthaus together with the State of Hesse commissioned a large-scale study to identify the range of impacts that airports have on the health and quality of life of residents. The Noise-Related Annoyance, Cognition and Health[130] (NORAH) study ran from 2011-2013 and focused on four airports: Frankfurt, Cologne/Bonn, Stuttgart, and Berlin-Schönefeld. The study concluded that aviation noise was associated with higher noise annoyance than road or rail traffic noise at comparable long-term levels. The study also showed that exposure to higher levels of night-time noise had a higher associated health risk.

The ongoing EU co-funded ANIMA (Aviation Noise Impact Management) project[131] (2017-2021) is focused on reducing annoyance related to noise pollution around airports by looking at non-acoustic factors.

Some of these non-acoustic factors have also been emerging more strongly in the noise management strategies of airports. The 2019 ACI Europe publication on 'Sustainability strategy for

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[124] ACI Europe (2018), Addressing the future of aviation noise, available at: https://www.aeroport.fr/uploads/documents/voir-l'etude-sur-le-bruit.pdf?v12"https://www.aeroport.fr/uploads/documents/voir-l'etude-sur-le-bruit.pdf?v12

[125] Ibid.

[126] G. Alonso et al (2017) The efficiency of noise mitigation measures at European airports, Transportation Research Procedia 25

[127] European Parliament (2021) Impact of aircraft noise pollution on residents of large cities https://www.europarl.europa.eu/RegData/etudes/STUD/2020/650787/IPOL_STU(2020)650787_EN.pdf

[128] ACI Europe (2018), Addressing the future of aviation noise, available at: https://www.aeroport.fr/uploads/documents/voir-l'etude-sur-le-bruit.pdf?v12

[129] Ibid.

[130] NORAH. NORAH's study publications. Available at: https://www.norah-studie.de/en/

[131] ANIMA. Project overview. Available at: https://anima-project.eu/the-anima-project/

airports'[132] categorises noise not as an environmental impact but rather as a social one, closer to UN goals (SDG 3 on healthy living and well-being and SDG 11 on sustainable urbanisation). This aspect is particularly important for the airport's strategy for closer community and local engagement with residents living close in airports.

Despite the focus on a wider range of approaches, reducing noise at source is still very much an important aspect of noise solutions. The EU is continuing to invest in research and solutions for reducing noise at source via its Joint Undertaking CleanSky[133] specifically through research on quiet aircraft as well as through Single European Sky Air Traffic Management (SESAR)[134] schemes research on improving aircraft operation procedures.

2.2.3.4 Agglomerations

Sustainable Development Goal (SDG) 11[135] focusses on sustainable cities and communities, improving health and environmental protection in cities, communities, and agglomerations. The WHO has categorised noise from road traffic the second most harmful environmental stress factor in Europe, only surpassed by air pollution. According to calculations by the European Environment Agency (EEA), road-traffic noise in and outside of urban areas is the dominant source of noise affecting human health. In 2018, it reported that "more than 75 million people in urban areas in the EU are estimated to be exposed to road traffic noise above 55dB Lden (day–evening–night noise level)"[136]. One factor that affects the perceived level of noise apart from the objective measurable noise level is the degree of urbanisation.

This was empirically highlighted by the WHO.[137] The key finding was that individuals in EU cities were more likely to report noise from neighbours or from the street than those living in towns, suburbs or rural areas. Another alarming insight of the report was that poor people tend to face more challenges in their living situation, a finding that was most pronounced in cities. It reported that "the prevalence of poor housing, overcrowding, exposure to noise [...] in the EU was higher for the population living below 60% of the median equivalised income compared with the population above this level".[138]

Box 2.1 Illustrative example of Noise Mapping in Hamburg

There is no structured comprehensive scheme for noise abatement in Hamburg, though there are several measures that contribute to the reduction of environmental noise.

The airport of Hamburg, for example, has limited the use of certain starting process that were implemented in 2012, where cutback is much lower than with other departure procedures. Airlines and pilots have the choice between two noise reducing departure procedures, labelled NADP 1 and NADP 2 (Noise Abatement Departure Procedures) by the ICAO. Additionally, there is a recommendation to use a different departure procedure and the number of night-time flights has been limited. (Flughafen Hamburg 2001 and 2017).

With regards to road transport, local policy-makers built a noise barrier surrounding highway A7 as a way to reduce noise emission resulting from the expansion of the highway from six to 10 lanes. The barrier has partially been completed. (Hamburg BWVI 2014)

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[132] ACI Europe (2019) Sustainability strategy for airports https://www.aci-europe.org/downloads/resources/aci%20europe%20sustainability%20strategy%20for%20airports.pdf

[133] Clean Sky 2, Clean Sky 2 website. Available at: https://www.cleansky.eu/

[134] SESAR JU, Single European Sky (SES) initiative's website. Available at : https://www.sesarju.eu/

[135] UN. Sustainable Development Goals. Available at: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[136] Eurostat (2019). SDG 11 – Sustainable cities and communities. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/SDG_11_-_Sustainable_cities_and_communities#Sustainable_cities_and_communities_in_the_EU:_overview_and_key_trends

[137] WHO (2011). Burden of disease from environmental noise. Available at: http://www.euro.who.int/__data/assets/pdf_file/0008/136466/e94888.pdf.

[138] *Op.cit.* Eurostat 2019.

To address road traffic in urban areas, the city published a master plan (Hamburg 2020) which included the development of the public charging infrastructure for electric vehicles (City of Hamburg, 2018). This plan includes a mobility programme as part of the continuous development plan for urban traffic. A clean air plan (Luftreinhalteplan LRP 2017) aims to reduce annual averages of NO_2, while the city has a strategy to digitalise the traffic system.

These complementary policies are all part of a wider plan to reduce noise in Hamburg, as they affect traffic, electronic mobility and general urban mobility.

3 Analysis of noise action plans and stakeholder consultation

3.1 Overview

An essential part of the desk-based research phase is the analysis of noise action plans with a view to identifying noise solution measures that have been implemented and planned by Member States. Analysis of the action plans have been carried out on two levels; an overarching look at 200 action plans was completed identifying the types of noise solutions that have been implemented. Furthermore, in a second stage, based on the results of the generic mapping, in-depth analysis of 100 noise action plans was carried out to evaluate how legislation drove the implementation of these measures, and to identify the main challenges, bottlenecks and good practices. The findings of these assessments feed into both the cost-benefit analysis as well as the second stage of the study, which focuses on identifying how the current legislative landscape could be improved or better focused to deliver the overarching health objectives.

Findings of the noise action plan analyses are detailed below and will be shared with relevant stakeholders during the second project workshop. Based on the results as well as feedback and comments received from stakeholders, in the final part of the study, policy recommendations will be put forth facilitating uptake of good practices and improving effectiveness of noise solution measures.

In terms of the focus of the action plan analysis during the inception phase of this project, together with the Commission Services, we have identified a list of potential noise solutions (see table below) that could contribute to the overarching objective of this study and achieve a 20-50% reduction of health burden. Specific attention is paid to the extent to which these noise solutions were implemented and to what extent national or local initiatives facilitated their wider application.

Table 3.1 List of potential noise solutions

Source	Noise solution	Examples
Road	2dB reduction of noise from tyres	Tyres with lower average noise label value
	2dB reduction of noise by road surface	Porous asphalt and/or smooth asphalt
	At least 2dB reduction of whole vehicle noise	New noise limits, electric vehicles
	Noise barriers	Standard or special, including absorbent or tilted barriers and lane barriers
	Re-routing or limiting road traffic	Congestion charge or access restrictions for high dB areas and vehicles
	Acoustical site planning: increasing the sound attenuation between the noise source and the receiver via parks, courtyards, etc.	Urban planning on the national or local level
	Retrofitting of residential and communal buildings	Government incentives for homeowners Improved insulation, noise cancelling solutions
	Extending land barrier, changing land-use	Acquisition of dwellings

Source	Noise solution	Examples
Rail	2dB reduction from infrastructure improvement	Rail grinding, quieter rail pads, rail dampers, rail shielding (>1dB can be achieved)
	1dB reduction from new rolling stock	New generation rolling stock with very smooth wheels, > 2dB on smooth tracks
	Noise barriers	Standard or special, including absorbent or tilted barriers and low barriers near track
	Retrofitting of residential and communal buildings	Improved insulation, noise insulation solutions
	Extending land barrier, changing land-use	Acquisition of dwellings
Aviation	Landing and take-off improved profiles	Flight procedures
	Dispersion/concentration of flights	Route optimisation
	Operating restrictions/curfew	Airport regulation
	Operating restrictions/prohibition of operation for noisier aircraft	Airport regulation
	Forced phase out of older aircraft	Airport regulation
	Acquisition of new, lower noise emission airplanes	National level incentives for airlines
	Retrofitting of residential and communal buildings	Government incentives for homeowners to improve insulation, noise cancelling solutions
	Extending land barrier, changing land-use	Acquisition of dwellings

3.2 Overarching review of noise action plans

In the first and second phases of the study 200 noise action plans (NAPs) were reviewed, identifying the list of noise solution measures that had been planned and implemented in the Member States.

The analysis began with the selection of Member States where the criteria included:

- Availability of action plans in the categories of roads and railways inside agglomerations of more than 100,000 inhabitants, major roads of more than 3 million vehicles a year, major railway lines of more than 30,000 trains a year and around major airports of more than 50,000 movements a year; and
- Geographic diversity ensuring noise solutions adaptable to various climatic conditions are considered.

At the preliminary stage, a long list of 21 Member States were selected, taking into consideration an equal balance between small and large countries as well as geographic distribution: Austria, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Netherlands, Poland, Portugal, Romania, Slovakia, Spain and Sweden.

The next step was to analyse these countries in terms of availability of noise action plans as per January 2020. We have identified a short list of 16 countries that had submitted action plans according to the 2019 requirements: Austria, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and Sweden. The selection includes some of the largest countries in Europe (France, Spain, Germany and Poland) as well as smaller ones (Austria, Lithuania, Latvia) and ensures broad geographic coverage. In the shortlisted 16 Member States, 200 NAPs were selected considering proportionality in terms of the size of the country and relevance of noise source (number of people exposed) – i.e. larger group of NAPs (38%) are those for roads. However, this criterion has been subjected to data availability.

The action plans were scanned in terms of information on planned measures as well as information on measures implemented. Data on availability of limit values, public participation, evaluation of NAPs and evaluation of measures implemented were also collected. To the extent possible, our subsequent analysis compares planned measures with measures already in place. However, in the current NAPs summary template there is no specific field to provide such information. The measures already in place were provided only in some NAPs, and the analysis therefore could contain a bias that should be taken into account when evaluating the obtained results. In addition, information on possible challenges and bottlenecks that may have prevented full implementation of planned activities is collected from an in-depth analysis as well as complementary interviews with relevant stakeholders.

Information feeding into the analysis was sourced from the European Environment Agency's Reportnet system[139]. A detailed breakdown of the selection for the overarching analysis can be found in the table below.

[139] The analysis is based on data reported by Members States in Reportnet corresponding to DF7_10 Noise action plans (2019 reference year) and delivered up to 01/01/2020. Reportnet is the European infrastructure for supporting environmental data and information, and it is the official place where countries report data according to the END specifications. Data is available at the following link:

https://cdr.eionet.europa.eu/ReportekEngine/searchdataflow?dataflow_uris=http%3A%2F%2Frod.eionet.europa.eu%2Fobligations%2F371&years%3Aint%3Aignore_empty=2019&partofyear=&reportingdate_start%3Adate%3Aignore_empty=&reportingdate_end%3Adate%3Aignore_empty=&country=&release_status=released&sort_on=reportingdate&sort_order=reverse&batch_size=

Table 3.2 Basis of noise action plan selection[140]

Countries	Availability	Number of agglomerations available (1/1/20)	Selected	Number of major roads reports	Selected	Number of major railways reports	Selected	Number of major airports	Selected	Total analysed by country	Comments
Austria	Webforms	23 (six agglomerations)	4	9	5	1	1	1	1	11	Agglomerations: each source is provided as separate NAP
Bulgaria	Webforms	5	**3**	0	0	0	0	0	0	3	
Croatia	Webforms	2	2	6	6	1	1	0	0	9	
Denmark	Webforms	2	2	1	1	1	1	1	0	4	
Estonia	Webforms	2	2	1	1	0	0	0	0	3	
Finland	Webforms	10	4	1	1	1	1	1	0	6	
France	Webforms	5	5	43 (supposed road segments)	15	18 (supposed rail segments)	8	0	0	28	All sources can be analysed (nothing to be discarded)
Germany	PDFs / words	28 (14 agglomerations)	8	1,326 (supposed road segments)	16	13 (rail segments from 3 states and 1 report from the EBA)	4	13 (4 major airports)	3	31	Total that can be analysed: 12 agglomerations (Cologne and Hamburg to be discarded) and 3 major airports (Cologne-Bonn to be discarded)
Greece**	Not delivered	N/A		N/A		N/A		N/A			
Hungary	PDFs / words	1	0	0	0	0	0	1	0	0	Total that can be analysed: 0 agglomerations (Budapest to be discarded), nothing discarded for the rest of the sources

[140] (*) The noise action plans available in the corresponding countries both for agglomerations and major airports that have been discarded correspond to the noise action plans included in the in-depth analysis.

Countries	Availability	Number of agglomerations available (1/1/20)	Selected	Number of major roads reports	Selected	Number of major railways reports	Selected	Number of major airports	Selected	Total analysed by country	Comments
Ireland	Webforms	2	1	1	1	1	1	1	0	3	
Latvia	Webforms	1	1	1	1	1	1	1	1	4	
Lithuania	Webforms	0	0	1	1	1	1	0	0	2	
Luxembourg**	Not delivered	N/A		N/A		N/A		N/A			
Netherlands	Webforms	60	8	12	5	1	1	1	0	14	NAPs are provided by municipality. Larger agglomerations have separate NAP for each municipality
Poland	Webforms	32	**16**	19 (supposed road segments)	15	7 (supposed rail segments)	5	0	0	36	Total that can be analysed: 31 agglomerations (Warsaw to be discarded), nothing discarded for the rest of the sources
Portugal	Webforms	3	3	47	12	0	0	2	2	17	
Romania**	Not delivered	N/A		N/A		N/A		N/A			
Slovakia**	Not delivered	N/A		N/A		N/A		N/A			
Spain	Webforms	6	5	4 (supposed road segments-per regions, e.g.)	4	1	1	11	10	20	Total that can be analysed: 5 agglomerations (Bilbao to be discarded) and 10 major airports (Madrid to be discarded)
Sweden	Webforms	13	**5**	1	1	1	1	3	2	9	
TOTAL		144	69	1473	85	48	27	27	19		

** countries where, within a particular noise source, a random selection of NAPs was analysed

The analysis looked at the available NAPs and scanned to identify the types of noise solution measures that Member States planned to implement. The analysis revealed a long list of implementation measures within the following categories:

- Infrastructure investment;
- Source intervention (reduction of noise at source);
- Path intervention;
- Other physical interventions;
- Monitoring;
- Education and communication; and
- Mobility plans.

The following chapters contain a detailed assessment of the results of the NAPs including a projection of the generic review over the detailed country level assessments and a comparative analysis of noise solutions between the selected Member States.

3.3 In-depth assessment of national action plans

To complement the overarching review of NAPs, the in-depth assessment of 100 NAPs was also carried out. The aim of the in-depth assessment is to identify the drivers behind the application of noise solutions and the extent to which the measures planned have actually been implemented. The assessment focused on the measures regardless of the country of origin. The aim was not to contrast the level of development in terms of compliance with the END but rather to see examples of the implementation of the various solutions.

Assessment of the action plans was carried out in a structured format based on a report template containing a set of guiding questions. The structure is defined in the box below. The completed assessments can be found in Annex 1 of this report.

Box 3.1 Structure of the in-depth assessment template

Background information

Transposition of the END Directive into national law

NAP noise reduction measures

Public consultation

Evaluation of the NAP

Legislative framework

The table below contains an overview of NAPs that have been analysed in detail. Some overlaps between countries are apparent due to countries with action plans studied in the generic review being part of the in-depth analysis. However, action plans from Belgium, Czechia, Cyprus, Hungary, Italy, Malta and Romania were also analysed. The selection of the countries for the in-depth assessment was driven by the aforementioned criteria of availability, size (population) and geographic balance.

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Table 3.3 In-depth assessment of national action plans

Country	Level	Source
Austria	National road plan (2013)	Road
	Regional road Carinthia (2013)	
	Regional road Salzburg (2013)	
Belgium	Wallonia (2017)	
Croatia	Split-Dalmatia road section (2019)	
Denmark	National roads (2013)	
Germany	Regional road Bayreuth town (2015)	
Ireland	Cork county (2013)	
Italy	Highway dei Fiori (2013)	
	Torino-Alessandria-Piacenza (2013)	
Latvia	National road plan (2014)	
Lithuania	National road plan (2014)	
Malta	General noise action plan focusing mostly on roads (2013)	
Netherlands	National road plan (2013)	
	North Holland province roads (2013)	
	South Holland province roads (2013)	
Poland	Lubuskie Voivodship (Swiebodzin and Nowa Sol) (2011)	
	National road in Warminsko Mazurskie (2014)	
Portugal	IC2 Batalha Sul – IC1 Porto road section (2015)	
Spain	Seville (2014)	
Sweden	National road (2015)	
Austria	National rail (2013)	Rail
Belgium	Flanders (2019)	
Croatia	National railway (2018)	
Czechia	City of Prague (2016)	
Denmark	National rail (2013)	
	National rail (2018)	
Germany	National rail (2015)	
	National rail (2018)	
Hungary	National railway (2014)	
Ireland	National major railway (2014)	
Italy	Railway junction Sacconago – Malpensa (2014)	
Latvia	Railway section Salaspils – Aizkraukle (Railway line Riga-Krustpils) (2013)	
Lithuania	National rail (2014)	
Netherlands	National rail plan (2013)	

Poland	Regional rail Wielkopolska (2014)	
Portugal	Linha do Sul I (2020)	
	Linha do Minho I (2020)	
Romania	Bucharest-Brazi railway section (2013)	
Spain	Basque country (autonomous community) (2015)	
	Valencia (autonomous community) (2017)	
Sweden	National rail plan (2015)	
	National rail plan (2018)	
Austria	Schwechat (2013)	Aviation
Bulgaria	Sofia airport (2020)	
Czechia	Prague/ Ruzyně airport (2011)	
Denmark	Copenhagen Kastrup (2013)	
	Copenhagen Kastrup (2018)	
Finland	Helsinki/Vantaa (2013)	
France	Paris/Charles de Gaulle (2014)	
Germany	Berlin/Tegel (2014)	
	Frankfurt (2014)	
	Cologne (2016)	
Hungary	Budapest airport (2018)	
Ireland	Dublin airport (2013)	
	Dublin airport (2018)	
Italy	Milan/Malpensa (2014)	
	Milan/Malpensa (2018)	
	Bologna (2018)	
Latvia	Riga airport (2013)	
Netherlands	Amsterdam/Schiphol (2013)	
Portugal	Lisbon airport (2019)	
Romania	Bucharest airport/Henri Coanda (2013)	
Spain	Madrid airport (2014)	
	Madrid airport (2019)	
Sweden	Stockholm/Arlanda (2015)	
Austria	Vienna (2013)	Agglomeration
Belgium	Charleroi (2014)	
Cyprus	Nicosia and Limassol (2015)	
Czechia	Prague (2016)	
Denmark	Copenhagen (2014)	
Estonia	Tallinn (2014)	
Finland	Helsinki (2013)	
	Oulu (2013)	

France	Paris (2014)	
	Lyon (2014)	
	Grenoble (2014)	
	Greater Paris (2019)	
	Nice Côte d'Azur Metropole (2019)	
	Grenoble Metropole (2019)	
	Bordeaux Metropole (2019)	
Germany	Berlin (2014)	
	Hamburg (2013)	
	Cologne (2016)	
Hungary	Pecs (2013)	
	Pecs (2019)	
Ireland	Dublin (2014)	
	Limerick (2018)	
Italy	Milan (2013)	
	Bologna (2018)	
Latvia	Riga (2014)	
Lithuania	Vilnius (2014)	
Netherlands	Utrecht (2014)	
	Amsterdam (2015)	
Portugal	Lisbon (2014)	
Spain	Vitoria Gasteiz (2014)	
	Bilbao (2014)	
	Bilbao (2019)	
	Madrid (2014)	
	Barcelona (2014)	

This list of NAPs follows the analysis of two rounds of 50 NAPs, corresponding to different phases of the study. The results of the analysis containing a review of the various measures and their level of implementation can be found in the subsequent chapters. Furthermore, on different occurrences, NAPs for the same agglomeration, airport, road or rail sections were analysed for both the second and third round of mapping and planning to see if the effective implementation of planned measures has been carried out.

The subsequent chapters detail noise solutions included in the NAPs examined for:

- Road
- Rail
- Aviation
- Agglomerations

3.4 Solutions for the reduction of road traffic noise

Results from overarching assessment

Based on the results of the assessment of 200 NAPs, the largest number of interventions as well as the most varied types of interventions are planned for the reduction of road transport noise. A total of 85 NAPs were analysed corresponding to roads and major roads, excluding agglomerations. Mobility plans, source and infrastructure intervention measures are among the most widely used noise solutions across the countries.

Implemented measures

Road surface and noise barriers are the most commonly used solutions, which depending on the geographic area in question and the surrounding environment are combined with new infrastructure developments such as roads, embankments or soundproof windows and land use planning.

Table 3.4 Measures implemented on roads outside agglomerations

	Measure	DE	DK	NL	PL	PT	Total(%)
Source interventions	**Road surface**						25,1
	Reducing traffic density - Encourage cycling and walking						0,7
Mobility plans	Traffic control						2,9
	Speed limit						2,2
	New by-pass road						8,7
Infrastructure interventions	**Embankment**						7,3
	New roads						7,3
	Buffer parking lots outside the city						0,7
	Land use planning						0,7
Path interventions	**Noise barriers**						25,5
	Sound-proof windows						8,7
	Building insulation						8,0
Other physical interventions	Quiet areas						1,5
Education and communication	Promote sustainable mobility						0,7

Comparing the above road solutions with those implemented within agglomerations (table below) we can see that increased attention is being given to urban planning and traffic design. By combining street space design, development of roundabouts and cycle lanes with education campaigns and other incentives, cities clearly aim to maintain a dynamic flow of people and goods while achieving sustainability.

It is nonetheless difficult to compare the impacts of education campaign versus infrastructural developments. Based solely on the numbers, it seems that infrastructure and source interventions outweigh education and communication campaigns. However, the latter interventions may take place over a longer timescale. Details of these campaigns were not clear from the overarching analysis.

Table 3.5 Measures implemented on roads inside agglomerations

	Measure	BG	DE	EE	ES	FI	IE	NL	PL	Total %
Source interventions	**Road surface**									10.8
	Regulation of routes									6.2
	Reducing traffic density - Encourage cycling and walking									3.1
	Reducing traffic density - Promoting public transport									1.5
	Smart traffic management									1.5
Mobility plans	**Speed limit**									12.3
	Traffic control									3.1
	Car pooling									1.5
	Improve public transport fleet									1.5
	Incentive for environmentally friendly transport modes									1.5
	Optimisation of modal split									1.5
	Traffic calming									1.5
	Traffic restriction									1.5
	Traffic restrictions									1.5
Infrastructure interventions	**Land use planning**									6.2
	Roundabouts									4.6
	Buffer parking lots outside the city									1.5
	Cycle lanes									1.5
	Cycle parking									1.5
	New roads									1.5
	Noise zoning									1.5
	Street space design									1.5
Path interventions	**Noise barriers**									13.8
	Sound-proof windows									3.1
Other physical interventions	Green areas									3.1
	Quiet areas									3.1
Education and communication	Increase public awareness									3.1
	Promote sustainable mobility									1.5
Monitoring	Noise monitoring									3.1

Planned measures

Reported data on already implemented measures is more limited compared to planned measures. As noted above, the current format of the questionnaire used to complete the NAPs summary does not provide a specific section for previously implemented measures. However, looking at the countries and NAPs that reported both implemented and planned measures, one could observe certain continuity in the use of noise solution with road surface, noise barriers, sound proofing and quiet areas appearing most frequently among the planned measures.

Mobility plans were the most frequently cited planned measures and appeared in 29% of the action plans, with speed limits and traffic re-routing being the most used noise mitigation instrument. Among source interventions, which appeared in 22% of the action plans, road surface improvements were by far the most frequently used noise abatement measures. Whereas for infrastructure interventions, which appeared in 18% of the reviewed action plans, new by-pass roads were most frequently mentioned. The following table summarises the types of interventions that were implemented in the reviewed action plans.

Table 3.6 Planned noise solution measures overview

Type of measures	Number of instruments	Share of occurrence in the total
Mobility plans	128	29%
Source intervention	96	22%
Infrastructure intervention	82	18%
Path intervention	61	14%
Other physical intervention	37	8%
Education and communication	32	7%
Monitoring	8	2%

As the above table shows, a wide variety of instruments is being planned. The following tables provide a more detailed breakdown of the types and the frequency of instruments that are used in the Member States reviewed.

Path interventions such as noise barriers, soundproof windows and building insulations are most commonly included among planned measures. These three measures combined can be found in over 43% of the action plans. Additionally, road surface improvements and speed limits are also frequently cited. Noticeably, restrictions of heavy-duty vehicles, such as trucks and freight transport in general, along with measures that aim to raise awareness and improve public transport, are scarce.

Table 3.7 Measures planned outside agglomerations

Measure		AT	DE	DK	EE	ES	FI	FR	HR	IE	LT	LV	NL	PL	PT	SE	Total %
Source interventions	**Road surface**																18.3
	Reducing traffic density - Promoting public transport																0.6
	Regulation of routes																0.4
	Reducing traffic density - Encourage cycling and walking																0.2
	Promotion of electrical vehicles/ low-noise vehicles																0.1
Mobility plans	**Speed limit**																7.2
	Traffic management (not specific)																4.5
	Truck restrictions																0.9

	Reduction of freight transport	0.6
	Speed control	0.6
	Traffic calming	0.3
	Traffic re-routing	0.3
	Traffic restriction	0.2
	Improve public transport fleet	0.2
	Traffic control	0.2
	Car pooling	0.1
Infrastructure interventions	New by-pass road	4.7
	Land use planning	3.9
	Noise zoning	2.7
	New roads	0.3
	Road diversion	0.2
	Roundabouts	0.2
	Buffer parking lots outside the city	0.2
Path interventions	**Noise barriers**	21.0
	Sound-proof windows	12.2
	Building insulation	10.4
	Building design	0.2
Other physical interventions	Quiet areas	5.4
	Green areas	0.2
	Green noise barriers	0.1
Education and communication	Promote sustainable mobility	0.5
	Increase public awareness	0.3
	Education	0.1
Monitoring	Noise monitoring	2.4

A wider list of measures can be found for road traffic noise solutions inside agglomerations, but road surface improvements are still the most frequently applied noise solutions measures. Attention is Increasingly being put on traffic improvements as well as the use of bicycles and quiet areas. While environmentally friendly solutions are present – i.e. low emission buses, recharging stations for e-vehicles – these are still relatively infrequent and in general more could be done to combine the use of sustainable technologies with urban planning and land-use design. Furthermore, similar to the road measures outside agglomerations, restrictions on heavy-duty vehicles are also sporadic.

Table 3.8 Measures planned inside agglomerations

		AT	BG	DE	DK	EE	ES	FI	FR	HR	IE	LV	NL	PL	PT	SE	Total (%)
																	%
Source interventions	**Road surface**																10.2
	Smart traffic management																2.0
	Reducing traffic density - Encourage cycling and walking																1.7

	Reducing traffic density - Traffic management and parking	1.7
	Regulation of routes	1.7
	Reducing traffic density - Promoting public transport	1.5
	Tyres	1.1
	Promotion of electrical vehicles/ low noise vehicles	0.9
	Traffic flow	0.4
Mobility plans	**Speed limit**	6.3
	Traffic control	3.9
	Improve public transport fleet	2.0
	Traffic re-routing	2.0
	Traffic calming	1.5
	Traffic restriction	1.5
	Traffic restrictions for heavy vehicles	1.3
	Incentive for environmentally friendly transport modes	1.1
	Low-emission buses	1.1
	Electric vehicles	0.9
	Optimisation of modal split	0.9
	Traffic management (not specific)	0.9
	Truck restrictions	0.9
	Develop and improve public transport network	0.7
	Traffic restrictions	0.7
	Car pooling	0.4
	Electric buses	0.4
	Electric recharging stations in parking	0.4
	Restrictions	0.4
	Urban mobility plan	0.4
	Active noise control measures	0.2
	Municipal renting bicycle system	0.2
	Real time information on traffic vehicles/congestion	0.2
	Reduction of freight transport	0.2
	Traffic restrictions for heavy vehicles (night time)	0.2

Infrastructure interventions	Land use planning	3.7
	Cycle lanes	2.6
	New roads	2.2
	New by-pass road	1.7
	Pedestrian streets	1.3
	Buffer parking lots outside the city	0.9
	Cycle parking	0.7
	New viaduct	0.7
	Noise zoning	0.7
	Roundabouts	0.7
	New bus lane	0.4
	Construction of a collision free road junction	0.2
	Embankment	0.2
	Street space design	0.2
Path interventions	**Noise barriers**	5.9
	Sound-proof windows	4.1
	Building insulation	2.2
	Acoustic quality of new buildings	0.2
	Building design	0.2
Other physical interventions	**Quiet areas**	5.7
	Green areas	0.9
	Protection of spaces, landscapes, sites	0.9
	Green noise barriers	0.4
	Soundscape	0.2
Education and communication	**Increase public awareness**	4.6
	Promote sustainable mobility	3.9
	Dissemination of noise information	2.6
	Education	0.4
	Complaints	0.2
Monitoring	Noise monitoring	1.3

When comparing the list of Member State proposed/implemented noise solutions with those that are contained in the predefined list (Table 3.1) of our study, we see that some elements, such as new road development, noise barriers and urban planning, do appear, while others such as tyre-related measures only appear in a few NAPs, while the acquisition of dwellings does not appear at all. This may point to a difference in perception between European level and national level or local level planning as it relates to efficiency both in terms of costs and objectives met, as well as competences of the different administrative levels. Another point, specifically relating to infrastructural interventions, is that the use of alternative transport modes, primarily bicycles, and the development of related infrastructure feature prominently in road action plans of agglomerations. Based on recent trends of increased availability of alternative transport modes including e-scooters, e-bikes future action plans may place further emphasis on these modalities.

Some of the measures listed in the above tables are exclusive of NAPs inside agglomerations, mainly those related to sustainability campaigns, most traffic restrictions, promotion of electric vehicles, and measures related to public transport fleet. Another notable finding is the relative absence of pedestrian traffic increase related measures. While some infrastructure investments – i.e. quiet areas or land use planning – may in fact include the expansion of pedestrian-only zones and other modifications of street networks to increase pedestrian traffic, the details of such concept were not immediately clear from the analysed action plans. To identify further details for the above listed measures and to compare Member State approaches, in-depth analysis of noise action plans containing the above listed measures were carried out.

Results from the in-depth assessment

The in-depth assessment focused on the analysis of the implementation including the various road-specific noise abatement measures, the level of implementation (national-regional-local) as well as cost-benefit considerations. Due to limited data availability on the implemented measures, we blended findings on both planned and implemented measures. In some cases, we highlight that measures are planned when the information is available.

Geographically, the noise action plan analysis for roads covered a total of 15 countries: Austria, Belgium, Croatia, Denmark, Germany, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Spain and Sweden. The majority of the analysed documents were from the second NAP round from around 2013/2014. Some noise action plans, however, were not implemented during this timeframe, as is the case in Croatia (Split-Dalmatia road section) where the first noise action plan was published in 201. All Croatian measures are therefore new and no evaluations of previous results are available.

Noise solutions

Inspecting the variety of measures implemented for roads, we were able to confirm the earlier assumptions of the overview table. Noise reduction solutions consisted, to a large extent, of infrastructure interventions, such as quiet road surfaces and noise barriers which were used in combination with path interventions including insulation of houses, quiet tyres and quiet areas. Road maintenance (oftentimes carried out in connection with application of quiet pavement) and continuous noise monitoring can serve as a way of ensuring the effectiveness of these physical solutions, as mentioned in some countries such as Austria, Denmark and Germany. Therefore, many noise action plans combine these measures, such as the case in Denmark, where the range of noise solutions cover noise barriers, insulation of homes, quiet asphalt and road maintenance. However, according to interviewed stakeholders, before selecting the range of measures, it is important to first inspect the quality and age of the road in order to identify measures that can provide effective noise solutions.[141]

Other noise solutions that were implemented or planned by the responsible authorities include mobility plans and consist of the development of public transport, cycling networks, pedestrian infrastructure, traffic control and speed limits. Examples include the Salzburg province in Austria and

[141] Questionnaire responses received from representative of European Automobile Manufacturers' Association (ACEA) on 4 September 2020.

Bayreuth in Germany, where competent authorities expanded the cycling networks. In Seville, crosswalks, pedestrian overpasses, speed limit zones of 30km/h, and traffic light control were implemented as measures in residential areas. Depending on the types of roads, however, it may very well be the case that pedestrian access is not relevant, e.g. for highways, major roads etc.

Regarding noise sensitive areas (residential areas, hospitals, schools, etc.) in or around cities, the subject of improving pedestrian access was generally less frequently included in the action plans compared to the use of noise barriers, noise insulation of buildings, quiet asphalt and road maintenance as noise solutions. Overall, road surface maintenance and new asphalt are considered highly efficient measures and can be applied where they are needed, avoiding the waste of resources.[142]

The in-depth analysis showed that the reason for speed limits (i.e. noise abatement) should be communicated clearly to the public in order to enhance compliance among the public.[143] In France, the speed limits were not clearly indicated to the public, while in Germany and Switzerland, some signs at the entrance of inhabited areas associate speed limits with noise abatement. In France this happens mostly in areas close to hospitals.

Costs of noise solutions

Calculations on the cost of specific measures were provided by some EU countries. In Portugal, the per capita cost of quiet road surfaces was calculated for the 182km-long road section IC2 Batalha Sul – Porto (IC1). The costs amounted to around EUR 803 per capita for noise reduction below 55dB(A) at night. Also, the Spanish city of Seville estimated that the total cost of planned measures, amounts to EUR 41,082.65. Both unit prices of each measure and their total costs are indicated in the table below.

Table 3.9: Total and per unit cost of measures in Seville, Spain

Measure	Price per unit (in EUR)	Total cost (in EUR)
Quieter traffic: Pedestrian overpass	4,000	16,000
Traffic regulation: Programme calculation, development and load on existing traffic controller	1,600	1,600
Signalling: Installation of new limitation signs for speed	1,200	2,400
Signalling: Repainting of road markings	2,100	4,200

Poland also indicates the cost per unit for various noise abatement measures, as shown in the table below.

Figure 3.1: Total and per unit cost of measures in Poland

Measure	Unit cost (net)	Estimated total cost
Modernisation of the road surface	150 PLN/m^2	approx. PLN 3 million
Performance of the ecological review	10,000 PLN/km	PLN 20,000
Speed limitation	5,000 PLN/section	PLN 5,000

[142] Questionnaire responses received from representative of European Tyre and Rim Technical Organisation Secretary General (ETRTO) on 9 October 2020.

[143] Interview conducted with representative of BRUIPARIF (France) on 8 October 2020.

Cost-benefit analyses and cost effectiveness

Moreover, in some rare cases, countries such as the Netherlands have conducted cost-benefit and cost-effectiveness calculations for measures. This was the case for quieter pavement in the Netherlands. The example of the North Holland NAP provides details about cost-benefit calculations regarding the application of quieter asphalt, which is estimated to cost an extra EUR 10,000 per year. The calculations show that at 51% of the total investment in quieter asphalt (EUR 240,000 in this case) 79% of the total benefits are reached, indicating the point at which the marginal benefits start to decrease with increased marginal cost. The Danish Road Directorate also placed much emphasis on the cost-effectiveness of measures and included details of more than 10 projects and studies that aim to increase the cost-effectiveness of quiet pavement, noise barriers, roundabouts and traffic flows, and road maintenance in the noise action plan of Denmark's national roads.

Noise reduction potential and impact

Overall, quiet road surfaces appear to be a successful and popular measure as shown by one example in the Netherlands (South Holland province NAP) where the use of quieter asphalt on priority road sections resulted in a significant reduction of noise-exposed dwellings and inhabitants between 2006 to 2011. Overall, the number of dwellings exposed to noise above 65dB decreased by 415 (from 1,250 dwellings in 2006) due to the measures of the first NAP round. Additionally, the number of inhabitants exposed noise of over 55dB was lowered by 4,700 (from 18,100 dwellings in 2006).

Another example from the Netherlands (North Holland province NAP) shows that there can be a discrepancy between noise levels and the number of noise-affected residents due to the implementation of adequate noise abatement measures. Compared to the previous noise mapping round (2009-2013), North Holland noted an increase of 12% in noise levels due to traffic growth. However, 48% of the population perceived a decrease in noise levels due to the use of quiet road surfaces. For 39% of the population, noise levels remained roughly similar. Around 120km of quieter road surfaces were built as part of the implementation period of 2009-2013.

Some countries focus more on future-oriented impact assessments to demonstrate the effectiveness of planned measures. In 2013, the Carinthia region in Austria estimated that 2,204 residents within identified noise hotspots will experience decreased noise burden as a consequence of planned measures. These planned measures are 1) passive measures on buildings (insulation of windows, soundproof ventilators), 2) active measures on roads (noise barriers), and 3) the application of quieter road surfaces in the case of future road maintenances.

The perceived benefits of noise barriers and improved road surfacing were found to outweigh those of other interventions. The table below compares figures from two Member State NAPs.

Table 3.10 Perceived benefits of various noise solution measures

Noise solution	Noise reduction NL	Noise reduction IE
Noise barriers	5-10dB	3-5dB
Quieter surfaces	2-6dB	2-3dB
Quiet tyres	1-2dB	1-2dB
Façade insulations	Only interior noise reduction	5-10dB

As Ireland had more versatility in terms of noise solutions, identified benefits also related to:

- Speed controls and speed limit reductions: 1-3dB

- Traffic signals co-ordination (minimisation of braking/acceleration at junctions): 1-3dB within 50m of junction
- Alternative modes of transport (modal shift to public transport, bicycles, walking): 0.5dB per 10% reduction
- Lower noise vehicles (policies to support hybrid and electric vehicles): 1-3dB (if substantial changeover)
- Removal of rumble strips (traffic calming): 3-5dB within 20m
- Set-back from roads rail: 3dB per doubling of distance
- Use of commercial development buildings as noise screens: 10dB on quiet façade, and screened outdoor areas
- Location of non-sensitive areas such as stairwells, kitchens, bathrooms on high noise side: 10dB in bedrooms

Geographic variance

The selection of noise solutions can be highly dependent on the geographic features of the area in question. The 2013 noise action plan for regional roads in Salzburg province, Austria, includes important lessons learned for noise abatement measures in mountainous areas, which have both residential areas as well as freight passage routes. In these mountainous regions, speed limits of below 50km/h are considered not desirable since they decrease the efficiency of freight traffic. Moreover, noise barriers have no effect in these areas with narrow street canyons. Therefore, the sound insulation of windows is considered the most effective solution. However, this is only relevant when people are inside buildings. Another solution considered in this area is modal shift from road freight traffic to increased rail freight traffic through a targeted subsidy programme (10% of project costs subsidised by regional government and 30-40% by the national government). This modal shift was also considered a viable solution in the mountainous region of Carinthia, Austria.

Conclusions

Overall, the examples reviewed indicated that Member States may prefer noise barriers, quiet road surfaces and road maintenance as the main solutions for addressing noise pollution. These measures are usually combined with various other source interventions, infrastructure interventions and mobility plans depending on the availability of resources, including finances and technological solutions. A less frequent combination includes the use education and communication campaigns.

3.5 Solutions for the reduction of rail traffic noise

Results from overarching assessment

The overarching analysis of 200 action plans included the analysis of 13 Member States with rail specific measures. Some of these measures were included in rail specific action plans as was the case for Denmark, France, Germany and the Netherlands. Additionally, rail noise solution measures were analysed in agglomeration action plans of the following Member States: Austria, Bulgaria, Croatia, Denmark, Finland, France, Germany, Ireland, Latvia, Lithuania, Netherlands, Poland and Sweden. A total of 27 noise action plans were analysed corresponding to railways and major railways (including agglomerations).

Implemented measures

As explained in the case of roads, the information provided by countries on already implemented measures is limited compared with the planned measures. These measures are listed in the table below.

Table 3.11 List of noise solution measures implemented for rail outside agglomerations

	Measures	DE	DK	FR	NL	Total (%)
Source interventions	**Rail grinding**					17.4
	Rail damper					13.0
	Rail wheel absorbers					13.0
	Low noise rail					4.3
	Rail track improvement					4.3
Infrastructure interventions	Noise zoning					4.3
Path interventions	Noise barriers					21.7
	Building design					4.3
	Building insulation					4.3
Other physical interventions	Quiet areas					13.0

Given the characteristics of the railways sector, most relevant intervention at source are taken outside of agglomeration given the intensity of traffic and the localisation of the railways. Looking at rail traffic noise solutions inside agglomerations a narrower list of measures can be found, which relates mainly to the regulation of routes

Table 3.12 List of noise solution measures implemented for rail inside agglomerations

	Measure	BG	DE	ES	Total (%)
Source interventions	**Regulation of routes**				11.8
Infrastructure interventions	Land use planning				23.5
Path interventions	Noise barriers				35.3
	Sound-proof windows				5.9
Other physical interventions	Green areas				5.9
	Quiet areas				5.9
Monitoring	Noise monitoring				11.8

Planned measures

The action plans also contained several planned measures some of which may have been carried over from previous reporting periods. Comparing the implemented solutions with those planned (table below), it is notable that Member States are ambitious both in terms of the range and the number of future measures. Noise barriers are the most common measure among those already implemented or planned. It is worth noting that quiet areas as an abatement measure were widely reported.

Furthermore, current measures come from rail specific action plans, while many of the planned measures are linked to action plans of agglomerations. In fact, over 30% (24 out of 67) of planned noise solutions came from action plans of agglomerations. Also, it is notable that most rail-related measures contained in the action plans of agglomerations refer to future activities as opposed to current ones, which could be explained by strategic decisions of improving connectivity with further urban areas or improved access to financing.

It was not immediately clear from the overview whether the planned activities are newly introduced or were planned in the previous reporting period. Additional information on the strategies related to railway noise reduction was collected from the in-depth assessments.

Table 3.13 List of noise solution measures planned for rail outside of agglomerations

	Measures	AT	DE	DK	ES	FI	FR	HR	IE	LT	LV	NL	PL	SE	%
Source interventions	**Rail grinding**														16.4
	Rail maintenance														11.4
	Rail track improvement														8.6
	Rail damper														3.5
	Electrification of railway network														2.9
	Freight transport using electric locomotives														2.9
	Retrofitting existing trains														2.9
	Low noise rail														1.0
	Low noise tracks														1.0
	Use of new wagons/new trains														0.5
Mobility plans	Traffic management (not specific)														2.9
Infrastructure interventions	**Land use planning**														6.1
	New railways lines														1.0
	New freight transport (rail) bypass														0.5
Path interventions	**Noise barriers**														24.9
	Building insulation														4.4
	Sound-proof windows														1.6
Other physical interventions	Quiet areas														5.4
	Protection of spaces, landscapes, sites														0.5
Monitoring	Noise monitoring														1.7

Comparing the planned noise solutions in and outside of agglomerations, we can see that some measures such as the electrification of the network or rail damper are specific to areas beyond agglomerations. At the same time retrofitting and the use of new wagons are planned as part of the strategy of agglomerations. Whether this is an issue of costs, competences or is linked to higher policy level objectives of agglomerations, is not clear from the action plans.

Table 3.14 List of noise solution measures planned for rail outside of agglomerations

	Measure	BG	DE	ES	FI	FR	HR	LV	NL	PL	SE	Total (%)
	Rail maintenance											7.7

Source interventions	Rail grinding	5.1
	Regulation of routes	3.4
	Rail track improvement	2.6
	Rail wheel absorbers	1.7
	Low noise rail	0.9
	Low noise tracks	0.9
Mobility plans	Traffic management (not specific)	1.7
Infrastructure interventions	**Land use planning**	11.1
	New railways lines	1.7
Path interventions	**Noise barriers**	16.2
	Sound-proof windows	8.5
	Building insulation	3.4
Other physical interventions	**Quiet areas**	15.4
	Green areas	3.4
	Protection of spaces, landscapes, sites	3,4
Education and communication	Dissemination of noise information	6.8
	Complaints	0.9
Monitoring	Noise monitoring	5.1

Results from the in-depth assessment

The in-depth assessment looked at rail action plans from 16 Member States: Austria Croatia, Czechia, Denmark, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Spain and Sweden. In contrast with the predefined list of rail measures (Table 2) we saw a greater variety of noise solutions being planned, which included sources interventions, mobility plans, infrastructure interventions, path interventions, as well as different financing schemes. The in-depth assessment was also seeking to identify any constraints, such as costs or lack of information, that may prevent the completion of planned activities or contribute to a less efficient delivery of results. Overall, the in-depth analysis showed that many railway noise action plans give detailed, comprehensive information about, *inter alia*, the timeframe, cost, and impact of the planned measures.

Noise solutions

Overall, common measures that were implemented or planned are rail grinding, noise barriers, track vibration dampers and embankments solutions. Additionally, innovative or unique solutions were identified during the in-depth analysis. One such solution was identified in the Basque country where noise was reduced through lane irrigation. For this solution, water sprinklers by the railway stations were installed to reduce noise in densely populated areas. Sweden included the purchase of property with high noise levels in its catalogue of measures in both 2015 and 2018, but it has given no indication of the effectiveness of this action. In Lithuania, the relocation of 35 homes is part of the 2014 national railway noise action plan. The estimated overall results of the Lithuanian measure do not distinguish between the types of measures, and therefore it cannot be determined the extent to which relocation has played a part in achieving goals.

Many Member States followed the timeframe established by the END when developing railway NAPs. Some variability and unique characteristics regarding the timeframe of implementation were identified in our analysis. The national rail action plan of Lithuania, for instance, distinguished clearly between currently planned and long-term measures. Within these two categories, the measures were divided into those which were under consideration but not selected and those which were eventually selected. Portuguese NAPs (Linha do Minho and Linha do Sul) divide the implementation into two consecutive phases that presumably aim to streamline the process. In Bucharest-Brazi in Romania, the implementation of the measures is estimated to exceed the five-year timeline established by the END, which is why the measures are considered a longer-term strategy.

Extent of measures

Data on the extent of measures are listed in a clear, detailed way in the Lithuanian railway NAP, which serves as a good example. The NAP contains a long list of the types of measures planneed (e.g. noise barrier), the location where they will be implemented, the length of measure (in km), area of measure (in square metres) – i.e. it provides comprehensive information on the planned measures.

Noise limits

Noise limits vary between country or even administrative regions. Several countries, as can be found in the example of the Portuguese railway NAPs, establish different noise limits depending on the specific area. Determinants for these noise limits can include the noise burden of the area or the proximity of hospitals and kindergartens within these areas. Notably, Austria additionally indicated noise limits for external sound pressure levels for different types of railway vehicles, as the table below demonstrates. These limits are based on the Austrian Rail Vehicle Noise Permissibility Ordinance from 1993 (SchLV, BGBl. No. 414/1993)[144]. TSI noise specifies noise limits for 1) stationary noise, 2) starting noise, 3) pass-by noise, 4) driver's cab interior noise. The TSI noise and Austrian limits are roughly within the same range but do not entirely overlap. The 2018 NAP for Austria's national railways states that the national transposition of TSI noise makes it necessary to revise the applicable Rail Vehicle Noise Permissibility Ordinance, which was last updated in April 2016 – this revision is currently underway.

Table 3.15: Noise limits set by Austrian national legislation[145] on rail vehicles

Type of vehicle	External sound pressure level in dB (A-rated)[4]
Electric locomotives	84
Electric railcar	82
Diesel locomotives	86
Diesel railcar	84
Passenger wagons (incl. luggage vehicles)	80-83
Freight wagons	81-85
Auxiliary vehicles	86

Costs of noise solutions

Details about the cost of the measures were provided by numerous countries. Valencia in Spain, for example, specifies that the estimated cost of constructing noise barriers is EUR 220 per m^2. Romania (Bucharest Brazi) determined that the construction of a noise screen of a 2.5m height and 104m

[144] *Rail Vehicle Noise Permission Ordinance (SchLV), Federal Law Gazette No. 414/1993. Schienenfahrzeug-Lärmzulässigkeitsverordnung (SchLV), BGBl. Nr. 414/1993:* https://www.ris.bka.gv.at/NormDokument.wxe?Abfrage=Bundesnormen&Gesetzesnummer=10012265&FassungVom=2021-02-15&Artikel=&Paragraf=1&Anlage=&Uebergangsrecht=

[145] Rail Vehicle Noise Permission Ordinance (SchLV), Federal Law Gazette No. 414/1993. *Schienenfahrzeug-Lärmzulässigkeitsverordnung (SchLV), BGBl. Nr. 414/1993*

length would cost about EUR 39,000 (EUR 156 per m^2). Lithuania indicates that rail dampers cost about EUR 350 per metre of track (2 rails). The retrofitting of freight wagons for the track access pricing scheme in Germany is estimated to have cost around EUR 309 million between 2012 and 2020, making it one of the most expensive noise measures.

Financing noise solutions

Regarding the financing of the implementation some NAPs focused on alternative options. Denmark, for instance, has identified noise partnerships as an innovative solution. Noise partnerships are financial partnerships between public and private owners of property that allow involved parties to jointly pay and carry out a project that can reduce the noise nuisance from railways. The partnership gives affected citizens a direct opportunity to co-determine how noise reduction occurs. Typically, this involves the construction of noise barriers or the insulation of buildings where these are most appropriate.

Other unique financing solutions were found in Austria and Germany where price-charging systems are tested or already implemented to encourage the use of low-noise measures. Germany has continuously implemented track access pricing scheme (Lärmabhängiges Trassenpreissystem (LaTPS)) throughout the noise action planning period of 2015 as well as in 2018. The track access pricing scheme compels trains that do not yet have noise-reducing technology (e.g. whisper brakes) to pay a surcharge to access rail track that is applied to quiet trains. This applies in particular to freight transport. The aim of the scheme is to speed up noise abatement in rail transport. Wagon owners can receive subsidies from the Federal Ministry of Transport for the retrofitting of noisy freight wagons. Since December 2020, Germany has been attempting to prohibit the operation of noisy freight wagons by law. However, the European Commission started infringement procedures against Germany on this law in May 2020. The European Commission says that (noisy) freight wagons should not be banned from circulation in the EU by national uncoordinated measures[146]. At present, Germany and the European Commission lead an ongoing discussion on this matter. In Austria, a noise-based infrastructure charge was tested in 2013 and implemented in 2017 to increase the use of low-noise railway tracks and vehicles. A bonus would be given to quiet freight trains or louder trains using quieter routes as part of this charging scheme. Therefore, it is a bonus system, while the German track access charging scheme is a bonus-malus system. Additionally, the Czech Republic has also implemented a track access charging system to reduce noise pollution.

Conclusions

As mentioned earlier, not all action plans contain the same amount or even the same level of information on measures implemented as well as their associated costs and benefits. Measures planned and implemented in the different Member States also vary significantly. However, based on the in-depth analysis, some overarching findings can be drawn. Rail developments enhancing noise abatement carry a substantial price tag. While several support mechanisms are available at a European level, stakeholders will only be able to utilise these support mechanisms if appropriate support is also provided at the national and local level. This includes not only finances but capacity and wider social support from NGOs, citizens and other interested parties.

Moreover, communication and education campaigns highlighting the wider public health, socio-economic and environmental benefits of noise reduction measures are essential as they can help substantiate requests for further financing. The case of the Basque country (Spain), for instance, highlights the importance of education as a way of reducing railway noise and especially in terms of

[146] The approach of the EU on the phasing out of noise trains is based on the TSI noise. From December 2024 onwards, TSI noise-induced quieter routes will be implemented. Therefore, from 2024, the number of retrofitted wagons will increase in the Member States.

changing the behaviour of the local public and stakeholders. In order to raise awareness and increase knowledge, the Basque country foresees the following educational noise abatement measures: 1) publication of noise maps and NAP online, 2) publication of the concrete implemented measures that reduced noise pollution, 3) sharing internally the results of the noise maps and NAP, 4) promoting the use of public railway transport, emphasising the noise benefits of trains compared to road transport. These additional campaigns should be understood as going beyond the regular public consultation campaigns that precede some investments.

Another important consideration is finding the right combination of measures to achieve the highest level of public health benefits. This may be dependent on access to advanced planning procedures. It is a time-consuming and costly exercise that requires continuous monitoring of rail infrastructure and its impact on dwellings and agglomerations. It may also require close collaboration with neighbouring country authorities to better coordinate and plan joint initiatives. The latter would allow for the levelling out of any infrastructural backlogs that may exist and could hamper the utilisation of infrastructure improvements.

3.6 Solutions for the reduction of aviation traffic noise

Results from overarching assessment

The 200 action plans covered by the overarching analysis included 19 airport specific plans from six countries: Austria, Germany, Latvia, Portugal, Spain and Sweden. Additional aviation-related noise solution measures were identified in the action plans of agglomerations of Bulgaria, France and Estonia. A total of 22 NAPs were analysed corresponding to major airports, including NAPs for agglomerations.

Implemented measures

The types of measures that have been implemented are summarised in the table below.

Table 3.16 List of implemented noise solutions for aviation

	Measures	DE	ES	LV	PT	%
Source interventions	Regulation of routes					20
	Air operational measures					13
	Certification limits for aircraft					11
	Airport curfew					10
	Noise tax for aircraft					9
	Threshold (shift) for operations					2
	Aircraft engines inspection					1
Mobility plans	Renew aircraft fleet					1
Infrastructure interventions	Noise zoning					6
	Anti-icing areas					1
Path interventions	Building insulation					7
	Noise barriers					1
Education and communication	Complaints					11
Monitoring	Noise monitoring					6

When comparing with the implemented noise solutions for aviation within agglomerations, some similarities can be noted, notably air operational measures, airport curfews and regulation of routes. Noise monitoring is also mentioned, especially inside agglomeration. Aviation measures inside agglomeration tend to include quiet areas, which is not the case for the other NAPs. The range of measures, however, is greater for the airport NAPs, with mobility plans, infrastructure interventions, path interventions, and education and communication measures.

Table 3.17 List of implemented noise solutions for aviation inside agglomerations

	Measure	BG	EE	Total
Source interventions	Air operational measures			20.0
	Airport curfew			20.0
	Regulation of routes			20.0
Other physical interventions	Quiet areas			20.0
Monitoring	Noise monitoring			20.0

The list of aviation measures identified as having been implemented go beyond those that were listed at the start of the project as possible solutions (table 3.1) insofar as they include complaint procedures for the public, certification limits for aircraft, airport curfew and threshold for operations. These two measures illustrate opposite aspects of interventions. While one relies on bottom-up pressure exerted by citizens and the wider public, the other one facilitates innovation into low noise emission aircraft by setting stringent standards for certifying aircraft. The planned measures enlisted in the NAPs (tables below) show that most activities will be continued, presumably based on earlier results of effectiveness.

Planned measures

In comparison to currently implemented measures, two new planned solutions are identified: land use planning and new flight paths. While one of the new measures focuses on better managing physical distancing between the airport and dwellings, the other is dedicated to reducing the noise at source. Together with airport curfews and night-time bans, which target the main noise issue from aircraft, threshold for operations and new flight paths, these measures can ensure significant noise reduction, both from flights and ground traffic.

Table 3.18 List of planned noise solutions for aviation outside agglomerations (airport specific action plans)

	Measures	AT	DE	ES	LV	PT	SE	%
Source interventions	**Air operational measures**							12.1
	Regulation of routes							12.1
	airport curfew							11.2
	Noise tax for aircraft							7.8
	Threshold (shift) for operations							3.4
	Certification limits for aircraft							1.7
	Aircraft engines inspection							0.9
Mobility plans	Renew aircraft fleet							8.6
Infrastructure interventions	Noise zoning							8.6
	Land use planning							1.7
	Anti-icing areas							0.9
Path interventions	**Building insulation**							12.1
	Noise barriers							0.9
	Sound-proof windows							0.9

Education and communication	Complaints	8.6
	Dissemination of noise information	0.9
Monitoring	Noise monitoring	7.8

Comparing aviation noise solution measures of agglomerations to those outside of agglomerations, we see quiet areas and the protection of spaces as novelties. These two solutions may be used to further reduce noise pressure on certain residential areas. Using these solutions may also highlight the fact that previous measures have not been deemed satisfactory by the public and the authorities.

Table 3.19 List of planned noise solutions for aviation inside agglomerations

	Measure	AT	BG	DE	ES	FR	LV	NL	PL	SE	%
Source interventions	Air operational measures										5.1
	Regulation of routes										3.8
	airport curfew										1.3
Infrastructure interventions	**Land use planning**										11.4
	New flight path										1.3
Path interventions	**Noise barriers**										17.7
	Sound-proof windows										10.1
	Building insulation										5.1
Other physical interventions	**Quiet areas**										20.3
	Protection of spaces, landscapes, sites										5.1
Education and communication	Complaints										1.3
Monitoring	**Dissemination of noise information**										10.1
	Noise monitoring										7.6

Results from the in-depth assessment

The in-depth assessment examined 23 action plans form 16 countries including Austria, Bulgaria, Czechia, Denmark, Finland, France, Germany, Ireland, Italy, Hungary, Latvia, the Netherlands, Portugal, Romania, Spain and Sweden. The results of the in-depth assessment indicate that the trend towards employing a wide combination of measures to lower noise emission levels around airports and improve the management of current emission limits is continuing.

Noise solutions

The measures in place are largely a continuation of previous noise solutions with improvements resulting from updated technical implementation and innovation. There are also exceptions as in the case of Copenhagen Kastrup airport, where there are no planned measures identified. The NAP provides only the list of the measures already in place, such as noise impact assessment for operational buildings or construction sites, changes affecting the noise load from the airport, updated procedures for the treatment of exceedances of maximum noise from take-offs and landings at night, among other regulatory dispositions.

In the case of Madrid's Barajas airport, a review of the 2014 and 2019 action plans shows that progress has been made over the years by adding more clarity to some of the infrastructural and source interventions. An example is the advanced mapping of noise sensitive areas that precede the determination for the use of preferential runways. The 2014 action plan also included land planning measures which were used to encourage construction of dwellings that are compatible with airport activity and noise emission levels. In fact, the 2014 measures were already a continuation of previous activities stemming from the measures of the Sound Insulation Plan, which was drafted to accompany the airport's expansion in 1996 and 2001.

Table 3.20 Madrid Barajas airport noise solution measures

2014 measures	2019 measures
Use of preferential configuration of segregated runways.	Use of preferential runways, based on noise-sensitive areas.
Displacement of thresholds in variable amounts for reasons of sound attenuation (500m for the 32R and 18L headers, 928m for the 32L headers and 814m for the 18R headers).	Displacement of thresholds in variable amounts for reasons of sound attenuation (500m for the 32R and 18L headers, 928m for the 32L headers and 814 meters for the 18R headers).
Design and optimisation of trajectories (P-RNAV type SID manoeuvres, for daytime and all headers used for take-offs).	Design and optimisation of trajectories (P-RNAV type SID manoeuvres, for daytime and all headers used for take-offs).
Operational procedures for take-off noise abatement.	Operational procedures for take-off and landing noise abatement, limitations on the use of reverse thrust, CDA manoeuvres, restrictions on runway and height procedures, etc.
Landing noise abatement operational procedures (limitations on operations approach and landing and total restriction on the use of reverse power for landings in night time, continuous descent manoeuvres (CDA)).	
Noise abatement operational procedures for ground operations (limitations on the use of the auxiliary power unit (APU) and engine testing).	Noise abatement operational procedures for ground operations (limitations on the use of the auxiliary power unit (APU) and engine testing).
Disincentive measures for noisy aircraft noise charge intended to discourage the use of the noisiest aircraft by imposing penalties on the amount of the landing charge for aircraft exceeding noise certification limits established.	Noise charge intended to discourage the use of the noisiest aircraft by imposing penalties on the amount of the landing fee for aircraft exceeding noise certification limits established.
Limit the use of certain areas of the airfield during the night period.	

A similar pattern emerges from the action plan for Schwechat airport in Vienna where key measures constitute a continuation from previous planning periods and are focused on aircraft operations including take-off and landing procedures, as well as fly paths in combination with noise insulation measures for dwelling in the vicinity of the airport. Several challenges were also identified by the action plan including further measures that could be taken for the optimisation of flight paths, curfews, improved maintenance/soundproofing of buildings. This latter challenge is particularly important as the number of people living in the vicinity of the airport and impacted by higher noise emission levels has increased from 2008 to 2014. However, no information is provided on whether construction guidelines around the airport have been revised to include further insulation requirements. Again, advanced planning, taking into consideration the impacts of various socio-economic changes such as housing needs and real-estate prices, is essential for meeting public health objectives.

The same measures are found to have been implemented at Frankfurt airport, one of the busiest in Europe. According to the airport's own estimations in 2012 around 207,500 residents were affected by daytime airport noise and 40,600 by night-time noise. Similar to the example of Vienna, the number of people exposed to noise disturbances by day is forecast to increase by 25% (276,700) in and by 85% (153,200) by night. In addition to infrastructure investment, the airport as part of its mitigation strategy has also been introducing measures such as the acquisition of dwellings, bans on construction and restriction of land use. Another noteworthy measure introduced by the airport is economic control measures which indicate the consideration of wider socio-economic tendencies such as the correlation between housing prices and low-income households.

Table 3.21 Milan Malpensa airport noise solution measures

2013 measures	2017 measures
Continuation of the awareness raising action towards the airlines for the use of better performing aircraft (low noise)	Type of aircraft: implementation of the ICAO Annex 16 noise certification; awareness-raising action aimed at abandoning the oldest aircraft
Testing of new take-off routes	Anti-noise procedures on take-off routes and traffic distribution. Regarding the spatial and temporal distribution of flight operations, a specific scheme for the use of runways and operating restrictions for the night period is in force.
Implementation and modernisation of noise monitoring network with the introduction of more efficient control units capable of acquiring more information	
Unit specialisation operational monitoring of noise and improvements to the airport noise acquisition system	
Awareness of public administrators of the need not to build in the vicinity of the airport	
	Noise abatement procedures: in addition to the routes with less impact and a functional distribution of traffic on them, provisions are in force that optimise the vertical flight profiles with regards to both the initial climb phase and the approach phase.
	Ground activities: the following are regulated: - Reverse thrust - Auxiliary Power Units (APU) - Engine tests

Comparison of measures at Milan Malpensa between the rounds of 2013 and 2017 show the continuation of previous measures as well as implementation of new solutions. Noise abatement measures on operational procedures were added, as well as ground operations (for instance APU).

In addition to using a combination of measures, some airports such as Sofia airport in Bulgaria focus on long-term measures such as:

- Workshops and awareness raising campaigns about environmental noise;
- Investments in IT platforms that could facilitate communication with the public on noise level; and
- Direct noise complaints.

Sofia Airport is the only airport in southern-eastern Europe that has installed noise protection screens for the aircraft engine testing platform providing noise abatement reduction around 15dB(A) to 17dB(A).

Another example of long-term measures can be seen at the airport in Riga. Planned measures include operating restrictions on take-off procedures, prohibition of overflight in noise-sensitive airspaces zones, fleet development plan (AirBaltic), and cooperation with noise-affected municipalities. In the long-term, several actions are foreseen including: new arrival procedures; runway relocation away from residential areas; ensuring that municipalities affected integrate the airport NAP in their urban planning; and future development plans. Furthermore, the Riga airport NAP provides justification for each of the measures.

NAPs from several airports also include transparency and communication measures. For instance, the NAP of Madrid`s Barajas includes measures ensuring access to information for the public via websites and interactive noise maps. Lisbon airport, on top of the already implemented wide range of measures on flight operations, also plans to introduce communication and information measures, as well as surveys with the population. The involvement of the public and transparency are also key measures for Dublin Airport, with a noise complaint system, a flight track monitoring system (Webtrack), and engagement with the communities through the Dublin Airport Environment Working Group.

Table 3.22 Dublin Airport noise solution measures

2013 measures	2018 measures
The future implementation of the EU's 'Balanced Approach' (reducing the noise at source, planning and land use, operational noise abatement procedures, operating restrictions)	Shift towards quieter aircraft due to noise certification, incentive FlyQuiet programme and the annual reporting on progress on introducing quiet aircraft
	Noise abatement operating procedures; progress report on a review of Departure Noise Abatement Procedures
	Closure of Cross-wind Runway and Runway 29/11 and the construction of a new north runway
Expected positive outcome of the installation of Noise and Flight Track Monitoring System on aircraft approach and departures in relations to emitted noise levels. The system has seven off-site noise monitoring terminals for producing Noise & Flight track monitoring reports	Regular monitoring of noise contours (i.e. the production of annual noise contour report); active response to noise complaint management system; introduction of 'live' promoting software (Webtrack); 2019 onwards: progress report on new noise locations from Noise Flight Track System
Monitoring of aircraft track and noise issue by the Dublin Airport Stakeholders Forum (Environmental Group)	Active engagement with local communities though Dublin Airport Environment Working Group – DAEWG and St Margaret's Community Liaison Group
Restricted land use and housing development nearby airport preventing future conflict between airport operations and residents	2019-onwards: Encroachment analysis report relevant to land use planning nearby Dublin airport
Buildings insulation due to the conflict between residential areas and noise contours	Continuing buildings insulation programme where needed

Furthermore, Dublin airport takes into consideration the importance of residential urban planning in the vicinity of the airport, as in the past issues arose in relation to the impact of airport noise on newly built dwellings. As it was not possible to mitigate noise from the source, both NAPs have envisaged alternative solutions including building insulation, regular noise contour monitoring, restrictions on urban planning and land use. Dublin airport is implementing the FlyQuiet programme to ensure transition towards a completely 'quiet' air fleet at the airport.

The reviewed action plans indicate that a wide variety of measures are focused on noise mitigation both from the receiver as well as the noise source perspective. For instance, several airports implement insulation schemes (Paris Charles de Gaulle, Liszt Ferenc in Budapest) for dwellings in the airports' surroundings. Budapest airport even seeks to repair roofs affected by aircraft that fly overhead. The airport also implements measures such as noise protected areas for engine testing, a limit on the number of operational procedures, and restrictions on landing and take-offs. A combination of measures at the source and at the receiver is also observed in Bologna airport, with curfew and restrictions for some aircraft, a penalty regime, and noise monitoring at the airport and infrastructure development including lengthening the runway to avoid low flights over residential areas.

Costs of noise solutions

Information on costs is mostly lacking in the airport NAPs. Some NAPs provide limited information, such as Frankfurt, which indicates that a mix of public and private funds were utilised for the implementation of the aforementioned measures including EUR 335 million for passive noise protection and EUR 265 million for noise insulation. The increasing number of flights in Europe and the corresponding economic benefits such as job creation and increasing GDP output are often viewed as positive signals for the overall economic development of a region or a country.

In the case of Schwechat airport noise solutions measures were selected and implemented based on their derived environmental benefit and cost effectiveness. While a detailed breakdown of costs associated with the individual measures was not available, the action plan indicates the costs of noise maps as EUR 100,000 (2012).

Outstanding information on NAPs

Given that thresholds requiring reporting on noise limits have changed over the years, some airports submitted their first NAP in the third round. This is the case for Sofia Airport (2020) as in previous rounds the airport did not reach the threshold reporting values. A separate NAP for Dublin Airport has also been produced as previously its noise mitigation plan was integrated in the agglomeration NAP of the area.

3.7 Agglomerations

As shown in the above chapters, in addition to transport related action plans, those of agglomerations were also assessed. The objective here was to identify how urban areas integrate noise reduction measures and address more than one transport mode. This is especially important in light of European incentives to invest in sustainable and integrative transport systems. It is essential that the reduction of noise emission levels from transport is incorporated into the wider policy planning instruments as well as the local planning mechanisms to ensure that the investments into specific transport infrastructures are optimised.

Results from overarching assessment

The overarching assessment looked at 69 agglomeration action plans from 15 Member States: Austria, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and Sweden. Most of the noise solutions contained in the action plans of agglomerations have already been detailed in the relevant chapters for road, rail or aviation. However, there are several solutions, both current and planned, that relate to more than one transport modes. Not all agglomerations currently use solutions that would lead to a greater focus on road transport in their agglomeration action plans. Nonetheless, almost all of them plan to do so in the future.

Implemented measures

The tables below provide examples of implemented noise solutions in agglomeration as general measures not specifically targeting a given noise source. As agglomerations face several sources of noise, a wide range of measures are proposed also for road, rail or aviation.

Table 3.23 List of implemented noise solutions in agglomerations relevant for unspecified transport noise sources

Country	Measure	Category
Bulgaria	Noise monitoring	Monitoring
Germany	Land use planning	Infrastructure interventions

	Noise barriers	Path interventions
	Sound-proof windows	Path interventions
	Green areas	Other physical interventions
	Quiet areas	Other physical interventions
Spain	Noise monitoring	Monitoring

Planned measures

The list of planned measures is significantly longer than any of the previous tables describing in detail the measures in other sectors. This reflects possibly also on the growing importance of integrative transport measures and their role in improving transportation flow, connectivity and sustainability of cities. While these general noise abatement solution measures are relatively broad in nature, some areas remain outside the current scope of activities – i.e. measures addressing work from home and increasing vehicles and ride shares are solutions that could be strengthened.

Table 3.24 List of planned noise solutions in agglomerations for unspecified transport noise sources

Country	Measure	Category
Bulgaria	Land use planning	Infrastructure interventions
	Noise barriers	Path interventions
	Protection of spaces, landscapes, sites	Other physical interventions
	Green areas	
	Quiet areas	
	Complaints	Education and communication
	Dissemination of noise information	
	Noise monitoring	Monitoring
	Regulation of routes	Source interventions
Germany	Quiet areas	Other physical interventions
	Sound-proof windows	Path interventions
	Green areas	Other physical interventions
	Land use planning	Infrastructure interventions
	Regulation of routes	Source interventions
	Noise barriers	Path interventions
Spain	Dissemination of noise information	Education and communication
	Noise monitoring	Monitoring
	Land use planning	Infrastructure interventions
	Traffic management (not specific)	Mobility plans
	Protection of spaces, landscapes, sites	Other physical interventions
	Quiet areas	
	Green areas	
	Noise barriers	Path interventions
	Building insulation	
France	Dissemination of noise information	Education and communication
	Land use planning	Infrastructure interventions
	Quiet areas	Other physical interventions
	Dissemination of noise information	Education and communication
	Quiet areas	Other physical interventions

Latvia	Quiet areas	Other physical interventions
Poland	Noise monitoring	Monitoring
	Dissemination of noise information	Education and communication
	Sound-proof windows	Path interventions
	Noise barriers	Path interventions
	Land use planning	Infrastructure interventions
	Green areas	Other physical interventions
Netherlands	Building insulation	Path interventions
Sweden	Building insulation	Path interventions
	Noise barriers	Path interventions
	Quiet areas	Other physical interventions
	Sound-proof windows	Path interventions

Among the most frequently recurring elements are quiet areas, land-use planning and the dissemination of noise information signifying the importance of wider urban planning measures, transparency of information and awareness raising. Complementing these activities are targeted measures at home such as building and window insulation and noise barriers.

Results from the in-depth assessment

The in-depth assessment examined 34 noise action plans of agglomerations from 17 countries: Austria, Belgium, Czechia, Cyprus, Denmark, Estonia, Finland, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Portugal and Spain.

Noise solutions

As agglomerations often face noise emissions from several sources, a wide range of measures are implemented and proposed in the NAPs. For instance, the Helsinki agglomeration action plan includes 23 noise solution measures including taking noise emission into account during public procurement tenders (vehicles), traffic planning, promoting public transport, walking and cycling, silent pavements, e-vehicles and land planning via quiet areas. Communication and outreach are also part of the wider procedure; notifying the media and the public about the ongoing efforts can raise awareness about the importance of noise reduction. Such an outreach campaign has become increasingly important as the number of people living in high noise areas has increased. Consequently, tram lines have been extended and road traffic has also increased. To counter these impacts, especially for people living in old residential housing, the zoning regulations were reviewed to assess the extent to which noise abatement measures would need to be implemented. An innovative element in the NAP for the city of Riga includes speed reduction and the development of a barrier made from noise-absorbing plants along the railway.

Agglomerations can face quite high levels of noise, depending also on the density of population. For instance, Paris, as one of the largest agglomerations in Europe, focuses on noise solutions for those exposed to higher levels of noise pollution. Over 10% of the city's population is exposed to a Lden level over 68 dB(A) which represents 231,088 citizens. The plan defines high-stake areas and identifies road traffic as the main source of noise. The city introduced several measures reducing both the noise at source and increasing the public's awareness about alternative transport modes. These include spatial planning by introducing pedestrian only zones, launching traffic reduction programmes, improving house insulations and introducing noise certification schemes for transport haulers. The noise solution measures have been progressively improved and adapted to the changing needs of the local population. More recently communication campaigns have been launched to raise awareness about quiet areas, and outreach towards the public has been increased.

The current NAP for Paris is extended to the Greater Paris Metropole. It still follows the same type of measures, such as façade insulations, improvements to mobility and road and road surface interventions.

In most of the French agglomerations analysed, noise mitigation measures are also aligned with 'black hotspots' for noise mitigation action, which is required by the French national legislation. In Bordeaux Metropole, the current NAP (2020-2024) unusually includes a sound plan, on top of the noise action plan. The aim is to ensure continuation of existing measures, while the sound plan contains the new measures focusing on perception of noise and quality of the sound environment.[147] This positive vision underlines the benefits of an improved sound environment. This sound plan includes, for instance, the management of green spaces in order to limit noise pollution, integrating acoustic considerations into the renovation process of dwellings, setting a noise observatory or experimenting with the cross consideration of noise and air quality in a few development projects and public spaces, as well as awareness-raising measures. Evaluations of noise perceptions are also planned.

Agglomerations often identify high-stake areas, which can relate either to specific interventions such as quiet areas or locations such as specific areas of noise protection in Spain. The latter are developed notably in the Bilbao NAP, with specific measures aiming to reduce the noise levels from several sources in such parts of the territory. This includes defining priority action, establishing specific indicators, promoting silent transport and reducing speed. Quiet areas are also well developed in the Bilbao NAP, with the aim of creating urban oases, and ensuring that a large share of the population has access to quiet areas. Vitoria-Gasteiz also has several measures for quiet areas. The city was named European Green Capital in 2012, notably for its greenbelt, a series of parks surrounding the city and identified quiet areas. The plan seeks to implement action valuing and protecting quiet areas, as well as establishing an acoustic oasis in each neighbourhood, as well as a quiet itinerary.

Costs of noise solutions

Information on costs is rarely presented in the NAPs. The Lisbon agglomeration action plan presents its costs-benefits analysis and strategy, leading to a selection of measures to be implemented. The results helped identify priority areas. Based on the results and the total costs of the NAP (EUR 9 millions), the authorities decided to implement the proposed measures in three phases during a period of five years: 24 areas in the first phase (79% reduction of population exposed to higher levels and a third of the budget); one area in the second phase (13% reduction of population exposed to higher levels and a third of the budget); four areas in the third phase (8% reduction of population exposed and a third of the budget).

Information on financing is provided by the 2014 Paris NAP, which had an overall budget of EUR 1.2 billion covering the implementation of noise solutions for the period between 2015-2020. Milan is another city facing challenges with rail, aviation and heavy-duty vehicle noise from roads. City officials aimed to reduce traffic by introducing road pricing and identifying 30 km/h zones as well as by improving insulation and extending noise barriers. Dynamic acoustic mapping was a partly EU-financed project on which the city spent over EUR 60.000.

Financing needs are a key element for the completion of NAPs. Some measures benefit from the support of a public scheme, such as insulation in Bordeaux. However, these schemes are often limited in time, and the insulation should continue even though the financial support is ending. In the case of Bordeaux, the scheme was supported by a French state agency and will now be supported by the Metropole. This could be an issue, in general, for the continuation of measures implemented in

[147] Interview with a Bordeaux Metropole stakeholder.

agglomerations. The lack of financing was pointed out by a stakeholder as a key barrier for noise reduction.

Conclusions

In the noise action plans of agglomeration, road traffic noise and their mitigation is the most frequently cited element. Not all NAPs contain clear results of previously implemented measures. An example is Nice Côte d'Azur Metropole, where in 2009, 11% of the population were living in an environment with noise levels above 68dB(A) Lden, originating mostly from road noise. In 2016, noise solution measures implemented reduced this share to 5% (a reduction of 25,000 inhabitants). In other cases, the results are not available from the NAPs. Instead the emphasis is put on listing the planned future mitigation efforts.

The Nice Côte d'Azur Metropole NAP lists several measures for mobility, with actions targeting specifically sustainable mobility and its impact on noise levels, with the promotion of bicycles and electric vehicles. There is also an emphasis on mobility in the NAP for Tallinn agglomeration, among other types of measures. For instance, measures on mobility expected to have an impact on noise include:

- Identifying the impact of environmental noise in traffic planning
- Increasing the use of public transport
- Reduction of noise from public transport (including trams and railways)
- Preference for soft modes of transport
- Speed limits
- Curfew for heavy duty vehicles and diversion from noise-sensitive areas

Another key element is continuity. In the case of the city of Pecs, a comparison of measures between two reporting periods has shown that the number of noise solution measures has increased, and while broad alignment with previous objectives on improvements of alternative transport modes such as bicycles was maintained, a number of road development projects were also incorporated in the third round action plan.

Table 3.25 Pecs agglomeration noise abatement measures

2013 measures	2019 measures
Traffic management particularly restricting and limiting heavy duty vehicles above 7.5 tonnes	Monitoring of restrictions for heavy duty vehicles (long-term strategy 2030)
	Monitoring of traffic restrictions (long-term strategy 2030)
Road infrastructure development: new road surfaces but no mention of quieter surfaces	Road development (long-term strategy 2030)
Re-organization of public transport	Continuous development of public transport (increasing modal-split, parking, acquisition of new buses)
Development of bicycle routes	Bicycle routes (long-term strategy 2030)
Introduction of e-bike services	
Education campaigns and awareness raising measures	Awareness-raising measures (long-term strategy 2030)
	Public communication (long-term strategy 2030)
	Development of route M60 (outside city limits)
	Development of major and minor roads within the city
	Noise monitoring network development and management (long-term strategy 2030)
	By-pass roads (long-term strategy 2030)
	Development of natural noise protection barriers (long-term strategy 2030)

NAPs of agglomerations need to balance regional and local development objectives, mobility needs and the public health consequences of high noise exposure levels. For instance, the city of Charleroi in Belgium combined noise output of road and rail transport with that from the nearby airport. All three sources of noise contribute to higher exposure levels in the area. The solutions implemented aim to maintain the economic development prospects while reducing noise pollution. They include:

- The creation of an urban logistics centre to reduce the presence of heavy goods vehicles in the city centre;
- Traffic modifications;
- Promotion of car sharing services; and
- The promotion of bicycle use.

Creating an integrated approach that addresses the key noise sources and yet adapts to the socio-economic and geographic conditions of the area is of key importance. This integrated approach can be illustrated by aligning the NAP with other strategic plans on mobility or urban planning. For instance, Tallinn mentions several plans in its NAP, which coincide with the objectives of the plan, such has the Tallinn Environmental Strategy 2030 that has goals on noise. It is also the case for Lisbon, which integrates the measures of other plans (local plans, urban plans) into the measures planned for the priority areas identified. Furthermore, some agglomerations provide organisational measures, and/or measures targeting noise from the agglomeration/municipality services (waste collection, green spaces maintenance, and building permits). Some agglomerations also develop monitoring strategies. For instance, Nice Côte d'Azur Metropole outlines monitoring measures, as well as a checklist of measures implemented, not implemented or postponed from previous NAPs. They indicate for instance a completion rate of 90% on a previous plan. The agglomeration of Lisbon also sets the basis for a monitoring system in its action plan.

As for the consultation of stakeholders from agglomerations,[148] or from associations working in agglomerations, several elements were proposed. Stakeholders mentioned the possibility to integrate similar schemes for air quality regulation, with reduction targets or exposure limits, or even penalty schemes. In the Paris region, Bruitparif is installing innovative sensors capable of identifying the source of noise, as well as developing noise radars. Most stakeholders agreed that there was an added value of mapping and planning, which allowed the municipality or other relevant authorities to have an overview on the noise situation and its health impacts. Stakeholders also suggested the implementation of review and monitoring processes at the EU level. One of the interviewees pointed out the lack of regulation on the issue of harbour noise, which can impact the noise situation in agglomerations. Other noise sources to tackle were mentioned as well (leisure, nightlife for instance). A key source of noise which should also be targeted according to stakeholders is noise from two-wheelers. In a study carried out by the Acoucité noise observatory in Aix-en-Provence on a road section limited at 30 km/h, two-wheelers were found to cause 50% of the limit overshoots (up to 3dB over the limit) and 65% of high overshoots (more than 3dB over the limit) during the day. At night, cars were responsible for 45% of overshoots, and 25% of high overshoots, while two-wheelers caused 65% of the latter.

In terms of the efficiency of measures, however, stakeholders mostly highlighted the impact of quiet surfaces, soft modes of mobility and speed limits, if there is a good communication showing the speed is limited for noise reasons. Targeting driving behaviour was also mentioned as one of the key areas for improvement of the noise situation.

One of the key issues found during the assessment of agglomeration noise action plans is the importance of public buy-in. In contrast with airport noise action plans, where communication and

[148] Interviews with two French municipalities, a Spanish neighbours' association, and a French noise monitoring association.

public awareness is a central feature, buy-in is not reflected in agglomeration action plans, except for a few (Helsinki, Bordeaux Metropole, Nice Côte d'Azur Metropole, Lisbon). On this note, a stakeholder highlighted that public participation in consultations organised in conjunction with the NAP process is often low, even with the communication and awareness raising measures. The disturbance caused by overflights and night flights on the daily lives of homeowners has culminated in protests and led to nationwide debates between house owners impacted, travellers and the aviation industry. In the case of agglomeration, the issue is more muddled as everyone is impacted, and many people also benefit from the utilisation of transport modes causing the pollution. Clear delineations of homeowners impacted and beneficiaries are rare. In fact, most people fall into both categories and could be addressed as such. They must be informed of the impact higher noise levels have on their health and how they themselves contribute to the problem. Heightened public awareness could also bring increased transparency and accountability from those who are in breach of noise thresholds.

3.8 Limitations of research

During the in-depth analysis of NAPs, some limitations were encountered both in terms of availability and depth of information. According to the END, Member States must produce noise maps and noise action plans every five years. However, Member States report this data through the EEA's Reportnet website on a voluntary[149] basis. This implies that time-comparable data on noise action plans may not always be available on the platform. Information submitted by Member States includes references to action plan summaries (DF7 and DF10), which do not always provide a link to the original document.

National action plans contain various levels of details on costs, cost-effectiveness of noise solution measures, which makes comparative analysis on these factors challenging. Additionally, several other areas relating to noise solution measures, planned and implemented, contain varying levels of quantity and quality of information across NAPs. The lack of harmonisation of NAP reporting poses challenges for the comparability and the evaluation of the efficiency of previous measures. Furthermore, as NAPs rely on noise maps, it is necessary to have harmonised calculation methods (e.g. the application of CNOSSOS in the future noise reporting round) and ensure comparability between different rounds in order to be able to identify the effective noise solutions. On this point, stakeholders pointed out difficulties in adapting to methods that were changing too often, and they welcomed a harmonisation of methods across the EU for comparability reasons.[150]

The list below indicates the main limitations identified during the analysis:

- Uneven quantity of content, structure and information across the NAPs or across countries;
- Lack of data on effectiveness of measures and absence of harmonised processes for the evaluation of effectiveness. However, some agglomerations develop indicators for each of their measures;
- Lack of data on the monitoring and evaluation and the evaluation process criteria of NAPs;
- Lack of data on cost effectiveness, particularly of individual measures. However, some of the second group of 50 NAPs analysed provided cost-benefits analyses.

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[149] COM/2011/0321 REPORT FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT AND THE COUNCIL On the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52011DC0321&from=BG

[150] Interview with a French municipality representative.

- Lack of data on costs per measure or overall budget for most of the NAPs;
- Lack of data on the length of road/surface area/number of dwellings concerned by the measure for some NAPs;
- Uneven data on public consultations across NAPs;
- Lack of data on what are considered the main sources of noise in the NAPs;
- Lack of data on highlighting 'bad' and 'good' practices;
- Lack of contact details for more information on the NAPs;
- Uneven data on whether the measures outlined in the NAPs are new measures or a continuation of existing measures planned and implemented during the first round of NAPs from 2008-2013;
- Difficult comparability of data between two rounds, as the END eligibility criteria changed and some agglomerations, roads, airports and railways became eligible in 2018 only;
- Difficult comparability of data due to regulatory changes introduced by the responsible authorities for the NAPs between 2013 and 2018. This prevents the possibility of an analysis of agglomerations between the two rounds, and explains the lack of information on evaluation of previous NAPs (e.g. French agglomerations). Similarly, in the case of Ireland the content of agglomeration NAPs is decided at local level, so the decision on reporting on all noise sources (road, railway, airport) may not be consistent between noise reporting rounds. However, some countries display a clear continuation of NAPs between 2015 and 2018, making them easy to compare (e.g. Germany);
- Due to the small size of some EU Member States, the size of the airports, rail and road network, and agglomerations is not large and/or busy enough to surpass the threshold beyond which all countries must develop NAPs. This is the case in Cyprus, Malta, Croatia, Slovenia where noise action planning is in its early stages and therefore relatively lacking compared to other EU countries; and
- The European Commission launched infringement procedures against Member States that do not comply with the Environmental Noise Directive's rules on producing noise maps and adopting noise action plans. In 2020, the European Commission decided to bring Portugal and Slovakia to the European Court of Justice, and 10 other countries are under infringement procedures: Belgium, Cyprus, Czech Republic, Germany, Spain, Greece, France, Hungary, Italy and Poland.[151] The lack of NAPs for national level rail and road infrastructure across different rounds impedes the assessment and comparability of countries with similar local noise conditions.

Some of these limitations are countered during stakeholder consultations, which aim to clarify inconsistencies and fill in information gaps. However, in some cases it may be difficult to collect additional information as these may not be readily available or collected at the Member State level. With regards to future development and harmonisation of the reporting content, it could be helpful to request that Member States highlight where data is unavailable and the reasons for that, not only for comparative assessment of results, but also for the identification of primary data collection needs.

[151] "Noise: Commission decides to refer Portugal and Slovakia to the Court of Justice of the EU for their failure to map noise and draw up noise action plans", European Commission, July 2020, available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_20_1233

4 Legislative drivers

4.1 Overview

This chapter looks at the causal links that can be identified based on the legislative landscape in Europe and the number and types of noise solutions that have been implemented. We seek to define:

- How legislation drives the implementation of noise abatement solutions; and
- How successful these measures are in terms of reaching their objectives (reducing noise, reducing the health burden of the number of people who are exposed to higher noise pollution etc.).

This assessment is built on the findings of the literature review, stakeholder interviews and the analysis of the national action plans.

To define the efficiency of the current legislative landscape, a baseline scenario first needs to be built up based on the objectives of the overarching legislative elements on the international and the EU level. This can be visualised through an intervention logic graph, which depicts how legislation was originally expected to work and what was its main underlying assumptions.[152]

In the EU, the objectives and principles of END provide the baseline for the evaluation of the drivers of noise abatement solutions. While evaluating legislative drivers, a broader scope of EU noise policy needs to be considered, including the 7th Environmental Action Programme (7thEAP - Living well, within the limits of our planet) and the EU source directives. Although the link between END and sources directives is not well established, the latter provides significant elements of noise control at source, which seem to be a cost-effective solution for tackling noise disturbance. Regarding the 7thEAP, it provides for the EU's commitment to decrease significantly the noise pollution in line with WHO recommendations.

In a wider international setting, the UN Sustainable Development Goals, WHO's Environmental Noise Guidelines for the European Region and guidelines from relevant international transport organisations such as the International Civil Aviation Organization (ICAO)[153], International Union of Railways (UIC) or the International Road Transport Union (IRU) [154] must be examined. On the Member State level two factors are taken into consideration: the extent to which the country adapts and complies with the aforementioned international guidelines and EU law; and the efficiency of implementation at the local level. [155] In addition, the outcome of public consultations and complaints procedure could be considered as drivers of noise abatement solutions.

Part of the information used to evaluate the existence and efficiency of legislative drivers comes from the desk-based research phase including the evaluation of NAPs. The in-depth assessment of NAPs contained a chapter specifically looking at the extent to which the provisions of the END have been implemented and identified the relevant policy national measures that were used to adapt the END provisions. This information, however, was not in all cases readily accessible from the action plans and complementary literature review. Consequently, several bilateral interviews were carried out with relevant stakeholders to fill gaps and gather further information related to local implementation. A list of the interviews that have been carried out so far is provided in Annex 3.

[152] European Commission Better Regulation Tool 46: designing the evaluation https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-46_en_0.pdf

[153] ICAO Reduction of Noise at Source https://www.icao.int/environmental-protection/pages/Reduction-of-Noise-at-Source.aspx

[154] International Road Transport Union (2012) Position paper on noise https://www.iru.org/resources/iru-library/iru-position-vehicle-noise-2012

[155] UIC network on noise and vibration https://uic.org/sustainable-development/noise-and-vibration/

The baseline intervention logic was readjusted in line with first interim results of the project. The revised baseline intervention logic is the result of the assessment of the relevant policies and legislation throughout the research project conducted during this study. In addition, a causal framework – used by the EEA and WHO, namely DPSIR (Driving forces – Pressure – State – Impact – Responses) and DPSEEA (Drivers – Pressures – State – Exposure – Effect – Actions) – has also been prepared. The aim of the causal frameworks is to facilitate a better understanding of the linkages that exist between relevant legislation and policy options and noise abatement solutions. These topics are further discussed in Chapter 8 of this report.

4.2 Framework of linkages between health, environment and development

Understanding the environmental impacts of the current legislative and policy landscape requires adequate indicators and the understanding of direct and indirect effects of these measures. To support such environmental assessments often the Driver-Pressure-State-Impact-Response framework is used (DPSIR), which is a structured causal framework developed by the EEA to help decision makers understand environmental stressors and design well-balanced solutions often known as "responses" or "actions". The DPSIR framework aims to provide transparency for evidence-based decision making at EU, national or local level, and seeks to increase stakeholder buy-in.

In the context of this study, human health impacts are represented in terms of exposure and resulting health effect. Therefore, this analysis will refer to the further expanded WHO methodological DPSIR framework for health purposes which includes Driving forces – Pressures – State – Exposure – Effect - Action (DPSEEA). Driving forces are understood as factors that generate pressure which ultimately affects both the environment and human health through various exposure pathways that connect people with their surrounding environment. It is important to understand the key interventions (legislative or policy) in this context as well as the level of their political and societal acceptance.[156]

This DPSEEA framework creates a system that transparently links responses/actions (that require political reforms, investment and buy-in) to stress factors, which in turn facilitate the implementation of decisions that directly address environmental and human health concerns. The response/action element is the decision-makers' focus within the DPSEEA framework. In the context of this study, the response/action element represents a mitigation of hazardous noise pollution as well as the adaptation of actions and targets for one or more elements of the DPSEEA framework:

- **Driving forces (D)** are characterised as social, demographic and economic activities that motivate the relevant process. These can include population growth, urbanisation, increasing mobility (traffic), technological development, economic and/or policy development, infrastructure development and public opposition to new infrastructure. The response/action to a driver would constitute doing fewer or none of the activities that may result in a negative impact.

- Driving forces generate **pressures (P)** on the environment and human health that induce negative changes and increase health burden. Pressures may include the increase of noise emissions that can have an impact on biological systems and human health. The response to a pressure could be the reduction of pollution-inducing activities by changing the relevant processes or applying noise abatement solutions and therefore making activities less impactful.

[156] Michael Fizz, Indicators: Chapter 7 Framework for linkages between health, environment and development, WHO, available at: https://www.who.int/mediacentre/events/IndicatorsChapter7.pdf?ua=1.

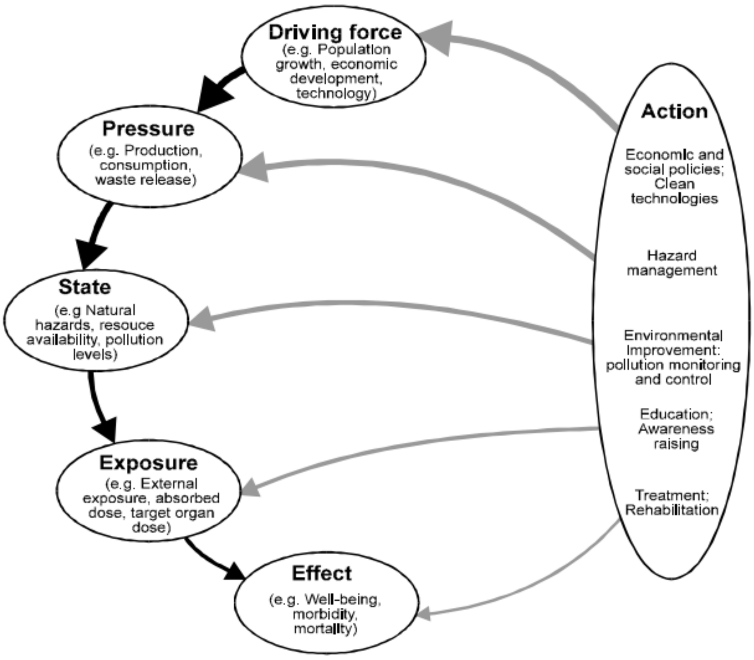
- In response to pressures the state of the environment is modified. Environmental **State (S)** is represented by noise reception levels. They are often expressed in terms of magnitude of hazard. Response to this problem would be to encourage dispersion or removal of hazardous noise levels (e.g. by introducing physical measures for noise reduction). State responses could also ensure that sensitive receptors (citizens) are not in areas of high or impactful concentrations.
- As a result of these hazards the risk on health may occur. **Exposure (E_1)** refers to o the intersection between the number of people exposed to different average noise levels in the environment (noise reception levels).[157] Exposure may be measured by monitoring or modelling techniques.
- Exposure to hazard results in health **effects (E_2)**, which constitute to negative outcomes. Within the context of this study this means health impacts resulting from the exposure of a receptor (humans) to hazardous noise levels. Impacts can include death and/or illness due to heart disease and stress, sleeping disorder, reduced productivity, cognitive impairment and mental health issues. The response to such effects can be taken by measures at source, in the transmission path or at the receiver, which aim, essentially, to make the environment (and/or receptors) more resilient to the effects/impacts.
- **Actions (A)** are responses to effects which may require changes in legislation, policies or hazard management approaches including noise monitoring and control, awareness raising, education, treatment and rehabilitation. The focus on specific policy objectives does not lead naturally to the consideration of impacts that may be beneficial (co-benefits) or disadvantageous (trade-offs) for other policy areas. Hence, each action should be appropriate and balanced to achieve the desired outcome with no adverse impacts (reduction of an increasing traffic vs mobility needs). While developing appropriate actions to tackle noise pollution, decision-makers should identify possible adverse impacts of these actions to achieve optimal results with their interventions, which would comprise a full range of environmental, social and economic aspects. This approach allows the decision-makers to work towards the maximisation of co-benefits of their action across various policy areas.

Some pollution mitigation actions may have adverse impacts that go beyond its specific focus area. Measures taken to reduce traffic, for example, can affect air pollution, noise, accident rates, greenhouse gas emissions but can also lead to unintended economic and social impacts. The wide variety of impacts brought on by pollution mitigation create the need for a robust and far-reaching analysis involving experts from various fields. Some unintended impacts of mitigation measures are quantifiable relatively easily and can be integrated directly within a policy appraisal process (an example being the monetised health benefits of reduced nose pollution arising from noise abatement measures). Others results, such as social inequality, may be qualitative. This may create a challenge in terms of partial assessment, where only some effects are quantified and monetised. Knowledge of the interdependencies of the various impacts and trade-offs enables legislators and policy-makers to better understand the correlations that may exist between various policy instruments. The presence of trade-offs should not impede the implementation of a legislation or policy measure, unless they negate the overall benefit of the policy. The use of co-benefits to justify policies also needs to be made with care; there may be more efficient ways to realise the co-benefits (e.g. The DPSEEA framework, is an efficient tool for assessment of risks associated with environmental pollution and related to it health burden, where the chain from driving force to source

[157] WHO, Environmental Health Indicators Framework and Methodologies, 1999, available at: https://www.who.int/ceh/publications/cehframework/en/.

activity and thence to health effect via emissions and exposure is evident.)[158] Understanding the drivers as well as the possible indirect and directs effects of a policy measure can help decision-makers evaluate and develop adequate interventions to mitigate the health burden of noise pollution.

Figure 4.1 The DPSEEA framework



Source: WHO

4.3 Legislative Drivers

4.3.1 International and EU-level drivers

The overarching international policies aim to protect human health by reducing inequalities and creating sustainable communities (UNSDG 3, 10 & 11), provide recommendations on minimum noise thresholds (WHO), create noise standards (ICAO), support operational efficiency and offer technical advice (UIC, IRU). The END at the EU level integrates these overarching development guidelines and takes into consideration the recommendations of the international industry associations. It provides a noise management framework for Member States to implement.

The in-depth assessment of specific action plans indicated that the implementation of the END had a significant impact and provided an EU-wide legislative framework for:

- Implementing regional and national level initiatives;
- Providing transparency on the implementation and efficiency of previous measures;
- Allowing feedback from the public and interested stakeholders; and
- Creating a platform for comparative analysis specifically as it refers to:
  - identification of best practices;

[158] Ibid.

- cross-border initiatives.

Most Member States transposed the END into their national legislation via their **environmental or health-related legislation**. An overview of the transposition measures identified in reviewed NAPs are shown in Annex 2.

This transposition of the END via specific legislative is an key indicator of the degree to which national legislators are tackling noise pollution. Additionally, some member states transposed the provisions of the END via their relevant **safety acts and sectorial legislation** (road, rail and aviation), either at a national or regional level. While the legislative provisions created a legal background in terms of transparency of operations and accountability for polluters, they also helped to harmonise noise solutions and facilitated the adoption of good practices by way of making national action plans available for all interested stakeholders. However, a distinction should be made between legislation concerning the implementation of the END and other noise-related policies, such as noise limits values adopted at the national level.

While EU level legislation is an important element of the overall noise solution framework, several measures have already been in place prior to – or have been developed in parallel with – the requirements of the END coming into force. This is due largely to bottom-up pressure from citizens and stakeholders impacted by noise pollution. The main role of EU noise policy was to introduce harmonised requirements as a way of producing top-down pressure on stakeholders and authorities operating and/or overseeing noise at source measures.

In addition to the relevant legislation, other policy instruments including strategic plans, programmes and planning documents at EU, national and local level are also considered as key tools for tackling noise pollution. The role of policy instruments (e.g. urban planning, land use or mobility plans) play an increasingly significant role in the expansion of urbanised areas, urban sprawl and related infrastructure growth. Due to the complexities of the sources, distribution and impact of various noise levels, it is imperative that EU legislative measures remain sufficiently flexible to accommodate regional specificities of climate and weather as well as urban development trends, innovation and the cost effectiveness of measures. Within the relatively wide concept of urban development trends, specific attention must be paid to socio-economic issues such as housing, poverty and mobility needs to avoid a disproportional impact of noise pollution on low-income households or marginalised communities. Examples have shown that transport infrastructure operators alone have a relatively limited toolkit to counterbalance larger socio-economic trends. These may include the acquisition of dwellings or banning/limiting the number of housing developments in the vicinity of high noise areas. A less frequently used solution was communication and dissemination of information particularly one that focuses on the health impacts of noise pollution not only on the level of noise. To facilitate wider outreach and communication with citizens highlighting health implications of noise exposure, several stakeholders must cooperate including the transport operators/managers, local and national authorities as well as NGOs and public health representatives. In addition to education and dissemination campaigns collaboration/consultation between these stakeholders could support urban planning and smart city initiatives targeting sustainable environments.

Additionally, no indication was found that infrastructure relocation would be among the considered options for reduction of noise at source. Limiting traffic at certain times or on specific section of roads, rail or airways is among the solutions used, but complete relocation of the noise source infrastructure (airport, railway, road) was not mentioned. This is largely due to the associated financial costs of such a move. Instead, attention was paid to reduce noise at the receiver via new insulation, urban planning, introducing quiet areas, etc. The combination of these measures with the

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introduction of low noise emission vehicles and aircraft may reduce noise induced health burden, although the extent of this has not been identified by the action plans.

As mentioned above, flexibility of implementation is important to allow for the development of specific noise solutions adapted to the needs of the given region and its socio-economic needs. However, it can also lead to differences in implementation. These differences may be a result of different strategies related to the development of certain area, although some stakeholder interviews identified challenges related to the financing of noise solutions due to a requirement on co-financing of these investment. Bridging the financing gap is a national and/or regional decision which is often determined by long-term strategic priorities. One possible way to bridge the financing gap and highlight the importance of noise solution measures is to underline the linkage between public health and noise exposure specific to the region or urban area in question. Furthermore, investment in the field of mobility could be aligned with relevant noise abatement measures.

4.3.2 Member State Level Drivers

This sub-section provides an analysis of legislation and other instruments identified during the in-depth analysis of the 100 NAPs. First, an overview and country analysis is presented, followed by a detailed analysis of the instruments and legislative frameworks developed at the different policy-making levels across the Member States. Finally, legislation and other instruments are analysed in terms of their sectorial (road, rail, aviation or other) impacts. This review seeks to identify interventions that support the implementation of noise abatement measures and noise policy. The full list of relevant Member State legislation and other policy instruments is available in Annex 7.

4.3.2.1 In-depth NAP analysis of legislation and other policy instruments

In this sub-section, legislation and other instruments from the Member States are analysed. National noise legislations tend to interlink with various other local policy measures, and therefore, within the context of this study, research on national policy instruments was focused on the relevant transport measures. Data and information feeding into the comprehensive overview of available national legislation was sourced from the in-depth analysis of 100 NAPs (see Chapter 3). It is noted that Member State noise legislation measures may go beyond transportation noise and consequently our analysis captures only a specific segment. In addition, a complementary list of legislation derived from EU databases and similar sources that indicates the transposition of the END in the Member States can be found in Annex 2.

A total of **357 different legislations and other instruments were identified** in the 100 NAPs from the in-depth analysis. These instruments have national, regional, and local dimensions. During the analysis, each legislation and other instrument was labelled with a specific sector and policy area to ensure that both an overarching, 'big picture' of the collected data as well as an in-depth, finely granulated picture could be provided.

Country analysis of legislation and other policy instruments

The below graph displays the total number of items of legislation and other instruments that were identified during the in-depth analysis of 100 NAPs.

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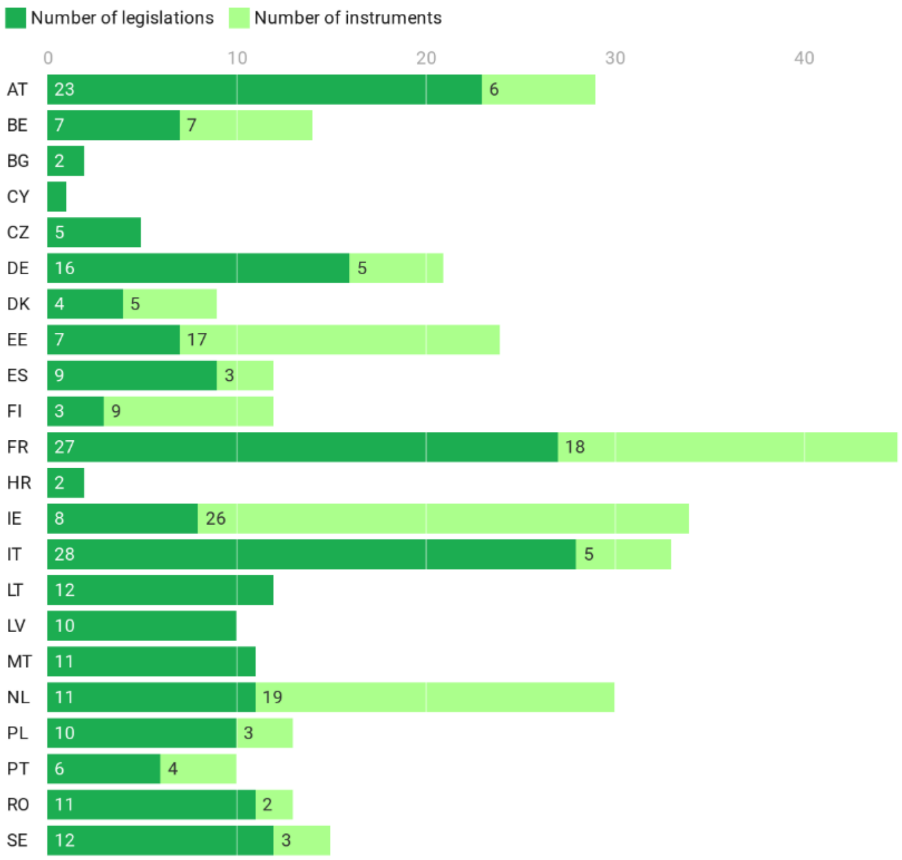
Figure 4.2. Number of legislation & other instruments per Member State[159]



Overall, the highest number of legislative items and other instruments was found in the NAPs of France, Ireland, Italy, the Netherlands, and Austria. Regarding instruments other than legislation, France, Ireland, the Netherlands, and Estonia, in particular, have developed a considerably wide range of instruments from guidelines and manuals, national and regional environmental and/or development strategies to tools related to urban planning and land use.

Among these other instruments, various types were identified during the analysis, the main selection of which is indicated in the table below. Therefore, this list is not exhaustive but presents the most relevant non-legislative policy instruments. Examples that were taken from the 100 analysed NAPs may be allocated to one or even multiple types of other policy instruments, as the objectives of these instruments may overlap.

Table 4.1: Selection of relevant other policy instruments and examples

Type of other policy instrument	Examples from analysed NAPs
Sound condition guidelines and related instruments	• *Austria*: Guideline for the Noise Abatement of Existing Railway Lines for the Uniform Regulation of Noise Protection Measures on Existing Railway Lines

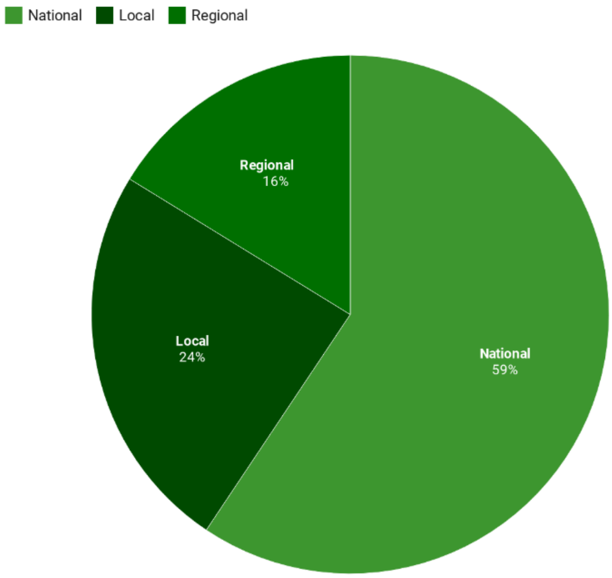
[159] source: data compiled by the author based on in-depth analysis of 100 NAPs

Urban design manuals, urban development plans and urban planning documents	• *Ireland*: Urban Design Manual and the Design Manual for Urban Road and Streets 2013 in Dublin agglomeration • *Estonia*: General plan of the city of Tallinn and district plans
National and regional spatial strategies	• *France*: Metropolitan Green-Blue Plan in Grenoble agglomeration 2019 • *Poland*: Plan of Spatial Development for the Greater Poland Voivodeship • *Poland*: The regional development strategy of Greater Poland voivodship until 2020
National aviation guidelines, studies, and policies	• *Ireland:* Dublin airport guidance document on "Environmental Protection Agency Guidance Note for Noise Action Planning" • *Finland:* Finavia study on the effects of aircraft noise for Helsinki Airport • *France:* CDG airport noise exposure plan and noise annoyance plan • *Austria:* ÖAL (Austrian Working Group for Noise Abatement) Guideline No. 24 Sheet 1 "Noise Protection Zones in the Vicinity of Airports Planning and Calculation Principles"
Transport or mobility plans	• *Belgium:* Communal Mobility Plan (2015-2020) in Charleroi • *Estonia:* Transport Development Plan 2006-2013 • *Netherlands:* Clean Transport 2010-2014 in Utrecht • *Netherlands:* Multi-annual programme infrastructure, space and transport for national roads
Noise abatement programmes	• *Netherlands:* Sound Insulation Programme Schiphol • *Netherlands:* Remediation programme Traffic noise for Netherlands • *Germany:* I-LENA programme (*Initiative Lärmschutz-Erprobung neu und anwendungsorientiert* - New and Application-Oriented Noise Abatement Testing Initiative) for promotion of testing of innovative noise abatement technologies on infrastructure
Environmental strategies at national or regional level	• *Poland:* The Environmental Protection Programme • *Netherlands:* Sustainability Agenda (2015), Amsterdam agglomeration
Investment programmes	• *Germany:* Future Investment Programme (ZIP) • *Germany:* Infrastructure Acceleration Programme II (IBP II)

Governance levels analysis of legislation and other policy instruments

The in-depth analysis of the 100 NAPs identified a number of noise specific legislative items and other policy instruments enacted at various policy-making and governance levels in the Member States. The collective term of "other policy instruments" includes long-term strategies, mobility plans, urban plans, land-use plans or other types of plans and strategies as mentioned above. As shown in the figure below, a great majority of identified legislation and policy instruments were established at the national level (59%), followed by the local level (24%) and the regional one (16%).

Figure 4.3. Laws and other instruments by policy-making level[160]



Some federal states such as Austria and Belgium have a relatively high ratio of regional legislation compared with centralised and decentralised states, which have a clear predominance of the national instruments. When comparing the various policy instruments that are used in federal states, in Austria for example, 13 out of the 14 policies fall under legislation, while in Belgium, it is six out of 12.

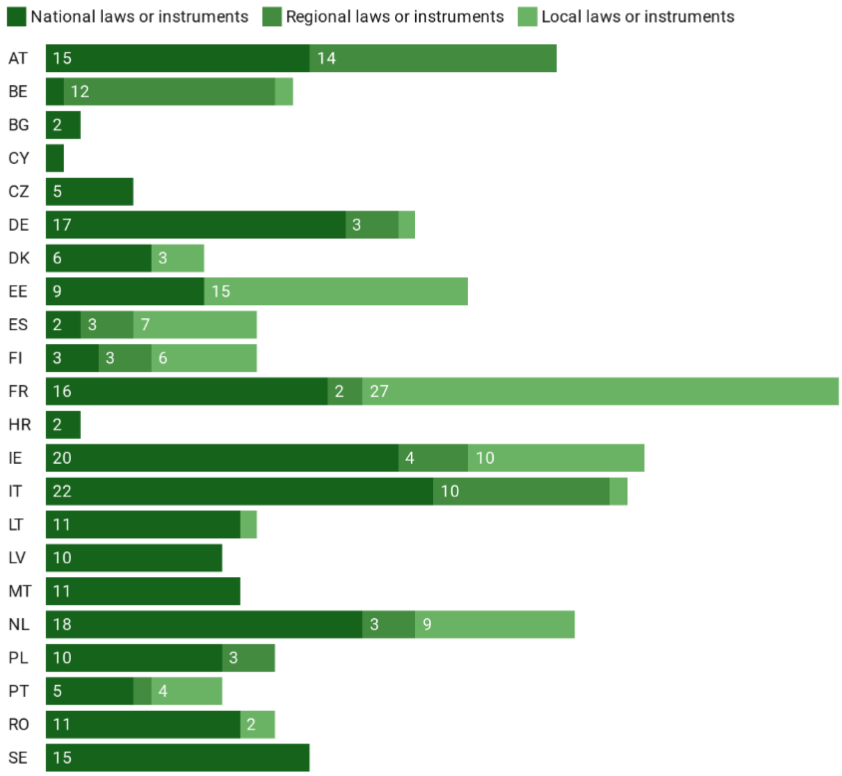
Looking more in-depth at some of the Member States, a specific pattern is apparent in France: a strong national legislative framework supplemented by local legislation. For instance, 51% of the elements identified as legislation were implemented at the national level, while 40% were local laws (11 legislative instruments). However, of those 11 laws, eight were decrees dedicated to the specific infrastructure (Paris-Charles-de-Gaulle airport). The remaining three local laws represent municipal decrees from Nice on noise, delivery hours and the closing times of night shops.

Nevertheless, a more gradual split of instruments can be also observed in Spain, where adopted legislation, represents a near-equal split between the three policy-making levels including four at the local level, three at the regional level, and two at the national one. This tendency can be explained by the fact that in Spain the END may be implemented at both the national and regional level. Therefore, the three regional laws correspond to the laws for the autonomous communities of Andalusia, Basque Country and Valencia.

Moreover, local authorities (municipalities) in some countries have the competence to adopt legislation in specific areas (e.g. definition of the noise limits). For instance, in Spain, Vitoria-Gasteiz and Bilbao implement municipal ordinances on noise and vibration. By contrast while some countries delegate competences to their regional or local authorities, others, such as Sweden, centralise legislative and policy instruments at the national level. The figure below represents the ratio between national, regional and local legislation and policy instruments across the Member States.

[160] Source: data compiled by the author based on in-depth analysis of 100 NAPs

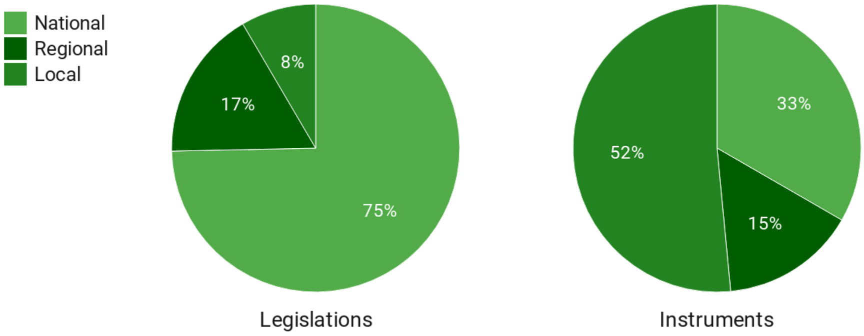
Figure 4.4. Laws and other instruments per policy level and Member State[161]



Finally, the analysis has shown that the split between legislations and other instruments is also closely linked to the governance system of the individual countries. As indicated above, in most of the centralised countries, there is a clear tendency to adopt the legislation at the national level (75%) whereas other policy instruments are mostly developed at the local and regional level (respectively 52% and 15%). When looking more in depth into the other instruments in France, their geographical split is striking. The majority (88%) of the analysed policy instruments are drafted and implemented at the local level, with the remainder developed at the national level. This shows that noise policy in the country is quite centralised in terms of legislation, and that other instruments constitute policies and tools for territorial development. For instance, the NAP for the agglomeration of Nice Côte d'Azur Metropole refers to an administrative mobility plan, a code of conduct for nightlife, an environmental charter, a charter on green construction sites and an environmental charter for the harbour.

[161] Source: data compiled by the author based on in-depth analysis of 100 NAPs

Figure 4.5. Legislations and other instruments per policy-making level[162]



In general, across Member States a range of policy instruments promote territorial development and improvement of the well-being of its inhabitants. At the regional and local level, these instruments often address key socio-economic and environmental challenges, such as employment, business development, connectivity/mobility, public services, green transition economy, governance, etc.

The other instruments at the local and regional level vary in their policy area, across Member States the development of urban and land-use planning instruments dominates. In fact, out of the 87 local legislations and other instruments that were identified in the NAPs from the in-depth analysis, 20 could be considered urban or land-use planning. This trend was especially apparent in NAPs from Estonia, Finland, France, Ireland, the Netherlands and Portugal. With regards to agglomerations, urban planning instruments are clearly used to address noise challenges, such as the Municipal Plans of Territorial Planning in Lisbon. When presenting the noise measures, the NAP specifies that it includes already implemented solutions from those municipal plans that have noise issues. Development plans are also identified, with infrastructure plans at the national level (in Netherlands for major roads) and regional level (Poland). Also, in some countries socio-economic developments can be addressed in the regional planning instruments. This is particularly the case for the Central and Eastern European countries (e.g. Poland).

With regards to the links between urban planning instruments and noise abatement measures, an in-depth analysis of the NAPs revealed several cases of such interdependencies. For instance, all NAPs of French agglomerations mention two local instruments used for urban planning and development. First, the Local Urban Plan (PLU, and PLUi for the intercommunal level), which is the key tool used by agglomeration for the purpose of urban planning. The second instrument is the Territorial Coherence Scheme (SCoT), which aims to develop a long-term territorial strategic planning.[163] While drafted at the local level, both instruments derive from the national legislation relevant for urban solidarity and renewal[164] and relevant provisions of the French Urban Code.

In addition, in the NAP for Lisbon agglomeration, the measures considered are presented as either new measures defined in the NAP, measures coming from other instruments, measures where further studies are required, or measures coming from the local plans of the urban districts (Municipal Plans of Territorial Planning), as explained above. This shows that the Portuguese agglomeration integrates noise into a wider policy planning based on the existing provisions local urban development plans. Finally, the NAP for Tallinn agglomeration lists more than 15 local plans, programmes and initiatives, mostly

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[162] Source: data compiled by the author based on in-depth analysis of 100 NAPs

[163] https://www.cohesion-territoires.gouv.fr/le-scot-un-projet-strategique-partage-pour-lamenagement-dun-territoire

[164] https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000000207538

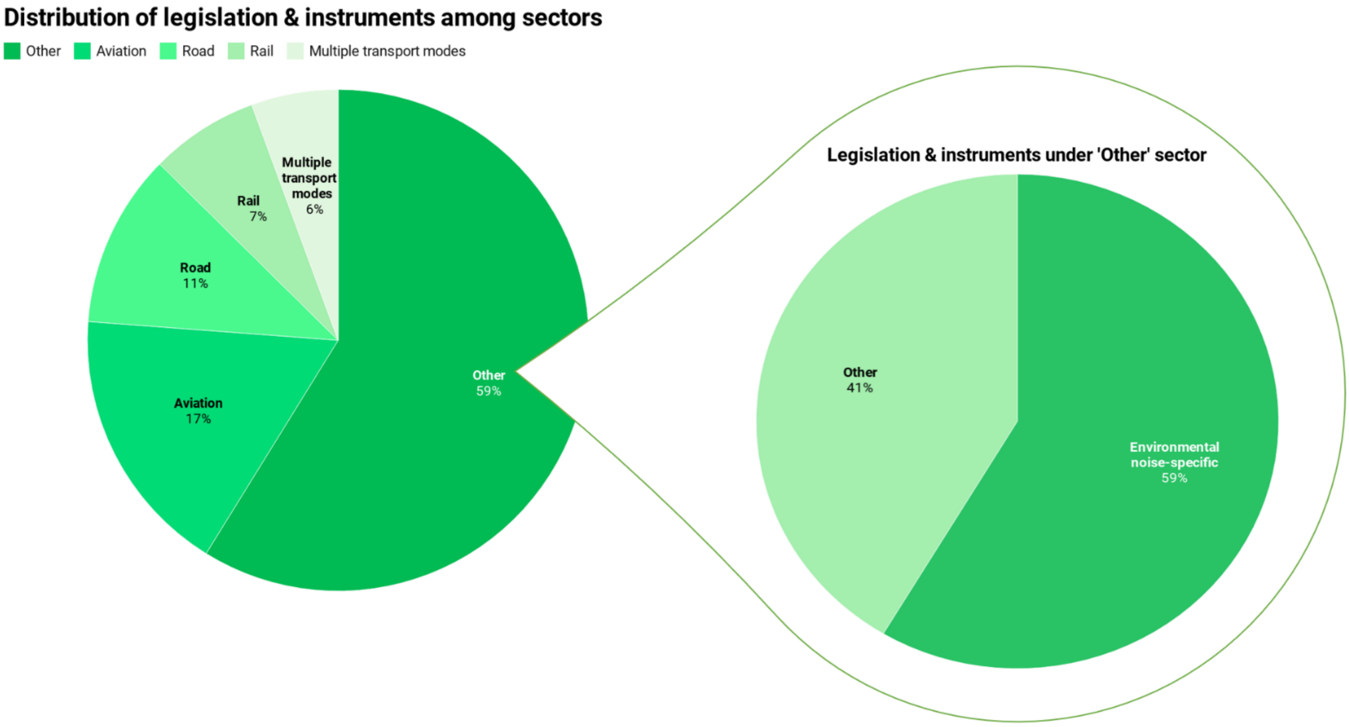
focusing on urban development and mobility, that were considered during NAP's development and which arguably may have an impact on the city's noise levels. It includes general development plans for the agglomeration and its districts, plans targeting buildings, as well as traffic development and traffic management plans. Moreover, the NAP refers to long-term development and environmental strategies, such as the Estonian environmental strategy and the "Tallinn 2030" strategy.

As previously mentioned, agglomerations seeking to manage multiple noise sources in densely populated areas can face challenges. In urban and peri-urban environment the issue of noise disturbance needs to be balanced with the public's increasing need of, and at times reliance on, mobility. The in-depth analysis of NAPs demonstrated that for most agglomerations the issue of traffic noise is intertwined with several other policy areas, such as public transport, economic and regional development. As an urban-planning instrument, NAPs are a meaningful tool for providing and integrated approach for tackling noise pollution. Also, numerous stakeholders consulted during the study pointed out that urbanisation and urban planning should take into consideration noise abatement measures.

Sectoral distribution of identified legislation and other policy instruments

During the analysis of the dataset, sector-specific noise legislation and other instruments were also reviewed. This sectorial approach of the Phenomena study included aviation, rail, road and integrated transport modes (within agglomerations). The figures below presents the distribution of legislation and other instruments across the sectors covered by the Phenomena study.

Figure 4.6 Distribution of legislation & other instruments among sectors and share of environmental noise-specific legislation & other instruments[1]



As the pie chart above illustrates, a large share of aviation-specific laws and other instruments (17%) were identified. The reason for this may be that aviation and airports require technically specific details that do not apply to any other transport sector. Road-specific instruments (11%) had the second highest share of the identified regulatory measures. Laws and instruments applying to railways (7%) and multiple transport modes (6%) have the lowest share among the 100 NAPs analysed.

The largest share of relevant legislative instruments is allocated the category 'Other', as the chart above demonstrates. This 'Other' category in the chart refers to a cluster of different laws and other instruments, covering areas such as environmental noise, environmental protection, urban planning, land-use planning and construction. Among these, most refer to environmental noise-related instruments (59%), many of which represent transpositions of the END into national law. Overall, 76% of these environmental noise laws and other instruments are national, 17% are regional, and 7% local, according to calculations based on the in-depth NAPs analysis. Therefore, in the 22 analysed Member States environmental noise laws and other instruments were mostly adopted at a national level. Furthermore, these findings only give a rough overview of the connection between the type of instruments (either legislation or other instrument) and governance levels (national, regional, local). Therefore, an in-depth analysis of the use of legislation and other instruments at different governance levels is performed in the following segment.

This in-depth analysis reveals that there are differences between the share of national, regional and local governance level among both legislations and other instruments. As the table below shows, national environmental noise legislation and other instruments are the most applied. However, the ratio of regional and local instruments is higher among other environmental noise instruments than among environmental noise legislations. This demonstrates that a significant number of other instruments such as non-legislative plans, strategies, initiatives, or guidance documents are developed and implemented at the regional (17%) and local (17%) level. This finding has important implications for the planning of noise abatement actions in Member States regarding the level of governance.

Table 4.2: Share of national, regional, and local-level environmental noise instruments and legislation[165]

	Other environmental noise instruments		Environmental noise legislation	
Governance level	**Total number**	**Percent**	**Total number**	**Percent**
National	12	67%	81	77%
Regional	3	17%	18	17%
Local	3	17%	6	6%
All	18	100%	105	100%

4.3.2.2 Rate of implementation of relevant noise policies

An analysis of the rate of implementation of relevant legislative measures was carried out to ascertain the balance that exists between Member States in terms of the enforceability of specific instruments. The rate of implementation of relevant policies was evaluated on the basis of infringement procedures (specifically for EU legislations) as well as availability and perceived effectiveness of national measures. Data on availability and effectiveness of local measures were sourced from stakeholder interviews.

[165] Source: data compiled by the author based on in-depth analysis of 100 NAPs

4.3.2.2.1 Infringement procedures

Member States, through national competent authorities, are responsible for the implementation of the END including collecting and approving noise maps and action plans. National competent authorities in Member States inform the European Commission on the status of END implementation. In case of non-compliance, the Commission can initiate infringement procedures against the countries that fail to implement the EU law. Given that the END does not prescribe noise limit and target values (END recommends WHO European Region 2018 threshold values), the Commission can only initiate non-compliance procedure based on Member States' failure to report noise maps and NAPs. This excludes implementation of noise limit values that is regulated at the national level. There were no major issues with the legal transposition of the END into national laws.[166] However, the implementation of the END has suffered from long delays in drawing up and adopting the action plans for noise management.[167] The costs of non-compliance with legal obligation of noise legislation in the EU, considering health burden were estimated to be between **EUR 24.6 billion and EUR 36.8 bn per year** (2017).[168] Consequently, the Commission has started official enquiries for non-compliance and infringement cases against Member States

According to Art. 258 TFEU, the Commission may initiate infringement procedure against a Member State that does not comply with the EU law. The infringement procedure starts with the sending of a Letter of Formal Notice that requests information from Member States on unfulfilled EU obligations within two months.[169] If a Member State does not react, the Commission can issue a Reasoned Opinion requesting the Member State to inform the Commission on measures taken to ensure legal compliance. If the Member State continues its non-compliance after the reasoned opinion, the Commission can bring the case in front of the European Court of Justice. However, the majority of infringement cases are settled prior to a court appeal.[170] If a Member State fails to comply with the first Court ruling, the European Commission can initiate second infringement procedure (Art. 260 (3) TFEU).[171] The table below compiles the list of relevant non-compliance cases since 2004.

Table 4.3 List of infringement cases

Year	Procedure and Countries		
	Letter of formal notice Art. 258 TFEU	**Reasoned opinion Art. 258 TFEU**	**Referral to Court Art. 258 TFEU**
2020	Greece	Cyprus	Slovakia, Portugal
2019		Belgium, Poland	
2018	Belgium, Cyprus	Spain, Portugal, Croatia, Italy	
2017	Greece, Romania, Cyprus, Czechia, Portugal, Poland, Belgium, Croatia	Slovenia, Germany, Slovakia, Hungary	
2016	Germany, Slovenia, Spain, Hungary, Slovakia, Italy		
2013	Italy, France		

166 END First implementation report (2011). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52011DC0321&from=EN

167 European Commission (2016). REFIT Evaluation of the Directive 2002/49/EC relating to the assessment and management of environmental noise. Available at: https://ec.europa.eu/environment/noise/pdf/staff_working_doc_refit_evaluation_environmental_noise.pdf.

168 The costs of not implementing EU environmental law. Available at: https://ec.europa.eu/environment/eir/pdf/study_costs_not_implementing_env_law.pdf

169 FAQ EC Infringements. Available at : https://ec.europa.eu/commission/presscorner/detail/en/MEMO_12_12

170 Ibid.

171 Ibid.

2010		Malta	Malta
2009	Malta		
2007	Austria		
2006	Ireland		France,
2005		Belgium, Czechia, Portugal, France, Finland, Austria, Ireland, Luxembourg, United Kingdom, Greece, Italy, Germany	Austria, Luxembourg, Portugal, Czechia, Ireland, United Kingdom, Greece
2004	Slovakia, Greece, Sweden, Czechia, Belgium, Germany, Austria, Portugal, Italy, Ireland, Luxembourg, France, Finland, United Kingdom		

The European Commission is currently pursuing active infringement cases against the following Member States: Cyprus, Czechia, Greece, Germany, France, Hungary, Italy, Portugal, Poland, Slovakia, Spain.[172]

Although the infringement procedure is a useful tool for ensuring compliance with EU law in the field of noise policy, some stakeholders pointed out that non-compliance is often linked to delays in the reporting obligation. However, stakeholders consulted emphasised that the **delays are often due to smaller Member States suffering resource constraints (financial, organisational, procedural and human resources), rather than a lack of political will to comply.**[173]

4.3.2.2.2 Implementation rate

The analysis of the implementation rate is based on findings from 18 interviews and surveys with public authorities in the Member States carried out by the research team throughout January 2021. Findings on the implementation of legislation, drivers and obstacles of a successful implementation, non-legislative noise solutions, and EU-level initiatives to foster implementation are presented below.

Overview on implementation of legislation

From the overview of legislation and other policy instrument in the section above, it is apparent that instruments related to the management of noise pollution are fragmented across various policy areas. However, two key components are always present: a general national legislative framework, which may be related to noise-specifically or to environment, health and atmospheric protection;[174] and executive texts derived from national frameworks such as governmental resolution, orders, decrees, regulations etc. which are implementing national provisions. The latter instruments are often more technical and practical, providing the content of strategic noise maps and noise action plans (Poland), and detail on the spatial plan to limit ambient noise (Estonia), among other things. Also, the implementation of the legislative framework is often supplemented by the development of

[172] European Commission infringement decisions. Database accessed on 6 January 2021. Available at: https://ec.europa.eu/atwork/applying-eu-law/infringements-proceedings/infringement_decisions/index.cfm?lang_code=EN&typeOfSearch=false&active_only=0&noncom=0&r_dossier=&decision_date_from=&decision_date_to=&DG=ENVI&title=noise&submit=Search&fbclid=IwAR0y_ml54475PVo31ums_Sr-xKiRn3-syVZkMWWjvLJXr4c7E8wgzsDnTq4

[173] Evaluation of Directive 2002/49/EC Relating to the Assessment and Management. Available at: https://op.europa.eu/en/publication-detail/-/publication/7febde6d-9a89-11e6-9bca-01aa75ed71a1

[174] Such as the Noise Protection Act in Bulgaria, Law on the protection of public health in Czechia, Environmental Protection Act in Poland, Atmospheric Air Protection Act and Public Health Act in Estonia etc.

guidelines (e.g. The Method Guideline for the Measurement and Assessment of Environmental Noise, Ministry of Health, in Czechia, and the Government Decision on Guideline Values for Noise Levels in Finland).

A range of national authorities can thus be considered to be involved in the drafting and adoption of the relevant legal texts, from ministries through national environmental or health agencies to regional and local authorities (e.g. prefects, municipalities etc.). Consequently, these bodies may also oversee the implementation and enforcement of these instruments. For instance, in Austria road traffic noise from motorways is regulated at national level, while noise from other major roads is regulated at regional state level. According to stakeholders, in some cases fragmented governance of noise management can lead to confusion about which provision applies in each case, and what are the interdependencies between them.

At the same time, it must be noted that in some cases we can observe a historical continuity of legislation adopted between 1970 and 1990 (e.g. Austria, Czechia, Estonia and Luxembourg), with most legislation constituting a transposition of EU law. The stakeholders agree that since the adoption of the END the number of adopted actions in the field of noise has significantly increased. In this regard, the END is perceived unequivocally by almost all the stakeholders as a complementary element of national noise-related policies, which over time has become a major driver for legislative and policy development. Most of the stakeholders consider the adoption and reporting of noise maps and NAPs as the most important driver of the EU noise management framework and driver of national implementation of noise abatement measures. The noise maps and NAPs allow for an identification of the key sources of noise, showing where the limit values are exceeded significantly across the Member States and provides a clear evidence of actions to be undertaken. Other major drivers steering further legislative developments in the area of the noise managements include the public demand (e.g. Bulgaria, Belgium, Austria, Lithuania and Luxembourg), complaints (e.g. Austria and Slovakia), public consultation (Hungary) and surveys (Microcensus four-yearly survey assesses the impact and annoyance of noise among residents in Austria[175]). Among other drivers indicated by stakeholders are also NGO pressure, requests from national health care centre or environmental protection agencies (Lithuania and Ireland) and the proximity of the main road sector to the settlements (Bulgaria). Finally, some of the stakeholders indicated that the increasing awareness of the administration of the noise issue plays an important role in the enforcement of the current legislation and putting forward new proposals. Development of national legislative frameworks is often motivated by the wish for a uniform and comprehensible procedure for noise protection including health impacts and annoyance.

The evaluation of the rate of implementation of the noise-related legislation should be based on **defined success factor indicators.** As a result, **many stakeholders report difficulties, since most countries do not have an established mechanism for measuring and quantifying such success factors**. However, given the lack of indicators for evaluating the END and related legislation implementation, an alternative way of assessing it could be to **examine data sources** such as (i) lack of complaints, (ii) timely performance of noise maps and adoption of NAPS by competent authorities (although their implementation is often limited – NAPs); and (iii) decreasing number of inhabitants exposed from strategic noise maps or NAPs.

[175] https://www.laerminfo.at/ueberlaerm/laermbetroffenheit.html; http://www.statistik.at/web_de/statistiken/energie_umwelt_innovation_mobilitaet/energie_und_umwelt/umwelt/umweltbedingungen_verhalten/index.html

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Based on the abovementioned alternative indicators, most of the stakeholders consider that the legislation has been successfully implemented in their countries, although slight delays to the adoption of NAPs are often mentioned by smaller countries such as Austria, Belgium, Hungary and Luxembourg.

Finally, it is important to estimate to what extent the adopted legislative framework allows for the effective implementation of the noise abatement measures. Under the reviewed legislation the noise sources can be divided into two groups: those under the scope of the END (strategic threshold values[176]); and those managed by national legislation imposing obligatory national noise limit values. The latter applies to noise sources outside the scope of the END, which depending on the country, may be adopted at various governance levels. A recent study has confirmed that **around 90% of EU Member States have adopted some sort of limit values for environmental noise** with a legal obligation to verify the noise pollution levels.[177] Noise maps and actions plans, which were developed according to the END, identify the locations with the highest noise levels, where the noise abatement measure are most needed and list priority areas for interventions. This is how NAPs became the driving force for the implementation of noise abatement solution by supporting stakeholders in their efforts to curb emissions to reach noise limit values in case of excessive pollution. However, some stakeholders have pointed out that the adopted NAPs are only planning instruments and their implementation can deviate based on the availability of resources. Hence, the implementation of noise abatement measures depends on the availability of resources and financing. Also, some stakeholders mentioned discrepancies between new and existing infrastructure. While the implementation rate of noise abatement solutions is very high for new infrastructure/projects, it seems more problematic for pre-existing ones (e.g. Austria, Bulgaria, Lithuania and Luxembourg). Hence, implementation could be more effective if a better balance was struck between current and new noise abatement solutions.

Drivers of effective/successful implementation and enforcement

Based on the findings of the stakeholder interviews, the following main drivers were found to support effective/successful implementation of noise policies:

- Complaints and demands from citizens;
- Sufficient funding;
- Initiatives and experience of government authorities;
- Supportive legislation and processes;
- Impact assessments;
- Cooperation among stakeholders;
- External noise experts; and
- Legally binding noise limits.

The list shows that both bottom-up (citizen compliant) and top-down measures (legislative initiatives) are equally important and thus awareness raising at both levels is required, in addition to

[176] Target value approach

[177] European Network of the Heads of Environment Protection Agencies, Overview of critical noise values in the European Region, October 2019, available at https://epanet.eea.europa.eu/reports-letters/reports-and-letters/ig-noise_critical-noise-values-in-eu.pdf/@@download/file/IG%20Noise_Critical%20noise%20values%20in%20EU.pdf.

the availability of sufficient financing and external noise experts. The main features of the above listed drivers are shown in the table below.

Table 4.4: Drivers of successful noise policy and measure implementation

Drivers of successful implementation	Description
Complaints and demands from citizens	This factor has been defined as a strong driving force behind successful implementation of noise measures, according to statements from Central and Eastern European countries such as Austria, Hungary and Slovakia. It is clear that direct feedback from the public, who are the primary burden bearers of excessive noise pollution is an essential element of the identification of noise hotspots. Legal obligation for authorities to further investigate complaints is an important first step for mitigation.
Sufficient funding	The availability of sufficient funding, whether EU or nationally sourced, is considered a central driver of noise policy implementation. The timely and effective allocation of financial resources allow stakeholders (particularly contracted experts and companies) to measure noise levels adequately, make forecasts and install abatement measures such as noise barriers.
Initiative and capacities of government authorities	The initiative and experience of governments to take action is considered a vital factor for implementation. According to a statement from Hungary, this can depend on the size of the country or the in-house experience. The results from the stakeholder consultation suggest that public authorities' awareness and knowledge of noise pollution impacts is also a central driving force for implementation. This awareness in administration may stem from the personal involvement of staff or from the political agenda of governments, and it is a main driver aligning noise policy and initiatives with other priorities, therefore encouraging a successful implementation. Stakeholder consultation also suggested that smaller administrations should calculate the time needed for organising public procurement procedures for noise maps early in the process. Only France, Germany and the Netherlands have enough internal government resources to produce noise action plans and noise maps. By contrast, most other EU countries outsource and carry out public procurement for noise maps (Luxembourg or Austria, for instance). Moreover, in Belgium, for example, action plans are produced by the local administrations. As for updates on the Reportnet platform, national authorities would benefit from instructions on how to insert data for the 2022 round.
Supportive legislation and processes	According to a response from Austria, Supreme Court decisions can significantly drive implementation forward. Furthermore, it was found that the requirement of uniform, objective, and comprehensible procedures, compliance checks, mandatory authorisation processes for noise solutions, and reporting obligations can enhance the rate of implementation. In addition, Estonia highlights that verification processes that check the compliance of plans with relevant legal requirements are another driver improving implementation rates. For instance, the Romanian Road Administration Company (NCRIA) has had a designated special unit since 2007 for managing all legislative requirements regarding road noise issues related to the EU Directive. The above processes and supportive legal frameworks can be further improved if potential health impacts and the annoyance of transport noise are taken into account. A statement from Ireland points out that EU requirements also further create incentives for implementation.
Impact assessments	Impact assessments on, for instance, land-use planning, buildings and construction, environmental issues, and environmental permissions are considered a useful tool for driving implementation and provide a basis for further, well-informed action.

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Drivers of successful implementation	Description
Cooperation among stakeholders	Smooth communication and collaboration between stakeholders – particularly public authorities – are beneficial to the implementation of noise policies. As indicated in the section on obstacles of enforceability below, a lack of cooperation among relevant stakeholders can be a major obstacle to the successful implementation of noise policies, according to the stakeholder consultation (e.g. Latvia).
External noise experts	Solid expertise on noise and related issues is a key component for the successful and effective enforcement of noise policies. Sufficient expertise on noise can be an issue in smaller countries where governments potentially lack departments and staff specialised in the field of noise policy. Therefore, support of external noise experts can ensure the technical adequacy of noise assessments and consultations and can also compensate for lacking expertise and experience within governments. This point is also explained in the section below on obstacles to the implementation of noise measures.
Legally binding noise limits	Legally binding noise limits were identified as instruments that support and provide a framework for the effective implementation of noise policies and abatement measures. A respondent from Belgium adds that the EU should advance this step and propose noise limit values for the END revision.

In addition to the above information, stakeholder consultation collected assessments on the influence of legislation, in particular on successful implementation of noise abatement measures. The majority of consulted public authorities (e.g. Austria, Czech Republic, Finland, Hungary, Lithuania, Slovakia) responded that they believe **legislative instruments** have a strong, positive influence on implementation rates. The Greek response agrees to some extent, stating that legislation is influential as long as high-level officials are responsible for its enforcement. The public administration plays an especially key role here. The **awareness of noise issues among public administration staff** (not government officials per se) can actively and successfully drive implementation, especially by exercising control and following up on legislation, as mentioned by Austria, Belgium, and Luxembourg. A response from Hungary emphasised national, non-END noise legislation, which is considered greatly beneficial as it uses solid noise limits that are obligatory and widely enforced by public authorities with strong success rates. By contrast, Hungarian END transpositions assume a softer, target value-based approach and therefore serve as complementary instruments to identify and manage the most significant noise hot spots and noise sources though strategic noise mapping and action planning.

Responses from Ireland and Latvia say that the **actual planning and development** of noise measures has an impact on implementation, since it results in real, tangible noise solutions such as noise barriers, low-noise pavements, and realignments of noise-related support schemes.

Main obstacles to enforceability

A broad variety of reasons for the failure of implementation have been identified during the consultation with public authorities. The main obstacles to the enforcement of noise abatement measures, which the stakeholders explained, are presented in the table below. These main obstacles are financial limitations, lack of competency, complexities of public administration, unawareness or neglect of noise policies in governments and among stakeholders, lack of information on health impact per situation, noise-specific limitations, increasing urbanisation, shared responsibility between multiple authorities, lack of compliance and checks of compliance, lack of coherence among legislations, and land-use planning circumstances.

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Table 4.5: Main obstacles to enforceability of noise policies and measures[178]

Obstacle	Description
Financial limitations	The majority of stakeholders (Austria, Bulgaria, Hungary, Lithuania, and Luxembourg, Romania, Slovakia) agree that a lack of funding and/or of different funding sources are a main obstacle to enforceability. This is strongly related to the cost of noise measures, which is why sometimes the cheapest (yet ineffective) measures are selected. In addition to funding as such, countries such as Austria and Finland also highlight that the economic situation plays a role in the enforceability of noise measures. Overall, financial limitations have been identified as the most frequently mentioned obstacle.
Lack of competency	Several responses (Ireland, Lithuania, Romania) point towards the lack of noise-related expertise among stakeholders that are responsible for the implementation of noise abatement measures. Specifically, a response from Ireland highlights that very few representatives of local authorities have competencies related to noise. Related to this issue may be the lack of application of adequate methodological tools: not all solutions are well quantified by the prediction methods in use, e.g. vehicle emissions (electric cars, motorcycles), tyres, smooth tracks and others.
Competency and initiative in public administration	Complex administrative procedures can, in some cases, inhibit the successful implementation of noise reduction measures, as a response from Luxembourg points out. This also relates to unclear competencies in terms of control and sanctions in the public sector. Delays in the implementation of noise-related legislation may also be associated with procedural matters regarding authorisation from different levels of government (noise maps are approved by the national/federal level). As explained in the section on drivers of a successful implementation, awareness about noise issues among administration staff can tackle this issue.
Lack of human resources	Issues with the implementation of noise legislation can also arise from lack of human resources in public administrations and department organisation. For instance, Wallonia (Belgium) has a new office that now oversees road, rail, and airport noise together with a staff of 9-11 people. The lack of human resources and administrative organisation is particularly affecting small states compared to large states such as France of Germany, as they have more human resources and administrative capacities.
Political priorities	Respecting and supporting noise policies is also the political choice of regional governments which need to balance different pressuring financial priorities for funding initiatives (it is relevant also for post-COVID-19 economic recovery in the same way that it was relevant for the 2008 financial crisis).
Unawareness or neglect of noise policies in governments and among stakeholders	Notably, stakeholders from countries such as Belgium and the Czech Republic indicated that lack of awareness or initiatives regarding noise abatement are another obstacle. This issue may be connected to political priorities or a lack of circulation of relevant information among public authorities and implementers.
Lack of information on health impact per situation	Connected to the above issue of lack of awareness may be the lack of information on the health impact of noise, such as specific circumstances in agglomerations, near airports, roads, or railway lines in each Member State. Impacts may vary depending on these circumstances.
Noise-specific limitations	Strict noise limit values can be major obstacles as they are difficult to enforce and comply with. This relates strongly to issues regarding inadequate normative frameworks, difficulties of systematic checks of adherence to limit-values, and inadequate addressing of non-compliance cases.

[178] Source: data collected by the author in the course of the study

	Another major obstacle, as mentioned by a Romanian response, is a potential lack of correlations between limits for the indicators Lden (60dB) and Lnight (50dB) with the specific infrastructure and building situations in Member States.
Increasing urbanisation	Member States such as Estonia and Finland have mentioned that growing urbanisation can pose obstacles for the successful enforcement of noise measures. The increased use of cars and rising traffic may make it difficult to meet noise limit targets and target values. To tackle this problem, Tallinn city has favoured the use of public transportation and cycling. A lack of space in cities can also be an obstacle due to potential spatial restrictions in urban planning and construction or the high population density, which leads to a high number of people affected.
Shared responsibility between multiple authorities	Another main obstacle is that the implementation of noise measures and noise policies can be a shared responsibility of multiple authorities. A lack of adequate communication and coordination can be a key issue here. Furthermore, an Estonian authority mentioned that conflicts of interest between urban planners and health officials can also create significant obstacles.
Lack of compliance and checks of compliance	Mentioned by several countries (Greece, Luxembourg, Slovakia) are issues regarding compliance with noise policies and control thereof. An insufficient obligation for implementation and a lack of systematic or appropriate checks of compliance are specifically cited. In some cases, this incompliance may stem from a lack of available noise monitoring tools. For instance, the Prefecture of Eastern Attica in Greece, where environmental auditors that must measure the noise produced by Athens International Airport work, does not have monitoring machines with which they can measure aircraft noise. Therefore, noise monitoring has not been carried out since 2004. This issue may be connected to the obstacle of financial limitations.
Lack of coherence among legislations	Legislation that is not harmonised in a coherent way to support noise policies can be considered another obstacle. Lithuania, for instance, reported that the Law on Noise Management, Law on Roads, Law on Territorial Planning, Law on Special Land Use Terms, and Law on Construction should be well harmonised. Road protection zones, as defined in the Law on Roads and described in the Law on Special Land Use Terms should also have significance or function as one of the noise-preventive (planning) measures.
Land-use planning circumstances	Land-use planning and construction that was carried out in the past makes it difficult to completely restructure and rebuild areas of land or even specific constructions such as low noise barriers. Entire communities around airports, for instance, are difficult to relocate. Furthermore, community structures may only change slowly over time. Finally, mobility restrictions caused by previously done land-use planning can cause issues for implementation of noise policies in practical terms.

Non-legislative noise solutions and instruments

As presented above, other non-legislative policy instruments play an important role in the effective implementation of noise policy, especially at the local level. This is particularly relevant for agglomerations, which have often developed a great variety of planning, including urban planning, documents. The relevance of these non-legislative initiatives was also confirmed by the interviewed stakeholders. In Belgium, for example, financial support is provided for housing insulation around the vicinity of four airports. Another example is Austria, where initiatives include service instructions and agreements between regional authorities on noise abatement measures of railway lines. Similar co-operations also exist between associations of infrastructure operators. Estonia also recommends to its local authorities the drafting of noise maps and actions plans, for areas that may not be within the scope of the END. In Lithuania, the public road administration authority shares its guidelines on the implementation of noise mitigation measures.

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Analysis of the NAPs and supplementing interviews have identified that using non-legislative tools as complementary elements to NAPs helps facilitate the efficiency of noise mitigation efforts. For instance, in the Czech Republic, noise issues are included in spatial planning plans and programmes, while in Latvia, noise management is part of spatial planning and development. In Estonia, agglomerations integrate their noise maps within their general agglomerations plans. This confirms what had been seen in the analysis of Tallinn agglomeration's noise action plan, where several development and urban planning tools had been mentioned and considered. In Finland, noise is always considered in land-use planning and environmental and building permits. In the case of Ireland, it was highlighted that Dublin City Council and Limerick City Council had developed a strong practice connecting noise solutions and policy with other planning instruments. In Limerick, the Council seeks to implement a national policy objective[179] referring to the management of noise and prevention of exposure to undesirable noise levels in new developments, by ensuring that noise assessments are carried out in the planning of these developments. The principles of good acoustic design are then applied, following a guidance document[180], ensuring that predicted noise levels (inside and outside) are within the WHO recommendations. An Acoustic Design Statement is then carried out. Finally, in Slovakia, noise is taken into account when new infrastructure investments are prepared.

However, usually, these plans or other non-legislative instruments pre-date the NAPs and the noise policy objectives. Therefore, they were not necessarily drafted by taking noise into consideration, but when preparing the NAP, these measures are seen as potentially having an impact on the noise situation of the given agglomeration. However, their measures are merely taken or mentioned in the NAP. In some Member States, such as Hungary, although the development strategies are not noise driven, their measures can be mentioned in the NAPs of agglomerations. In Luxembourg, this is also true regarding mobility, which given the size of the country is the key policy issue Therefore, often during the development of mobility strategies noise pollution is examined. However, it does not act as decision criteria. However, some of the stakeholders stressed that further linkages between other instruments (strategic documents and plans) and noise planning should be strengthened. It is argued that the convergence between various plans and alignment between their objectives could improve the delivery of their objectives.

Overall, the instruments of infrastructure and building planning procedures and permits were implemented in Member States via regulations[181]. In most cases, the infrastructure and building permits were said to be effective or relatively effective in their implementation and in fostering noise abatement.

Planning was highlighted by stakeholders as one of the most effective instruments, overall. Others emphasised that political culture, political will and the level of expertise of local authorities were a key success factor. Some areas for improvement were highlighted, such as a lack of land-use planning rules and detailed legislation in some of the Member States. It was also emphasised that the assessment of noise levels was rarely applied, and noise exposure not always considered in some countries.

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[179] National Policy Objective 65

[180] Professional Practice Guidance on Planning & Noise: New Residential Developments" (2017) (ProPG)

[181] Spatial planning and development, environmental impact assessment and environmental management, planning systems and acts, construction and infrastructure, urban legislation

European level initiatives to foster noise abatement measures implementation

Overall, stakeholders evaluated the END positively and perceived it as a key driving force of national noise-related policies. However, to achieve the ultimate objective of reducing noise induced health burdens by at least 20%, stakeholders put forth **proposals** for the revision of the END to foster harmonised noise abatement implementation across the EU. Firstly, non-binding thresholds for NAPs stemming from the END are too weak and an inclusion of **noise limit values** should be considered. This would greatly support the efficient implementation noise abatement measures. Secondly, it was pointed out that the scope of the END could be further broadened to include smaller airports than the current range. Thirdly, the END revision should also include an **update** of several **definitions**, such as agglomerations.

Furthermore, according to the stakeholders, a better implementation of the END and noise abatement solution could be supported by developing **common guidelines** and methodologies at the EU level. Among others, the commonly developed guidelines could foster the harmonisation of the NAPs development, implementation and evaluation across the EU. Such guidelines could include elements on specific goals of these planning documents, the drafting and monitoring practices (evaluation of implemented measures). In addition, the scope of the guidelines could also include common methodologies for designation of quiet areas, insulation schemes around airports, or measuring the implementation of actions. In addition, some stakeholders also indicated the need for guidelines on the cost-benefits analysis of noise abatement measures.

Also, the study has shown that there is a lack of **shared knowledge** of good practices among the key stakeholders. According to multiple exchanges during the interviews and workshops, it was highlighted that the mapping, identification and exchange of best practices have a significant potential to effectively foster the implementation of NAPs and the noise abatement measures. Thus, the process of developing and implementing NAPs could be improved by ensuring a common understanding of best practices among Member States. Stakeholders also indicated that the **time** between noise mapping and planning can be too short. Overall, the NAPs and the implementation of the aforementioned planning documents across various policy fields could be better aligned. This would improve effectiveness of the planning processes, and perhaps decrease the potential administrative burden. Coordinated planning could foster better implementation and help achieve better results in noise abatement.

Finally, most of stakeholders indicated that the **availability of funding** from the resources dedicated to the reduction of the noise pollution level could effectively foster the implementation of noise solutions. Current legislative and non-legislative instruments, relevant within the context of this study, have been further analysed in Chapter 8, with the aim of identifying points of potential improvement in order to achieve an at least 20% reduction of health burden associated with transport noise.

4.4 Intervention logic

The intervention logic aims to present the rationale for the intervention, clearly demonstrating the problems that the intervention plans to solve and by what actions. The intervention logic represents the causal relationship between the needs, objectives and inputs that drives the action of intervention and results in a form of desired outputs, results and impacts. Based on the first interim results of the project, the initial intervention scheme prepared at the proposal stage has been readjusted. For the purpose of comparison, an initial baseline intervention logic is presented in the figure below, while its revised version can be found on the subsequent page. The graph is not an illustration of the functioning of the END but rather presents an amalgamation of the relevant EU- and national level noise policies.

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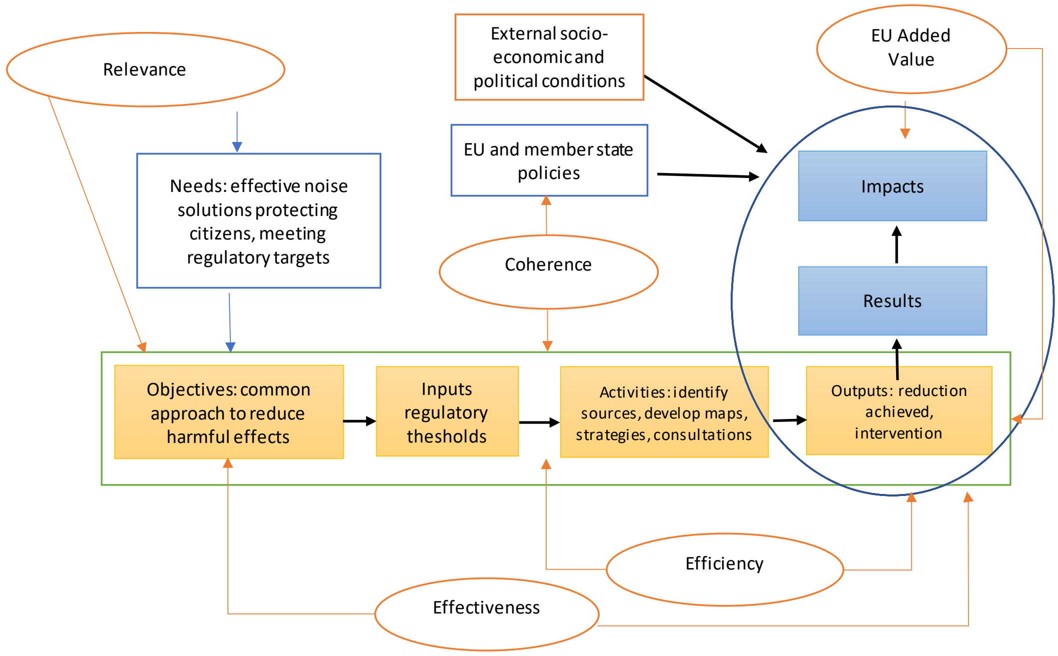
Figure 4.7 Baseline intervention logic



As shown above, relevant policies identify the need for introducing effective noise solutions to protect citizens from unhealthy levels of noise exposure. Their overarching objective is to reduce harmful effects by using a variety of measures. Inputs to the measures are the regulatory drivers such as the noise exposure limits or thresholds as well as source limit directives. A wide range of activities are implemented to comply with the regulatory inputs and meet the objectives including physical interventions, restrictions, limitations at the source, interventions at the receiver, education and communication. Outputs are defined as the interventions completed, such as, for instance, flight restrictions, retrofitting of wagons or quieter pavements.

Results under this baseline scenario are the noise reductions achieved and the improved public health outcomes realised. Corresponding impacts could, in theory, include wider public health improvements, increased number of sustainable transport-related innovative solutions, increased public awareness of noise induced health impacts and wide-scale sustainable urban development concepts. During the assessment, however, we found relatively limited evidence of such impacts partly because socio-economic trends (including urbanisation and transport innovation) can change faster than regulatory mechanisms and noise solution impacts. Consequently, the delineation of noise solution measures can be difficult especially when considering changes in external socio-economic conditions including housing crises or population increase.

The revised intervention logic, presented below, shows how an improved regulatory environment could facilitate the delivery of reduced noise-induced health burden. The updated graph builds on the inefficiencies of the current EU and Member State-level regulatory environment, which stem from:

- Indicative EU-level noise values;
- Discrepancies between Member States' regulatory requirements related to minimum noise levels;
- Absence of harmonised EU-level requirement for evaluating the efficiency of previous noise solutions/action plans;

- Underestimation of fast-growing socio-economic trends such as urbanisation, transport innovation and increasing connectivity within territories; and
- Differences between Member States in the availability of financial and human resources allocated for the implementation of noise solution measures.

Additionally, there are differences in the approaches that Member States developed for tackling noise pollution (e.g. a combined approach in agglomerations versus transport-specific approaches), which may be explained by regional specificities and governance. Finally, the revised intervention logic draws linkages with the structured causal framework DESPEEA that was discussed above (4.2). The scheme shows how an understanding of the Driving forces-Pressures-State-Exposure-Effect-Action can provide background information, which helps to identify the needs, objectives and inputs of actions to be defined under this intervention logic. In turn, the actions developed in this intervention aim to reduce the main issues identified in the DEPSEEA. While some actions will aim to reduce driving forces and pressures leading to the exposures, other actions are state-based, exposure-based or effect-based.

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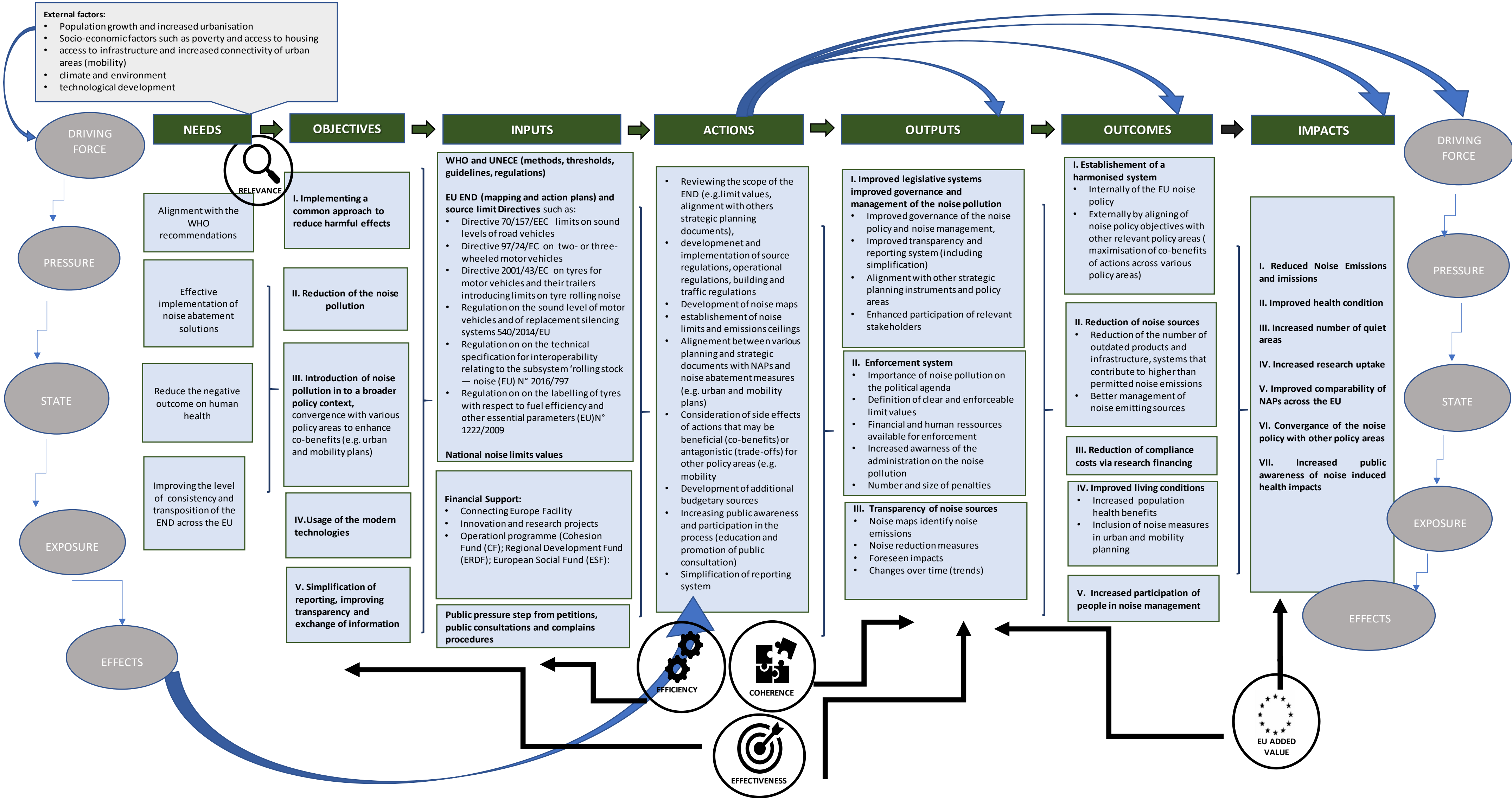
Figure 4.8 Revised intervention logic



The revised intervention logic presents more defined needs and objectives for reducing noise pollution and relates it to the health burden. These needs and objectives can be met by a more effective implementation of a common approach to noise reduction, which also takes socio-economic characteristics into account (e.g. population growth and increased urbanisation, share of low-income households, increasing connectivity in densely populated urban areas and transport innovation). Therefore, the **needs** indicated in the revised intervention logic are further disaggregated to sub-objectives, which aim to reduce noise pollution across the EU and connect it to the health burden. Consequently, the **objectives** in the revised intervention logic reflect a more holistic approach and focus not only on the reduction of noise pollution but on elements such as the usage of modern technologies, improvement of transparency and exchange of information as well as the alignment of noise policy in a broader legislative context to enhance possible co-benefits across various policy areas. This set of parallel objectives would help better achieve the primary goal of a reduced health burden caused by noise.

Corresponding **inputs** that aim to achieve these changes comprise a wide variety of tools covering international, EU and national legislation; the financial resources needed to achieve objectives (budgetary as well as human resources); and public pressure which can be perceived as a driver for change. As the study demonstrated, the availability of financial resources plays an important role in the effective implementation of noise abatement measures. Thus, the revised intervention logic emphasises those supporting measures which can further enhance the application of the relevant regulatory frameworks, such as financial assistance or stakeholder involvement. Consequently, the **actions**, which are formulated using the relevant inputs to meet the predefined objectives, include: 1) reviewing the scope of the END; 2) development and implementation of operational regulations at EU Member State-level (e.g. relevant building and traffic regulations as well as urban planning and architectural measures); 3) development of noise maps; 4) establishment of noise limits; 5) alignment of various planning and strategic documents with NAPs; 6) consideration of noise policy impacts for other policy areas; 7) development of additional budgetary sources; 8) development of inclusive and active public consultations; and 9) improving reporting obligations.

Thus, the identified **outputs** are clustered around three main categories: (i) improved legislative systems which improve governance mechanisms and the management of noise pollution; (ii) enforcement of implementation to carry out the identified action at the national level, enhanced by the availability of necessary financial and human resources and the development of restrictive measures in case of non-compliance with the requirements (sanctions and penalties); and (iii) transparency of noise sources and reduction of noise levels over time (monitoring of change over time, including estimation of impacts). Overall, the output and results of this intervention scheme are defined by the efficiency of the implementations of noise abatement solutions. The overall impacts refer to the primary objective of the intervention of reducing the health burden.

The expected **outcomes** of the intervention scheme are centred around five main categories which align with the established **objectives**: (i) establishment of a harmonised system, which would lead to (ii) reduction of noise sources achieved by (iii) decreasing compliance costs via research financing, which implies (iv) better living conditions of the population affected. Ultimately, the outcomes would result in increased and active participation of people in noise management, which in turn could be a vector of pressure and change.

The corresponding **impacts** could include reduced noise emissions, wider public health improvements, increased research uptake, increased comparability of noise-related data across the EU, the convergence of noise policy with other policy areas and higher public awareness of noise-induced health impacts.

Finally, it is currently unclear whether individual measures can reduce the health burden of noise exposure by 20-50%. However, the revised intervention logic emphasises an effective implementation that relies on a combination of measures including compliance with relevant EU and

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national policies as well as innovation and collaboration. Coherence between EU and Member State policies including those on thresholds and noise emission limits are essential for achieving cohesion between noise abatement measures in the Member States. Moreover, increased coherence between noise policy and other various policy areas to enhance co-benefits (e.g. urban and mobility plans) should be explored to facilitate a more effective implementation of noise abatement measures. A presentation of effective implementation is provided in the following chapters which summarise good practices identified in the analysis of the action plans. These findings were cross-checked and validated with stakeholders during the November 2020 workshop and the last interview round carried out from December 2020 to January 2021.

4.5 Preliminary list of solutions and best practices from NAPs

This section provides list of recommended solutions and best practices, based on the results from the analyses of NAPs and stakeholder consultations. These preliminary lists of solutions and best practices may serve as baseline for future policy decisions. Table 4.3 presents a list of recommended solutions, while Table 4.4 offers a selection of noise action plans and analyses that are worth examining since they are good examples of comprehensive, insightful plans.

Table 4.6 List of solutions and best practices

Sector	Solution	Examples	Notes
Road	Speed limits	Croatia Split-Dalmatia County	The NAP suggests the control of vehicles speed limits as a measure for noise reduction. The presence of speed cameras and the cooperation with police on vehicles speed surveillance should contribute to more careful driving on roads.
	Quiet pavement	Netherlands National Roads	Through the NAP, it is apparent that the Netherlands makes an effort to communicate the benefits of quiet pavement, pointing to different types of quiet asphalt and the noise reduction potential in dB.
	Use of traffic lights	Seville roads	Optimisation of traffic lights control, applying short cycles so that the speed of passage through crossings is moderated.
	Research on cost-effectiveness of solutions	Austria National Roads	Austria is conducting an infrastructure research project to optimise noise barriers by developing a method to find the best solution for noise barrier planning regarding costs and effectiveness. In this project, the wall geometry based on the wall costs, the exceeding of limit value, and secondary conditions are optimised. The mathematical formula is based on the established Austrian Regulations and standards for road and railway noise abatement projects. The functioning is demonstrated with concrete examples.
	Noise barriers	Torino-Alessandria-Piacenza (Italy)	The Road section A21 Torino-Alessandria Piacenza connects three Italian regions as part of the highway Torino to Brescia. The road crosses 53 municipalities. The neighbouring area is protected by the installation of noise barriers, which are considered the most efficient noise reduction measure,.
	Replacement of traditional with 'quiet' asphalt	Highway Fiori A10 Savona-Ventimiglia-French Border	NAP for A-class highway road suggests that the replacement of traditional pavements with sound-absorbing pavements is the best noise reduction measure for eliminating noise from source.
	Early stages of planning	Sweden National Roads	Prevention of noise using four-step planning principles: (1) influence transport needs and the

			choice of transport; (2) better use of existing roads; (3) limited use in some circumstances; and (4) new investment and developments.
	Expansion of cycling network	Austria, Salzburg regional roads	Salzburg province cycling network investment programme 2006-2015 (continuation of 2002-2005 programme) to encourage use of bicycles.
	Optimising freight traffic	Austria, Carinthia regional roads	The plan includes two potential solutions: 1) freight exchanges to avoid empty runs/trips of vehicles and 2) a modal shift from road to rail for unavoidable freight traffic.
Rail	Noise barriers & embankments	Latvia Major Railways	Regarding the planning of the measures and outlining them in the NAP, Latvia has integrated detailed information on the exact extent of measures to be implemented (in metres) and their costs as well as the expected decrease in the percentage of residents affected by the noise, thereby ensuring transparency.
	Noise barriers composed of different materials and height	Croatia National Rail	The first Croatian national railway NAP mentions that noise barriers are the most frequently used noise solution. They can be composed of different materials and height depending on local characteristics.
	Monitoring	Basque country rail (Spain)	The Basque country rail NAP (Spain) provides in-depth data on the evaluation results of the previous round. The measures (preventative noise plan, management plan, system improvement plan, corrective plan, informational and educational plan, modernisation of tracks, lane irrigation, gradual renewal of fleet, modification of track paths, covering/burying of stations) had a significant impact and reduced the number of people exposed to noise above the limits by 25%. The Basque country's future estimations also indicate a reduction of noise-affected people in Zamudio, for instance, from 7.33% to 0.75%.
	Ensuring that noise mitigation measures are expanded through predictive assessment	Netherlands National Rail	The Netherlands clearly maps out by how many kilometres of railway tracks, rail dampers, and noise barriers are planned and as a percentage of the total. Furthermore, it states the ratio of quiet rolling stock by 2020. According to the assessment, the Netherlands forecasts to have 95% quiet freight wagons by 2025. The typical noise reduction levels (in dB) of these measures is also considered and included in the NAP.
	Path interventions (maintenance and optimisation)	Prague	Line reconstruction and optimisation of identified noise 'hotspots' (e.g. Prague - Podbaba and Úvaly; Prague - Beroun line, i.e. including Černošice). The maintenance of the railway line, its modernisation, and the acceleration of the fundamental modernisation of the rolling stock are often the most effective anti-noise measures.
	Website database and the public consultation on noise	Sacconago – Malpensa (Italy)	FERROVIENORD maintains an online database that records feedback from citizens on present and past noise mitigation measures. Hence, the evaluation of past noise interventions and the planning of new interventions are also considered from a 'real-life' perspective throughout the period between NAPs reporting.
	Railway noise reduction manuals	Sweden National Railway	Noise reduction measures include all stages of community planning, infrastructure planning, safeguards and noise at source measures. The approaches and the proposed

			measures together must lead to a 'target image' summarised as "A society with a good sound environment without disturbing vibrations".
	Lane irrigation	Basque country rail	Reduction of noise pollution through lane irrigation. Water sprinklers were installed by the railway stations to reduce noise in densely populated areas.
	Track access pricing scheme	Germany national rail	Track access charges for freight wagons in Germany include a bonus-malus system depending on noise due to the braking system. The quieter K-block or LL-block braked wagons are given a bonus, whereas the noisier cast-iron block braked wagons are given a malus.
	Noise-dependent infrastructure use charge/ Track access pricing scheme	Austria national rail	Similar to the German track access pricing model, Austria implements a price bonus for quiet freight trains or louder trains using quiet routes (no malus is applied, unlike in the German scheme). The initiative was started in 2017.[182]
	Track access pricing scheme	Czech Republic	The Czech Republic also implements a track access pricing scheme for noise abatement.
	Systematic noise abatement initiative for public and freight transport	Austria national rail	2020/21 'Quiet tracks' initiative for public and cargo rail transport to systematically replace all loud brakes in freight trains, use quiet train types, and grind tracks[183].
	(Financial) noise partnerships	Denmark national rail	Noise partnerships, which are financial partnerships between public and private owners of buildings/property, that allow the involved parties to jointly pay and carry out a project that can reduce the noise nuisance from railways. The noise partnerships give the affected citizens the direct opportunity to co-determine how noise reduction occurs.
Aviation	Noise protection screen	Sofia Airport	Sofia Airport is the only airport in the south-eastern Europe that has installed noise protection screen for the aircraft engine testing platform. It is providing noise abatement reduction around 15dB(A)-17 dB(A).
	Good cooperation between airport stakeholders and urban planning measures	Dublin Airport	Dublin Airport NAP for the second noise reporting round was the part of the Dublin Agglomeration NAP while for the third noise reporting round it represents the separate NAP. The Dublin Airport is located in Fingal County, which is responsible for drafting the noise action plan. The continuity of involvement of local authority on noise action plan ensures synchrony with urban planning measures that should anticipate potential clash with noise contours.
	The use of technology	Helsinki Vantaa Airport	The WebTrak is a public internet application provided by Finavia that allows authorities, residents and other interested parties to give feedback and monitor aircraft routes and noise levels using a system based on radar data.
	Cost-effectiveness	Milano Malpensa Airport	The NAP mentions the cost of noise solution and the number of impacted population.
	Financial support scheme to noise insulation of buildings	Paris-Charles de Gaulle, Adolfo Suarez Madrid-Barajas, Frankfurt Airport	These schemes include the compensation/financial support for noise insulation in buildings in high-noise zones. For noise from Frankfurt Airport, access to supportive loans for noise-affected residents to purchase housing outside of noise zones within the federal country of Hessen has been granted.

[182] https://www.laerminfo.at/laermschutz/vermeidung/Laermabhaengiges-Trassenentgelt.html

[183] https://konzern.oebb.at/de/leise-gleise; https://konzern.oebb.at/de/leise-gleise/massnahmen/laermschutz-fahrzeuge-gv

	Framework/institution for dialogue with local communities	Paris-Charles de Gaulle, Adolfo Suarez Madrid-Barajas	Paris Charles de Gaulle Airport has several structures, including committees and a house of the environment for the local communities to access information. For Madrid-Barajas, information is available online for local communities, and the airport has a technical working group on noise and environmental monitoring committees, as well as a committee for the establishment of the noise measures and the action plan.
	Urban-architectural measures	Prague Ruzyně Airport	The main principles of the measure can be applied within the framework of spatial planning: (1) noise protection zone; (2) monitoring changes in airport operations; and (3) urban planning with noise cancelling measures.
	Projects to strengthen collaboration with residents and stakeholders	Schwechat, Vienna Airport	For the public consultation stage of the NAP, the forum *Verein Dialogforum Flughafen Wien-Schwechat*, which mediates public participation and opinion, was established. Furthermore, a noise protection office (*Lärmschutzbüro*) was also set up for citizens to obtain information and consultation. Finally, the webpage www.laerminfo.at offered citizens and residents the opportunity to not only submit their opinions but also access information on environmental noise (website is still updated in 2020).
		Tegel, Berlin Airport	As part of the NAP for the agglomeration of Berlin, the public consultation for Tegel Airport included various interest groups and associations, a public forum (*Forum Lärmminerungsplanung*), and a public internet platform under the motto: *Berlin wird leiser – aktiv gegen Verkehrslärm* (Berlin is becoming quieter – active against traffic noise).
	Long-term noise measures	Stockholm Arlanda Airport	The long-term measure goals and the most cost-efficient noise solutions are the 'measures at source' (e.g. aircraft, operation procedures, etc.)
	Research projects to investigate impact of noise on health	Frankfurt Airport	In the context of the NAP for Frankfurt Airport, the noise effect and perception study NORAH (Noise-Related Annoyance, Cognitions, and Health) was conducted.
Agglomeration	Urban transport	Copenhagen	Copenhagen has an ambition to become the best cycling city, with a third of all urban traffic and transport being by bicycle. The bicycle projects consist of extending bicycle paths and networks across the city.
	Planning process	Dublin	The planning system is preventing noise situations thanks to the introduction of certain restrictions. The Irish experience offers 'best practices' manuals such as that on the 'multi-function' uses of a street, 'Urban Design Manual and the Design Manual for Urban Road and Streets 2013'.
	Planning process	Limerick	The measures for preventing the construction of new residential areas nearby major roads in Limerick County are contained in the manual, 'Professional Practice Guidance on Planning and Noise: New Residential Developments – ProPG'.
	Monitoring programme	Lisbon	The NAP presents a monitoring programme, as well as the literature and material used to design it and monitoring periods.
	Coordination with existing plans	Lisbon	The measures planned in the Lisbon NAP are presented alongside those included in local urban plans or mobility plans, in order to take into account

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			what is already being implemented and could have an impact on noise.
	Sound plan	Bordeaux Metropole	In the Bordeaux NAP, the continuing measures are listed in the noise plan, while the new measures are presented in a sound plan, focusing on improving the sound quality in the Metropole.
	Electrification of train tracks	Grenoble	The section of the Sillon Alpin train that crosses the city of Grenoble was modernised and became electric.
	Support scheme for the insulation (acoustic and thermic) of buildings	Grenoble, Paris	In Grenoble, the MurMur scheme supports sound and thermic insulation. In Paris, several initiatives for insulation since the 2000s are mentioned in the NAP.
	Promoting car sharing in the agglomeration	Grenoble, Paris	Grenoble and Paris have car-sharing services: CitéLib in Grenoble and AutoLib in Paris.
	Low urban noise walls	Nice Côte d'Azur Metropole	Nice Côte d'Azur Metropole is experimenting and evaluating the impacts of low urban noise walls of a metre high and constructed using different materials (concrete, metal and plexiglass). The aim is to improve the quality of sound atmosphere.
	Green neighbourhoods	Paris	The NAP lists 36 green neighbourhoods benefitting from low traffic and low-speed limits.
	Vehicle procurement criteria	Helsinki	Noise pollution is one of the criteria in the city's public procurement for vehicles. The city is increasing the share of hybrid and electric buses.
	Education and communication	Milan	Activities in schools and with pupils for the International Noise Awareness Day (in five years around 1000 pupils from Milan participated in the initiative).
		Bordeaux Metropole	The NAP provides several educational and awareness raising measures, related to quiet areas and awareness on noise. There are as well measures on the promotion of sound heritage.
	Noise abatement intervention priorities	Oulu	The priority for noise abatement interventions are people exposed to noise levels above 65dB during the day or above 60dB at night.
	Transport-organisational measures	Prague	Restricting the access of heavy vehicles in urban roads by shifting their routes towards major roads/highway, as well as introducing fees/tolls for access to urban roads.
	School programmes	Barcelona, Bilbao	Both cities mention the Agenda 21 school programme on sustainability in their list of measures.
	Closing traffic lanes on weekends and public holidays	Paris	This scheme is part of the Paris Breathe programme that tackles air pollution but is also beneficial for noise pollution-related challenges.
	Acoustic oasis and quiet itineraries in neighbourhoods	Vitoria-Gasteiz	The city has a greenbelt, while the NAP highlights a focus on the implementation of acoustic oases in neighbourhoods.
	Acoustic road surfaces	Paris	The acoustic road surfaces have been applied to selected sections of the ring.
	Noise radars	Nice Côte d'Azur Metropole	The Metropole is experimenting with noise radars.
	Collaboration with national and regional stakeholders to develop and promote NAPs	Vienna	The implementing municipal authority MA22 involved the company running most of Vienna's public transit network, Wiener Linien, the chairmen of Vienna's 23 districts, residents and members of the public, transport companies, NGOs, and the Chamber of Labour Vienna (*Arbeiterkammer Wien*) in 2012 and

			2013, organising consultations, workshops, and planning and coordination talks.
		Berlin	A public forum (‘*Forum Lärmminerungsplanung*’) was implemented, in which the individual stages of the NAP process were presented and discussed. Various interest groups participated (ADAC – General German Automobile Club, ADFC – German Cyclist’s Association, *Fuhrgewerbeinnung* – Association for road haulage, *Handwerkskammer* – Chamber of crafts, IHK – chamber of commerce and industry, real estate industry, health insurances, fractions of the house of parliament, various environmental associations) A public internet platform under the motto ‘*Berlin wird leiser – aktiv gegen Verkehrslärm*’ (Berlin is becoming quieter – active against traffic noise) was opened early on in process in 2013. This public platform was prepared, promoted and facilitated by press activity, post cards, posters, a press conference, a public speech, social media engagement and public events.
	Completion rate	Nice Côte d’Azur	The NAP provides detailed information on the implementation of the previous NAP, including implemented measures and non-implemented ones, with a completion rate of 90%.

Additionally, it is worth mentioning the importance of public consultations, which have been carried out to different degrees in the Member States reviewed. Two good examples of public consultations, which have gone beyond standard procedures, were found in Austria, Germany and Ireland. Austria offered local citizens the opportunity to participate in dialogue events with responsible railway noise committees in 2013, in addition to the national six-week consultation. Germany’s 2013 public consultation included a questionnaire with multiple-choice questions to make it easier for the public to provide answers. The consultation was carried out in two phases that received a total of 20,795 contributions from the public. The second phase was just 16% of the first phase participation. However, the overall participation was higher than in many other Member States where participation rates tend to be generally low. In Ireland the national rail NAP is available for public consultation even though the noise measures are decided by responsible counties. The public engagement offers a possibility for input from public institutions, responsible counties and citizens.

Table 4.7 Good examples of noise action plans and their analyses

Country	Sector	Location & Details	Notes
Austria	Road	National	This NAP includes a discussion on carrying out research projects to investigate noise reduction measures and to optimise cost effectiveness.
	Aviation	Schwechat, Vienna Airport	This NAP detailed information on noise measures, noise limits, and the actions taken to ensure public engagement.
	Agglomeration	Vienna	This NAP provides a detailed account of the public consultation, which involved a variety of different stakeholders.
Belgium	Rail	Flanders	This NAP provides information on expected results and information on which organisation provides budget for the measures.

Country	Sector	Location & Details	Notes
Croatia	Rail	National	The NAP mentions the costs of measures for short-, medium- and long-term plan. The proposed noise reduction measures should ensure the optimal cost-benefit ratio.
	Road	Split-Dalmatia County	The NAP is proposing innovative solutions in the local context. For example, it envisages the use of 'quiet' asphalt even though the NAP states that Croatia does not yet have roads with 'quiet' asphalt. Furthermore, the NAP also includes in noise action 'insulation measures' even though there are no laws in Croatia obliging the implementation of 'passive' noise measures in critical noise situations.
Czechia	Agglomeration	Prague	The NAP covers an overview on measures on urban road, urban rail and airports on the territory of the Prague agglomeration.
	Airport	Prague Ruzyně Airport	The NAP gives an estimated cost effectiveness assessment and an overview of past and present noise solutions.
	Rail	Prague	Prague is an important national and European railway junction that connects three railway corridors. The railway line covers mainly passenger transport. The railway operator is targeting measures at source, as it does not see benefits from 'passive' noise measures that belong to private and public buildings owners according to the Czech law.
Denmark	Agglomeration	Copenhagen	The NAP is very detailed and ambitious including noise targets and future forecasts on noise reduction. It offers detailed explanations on past and present noise abatement measures as well as the socio-economic costs from noise.
	Aviation	Copenhagen Kastrup Airport	The NAP states the most common sources of aircraft noise (take-offs and landings), but it does not list short- and long-term noise mitigation measures due to the reassessment of national noise framework (2013). This example shows how NAPs depend on national noise strategies.
Germany	Aviation	Frankfurt Airport	Compared to the NAPs for Berlin Tegel Airport and Cologne Airport, which are integrated into the NAPs for their respective agglomerations, a separate NAP was created for Frankfurt Airport. While this NAP may not be as

Country	Sector	Location & Details	Notes
			comprehensive as others in this list, it provides detailed information on noise solutions, noise limits and public consultations.
	Rail	National	This NAP provides very detailed information about the various noise abatement efforts and projects, the budgets and the public consultation. The structure and content of both the 2013 and the 2018 NAP are cohesive, displaying clear, continuous action. Additionally, the NAP (like all German NAPs) have well-established national noise limits, based on the type of building or area where the noise occurs.
Estonia	Agglomeration	Tallinn	The NAP provides a very comprehensive overview of the implemented and planned measures, as well as modelling of noise solutions and responsible authorities for each of the measures.
Finland	Agglomeration	Helsinki	The NAP offers a detailed overview of past and present noise situation and solution measures. It also gives a good example of public consultation along with high number of engaged stakeholders and received NAP opinions.
	Agglomeration	Oulu	The NAP contains between road measures related to 'highway' and 'urban' traffic noise, according to the prioritisation of intervention, with the higher noise levels having precedence.
	Airport	Helsinki Vantaa Airport	The NAP is one of the best practices' examples covering in details noise reduction solutions in different circumstances. It offers also forward-looking perspective on noise situation 10 years later (2025).
France	Agglomeration	Grenoble (2014)	This NAP is very detailed and provides some uncommon measures, as well as good practices. It also assesses expected and proven impacts of the measures implemented.
	Agglomeration	Paris	The NAP highlights past actions carried out and new measures planned. The new measures are a continuation of what has been done since the 2000s. The NAP also aims to coordinate urban planning and sustainability requirements with the reduction of noise levels.
	Agglomeration	Bordeaux Metropole	The NAP is very detailed and provides an overarching and integrated vision on noise and public policy. More than a noise plan, it contains a sound plan. It stresses how public services can improve their activities in terms of noise.
	Agglomeration	Nice Côte d'Azur Metropole	The NAP is very detailed about the planned and already implemented

Country	Sector	Location & Details	Notes
			measures. It also provides a completion rate of the previous NAP.
	Aviation	Paris-Charles de Gaulle Airport	The NAP gives a detailed outline of the past and current measures implemented. Strengths include a support scheme for the insulation of buildings and a good communication system with local communities.
Ireland	Road	Cork County	This NAP includes information on dB reduction per noise measure.
	Agglomeration	Dublin	The NAP offers a comprehensive overview on noise situation in the whole territory of the Dublin agglomeration, which covers four counties (Dublin City Council, Dún Laoghaire - Rathdown County Council, Fingal County Council and South Dublin County Council), roads, rail and Dublin Airport.
	Agglomeration	Limerick	The NAP focuses only on road traffic noise, as the agglomeration does not cover any airport of rail routes. The NAP is an excellent example of noise prevention measures that includes both urban and infrastructural planning with noise consideration, as well as the technological upgrade of noise monitoring tools and investing in noise specialists within the county administration.
	Airport	Dublin Airport	Both NAPs from the second and third round illustrate good evaluation approach. The results will include 'before and after' evaluations of any noise mitigation measures. The evaluation of NAP will take place in the fifth year and include the measures that continue from the previous period, if needed.
	Rail	National	The NAP mentions major railway lines with the Dublin agglomeration covering 83% of all railway lines. However, the NAP does not mention concrete noise measures as these measures are present in specific NAPs. However, national NAP is available for comments from the public consultations.
Italy	Agglomeration	Milan	The agglomeration covers the area of municipality of Milan that includes the numbers of people exposed to noise from road, rail and airport (Milano Linate). In the noise solution part, the NAP mentions only road-related solutions. The Italian law on noise limits makes a distinction between noise emission and emission limits in six zone categories (protected, residential, mix, intensive human activity, industrial and exclusive industrial zones).

Country	Sector	Location & Details	Notes
	Aviation	Milano Malpensa Airport	The NAP gives a good overview of noise reduction measures, costs of intervention and the size of the beneficiary population.
	Rail	Sacconago-Malpensa	The NAP explains noise measures on non-high speed rail line (below 200km/h) where the noise from engines and inside carriages (e.g. air-conditioning, ventilation system, traction motors and other auxiliary equipment) is more disturbing than rolling stock noise. However, the NAP gives priority to active noise interventions (i.e. wheel, tracks) compared to "passive" measures (acoustic barriers, relocation of residents).
	Road	Torino-Alessandria-Piacenza	The NAP gives a good example of the evaluation of noise measures in relation to (1) the number of people exposed to environmental noise in 2013, (2) expected results following new measures in 2017 and (3) expected efficiency (increase or decrease of people exposed to environmental noise.).
	Road	Savona-Ventimiglia-French Border	NAP is mentioning effective measures for the noise reduction from highways. Those measures are noise barriers and the replacement of traditional pavements with sound-absorbing pavements.
Latvia	Rail	National	This NAP contains detailed information on the costs, extent, and noise reduction levels of the measures. Like all Latvian NAPs, this indicates clear national noise limits, based on the type of building or area where the noise occurs.
Lithuania	Rail	National	This NAP contains a long, clear list of measures which were considered (and not selected) and which were eventually selected. The NAP also distinguishes between currently planned measures and long-term strategies. Additionally, the NAP contains a long list indicating the types of measure (e.g. noise barrier), location of where measure will be implemented, length of measure (in km), area of measure (in square metres). Finally, the NAP indicates in detail the number of people who will benefit from the measures.
Netherlands	Rail	National	This NAP contains comprehensive information on noise solutions, the extent/amount of the noise measures, and the budget for the NAP measures.
	Agglomeration	Utrecht	This NAP and its analysis complement the interview with the representatives of the city of Utrecht from April 14, 2020.

Country	Sector	Location & Details	Notes
Portugal	Agglomeration	Lisbon	The Lisbon NAP provides expected results, as well as common measures with other plans (urban plans, local plans, etc). it also provides a very detailed cost-benefits analysis.
Spain	Agglomeration	Vitoria-Gasteiz	One strength of this NAP is the focus on quiet areas and urban oases. The agglomeration also has a greenbelt.
	Agglomeration	Bilbao (2014 and 2019)	Both NAPs provide evaluation elements and indicators for some of the measures, as well as a comparison of noise exposure.
	Agglomeration	Barcelona	The NAP provides good information on the quiet areas, and on the priority levels of each measure.
	Rail	Autonomous community of Valencia	The NAP is very complete, and provides details of the measures, the costs, cost-benefits, exposure and evaluation of the NAP.
	Road	Seville	The NAP provides a very comprehensive explanation of the methodology followed for the selection and prioritisation of areas for action. Detailed information on costs is also provided.
Sweden	Road, Railway and Airport	National	The National NAP from the Swedish Transport Administration gives national level overview on noise 'hotspots' and measures for major roads, railways and airport. The 2018 railway NAP also contains a section on the health impacts of noise, one of only few a NAPs to do so.

4.6 Conclusions

Based on the overall analysis of the different NAPs and stakeholder consultations, the following conclusions and recommendations can be drawn:

- NAPs are relatively descriptive and comprehensive, providing information on the planned measures, the results from the noise mapping, public consultations and other data. Most of them have both a strategic and operational focus.
- Some NAPs also mention a long-term strategy or a cooperation with mobility planning and sustainability considerations. For instance, noise considerations must be taken into account in urban planning or paired with sustainability and climate actions. The latter would be, for example, insulation of dwellings both for noise and thermic reasons.
- **Some NAPs provide reduction targets in terms of people exposed** to high noise levels, and therefore provide goals for the given timeline. However, most NAPs analysed lack such targets, along with evaluation data for the current NAPs. Data on the evaluation of previous NAPs was provided in an uneven way across NAPs.
- Innovative measures are observed in some NAPs, but the majority keep to common solutions.
- Countries that have developed comprehensive NAPs include Austria, France, the Netherlands and Spain, as indicated in the table above.

Furthermore, stakeholder interviews demonstrated that the adoption and implementation of noise abatement measures is a complicated issue. The complexity of noise management relates to the fact that the topic lies at the crossroads of different policy areas (environment, health, transport, urban planning, road safety, construction and product life cycle etc.) and its efficient management requires a broad coordination of policies at the national, local, regional and EU level. Stakeholders believe that it may be possible to reach END targets by combining noise action plans with air quality plans, road safety measures as well as, broadly speaking, urban planning in the agglomerations. It seems that when measures are taken in other sectorial areas (e.g. air quality, urban planning, green city, traffic safety etc.) their adoption could also mutually benefit noise abatement measures. Given increasing urbanisation, urban planning has a growing effect on the volume of traffic, vehicles distribution, traffic condition and consequently on the noise pollution. A better understanding of the relationship between noise pollution and urban planning would leverage the prevention of noise measures.

Furthermore, stakeholders mentioned that the methodology of noise monitoring could be improved by using other indicators than Lden, such as those that focus on noise events, their frequency and intensity. Using sensors capable of identifying the responsible noise source was also proposed. Hence, the abovementioned reasons for intra- and inter-agency cooperation, especially at the city level, should be further considered. This cooperation could also resolve some of the budgetary challenges that the implementation of noise measures is currently facing. Some stakeholders mentioned that urban areas do not have a sufficient, dedicated budget for adopting relevant noise abatement measures. In their view, linking noise measures with other city-related projects could help secure additional funding for implementing relevant actions. However, further cooperation between different sectoral areas also requires awareness-raising among the representatives of the relevant department at the national, regional and local level.

Harmonisation and synthetisation of NAPs

The research, NAPs analysis, and stakeholder consultations show that there is no overarching common approach to the creation of NAPs between Member States. While some NAPs are very detailed and comprehensive, others lack important data. The section on the limitations of the research above outlined commonalities among the NAPs. However, it can be concluded overall that the countries approach the developments of NAPs differently, focusing on different priorities. Therefore, it is important to highlight that the creation of NAPs should be more harmonised and synthesised to provide better guidance to Member States.

Monitoring of NAP implementation

The stakeholder interviews offered the insight that there is a lack of control over the implementation of NAPs. They feared that a lack of mandatory rules and obligations to implement the NAPs would hamper the achievement of noise reduction and mitigation goals. Assessing the implementation rate of previous NAPs could not be carried out as the information was lacking in the NAPs.

Common guidelines and good practices

Furthermore, insight gained from the research shows that there is a lack of shared knowledge of best practices. For agglomerations, the share of good practices happens through European organisations (Eurocities, etc). Stakeholders also indicated a lack of common guidelines to NAP drafting, as well as for evaluating previous measures. Thus, the process of developing and implementing NAPs could be improved by ensuring a common understanding of best practices among Member States.

5 Calculation methodology

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5.1 Introduction

This chapter describes the methodology for assessing health benefits of noise abatement solutions and scenarios at EU level. The methodology is based on a causal-chain approach for health-impact assessment. The causal chain starts from the noise sources:

- Road traffic
- Rail traffic
- Aircraft traffic

It ends with the negative health effects of people in the EU exposed to noise. The health effects are expressed in three ways: i) numbers of people affected; ii) healthy life years lost; and iii) monetised health effects in euros.

Health benefits of noise abatement solutions are derived as the differences between results calculated for two scenarios:

- A baseline scenario
- A scenario with one or more noise abatement solutions

The methodology includes a cost-benefit analysis, which compares the costs of noise solutions with the health benefits expressed in euros. The focus is on the period 2020-2035.

Test-site calculations are used to validate the methodology. Various types of test sites are considered, with different noise solutions such as noise barriers and rerouting traffic.

The outline of the chapter is as follows.

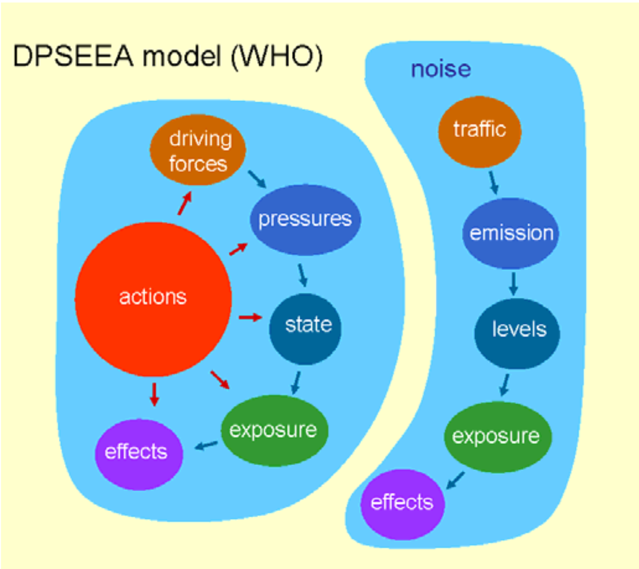
- Section 5.2: general description of the methodology
- Section 5.3: noise exposure distributions
- Section 5.4: noise source models
- Section 5.5: noise abatement solutions
- Section 5.6: health burden and costs of noise
- Section 5.7: costs of noise solutions
- Section 5.8: cost-benefit analysis and appraisal period
- Section 5.9: test-site calculations
- Section 5.10: methodological elements specific for road traffic noise
- Section 5.11: methodological elements specific for railway noise
- Section 5.12: methodological elements specific for aircraft noise
- Section 5.13: uncertainty and limitations of the methodology
- Section 5.14: exposure-response functions

5.2 General methodology

The methodology is based on the DPSEEA approach for environmental health impact assessment, recommended by WHO[184,185,186]. Here DPSEEA stands for Driving forces – Pressures – State – Exposure – Effects – Actions, as illustrated in Figure 5.1. The figure also indicates the various elements for the case of traffic noise:

traffic – emission – levels – exposure – effects.

Figure 5.1. The DPSEEA approach for health impact assessment, in general (left) and for traffic noise (right).



In Table 5.1 the DPSEEA chain (or causal chain) for road traffic noise is illustrated in more detail. The impact assessment starts with the specification of the relevant traffic parameters (top of right column in the table). Next the sound emission of the vehicles on the roads is calculated. Then the noise map is calculated, i.e. the noise levels in the environment. Then the exposure distribution is determined: numbers of people exposed to different average noise levels (this is explained in more detail below). Finally, the health effects are calculated from the exposure distribution, expressed in three ways:

i) Numbers of people with the following negative health effects:
   - annoyance
   - sleep disturbance
   - myocardial infarction
ii) Healthy life years lost (DALYs)
iii) Monetised health effects in euros

184 http://www.integrated-assessment.eu/eu/guidebook/dpseea_framework.html

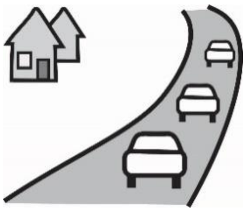
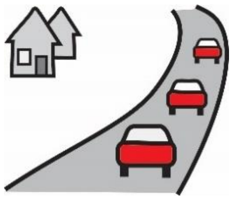
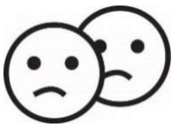
185 D. van den Hout, E. Salomons, H. Polinder, S. Janssen, Jamie Graham, V. Máca, E. Kuusisto, "Integrated Environmental Health Impact Assessment for noise due to urban road traffic", Deliverable D 7.1.9 of the Heimtsa project, 11 March 2011.

186 E. Salomons, D. van den Hout, S. Janssen, U. Kugler, V. Máca, "Method for predicting future developments of traffic noise in urban areas in Europe", proceedings Internoise 2010, Lisbon, Portugal.

For annoyance, both numbers of *annoyed* persons and numbers of *highly annoyed* persons are considered. For sleep disturbance, both numbers of *sleep-disturbed* persons and numbers of *highly sleep-disturbed* persons are considered. See Section 5.6 for details.

The methodology is illustrated here for road traffic noise but can also be applied to railway noise and aircraft noise. Elements that are specific for road, rail and air transport will be described later in this chapter.

Table 5.1. Illustration of the DPSEEA chain for impact assessment of road traffic noise.

traffic		- road network - traffic volumes - driving speeds - vehicle types
emission		sound emission of vehicles - propulsion noise (engine) - rolling noise (tyres and road)
levels		sound propagation (noise map calculation) - buildings - noise barriers
exposure		numbers of people exposed to noise levels
effects		annoyance, sleep disturbance, myocardial infarction healthy life years lost monetised health effects in euros

The noise methodology used here deviates from the ideal DPSEEA approach in the representation of noise exposure. Rather than using the 'true' noise exposure of people moving along their daily trajectories in their houses and outside[187], noise levels at the façades of the dwellings are used as approximations:

façade level = approximation for 'true' noise exposure

This approximation is commonly used in impact assessment studies of environmental noise – for example, in the EU project Heimtsa[185,186].

Noise is a very local phenomenon and requires detailed data on the noise sources and the infrastructure. Consequently, calculations of traffic noise maps are very complex. A single calculation model[188] for the noise levels (façade levels) in the complete EU does not exist. Fortunately use can be made of noise maps and noise exposure distributions of EU Member States, collected by the EEA[189] in the framework of END noise mapping.

END exposure distribution = approximation for 'true' exposure distribution

The END exposure distributions represent the year 2017. These are used as a starting point for extrapolation to the appraisal period 2020-2035 of this study. In this way there is no need for an explicit upscaling of local results to EU level.

Upscaling to EU level is performed implicitly by the use of END exposure distributions for the whole EU.

Table 5.2 illustrates the methodology for calculating health effects for a baseline scenario and an *alternative scenario*, i.e. a scenario with one or more noise solutions. The baseline scenario takes into account autonomous developments of traffic, cities, and population in the period 2020-2035. The alternative scenario also considers the effect of noise solutions. Examples of noise solutions are quiet vehicles (such as electric vehicles), speed limitation, and quiet road surfaces.

As described above, the END exposure distributions of 2017 are used as a starting point. Noise level changes are calculated for the period 2017-2035 and these changes are applied to the 2017 exposure distributions. This is illustrated by the following examples for road traffic.

- For the baseline scenario, the noise levels gradually change due to various effects:
    - Autonomous traffic growth (typically 1% per year for road traffic),
    - Gradual change of vehicle fleet with increasing numbers of hybrid and electric vehicles.
- For the alternative scenario, additional noise level reductions may be achieved by various noise solutions:
    - Noise emission solutions (quieter vehicles, quiet road surfaces),
    - Other types of solutions.

[187] It is virtually impossible to determine the 'true' noise exposure of people. This would require not only the complete sound level history as a function of time of the day for a person, but also the application of some kind of 'context filter', to account for the fact that the effects of noise depend on the context. Noise may be more annoying when you are reading a book in a park than when you are walking in a busy shopping street, for example.

[188] In this context a calculation model is a set of digital data that represents the real world, with noise levels calculated from input data for the environment (buildings, roads, etc) and the noise sources (traffic).

[189] "Noise observation and information service for Europe", see http://noise.eea.europa.eu/

In addition to noise solutions, reception limits are also considered as a possible element of a scenario. A reception limit may be a *driver* for noise solutions.

The case of a noise emission solution is useful for explaining the methodology. For example, if all vehicles became 5dB quieter (this is a hypothetical situation), then all noise levels on the noise map would decrease by 5dB. The level change of 5dB is applied to the 2017 exposure distribution, which results in a changed exposure distribution for the years after which the solution has been implemented. This is illustrated in Figure 5.2.

From the exposure distributions, the health effects (expressed in three ways, see Table 5.1) are calculated for the two scenarios. Finally, the difference between the effects for the two scenarios is equal to the health benefit for the noise solution.

health benefit = health effects for baseline scenario - health effects for alternative scenario

Thus, a positive value for the health benefit represents an *improvement*. i.e. a situation where health effects (annoyance, sleep disturbance, myocardial infarction, DALYs, Euros) are lower for the alternative scenario than for the baseline scenario.

Figure 5.2. Illustration of the effect of an emission reduction on the reference exposure distribution (2017).

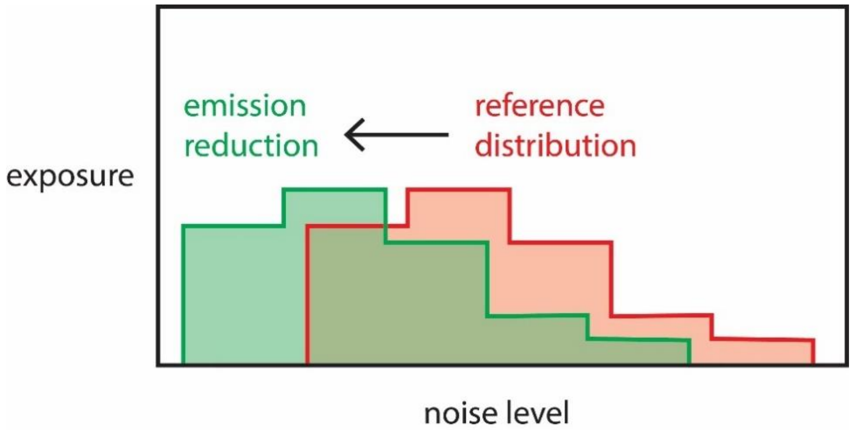
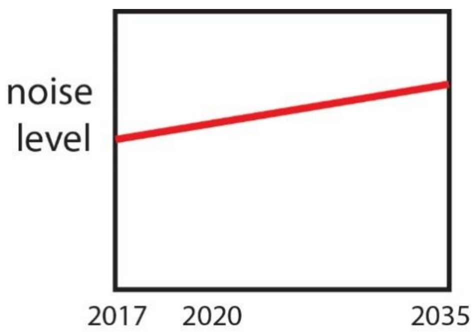
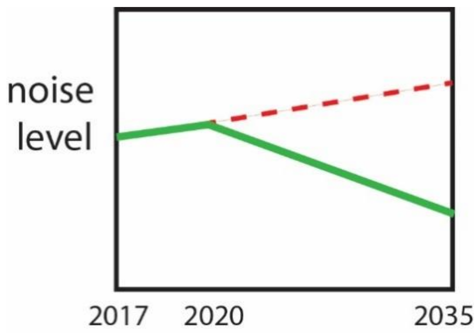
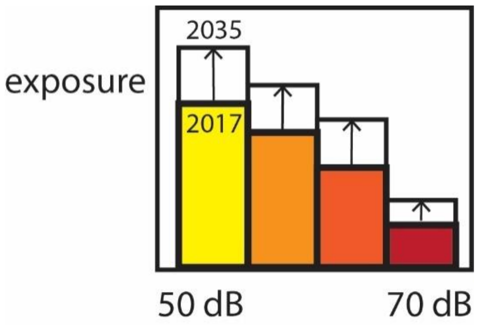
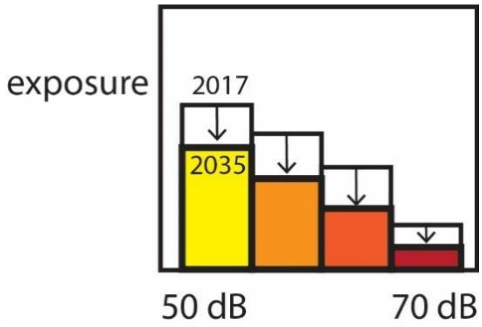
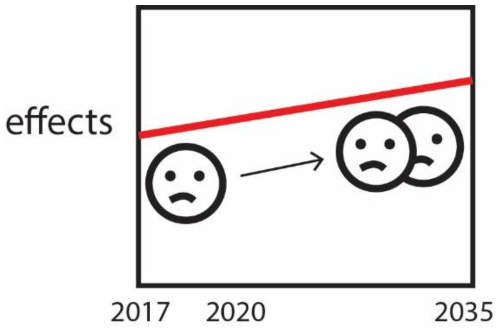
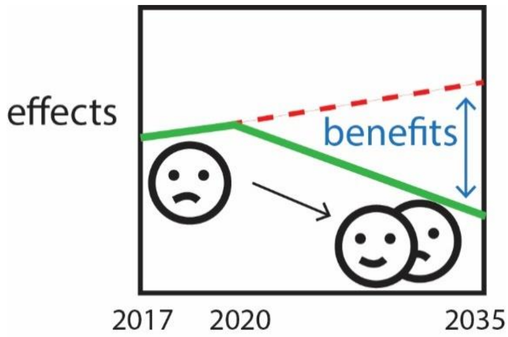


Table 5.2. Illustration of methodology for calculating health effects for a baseline scenario and an alternative scenario. The difference between the two is equal to the health benefits.

<table>
<tr><th></th><th>baseline scenario</th><th>alternative scenario</th></tr>
<tr><td>traffic
emission
levels</td><td>
</td><td>
</td></tr>
<tr><td>exposure</td><td>
</td><td>
</td></tr>
<tr><td>effects</td><td>
</td><td>
</td></tr>
</table>

5.3 Noise exposure distributions

As described in Section 5.2, the END exposure distributions of façade levels play a central role in the methodology. The END exposure distributions are calculated by EU Member States according to the methods and rules described in the END[190]. The EEA has collected the distributions on a website[189].

The END distributions are calculated separately for road traffic noise, railway noise, and aircraft noise. A distinction is made between noise exposure in urban agglomerations and noise exposure outside agglomerations. As described in Section 5.2, the noise exposure of a person is represented by the façade level at the dwelling of the person (at the most-exposed façade, ignoring the façade reflection). The façade level is also used in exposure-response relations:

- The day-evening-night level L_{den} for annoyance
- the night level L_{night} for sleep disturbance

Therefore, the END prescribes that exposure distributions must be calculated both for L_{den} and for L_{night}. The distributions are illustrated schematically in Figure 5.3. The values of L_{den} and L_{night} are given in 5 dB intervals. The heights of the five bars in a distribution represent either absolute numbers of people or percentages of people exposed to the five level intervals (this is explained further below). The distributions depend on many parameters, such as traffic parameters, road network, population density, infrastructure and topography. The calculated exposure distributions are subject to uncertainties due to uncertainties in the input parameters. In addition, there are uncertainties due to model limitations and approximations. It should be noted that different (national) noise models have been used for calculating the distributions for the various EU Member States.

Figure 5.3. Schematic illustrations of END exposure distributions with L_{den} (top) and L_{night} (bottom).

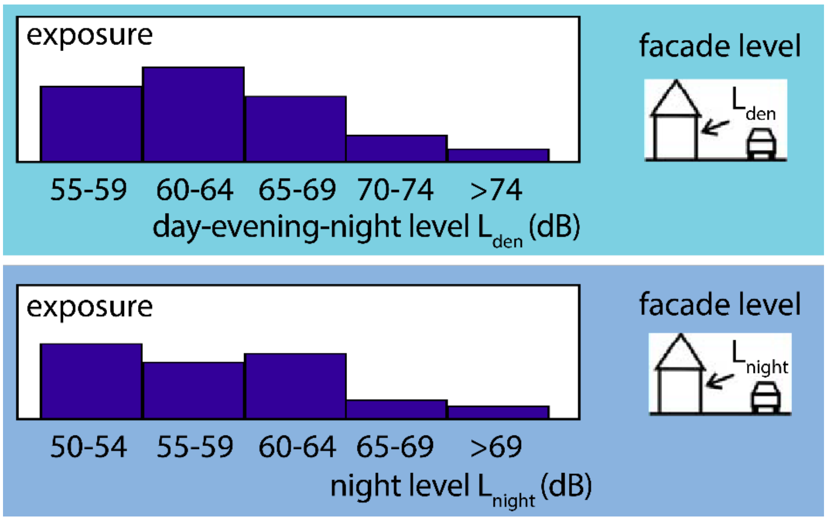


Figure 5.4 shows EU average exposure distributions for road traffic noise in urban agglomerations, derived from the END data for 2017[189]. The END data is not complete, as data from many agglomerations was not reported. Data from 229 agglomerations was used here, with a total population of 84 million. The exposure in Figure 5.4 is expressed as a percentage of the total

[190] "Environmental Noise Directive" 2002/49/EC, 25 June 2002.

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population. The total EU urban population is around 334 million (excluding UK), so four times higher than the agglomerations total. By expressing the exposure as a percentage, the distributions in Figure 5.4 can be used also for the EU.

Summing over the 5 dB intervals in Figure 5.4 yields a total exposure with L_{den} ≥ 55 dB of 44.8%. For the population of 84 million this corresponds to 37.7 million. For the population of 334 million in EU urban areas this corresponds to about 150 million. This linear extrapolation to the total urban EU population is an approximation. It is assumed that the END data, which is based on cities with inhabitants of 100,000 and higher, also applies approximately to cities below 100,000.

Figure 5.5 shows EU summed exposure distributions for major roads outside agglomerations, derived from the END data for 2017. In this case the exposure is expressed not as percentages, but as the absolute number of persons exposed in millions. The data for major roads is assumed to be more complete than the data for agglomerations. The total road length represented by the data is about 350,000 km, as follows from the data on the EEA website.

The 2017 exposure distributions in Figure 5.4 and Figure 5.5 are compared with distributions from previous END noise mapping rounds in 2012 and 2007 in

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Figure 5.6 and Figure 5.7, respectively. The observed differences between the three years may be partly ‘real’ differences, and partly due to uncertainties in the calculations. The fact that the differences are relatively small suggests that the uncertainties are relatively small.

Figure 5.4. EU average exposure distributions for road traffic noise in agglomerations, based on the END data for 2017.

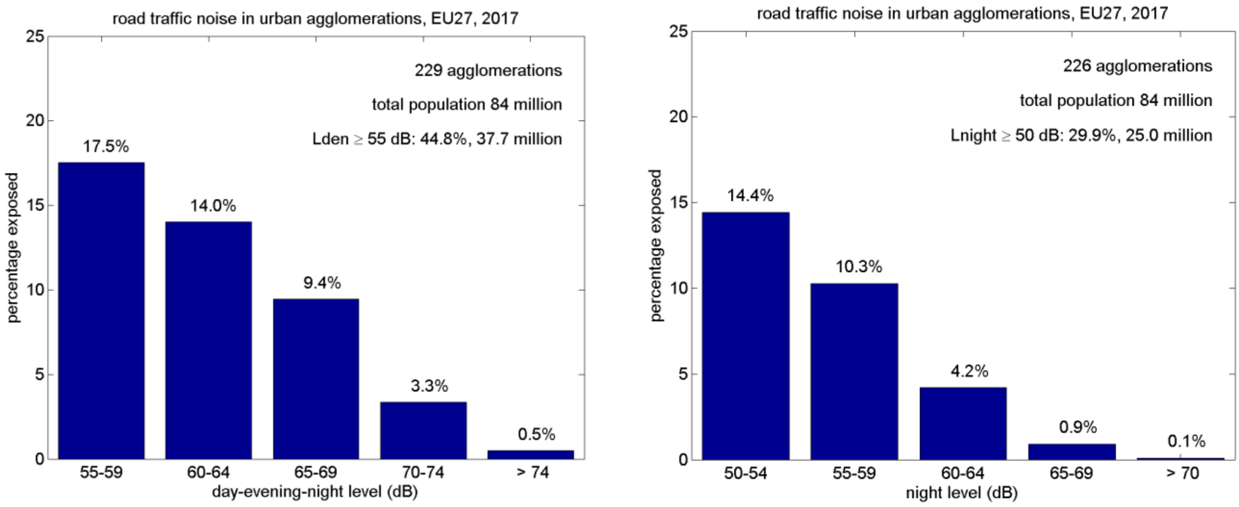
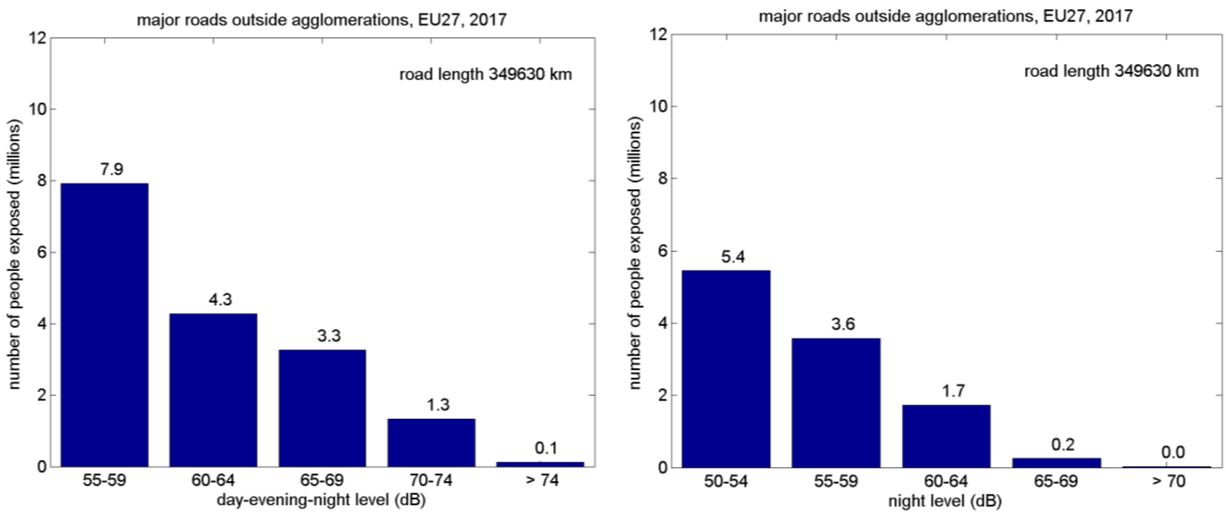


Figure 5.5. EU summed exposure distributions for noise from major roads outside agglomerations, based on the END data for 2017.



Extrapolation below the END exposure limits

For the application of the health impact assessment methods described in Section 5.6, the exposure distributions were extrapolated to include two 5 dB intervals below the END exposure limits of 55 dB L_{den} and 50 dB L_{night}[185,186,191,192]. For road traffic noise in urban areas, the extrapolation approach developed in the project Heimtsa[185,186] is used here:

$$P_1 = 1/3\ P_{rem},\ P_2 = 2/3\ P_{rem},\ \text{with}\ P_{rem} = 100 - (P_3+P_4+P_5+P_6+P_7). \qquad (1)$$

Here P_j is the percentage exposure of interval j (j=1-7), where j=3-7 correspond to the original distribution with five intervals. This is an approximation. The form of the exposure distribution depends on the precise layout of buildings and roads in a city[193]. For major roads outside urban areas, the following approximation is used:

$$N_1 = N_3 + 2\ \Delta N,\ N_2 = N_3 + \Delta N,\ \text{with}\ \Delta N = \max(0, N_3 - N_4). \qquad (2)$$

Here N_j is the absolute exposure (in millions) of interval j (j=1-7), where j=3-7 correspond to the original distribution with five intervals. The approach (2) is also used for railway noise, both inside and outside urban agglomerations. Again, this is an approximation. For example, the propagation of railway noise into a city depends on the precise urban layout. In contrast to urban road traffic noise, not all dwellings in a city are exposed to urban railway noise, so extrapolation approach (2) is more appropriate for urban railway noise.

The above extrapolation schemes could in principle be optimised by means of extensive noise mapping calculations. However, noise models are less reliable for low exposure levels, for example because the prediction of noise levels in shielded urban areas such as courtyards depend on multiple reflections in street canyons. Optimisation of the extrapolation schemes was beyond the scope of the present study.

[191] "Methodological guidance for estimating the burden of disease from environmental noise", World Health Organization 2012.

[192] "Implications of environmental noise on health and wellbeing in Europe", Eionet report – ETC/ACM 2018/10.

[193] E.M. Salomons and M. Berghauser Pont, "Urban traffic noise and the relation to urban density, form, and traffic elasticity." Landscape and Urban Planning 108 (2012) 2-16.

It should also be noted that the extrapolation below the END exposure limits is particularly important for absolute health impact assessment, since a part of the health burden is caused by exposure below the limits. For the present study, however, the effect of the extrapolation is much smaller, as this study focuses on *changes* in the health burden.

For aircraft noise, the extrapolation was based on the results of a previous study performed by Anotec[194],, covering the vast majority of the EU airports falling under the END directive.:

$$N_1 = a\, N_{sum},\ N_2 = b\, N_{sum},,\ \text{with}\ N_{sum} = N_3+N_4+N_5+N_6+N_7 \qquad (3)$$

Here the coefficients are a=3.2 and b=1.8 for L_{den} and a=4.6 and b=2.0 for L_{night}.

The exposure distributions for the year 2017, including the values extrapolated as described above, are given in the two tables below. It should be noted that the extrapolated values have a high uncertainty. This is not a problem since this study focuses on *changes* in the noise health burden. The absolute health burden depends also on the exposure below the END limits, but changes in the health burden are less dependent on it.

Table 5.3. EU27 exposure (in millions) as a function of L_{den}, for the year 2017, including extrapolated values below the END limits.

	45-49	50-54	55-59	60-64	65-69	70-74	>75	total
road, urban	61.37	122.75	58.50	46.79	31.53	11.17	1.64	333.75
road, non-urban	15.23	11.58	7.93	4.28	3.27	1.33	0.13	43.74
rail, urban	29.03	21.73	14.42	7.11	3.26	1.02	0.32	76.88
rail, non-urban	9.97	7.50	5.03	2.56	1.26	0.59	0.33	27.25
aircraft	7.809	4.393	1.831	0.512	0.082	0.015	0.000	14.642

Table 5.4. EU27 exposure (in millions) as a function of L_{night}, for the year 2017, including extrapolated values below the END limits.

	40-45	45-49	50-54	55-59	60-64	65-69	70-74	total
road, urban	77.96	155.92	48.17	34.31	14.01	3.05	0.32	333.75
road, non-urban	9.18	7.31	5.45	3.58	1.73	0.25	0.03	27.53
rail, urban	25.00	18.47	11.94	5.41	2.22	0.66	0.18	63.88
rail, non-urban	8.75	6.54	4.33	2.11	1.00	0.47	0.24	23.44
aircraft	4.609	2.004	0.767	0.200	0.031	0.004	0.001	7.616

[194] Anotec report PAN076-2-1 "Noise exposure distribution around European airports – Phase 2 Final report", study performed by Anotec for RIVM, and Health Impact Assessment for Noise in Europe ETC/ACM Technical Paper 2014/9 — Eionet Portal (europa.eu)

Test sites

To validate elements of the methodology, calculation results have been compared with results of detailed noise-mapping calculations for test sites. This is particularly useful for the effects of noise solutions such as noise barriers or rerouting traffic. The role of test sites is described further in Section 5.9.

Detailed noise abatement solutions

In Section 5.2 the general approach was described for calculating the effects of noise abatement solutions. For source emission solutions, such as quieter vehicles, first an average noise level *change* (or reduction) is calculated. Next, the noise level change is applied to the exposure distributions. Finally, the health effects are calculated from the modified exposure distributions.

Some road traffic noise solutions require a detailed consideration of various types of roads in an urban agglomeration. For example, quiet road surfaces are more effective on motorways than on low-speed urban streets. Therefore, use is made of a model for calculating the noise level change that takes into account different road types, based on a model previously developed for the Netherlands[195,196]. The model distinguishes various road types: residential streets, arterial roads, main roads, motorways, with a further distinction between urban and nonurban roads, and also between intermittent or free-flowing traffic. The model allows for a noise solution to be implemented only on some of the different road types. This is described further in Section 5.10.

For railway noise and aircraft noise, similar arguments apply to the detailed modelling of some noise abatement solutions. For railway noise, for example, different types of railway tracks are considered.

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[195] M. Dittrich, F. de Roo, "Beleidsindicator geluid wegverkeer", TNO-report June 2015, TNO 2015 R10673.

[196] M. Dittrich, J. Sliggers, "A policy indicator for road traffic noise emission", Internoise, Hamburg 2016

Figure 5.6. EU average exposure distributions for road traffic noise in agglomerations, based on the END data for 2017, 2012 and 2007.

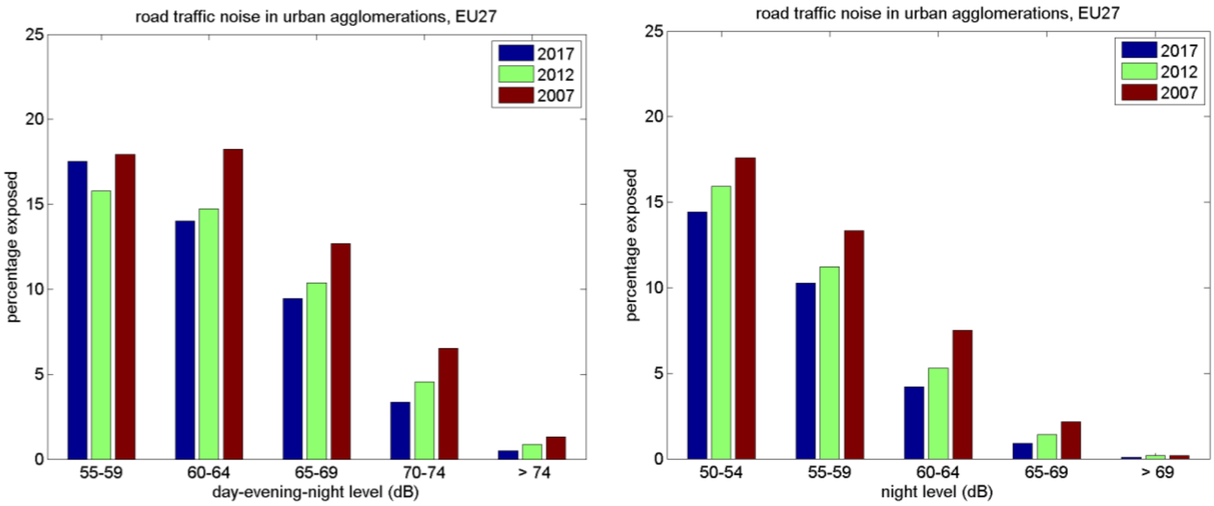
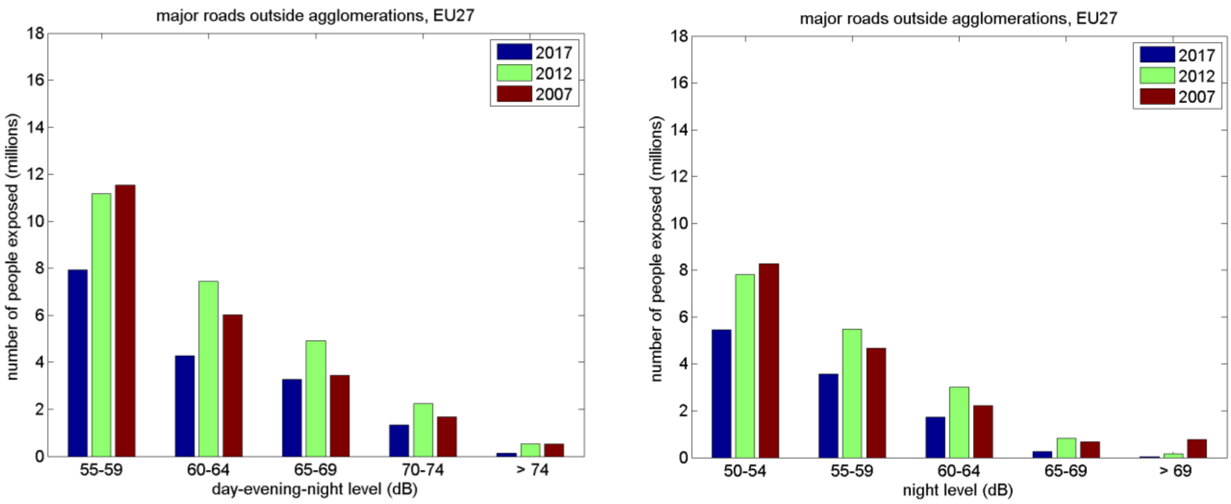


Figure 5.7. EU summed exposure distributions for noise from major roads outside agglomerations, based on the END data for 2017, 2012 and 2007.



5.4 Noise source models

In general, the noise source models used for this analysis should give a proper representation of the noise emission solutions considered. For road traffic noise, for example, a source model is used that takes into account propulsion noise and rolling noise as separate emission contributions, in order to obtain accurate results for noise solutions aimed at engines, tyres, and road surfaces. Such a distinction is often not made in the statutory models used in noise mapping.

The specific noise source models for road traffic, rail traffic, and aircraft traffic are described separately in Sections 5.10-5.12, respectively.

5.5 Noise abatement solutions

Noise abatement solutions are divided into the following four categories.

1) Noise solutions at source.
   - Examples: vehicle, traffic, and source-infrastructure measures, including quiet vehicles, electric vehicles, quiet tyres, and quiet road surfaces.
2) Noise solutions in the propagation path.
   - Example: noise barriers.
3) Noise solutions at receiver.
   - Examples: dwelling insulation, quiet façade.
4) Noise solutions aimed at the infrastructure and spatial urban planning.
   - Examples: rerouting traffic, dwelling relocation.

In addition to these four categories of noise solutions, the methodology also considers the possibility to specify a reception limit (i.e. an upper limit of the L_{den} or L_{night} noise level), as an alternative to the selection of a set of specific noise solutions.

The effect of a reception limit represents the *potential* effect of a set of noise solutions.

Reception limits may be considered as *drivers* for the noise solutions. A reception limit may be the driver for a set of noise solutions that together have the effect that noise levels do not exceed the imposed reception limit. In general, a reception limit may have various effects on the exposure distribution: it may affect only the levels above the limit, or it may have an additional effect on the levels below the limit. In this study it is assumed that only the levels above the limit are affected, and these levels are decreased to the limit level.

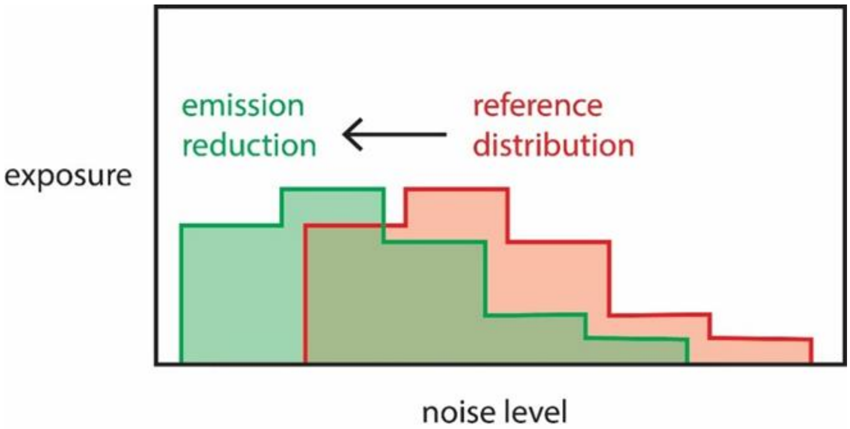
In principle, the effect of a noise solution at source is straightforward. If the emission of a source is reduced by 5 dB, for example, then received sound levels due to this source are all reduced by 5 dB. In practice, however, there are many different sources, such as motorways and urban streets, with different emission reductions. Therefore, the approach is to first calculate a weighted-average emission reduction over all sources, and next apply this reduction to the reference exposure distribution (from 2017 END data)[197].

[197] This approach is also used for calculating the effect of developments in the baseline scenario on the exposure distributions. The developments include annual growth of traffic and population.

The effect of an emission reduction is approximated by shifting the EU reference exposure distribution by a weighted-average emission reduction.

This is illustrated in Figure 5.8.

Figure 5.8. Illustration of the effect of an emission reduction on the exposure distribution.



Noise solutions at receiver require other considerations. Dwelling insulation has no effect on (outside) façade levels but may lead to a reduction of the negative effects of noise. An increase of dwelling insulation may be represented by a decrease of the (outside) façade level, but this decrease is expected to be smaller than the increase of dwelling insulation (in decibels). As an approximation it is assumed that (additional) dwelling insulation has the effect that the inhabitants can be eliminated from the exposure distributions.

A quiet façade allows the inhabitants to have a bedroom at the quiet side of the dwelling, for example. Research has shown that the effect of a quiet façade is approximately equivalent to a reduction of the noise level on the most-exposed façade by 2 dB[198,199].

Noise solutions in the propagation path have effects that depend to a large extent on the actual situation. For example, the effect of a noise barrier depends on the barrier properties and on the positions of the sources and receivers. As a practical approach, an average sound level reduction due to a barrier will be used, which is applied in the methodology in the same way as with source emission reductions.

Noise solutions aimed at the infrastructure and spatial urban planning have effects that depend probably even more on the actual situation. This will be illustrated by test-site calculations of rerouting traffic in urban areas, to get an impression of what can typically be achieved with this solution.

In the scope of this study, only existing and available noise abatement solutions are considered. The reason is that even though innovative solutions may be under development, these generally take several years to come onto the market, obtain approval for general application, and then be sufficiently widely implemented to impact on noise exposure at EU level.

[198] Y. de Kluizenaar, E.M. Salomons, S.A. Janssen, F.J. van Lenthe, H.Vos, H. Zhou, H. Miedema, J.P. Mackenbach, "Urban road traffic noise and annoyance: The effect of a quiet side", J. Acoust. Soc. Am. 130, (2011), 1936.

[199] EC Life+ project QSIDE 2010-2013, "The protection of quiet facades and quiet urban areas", see http://www.qside.se/

In the next chapter, the selected noise solutions are described separately, with their aspects relevant to this study.

5.6 Method for calculating the health burden and costs of noise

As described in Section 5.2, the methodology is based on the DPSEEA approach for health impact assessment of environmental noise. This section describes how the health effects are calculated from the EU exposure distributions. Two different calculation methods are used:

- Method 1, described in a recent handbook on the external costs of transport[200],
- Method 2, developed in the framework of EU project Heimtsa[185,186].

For both methods, the EU exposure distributions with 5 dB intervals are used as input. The distributions are extrapolated below the lower limits of 55 dB L_{den} and 50 dB L_{night}, as described in Section 5.3.

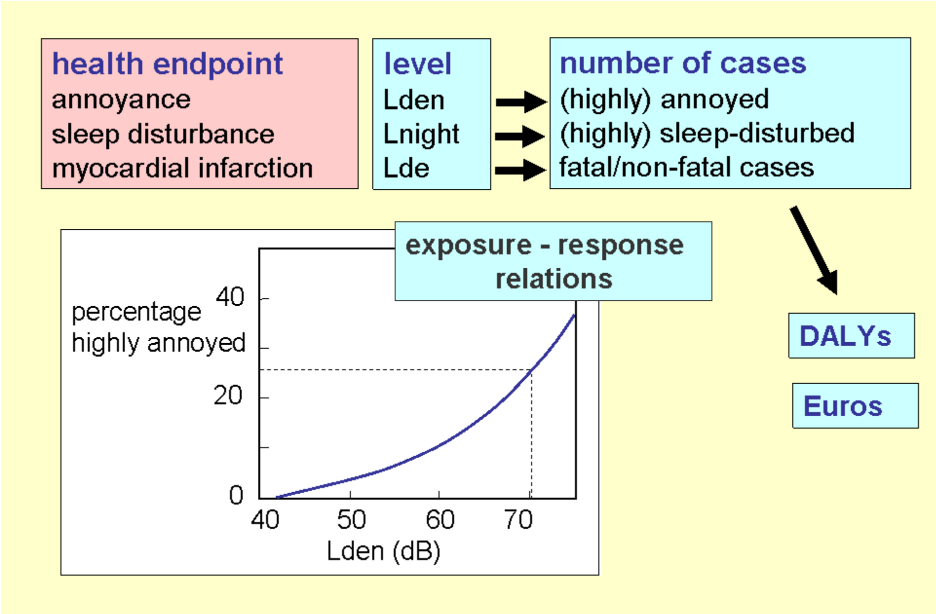
Method 1 yields the total external costs of health effects caused by noise[201], for the three transport modes. Method 2 also yields the total costs, but in addition numbers of affected people are calculated, as well as numbers of healthy life years lost (DALYs). By using both methods, a broader picture of the health burden is provided than with a single method. The costs estimated with method 1 are considerably higher than the costs estimated with method 2, up to a factor of 4 (see Sections 5.10-5.13 and Chapter 7 for details). This difference reflects the fact that noise impact assessments are subject to a large uncertainty (see Section 5.13).

Figure 5.9 presents a simple graphical illustration of method 2. The elements in the figure, such as exposure-response relations, are described in the subsections below.

[200] "Handbook on the external costs of transport", January 2019, report prepared by H. van Essen (CE Delft) et al for the European Commission.

[201] The costs of the health effects of noise (or the "costs of noise") are also referred to as monetized health effects of noise. These should be distinguished from the costs of noise solutions, which are described in the next section.

Figure 5.9. Illustration of method 2 for calculating health effects of noise. The exposure response relation for high annoyance by road traffic noise is shown as an example. Source: Heimtsa report[185].



Effects of noise, exposure-response functions

Long-term exposure to environmental noise causes various negative health effects[202]:

- annoyance,
- sleep disturbance,
- myocardial infarction / cardiovascular disease,
- tinnitus,
- cognitive impairment in children.

In this analysis the focus is on the first three effects: annoyance, sleep disturbance, and myocardial infarction[203], following the approach in EU project Heimtsa[185,186]. The prevalence of these effects is calculated with exposure-response functions (ERFs). For example, there is an ERF for the percentage of annoyed persons in a population as a function of the façade level L_{den}. There is also an ERF for the percentage of highly-annoyed persons[204], which is shown in Figure 5.9. Similar ERFs are available for sleep disturbance, with the noise level L_{night} as exposure level. For myocardial infarction an ERF has been derived that yields the odds ratio[205] for myocardial infarction as a function of exposure level L_{de} or $L_{day,16h}$, which is the equivalent level over the period 7h-23h. The ERFs have been derived from the results of a large number of surveys of the effects of noise[202].

[202] "Burden of disease from environmental noise. Quantification of healthy life years lost in Europe", WHO publication, 2011.

[203] The EU health burden contributions of the three health effects annoyance, sleep disturbance, and myocardial infarction are much larger than the contributions of tinnitus and cognitive impairment in children (EEA 2018).

[204] The category 'highly annoyed' represents all people with annoyance ratings higher than 72 on a rating scale from 0 (not annoyed at all) to 100 (extremely annoyed). The category 'annoyed' represents people with annoyance ratings higher than 50. The categories 'highly sleep-disturbed' and 'sleep-disturbed' are defined analogously.

[205] The odds ratio is a good approximation of the relative risk, from which the percentage of myocardial infarction cases attributable to environmental noise is calculated.

Recently, WHO has published new ERFs for high annoyance and high sleep disturbance[206]. The new ERFs deviate from previous ERFs for railway noise and aircraft noise. The present analysis takes these new ERFs into account in an approximate way; see Section 5.14.

With method 2, the ERFs are used to calculate total numbers of people in the EU with (high) annoyance, (high) sleep disturbance, and myocardial infarction[207]. These numbers are calculated from the EU exposure distributions.

DALYs

With method 2, the health effects are expressed in DALYs[208], or 'healthy life years lost'. The DALYs are calculated from the numbers of people that are highly annoyed, highly sleep disturbed, and people affected by myocardial infarction. A DALY weight of 0.02 is used for 'high annoyance'[209,206] and 0.07 for 'high sleep disturbance'[210,206]. For myocardial infarction, the definition DALY = YLL + YLD is used[207]. Here the number of life years lost, YLL, is equal to the number of fatal cases (25% of the total number) multiplied by the mean number of life years lost per case (8 years). The years lost due to disability, YLD, is equal to the number of non-fatal cases multiplied by the DALY weight of 0.405[211,206].

Monetary valuation

The methodology includes a monetary valuation of the health burden. Ideally the valuation includes all changes in welfare caused by the noise, including for example medical expenses for treatment, lost wages, and a change in life expectancy or premature death. As indicated before, two different methods are used for monetary valuation, method 1 and method 2.

Monetary valuation with method 1

Method 1 is based on a table of values for the costs of environmental noise, reflecting the welfare loss per decibel increase. The values are based on studies reported in the literature and are reproduced here in Table 5.5.

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206 "Environmental Noise Guidelines for the European Region", World Health Organization 2018.

207 For myocardial infarction the same exposure-response function is used for road, rail, and air traffic noise; see discussion by Babisch in 'Environmental Burden of Disease', WHO report 2011, page 31.

208 DALY = Disability Adjusted Life Year

209 A.B. Knol and B.A.M. Staatsen, "Trends in the environmental burden of disease in the Netherlands, 1980 – 2020", RIVM report 500029001, 2005. http://www.rivm.nl/en.

210 "Night noise guidelines for Europe", World Health Organization 2009, http://www.euro.who.int/document/e92845.pdf

211 C.D. Mathers et al., "Global burden of disease in 2002: data sources, methods and results", Global programme on evidence for health policy discussion paper no. 54, 2003 (revised 2004), World Health Organization. http://www.who.int/healthinfo/paper54.pdf.

Table 5.5. Values of the costs of traffic noise for the EU28, in units of Euro/dB/person/year[200].

Lden (dB)	road			rail			aircraft		
	annoyance	health	total	annoyance	health	total	annoyance	health	total
50-54	14	3	17	14	3	17	34	5	39
55-59	28	3	31	28	4	32	68	6	74
60-64	28	6	34	28	6	34	68	9	77
65-69	54	9	63	54	9	63	129	12	141
70-74	54	13	67	54	13	67	129	16	145
>74	54	18	72	54	18	72	129	21	150

A distinction is made between two contributions to the costs of noise, one from annoyance and one from health; sleep disturbance is assumed to be part of annoyance[212]. The values for aircraft are considerably higher than for road and rail. This is in line with the exposure-response relations for annoyance by the three transport modes[202]. The cost increase with increasing sound level is also in line with the general shape of the exposure-response relations. A threshold of 50 dB is assumed, which means that effects are neglected below 50 dB. The total integrated costs for a person exposed to 62 dB road traffic noise, for example, is calculated as follows:
5x17 + 5x31 + 2x34 = 308 Euros/person/year. The total integrated costs for the EU are calculated by combining the table with the EU exposure distributions.

Monetary valuation with method 2

Method 2 for monetary valuation of the effects of noise is based on an extensive literature survey[185]. As described before, a distinction is made between three health endpoints: annoyance, sleep disturbance, and myocardial infarction.

- For annoyance, a fixed cost of 85 Euro per annoyed person per year, based on HEATCO[213], is used[214].
- For sleep disturbance, the costs are calculated in terms of productivity loss caused by high sleep disturbance, with a value of 2% of GDP per employee[215].
- The total costs for myocardial infarction are calculated from the morbidity costs (7300 Euro per case) and the costs of life years lost with 40 000 euro per life year[216].

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[212] In the present study the total values in Table 5.5 are used. These are referred to here as 'health costs, since annoyance and sleep disturbance are considered also as health effects.

[213] S. Navrud, Y. Trædal, A. Hunt, A. Longo, A. Gressmann, C. Leon, R. Espino, Markovits-Somogyi, F. Meszaros (2006) Economic values for key impacts valued in the Stated Preference surveys, Deliverable four, HEATCO – Developing Harmonized European Approaches for Transport Costing and Project Assessment, available at https://www.yumpu.com/en/document/view/2210784/.

[214214] The value of 85 Euro per annoyed person (including highly annoyed persons) is based on the HEATCO project (footnote 213), and is valid for road and rail traffic noise. For aircraft noise, the same value is used as for road and rail traffic noise (HEATCO gives no value for aircraft noise). This is based on the fact that in Method 1 the values for aircraft noise are about a factor of 2 higher than for road traffic noise, which approximately corresponds with the difference between the exposure-response functions for road traffic noise and aircraft noise.

[215] This is based on Godet-Cayré et al., "Insomnia and absenteeism at work. Who pays the cost?", Sleep Vol. 29, 2006, pp. 179-184. The same value of 500 Euro is used as in the HEIMTSA project, since the variation of the GDP since 2011 is negligible (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?locations=EU).

[216] The contribution from myocardial infarction is typically one order of magnitude smaller than the contributions from annoyance and sleep disturbance. In the literature, various values have been used for the value of a life year. A value of 78 500 Euro is used, for example, in "Environmental noise in Europe – 2020", EEA report No. 22/2019. A value of 110 987 Euro is used in "Evaluation of Directive 2002/49/EC relating to the assessment and management of environmental noise", EC report, 2016. In the present study the value of 40 000 Euro is used, which was used in the Heimtsa project.

In the project Heimtsa it has been found that monetary values calculated with method 2 are about a factor of 2 lower than monetary values calculated from the DALYs for the three endpoints, using the monetary value of a life year indicated above[185]. A difference of a factor of 2 may be considered as a good agreement for this type of calculations. Monetary valuation via the DALYs has also been used or considered in other studies[217,218,219]. The approach of the EEA calculator of health effects and costs[219] is similar to the approach of Heimtsa.

5.7 Costs of noise abatement solutions

The costs of noise abatement solutions are based on data from the literature and web resources, and where these are lacking, best estimates. These costs include initial implementation costs (investment) such as purchase, construction and installation, and life cycle costs (LCC), mainly for maintenance and removal or replacement. The implementation costs are incurred initially whereas the LCC are applicable over the whole life of the solution concerned. The cost estimates are listed in Table 5.6 - Table 5.8 below.

Road traffic speed restrictions

For road traffic speed restrictions, there are no significant costs for implementation or maintenance. There are, however, costs related to the travel time loss caused by speed restrictions. These costs may be estimated from the gross domestic product (GDP) per capita and per working hour, which is about 20 Euro/person/hour for the EU. This value is a crude approximation, ignoring the fact that there are also non-work-related trips and costs associated with freight transport. In a Dutch report[220], values are reported for different types of automobile trips, ranging from about 8 Euro/person/hour for non-business trips to 26 Euro/person/hour for business trips. An average value of 9 Euro/person/hour is given, which is used here (denoted as V). This average value is a reasonable representation of the values given in the EC handbook on the external costs of transport[221], for different EU countries, business and personal trips, and short and long trips.

Travel time is calculated from the values of (maximum) vehicle speed and road length for the eight road types and three vehicle types (see Section 5.10). Travel time loss is denoted as T, expressed in hours. The annual cost of speed restrictions is then calculated as $C = N \cdot T \cdot V$, where N is the number of vehicles per year, and one person per vehicle is assumed. To account for the fact that travel time loss occurs mainly outside the daily traffic peaks in the morning and evening, only 1/3 of the vehicles in the daytime is taken into account. The costs are summed over the eight road types and three vehicle types considered.

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217 "Environmental noise: valuing impacts on sleep disturbance, annoyance, hypertension, productivity and quiet", Defra report, November 2014, www.gov.uk/defra

218 "Decision and cost/benefit methods for noise abatement measures in Europe", report prepared for EPA Network Interest Group on traffic noise abatement, February 2018.

219 "Noise Health and Costs Calculatorv3 EEA", excel file downloaded from the CIRCA website.

220 P. Warffemius, "De maatschappelijke waarde van kortere en betrouwbaardere reistijden", report KiM-13-A03a, Dutch Ministry of Infrastructure and Environment, 2013, Table 3.1. URL: https://www.kimnet.nl/publicaties/rapporten/2013/11/18/de-maatschappelijke-waarde-van-kortere-en-betrouwbaardere-reistijden

221 "Handbook on the external costs of transport", January 2019, report prepared by H. van Essen (CE Delft) et al for the European Commission. The figures for Value of time are given in Table 87, and are based on a UK study from 2015.

Table 5.6. Costs of noise abatement solutions for road traffic

Noise abatement solution	Implementation costs	Maintenance/LCC costs	Remarks
Quieter tyres	+0-2% per tyre Average price € 50,-.[222] 300m x 4 tyres every 4 years = 300 M€/year.	No additional cost	Industry R&D and additional manufacturing costs, passed on to consumer
Quiet road surfaces	Average cost of standard surface is taken at € 40/m2, Quiet surfaces are about 5-10% more expensive, so around € 3 / m^2 increase.[223] Cost is calculated for total new quiet surface area per annum per road type.	Maintenance is approx. 10% of implementation costs, so € 4 /m2/annum. Additional maintenance cost is then € 0,40 /m2/annum Cost is calculated from total existing quiet surface area per road type.	Costs only for paving, difference with conventional surface. Costs borne by national or local road authorities. Limitations in some conditions.
Quieter vehicles	1% price increase, 19 m vehicle/annum -> 190 ME/annum.	No additional cost	Industry R&D and additional manufacturing costs, passed on to consumer
Noise barriers standard or special, including absorbent or tilted barriers and lane barriers	Approx. M€ 0,5 x height in m per km	€ 2000,- per km/annum, i.e. cleaning and repair.	Costs borne by national or local authorities
Re-routing or limiting road traffic, e.g. by a congestion charge or access restrictions for areas with high noise exposure and noisy vehicles, including low emission zones (LEZ)	Indicative: 1 M€ per km^2 i.e. road signing, administration, equipment, road modification.	0,2 M€ per km^2 per annum	A large part of these costs may be recovered via access charging, fines, parking tariffs and taxes, all borne by the general public.
Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, parks, courtyards, and urban planning	Indicative: 10-100 M€ per km^2 , depending on extent of change; Design and reconstruction costs of buildings and roads, not including private property.	No additional cost	The net costs may be neutral if land use is optimised and generates tax revenues, higher income and property value.
Sound insulation of buildings	Average 10 m^2 per dwelling at € 100 / m^2 [224] € 1000/per dwelling	No additional cost	Only includes additional insulation funded or subsidised by authorities, where reception limits are exceeded.

[222] See tyre sales websites (2020)

[223] www.silentroads.nl (2015)

[224] Based on sales websites for double glazing, including installation

Table 5.7. Costs of noise abatement solutions for railways

Noise abatement solution	Implementation costs	Maintenance/LCC costs	Remarks
Infrastructure[225] measures incl. rail grinding, quieter railpads, dampers or shielding	Grinding: no implementation cost Quieter railpads € 3000/km Rail dampers or shielding: 0,6 M€/km	Acoustic grinding per km run: € 3000/km None Potential replacement after 10-15 years	Costs borne by infrastructure managers or authorities Quieter railpads and dampers mainly for tracks with soft railpads
Quieter rolling stock, including smooth, damped or optimized wheels and quieter powertrains	0-2% of vehicle price depending on additional features; assume 1%. Turnover of rail vehicles in EU 27 = 25 B€, 1% = 250 M€/annum	Silent brake blocks have higher maintenance costs. Neglected here.	Costs borne by rolling stock owners
Noise barriers standard or special, including absorbent or tilted barriers and low barriers	Approx. M€ 0,5 x height in m per km	€ 2000,- per km/annum, i.e. cleaning and repair.	Costs borne by infrastructure managers or local authorities
Re-routing or limiting railway traffic, for example by (night-time) bans on noisier rolling stock.	Variable but deemed small. A value of 100 M€/annum is used.	Operational inflexibility and longer routes add to operational costs. Neglected here.	Costs borne by train operator companies. Exposure may be shifted to another location.
Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, parks, courtyards, and urban planning at national or local level	Indicative: 10-100 M€ per km^2, depending on extent of change; Design and reconstruction costs of buildings and roads, not including private property.	No additional cost	The net costs may actually be neutral if land use is optimised and generates tax revenues, higher income and property value.
Sound insulation of buildings	Average 10 m^2 per dwelling at € 100 / m^2 [226] € 1000/per dwelling	No additional cost	Only includes additional insulation funded or subsidised by authorities, where reception limits are exceeded.

[225] https://www.treinreiziger.nl/wp-content/uploads/2017/11/Presentatie-Railpads.pdf

[226] Based on sales websites for double glazing, including installation

Table 5.8. Costs of noise abatement solutions for aircraft

Noise abatement solution	Implementation costs	Maintenance/LCC costs	Remarks
Improved flight profiles	Development of procedures, flight trials, adaptation of avionics, initial training, etc. 100M€	Training of flight crew and ANSP staff 25M€/year However: cost **savings** (fuel): 150M€/year	Costs borne by airlines and ANSPs Fuel savings benefit airlines
P_RNAV	Adaptation of avionics (if any), initial training, etc. 50M€	None	Costs borne by airlines and ANSPs Fuel savings benefit airlines
Total Night curfew	Assumed profit loss: 6000€/operation[1] Total ops in EU 2017: 8.75M 10% night flights, of which 50% is lost: 437.500ops/year Total cost: 2.6 billion	Revenue loss: 2.6 billion/year	Costs borne by airlines Indirect loss due to tourism and other revenue losses not included (may be multiple of indicated cost[227])
Night curfew for non-Chapter 4 aircraft only	Assumed that non-Chapter 4 aircraft can be replaced by compliant aircraft in same fleet	Assumed to be cost neutral	
Forced phase-out of non-Chapter 4 aircraft	Non-chapter 4 aircraft are ~3% of total aircraft fleet. Assumptions: 50% replaced by other aircraft of airline 25% natural replacement 25% new purchased	Additional depreciation cost but compensated by fuel savings: Total cost **saving** of 100M€ per year	Costs borne by airlines
Sound insulation of buildings	Average 20 m^2 façade per dwelling at € 100 / m^2 + 60 m^2 roof at € 200 / m^2 € 14.000/per dwelling Estimated nº dwellings affected: 16000 (assuming other 16000 have already been insulated in 2020) Total cost 224M€	No additional cost	Only includes additional insulation funded or subsidised by authorities, where reception limits are exceeded.

[227] Ban on night flights at Heathrow Airport - A quick scan Social Cost Benefit Analysis - 2011

Buffer zone	Purchase of dwellings inside buffer zones € 120.000/per dwelling[228] Estimated nº dwellings affected: 5000 Total cost 600M€	No additional cost	Costs borne by airports
Stakeholder engagement	Noise monitoring system, noise committee, events, consulting, training, etc. Total implementation cost 100M€	800.000€/year/airport 50M€/year	Costs borne by airports

5.8 Cost-benefit analysis and appraisal period

Costs and benefits are estimated on an annual basis over the whole appraisal period 2020-2035. The highest costs tend to be at the time of implementation and decrease over time, whereas the benefits grow gradually, especially if evolution of the vehicle fleet determines average noise levels.

In the calculation of annual costs and benefits, a correction is made for future growth based on the interest rate, and for the value decrease over time based on a discount rate. The discount rate is applied to determine the present value of future amounts, effectively lowering these with increasing years.

A discount rate r_d of 4% and an interest rate r_g of 1% are applied for both costs and benefits for the whole appraisal period, as suggested in the EU guidelines[229].

The discounted value of the benefit in year i is calculated with the following formula

$$B_i = B_0(1 + r_g)^i/(1 + r_d)^i$$

with

- B_i = benefit value in year i,
- B_0 = initial benefit value (year i=0),
- r_g = interest rate,
- r_d = discount rate.

For the appraisal period 2020-2035, the benefits and costs are accumulated over the whole period of n years, resulting in total benefits $B_{tot,n}$ and total costs $C_{tot,n}$:

$$B_{tot,n} = \sum_{i=1}^{n} B_i(1 + r_g)^i/(1 + r_d)^i$$

$$C_{tot,n} = \sum_{i=1}^{n} C_i(1 + r_g)^i/(1 + r_d)^i.$$

[228] NAP Milan Malpensa airport 2017

[229] "Guide to cost-benefit analysis of investment projects", EC report 2015, See: https://ec.europa.eu/regional_policy/sources/docgener/studies/pdf/cba_guide.pdf

For each scenario, the benefit to cost ratio for the appraisal period of n years is calculated over the whole appraisal period from

$$BCR_n = \frac{B_{tot,n}}{C_{tot,n}}.$$

For BCR > 1 the benefits exceed the costs, meaning the investment is worthwhile. For a short appraisal period, the BCR ratio tends to be lower than for a longer period.

Notably, some of the noise abatement solutions take effect over a longer period than 10 years, for example in the case of vehicle limits where fleet replacement is a factor, and for urban planning, which can take several years to complete and to take effect. In these cases it can be expected that a longer appraisal period than 10 years is required to reach a positive BCR ratio. Therefore we selected the appraisal period 2020-2035.

The so-called Net Present Value (NPV) is the difference in accumulated benefits and accumulated costs in year n:

$$NPV_n = B_{tot,n} - C_{tot,n}.$$

The NPV is normally negative before reaching a 'break-even' point after several years, after which the benefits exceed the costs. Any project or noise solution will tend to have a break-even point after which the total benefits exceed the total costs.

5.9 Test site calculations

In this section, the test site calculations are described. These calculations have been used for validating elements of the methodology and to assess uncertainties. Detailed results of the test site calculations are presented in three Annexes (4, 5 and 6). Here, a brief summary is given of the results.

Purpose

A central role in the methodology is played by the EU exposure distributions (see Section 5.3). The EU exposure distributions have been derived from the END distributions from the member states, for agglomerations and for the areas outside the agglomerations. The data is subject to uncertainty due to uncertainties of input parameters, differences in definitions between countries and within countries, and differences in noise calculation methods between countries.

To get an impression of the uncertainty, the END results have been compared with the results of a number of noise-mapping calculations for test sites. The following types of test sites have been considered (see Table 5.9):

- sub-areas of urban agglomerations with road and rail traffic noise,
- areas near major roads and major railways,
- airports and surrounding area.

For the comparison, the scale difference between the test site and the whole EU or country should be taken into account. This can be done by expressing exposure as a percentage of the population, for example. It can also be done by looking at the shape of the exposure distribution rather than the absolute numbers.

The test site calculations have also been used for assessing the effects of noise abatement solutions. Two examples are the following.

- *Noise barrier*. The effect of inserting a noise barrier in a specific situation has been investigated by comparing the results of two test site calculations, one with and one without the barrier.
- *Rerouting traffic*. A complex noise abatement solution is rerouting of urban traffic[230]. This has been investigated by test site calculations. For rerouting in test site Karlsruhe (DE), for example, the TNO noise-mapping tool Urban Strategy has been used, which includes a traffic model for rerouting traffic.

A point that has become clear from the test site calculations is that low-speed urban streets (50 km/h, 30 km/h) have a major effect on the exposure distributions. This point is important for the interpretation of END results for agglomerations. For some agglomerations, part of the urban streets has been neglected, while for other agglomerations all streets have been taken into account. Consequently, the methodology used here probably underestimates the contribution of low-speed urban streets, also in the baseline scenario.

Table 5.9. Different types of test sites for road traffic, rail traffic, and airports.

road traffic	rail traffic	airports
test sites in urban area larger than 1 km^2 urban road types: - residential streets - main roads - arterial roads - motorways	**test sites in urban area** larger than 1 km^2 track types: - rough - smooth - quiet traffic: - mixed - high speed - freight	**airports and nearby area** three size classes different degrees of implementation of the Balanced Approach
test sites near major road larger than 1 km^2 major road types: - trunk roads - motorways	**test sites near major railway** larger than 1 km^2 track types: - rough - smooth - quiet traffic: - mixed - high speed - freight	

[230] "Feasibility study: European city pass for low emission zones. Annex A: Standards and guidance document", Ecorys report, prepared for the European Commission, 2014. See https://urbanaccessregulations.eu/images/Reports/EU_draft_guidance_LEZ_Final_Report_Standards_and_Guidance_submitted.pdf

Selection and justification

The selection of test sites in this study was based on the following criteria.

- The test sites should cover the three transport modes, and both urban areas and major roads/railways. See Table 5.9.
- The test sites should cover several countries (although the number of countries may be limited; see arguments below). For road traffic noise and railway noise, four countries are considered: NL, ES, DE, BE. For aircraft noise, nine countries are considered: NL, DE, DK, ES, AT, IE, IT, PT, HU.

In addition there is the practical criterium that the GIS-based noise models for the test sites have to be available at the partners of this study.

It is not necessary to perform test site calculations at many locations all over Europe. Of course, there are local differences in noise exposure, but these are already represented in the EU exposure distributions, which are weighted averages of the distributions from the EU member states.

The results of this study are representative for the EU primarily due to the fact that the health effects are calculated from the EU exposure distributions, which are based on noise mapping results from all EU member states.

The test sites are primarily intended for testing the effects of noise solutions, which are not strongly dependent on the location in Europe. For example, a noise barrier along a busy road has approximately the same effect at different locations in Europe: a reduction of noise levels by typically 10 dB. This approximation has been tested by comparing results for different test sites (Amsterdam and Karlsruhe, for example).

The test sites for aircraft noise are an integral element of the methodology, as described in Section 5.12. Therefore, the test site calculations for aircraft noise are not described here.

Summary of results

Results of the test site calculations are reported in three Annexes, one for road traffic noise and one for railway noise. Here a brief summary of the results is presented.

Figure 5.10 shows an example of a calculated road-traffic noise map of a test site. The test site is a 4 x 4 km area in urban agglomeration Amsterdam. The blue vertical line represents a busy motorway, while the red and yellow lines represent other urban roads with lower vehicle speed.

Figure 5.11 shows road-traffic noise exposure distributions calculated for four urban test sites, i.e. four areas in urban agglomerations. For comparison, the EU average distribution for urban agglomerations is also shown. The graph gives an impression of local deviations from the EU average distribution. The high peak for Antwerp at 65-69 dB has been attributed to minor urban roads in the Antwerp area. As indicated before, these minor streets are sometimes ignored in noise-mapping calculations for the END. In general, the contribution from urban motorways is smaller than the contribution from other urban roads, partly because urban motorways are often screened by barriers or by office buildings.

Figure 5.12 shows exposure distributions for seven test sites with major roads, i.e. seven areas near major roads. The test sites are located in The Netherlands and Spain. For comparison, the EU average distribution for major roads is also shown. As the numbers of inhabitants in the seven test sites are different, the exposure is normalized such that the sum over the five interval is unity. The graph gives an impression of local deviations from the EU average distribution.

Figure 5.10. Road-traffic noise map of a 4 x 4 km area in Amsterdam. The color represents the L_{den} level in dB.

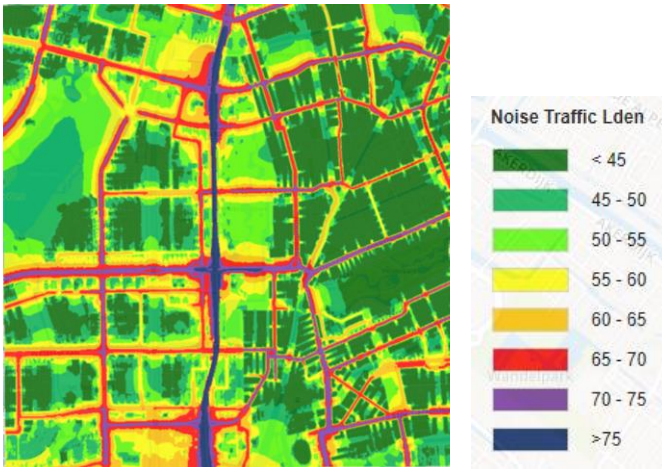
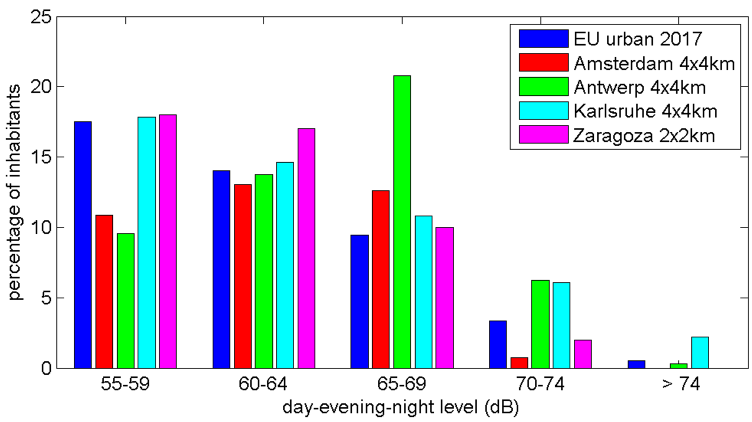


Figure 5.11. Road-traffic noise exposure distributions of four areas in urban agglomerations, and the EU distribution for urban agglomerations. The exposure is expressed as the percentage of the population in the area[231].



[231] As described in Sec. 5.3, the exposure distributions are extrapolated below the END limits of 55 dB Lden and 50 dB Lnight, for the purpose of health impact assessment.

Figure 5.12. Exposure distributions of areas near major roads in NL and ES, and the EU distribution for major roads. The exposure is normalized such that the sum over the five interval is unity.

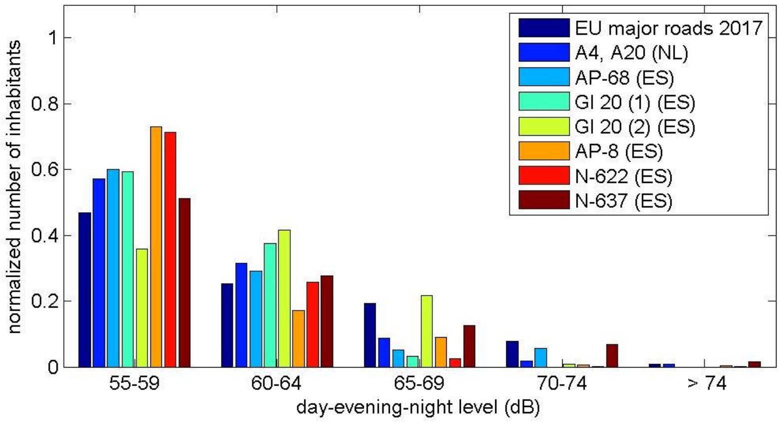


Figure 5.13 illustrates the effect of various road traffic measures on the exposure distribution of Karlsruhe. In this case the entire city was considered, which is much larger than the 4 x 4 km area considered above. The traffic measures include rerouting, speed reduction, and a car-free zone. As the measures are applied locally, in a limited area, the effect on the exposure distribution of the entire city is quite small. This conclusion also applies to local urban planning solutions such as tunneling.

Figure 5.14 shows the result of a test site calculation for analyzing the effect of noise barriers along motorways. The test site is a 4 x 4 km area near motorways A4 and A20 in The Netherlands. About 50% of the motorways in the area have noise barriers, to reduce the noise at the nearby dwellings. As a variation of the test site, the noise barriers were removed. The graph shows that the exposure with barriers (dark blue bars) is considerably lower than the exposure without barriers (red bars). The cyan bars represent an approximate calculation, based on the fact that about 50% of the roads have noise barriers. The cyan distribution was calculated from the red distribution (without noise barriers) as follows: 50% of the red bars was shifted by -10 dB (barrier attenuation) and 50% of the red bars was shifted by 0 dB (no barrier). The cyan distribution agrees well with the dark blue distribution from the noise map calculation. This confirms that the assumption of 10 dB barrier attenuation is a reasonable approximation in this case.

Figure 5.15 shows exposure distributions for eight test sites with major railways, i.e. eight areas near major railways in The Netherlands and Spain. For comparison, the EU average distribution for major railways is also shown. As the numbers of inhabitants in the eight test sites are different, the exposure is normalized such that the sum over the five interval is unity. The graph gives an impression of local deviations from the EU average distribution.

Figure 5.16 shows results of calculations for test case Fuenlabra, i.e. an area in Fuenlabra (ES) near a major railway line. The graph shows the distributions for the baseline scenario (green) and four alternative scenarios, which illustrate the effects of three types of noise abatement measures:

- source measures (yellow and red),
- noise barrier (blue),
- urban planning measure: screening by non-residential buildings (grey).

Overall, the noise barrier is the most effective measure in this case. It should be noted, however, that the effect of a noise barrier depends on the receiver height, which is 4 m in this case. For other receiver heights, such as with high apartment buildings, the effect of a barrier may be smaller. On the other hand, the effect of source measures does not significantly depend on the receiver height. These considerations should be kept in mind when comparing the effects of noise barriers and source measures.

The picture can't be displayed.

Figure 5.13. Exposure distributions for urban EU27 (blue), Karlsruhe (red), and Karlsruhe with various traffic measures (V23-V28).

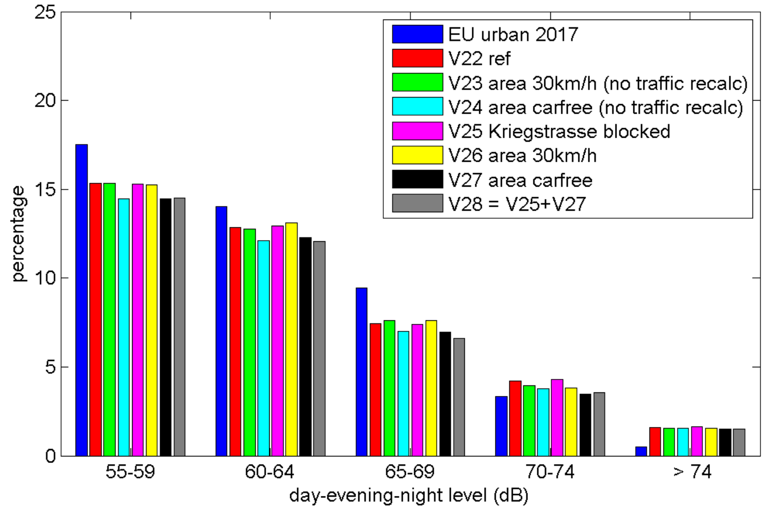


Figure 5.14. Exposure distributions for a 4x4 km area around motorways A4 and A20, with and without noise barriers. The cyan bars represent an approximate calculation.

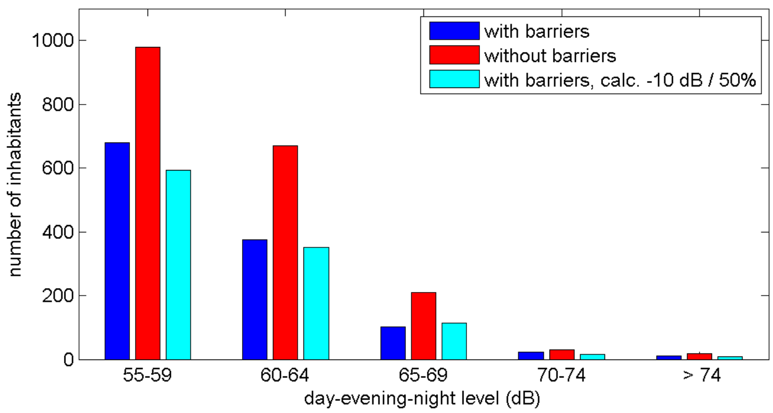


Figure 5.15. Exposure distributions of areas near major railways in NL and ES, and the EU distribution for major railway lines. The exposure is normalized such that the sum over the five interval is unity.

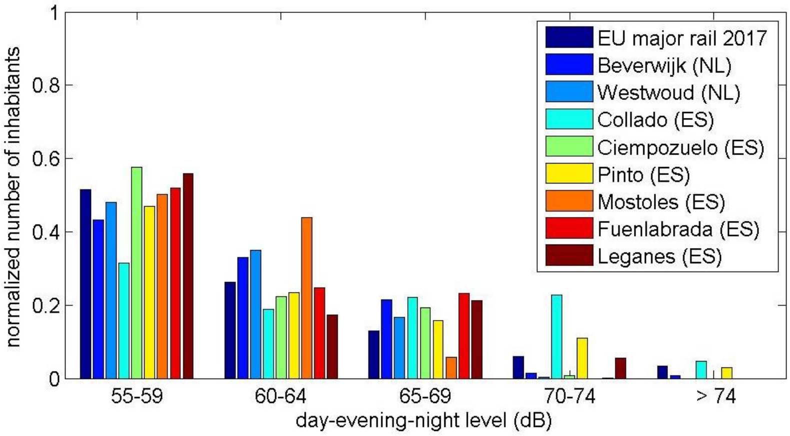
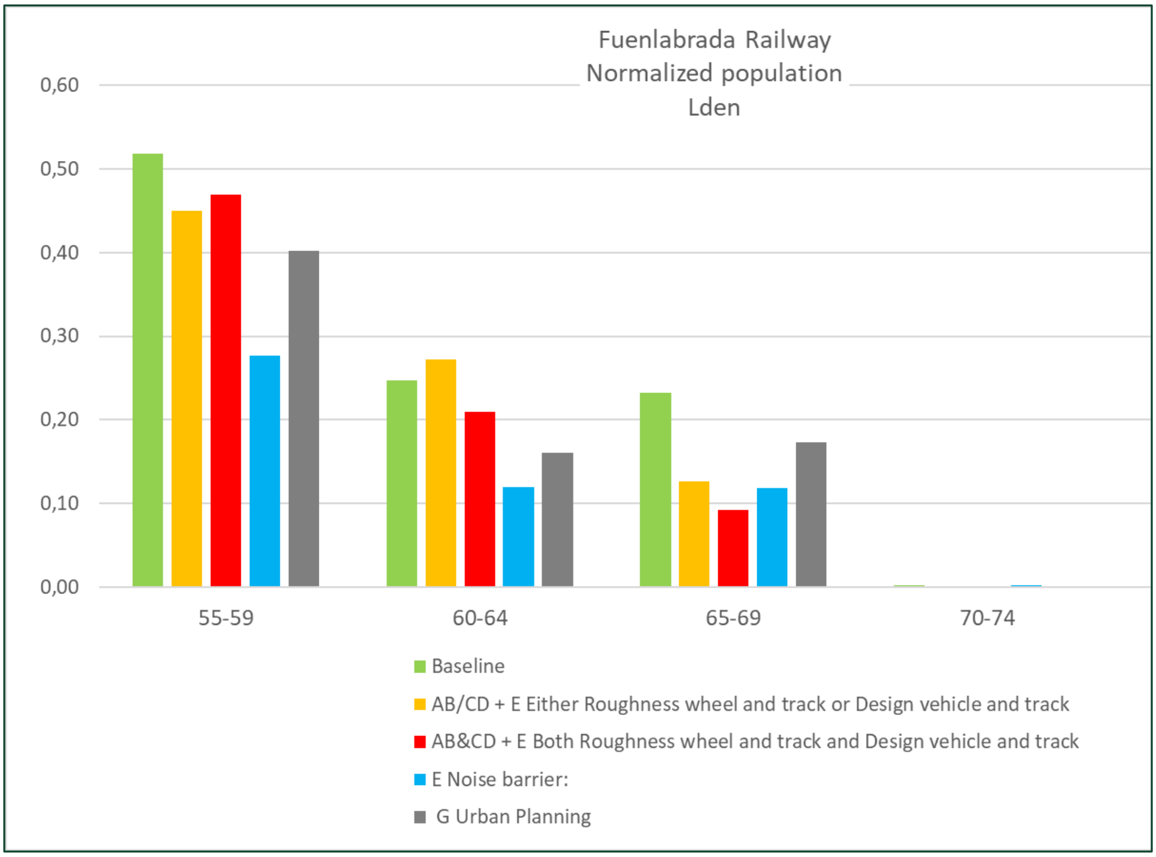


Figure 5.16. Exposure distributions for area around railway line in Fuenlabra: baseline and various solutions.



5.10 Road traffic noise

For road traffic noise, the methodology is based on the following EU exposure distributions for the year 2017 (see Section 5.3):

- exposure distributions for urban agglomerations (L_{den} and L_{night}),
- exposure distributions for major roads outside agglomerations (L_{den} and L_{night}).

Effects of noise abatement solutions (and autonomous developments) in the period 2017-2035 are taken into account by estimating a *change* of the 2017 exposure distributions. This is illustrated schematically in Figure 5.17. In Section 5.5 four types of noise abatement solutions were distinguished:

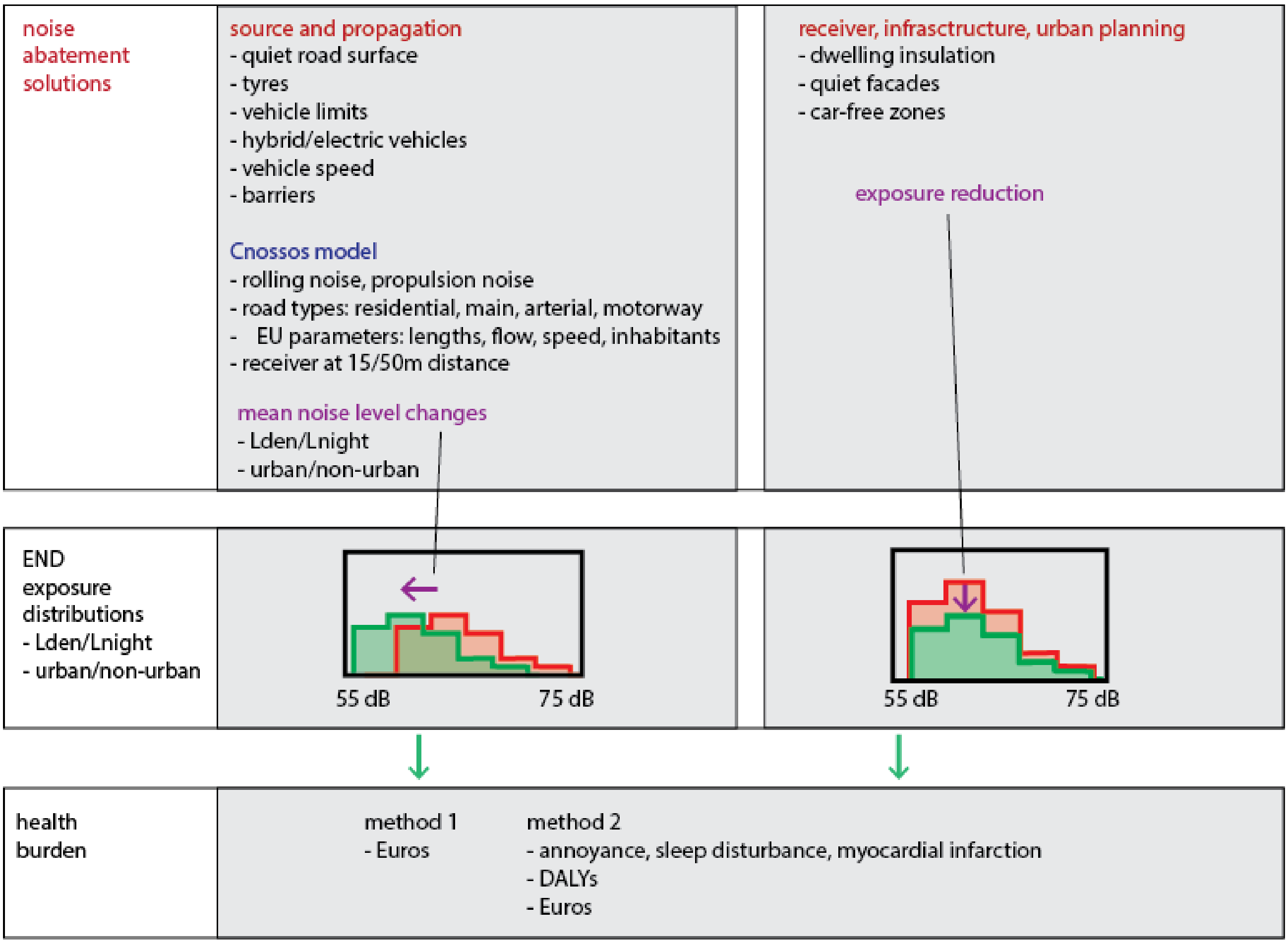
- solutions at source,
- solutions at receiver,
- solutions in the propagation path (barriers),
- solutions aimed at the infrastructure and spatial urban planning.

For solutions in the fourth category, such as traffic rerouting and urban planning, a general strategy cannot be specified and the change in exposure distributions can be derived from test-site calculations or ad hoc arguments.

For solutions at receiver, the change of the exposure distributions is not easy to assess. As described in Section 5.5, the effect of dwelling insulation is approximated by eliminating the inhabitants of dwellings with (additional) insulation from the exposure distributions. Also described in Section 5.5 is that the effect of a quiet façade is represented by a reduction of 2 dB of the outside façade level at the most exposed façade.

For solutions at source and solutions in the propagation path (barriers), an average noise level *change* will be determined, and applied to the exposure distributions. In the remainder of this section, the model is described that is used for calculating the average noise level change for solutions at source.

Figure 5.17. Illustration of the effects of different types of noise abatement solutions on the END exposure distributions, which are used to calculate the (reduced) health burden.



Road traffic noise emission model

The average noise level change due to a noise abatement solution at source is calculated with a model that is called 'road traffic noise emission model' in this study. The model yields noise levels L_{den} and L_{night} along eight different types of roads[232]. Noise levels $L_{den,j}$ and $L_{night,j}$ are calculated for all 19 years in the period 2017-2035 (j = 2017, 2018, ..., 2035). From these levels noise level *changes* are calculated:

$$\Delta L_{den,j} = L_{den,j} - L_{den,j=2017}$$
$$\Delta L_{night,j} = L_{night,j} - L_{night,j=2017}.$$

The level changes are zero for year j = 2017, and gradually change over time. The level changes are different for the baseline scenario and the alternative scenario with the noise solution.

The road traffic noise emission model takes into account:

- the emission of individual road vehicles (calculated with the Cnossos model),
- intensities and speeds of the vehicles on the different types of roads.

The model has been developed for situations in the Netherlands[195,196], and was adapted for this study by using parameters appropriate for the EU. The most important elements of the model are described below; for details, the reader is referred to the references.

Eight road types are distinguished in the model:

1) urban residential streets, intermittent flow,
2) urban residential streets, free flow,
3) urban main roads, intermittent flow,
4) urban main roads, free flow,
5) urban arterial roads,
6) urban motorways,
7) non-urban motorways,
8) nonurban main roads.

For the residential streets and main roads, 1/3 of the overall road length is assumed to have intermittent traffic flow whereas 2/3 of overall road length has free traffic flow.

Inhabited road lengths of the 8 types were estimated for the EU, and also numbers of inhabitants per km (see Table 5.10). Vehicle intensities and speeds were also estimated for the different road types (see Table 5.11). The fleet composition varies with road type. For example, the percentage heavy vehicles (trucks) is generally higher on non-urban motorways than on residential streets.

For each road type four subtypes are considered:[233]

i) roads with a standard road surface,
ii) roads with a standard road surface and noise barriers,
iii) roads with a quiet road surface,
iv) roads with a quiet road surface and noise barriers.

[232] These noise levels are not true emission levels, but rather noise levels at short distance from the roads.

[233] The distinction between roads with a standard road surface and a quiet road surface is made because it is assumed noise barriers are first put along road sections with a quiet road surface.

So there are 4x8 =32 different road types. We estimated that for road types 5-8 in the EU there is 5% with a quiet road surface and also 5% with a noise barrier.

From the vehicle intensities and speeds for the different road types and the vehicle emission model (described below), noise levels L_{den} and L_{night} are calculated at a distance of 15 m (non-motorway) or 50 m (motorway) from the road. For sound propagation, only geometrical spreading of sound waves is taken into account. Ground attenuation and air absorption are neglected. For barrier attenuation a mean reduction of 10 dB is taken into account[234].

Table 5.10. Lengths of eight road types (inhabited) and numbers of people along the roads.

	Type		Inhabited length (km)	Number of people per km
1	Residential street	Urban	1/3 * 965652	250
2	Residential street	Urban	2/3 * 965652	250
3	Main road	Urban	1/3 * 199796	500
4	Main road	Urban	2/3 * 199796	500
5	Arterial road	Urban	94118	500
6	Motorway	Urban	3824	1000
7	Motorway	Non-urban	34141	50
8	Main road	Non-urban	1517922	20

Table 5.11. Parameters of the vehicle flow on the eight road types.

	Type		Vehicle flow (vehicles per 24h)	Speed C1/C2/C3[235] (km/h)
1	Residential street	Urban	2000	30 / 30 / 30
2	Residential street	Urban	2000	50 / 40 / 40
3	Main road	Urban	9470	50 / 40 / 40
4	Main road	Urban	9470	50 / 50 / 50
5	Arterial road	Urban	33700	80 / 70 / 70
6	Motorway	Urban	48500	100 / 85 / 85
7	Motorway	Non-urban	48500	115 / 85 / 85
8	Main road	Non-urban	16000	80 / 80 / 80

[234] In practice, barrier attenuation varies due to variations of barrier height and other geometrical parameters. For a 5 m barrier along a road, the typical attenuation is 10 dB. To keep the methodology practical, only this typical value is considered.

[235] See Cnossos subsection below.

Cnossos vehicle emission model with corrections

To calculate the emission of individual vehicles, the emission model of Cnossos is used[236]. The implementation of Cnossos for this study is described in this section and is illustrated in Figure 5.18. The Cnossos model has separate contributions from propulsion noise and rolling noise. Three vehicle categories are considered:

- light vehicles (C1),
- medium-heavy vehicles (C2),
- heavy vehicles (C3).

Other vehicle types such as motorcycles are neglected in this study. The reason for this is that the other vehicle types have a very limited contribution to L_{den} and L_{night} levels at EU level, and they are normally not included in END noise-mapping calculations. When the vehicles of categories C1-C3 will become quieter in the future, contributions from the other vehicle types may become more important.

A correction term is applied to make the Cnossos emission model match the Dutch and German emission models[195]. The correction term is 4 dB for light vehicles and 5 dB for medium-heavy and heavy vehicles. The underestimation of road vehicle emission levels by Cnossos has been found also in other studies performed in the Netherlands and is partly due to a mismatch between the emission model and the propagation model in Cnossos[237].

The Cnossos model contains the following emission corrections:

- correction for quiet road surfaces,
- correction for vehicle acceleration at crossings or other obstacles,
- correction for studded tyres.

The correction for quiet road surfaces depends on frequency and driving speed. The same correction is used in the Dutch calculation method[238]. To keep the methodology simple, the non-spectral version of the Dutch method was implemented[195]. In line with this, the Dutch model was also used for the correction for vehicle acceleration, which is applied for roads with intermittent traffic flow. The correction for studded tyres is replaced by a more general correction for quiet tyres[195].

This formulation of the vehicle emission model makes it possible to calculate the effects of the following noise reduction measures, for the three vehicle types:

A)	vehicle emission reductions	(propulsion noise correction)
B)	reduction by quiet tyres	(rolling noise correction)
C)	reduction by a quiet road surface	(rolling noise and propulsion noise correction).

For the vehicle emission reductions (A), six types are considered[195]:

1) 2015: no reduction, current fleet,
2) 2016: reduction according to 2016 emission limits,

[236] "Commission Directive (EU) 2015/996, of 19 May 2015, establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council". Official Journal of the European Union. 19 May 2015. The annex describes the calculation method "Cnossos-EU" of simply "Cnossos".

[237] Currently, the EC is coordinating the development of a correction of Cnossos for this mismatch. See RIVM report 2019-0023, "Amendments for CNOSSOS-EU", Table 16.29.2.

[238] Dutch calculation methods for environmental noise: Reken- en meetvoorschrift geluid 2012 (RMG2012), Staatscourant Nr. 11810, 27 juni 2012. For road and rail traffic noise, a non-spectral method SRM1 is described and a spectral method SRM2.

3) 2020/22: reduction according to 2020/22 emission limits,
4) 2024/26: reduction according to 2024/26 emission limits,
5) hybrid vehicles: reduction of propulsion noise by 5 dB,
6) electric vehicles: reduction of propulsion noise by 10 dB.

The values of the vehicle emission corrections $\Delta L_{W,veh}$ are given in Table 5.12, for five vehicle categories. The conversion to categories C1-C3 is as follows:

$$\Delta L_{W,veh}(C1) = 10 \log_{10} (0.9\ 10^{(\Delta LW,veh(car)/10)} + 0.1\ 10^{(\Delta LW,veh(van)/10)})$$

$$\Delta L_{W,veh}(C2) = 10 \log_{10} (0.1\ 10^{(\Delta LW,veh(bus)/10)} + 0.9\ 10^{(\Delta LW,veh(truck)/10)})$$

$$\Delta L_{W,veh}(C3) = \Delta L_{W,veh}(\text{heavy truck}).$$

The reduction of tyre noise (B) is also a type of vehicle emission reduction but is included here as a separate reduction. It is quantified by the tyre label[195]. The correction for tyre noise reduction is calculated with the following formula[195]

$$\Delta L_{W,\ tyre} = (L_{label} - L_{label,\ mean}) \cdot f_{road}$$

where L_{label} is the tyre label, $L_{label,mean}$ is the mean tyre label (see Table 5.13), and f_{road} is a factor given by

$$f_{road} = a + b \cdot v$$

where v is the vehicle speed in km/h and a and b are coefficients given in Table 5.14 for the five road surface types considered in this study (see below).

For the reductions by a quiet road surface (C), the following five road surface types are considered (abbreviation in the Dutch model in brackets):

1) standard surface, dense asphalt concrete (DAB)
2) thin top layers (DGD)
3) porous asphalt (ZOAB)
4) double-layer porous asphalt (ZOAB2L)
5) double-layer porous asphalt fine (ZOABF2L).

The emission correction is zero for road surface type 1. The correction for quiet road surfaces is calculated with the following formula[195] based on the Dutch calculation method:

$$\Delta L_{W,\ surface} = s + t \cdot \log_{10}(v/v_{ref})$$

where reference speed V_{ref} is equal to 80, 70, and 70 km/h for vehicle categories C1-C3, respectively. This correction is applied both for rolling noise and propulsion noise, but for propulsion noise t=0 is used. The values of the coefficients s and t are given in Table 5.15.

Figure 5.18. Implementation of the Cnossos model for the present study. The final mean noise levels ($L_{den,urban}$, $L_{den,non\text{-}urban}$, $L_{night,urban}$, $L_{night,non\text{-}urban}$) are used for the modification of the END exposure distributions, as illustrated in Figure 5.17.

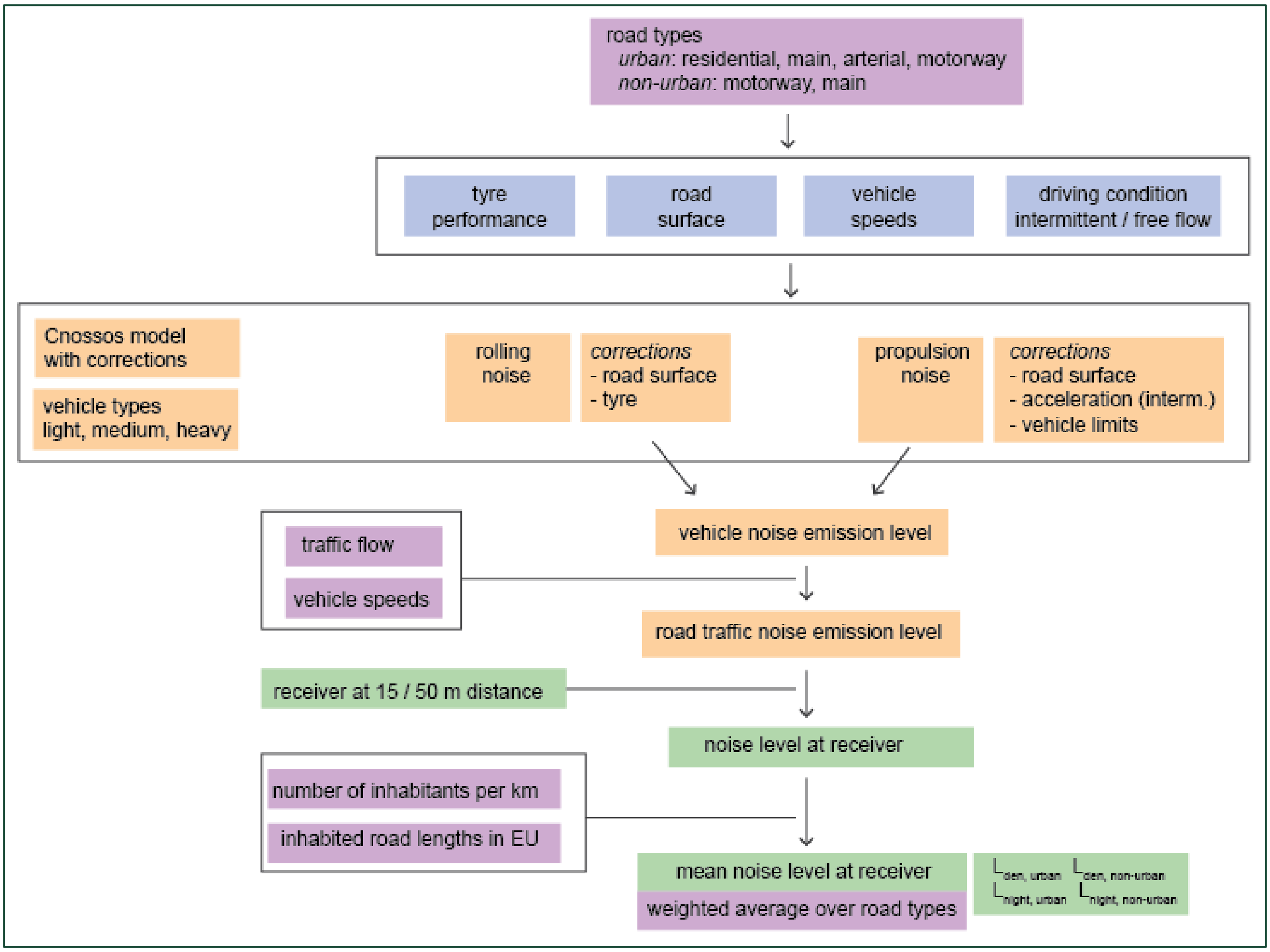


Table 5.12. Vehicle emission corrections for six emission limits / vehicle types and five vehicle categories.

Vehicle category	2015	2016	2020/22	2024/26	hybrid	electric
car, C1	0	-0.186	-2.084	-4.062	-5	-10
van, C1	0	-0.186	-2.084	-4.062	-5	-10
bus, C2	0	0	-1.796	-2.827	-5	=10
truck, C3	0	0	-1.796	-2.827	-5	-10
heavy truck C3	0	0	-1.5	-3.5	-5	-10

Table 5.13. Minimum, maximum, and mean tyre labels, for vehicle categories C1-C3.

Vehicle category	minimum	maximum	mean
C1	66	74	70
C2	69	76	72
C3	70	78	75

Table 5.14. Coefficients a and b for the tyre noise correction, for vehicle categories C1-C3 and road surface types 1-5 (1 = dense asphalt concrete, …).

Vehicle category	coefficient	1	2	3	4	5
C1	a	0.7167	1	0.4203	0.5288	1
	b	0.000621	0	-0.000690	-0.000493	0
C2	a	0.6661	0.95	0.3607	0.6	0.95
	b	0.0008036	0	-0.001786	0	0
C3	a	0.6038	0.9	0.2188	0.7	0.9
	b	0.001164	0	0.005822	0	0

Table 5.15. Coefficients s and t for the road surface correction, for vehicle categories C1-C3 and road surface types 1-5 (1 = dense asphalt concrete, …).

Vehicle category	coefficient	1	2	3	4	5
C1	s	0	-3.4	-1.4	-4.5	-6.5
	t	0	-2.5	-6.5	-3.0	-0.1
C2	s	0	-1.3	-3.1	-5.2	-5.3
	t	0	0.5	0.2	4.7	-0.8
C3	s	0	-1.3	-3.1	-5.2	-5.3
	t	0	0.5	0.2	4.7	-0.8

Baseline scenario for road traffic noise

The baseline scenario (Business as Usual, BAU) is defined by the situation for road traffic noise in 2017-2020, and its autonomous development in the period until 2035. Traffic growth, if sufficiently large and continuous, can increase the health burden and in some cases cancel out the effects of noise abatement efforts.

In general, parameters of a baseline scenario for road traffic noise are:

- Infrastructure length/size and characteristics,
- Traffic volume and fleet characteristics,
- Foreseen evolution of vehicle source levels,
- Foreseen evolution of scale and effectiveness of noise abatement solutions,
- Population density and exposure near infrastructure,
- Urban and rural spatial planning and land use.

Each of these parameters change with growth of traffic, infrastructure and land use. They also can strongly interact with developments in other domains such air quality, safety, and energy consumption. For the present analysis we have included the relevant developments in the baseline scenario, based on EC reference scenario[239]. This is represented in Table 5.16. The developments in the baseline scenario reflect existing noise-reduction solutions based on existing legislation (while *additional* noise-reduction solutions will be considered as elements of alternative scenarios).

An annual traffic growth of 1% is assumed, based on growth figures[239] for passenger and freight road traffic.

The 2016 EU reference scenario[239] gives the following percentages for hybrid and electric vehicles in 2030: 25% hybrid and 2% electric.

From a more recent EC document[240] and communication with the EC[241], the following values were derived:

- cars
  - Hybrid 6% in 2030
  - Electric 14% in 2030
- vans
  - Hybrid 6% in 2030
  - Electric 8% in 2030.
- buses
  - Hybrid 7% in 2030
  - Electric 18% in 2030.
- trucks (heavy goods)
  - Hybrid 16% in 2030
  - Electric 1% in 2030.

[239] "EU reference scenario 2016 energy, transport and GHG emissions trends to 2050", See: https://ec.europa.eu/energy/sites/ener/files/documents/20160713%20draft_publication_REF2016_v13.pdf

[240] EC document 2020, "Investing in a climate-neutral future for the benefit of our people", https://eur-lex.europa.eu/legal-ontent/EN/TXT/HTML/?uri=CELEX:52020SC0176&from=EN

[241] Email from Marco Paviotti, 8 October 2020

These new values were used for the present study. For 2035 these percentages are linearly interpolated, assuming zero values in 2020 as an approximation (in 2018 there were 0.8% hybrid and 0.2% electric in the EU[242]).

In addition, the expected development of the EU population is taken into account in the baseline scenario. A total EU population of 445 million in 2017 is assumed (excluding UK). It is assumed that 75% is living in urban areas[243]. A value of 0.1% is assumed for annual population growth[239].

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[242] European Automobile Manufacturers Association, "Vehicles in use, % share 2018".

[243] "The state of European Cities 2016". Eurostat https://ec.europa.eu/eurostat/statistics-explained/

Table 5.16. Parameters of the baseline scenario for road traffic noise. For 2020-2035 linear interpolation is used.

Percentage compliance with vehicle emission limits

vehicle limits 2017-2020

vehicle	2015	2016	2020/22	2024/26	hybrid	electric
car/C1	100	0	0	0	0	0
van/C2	100	0	0	0	0	0
bus/C3	100	0	0	0	0	0
truck/C3	100	0	0	0	0	0
heavy truck/C3	100	0	0	0	0	0

vehicle limits 2035

vehicle	2015	2016	2020/22	2024/26	hybrid	electric
car/C1	15	15	30	10	9	21
van/C2	15	15	35	14	9	12
bus/C3	15	15	25	8	11	27
truck/C3	15	20	30	10	24	2
heavy truck/C3	15	20	30	10	24	2

Tyre label

tyre label 2017-2020

C1	70
C2	72
C3	75

tyre label 2030

C1	70
C2	72
C3	75

Traffic growth

annual traffic growth percentage 2017-2030: 1.0

Road lengths

roads 2017-2020

1-2	3-4	5	6	7	8[244]	
965652	199796	94118	3824	34141	1517922	km inhabited road length
250	500	500	1000	50	20	inhabitants per km
0	0	4706	191	1707	75896	km barrier
0	0	4706	191	1707	75896	km quiet road length
1	1	2	2	3	3[245]	type quiet road surface

roads 2035

1-2	3-4	5	6	7	8	
965652	199796	94118	3824	34141	1517922	km inhabited road length
250	500	500	1000	50	20	inhabitants per km
0	0	4706	191	1707	75896	km barrier
0	0	4706	191	1707	75896	km quiet road length
1	1	2	2	3	3	type quiet road surface

[244] The eight road types were defined before as follows: 1-2 = urban residental, 3-4 = urban main, 5 = urban arterial, 6 = urban motorway, 7 = nonurban motorway, 8 = nonurban main.

[245] The five road surface types were defined before as follows: 1 = dense asphalt concrete, 2 = thin top layers, 3 = porous asphalt, 4 = double-layer porous asphalt, 5 = double-layer porous asphalt fine.

Example

The application of the road traffic noise emission model will now be illustrated with an example. Graphs of calculated noise levels, exposure distributions, and health effects are shown in Figure 5.19 - Figure 5.23.

The figures show results for two scenarios:

- V_0 - baseline scenario (autonomous developments),
- V_1 - scenario with 3-5 dB quieter tyres (this is scenario B in chapter 7).

It is assumed that the tyre noise is reduced by 3-5 dB in a period of four years (2020-2024), as the average lifetime of tyres is four years.

The graphs in Figure 5.19 show the L_{den} and L_{night} levels in 2035 for the 4x8 road types, and the numbers of people exposed to these levels (based on estimated numbers of inhabitants per km road length). The lengths of roads with noise barriers and quiet road surfaces in the EU are much smaller than the total road lengths; consequently, the exposure numbers are nearly zero for roads with quiet road surface and/or barriers.

Above the graphs mean values of L_{den} and L_{night} are given, calculated by weighted averaging over the 8x4 road types, using the numbers of exposed people as weights. In the text boxes below the graphs, the most important input parameters are specified. For annual traffic growth in 2017-2035, the value of 1% is used, and for annual population growth a value of 0.1% is used. Comparing the results for scenarios V_0 and V_1 it is seen that the effect of quiet tyres is larger in nonurban areas than in urban areas. This is as expected, since rolling noise is more important in in nonurban areas than in urban areas.

Figure 5.20 shows the exposure distributions for the two scenarios, for years 2017 and 2035. The distributions for 2017 are based on the 2017 END data (as described in Section 5.3), where an EU urban population of 75% of the total population of 445 million has been assumed.

The distributions for years 2018-2035 were derived from the distributions for year 2017, by applying a horizontal shift δL. The value of δL for 2030 is indicated in the graphs, and is derived from the mean levels for the 8x4 road types.

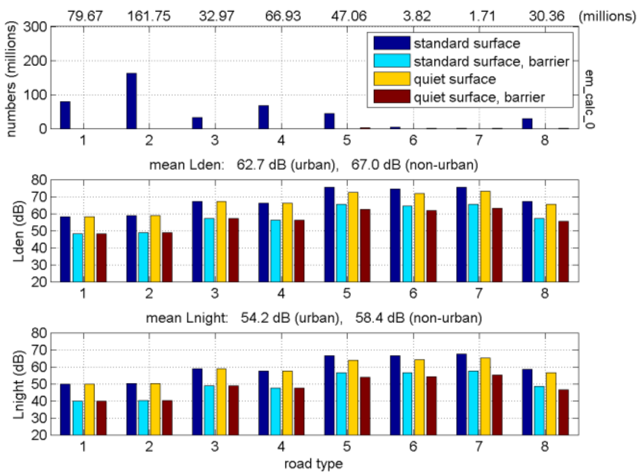
Figure 5.21 shows graphs of the health effects for year 2030, expressed in Euros, DALYs, and numbers of people affected.

Figure 5.22 shows the evolution of health costs and DALYs in the period 2017-2035. The health costs in Euros are approximately a factor of 4 higher with method 1 than with method 2. The percentage reduction due to the noise solution, however, is approximately equal with method 1 and method 2.

Figure 5.23 shows the result of the cost-benefits-analysis. The graph shows the benefits in the period 2017-2035, together with the costs of the noise solution, which is 300 million Euro per year in this case. The health benefits gradually increase over time in the period 2020-2024. The cumulated benefit-cost-ratio is indicated in the legend of the figure.

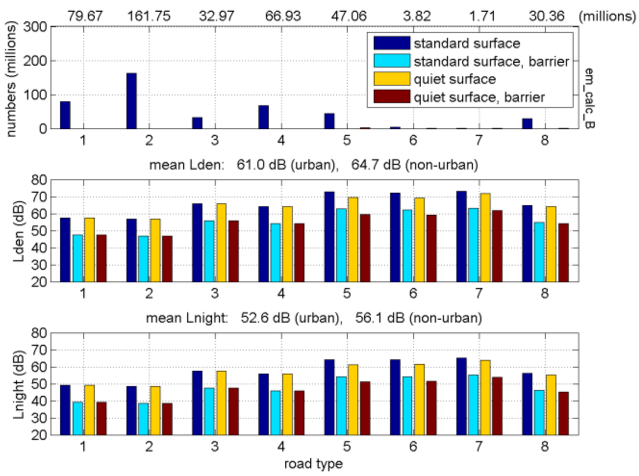
Figure 5.19. Illustration of the road traffic noise emission model, for baseline scenario V0 (left) and for scenario V1 with 3-5 dB quieter tyres in 2024 (right). The graphs show results for 2035. The text blocks show the most important input parameters of the model.

V_0 - baseline scenario




```
----------------------------------------------------------------
vehicle limits 2017-2020
vehicle            2015     2016   2020/22   2024/26    hybrid  electric
car/C1              100        0         0         0         0         0
van/C2              100        0         0         0         0         0
bus/C3              100        0         0         0         0         0
truck/C3            100        0         0         0         0         0
heavy truck/C3      100        0         0         0         0         0
vehicle limits 2035
vehicle            2015     2016   2020/22   2024/26    hybrid  electric
car/C1               15       15        30        10         9        21
van/C2               15       15        35        14         9        12
bus/C3               15       15        25         8        11        27
truck/C3             15       20        30        10        24         2
heavy truck/C3       15       20        30        10        24         2

----------------------------------------------------------------
tyre label 2017-2020
C1    70
C2    72
C3    75
tyre label 2035
C1    70
C2    72
C3    75

----------------------------------------------------------------
annual traffic growth percentage 2017-2035:    1.0

----------------------------------------------------------------
road types:
  urban: residential(1-2), main(3-4), arterial(5), motorway(6)
  non-urban:  motorway(7), main road(8)

quiet road-surface types:
  1(DAB), 2(DGD), 3(ZOAB), 4(ZOAB2L), 5(ZOABF2L)

----------------------------------------------------------------
roads 2017-2020
    1-2      3-4       5       6       7       8
 965652   199796   94118    3824   34141 1517922    km inhabited road length
    250      500     500    1000      50      20    inhabitants per km
      0        0    4706     191    1707   75896    km barrier
      0        0    4706     191    1707   75896    km quiet road length
      1        1       2       2       3       3    type quiet road surface
roads 2035
    1-2      3-4       5       6       7       8
 965652   199796   94118    3824   34141 1517922    km inhabited road length
    250      500     500    1000      50      20    inhabitants per km
      0        0    4706     191    1707   75896    km barrier
      0        0    4706     191    1707   75896    km quiet road length
      1        1       2       2       3       3    type quiet road surface
```

V_1 - scenario with quiet tyres




```
----------------------------------------------------------------
vehicle limits 2017-2020
vehicle            2015     2016   2020/22   2024/26    hybrid  electric
car/C1              100        0         0         0         0         0
van/C2              100        0         0         0         0         0
bus/C3              100        0         0         0         0         0
truck/C3            100        0         0         0         0         0
heavy truck/C3      100        0         0         0         0         0
vehicle limits 2035
vehicle            2015     2016   2020/22   2024/26    hybrid  electric
car/C1               15       15        30        10         9        21
van/C2               15       15        35        14         9        12
bus/C3               15       15        25         8        11        27
truck/C3             15       20        30        10        24         2
heavy truck/C3       15       20        30        10        24         2

----------------------------------------------------------------
tyre label 2017-2020
C1    70
C2    72
C3    75
tyre label 2035
C1    66
C2    69
C3    70

----------------------------------------------------------------
annual traffic growth percentage 2017-2035:    1.0

----------------------------------------------------------------
road types:
  urban: residential(1-2), main(3-4), arterial(5), motorway(6)
  non-urban:  motorway(7), main road(8)

quiet road-surface types:
  1(DAB), 2(DGD), 3(ZOAB), 4(ZOAB2L), 5(ZOABF2L)

----------------------------------------------------------------
roads 2017-2020
    1-2      3-4       5       6       7       8
 965652   199796   94118    3824   34141 1517922    km inhabited road length
    250      500     500    1000      50      20    inhabitants per km
      0        0    4706     191    1707   75896    km barrier
      0        0    4706     191    1707   75896    km quiet road length
      1        1       2       2       3       3    type quiet road surface
roads 2035
    1-2      3-4       5       6       7       8
 965652   199796   94118    3824   34141 1517922    km inhabited road length
    250      500     500    1000      50      20    inhabitants per km
      0        0    4706     191    1707   75896    km barrier
      0        0    4706     191    1707   75896    km quiet road length
      1        1       2       2       3       3    type quiet road surface
```

Figure 5.20. Exposure distributions for the years 2017 and 2035, calculated with the model results from Figure 5.19 for scenarios V0 (left) and V1 (right). Each graph indicates the value of the average noise level change that was used to calculate the 2035 distribution from the 2017 distribution.

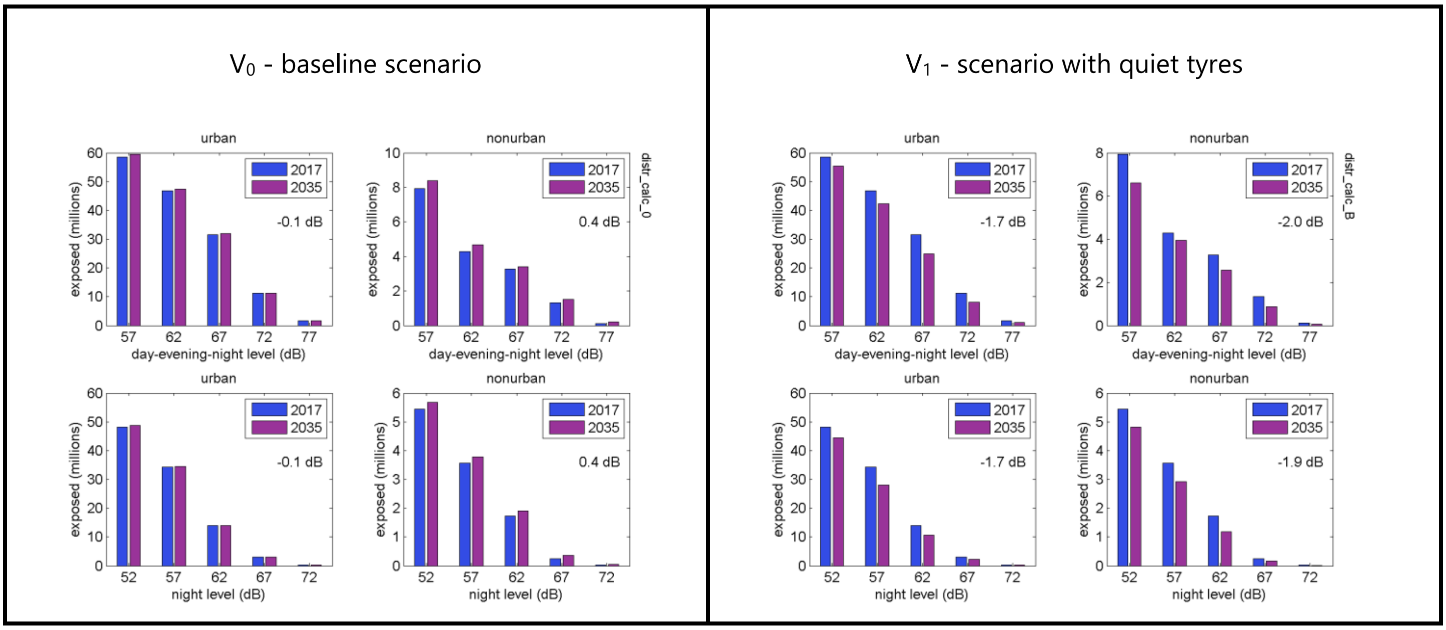


Figure 5.21. Health effects for year 2030 calculated from the distributions shown in Figure 5.20.

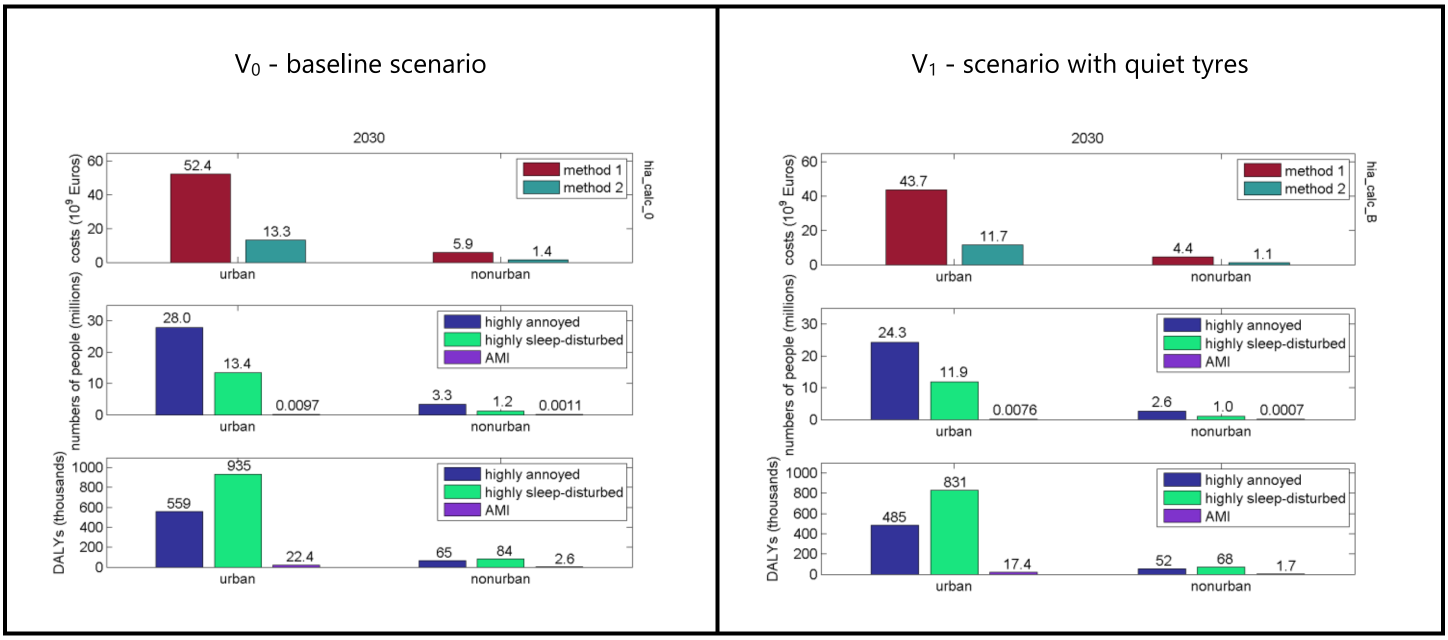


Figure 5.22. Health costs (left) and DALYs (right) in the period 2017-2035.

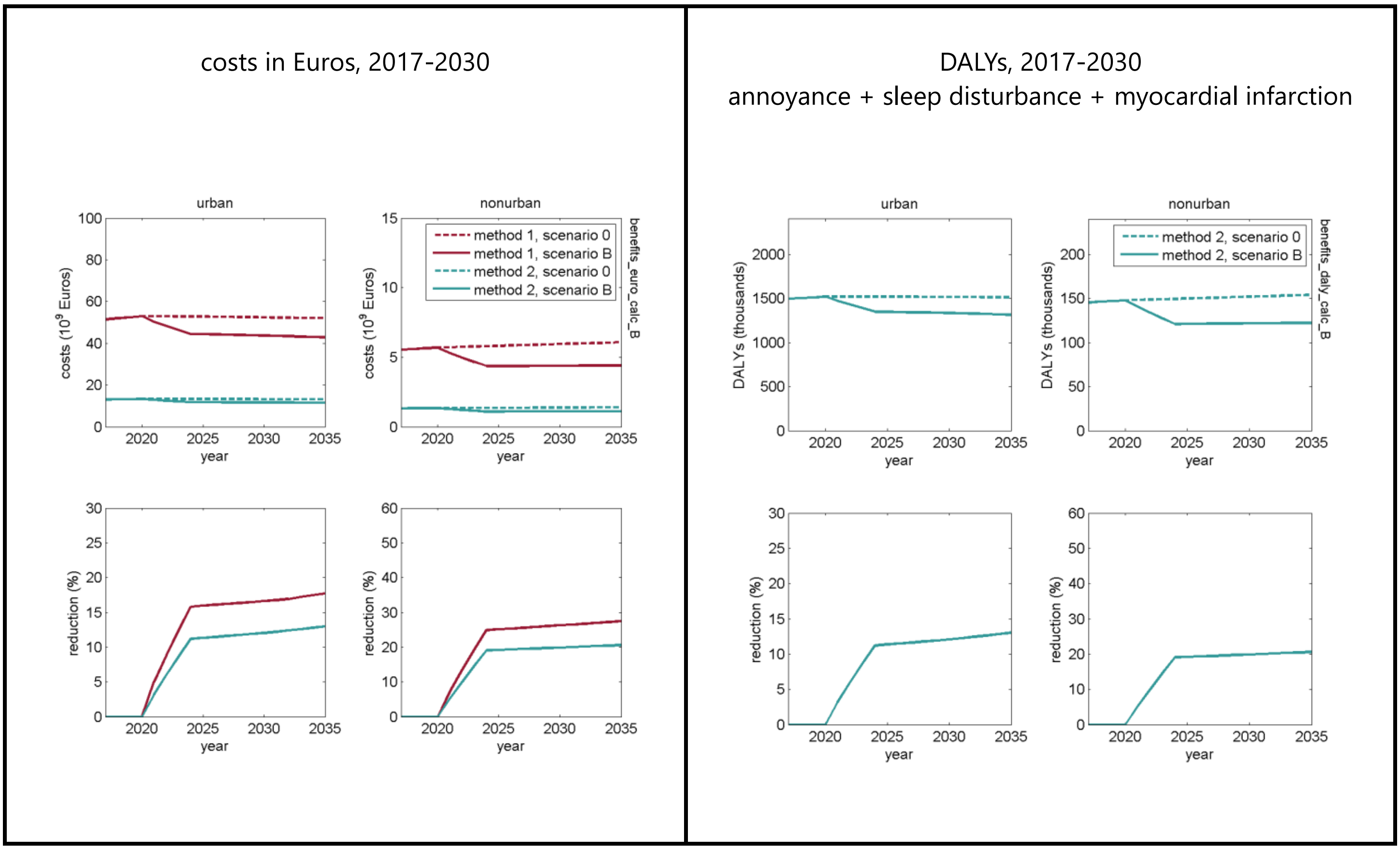
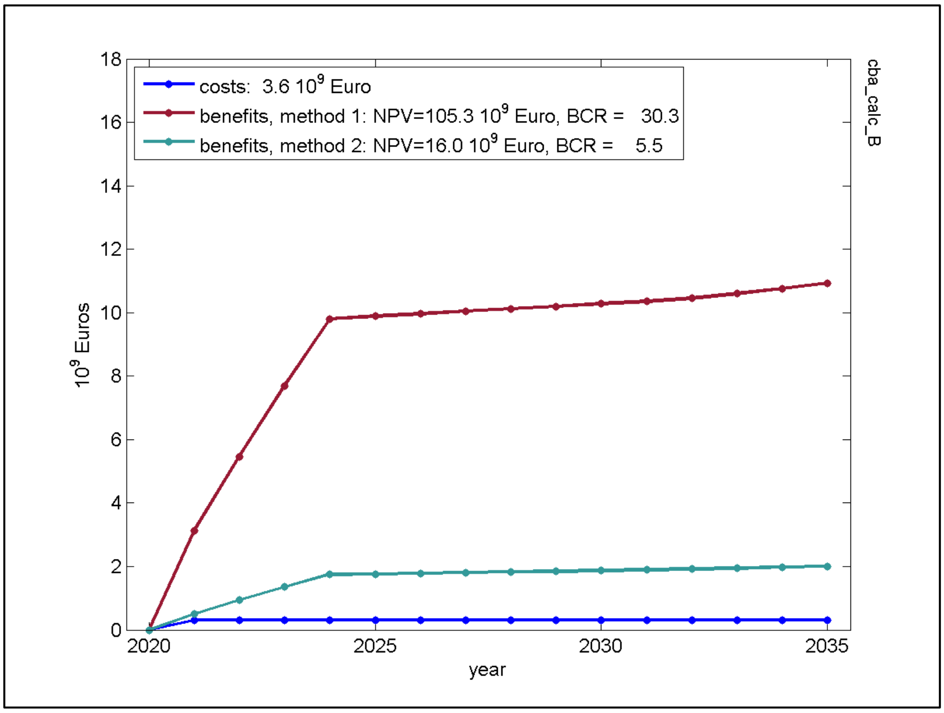


Figure 5.23. Monetized health benefits and costs for implementation of the noise solution in the period 2017-2035.



5.11 Railway noise

The methodology for railway noise is similar to the methodology for road traffic noise described in the previous section. The methodology is based on the following EU exposure distributions for the year 2017:

- exposure distributions for railway noise in urban agglomerations (L_{den} and L_{night}),
- exposure distributions for major railway lines outside agglomerations (L_{den} and L_{night}).

Effects of noise abatement solutions (and autonomous developments) in the period 2017-2035 are taken into account by estimating a *change* of the 2017 exposure distributions. In Section 5.5 four types of noise abatement solutions were distinguished:

- solutions at source,
- solutions at receiver,
- solutions in the propagation path (barriers),
- solutions aimed at the infrastructure and spatial urban planning.

For solutions in the fourth category, such as urban planning, a general strategy cannot be specified and the change in exposure distributions can be derived from test-site calculations or ad hoc arguments.

For solutions at receiver, the change of the exposure distributions is not easy to assess. As described in Section 5.5, the effect of dwelling insulation is approximated by eliminating the inhabitants of dwellings with (additional) insulation from the exposure distributions.

For solutions at source and solutions in the propagation path (barriers), an average noise level *change* will be determined, and applied to the exposure distributions. In the remainder of this section, the model is described that is used for calculating the average noise level change for solutions at source.

Railway noise emission model

The average noise level change due to a noise abatement solution at source is calculated with a model that is called 'railway noise emission model' in this study. The model yields noise levels L_{den} and L_{night} along ten different types of railway lines[246]. Noise levels $L_{den,j}$ and $L_{night,j}$ are calculated for all 19 years in the period 2017-2035 (j = 2017, 2018, ..., 2035). From these levels noise level *changes* are calculated:

$$\Delta L_{den,j} = L_{den,j} - L_{den,j=2017}$$
$$\Delta L_{night,j} = L_{night,j} - L_{night,j=2017}.$$

The level changes are zero for year j = 2017, and gradually change over time. The level changes are different for the baseline scenario and the alternative scenario with the noise solution.

The railway noise emission model takes into account:

- the emission of individual railway vehicles (calculated with the Cnossos model),
- intensities and speeds of the vehicles.

[246] These noise levels are not true emission levels, but rather noise levels at short distance from the railway lines.

Following the EU exposure distributions, a distinction is made between railway lines in urban agglomerations and (major) railway lines outside urban agglomerations. For both cases five different types of railway lines are considered:

1) F50: freight line with speed 50 km/h
2) F80: freight line with speed 80 km/h
3) P60: passenger line with speed 60 km/h
4) P140: passenger line with speed 140 km/h
5) P200: passenger line with speed 200 km/h.

This yields a total of ten different railway line types, five in agglomerations and five outside agglomerations.

In EU 27 the total railway lengths are presently as follows[247]:

- 164 385 km passenger and freight mixed
- 18 553 km passenger only
- 16 324 km freight only.

Consequently, the *partly overlapping* lengths of either freight or passenger lines are as follows:

- S_P = 182 938 km passenger
- S_F = 180 709 km freight.

These are total lengths. Only a fraction of the lines has dwellings and inhabitants at short distance. A value of 0.2 is assumed for this fraction (this value has no effect on the final results for noise exposure). The resulting inhabited lengths of the ten types of railway lines are given in Table 5.17. The values in the third column for the number of people per km were estimated from the numbers of exposed people to railway noise (L_{den}>55dB), as given in the 2017 EEA datafile with END noise-mapping results[189]:

- Agglomerations: all 6.2 million, major 3.5 million
- Major railways: 13.8 million (including agglomerations), 9.8 million (outside agglomerations).

The values in the fourth column in the table yield totals of 6.3 million in urban agglomerations and 10.1 million outside agglomerations.[248]

Other (adjustable) parameters of the ten types of railway lines are given in Table 5.18.

For each railway type three subtypes are considered:

i) railways without noise barriers,
ii) railways with a low noise barrier,
iii) railways with a high noise barrier.

[247] Sources:
i) https://ec.europa.eu/eurostat/web/transport/data/database,
ii) https://www.statista.com/statistics/451818/length-of-high-speed-railway-lines-in-use-in-europe-by-country/,
iii) Ramos M.J., Blanes N., Population exposure to noise from different sources in Europe, 2017.

[248] The numbers of people (and further subdivisions in the next section) are used only as weighting factors for calculating mean noise levels at 50 m distance from the railway lines. Level differences (due to autonomous developments and noise solutions) are used for calculating changes in EU exposure distributions.

So there are 3x10 = 30 different railway types. Typically, low noise barriers are 1 m high and are placed at a distance of 1 m from the track. High noise barriers are typically 2 to 3 m high and are placed at a few meters distance. For both low and high barriers a barrier attenuation of 10 dB is assumed.

Lengths of railway lines with low and high barriers were obtained from the following information[249]:

- Presently there is 3000 km length of high barriers (2 to 3 m),
- Another 500 km of high barriers length is expected over the next ten years,
- Presently there is only 10 km of low barriers.

This implies that we have the following length fractions of the total railway length in the EU:

- no barriers, fraction 0.99,
- low barriers, fraction 0.00,
- high barriers, fraction 0.015.

and also that the fraction of high barriers will increase from 0.015 to 0.0175 over the next ten years. The fraction 0.0175 is used for 2035, and for intermediate years linear interpolation is applied.

Table 5.17. Lengths of ten railway line types and numbers of people along the lines.

Type	Length (km)	Number of people per km	Total number of people (millions)
F50 urban	0.25 S_F * 0.2 = 9035	175	1.6
F80 urban	0.25 S_F * 0.2 = 9035	175	1.6
F50 nonurban	0.25 S_F * 0.2 = 9035	275	2.5
F80 nonurban	0.25 S_F * 0.2 = 9035	275	2.5
P60 urban	0.1667 S_P * 0.2 = 6098	175	1.0
P140 urban	0.1667 S_P * 0.2 = 6098	175	1.0
P200 urban	0.1667 S_P * 0.2 = 6098	175	1.0
P60 nonurban	0.1667 S_P * 0.2 = 6098	275	1.7
P140 nonurban	0.1667 S_P * 0.2 = 6098	275	1.7
P200 nonurban	0.1667 S_P * 0.2 = 6098	275	1.7

Table 5.18. Parameters of the vehicle flow on the ten railway line types.

Type	Vehicle flow, [d e n] (units per hour)	Speed (km/h)	Axles per unit	Unit length (m)
F50 urban	[50 40 20]	50	4	15
F80 urban	[50 40 20]	80	4	15
F50 nonurban	[50 40 20]	50	4	15
F80 nonurban	[50 40 20]	80	4	15
P60 urban	[50 40 20]	60	4	26
P140 urban	[50 40 20]	140	4	26
P200 urban	[50 40 20]	200	4	26
P60 nonurban	[50 40 20]	60	4	26
P140 nonurban	[50 40 20]	140	4	26
P200 nonurban	[50 40 20]	200	4	26

From the vehicle intensities and speeds for the different railway types and the vehicle emission model (described below), noise levels L_{den} and L_{night} are calculated at a distance of 50 m from the railway. For sound propagation, only geometrical spreading of sound waves is taken into account. Ground

249 "Railway noise in Europe", UIC report, March 2016. See: https://uic.org/IMG/pdf/railway_noise_in_europe_2016_final.pdf

attenuation and air absorption are neglected. For barrier attenuation a mean reduction of 10 dB is taken into account.

All parameters of the railway noise emission model are allowed to vary with the year, in the period 2017-2035. In addition, an overall annual rail traffic growth of 1.4% is assumed, based on the EU reference scenario 2016[239].

Cnossos vehicle emission model

To calculate the emission of railway vehicles, the emission model of Cnossos is used[236]. A railway vehicle is modelled as a point source at height 0.5 m. The point source represents the emission of rolling noise. The focus is on passenger and freight trains with speeds up to 200 km/h. Traction noise and aerodynamic noise are neglected.

The rolling-noise model takes into account the following elements:

- wheel and rail roughness
- vehicle transfer function
- track transfer function.

Vibrations are excited by wheel and rail roughness. The transfer functions represent the effects of the vehicle and the track on the sound generation. The vibration wavelengths are converted to a 1/3-octave band frequency spectrum through the train speed. The transfer functions take into account the number of axles per vehicle.

The rolling-noise emission model takes into account horizontal source directivity, with a sine-squared function representing the dipole character of rolling noise. Vertical directivity is neglected in this study.

Categories of roughness, track type, and vehicle type

For each of the ten railway types described before, three subdivisions are considered.

Five categories of wheel-rail roughness R1-R5 are considered:

- R1: CI netrail
- R2: disc netrail
- R3: disc smoothtrack
- R4: KB smoothtrack
- R5: srm cat 8

Seven categories of track type T1-T7 are considered:

- T1: monosoft
- T2: monomed
- T3: monostiff
- T4: bibosoft
- T5: bibomed
- T6: bibostiff
- T7: wooden

Six categories of vehicle type V1-V6 are considered:

- V1: wheel 920
- V2: wheel 840
- V3: wheel 680
- V4: wheel 1200
- V5: freight
- V6: damped wheel

For the baseline scenario, the values of the length fractions $F_{R,j}$, $F_{T,k}$, and $F_{V,n}$ for these subdivisions are given in Table 5.19 - Table 5.21. This means, for example, that the length of type 'F50 urban' lines with subtypes Rj, Tk, and Vn is:

$$S_{F50urban}\ F_{R,j}\ F_{T,k}\ F_{V,n}$$

where $S_{F50urban}$ is the total length of all railway lines of type 'F50 urban' (see Table 5.17).

Table 5.19. Fractions $F_{R,j}$ (j=1,...,5).

Type	R1	R2	R3	R4	R5
F50 urban	1/5	1/5	1/5	1/5	1/5
F80 urban	1/5	1/5	1/5	1/5	1/5
F50 nonurban	1/5	1/5	1/5	1/5	1/5
F80 nonurban	1/5	1/5	1/5	1/5	1/5
P60 urban	1/5	1/5	1/5	1/5	1/5
P140 urban	1/5	1/5	1/5	1/5	1/5
P200 urban	1/5	1/5	1/5	1/5	1/5
P60 nonurban	1/5	1/5	1/5	1/5	1/5
P140 nonurban	1/5	1/5	1/5	1/5	1/5
P200 nonurban	1/5	1/5	1/5	1/5	1/5

Table 5.20. Fractions $F_{T,k}$ (k=1,...,7).

Type	T1	T2	T3	T4	T5	T6	T7
F50 urban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
F80 urban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
F50 nonurban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
F80 nonurban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P60 urban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P140 urban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P200 urban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P60 nonurban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P140 nonurban	1/7	1/7	1/7	1/7	1/7	1/7	1/7
P200 nonurban	1/7	1/7	1/7	1/7	1/7	1/7	1/7

Table 5.21. Fractions $F_{V,n}$ (n=1,...,6).

Type	V1	V2	V3	V4	V5	V6
F50 urban	33/100	20/100	5/100	2/100	30/100	10/100
F80 urban	33/100	20/100	5/100	2/100	30/100	10/100
F50 nonurban	33/100	20/100	5/100	2/100	30/100	10/100
F80 nonurban	33/100	20/100	5/100	2/100	30/100	10/100
P60 urban	33/100	20/100	5/100	2/100	30/100	10/100
P140 urban	33/100	20/100	5/100	2/100	30/100	10/100
P200 urban	33/100	20/100	5/100	2/100	30/100	10/100
P60 nonurban	33/100	20/100	5/100	2/100	30/100	10/100
P140 nonurban	33/100	20/100	5/100	2/100	30/100	10/100
P200 nonurban	33/100	20/100	5/100	2/100	30/100	10/100

Baseline scenario for railway noise

The baseline scenario (Business as Usual, BAU) is defined by the situation for railway noise in 2017-2020, and its autonomous development in the period until 2035. It includes the effects of remaining retrofit programmes and of Quiet routes from 2024, both leading to a majority of quiet freight wagons. The same general considerations apply as for road traffic noise.

For the present analysis we have included the relevant developments in the baseline scenario, based on EC reference scenario[239]. This is represented in Table 5.22. An annual traffic growth of 1.4% is assumed[239]. As described before, the fraction of high barriers will increase from 0.015 to 0.0175[249].

The picture can't be displayed.

Table 5.22. Parameters of the baseline scenario for railway noise, for 10 railway types (1-10).

1	2	3	4	5	6	7	8	9	10	
Fractions of classes of roughness R1-R5, track (T1-T7), vehicles (V1-V6)										
2017-2020 roughness R1-R5										
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R1
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R2
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R3
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R4
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R5
2017-2020 track T1-T7										
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T1
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T2
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T3
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T4
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T5
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T6
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T7
2017-2020 vehicle V1-V6										
0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	V1
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	V2
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	V3
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	V4
0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	V5
0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	V6
2035 roughness R1-R5										
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R1
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R2
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R3
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R4
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	R5
2035 track T1-T7										
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T1
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T2
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T3
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T4
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T5
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T6
0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14	T7
2035 vehicle V1-V6										
0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	V1
0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	V2
0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	V3
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	V4
0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	V5
0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	V6
Traffic growth	annual traffic growth percentage 2017-2035:	1.4								
Railway lengths										
2017-2020										
9035	9035	9035	9035	6098	6098	6098	6098	6098	6098	km inhabited
175	175	275	275	175	175	175	275	275	275	inh. per km
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	perc barr low
1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	1.50	perc barr high
2035										
9035	9035	9035	9035	6098	6098	6098	6098	6098	6098	km inhabited
175	175	275	275	175	175	175	275	275	275	inh. per km
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	perc barr low
1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	1.75	perc barr high

Example

The application of the railway noise emission model will now be illustrated with an example. Graphs of calculated noise levels, exposure distributions, and health effects are shown in Figure 5.24 - Figure 5.28.

The figures show results for two scenarios:

- V_0 - baseline scenario (autonomous developments),
- V_1 - scenario with smooth tracks in 2035 (5/27.5/20/20/27.5% for R1-R5).

Scenario V1 is equal to scenario A in chapter 7.

The graphs in Figure 5.24 show the L_{den} and L_{night} levels in 2035 for the 3x10 railway types, and the numbers of people exposed to these levels (based on estimated numbers of inhabitants per km road length). The lengths of railways with noise barriers in the EU are much smaller than the total railway lengths; consequently, the exposure numbers are nearly zero for railways with barriers.

Above the graphs mean values of L_{den} and L_{night} are given, calculated by weighted averaging over the 3x10 road types, using the numbers of exposed people as weights. In the text boxes below the graphs, the most important input parameters are specified. For annual traffic growth 2017-2035, the value of 1.4% is used, and for annual population growth a value of 0.1% is used. Comparing the results for scenarios V_0 and V_1 it is seen that the effect of smooth tracks is of the order of 4 dB.

Figure 5.25 shows the exposure distributions for the two scenarios, for years 2017 and 2035. The distributions for 2017 are based on the 2017 END data, where an EU urban population of 75% of the total population of 445 million has been assumed.

The distributions for years 2018-2035 were derived from the distributions for year 2017, by applying a horizontal shift δL. The value of δL for 2035 is indicated in the graphs, and is derived from the mean levels for the 3x10 railway types.

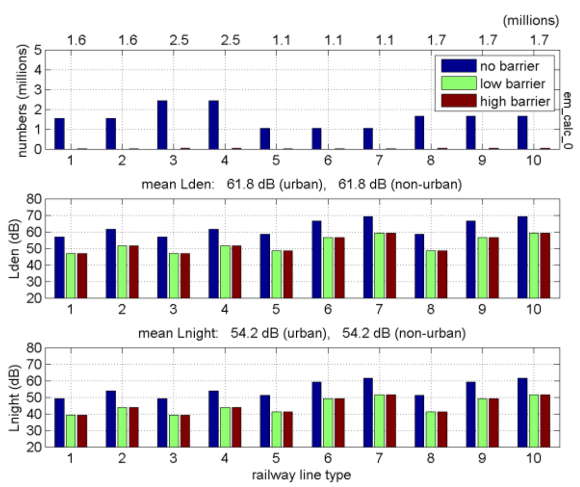
Figure 5.26 shows graphs of the health effects for year 2030, expressed in Euros, DALYs, and numbers of people affected. The values for the baseline scenario are about a factor of 5 lower than for road traffic noise (see Section 5.10).

Figure 5.27 shows the evolution of health costs and DALYs in the period 2017-2035. The health costs in Euros are approximately a factor of 2 higher with method 1 than with method 2. The percentage reduction due to the noise solution, however, is approximately equal with method 1 and method 2.

Figure 5.28 shows the result of the cost-benefits-analysis. The graph shows the benefits in the period 2017-2035, together with the maintenance costs of the noise solution (grinding), which is 3000 Euro per km. The health benefits gradually increase over time in the period 2020-2035. The cumulated benefit-cost ratio is indicated in the legend of the figure.

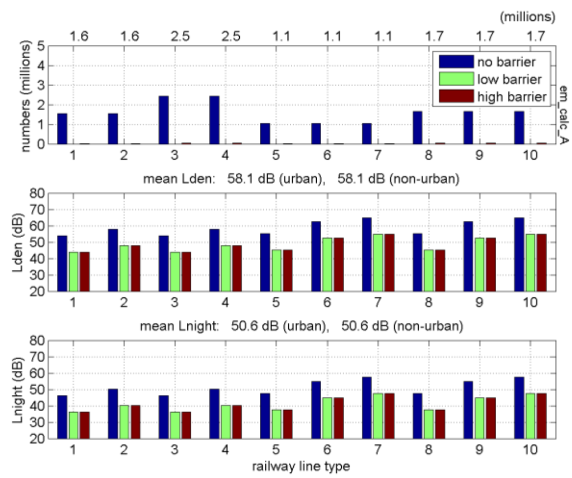
Figure 5.24. Illustration of the railway noise emission model, for baseline scenario V0 (left) and for scenario V1 with smooth tracks in 2035 (right). The graphs show results for 2035. The text blocks show the most important input parameters of the model.

V_0 - baseline scenario




```
---------------------------------------------------------------------------------
annual traffic growth percentage 2017-2035:    1.4
---------------------------------------------------------------------------------
railway line types (u=urban, nu=nonurban; 50u = 50km/h urban):
  (1-4) freight: 50u, 80u, 50nu, 80nu
  (5-10) passenger: 60u, 140u, 200u, 60nu, 140nu, 200nu
---------------------------------------------------------------------------------
       1       2       3       4       5       6       7       8       9      10
---------------------------------------------------------------------------------
2017-2020
    9035    9035    9035    9035    6098    6098    6098    6098    6098    6098 km inhabited
     175     175     275     275     175     175     175     275     275     275 inh. per km
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00 perc barr low
    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50 perc barr high
2035
    9035    9035    9035    9035    6098    6098    6098    6098    6098    6098 km inhabited
     175     175     275     275     175     175     175     275     275     275 inh. per km
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00 perc barr low
    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75 perc barr high
---------------------------------------------------------------------------------
2017-2020 roughness R1-R5
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R2
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R3
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R4
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R5
2017-2020 track T1-T7
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T1
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T2
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T3
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T4
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T5
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T6
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T7
2017-2020 vehicle V1-V6
    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33   V1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   V2
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05   V3
    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02   V4
    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30   V5
    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10   V6
---------------------------------------------------------------------------------
2035 roughness R1-R5
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R2
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R3
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R4
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R5
2035 track T1-T7
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T1
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T2
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T3
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T4
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T5
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T6
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T7
2035 vehicle V1-V6
    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33   V1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   V2
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05   V3
    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02   V4
    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30   V5
    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10   V6
---------------------------------------------------------------------------------
```

V_1 - scenario with smooth tracks in 2035




```
---------------------------------------------------------------------------------
railway line types (u=urban, nu=nonurban; 50u = 50km/h urban):
  (1-4) freight: 50u, 80u, 50nu, 80nu
  (5-10) passenger: 60u, 140u, 200u, 60nu, 140nu, 200nu
---------------------------------------------------------------------------------
       1       2       3       4       5       6       7       8       9      10
---------------------------------------------------------------------------------
2017-2020
    9035    9035    9035    9035    6098    6098    6098    6098    6098    6098 km inhabited
     175     175     275     275     175     175     175     275     275     275 inh. per km
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00 perc barr low
    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50    1.50 perc barr high
2035
    9035    9035    9035    9035    6098    6098    6098    6098    6098    6098 km inhabited
     175     175     275     275     175     175     175     275     275     275 inh. per km
    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00    0.00 perc barr low
    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75    1.75 perc barr high
---------------------------------------------------------------------------------
2017-2020 roughness R1-R5
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R2
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R3
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R4
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R5
2017-2020 track T1-T7
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T1
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T2
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T3
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T4
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T5
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T6
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T7
2017-2020 vehicle V1-V6
    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33   V1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   V2
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05   V3
    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02   V4
    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30   V5
    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10   V6
---------------------------------------------------------------------------------
2035 roughness R1-R5
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05   R1
    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28   R2
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R3
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   R4
    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28    0.28   R5
2035 track T1-T7
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T1
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T2
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T3
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T4
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T5
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T6
    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14    0.14   T7
2035 vehicle V1-V6
    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33    0.33   V1
    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20    0.20   V2
    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05    0.05   V3
    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02    0.02   V4
    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30    0.30   V5
    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10    0.10   V6
---------------------------------------------------------------------------------
```

Figure 5.25. Exposure distributions for the years 2017 and 2035, calculated with the model results from Figure 5.24 for scenarios V0 (left) and V1 (right). Each graph indicates the value of the average noise level change that was used to calculate the 2035 distribution from the 2017 distribution.

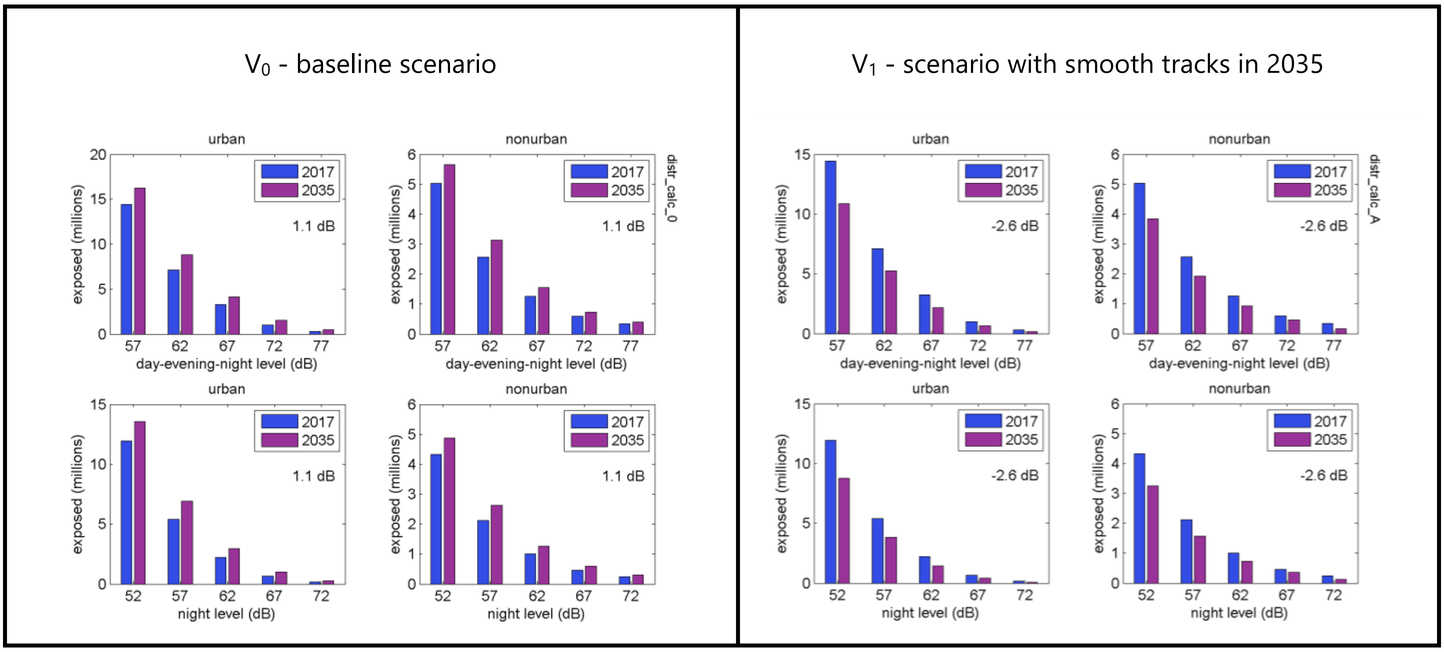


Figure 5.26. Health effects for year 2030 calculated from the distributions shown in Figure 5.25.

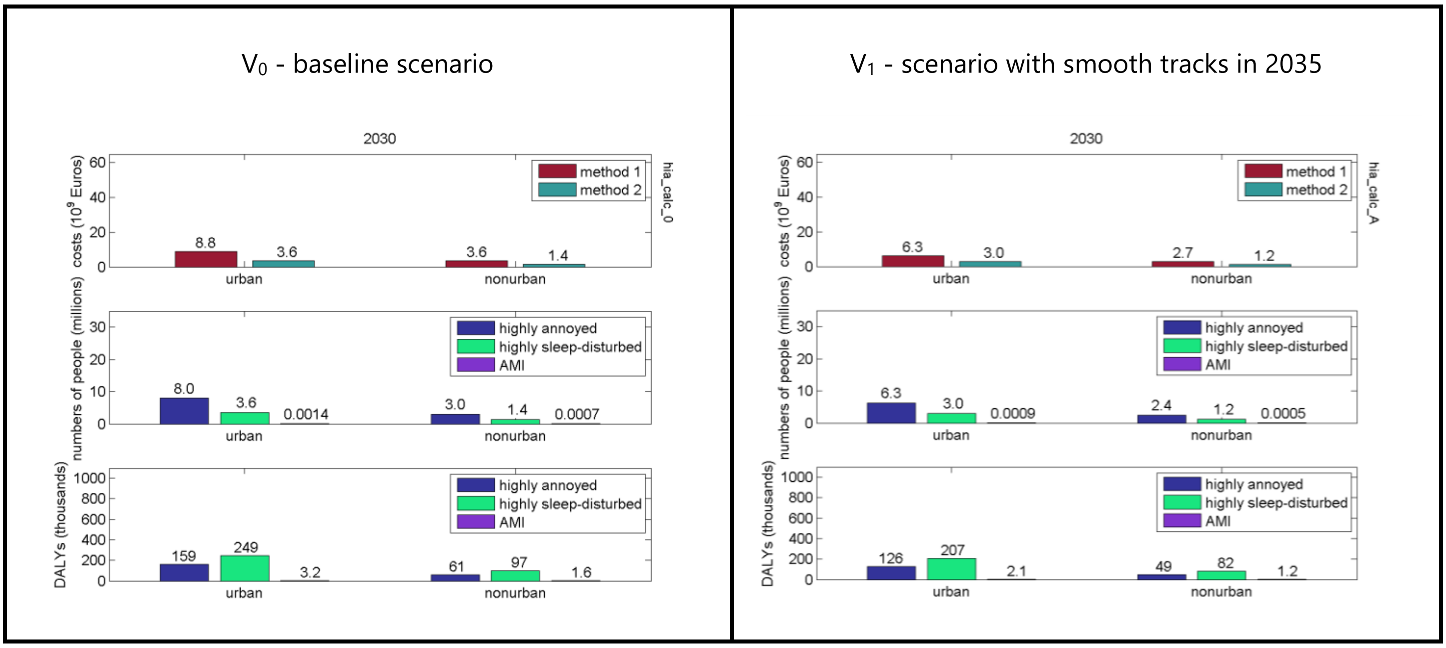
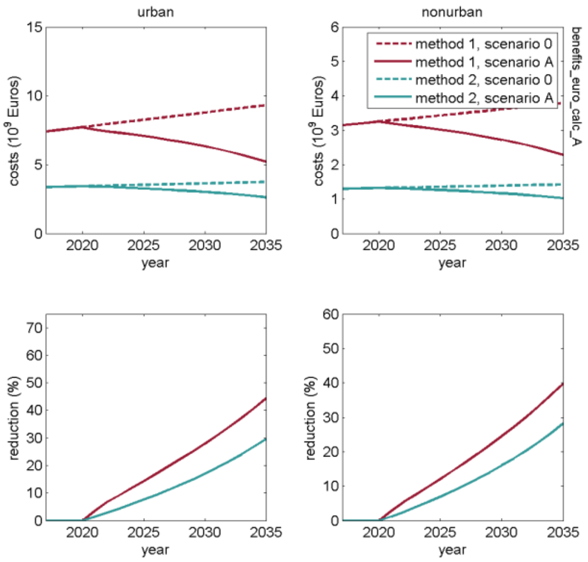


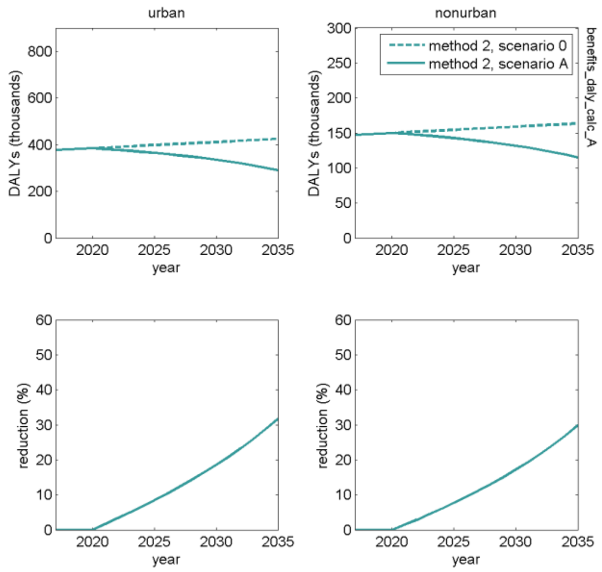
Figure 5.27. Health costs (left) and DALYs (right) in the period 2017-2035.

costs in Euros, 2017-2035



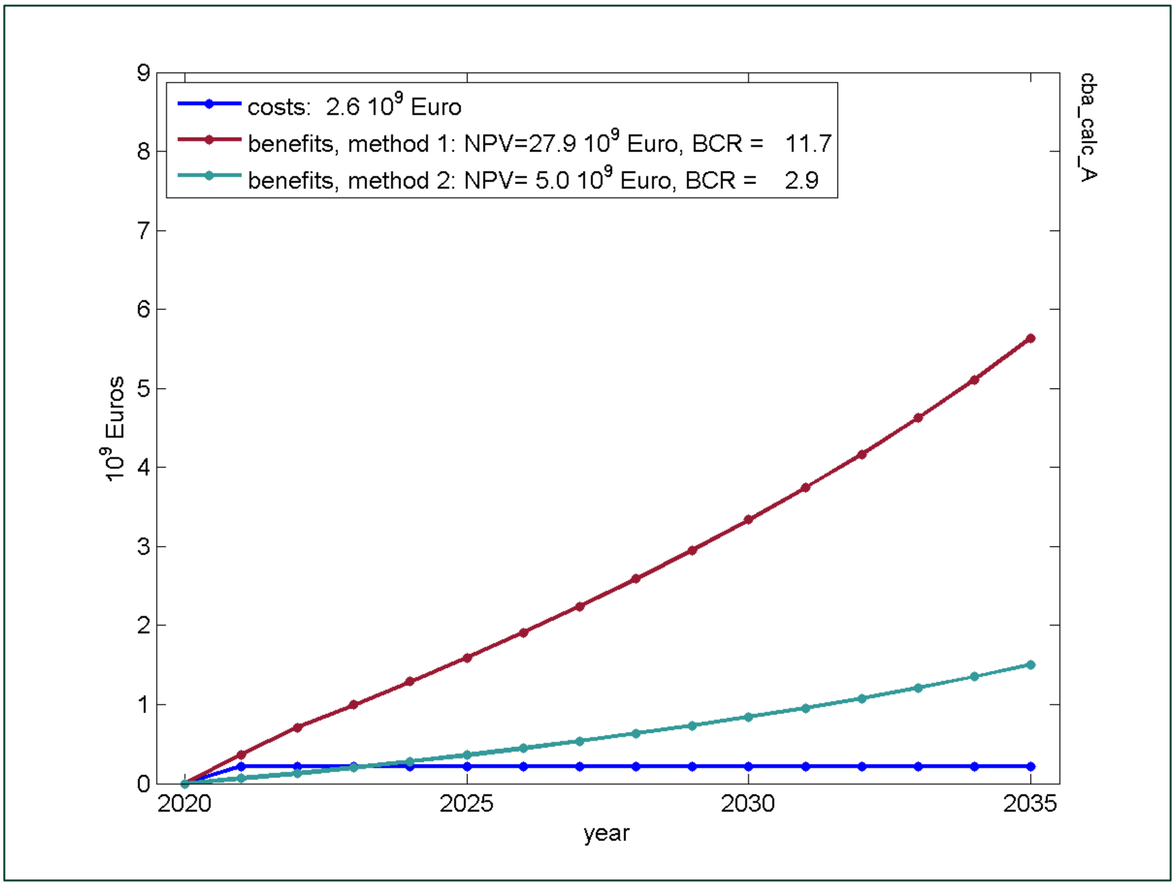
benefits_euro_calc1.png

DALYs, 2017-2035
annoyance + sleep disturbance + myocardial infarction



benefits_daly_calc1.png

Figure 5.28. Monetized health benefits and costs for implementation of the noise solution in the period 2017-2035.



5.12 Aircraft noise

For aircraft noise only the 60 EU27 airports that had to be included in the END 2017 round will be considered. The aircraft noise exposure of the EU population is largely determined by these 60 airports.

Due to the relatively limited number of "noise sources" as compared to road or rail traffic, special attention has to be paid to correctly establish the number of people exposed for each individual airport, since the contribution of each one to the total exposure is not negligible.

Determination of exposure to airport noise

Unfortunately, the data provided by the EEA, based on the END 2017 reporting, is not complete (e.g. all French airports are missing) and not consistent when considering the data for inside/outside agglomerations as compared with the reported total. Therefore, first a methodology needed to be defined to obtain a best estimate of the population exposure to airport noise for each individual airport. This methodology makes use of a classification of airports according to their size (i.e. number of yearly movements). This classification is also used for the assessment of noise solutions, based on the test site approach (Table 5.23).

Table 5.23. Classification of airports based on their size / definition of test sites

Class	Nº of yearly movements	Nº of airports	Examples (test sites)
Large	> 250.000	8	Amsterdam (AMS) Frankfurt (FRA) Copenhagen (CPH)
Medium	150.000 – 250.000	15	Vienna (VIE) Dublin (DUB) Palma de Mallorca (PMI) Lisbon (LIS)
Small	< 150.000	37	Cologne (CGN) Budapest (BUD) Naples (NAP) Gothenburg (GOT)

In the END 2017 dataset[189], data for aircraft noise exposure is provided on two datasheets of the file END_DF4_DF8_Results_2017_190101.xls.

On datasheet "Major air updated", data is provided for each of the 60 major airports:

- Number of people exposed Lden >55, >65, >75; *Including Agglomerations*
- Number of people exposed to different 5 dB noise bands (Lden, Lnight); *Outside Agglomerations*

On datasheet "Aggl_Air_Data", data is provided for agglomerations:

- Number of people exposed to different 5 dB noise bands (Lden, Lnight); *Inside Agglomerations*

None of these datasets is complete, but filling gaps by simply considering that "Including" = "Inside" + "Outside" appears not possible due to lack of coherence between the 3 datasets (probably due to a difference in interpretation by the Member States of what each dataset should represent) and especially because the dataset "Inside" does not contain any information for more than 50% of the 60 airports. Therefore, a gap filling methodology had to be developed to obtain the exposure distributions required for the health effect calculations.

In general, two alternative approaches exist to derive the total number of people exposed for the different 5 dB noise bands required:

1. Use the "Including Agglomerations" dataset

   Since exposure data is only given in terms of Lden >55, > 65 and >75, this dataset requires the determination of the distribution among the 5 dB noise bands, in addition to an estimate of the exposure data for the night period.

2. Use the "Inside Agglomerations" and "Outside Agglomerations" datasets

   These datasets are providing exposure for the required 5 dB bands for both Lden and Lnight, but due to the important gaps in the data for many airports, work is required to obtain full sets

Since in either of these two approaches significant gap filling needs to be performed, none of these alternatives could be considered the best, before actually applying the methods. Hereafter a description is given of the application of both approaches. The two approaches are referred two as option 1 and option 2 below.

Option 1

The first objective here is to establish the total number of people exposed >55 Lden. This information is not known for 12 of the 60 airports. To fill these gaps, use has been made of the population exposure calculations that Anotec did with SONDEO and which was later used in a study performed by RIVM for EEA[250]. The population data from this study was compared with the data provided for the END 2017 for those airports available in both datasets. Based on this relationship and the known SONDEO results an estimate could be made for the population >55 Lden for 8 of the 12 missing airports. For the remaining 4 (all smaller ones), for which no prediction was made in the RIVM study, an estimate was made based on the relationship Σ(Npop>55)/Σ(Nmov), which for the airports in the Small class was determined to be 0.29241 pop/mov. Multiplying the known number of movements for the missing airports by this factor, an estimate for the population >55 Lden was obtained.

The next objective was to determine the total number of people exposed >50 Lnight. This information is not available in the END dataset and therefore was derived from the mentioned SONDEO study, from which the factor Σ(Npop>50Lnight)/Σ(Npop>55Lden) = 0.425 was derived. This factor was used for all airports to obtain an estimate for the number of people exposed >50 Lnight.

The third step of the methodology is to convert the numbers > 55 Lden or > 50 dB Lnight to distributions over the different 5 dB bands, for both Lden and Lnight. For this step, use is made of relative distributions over the 5 dB bands, in percentages of the total number exposed to Lden > 55 dB or Lnight > 50 dB. Here three possibilities were identified:

a. Use the relative distribution as provided by EEA for END2017[251]
   This distribution was obtained for the EU28 airports, using significant gap filling
b. Use the relative distribution from the SONDEO study for RIVM, averaged over all airports
c. Use the relative distribution from the SONDEO study for RIVM, based on the three airport size classes

Table 5.24 presents the results of these three alternatives. The numbers in the table are percentages of the total number exposed to Lden > 55 dB or Lnight > 50 dB.

Table 5.24. Relative exposure distribution for airports (in % of total)

5dB distribution		Lden					Lnight				
Option	**Airports**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
1a	All	81.50	15.72	2.32	0.39	0.06	82.54	14.48	2.98	0.01	0.00
1b	All	72.97	22.29	3.94	0.80	0	76.24	19.78	3.10	0.68	0.21
1c	Large	80.27	16.75	2.33	0.65	0	84.13	12.90	1.98	0.78	0.21
	Medium	69.50	24.63	5.13	0.75	0	68.24	27.71	3.45	0.49	0.10
	Small	72.15	25.75	1.83	0.26	0	85.78	12.06	1.70	0.33	0.13

It can be seen that the distribution from the EEA study (1a) is very similar to that of the SONDEO study for large airports (1c-large). However, for medium and small airports the distributions are significantly different, where around 10% of the people in the band 55-59 dB is shifted to the band 60-64 dB. This is also found back in the average option (1b).

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[250] Implications of environmental noise on health and wellbeing in Europe - Eionet Report - ETC/ACM 2018/10

[251] "Noise indicators under the Environmental Noise Directive - Methodology for estimating missing data" Eionet Report - ETC/ATNI 2019/1

With these results the absolute exposure distribution can be calculated, by multiplying the total numbers Σ(Npop>55Lden) and Σ(Npop>45Lnight) by the percentages from Table 5.24.

Finally, summation over the 60 airports yields the EU27 distributions given in Table 5.25.

Table 5.25. Absolute exposure distribution for airports (in millions) calculated with Option 1

Pop (millions)		Lden					Lnight				
Option	Airports	55-59	60-64	65-69	70-74	>75	50-54	55-59	60-64	65-69	>70
1a	EU27 / END	1.994	0.385	0.057	0.010	0.001	0.858	0.151	0.031	0.000	0.000
1b	EU27 / END	1.786	0.546	0.096	0.019	0.000	0.793	0.206	0.032	0.007	0.002
1c	EU27 / END	1.778	0.573	0.082	0.013	0.000	0.681	0.276	0.034	0.005	0.001

Option 2

In this option the total number of people exposed to airport noise is derived from the datasets for Inside and Outside Agglomerations (sheets “Aggl_Air-Data” and “Mair-Data_Update” of file END_DF4_DF8_Results_2017_190101.xls). These datasets provide population in each of the 5 dB bands, for both Lden and Lnight.

For the “Inside” dataset, data for some agglomerations had to be combined, since they belong to the same airport. In addition, this dataset has been extended with some information provided in the file “NoiseDatabase_DF4_8_2017_190101_Aggl_MAirData.xlsx”, which was obtained via the EEA.

Depending on the availability of data for the airports in the Inside and/or the Outside datasets, the following methodology was followed:

1. Airport data available for both Inside and Outside

   This is the case for only 25 of the 60 airports. In this case the total population exposed for each noise band can be obtained directly from the sum of Inside and Outside.

2. Airport data available for Inside only

   This happens for only 2 of the 60 airports. For these airports the population exposed for Outside is calculated by:

   $$\text{Outside} = \text{Tot}_{av\_1} - \text{Inside}$$

   where Tot_{av_1} is the average of the 3 distributions calculated for that airport in Option 1.

   In case the resulting Population Outside was found to be negative, it is set to 0.

3. Airport data available for Outside only

   This happens for 25 of the 60 airports. For these airports the population exposed for Inside is calculated by:

   $$\text{Inside} = \text{Tot}_{av\_1} - \text{Outside}$$

   where Tot_{av_1} is the average of the 3 distributions calculated for that airport in Option 1.

   In case the resulting Population Inside was found to be negative, it is set to 0.

4. Airport data not available for Outside nor Inside

   This happens for 8 of the 60 airports. For these airports the following method is used:

Calculate the fraction $FR_i = Outside_1/Tot_{av\_1}$ for all 60 airports

where $Outside_1$ and Tot_{av_1} are the average of the 3 distributions calculated for that airport in Option 1.

Then the average values of FR are calculated for each 5 dB band, for both Lden and Lnight. These are given in the table below.

Table 5.26. Multiplication factor FR

	Lden					Lnight				
	55-59	60-64	65-69	70-74	>75	50-54	55-59	60-64	65-69	>70
FR	0.595	0.481	0.341	0.216	0.096	0.446	0.300	0.254	0.104	0.077

Then the following calculations provide the number of people Inside and Outside for the airports for which data is missing:

$Outside = FR \cdot Tot_{av\_1}$

$Inside = Tot_{av\_1} - Outside$

Once both the Inside and the Outside datasets have been completed according to the above described methodology, the total population exposed can be calculated by summing both results.

Finally, summation over the 60 airports yields the EU27 distributions given in Table 5.27.

Table 5.27. Absolute exposure distribution for airports (in millions) calculated with Option 2

Pop (millions)		Lden					Lnight				
Option	Airports	55-59	60-64	65-69	70-74	>75	50-54	55-59	60-64	65-69	>70
2	EU27 / END	1.767	0.543	0.094	0.016	0.000	0.737	0.166	0.024	0.002	0.000

Both Options 1 and 2 required a significant amount of gap filling. As neither option can be considered the most appropriate, it is therefore considered that the average distribution of all options would be the most adequate. Table 5.28 has been derived by averaging the results of options 1a, 1b, 1 c and 2. Exposure distribution at airport class level is also provided, as this may be required in subsequent parts of this study.

Table 5.28. Final exposure distribution for airports (in millions) for the year 2017

Pop (millions)		Lden					Lnight				
Option	Airports	55-59	60-64	65-69	70-74	>75	50-54	55-59	60-64	65-69	>70
Average	Large	0.401	0.087	0.013	0.003	0.000	0.148	0.037	0.006	0.001	0.000
	Medium	0.753	0.235	0.046	0.008	0.000	0.329	0.087	0.014	0.001	0.000
	Small	0.677	0.189	0.023	0.004	0.000	0.291	0.076	0.011	0.001	0.000
Total	**EU27 / END**	**1.831**	**0.512**	**0.082**	**0.015**	**0.000**	**0.767**	**0.200**	**0.031**	**0.004**	**0.001**
		2.440					**1.002**				

This analysis is based on the END results, and thus only covers noise levels above the END limits of 55 dB Lden and 50 dB Lnight. For the health impact assessment, the distributions are extrapolated to levels below the END limits, as described In Section 5.3.

From the above data some statistics have been derived, which may be useful in the study on noise solutions. The statistics are given in Table 5.29.

Table 5.29. Statistics on exposure distribution for airports

Airports	N	%N	%mov	%Pop >55Lden	%Pop >45Lnight	%Pop/ airport
Large	8	13	34	21	19	2.6
Medium	15	25	33	43	43	2.8
Small	37	62	33	37	38	1.0

From the table it can be seen that:

- The number of movements are equally distributed among the 3 classes
- The big airports are only responsible for around 20% of the population exposed to airport noise
- The medium airports are contributing slightly more to the total population exposed than the small ones, but the number of small airports is more than double that of medium
- On a per-airport base (last column), the large and medium airports contribute more or less equally to the population exposed, with an average contribution of around 2.7% of total population for each individual airport. Each small airport only contributes with an average 1% per airport.

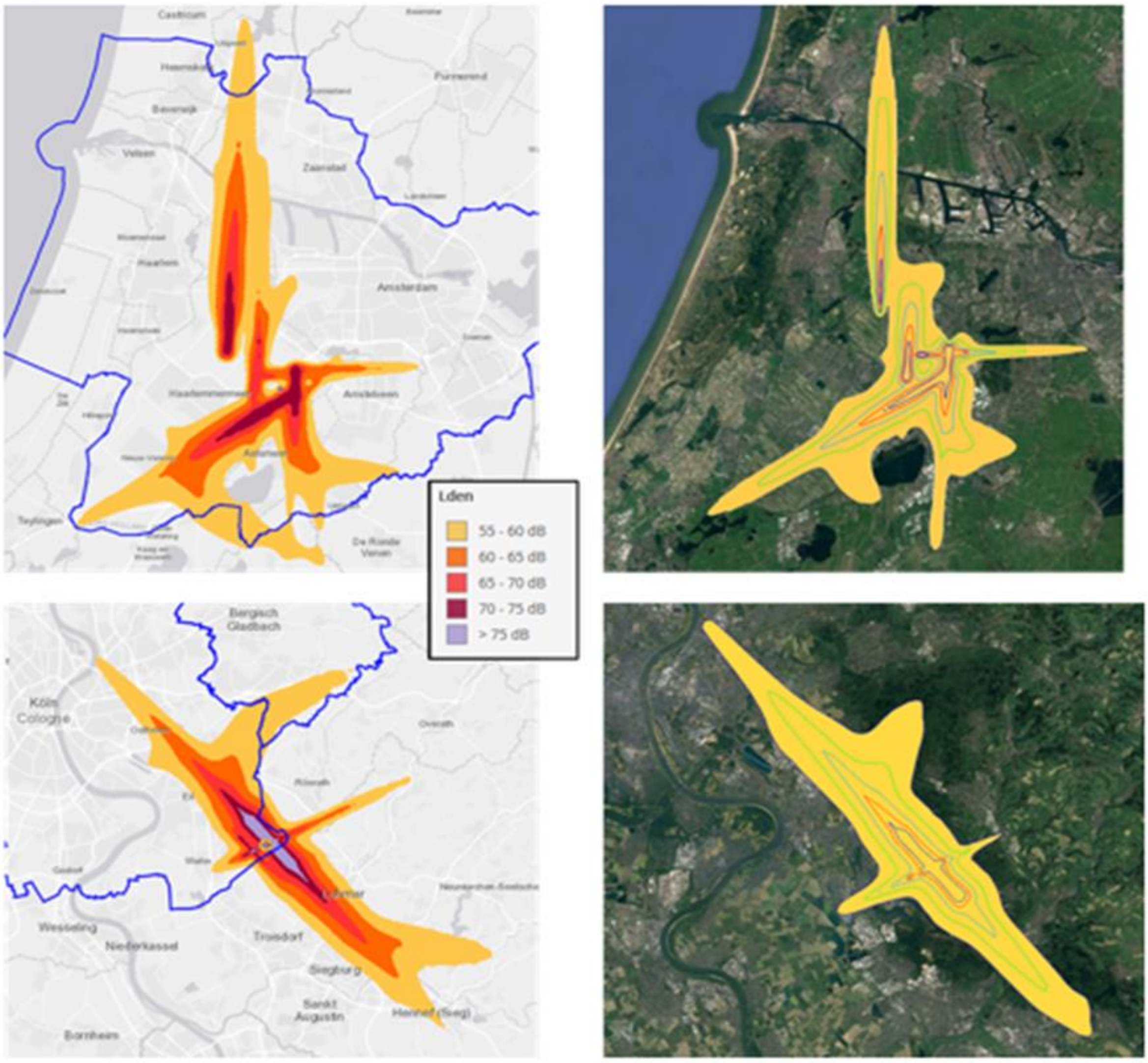
Methodology for Airport Noise

The effects of noise control measures at airports are rather different from that for road and rail. Only a limited amount of airports is of interest, but each airport has its own specificities (population relative to the airport, fleet mix, night movements, degree of implementation of noise control measures under the Balanced Approach, etc) which significantly influence the benefits to be obtained from noise solutions. On the other hand, it is to be noted that some of the solutions that may be proposed will have a positive effect on one airport, whereas the same measure on another airport may not have an effect at all. Even at a single airport a noise solution with a benefit at one location may have a negative effect at another location (e.g. shift of tracks). The effects at specific locations, and also the overall effect for the whole airport, will depend on the local situation and the actual solution considered. Therefore, the methodology to be followed for the assessment of noise solutions at airports is significantly different from that used for road and rail.

The noise model used for the calculation of the exposure distribution due to airport noise is the SONDEO model, developed by Anotec and compatible with ECAC Doc29 4th edition. The existing input dataset, covering 51 EU airports, was used in former EC studies and contains information on runway/track usage at the time of those studies. 10 of the 11 test airports are included in this dataset. Only for Budapest airport a new dataset had to be created. For the other 10 airports the aircraft fleet and airspace usage may have changed since the original studies. Since these airports will be used to assess the noise solution measures, it is important that the results are representative for the noise situation at these airports. To check this, publicly available data from the OpenSky network[252] was used to compare the current traffic movements with the original SONDEO input and the latter was adjusted where considered appropriate. Unfortunately, no reliable traffic data for Naples airport appeared to be available in the OpenSky database. With the thus updated dataset a prediction was made for 10 test airports, with the number of movements as reported for the END. Figure 5.29 shows an example of the results for END and SONDEO for 2 of the 10 airports, from which it can be concluded that, although similar, differences are present.

[252] OpenSky 2020.

Figure 5.29. END (left) and SONDEO (right) Lden noise contours for AMS (top) and CGN (bottom) airports.



The available data gives an indication that these differences may be, at least partly, attributable to a reduction in track dispersion in the current traffic as compared to the original dataset, which reduces the width of the lobes of the contours, at the expense of enlarging them. Due to this, a populated area may be affected in the old study, but not in the current dataset, or vice versa. The publicly available data, however, is not sufficient to update the dispersion model. As will be seen in the next chapter, track dispersion is one of the objectives of the noise control measures, and a correct modelling of the baseline scenario is therefore paramount. It was therefore decided to purchase a license for the OpenSky database, covering a much longer period of time, which provides sufficient information to perform a correct modelling of the track dispersion. At the same time, it allows for a better adjustment of the current aircraft fleet mix at the various airports, as well as the distribution of movements among the runways and tracks.

As a further improvement to former SONDEO studies, the GHS population grid[253] has been used.

Table 5.30 compares the population estimated by SONDEO with the END result for the 11 test airports, grouped by aircraft class. Also, here it can be seen that the SONDEO predictions are representative for the 2017 noise situation at these airports.

Table 5.30. Comparison between SONDEO and END results for the test airports and factor for scaling to EU27 (2017 traffic).

Airports	Population for Lden>55 dBA					Population for Lnight>50 dBA				
	Test			All		Test			All	
	SONDEO	END	Δ%	END	F	SONDEO	END	Δ%	END	F
Large	0.202	0.238	-15%	0.504	2.502	0.062	0.101	-39%	0.191	3.096
Medium	0.262	0.335	-22%	1.043	3.976	0.109	0.143	-24%	0.431	3.958
Small	0.172	0.219	-21%	0.893	5.180	0.086	0.093	-7%	0.380	4.391

Since the test airports only constitute a part of the total number of major airports in the EU27, the results from the SONDEO calculations need to be scaled up to EU level. For this, a scaling factor F is used for each airport class and for Lden and Lnight respectively.

The factor F is defined by:

F = Pop_tot_class / SONDEO_test_class

where:

Pop_tot_class = The population reported for the END for Lden>55 or Lnight>50 for all airports in each class

SONDEO_test_class = the population calculated by SONDEO for the test airports in each class

In this manner F accounts for the scaling to EU level, but also corrects for any error in the SONDEO estimates for 2017.

Now the noise model has been set up and provisionally validated, the calculations can be made at the test airports for the baseline situation and the different noise solution measures considered. The baseline case is described in more detail below.

The SONDEO scenario generator is used to create the input to the noise model, corresponding to the scenario considered. For the baseline situation, this is limited to multiplying the number of operations, used for the 2017 case, taking into account the yearly increase of 1.7861% (see description of baseline scenario below). The noise model is then executed with this new input for each of the 11 test airports and the following procedure is followed to establish the exposure distribution:

1. Determine the population exposed to Lden>55 and Lnight>50 dBA for each test airport.
2. Sum this population for the test airports in each airport class
3. Multiply the results from 2. by the corresponding factor F presented in Table 5.30
4. Determine the total population exposed by summing the results of the 3 classes, obtained in 3.

[253] Eurostat, 2016.

5. Determine the relative exposure distribution for the total of the 11 test airports.
6. Apply this distribution to the result of 4, yielding the absolute exposure distribution for the baseline case.

This procedure is repeated for all years in the 2018-2030 period. Table 5.31 gives the results of this exercise.

Table 5.31. Baseline exposure distribution for airports (in millions) for the years 2017-2030

	Pop ($\cdot 10^6$)	Lden					Lnight				
Year	**Nmov ($\cdot 10^6$)**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
2017	**8.818**	1.831	0.512	0.082	0.015	0.000	0.767	0.200	0.031	0.004	0.001
2018	8.976	1.866	0.521	0.084	0.015	0.000	0.788	0.205	0.031	0.004	0.001
2019	9.136	1.901	0.531	0.085	0.015	0.000	0.809	0.211	0.032	0.004	0.001
2020	9.299	1.936	0.541	0.087	0.016	0.000	0.830	0.216	0.033	0.004	0.001
2021	9.465	1.971	0.551	0.088	0.016	0.000	0.851	0.221	0.034	0.004	0.001
2022	9.634	2.006	0.560	0.090	0.016	0.000	0.872	0.227	0.035	0.004	0.001
2023	9.807	2.041	0.570	0.092	0.016	0.000	0.893	0.232	0.036	0.004	0.001
2024	9.982	2.076	0.580	0.093	0.017	0.001	0.914	0.238	0.036	0.004	0.001
2025	10.160	2.110	0.590	0.095	0.017	0.001	0.935	0.243	0.037	0.004	0.001
2026	10.341	2.145	0.599	0.096	0.017	0.001	0.956	0.249	0.038	0.004	0.001
2027	10.526	2.180	0.609	0.098	0.017	0.001	0.976	0.254	0.039	0.004	0.001
2028	10.714	2.215	0.619	0.099	0.018	0.001	0.997	0.260	0.040	0.005	0.001
2029	10.906	2.250	0.629	0.101	0.018	0.001	1.018	0.265	0.040	0.005	0.001
2030	11.100	2.285	0.638	0.103	0.018	0.001	1.039	0.270	0.041	0.005	0.001

The same procedure as described above will be applied to estimate the exposure distribution for the scenarios representing noise solution measures. The scenario generator needs to be configured such that the desired noise solution is correctly simulated. Depending on the exact measure, this may be done by redistributing certain operations over aircraft types, using new vertical profiles, changing the dispersion characteristics, etc.

Once the exposure distribution for the noise solution measure has been obtained, its effect on cost and health can be determined.

Baseline scenario for Airport Noise

The exposure distribution for 2017, given in Table 5.28, is extrapolated to the years 2020 up to 2030. For this, the Base Traffic Forecast from the European Aviation Environmental Report 2019 is used[254]. According to this forecast the number of flights will grow 25% in the period 2017-2030, which corresponds to a yearly growth of 1.7861%.

This growth rate will be adopted here. In addition, the following assumptions are made:

- The increase in number of movements is the same for all airports and is applied evenly to all aircraft movements, maintaining the same runway/track distribution
- The population distribution around the airports remains constant
- Airport infrastructure remains unchanged
- For the baseline case, the 2017 fleet composition is maintained until 2030.

Example: Noise exposure distribution for the insertion of new technology aircraft

The baseline case assumes a constant fleet composition, i.e. in 2030 still the same aircraft fleet will be used at the different test airports as the one that was flying in 2017. As a first exploratory example of what the new technology aircraft could contribute to reducing the noise at airports, a theoretical case is proposed, where all conventional A320/B737 aircraft are replaced by their new generation (NEO/MAX) equivalents. This replacement is supposed to be completed in 2025, year for which the exposure distribution will be determined. After this, the resulting fleet mix will remain constant again (now with all new tech aircraft), and only the 1.78% growth factor in movements will be considered, and the exposure distribution for 2030 will be calculated. In this scenario the number of operations will be kept the same as in the baseline.

Table 5.32 gives the SONDEO results for the test airports, covering steps 2 to 4 of the procedure, whereas Table 5.33 presents the relative exposure distribution for the 11 test airports together (step 5). The final result is presented in Figure 5.30.

Table 5.32. Population exposed at the test airports when replacing conventional by new technology aircraft (years 2025 and 2030)

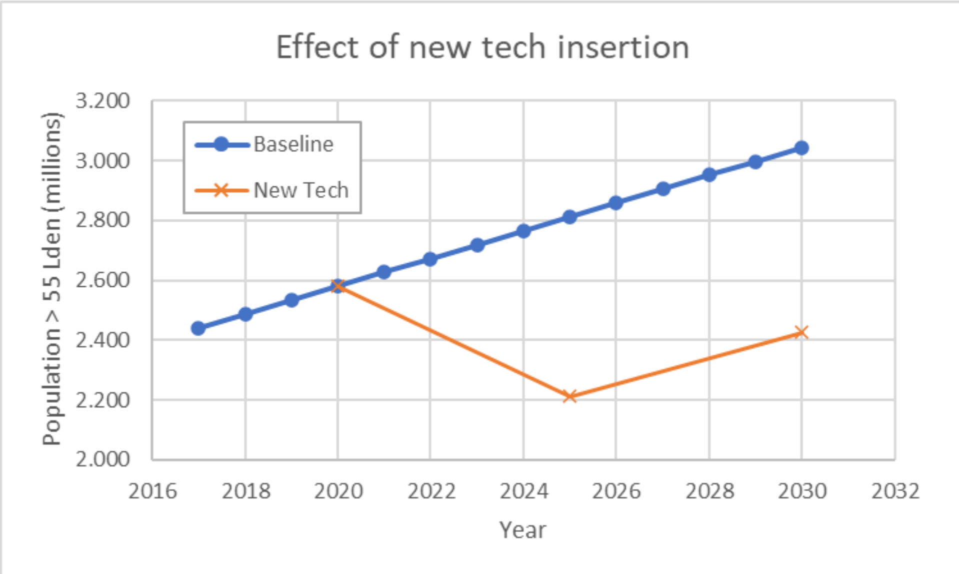
	2025				2030			
	Population (millions) for				Population (millions) for			
Airports	Lden>55 dBA		Lnight>50 dBA		Lden>55 dBA		Lnight>50 dBA	
	Test	All	Test	All	Test	All	Test	All
Large	0.179	0.449	0.069	0.215	0.202	0.506	0.077	0.238
Medium	0.212	0.843	0.095	0.377	0.228	0.907	0.102	0.404
Small	0.178	0.920	0.084	0.371	0.196	1.014	0.091	0.401
All		2.212		0.962		2.427		1.044

[254] EASA, 2019

Table 5.33. Change in Exposure distribution when replacing conventional by new technology aircraft (years 2025 and 2030)

		Population (millions) for									
		Lden					Lnight				
Year	Case	55-59	60-64	65-69	70-74	>75	50-54	55-59	60-64	65-69	>70
2025	Baseline	2.110	0.590	0.095	0.017	0.001	0.935	0.243	0.037	0.004	0.001
	New tech	1.561	0.564	0.079	0.008	0.000	0.733	0.204	0.023	0.002	0.000
	Change	-0.549	-0.026	-0.016	-0.009	0.000	-0.201	-0.040	-0.014	-0.003	-0.001
2030	Baseline	2.285	0.638	0.103	0.018	0.001	1.039	0.270	0.041	0.005	0.001
	New tech	1.706	0.606	0.103	0.013	0.000	0.783	0.231	0.028	0.002	0.000
	Change	-0.579	-0.033	0.000	-0.005	-0.001	-0.257	-0.040	-0.013	-0.003	-0.001

Figure 5.30. Change in exposure due to the insertion of new technology aircraft



As can be seen in Figure 5.30 the baseline case sees affected population grow over time, fully due to the traffic growth. When fleet replacement is taken into account, the number of people affected seems to be more or less stable, which is in line with the findings of the EASA 2019 report. The original assumption for the baseline of constant fleet composition seems therefore not appropriate. In the remainder of this study a natural fleet replacement shall thus be considered. To this end the 0.1 dB/year noise reduction as maintained by ICAO/CAEP WG1 is adopted for the baseline.

5.13 Uncertainty and limitations

There are two types of uncertainty in the results of this study:

- Uncertainty caused by assumptions and approximations in the methodology.
- Uncertainty caused by uncertainty in the model parameters and scenario parameters.

Both types of uncertainty are discussed in this section.

Assumptions and approximations in the methodology

There are assumptions and approximations in all elements of the methodology:

- Sound emission
- Exposure distributions
- Health effects
- Monetization and cost-benefit analysis.

For road traffic noise and railway noise, sound emission is calculated with a model that takes into account different types of roads and railway lines. These represent the real situation in the EU in an approximate way. The effects of noise reduction scenarios on the noise exposure of EU inhabitants is approximated by calculating noise level *changes* and applying these to the END exposure distributions, which were calculated by the EU member states, using various engineering calculation methods[255]. For aircraft noise the approach is slightly different, as exposure distributions are calculated for 11 airports, and the results are scaled up to EU level.

There are also approximations in the steps from exposure distributions to the health effects. Exposure-response functions provide only estimates of annoyance, sleep disturbance, and other health effects. An important approximation is the use of façade levels at the dwelling, as an approximation for the 'true' noise exposure of people. Health effects are also expressed in DALYs, using disability weights from the literature, which also have a considerable uncertainty.

The monetization is also a source of uncertainty, as noise valuation methods only provide crude estimates of the price of health effects in Euros. The costs of noise measures, which are used in the cost-benefit analysis, are also estimates and therefore a source of uncertainty.

Two noise valuation methods have been used in this study. The results presented in Chapter 7 show that the two methods yield different results for the absolute noise health burden, and also for the *changes* in health burden due to noise reduction scenarios. The differences are largest for road traffic noise, up to a factor of about 4. The two method agree much better on the *relative* changes in health burden, in percentages; in this case the difference is less than a factor of 2 in most cases. This is important, since an objective of this study is to identify noise scenarios that yield a 20 to 50% reduction of the health burden.

[255] Uncertainties in the END exposure distributions were discussed in Sections 5.3 and 5.9.

Uncertainty in the model parameters and scenario parameters

There are many input parameters for the calculation methodology used in this study. Examples are the following.

- Traffic parameters
- Vehicle emission parameters
- Road lengths
- Lengths of quiet road surface and noise barriers
- Annual traffic growth and EU population growth
- Costs for noise reduction measures.

All parameters are more or less subject to uncertainty. An additional source of uncertainty is the variation of the parameters over the appraisal period 2020-2035. For example, road vehicles are expected to become quieter, but the evolution of the fleet with increasing numbers of quiet tyres and hybrid and electric vehicles is a source of uncertainty.

To assess the effect of this type of uncertainty, various sensitivity analyses were performed. In Chapter 7 results will be presented for various scenarios, but in addition results will be presented for the same scenarios but with *modified* input parameters (see Sections 7.3 and 7.6). In some cases the effects of the variation of input parameters is large, in other cases it is small.

5.14 Exposure-response functions

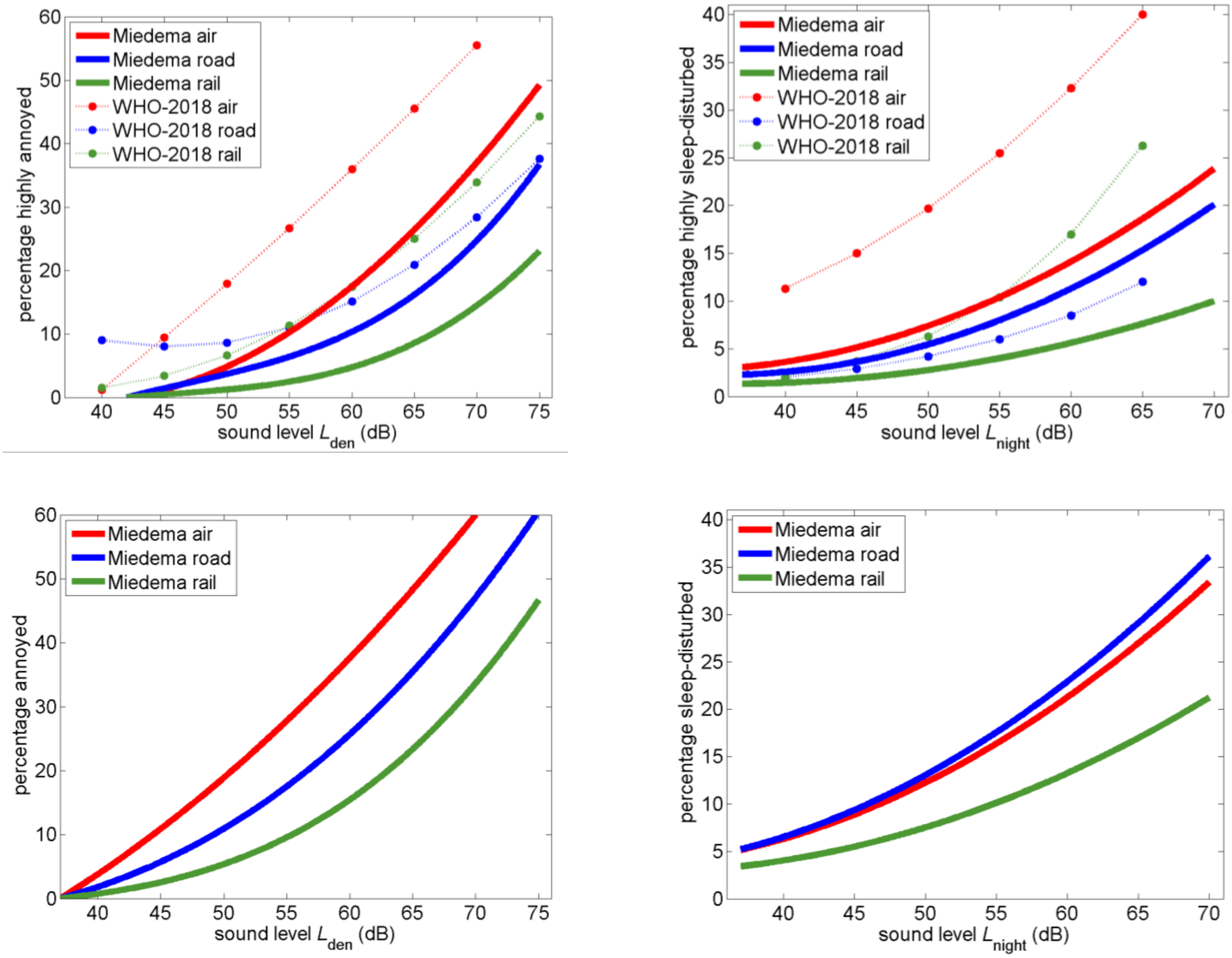
In this study, exposure-response functions (ERFs) are used for annoyance and sleep-disturbance, developed by Miedema and co-workers and reported for WHO in 2011[203] and 2009[210]. In 2018, WHO has published a report[206] with new ERFs for high annoyance (HA) and high sleep-disturbance (HSD). The new ERFs are given in the form of tables with percentages HA and HSD at levels Lden and Ln in 5 dB steps. The ERFs of Miedema and WHO are compared in the graphs below. Also shown are the graphs of ERFs of Miedema for A and SD.

The WHO ERFs are higher than the Miedema ERFs, in particular for rail and aircraft. Since there are no ERFs of WHO for A and SD, a practical solution is used in this study for all four (HA,HSD,A,SD):

- for road, use Miedema road ERFs,
- for rail, use Miedema air ERFs,
- for air, use Miedema air ERFs multiplied by a factor of 2, with a maximum of 100%.

For example, the Miedema air ERF gives about 17% highly annoyed at L_{den} = 60 dB (see graph below). For this study we use 34% (i.e. a factor of 2 higher than 17%), which is close to the value of 36% given by the WHO ERF at L_{den} = 60 dB.

Figure 5.31. Exposure-response functions for high annoyance, high sleep disturbance, annoyance, and sleep disturbance.



6 Potential of available noise abatement solutions

Authors: Michael Dittrich (TNO), Erik Salomons (TNO), Nico van Oosten (Anotec)

6.1 Introduction

In the context of this study and the terms of reference, a number of noise abatement measures are selected for each transport mode to assess their overall potential impact in terms of health benefits. These are broadly in line with the Commission Future brief on noise abatement approaches (2017). [256] and are well known.

Measures which are not yet available or require further research are not included here as in general, they would not have significant impact before 2030. This is because approval and market introduction can take several years, after which several more years are required before implementation over the whole fleet or infrastructure takes place.

Each measure is described in terms of its

- Principle
- Illustration
- Potential noise reduction
- Availability
- Implementation level
- Implementation time and life cycle
- Costs and benefits at EU level
- Triggers and obstacles for implementation at national or EU level
- Causal links to legislation
- Key references.

Quantitative cost estimates are set out in tables 5.4-5.6. The calculated benefits and CBA results are presented in sections 7.2, 7.4 and 7.6 for road, rail and aircraft respectively.

Noise abatement solutions for road, rail and aviation are applicable to noise both inside and outside agglomerations, which are therefore not treated separately in terms of noise solutions.

Application and implementation levels of noise abatement solutions differ substantially between member states and regions, which in turn depends on policy priority, traffic, fleet and infrastructure characteristics, and available funding.

Solutions related to land use, urban planning and traffic control are wider in scope than technical solutions at source or receiver, as there are many factors well beyond the question of noise exposure in terms of Lden/Lnight levels, such as safety, mobility, air quality, and social-economic issues. Although these factors are beyond the scope of this study, there are often synergies between them leading to higher benefits than when only noise exposure is considered. The noise abatement

[256] Science for Environment Policy (2017) Noise abatement approaches. Future Brief 17. Produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol. Available at: http://ec.europa.eu/science-environment-policy

The picture can't be displayed.

solutions described here are primarily physical, and in most cases there is a legislative trigger. This is often noise reception limits, which are regulated at national level, and differ between member states. The noise reception limits are assessed against noise mapping results, generated either for EU noise mapping or as separate planning models, such as those used for new infrastructure and/or new buildings. The source noise limits for vehicles are triggered at EU level.

Modal shift

Modal shift from road to other more sustainable means of transport also has potential as a noise abatement solution, either driven by policy or incentives.

Examples of modal shift, both at local or international level, are:
- introduction of light rail or electric buses and restriction of private vehicles;
- expansion of rail passenger traffic shifting from road and air transport to rail;
- shifting of road freight to rail or waterways; and
- discouraging of car use in urban centres and encouraging cycling and walking.

Modal shift includes both transport and tourism, passenger and freight. It is not included here as a separate solution, although it is in fact indirectly covered within individual solutions and scenarios such as electrification, mobility management, urban planning and access restrictions.

Modal shift goes beyond individual road traffic noise solutions in a much broader context and scope. In the report 'Modal shift in European transport: a way forward' (2018) [257], it is set out that the change at EU level is very slow in this respect, due to multiple obstacles including current infrastructure, fleets, private car ownership, transport costs and time, rate of digitization and others.

At EU level, targets have been set in the 2011 White Paper on transport[258], including a shift to rail, driven by environmental factors. However, the report states:

'Despite an increase in freight volumes, the modal share of road, rail and inland waterway freight transport remained substantially unchanged between 1996 and 2016, both for passenger and freight transport, with road transport showing a slight increase. Looking at future projections, ***road transport is expected to keep its predominant position both for the passenger and freight sectors****. However, its modal share is expected to decrease by a few percentage points, mainly to the benefit of rail transport.*

The Corona crisis has had some effects similar to modal shift, in particular

- a drop in road traffic, but shift from public transport to individual means such as car, bicycle and foot
- a significant drop in air traffic
- a drop in public transport

Recovery is expected to take some years in particular for the aviation sector.

Green Deal and climate ambition

[257] Pastori E, Brambilla M, Maffii S, Vergnani R, Gualandi E, Skinner I, 2018, Research for TRAN Committee – Modal shift in European transport: a way forward, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels

[258] 2011 EU White Paper on transport

In a recent impact assessment by the Commission on climate ambition for 2030[259], new targets and scenarios are set out for the European Green Deal, resetting the Commission's commitment to tackling climate and environment-related challenges. It also takes the potential impacts of Covid-19 into account, although these are still uncertain.

The Green Deal includes a dedicated roadmap with key policies and measures for a growth strategy towards a prosperous and healthy future, with no net emissions of greenhouse gases in 2050 (climate neutrality). To achieve this, more ambitious targets are required for 2030. This will affect the future fuel mix and electrification of transport and other sectors.

On transport policy, it is stated: '*Other policies that indirectly impact also GHG emissions of transport are diverse and include wide span of possible actions. **They include policies that impact modal shift, development of related infrastructure, traffic management systems, pricing systems addressing other externalities and promote digitalisation of the transport system**.*'

Therefore in the scope of this study, and in particular for noise abatement solutions, these factors are be taken into account, given that they will affect the vehicle fleets.

6.2 Solutions for road traffic noise abatement

The following noise abatement solutions for road traffic noise are set out and characterised in tables 6.2-6.8:

1) Tyre noise reduction via the tyre noise label
2) Reduction of rolling noise by road surface, such as porous asphalt and/or smooth asphalt and improved maintenance
3) Whole vehicle noise reduction, by quieter powertrains (e.g. electric) and tyres
4) Noise barriers, standard or special, including absorbent or tilted barriers and lane barriers
5) Traffic management including speed and access restrictions, such as re-routing or limiting road traffic, for example by a congestion charge or access restrictions for areas with high noise exposure and for noisy vehicles, including low emission zones (LEZ)
6) Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, urban layout, including renovation and reconstruction
7) Sound insulation of residential and communal buildings, including funding schemes for homeowners.

Solutions 1-4 and 7 are specifically driven by noise legislation and regulations, whereas solutions 5 and 6 are driven by many other factors, in particular traffic management, air quality, urban regeneration and economic growth. Vehicle noise of powertrains may also decrease in the next ten years due growth in electric vehicles, besides the tightening of all vehicle sound limits as foreseen in EU legislation. This depends on the evolution of the fleet, driven by other factors, in particular emission policy as stated in the Green Deal, and the 2050 ambition for a climate-neutral economy.

[259] Impact Assessment - Stepping up Europe's 2030 climate ambition - Investing in a climate-neutral future for the benefit of our people, European Commission, Staff Working Document, Final, 17 September 2020.

Solutions found in action plans

In the Noise action plan (NAP) analysis performed in this study, the solutions for road noise abatement were found in the percentages as indicated in table 6.1. These are not indicative of the actual extent, but give an impression of how often such measures are mentioned.

The results found here point towards the frequent application of traffic management, quiet road surfaces and infrastructure measures.

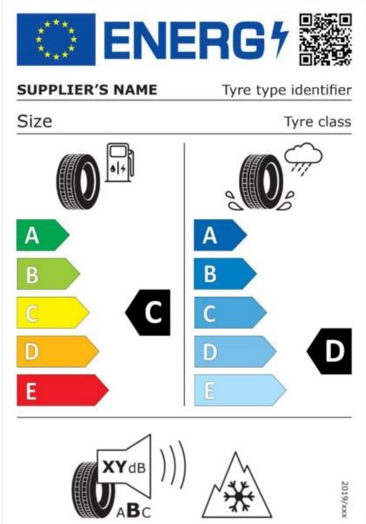
Table 6.1: Percentages of noise abatement solutions found in noise action plans in the EU.

Road noise abatement measure	Percentage in NAPs
Traffic management, flow, routing and other	18.2%
Traffic restrictions, access, vehicle types and other	4.1%
Speed limits	7.2%
Electrification	2.5%
Tyre noise reduction	0.9%
New bypass roads	3.4%
Quiet road surfaces	11%
Infrastructure measures, incl. reconstruction, renewal, land use	15.1%
Other spatial planning	3.2%
Quiet areas	5.2%
Noise barriers	7.7%
Soundproof windows	3.4%
Other building insulation and design	2.7%
Public communication and awareness	7.2%

Table 6.2 Tyre noise reduction via the tyre noise label

<table>
<tr><th>Noise abatement measure</th><th>Quieter tyres via the tyre label</th></tr>
<tr><td>Principle and example(s)</td><td>The European tyre label includes the key parameters wet grip (for safety), rolling resistance (for energy consumption) and noise (for environment).
Tyre noise depends on[260] speed and both tyre and road surface parameters, including the running surface of the tyre (profile), tread stiffness, belt stiffness, mass, width, diameter, relative groove volume, and on the road paving properties, including porosity and smoothness. Also the temperature affects the noise emission.

Tyres with lower average noise label value may produce less noise especially on smoother road surfaces..
For cars, tyre noise can be the dominant source from around 30 km/h, whereas for heavy vehicles, it may be above around 60 km/h. On heavy vehicles, traction tyres are of different design to others and therefore somewhat louder. Tyres on heavy vehicles can be quieter after wear, but also due to the larger diameter and contact patch which averages out part of the excitation. Retreaded tyres are not covered by the noise label, but are most relevant for lorries, trucks and buses, upto 50% in some countries.

Tyre limits could be tightened in two steps of 2 dB in the coming years, resulting in EU-wide benefits. Including retreaded tyres in the label scheme is also an option to ensure overall lower noise levels.</td></tr>
<tr><td>Illustration</td><td>


Tyre label including rolling resistance, wet grip and noise

<table>
<tr><th colspan="2">Stage 2</th></tr>
<tr><th>Nominal section width</th><th>Limit dB(A)</th></tr>
<tr><td>185 and lower</td><td>70</td></tr>
<tr><td>Over 185 up to 245</td><td>71</td></tr>
<tr><td>Over 245 up to 275</td><td>72</td></tr>
<tr><td>Over 275</td><td>74</td></tr>
</table></td></tr>
</table>

[260] Science for Environment Policy (2017) Noise abatement approaches. Future Brief 17. Produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol. Available at: http://ec.europa.eu/science-environment-policy

	Stage 2 noise limits (LAmax) for car tyres (C1) as set out in UN Regulation 117r4, referred to by EU Regulation 2019/2144 and in force from 2018/2020. The quietest tyres on the market are already 2-4 dB lower than these stage 2 limits. The picture is similar for types for larger vehicles.
Noise reduction	2-4 dB in the tyre noise depending on road surface, vehicle type and speed and tyre size. The potential is highest for smooth, absorptive and well maintained road surfaces. Noise reduction can be calculated for different road surfaces, such as in the EU CNOSSOS model, and has been measured in various studies.[261] Tyre noise is less dominant at lower speeds for which powertrain noise is stronger, i.e. in intermittent traffic, at junctions and crossings. Tighter noise limits and/or market incentives are required to drive levels down.
Modelling	This measure is at source. The main noise generation mechanisms are mechanical excitation of the tyre by the road surface and tread profile, and aerodynamic phenomena such as air pumping and resonances in tyre voids. Both the mechanical and acoustic response of the tyre contribute to the sound radiating due to tyre vibration. Empirical and numerical models are available for the noise emission as a function of tyre profile, dimensions, design and road surface characteristics. Tyre noise in relation to the noise label is not included as a parameter in national or EU prediction models, but the effect of the tyre label can be estimated by taking the average penetration of quieter tyres and the extent of smooth road surfaces.
Availability	Tyres with the lowest noise label value are already on the market, although in the minority[262]. Other parameters such as wet grip, rolling resistance, price and other performance parameters are also sales criteria.
Implementation level	According to a Dutch tyre database[263], around 20% of car tyres on the market in 2018 were 4 dB below the highest level of 72 dB(A). This would need to increase significantly in the coming years to around 80% to take effect in overall traffic noise levels. The potential is strongest if EU tyre noise limits are tightened, as previously proposed in the GRB (UNECE)[264].
Implementation time, life cycle	The average life of tyres is around 4 years, meaning that the major part of the fleet can be modified in this period once the label value decreases.
Costs and benefits at EU level	Costs are deemed to be limited as quieter tyres are already on the market, although their uptake is slow[262]. Further R&D may be required to align all technical requirements. No more than 2% in tyre price is foreseen once available on large scale. Tyres for electric vehicles are already more expensive due to their higher specifications (torque and loading). The benefits will be strongest for main roads and motorways with good quality road surface, depending on the average tyre label, road type/speeds, affected road length and numbers of exposed population. However, the overall roadside noise reduction is not immediate due to the evolution in the whole fleet.
Triggers and obstacles for implementation	Triggers for quieter tyres are the tyre noise limits, public awareness and pricing. The need for quieter tyres is also driven by reception limits, as far as their performance is reflected in national prediction models. The triggers for lower tyre noise limits at EU level are perceived need, clarity of the benefits and consensus. If the public can be convinced that tyres with a better label will reduce noise, but also save on fuel costs, that can be a major incentive. These benefits were identified in a TNO study from

[261] LEO study (CORE project), T. Berge, J. Ejsmont, P. Mioduszewski, Low Emission Optimised tyres and road surfaces for electric and hybrid vehicles - Feasibility study and cost/benefit analysis – Final report, December 2016.

[262] https://www.etrma.org/key-topics/tyre-regulations/

[263] VACO Tyre database, Netherlands, 2018

[264] https://www.unece.org/fileadmin/DAM/trans/doc/2016/wp29grb/GRB-62-11e-Rev.1-Add.1.pdf

	2014[265], [266]in which it was also concluded that safety and energy consumption to not have to be conflicting with noise performance. On the side of the road authorities, there is a strong need to reduce noise impacts, not only by quiet road surfaces but also where possible via quieter tyres. The STEER study[267] (2020-2021) has been initiated by CEDR to enhance the impact and proliferation of quiet tyres on European roads, taking into account uncertainties of the tyre label and representativeness for EU roads. According to a ACEA study[268] , by UTAC-CERAM, on noise versus other performance factors it is stated that 'Obtaining a low level of rolling sound performance without a compromise regarding other parameters essential for vehicle safety and CO2 emission reduction could not be proven as feasible by this study'. It is stated that further research is required here as still many questions remain on test methods and other tyre classes. A study by the European Tyre and Rim Association (ETRTO), also by UTAC-CERAM, presented at the 73rd GRBP[269] in 2021, concluded that wet grip and longitudinal and lateral aquaplaning can conflict with reducing tyre noise, based on comparison of a study sample of one tyre size (15% of replacement market, and for maximum speeds of 210-270 km/h) and ten different types including some winter tyres. It states that 'further reduction of rolling sound emissions will irremediably impact other tyre performances'. An additional finding was that the various tyre noise tests at different speeds all seem to correlate reasonably well. A question here is what the conclusions would be for lower speed and load ratings and the remaining 85% of other tyre sizes, given the speed limits on most European roads. Further review of performance of a wider range and of in-use tyres would provide better insight. A study for the Swiss Federal Office for the Environment[270] has investigated the potential for low noise tyres on different road surfaces and concluded that a potential of 4 dB is feasible, taking into account the ongoing trends in tyre width and height, hardness and wear. 14 tyres with different dimension, profile and noise label were tested on 12 different road surfaces. Since according to other studies, tyre noise reduction potential seems not significantly to diminish with tyre age, the study recommends that policy makers devote more resources to the proliferation of quieter tyres by improving label relevance and understanding. In a Danish study[271] the reduction potential for quieter tyres was investigated for 31 tyre models on 31 different road surfaces, Nordic and ISO. The correlation of the tyre label was found to be lacking for car tyres, but nevertheless a potential for noise reduction was identified especially if finer grade road surfaces were to be more widely used. In addition, the test procedure was recommended to be improved, including rougher road surfaces and better taking temperature into account. Obstacles to further progress are other sales criteria and parameters for tyres and competition aspects; required further R&D and adjustment of manufacturing resources. The noise reduction in practice is somewhat limited by the road surface and the presence of powertrain noise, which is higher for intermittent traffic and on gradients. Heavier and more powerful vehicles generally have wider tyres, which is

[265] S. van Zyl, F. de Roo, et al, Potential benefits of Triple A tyres in the Netherlands, TNO Report 2014 R10735 , 2014.

[266] M. Dittrich, F. de Roo, S. van Zyl, S. Jansen, H de Graaff, Triple A tyres for cost-effective noise reduction in Europe, Proceedings Euronoise, Maastricht, 2015

[267] https://www.cedr.eu/download/other_public_files/research_programme/call_2018/STEER.pdf

[268] ACEA - Tyre Performance Study, Noise vs other performances, 12/09/2019 – 70th GRBP.

[269] https://unece.org/sites/default/files/2021-01/GRBP-73-11e.pdf

[270] E. Hammer, E. Bühlmann, The noise reduction potential of "silent tyres" on common road surfaces

Grolimund + Partner AG, Bern, Switzerland, Proceedings Euronoise 2018, Crete.

[271] H. Bendtsen et al, NordTyre – the potential for noise reduction using less noisy tyres and road surfaces, Proceedings Euronoise 2018, Crete.

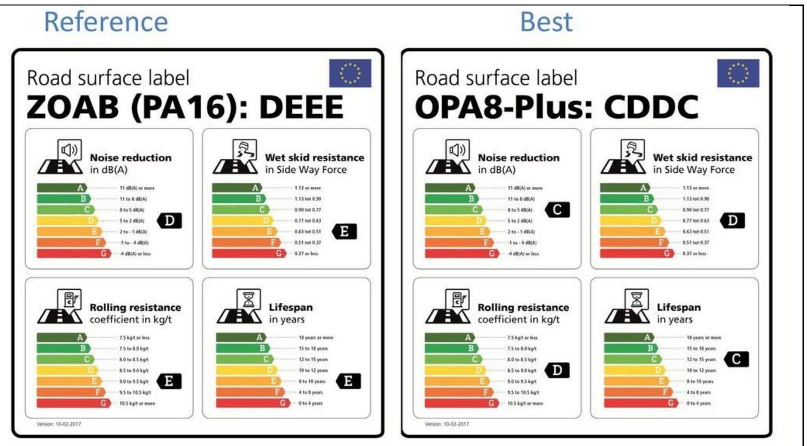
	often the case for SUVs, electric vehicles and sports vehicles. Increase in SUVs and electric vehicles leads to wider and thereby noisier tyres.
Causal links to legislation	Tyre noise limits in UN Regulation 117r4, referred to by EU Regulation 2019/2144; Tyre labelling regulation 2020/740.
References	261 262 263 264 268 268 269 270 269 270

Table 6.3 Reduction of rolling noise by road surface

Noise abatement measure	Quiet road surfaces
Principle and example(s)	Road surface characteristics directly affect tyre noise, and to a more limited extent part of the powertrain noise. Two key properties of the paving determine the noise reduction: surface roughness which causes tyre excitation, and the porosity, which reduces aerodynamic noise and absorbs reflected and propagated sound. Smoothness depends on aggregate size and finishing, but also on maintenance. Absorption depends on the flow resistivity, porosity and aggregate shape factors of the surface layer. Absorption can deteriorate over time due to clogging. Besides surface roughness and absorption, elasticity also plays a role. Poro-elastic road surfaces (PERS) have been developed and tested in several countries[272], and offer a potentially high noise reduction of 7-12 dB. It has however not yet reached wider application due to durability issues. PERS consists of rubber particles, stone aggregate, polyurythane and additives, but not bitumen. A road surface label has been proposed by the Netherlands[273], shown below, but not yet adopted.
Illustration	 Double layer porous asphalt (source CEDR, 2017)

[272] https://unece.org/DAM/trans/doc/2015/wp29grb/GRB-62-23e.pdf

[273] J. Sliggers: Road surface label, Push and Pull for Noise Emission Reduction from Road Traffic in the NLs and EU, Informal document GRB-65-27 (65th GRB, February 2017, agenda item 10)

	 Proposal for a road surface label, including noise reduction, wet skid resistance, rolling resistance and lifespan, in analogy with the tyre label. (Source: 65th GRB 2017[274],)
Noise reduction	Between 1-5 dB[275] [276] in tyre-road traffic noise compared to common dense asphalt concrete (DAC), depending on type, wear, speeds and traffic mix. The reduction potential also depends on the reference paving type, which varies per country, and the type of vehicle. The noise reduction tends to deteriorate with wear over time. If the starting point is a worn road with very rough surface, then reductions may well exceed 5 dB. Overall variation of noise emission due to road surface can cover a range of 13 dB including the extremes of surface quality.
Modelling	This measure is at source. Empirical models are available for the noise emission as a function of road surface roughness and absorption and tyre profile, dimensions and design. Road surface effects are also included in the EU-CNOSSOS model [277] [278]
Availability	Many varieties of quiet road paving are available, including porous asphalt, double layer porous asphalt, thin top layer asphalt.
Implementation level	In some countries it is applied on motorways and major roads, and on urban roads, especially in noise sensitive locations. According to CEDR, application on motorways and major roads is approximately 10 % in Germany and Denmark, 22 % in Spain, 30% in Greece, 55% in the UK and 88% in the Netherlands. Other countries have less than 10% or no available data. In many countries it is much less common, and especially in hilly and mountainous regions and those with more severe winter conditions.
Implementation time, life cycle	The average lifespan of quiet road surfaces is stated to be a few years shorter than for standard surfaces. The life can be for example 13-17 years for porous asphalt (Netherlands), whereas standard road surfaces will last around 18 years, or even 40 years for concrete surfaces[286]. It depends on the surface type, traffic volume and loading and climatic conditions. Several countries use porous asphalt only on a limited scale due to insufficient lifetime and higher winter maintenance costs.
Costs and benefits at EU level	Costs are higher than for conventional paving types due to initial construction and higher maintenance and replacement cost, between 5-

[274] J. Sliggers: Road surface label, Push and Pull for Noise Emission Reduction from Road Traffic in the NLs and EU, Informal document GRB-65-27 (65th GRB, February 2017, agenda item 10)

[275] F. G. Praticò, F. Anfosso-Lédée, Trends And Issues In Mitigating Traffic Noise Through Quiet Pavements, Procedia - Social and Behavioral Sciences 53 (2012) 203 – 212

[276] Low-noise road surfaces, Eurocities publication, Brussels 2015.

[277] EU-CNOSSOS prediction model 2015/996/EC

[278] https://pub.dega-akustik.de/ICA2019/data/articles/001200.pdf

	10%. Special quiet paving types may be up to twice the cost of conventional surfaces, but are expected to be cheaper once applied on a wider scale. The benefits are highest for main roads and motorways with speeds well above 30 km/h and limited powertrain noise, and for road stretches with denser population. Significantly, the benefits of quiet road surfaces are immediate after implementation locally, whereas quieter tyres take time to penetrate the vehicle fleet.
Triggers and obstacles for implementation	Triggers are perceived need, public pressure or local legislation, resulting either in action plans, or infrastructure planning, in particular for new or upgraded roads and new residential building close to roads. END noise mapping can be a trigger as the effect of implementing quieter road surfaces should show up in subsequent noise maps. Common obstacles are costs, maintainability and durability. Especially porous asphalt requires more maintenance and has a shorter life cycle due to wear, in particular due to winter conditions.
Causal links to legislation	END, 996/2015/EU noise prediction model, national prediction models and reception limits; local regulations and acts.
References	[275] [277] [278] [277] [278] [279]

[279] CEDR Technical Report 2017 noise-reducing pavements -01 State of the art in managing road traffic noise: noise-reducing pavements

Table 6.4 Whole vehicle noise reduction

Noise abatement measure	Whole vehicle noise reduction
Principle and example(s)	The noise emission of new vehicles is regulated by limits for pass-by noise in the type test. It inherently includes both powertrain and tyre noise. Tighter limits can result in a lower overall traffic noise level over time under the right conditions. Improvement of the type test methods (in particular ASEP[280]) will help to reduce real world noise levels. The majority of vehicles are cars, vans lorries, trucks and buses which tend to dominate the long term average Lden levels due to their numbers, but also motorcycles and mopeds contribute to noise pollution, in especially terms of peak noise levels.
Illustration	 Urban road traffic (Source: Google maps)
Noise reduction	2-4 dB reduction in type test levels (L_{urban}) is expected for individual vehicles by 2026, although the overall effect on real traffic noise emission depends on evolution and composition of the vehicle fleet, tyres and road surfaces.
Modelling	This measure is at source. Models are available for vehicle noise emission as a function of vehicle type, power/weight, speed, acceleration and load, tyres and road surface[281]. National and EU prediction models give an average sound source level over broad vehicle classes.
Availability	Quieter vehicles are in fact already available, but traffic noise levels depend on fleet composition and evolution.
Implementation level	All new vehicles put onto the market must comply with EU noise limits, but the whole fleet takes more than 10 years to replace. Some vehicle types are already more than 2 dB below the limits. However, the noise emission of individual vehicles may deteriorate over time, depending on wear, maintenance or tampering.
Implementation time, life cycle	The average life of vehicles is around 12 years (shorter or longer in some countries), meaning that this period is required for new noise limits to take full effect.
Costs and benefits at EU level	Costs are mainly Industry R&D costs and some additional manufacturing costs, which however are generally borne by the market, and at a lower level for large production volumes. These costs are deemed to be no more than 1 % in the price of the vehicle, as the technology is generally available, and due to mass production.
Triggers and obstacles for implementation	The trigger for vehicle noise limits is environmental policy, which is in turn driven by public demand for lower noise and consideration of health impacts by public authorities. For vehicle fleets, green procurement is a driver, for example for electric buses and utility vehicles. Obstacles are investment costs for industry, technical

[280] ASEP: Additional Sound Emission Provisions, part of the type test to cover more relevant engine running conditions

[281] ROTRANOMO/TRANECAM model, ROTRANOMO Workshop, Brussels 2004.

	constraints such as engine heat management, and market demand for some types of noisier (sports) vehicles. The type test requirements do not fully prevent the presence of some noisier vehicles in practice, and the type test sound levels do not properly reflect real world noise levels. The current and foreseen vehicle noise limits were in part based on previous studies including Venoliva[282]**Error! Bookmark not defined.** (2011), ACEA study[283] (2010) and subsequent studies[284]. A study on potential new L-category vehicle limits was performed in 2018.[285]
Causal links to legislation	Vehicle sound limits in EU regulation 540/2014/EU for M and N-category vehicles; Vehicle sound limits for L-category vehicles in EU Regulation 168/2013; Vehicle sound measurement method in UNECE Regulation 51.03, UNECE Regulation R41.04 for motorcycles, R63 for mopeds, R9 for three-wheeled vehicles; Tyre sound limits in UN Regulation 117r4, referred to by EU Regulation 2019/2144.
References	282, 283, 284, 285

Table 6.5 Noise barriers

Noise abatement measure	Noise barriers
Principle and example(s)	Noise barriers are widely applied along major roads and motorways in the EU, with typical average height varying from 2 to 4 m, but heights up to 10 m can be found. A variety of designs exists, including absorbent barriers, T-top barriers, titled barriers and lane barriers. Designs vary from wooden fencing to heavier stone or concrete structure. Cuttings and embankments also have an effect similar to barriers depending on geometry.
Illustration	 Transparent tilted noise barriers (Source: Google maps)
Noise reduction	The noise reduction strongly depends on the situation, but typically reductions of around 10 dB are found at receiver positions. The effect is largest for barriers close to the source or close to the receiver. The effect is less if a direct path of visibility to the traffic remains, such as for high buildings, near wide roads or higher dwelling positions. Barriers reduce both powertrain noise and tyre noise.
Modelling	This measure is in the propagation path.

[282] F. de Roo et al, Venoliva - Vehicle Noise Limit Values -Comparison of two noise emission test methods –Final Report, TNO Report MON-RPT-2010-02103, 2011.

[283] L. Pardo, H. Steven, Monitoring procedure in the vehicle noise regulation - ECE R 51 monitoring database, and cost/benefit analyses Study report ACEA/UTAC/TUV Nord, 2010

[284] F. de Roo, M. Dittrich, C. Bosschaart, B. Berry , Reduction of vehicle noise emission -Technological potential and impacts, TNO Report TNO-DV 2012 C100, April 2021

[285] Study on Euro 5 sound level limits of L-category vehicles, G. Papadimitriou et al, ISBN 978-92-79-70064-4, November 2017.

	Models are available for barriers as used in traffic noise prediction models. Key parameters are height, distance to source and receiver and difference between direct and indirect sound paths.
Availability	Widely available
Implementation level	Widely implemented, although less so for absorptive barriers, tilting barriers and lane barriers.
Implementation time, life cycle	For existing roads, a planning procedure and funding is required which can take several years. For new roads, integration and funding is generally easier although planning may take even longer. Life span depends on the design robustness (e.g. wood, concrete and stability), and may vary between 10-40 years. Life cycle costs depend on maintenance and repair of damage due to degradation.
Costs and benefits at EU level	Costs are mainly design, material and construction costs, and maintenance. Barrier costs are estimated at 500 Euro per m^2 , in practice varying between 250,- upto 1500,- depending on the design and durability. The associated benefits are the health benefits and amenity benefit due to reduced noise levels at dwellings.
Triggers and obstacles for implementation	Triggers are national legislation and public demand. Protection of quiet areas can also play a role. National legislation often sets reception limits which must be assessed by prediction models in the planning stage and before upgrading roads. Obstacles are cost, consultation, permits and planning stage duration, landscape and view obstruction. Cost/benefit considerations may actually lead to no implementation if the exposed population is small.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.
References	[286] [287]

Table 6.6 Road traffic management

Noise abatement measure	Traffic management , speed and access restrictions
Principle and example(s)	Re-routing or limiting road traffic volume or speed is a common solution for reducing the overall impacts of heavy and noisy traffic in both urban and rural areas and increasing quality of life. Noise reduction is a key effect, and sometimes a driver for its application. Numerous examples exist where public pressure has led to by-pass roads or rerouting of traffic to reduce environmental pressure on the local population. This is often also triggered by traffic increase, excessive congestion, pollution, and noise. It can also have large economic benefits if mobility and quality of the area improves. This type of solution has many different forms: - access restriction with penalty: either for certain times and/or vehicles, enforced - access charging, including parking management, congestion charging, low emission zones or tariffs for noisier vehicles - traffic routing without penalty, such as route advisory signs, slowdown and obstacles in routes and high parking tariffs to relieve city and town centres - speed restriction with penalty, effectively altering traffic flow and routing; for example, city -wide speed limit to 30 km/h

[286] CEDR Technical Report 2017-02 State of the art in managing road traffic noise: noise barriers

[287] QCity project: H Malker, N Å Nilsson, Description of benefits from various screening techniques (2006) http://www.qcity.org/downloads/SP4/D4-01_ACL_12M.pdf

	- traffic control by management of parking and parking tariffs Besides restrictions, incentives and mobility planning are also a means to reduce congestion and noise impact.
Illustration	 Example of planned extension of pedestrian zone in Brussels centre (Source: City of Brussels)
Noise reduction	Large noise reductions can occur where traffic is effectively rerouted. In some cases, it may just shift the noise exposure to elsewhere, but in a non-linear way: re-routing all traffic to another street will reduce the cleared street by about 10 dB, but increase levels in the other street by only 3 dB. Tunnels underneath or around city centres avoid this effect.
Modelling	This measure is at source. This type of solution is assessed with traffic flow and traffic noise prediction models as in noise mapping.
Availability	Widely available
Implementation level	Widely implemented, for example by-pass routes, tunnels, pedestrian zones, access charging and low emission zones. Examples and extent are shown at [289.] Information is exchanged and demonstration projects shared at EU level via the CIVITAS network[288].
Implementation time, life cycle	A planning and consultation procedure is required, which may take from months to years.
Costs and benefits at EU level	Costs may include planning and reconstruction, installation, enforcement and administration. These are estimated at around 1 million Euros per km^2 with large potential variations depending on the nature and extent of restrictions. Beside noise reduction, benefits are also to be expected in terms of improved air quality, safety and quality of life.
Triggers and obstacles for implementation	Triggers are pollution, congestion and noise, national legislation, local policy and public demand. Obstacles are cost, consultation, permits and planning stage duration, accessibility of the restricted area and subsequent effect on business such as retail.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.

[288] www.civitas.eu (European network City VITAlity and Sustainability)

References	289 290 291 292 293 294 295 296

Table 6.7 Urban and spatial planning

Noise abatement measure	Urban and spatial planning
Principle and example(s)	Urban and spatial planning includes the land use, layout, distancing and sound attenuation between source and receiver by buildings, parks, courtyards, screening, and landscape elements. The position and orientation of buildings and infrastructure can significantly affect noise at receiver positions. It is best applicable and cost-effective for new construction projects, in which noise emission and exposure can be considered beforehand. In existing situations, sound attenuation can be influenced by means of new buildings, absorptive facades or structures between traffic and dwellings, reconstruction, or relocation of dwellings, increasing the distance to the noise source. Parks or green spaces can be used to add some attenuation, depending on the reference situation, for example when changing from a hard open/reflective area to a park with larger sound attenuation due to absorption, dispersion or natural barriers such as hills or embankments. Common examples of urban planning are the placement of office and commercial buildings along roads to form a barrier towards dwellings. Residential buildings with quiet facades (at the back of a dwelling) or enclosed courtyards can create quieter living areas in otherwise noisy urban areas. New transport infrastructure underground or moved to other routes can significantly reduce noise at dwellings.
Illustration	 Example of residential building with loud side of quiet façade along a motorway (Source: Google maps)
Noise reduction	The noise reduction is entirely situation dependent. Building orientation and additional buildings acting as barriers can reduce façade noise levels relative to the source by around 10 dB and more.

[289] www.urbanaccessregulations.eu

[290] https://www.brussel.be/voetgangerszone

[291] https://ec.europa.eu/transport/themes/urban/cycling/guidance-cycling-projects-eu/cycling-measure/traffic-restrictions-and-charges_en

[292] https://ec.europa.eu/transport/sites/transport/files/cycling-guidance/mobility_in_good_cities.pdf

[293] Catalogue on Case Studies for Parking Management Solutions Push and Pull https://ec.europa.eu/transport/sites/transport/files/cycling-guidance/push_and_pull_catalogue.pdf

[294] www.cityhush.eu/results.html

[295] Cityhush project: S. Algers et al, Tools for creating Q-Zones, Selection of 5 reference sites for analysis, 2011

[296] Cityhush project: G Parry et al, Cost/benefit analysis of mitigation measures against potential benefits for local residents and park visitors

Modelling	This measure is in the propagation path. It is assessed with traffic noise prediction models as in noise mapping.
Availability	Widely available
Implementation level	Variable between countries, depending on consideration during planning phase and local/national legislation. Situation specific and different for existing and new dwellings.
Implementation time, life cycle	In general, a planning procedure is required, which may take from months to years. Once in place, the effect is permanent.
Costs and benefits at EU level	Costs may include planning, reconstruction and compensation and are estimated in the order of 10-100 million Euro per km^2. Benefits may include long term returns on real estate value, new housing, business potential, safety and improved traffic flow. For large (re)construction projects such effects are often taken into account in the long term business plan.
Triggers and obstacles for implementation	Triggers are economic development, urban construction, new infrastructure, national legislation and public demand. Obstacles are public opposition, costs, complexity and social-economic impacts.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.
References	[297] [298] [299] [300]

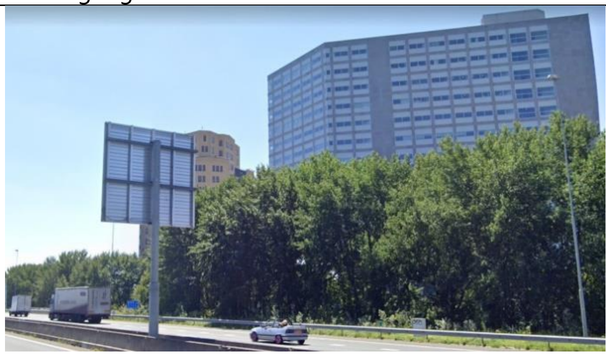
[297] QCity project: H. Malker, N. Å. Nilsson, Prototypes of high absorbing surface, 2006

[298] QCity project: M. Petz, R. Witte, Augsburg validation site – Town planning Performance report of applied measures – Augsburg, 2008

[299] QSide project: http://www.qside.se/overview.html

[300] Sonorus project (2016) http://publications.lib.chalmers.se/records/fulltext/242257/local_242257.pdf

Table 6.8 Sound insulation of residential and communal buildings

Noise abatement measure	Sound insulation of residential and communal buildings
Principle and example(s)	Sound insulation of residential and communal buildings is a common measure in urban areas and near busy roads, and consists of improved double or treble glazing, sealing of gaps and noise-reducing air vents. It may be funded by authorities above a certain noise threshold and under certain conditions. For existing properties, it may only be available if the traffic situation has changed, whereas for new buildings near roads, there may be public funding available to actually fulfil building regulations.
Illustration	 Façade and window insulation is commonplace near busy roads and allows building closer to the road. (Source: Google maps)
Noise reduction	The noise reduction is only within the dwelling with windows closed, and from 10 up to around 40 dB depending on the glazing type and the further façade insulation. The noise level at the façade, which is a crucial element of environmental noise legislation, is not affected. However, in a number of member states noise levels inside the dwelling are regulated.
Modelling	This measure is at the reception point, but not in the sense of the END, which considers the noise level at the façade. Dwelling sound insulation is determined on the basis of specified or measured insulation of glazing and building elements.
Availability	Widely available
Implementation level	Widely applied and already integrated with thermal insulation in new buildings.
Implementation time, life cycle	Sound insulation remediation programmes for existing buildings may take years to set up and complete and are not available in all member states. Once funded however, installation can be swift and the benefits immediate. New buildings near busy roads are often designed beforehand with sufficient sound insulation.
Costs and benefits at EU level	Costs are government or local authority funding for sound insulation per affected dwelling. These are variable, in the order of 1000-15 000 Euro per dwelling. The benefits are proportional to the number of insulated dwellings each year, although not expressed in terms of noise at the façade. An additional benefit is higher thermal insulation and thereby energy saving.
Triggers and obstacles for implementation	Triggers are new infrastructure or increased traffic volume, national legislation and public demand. Most new buildings are already well insulated for energy saving. Obstacles are mainly the costs, in particular where additional insulation is required specifically for noise reduction.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.
References	[301]

[301] Guidelines for Road Traffic Noise Abatement, Smile project, 2003

6.3 Solutions for railway noise abatement

For railways, the following noise abatement solutions are considered, set out below:

1) Infrastructure measures, such as rail grinding and milling, quieter rail pads, rail dampers or rail shielding
2) Quieter rolling stock, including smooth, damped or optimized wheels and quieter powertrains
3) Traffic management including re-routing, speed restrictions, access restrictions or noise access charging
4) Noise barriers, standard or special, including absorbent and low barriers near the track
5) Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, urban layout, including renovation and reconstruction
6) Sound insulation of residential and communal buildings, including funding schemes for homeowners.

Solutions for aerodynamic noise, such as vehicle streamlining, and for high speed slab tracks, such as absorptive plates, have less impact in the context of this analysis, as most high speed lines have less night operations, no freight trains, and a smaller total length than the rest of the network (9000 km in 2017). , Also the number of locations with speeds[302] with trains running above 250 km/h are less numerous and the numbers of exposed people in total are generally low compared to lines with conventional traffic and including freight. And in addition, rolling noise remains an important source upto 300 km/h in some situations.

The above solutions are set out in tables 6.10-6.15. Sound insulation, which is the same as for road noise, is shown in table 6.8 and 6.15.

Regional differences

For conventional and high-speed railways there are significant differences between member states and regions in Europe, also affecting the level of noise abatement. As set out in the UIC 2010 report 'Railway Noise in Europe', the following differences are indicated:

- Western Europe including Italy: high population density and high volume of transit traffic, public pressure for operational restrictions and noise reduction.
- Central Europe: high share of freight market, growth expected due to economic growth and East-West transit; a large part of freight fleet has tired wheels, which is an obstacle to retrofitting with composite brake blocks due to potential overheating during braking.
- UK: most of the fleet already has composite or disc brakes following national specifications.
- Northern countries Denmark, Sweden, Norway: Less freight and lower population density, and noise abatement programmes already in place. Finland, Latvia, Estonia and Lithuania have a wider gauge (1524 mm) linked to Russia, and also low population density.
- Spain and Portugal: Wide gauge (1668 mm), but standard gauge for high speed network; composite brake blocks already widespread following national specifications.
- Other countries with limited or no rail network: Cyprus, Malta.

[302] https://op.europa.eu/webpub/eca/special-reports/high-speed-rail-19-2018/en/

Light rail and trams

According to the UITP[303] Around 204 cities have light rail and tram (LRT) networks in Europe in 2018. Light rail systems are also railways and are generally treated in the same way in terms of noise legislation. Light rail is relevant for agglomerations in the sense of the END, and should be included in noise maps. They are typically close to dwellings, but have a shorter overall length than main railways and operate at lower speeds on average.

There has been a significant growth LRT of infrastructure in Europe from 2015 to 2018, by 3.9% from 8,943 km to 9,296 km, and further growth can be expected. These are widespread throughout Europe, with the most in Germany. The newer networks and rolling stock tend to be quieter than older ones due to design features such as low floor vehicles, wheel maintenance and rail grinding. The tracks differ from other railways, in particular tracks in streets, some with embedded rail.. Light rail is not specifically included in the analysis due to the relatively small impact at EU level.

Solutions found in action plans

Solutions for railway noise abatement found in the analysed action plans are indicated in table 6.9. As for road, these are not indicative of the actual extent, but give an impression of how often such measures are mentioned.

Table 6.9: Percentages of noise abatement solutions found in noise action plans for railways in the EU.

Railway noise abatement measure	Percentage in NAPs
Freight transport using electric locomotives	2%
Use of new wagons / new trains	2%
Traffic management	2%
Electrification of railway network	2%
Long track installation	2%
Low noise rail	2%
Low noise tracks	2%
Rail damper	4%
Rail maintenance	11%
Rail grinding	9%
Rail/track improvement	20%
New freight transport (rail) bypass	2%
New railway lines	4%
Noise barriers	9%
Soundproof windows	4%
Building insulation	4%
Land use planning	7%
Protection of spaces, landscapes, sites	2%
Quiet areas	6%
Noise monitoring	6%

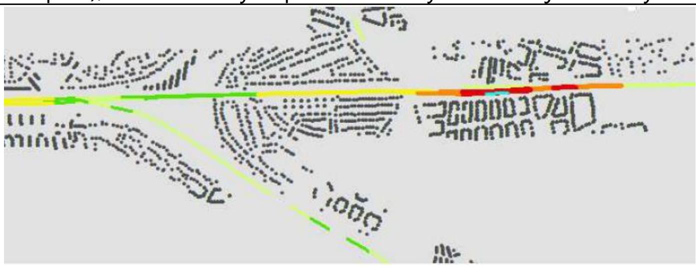
These results indicate the significant emphasis on track and rail maintenance and improvement.

In the following tables, recent information provided by CER/UIC[304] was also taken into account.

[303] Light Rail and Tram: The European Outlook, UITP, November 2019

[304] Preliminary communication from CER/UIC to this study on noise reduction and costs of noise abatement measures , October 2020

Table 6.10 Infrastructure measures

Noise abatement measure	Infrastructure measures
Principle and example(s)	A number of noise abatement measures are available for railway infrastructure at source, such as a) rail grinding and milling, b) quieter rail pads, c) rail dampers and d) rail shielding. As the rail is a major source of rolling noise, these can be effective, more so if the wheel and other sources are also treated. a) Acoustic rail milling produces a **low rail roughness**, which ensures that smooth wheels do not produce extra noise. This only works if wheel roughness is also sufficiently low and free of wheel flats (i.e. are well maintained). Rail roughness management including condition monitoring is a prerequisite to maintain low rolling noise levels and has additional benefits for preventative maintenance. Milling removes less material than grinding, and is most cost effective when applied to sections identified by monitoring. b) **Railpads** are relevant for their effect on rail vibration and sound radiation and can be optimized in some situations. Stiff railpads generally result in higher damping and lower noise from the rail, but more noise and vibration from the sleeper. Softer railpads, which are widely used on high speed and other networks, tend to result in higher noise levels, but can be damped. c) **Rail dampers** can also reduce rail vibration and thereby sound radiation, but mainly for tracks with low damping, i.e. with soft railpads. d) **Rail shielding** systems only reduce the sound radiation from the rail but can in some cases reduce the noise level by several dB. Besides the above measures, replacing old tracks by **new quieter tracks** is commonplace (e.g. concrete sleeper tracks instead of wooden sleepers), but is already in place on many of the major railways.
Illustration	 Example of roughness mapping of the rail network. (source: SWECO[305], Denmark)  Rail dampers on a monoblock ballast track (Source: TNO)

[305] Stig Junge, Using rail roughness measurements to monitor environmental railway noise and detect track faults at an early stage, Proceedings BNAM, Oslo, May 2020

Noise reduction	1-3 dB for rail grinding, if wheels are in good condition. 2-4 dB for optimized railpads, when starting from soft pads. 1-3 dB for rail dampers, on a rail with low damping. 1-4 dB for rail shielding depending on train and track type. These reductions are all dependent on the type, condition and properties of the rolling stock, the track, and the train speed, as these all affect the source contributions. It should be emphasised that these reductions will not all add up when the measures are combined. Each solution may be individually more effective in a specific situation (e.g. high speed, freight, mixed traffic).
Modelling	This measure is at source. Models are available for track/vehicle rolling noise emission as a function of wheel and track design and wheel/rail roughness, such as the TWINS model. The EU prediction model in 996/2015/EU includes the main sources of rolling noise, traction noise and aerodynamic noise, and includes the effects of roughness in the sound emission levels.
Availability	Acoustic rail grinding, railpads, rail dampers and rail shielding are all on the available, but are also undergoing further development.
Implementation level	Acoustic rail grinding is applied in some countries (DK, DE, NL), where there is a link to legislation. Optimised railpads are available and tests have shown good results on tracks with softer pads. Rail dampers are implemented on parts of some networks, although effectiveness tends to vary per situation. Rail web shielding is available but to date less widely applied, as results also can vary per application.
Implementation time, life cycle	Rail grinding and milling can be implemented with immediate effect. On-board noise monitoring or rail roughness sampling is used to assess track sections in noise sensitive areas. Grinding/milling may lead to some faster wear of the rail, but is applicable over a long timescale. But rail milling has been shown to actually save on maintenance costs[306] by reducing initial rail surface defects. Optimised railpads can be easily implemented by replacing older ones at relatively low cost and will have a similar lifespan of 10-15 years. Rail dampers and rail web shielding are additional components which are added to the rail, with an estimated lifespan of around 10 years. The replacement of railpads and adding of rail damping or shielding is most cost-effective when done during general track maintenance.
Costs and benefits at EU level	Rail grinding, but more effective milling, can be integrated into normal maintenance and actually provide savings on maintenance as found in Denmark. The life of rails can be extended by preventive milling, whereas normal grinding removes more material, shortening the life. The costs are estimated at 1000 Euro per km track, reoccurring in a 1-3 year cycle, but potentially lower if saving on rail life is taken into account. For railpads, the cost is minimal when replaced during normal maintenance or installed on new tracks, estimated at around 3000 Euro/km for existing track. Costs for rail dampers or rail shielding are mainly purchase, installation and maintenance costs, and replacement costs after around 10-15 years. These are estimated at around 600 Euro per meter of track. Benefits occur in the immediate reduction of trackside noise levels with the improvement of the track. Taking real roughness levels into account

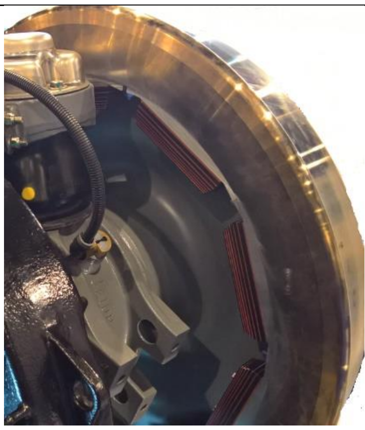
[306] Communication from SWECO to Banedanmark, Upper limit for rail roughness level – a business case study, April 2020.

	results in more realistic and often lower trackside noise levels in environmental predictions, reducing the need for more expensive abatement measures.
Triggers and obstacles for implementation	The trigger for any track related noise solution is noise regulation such as the END or national regulations, when predicted noise levels at the façade exceed reception limits. Complaints can also be a trigger. The choice of best solution is driven by cost and sustainability.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits
References	[307] [308]

[307] Railway noise in Europe, UIC, 2010, 2016

[308] UIC Network Noise and Vibration, Flyer 2019

Table 6.11 Quieter rolling stock

Noise abatement measure	Quieter rolling stock
Principle and example(s)	Quieter rolling stock, including smooth, **damped or optimized wheels and quieter powertrains and auxiliaries**. Over the last 20 years, rolling stock has gradually become quieter, in particular due to the improvement of wheel surface quality which is associated with the brake type. Noisy freight wagons, which contribute especially to night time noise, have gradually been replaced or retrofitted. Most modern passenger rolling stock has smooth wheels, although wheel flats still occur. In some member states, older rolling stock with cast iron brake blocks is still in operation. The monitoring and preventative maintenance of wheel flats would help reduce noise in practice, both for freight wagons and passenger rolling stock. This is illustrated in the recent project 'Innovativer Güterwagen'[309], in which several quieter wagon designs were developed, where in some cases, wheel flats were a limiting factor on the measured noise reduction. Besides the wheel surface, the wheel design affects noise production, in particular the damping. Wheel dampers and web-mounted disc brakes have resulted in additional noise reduction, in part of the passenger fleet. Beside rolling noise, traction noise and aerodynamic noise are relevant sources, which have also gradually improved over the years, and are limited by the Noise TSI. The noise performance of quiet rolling stock also depends on the track contribution, i.e. rail roughness, damping and radiation.
Illustration	 Wheel damper within the rim of the wheel  Modern EMU with quieter wheels due to wheel-mounted disc brakes (Source: TNO)

[309] Innovativer Güterwagon, https://www.bmvi.de/SharedDocs/DE/Anlage/E/forschungsprogramm-innovativer-gueterwagen-12.html

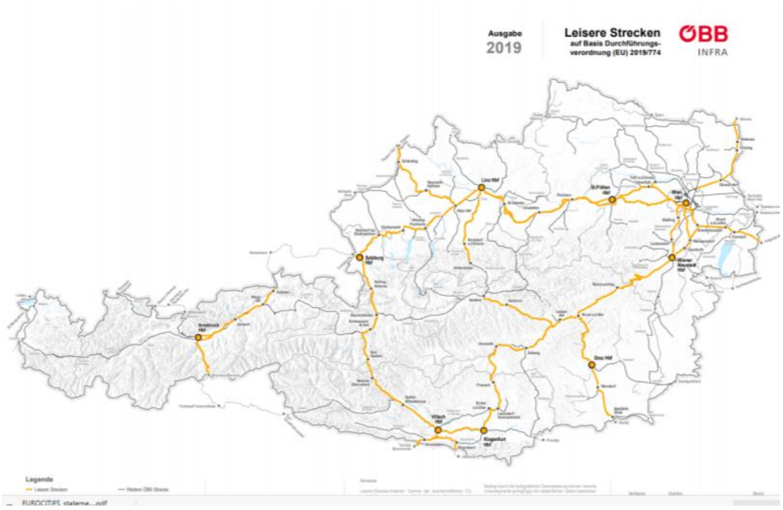
Noise reduction	For the existing fleet, the main options for noise reduction are retrofitting and improved maintenance. The potential reduction varies strongly, but for cast-iron block braked vehicles it is around 7 dB on a track with average rail roughness. On tracks with low rail roughness (e.g. milled rails) the potential reduction is larger and 1-3 dB more reduction is feasible if wheel roughness is well maintained, including wheel flats, not currently included in the TSI or EU legislation. For the passenger fleet, wheel design including damping can result in a 2-4 dB reduction, where not yet applied. For electric and diesel locomotives and powered units a potential of 5 dB reduction in traction noise is estimated for units older than 10 years. These reductions may be achievable either by replacement or retrofitting. For high speed trains, a further reduction from 1-5 dB in aerodynamic noise is considered feasible by streamlining, in future years for new rolling stock.
Modelling	This measure is at source. Models are available for track/vehicle rolling noise emission as a function of wheel and track design and wheel/rail roughness. The EU prediction model in 996/2015/EU includes the main sources of rolling noise, traction noise and aerodynamic noise.
Availability	Quieter freight wagons are available since the introduction of composite block brakes and the TSI regulation. Quiet passenger rolling stock is widespread, including units with wheel dampers or web-mounted disc brakes, some with smaller wheels.
Implementation level	Most braking systems on passenger trains are disc-braked and many freight wagons are composite block braked[310]. Improved wheel design for noise (damping and shape) is not yet fully implemented throughout the fleet. Both traction noise and aerodynamic noise can be reduced on new train types, and to a lesser extent at retrofit stage.
Implementation time, life cycle	Rolling stock has a life span of around 30 years including a major overhaul at 15 years. Some vehicles, in particular freight wagons, are in service for much longer. Wheelsets are replaced and maintained more frequently.
Costs and benefits at EU level	The main costs for quieter rolling stock are the retrofitting of older vehicles, and R&D and purchase costs of new quieter units. As retrofitting is already well advanced, only the additional costs for new quieter rolling stock are considered here, estimated at 1% price increase for quieter vehicles. Benefits occur in the gradual reduction of trackside noise levels with the improvement of the fleet. If wheel flat control is improved (e.g. integrated onboard monitoring), this will also have additional benefits for track wear.
Triggers and obstacles for implementation	Trigger is the market demand based on TSI and procurement requirements. Obstacles are investment costs and limitation of noise performance by the track quality.
Causal links to legislation	Vehicle noise limits in TSI 1304/2014/EU, trigger quieter vehicles Quieter routes, trigger the need for quiet vehicles NDTAC access charging (2015/429/EU), incentivises the use of quiet vehicles. The retrofit subsidy (CEF), speed up the implementation of quiet vehicles. The END indirectly triggers the use of quiet vehicles/trains via action plans. National legislation on reception limits drives the use of quiet vehicles via railway noise capacity planning.
References	[311] [312]

[310] However there are some TSI exemptions still allowing cast-iron block braked wagons until 2032.

[311] Railway noise in Europe, UIC, 2010, 2016

[312] UIC Network Noise and Vibration, Flyer 2019

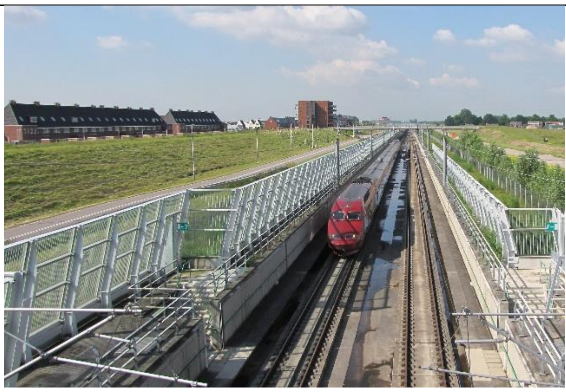
Table 6.12 Traffic management in relation to noise

Noise abatement measure	Traffic management including re-routing, speed restrictions, access restrictions or noise access charging
Principle and example(s)	Railway traffic management in relation to noise can include re-routing where available, reduction of speeds, access restriction for noisier rolling stock or noise differentiated access charging (NDTAC). In part, some of these solutions are regulated at EU level. NDTAC provides a means of internalisation of external costs due to noise. The Noise TSI Quieter routes[313] will regulate those routes with a high level of freight trains operated at night (more than 12), allowing only TSI compliant wagons from 8th December 2024.
Illustration	 Example of a Quieter routes map for Austria (Source: ERA)
Noise reduction	Quiet routes or re-routing: Depending on the starting point (percentage of noisier wagons) and assuming the same traffic volume, around 2-7 dB in the Lden level, also assuming that rail roughness is controlled. NDTAC: Noise reduction is variable depending on the uptake by wagon owners and operators, indicatively 2-3 dB reduction in the Lden level. Speed reductions of 20%, where allowable, could reduce pass-bys levels by around 3-4 dB.
Modelling	This measure is at source, and in terms of modelling is taken into account in traffic noise prediction models, via vehicle volumes, speeds, and vehicle noise emission levels.
Availability	Available, but limited to specific routes or locations due to traffic flow requirements, and primarily used for freight traffic.
Implementation level	The Quiet routes regulation is applicable from the end of 2024, after which the fleet should be fully retrofitted. A night time ban of noisier freight wagons exists on some alpine routes. Local speed restrictions at night apply in some urban areas. NDTAC is applied in some countries: NL, ,DE, AT, CH and CZ,, with differences in the bonus/malus system
Implementation time, life cycle	The Quiet routes regulation is already prepared, with railway maps available for each member state[314]. The Swiss ban on noisy freight wagons came into force on January 1st 2020.

[313] ERA quiet routes maps, https://www.era.europa.eu/content/noise-tsi-quieter-routes_en

Costs and benefits at EU level	The costs will be borne mainly by operators or wagon owners with wagons still equipped with cast-iron brake blocks, who will need to retrofit or replace such wagons in operation on the routes concerned. Benefits will occur for all routes with such restrictions. The costs of rerouting are deemed very high by the railways, due to lack of alternatives.
Triggers and obstacles for implementation	The main triggers are night time noise levels from freight trains in sensitive areas, and the noise reception limits in those areas. Obstacles are significant costs of re-routing and network capacity, shifting the exposure to elsewhere, and administrative burden and cost for NDTAC. Speed reductions on individual trains can reduce the network capacity. For railway traffic restrictions in general, the railway sector expects a competitive disadvantage to road transport.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts. TSI Noise 1304/2014, Quiet routes legislation, NDTAC legislation 2015/429 Connecting Europe Facility (CEF) – Funding for wagon retrofitting
References	

Table 6.13 Noise barriers, standard or special, including absorbent and low barriers near track

Noise abatement measure	Noise barriers, standard or special, including absorbent and low barriers near track
Principle and example(s)	Noise barriers are widely applied along railways in the EU, with typical average height varying from 1 to 4 m, but heights up to 10 m can be found. A variety of designs is found, including absorbent barriers, titled barriers, inter-track barriers and close barriers. Designs vary from wooden fencing to heavier stone or concrete structure. Cuttings and embankments also have an effect similar to barriers, although hard surfaces can diminish the barrier effect.
Illustration	 ( Barriers, top: along a high-speed line and bottom: close barriers on a conventional line (Source: top: TNO, bottom: ProRail)
Noise reduction	The noise reduction strongly depends on the situation, but typically reductions of 10 dB and higher are found at the receiver relative to the near track. For close barriers the reduction is around 3-7 dB depending on the configuration. The effect is largest for barriers close to the source or to the receiver. It is less if a direct line of sight to the railway remains, such as for high buildings, near multiple tracks or buildings in higher positions. Barriers reduce all the main railway sources of rolling, traction and aerodynamic noise, but sufficient height is required to reduce higher sources such as exhausts, roof-mounted equipment, and aerodynamic sources such as pantographs and roof discontinuities.
Modelling	This measure is in the propagation path. Models are available for barriers as used in railway noise prediction models. Key parameters are height, distance to source and receiver, difference between direct and indirect sound paths, and barrier absorption.
Availability	Widely available
Implementation level	Widely implemented, although less so for absorptive barriers, tilting barriers, close barriers and inter-track barriers.

	UIC mentions (2016) that 3000 km of barriers on 7 networks with heights between 2-3 m are installed, with another 500 km expected in the next 10 years. Close barriers are still under test, with only limited stretches implemented in Germany and the Netherlands, where reductions of 5-10 dB were found for the close track.
Implementation time, life cycle	For existing railways, a planning procedure and funding is required which can take several years. For new or upgraded railways, integration and funding is generally easier, although planning may take longer. Life span depends on the design robustness and may vary between 10-40 years. Life cycle costs depend on maintenance and repair of damage due to degradation.
Costs and benefits at EU level	Costs are mainly design, material and construction costs, and maintenance. Barrier costs are estimated at 500 Euro per m^2 , in practice varying between 250,- upto 1500,- depending on the design and durability. The associated benefits are due to the reduced noise levels at dwellings and in some cases safety, where barriers also serve as a perimeter fence.
Triggers and obstacles for implementation	Triggers are national legislation and public demand. National legislation often sets reception limits which must be assessed by prediction models in the planning stage. Obstacles are cost, consultation, permits and planning stage duration, and opposition against view obstruction. Cost/benefit considerations may actually lead to no implementation if the exposed population is small. For low barriers close to the track, safety considerations are still an issue and they are not yet approved in some countries.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.
References	[315] [316] [317]

[315] Railway noise in Europe, UIC, 2016

[316] 'Low barriers closer to the track allowed from 2020' (in Dutch), www.spoorpro.nl, 14 November 2019.

[317] QCity project: J. Nielsen et al, In-field measurements of the influence of low barrier on railway noise, 2009

Table 6.14 Urban and spatial planning, including renovation and reconstruction

Noise abatement measure	Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, including renovation and reconstruction
Principle and example(s)	Urban and spatial planning includes land use, layout, distancing and sound attenuation between source and receiver by buildings, parks, courtyards, screening, and landscape elements. As is also the case for roads, it is best applicable and cost-effective for (re-)construction of railways and surrounding infrastructure, in which noise exposure can be considered beforehand. Tunnelling, blind facades and non-residential buildings along the track are effective solutions in (re-) construction projects. In existing situations, sound attenuation can be influenced by means of new buildings, absorptive facades or structures between traffic and dwellings, or relocation of dwellings, increasing the distance to the noise source.
Illustration	 Example of tunnelling underneath urban area (Source: TNO)  Example of urban planning: office buildings between tracks and residential buildings (Source: Google maps)
Noise reduction	Broadly, more than 10 dB
Modelling	National or EU prediction models
Availability	Widely available
Implementation level	Widely applied, although blind facades are less common
Implementation time, life cycle	A typical timescale of 5-10 years including planning
Costs and benefits at EU level	Investment costs tend to be high (very high for tunnelling), but with potentially large returns in terms of real estate value, increased mobility and economic development. The costs are estimated around 10-100 million Euros per km^2 depending on the type of project.
Triggers and obstacles for implementation	Triggers are the need for renovation, regeneration, new housing, and the need to combine different functions into a limited area. Obstacles

	are costs, impact, planning procedures and the presence of existing dwellings.
Causal links to legislation	Planning procedures including those for infrastructure.
References	

Table 6.15 Sound insulation of residential and communal buildings, example for railway (further details see table 6.8)

Noise abatement measure	Sound insulation
Illustration	 4-track line with barrier on right side, glass-insulated balconies (curtain wall) on the left without barrier (Source: TNO)

6.4 Solutions for aircraft noise abatement

For the noise reduction at airports, the International Civil Aviation Organization (ICAO) has issued guidance, known as the Balanced Approach to Aircraft Noise Management (BA), which has been adopted by EU Regulation No. 598/2014 (also known as the Balanced Approach Regulation or "BAR"). The BA establishes 4 main fields of action:
1) noise reduction at the source
2) operational procedures
3) operational restrictions
4) land-use planning and management

More recently community engagement is considered an inherent element of the BA.

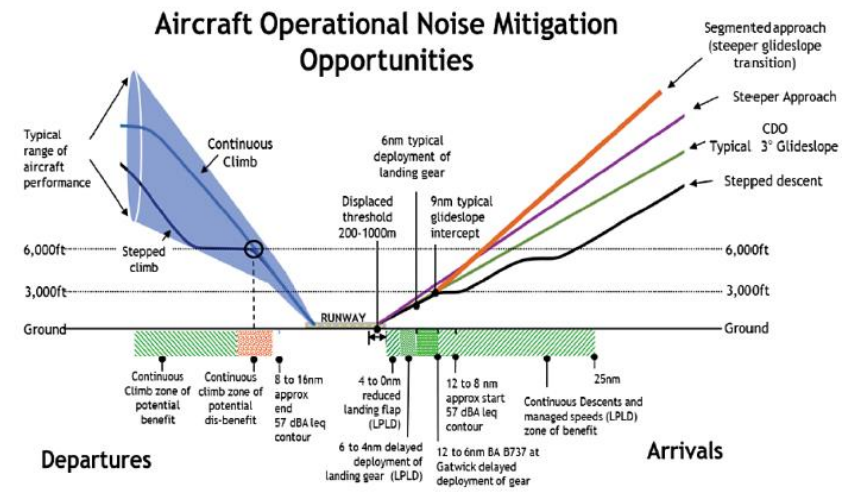
In the frame of the current study a solution for noise reduction at the source (solution 1) will not be directly provided as part of the scenario exercise, since noise at the source is regulated at the global level by the ICAO.

For airports, the following noise abatement solutions are considered, set out below:

1) Landing and take-off improved profiles (flight procedures)
2) Dispersion or concentration of flights (route optimization)
3) Operating restrictions - curfew (Airport regulation)
4) Operating restrictions - prohibition of operation for noisier aircraft (airport regulation)
5) Forced phase out of older aircraft (airport regulation)
6) Acquisition of new quieter aircraft (EU or national level incentives for airlines)

7) Sound insulation of residential and communal buildings, including government incentives for home owners
8) Extension of land barrier, land use planning including acquisition of dwellings.
9) Increased stakeholder engagement

Table 6.16 Landing and take-off improved profiles

<table>
<tr><th>Noise abatement measure</th><th>Landing and take-off improved profiles (flight procedures)</th></tr>
<tr><td>Principle and example(s)</td><td>The noise of an aircraft flyover, received at an observer on the ground, is mainly determined by the noise at source (engine power and aircraft configuration) and by the distance between aircraft and observer (both in the horizontal and vertical plane). These parameters are not independent (for instance, at higher take off power the aircraft will climb faster, resulting in an increase in the height over an observer) and may have inverse effects on the noise (higher power=higher noise, but longer distance=lower noise). Noise reductions may be obtained at a certain position by balancing the different effects, obviously always within the safety boundaries of the aircraft operation. The design of noise abatement flight procedures is all about getting this balancing right.
It should be noted that some flight procedures will give a noise benefit nearby the airport, with higher noise levels further away, whilst for others the effect is inverse. Depending on the location relative to the airport where the noise reduction is to be obtained, one or another flight procedure should be defined.
Examples of noise abatement flight procedures are Continuous Climb, Continuous Descent Approach and Low Power Low Drag approaches.</td></tr>
<tr><td>Illustration</td><td>


Source: Sustainable Aviation</td></tr>
</table>

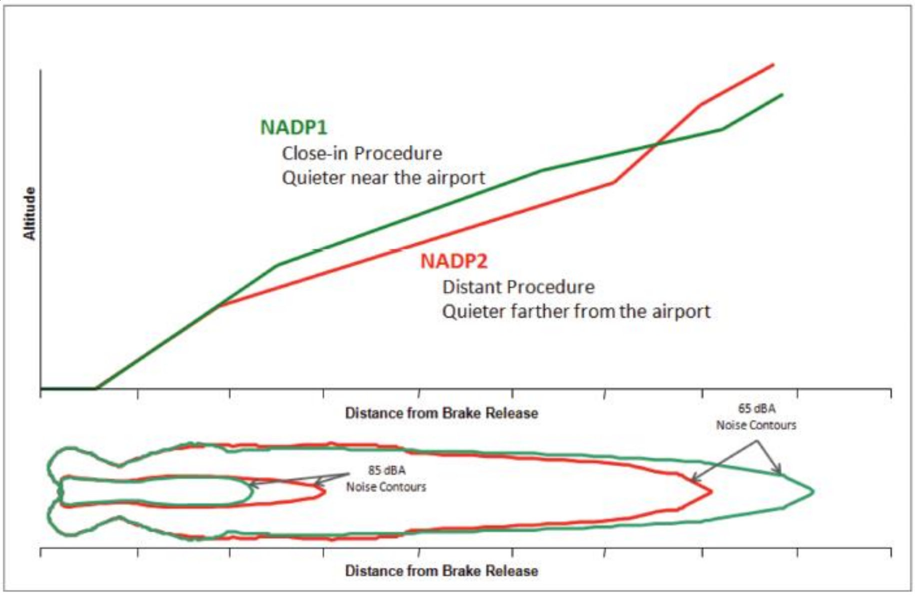
	 Source: Boeing
Noise reduction	The achievable noise reduction is completely situation dependent. Reductions of 1-3 dB may be expected to occur at certain locations. However, for the same flight procedure a noise increase could occur at other locations.
Modelling	Modelling of flight procedures can be done by means of the appropriate definition of so-called procedural profiles, where the engine and aircraft states are defined for the various segments of the procedure. However, care should be taken, especially in the approach case. The existing Noise-Power-Distance databases used in the modelling process are not fully representative for the clean aircraft configurations (no flaps, no landing gear), used during e.g. the Low Power Low Drag procedure.
Availability	Flight management Systems of modern aircraft allow for a variety of flight procedures to be followed accurately. Newly developed procedures could therefore be made available to pilots in a relatively easy manner.
Implementation level	Noise optimal flight procedures are very airport dependent. To avoid changing flight procedures for each individual airport, usually more standard procedures are used. Only in very noise sensitive cases a specific procedure will be used. Ever increasing automation of flight might enable implementation of noise optimal flight procedures for each individual airport.
Implementation time, life cycle	Depending on the type of procedure implementation may be “immediate” or may take much longer. For instance, procedures like CDA will require significant collaboration between Air Navigation Service Providers (ANSPs) and pilots and may influence the capacity at an airport, and therefore will require adequate assessment and planning for implementation. Flight procedures are aircraft type dependent.
Costs and benefits at EU level	Costs are mainly related to the required R&D at aircraft manufacturers, aircraft operators and, in cases like CDA, ANSPs.
Triggers and obstacles for implementation	Triggers to implement noise abatement flight procedures may be monetary (fines due to too high noise levels) or operational (e.g. allocation of better slots for quieter flights). In the case of CDA the main driver for implementation is usually reduced fuel consumption. The resulting noise reduction is sometimes considered a (beneficial) side effect. Obstacles may be safety of flight and in some cases an additional fuel consumption.
Causal links to legislation	Local noise legislation at airports, setting limits at noise sensitive locations.
References	https://www.sustainableaviation.co.uk/goals/noise/

Table 6.17 Dispersion or concentration of flights

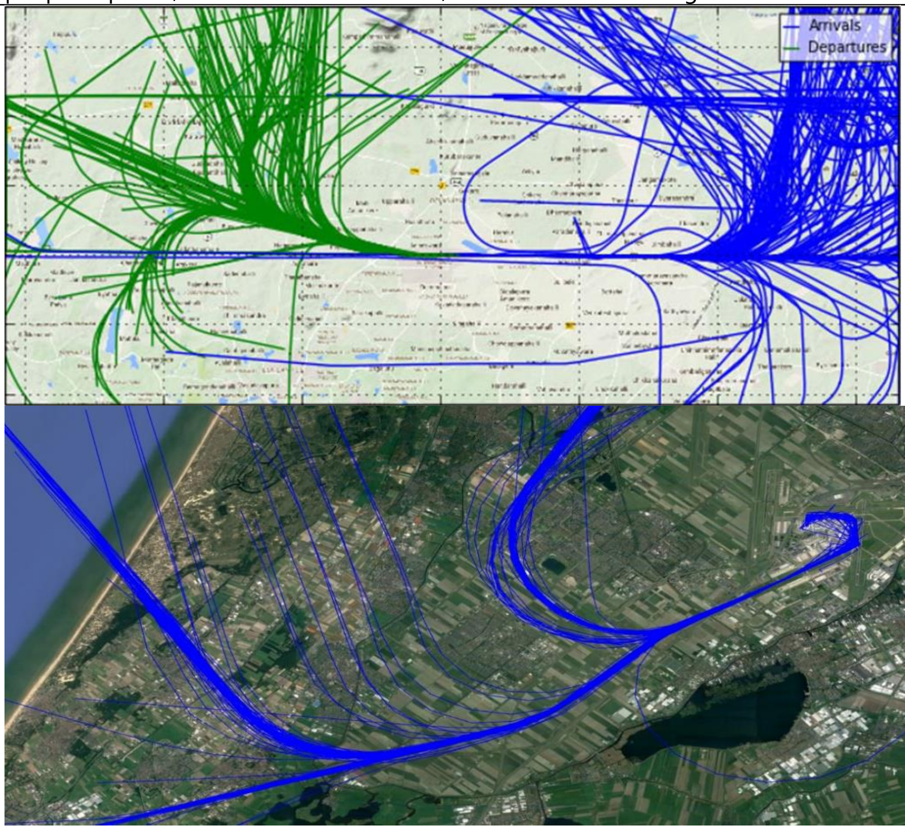
Noise abatement measure	Dispersion or concentration of flights (route optimization)
Principle and example(s)	Although aircraft usually have to follow a nominal flight track from or to the airport, they do have a certain degree of freedom in the horizontal plane. This can be used to concentrate aircraft in narrow corridors, to avoid noise sensitive areas or on the contrary, to spread the aircraft movements over a wider area, which may result in more people exposed, but to lower noise levels, a form of noise sharing.
Illustration	 Source: Anotec Egineering
Noise reduction	The noise reduction that may be obtained is completely airport dependent.
Modelling	The airport noise modelling methodology described in ECAC Doc 29 allows for the inclusion of horizontal dispersion in the flights. This feature can be configured so as to best simulate the actual or desired dispersion.
Availability	This measure has been taken at airports since decades. More recently Area Navigation (RNAV) enables more accurate flying of desired flight tracks.
Implementation level	In 2010 ICAO recommended the introduction of Performance Based Navigation (PBN), which includes RNAV. Since then, ever more airports have been introducing this and at a significant number of mayor airports this has been introduced.
Implementation time, life cycle	Implementation of RNAV requires a redesign of the airspace around an airport, thus requiring significant time.
Costs and benefits at EU level	The cost is mainly related to the redesign of the airspace. In the long run, less ground based navigation devices like VOR will be required, thus reducing cost of infrastructure.
Triggers and obstacles for implementation	More accurate flying may improve fuel consumption, which may be a trigger for implementation. However, shifting flights to a corridor to avoid noise sensitive areas may increase fuel consumption due to longer routes, which may be a barrier for introduction.
Causal links to legislation	ICAO Recommendation for the implementation of PBN
References	ICAO Doc 9613- Performance based navigation manual

Table 6.18 Operating restrictions - curfew (Airport regulation)

Noise abatement measure	Operating restrictions - curfew (Airport regulation)
Principle and example(s)	A curfew is a partial operating restriction that prohibits the operation of certain (or all) aircraft types during a specific time period. A well-known example is the night curfew that does not allow any take-off or landing during the night period.
Illustration	-
Noise reduction	The noise reduction that may be obtained is completely depending on the situation. At airports where a significant amount of night flights occur, the reduction will be important, whereas at an airport with almost no night traffic, the reduction will be negligible.
Modelling	This measure is modelled by changing the flight schedule.
Availability	This measure is in principle readily available.
Implementation level	Complete or selective night curfews have been implemented at a significant number of airports throughout the EU.
Implementation time, life cycle	The time required for the actual implementation of a curfew is limited. However, it should be demonstrated that this is the only economically and technically viable measure to reduce the noise. This demonstration, its adoption by all stakeholders and the process to be followed in line with Regulation 598 will take significant time.
Costs and benefits at EU level	The cost of especially night curfews may be significant for operators like couriers. Night curfews also will usually force a concentration of operations in the early morning or late evening, which may result in airport congestion with the corresponding delays. In addition these shoulder hours are very noise-sensitive in relation to sleep disturbance. Benefits are especially found in a reduced amount of sleep disturbance.
Triggers and obstacles for implementation	Community actions against night flights are an important trigger for the introduction of night curfews. The economic effects on operators may be significant and closure of a transport hub at a certain airport could have serious social consequences due to loss of jobs.
Causal links to legislation	Regulation 598
References	REGULATION (EU) No 598/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC

Table 6.19 Operating restrictions - prohibition of operation for noisier aircraft (airport regulation)

Noise abatement measure	Operating restrictions - prohibition of operation for noisier aircraft (airport regulation)
Principle and example(s)	Prohibition of operation for noisier aircraft is an operating restriction, excluding the access of certain aircraft types from operation at an airport. Usually this is based on the certification noise levels of the aircraft type. This ban may apply globally or may be restricted to certain periods of the day. In the latter case this could be considered a combination of the curfew measure mentioned earlier.
Illustration	-
Noise reduction	The noise reduction that may be obtained is completely depending on the situation. At airports where a significant amount of flights with noisier aircraft types occur, the reduction will be important, whereas at an airport with almost no such operations, the reduction will be negligible.

Modelling	This measure is modelled by changing the fleet mix operating at the airport.
Availability	This measure is in principle readily available.
Implementation level	Several airports have implemented restrictions for the noisiest Chapter 3 aircraft, usually limited to the night period.
Implementation time, life cycle	The time required for the actual implementation of this restriction is limited. However, it should be demonstrated that this is the only economically and technically viable measure to reduce the noise. This demonstration, its adoption by all stakeholders and the process to be followed in line with Regulation 598 will take significant time.
Costs and benefits at EU level	The cost of a ban on noisier aircraft may be significant for aircraft operators, since these aircraft are usually much cheaper (cost of ownership)[318]. On the other hand, this type of aircraft are not fuel efficient and direct operating cost may therefore be high.
Triggers and obstacles for implementation	Community actions are an important trigger for the introduction of this restriction. The economic effects on operators may be significant. Procedural requirements under Regulation 598 must be followed.
Causal links to legislation	Regulation 598
References	REGULATION (EU) No 598/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC

Table 6.20 Forced phase out of older aircraft (airport regulation)

Noise abatement measure	Forced phase out of older aircraft (airport regulation)
Principle and example(s)	Prohibition of operation for noisier aircraft is an operating restriction, excluding the access of certain aircraft types from operation at an airport. Usually this is based on the certification noise levels of the aircraft type. An example on an EU-wide restriction is the ban of all Chapter 2 aircraft from operation in the EU as of 1 April 2002. Due to the international character of aviation, such a forced phase out should be implemented on an EU-wide scale.
Illustration	-
Noise reduction	The noise reduction that may be obtained is completely depending on the situation. At airports where a significant amount of flights with noisier aircraft types occur, the reduction will be important, whereas at an airport with almost no such operations, the reduction will be negligible.
Modelling	This measure is modelled by changing the fleet mix operating at the airport.
Availability	This measure is in principle readily available subject to requirements under Regulation 598 and ICAO rules on non-discrimination etc.
Implementation level	The ban on Chapter 2 aircraft has been full since 1 April 2002. An unforced phase out of marginally compliant Chapter 3 aircraft has been going for quite some time, mainly due to the related high direct operating cost (fuel consumption).
Implementation time, life cycle	The time required for the actual implementation of this restriction is limited. However, it should be demonstrated that this is the only

[318] Internet search among aircraft broker sites shows values of less than 10% of the list price for aircraft of around 20 years old

	economically and technically viable measure to reduce the noise. This demonstration, its adoption by all stakeholders and the process to be followed in line with Regulation 598 will take significant time.
Costs and benefits at EU level	The cost of a ban on noisier aircraft may be significant for aircraft operators, since these aircraft are usually much cheaper (cost of ownership)[319]. On the other hand, this type of aircraft are not fuel efficient and direct operating cost may therefore be high.
Triggers and obstacles for implementation	Community actions are an important trigger for the introduction of this restriction. The economic effects on operators may be significant.
Causal links to legislation	Directive 92/14/EEC Regulation 598
References	REGULATION (EU) No 598/2014 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC

Table 6.21 Acquisition of new quieter aircraft (EU or national level incentives for airlines)

Noise abatement measure	Acquisition of new quieter aircraft (EU or national level incentives for airlines)
Principle and example(s)	The acquisition of new, quieter aircraft may be positively influenced by incentives. These may be of a direct monetary nature (e.g. higher taxes on noisier aircraft) or operational (preferred slot allocations for quieter aircraft). The introduction of quieter aircraft in the fleet is a very effective way of reducing the noise at airports.
Illustration	
Noise reduction	Most recent aircraft types like A320neo, B787 and A350 are in the order of 2-3 EPNdB quieter than their predecessors. This is mainly due to new engine technology, although also attention has been given to reduce the airframe noise, a mayor source in approach.
Modelling	The ANP database used for airport noise modelling contains data for several new aircraft types. For those that are not yet included appropriate substitutions are recommended
Availability	The newest aircraft types are on the market for some years now.
Implementation level	New aircraft types are gradually being introduced in the world fleet. Their share in the total is still modest
Implementation time, life cycle	Aircraft life in western countries is typically in the order of 15-20 years. Fleet roll-over has to be gradual due to manufacturing limitations. Backlogs of aircraft type deliveries may span several years. Many carriers are facing financial difficulties during the ongoing crisis in the sector.
Costs and benefits at EU level	Introduction of new aircraft types is costly and incentives need to be proportional to this. As can be seen from the example in section 5.12, benefits of introducing quieter aircraft are also significant.
Triggers and obstacles for implementation	Cost and delivery times are main barriers for a fleetwide introduction of new aircraft types. Also low fuel prices may make investment in new aircraft types less attractive. Current low interest rates on the other hand may be an incentive to invest for carriers with access to loans/equity despite the current crisis in the sector.
Causal links to legislation	ICAO Annex 16 /EASA CS36
References	

[319] Internet search among aircraft broker sites shows values of less than 10% of the list price for aircraft of around 20 years old

Table 6.22 Sound insulation of residential and communal buildings, including government incentives for home owners

Noise abatement measure	Sound insulation of residential and communal buildings, including government incentives for home owners
Principle and example(s)	Sound insulation of residential and communal buildings, is a common measure in residential areas around airport, and consists of improved double or treble glazing, sealing of gaps and noise-reducing air vents. It may be funded by the airport operator and/or authorities above a certain noise threshold and under certain conditions. For existing properties, it may only be available if the traffic situation has changed, whereas for new buildings, there may be public funding available to actually fulfil building regulations.
Illustration	 Source: wikiwand.com Façade, window and roof insulation is commonplace near airports.
Noise reduction	The noise reduction is only within the dwelling with windows closed, and from 10 upto around 25 dB depending on the glazing type and the further façade/roof insulation. The noise level at the façade, which is a crucial element of environmental noise legislation, is not affected. However, in a number of member states noise levels inside the dwelling are regulated.
Modelling	This measure is at the reception point, but not in the sense of the END, which considers the noise level at the façade. Dwelling sound insulation is determined on the basis of specified or measured insulation of glazing and building elements.
Availability	Widely available
Implementation level	Widely applied
Implementation time, life cycle	Sound insulation remediation programmes may take years to set up and complete and are not available in all member states. Once funded however, installation can be swift and the benefits immediate. New buildings near airports are often designed beforehand with sufficient sound insulation.
Costs and benefits at EU level	Costs are government or local authority or airport operator funding for sound insulation per affected dwelling. The benefits are proportional to the number of insulated dwellings each year, although not expressed in terms of noise at the façade.
Triggers and obstacles for implementation	Triggers are urban construction, new infrastructure, national legislation and public demand. Obstacles are public opposition, cost, social-economic impacts.
Causal links to legislation	END, 996/2015/EU prediction model, national prediction models and reception limits; local regulations and acts.
References	-

Table 6.23 Extension of land barrier, land use planning including acquisition of dwellings

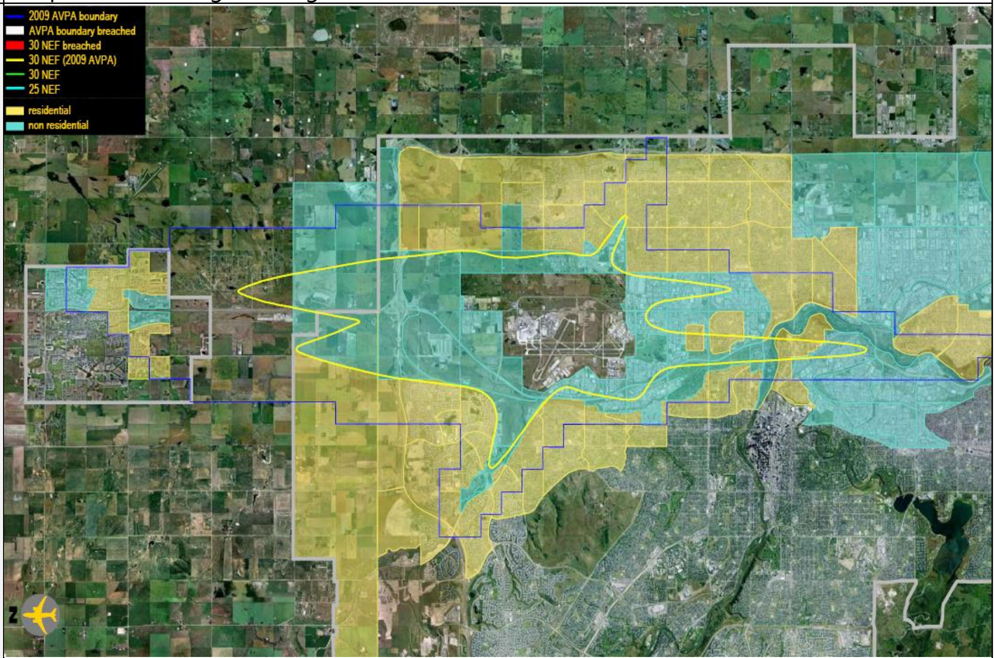
Noise abatement measure	Extension of land barrier, land use planning including acquisition of dwellings
Principle and example(s)	Airports require safety zones (funnels) in the area of extension of the runway centreline, to minimize casualties in the case of accident. These funnels are usually not big enough to also safeguard residents from noise impact. To reduce the noise levels in locations very near to the runway end is usually not feasible, due to the lack of available degrees of freedom of movement of aircraft in the initial (or final) segment of their flight. Also insulation of houses in these areas is mostly impossible at reasonable cost. Therefore the only way to avoid noise impact issues near to runways is usually to create a buffer zone without any incompatible land use. Cases exist where these zones have been reserved by design, from the start of the airport operation, but in other cases it might be necessary to acquire the existing dwellings in these areas.
Illustration	 Source: Airbiz/Calgary airport
Noise reduction	This measure does not directly create a noise reduction. It will allow to avoid exposure to unacceptable noise levels.
Modelling	Standard modelling of airport noise, with population re-located
Availability	Available
Implementation level	At few airports very long-term land use planning has been implemented. Some airports have opted for acquiring dwellings but due to the related cost this is not widely done.
Implementation time, life cycle	Land use planning is by definition long-term. 10 years or more are required to obtain real benefits from this. The time required for acquisition of dwellings may vary from quick (if high price offered) to very long, if house owners take their case to court.
Costs and benefits at EU level	Cost of preserving space for the future is mainly related to the missed opportunity of development (real estate), whereas usually the airport operator will have to bear the cost of acquiring dwellings. The benefits are the avoidance of areas with high noise impact
Triggers and obstacles for implementation	Triggers are the lack of economical or technically feasible alternatives. Obstacles are the economical cost and the usually very long time required, far beyond the 4-5 year cycles of elections.
Causal links to legislation	END, national legislation on max noise levels and land use planning
References	-

Table 6.24 Stakeholder engagement

Noise abatement measure	Stakeholder engagement
Principle and example(s)	Whereas most solutions are directed towards the reduction of noise exposure (i.e. reducing the noise levels received by the population), these do not always a reduction in the reported noise annoyance. Studies like those performed in the H2020 ANIMA project have highlighted that only about one third of the total annoyance is caused by actual noise levels. The rest is due to other factors, not necessarily related to noise directly. There are many such non-acoustical factors (e.g. trust in the airport, collaborative decision making, etc) that influence the way people will react on a given noise level. It has been found that stakeholder engagement can be a powerful tool to make communities around airports feel part of the whole environmental issue at the airport, and through this, reduce their sensitivity to noise. A well-known example is the implementation of the Dialogue Forum with residents at Vienna airport.
Illustration	 Source: Vienna airport
Noise reduction	This measure does not create a noise reduction. It is targeted towards the reduction of the sensitivity of people to noise.
Modelling	At present this can only be modelled by means of a change to the exposure-response relationship
Availability	Available
Implementation level	Only at a reduced number of airports stakeholder engagement has been implemented as part of the airport noise management strategy.
Implementation time, life cycle	Although the strategy itself can be implemented in a reduced time, its effect will take several years to flourish. The sometime deteriorated relationship between airport and residents needs to be turned into a positive one, building trust among the partners, which usually is a lengthy process.
Costs and benefits at EU level	The cost of stakeholder engagement is almost negligible if compared with other (noise reduction) solutions. However, the benefits that may be obtained are huge, since it could partially avoid large investments in other solutions and may avoid lengthy law suits.
Triggers and obstacles for implementation	Stakeholder engagement is still seen by many airports as "waking up sleeping dogs" and at present is mainly taken up at a late stage in noise management, when other solutions are considered insufficient. However, projects like ANIMA seem to be a way to trigger airports to assess this option in a much earlier stage. This field of action is still under development and clear guidelines and assessment methods are still lacking. Also cultural differences between countries make the "export" of solutions difficult. These are clear obstacles for a wider implementation.
Causal links to legislation	There is no legislation on stakeholder engagement.
References	-

7 Scenarios with noise abatement solutions

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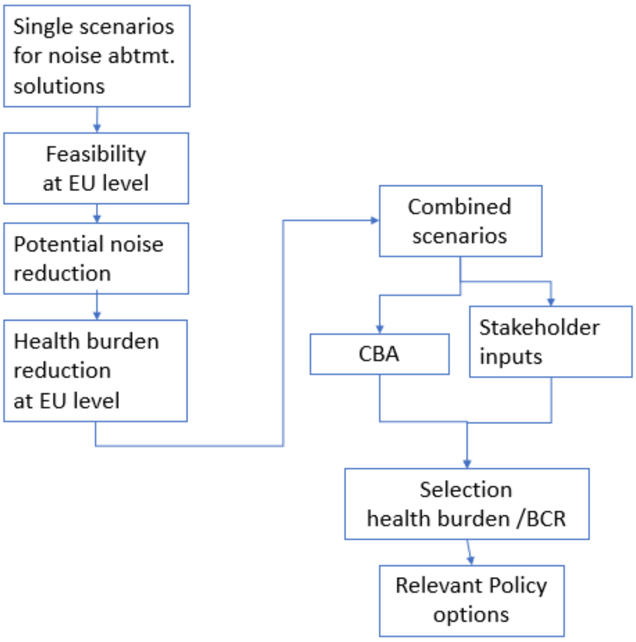
In this chapter, input parameters and results of calculations are presented for noise abatement scenarios of road traffic noise, railway noise, and aircraft noise. The scenarios are based on noise abatement solutions described in chapter 6. Two types of scenarios are considered:

- scenarios with a single noise abatement solution,
- scenarios with combined solutions.

The scenarios with a single solution represent those described in the previous chapter, with specified input parameters. The scenarios with combined solutions are proposed on the basis of their expected health burden reduction and benefit-to-cost ratio, as well as timescale, feasibility, and stakeholder inputs. A flow scheme indicating the selection process for single and combined scenarios is shown in Figure 7.1. Combined scenarios generally have the largest potential reductions in health burden.

Figure 7.1. Flow scheme of selection of single and combined scenarios



As described in Chapter 5, *health benefits* due to noise solutions are calculated as differences in health burden between a baseline scenario and a scenario with one or more noise solutions. The baseline scenarios for road, rail, and aircraft noise and the unit costs and benefits per solution have been specified in Chapter 5.

7.1 Road traffic noise: description of scenarios

For the road traffic noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Reduced vehicle noise emission and electrification
  - Modelled by changing the percentages of compliance with six different vehicle emission limits, per vehicle type.
- Reduced tyre noise
  - Modelled by reducing the tyre label per vehicle type
- More quiet road surfaces
  - Modelled by increasing the percentages of road lengths with quiet surface.
- More noise barriers
  - Modelled by increasing the percentages of road lengths with noise barriers.
- Vehicle speed reduction
  - Modelled by reducing the speeds per road type and per vehicle type.
- Vehicle access restrictions, car-free zones, rerouting
  - Modelled by changing the noise exposure distributions.
- Quiet facades
  - Modelled by changing the noise exposure distributions.
- Dwelling insulation
  - Modelled by changing the noise exposure distributions.

Vehicle access restrictions, car-free zones, and rerouting may be part of an *urban planning* scenario of a city. Such a scenario may also include more expensive solutions such as tunnelling or the construction of office buildings that shield dwellings from traffic noise.

In addition to the above physical noise solutions, scenarios with reception limits are also considered. Reception limits should be considered as triggers for physical solutions, and the effects of reception limits represent the *potential* effects of scenarios with noise solutions.

Scenarios with a single noise solution

In Table 7.1, scenarios A-J with a single solution are specified in quantitative terms. In the following, each scenario is briefly described. Calculation results are presented in the next section.

Scenario A is an increase of quiet road surface. The end situation in 2035 is specified in the table: 22.5% of roads of types 5-8[320] have a quiet road surface. For intermediate years, linear interpolation is applied. This means that for year 2030 the percentage is 15%, which is three times higher than the baseline percentage of 5%. The costs[321] are 3 Euro per m^2 for implementation and 0.4 Euro per m^2 for annual maintenance; the area was calculated from the road lengths assuming road widths of 6, 6, 12, 12, 16, 20, 20, 16 m for road types 1-8, respectively.

Scenario B is a reduction of the tyre noise levels, according to the tyre label, by 3-5 dB. Since the lifetime of tyres is about four years, the end situation with quieter tyres is reached in 2024, again

[320] Road type 5 = urban arterial road, type 6 = urban motorway, type 7 = non-urban motorway, type 8 = non-urban main road (see Chapter 5).

[321] All costs indicated for the various scenarios are in fact *additional* costs. For example, for scenario A the costs are the extra costs of quiet road surface, compared with th ecosts of standard road surface,

The picture can't be displayed.

with linear interpolation for the intermediate years. After 2024, the situation remains constant with quiet tyres. The costs are 300 million Euro per year.

Scenario C represents a faster compliance with new vehicle emission limits. For example, the percentage of vehicles complying with the newest vehicle limits of 2024/2026 is chosen three to four times higher than in the baseline scenario (see Table 7.1 for the exact percentages). For this scenario the percentages of hybrid and electric vehicles are kept at the baseline values. The costs are 190 million Euro per year.

Scenario D is enhanced electrification, with a higher percentage of hybrid and electric vehicles in 2035. The percentages of the other four vehicle groups are decreased, as the sum remains 100%. For the costs, the same 190 million Euro per year is used as for quieter vehicles.

Scenario E is an increase of noise barriers along roads of types 5-8. In 2035 12.5% of these roads have noise barriers, which is a factor of 2.5 higher than the baseline value of 5%. For the costs, an average barrier height of 5 m is used, which yields 2.5 million Euros per km of barrier.

Scenario F is a reduction of vehicle speeds in all urban areas. The reduced speeds in 2035 are specified in Table 7.1. For intermediate years, linear interpolation is applied, as an approximation for the gradual introduction of speed reductions. The costs are calculated from the average value of 9 Euro per person per hour, for the 'value of time'. The calculation was described in detail in Sec. 5.7, and takes into account a correction for the daily traffic peaks in the morning and evening.

Scenario G is the introduction of new car-free zones in urban areas, by means of vehicle access restrictions and traffic rerouting. It is assumed that the new car-free zones in 2035 cover 2.5% of the total urban area of END cities (i.e. cities reporting END noise maps). For the costs, 1 million Euros per km^2 is used for implementation and 0.2 million Euro per km^2 for maintenance.

> *Note*. Scenario G can also be interpreted as an urban planning / reconstruction scenario, where a 2.5% reduced noise exposure is achieved by urban planning solutions such as tunnelling and screening of dwellings by new office buildings. The costs of such urban planning solutions, however, are much higher than the costs of the traffic measures in scenario G (by a factor of 10 to 100), This should be taken into account when considering the results of the cost-benefit analysis.

Scenario H is the creation of quiet facades for 30% of the dwellings in urban area, which are assumed to have no quiet façade in 2020. A quiet façade is defined as a façade where the L_{den} level is low, for example 10 dB lower than the level at the most-exposed façade, or simply lower than 48 dB (this definition is used in Dutch cities such as Amsterdam). The effect of a quiet façade is modelled as a reduction of 2 dB of the L_{den} and L_{night} levels at the most-exposed façade[322]. The creation of quiet facades requires traffic measures such as rerouting. It is assumed to the 30% of dwellings with a quiet façade is achieved by traffic measures equivalent to measures required for car-free zones covering 15% of the total urban area.

Scenario I is an increase of dwellings with façade insulation. It is assumed that the percentage of dwellings with façade insulation, along roads of types 5-8, is increased by 10% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings can be neglected,

[322] QSIDE project, www.qside.se.

so these dwellings are eliminated from the exposure distributions. The costs are 1000 Euro per dwelling.

Scenario J is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated above, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from ‘no limits’ to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario an annual cost of 1 billion Euro was assumed. This value was derived by looking at the costs for scenario A (quiet road surface) and scenario G (car-free zones), assuming that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- ABC, combination of A, B, and C,
- ABCD, combination of A, B, C, and D,
- FGHI, combination of F, G, H, and I.

Scenario ABC is a combination of scenario A (quiet roads), scenario B (quiet tyres), and scenario C (vehicle limits). It is expected that this combination will have a larger effect than the single solutions separately. The three single solutions are independent of each other in the model, so the combination is straightforward. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

In combined scenario ABCD, electrification (scenario D) is also included. For the combination of scenario C (vehicle limits) and scenario D (electrification), the fleet percentages for the six limits in 2035 are changed as follows.

- cars: from 15/15/30/10/9/21% (baseline) to 0/0/18/32/19/31%.
- vans: from 15/15/35/14/9/12% (baseline) to 0/0/22/37/19/22%.
- buses: from 15/15/25/7.5/10.5/27% (baseline) to 0/0/12/30.5/20.5/37%.
- lorries: from 15/20/30/9.5/24/1.5% (baseline) to 0/0/22.5/32/34/11.5%.
- heavy trucks: from 15/20/30/9.5/24/1.5 (baseline) to 0/0/22.5/30/34/11.5%.

For the costs, the same value is assumed as for scenario ABC, as the costs for scenario C may be partly used for electrification instead of compliance with vehicle limits.

Scenario FGHI is a combination of scenario F (speed restriction), scenario G (car-free zones), scenario H (quiet façade), and scenario I (dwelling insulation). This combination is also expected to have a larger effect than the single solutions separately. The four single solutions are independent of each other in the model, so the combination is straightforward. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Calculation results for the combined scenarios are also presented in the next section.

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Table 7.1 Scenarios with a single noise solution for road traffic noise. In all cases a final situation in 2035 (or 2024 for scenario B) is specified; for intermediate years, linear interpolation is applied

Scenario	Description
A - quiet roads	The fractions of roads with a quiet surface are increased, for road types 5-8. The length percentages are 22.5% in 2035, which is a factor of 4.5 higher than the baseline value of 5%.
B - quiet tyres	The tyre labels for the three vehicle types are gradually decreased from 70/72/75 (baseline) to 66/69/70 in the period 2020-2024, and remain constant after 2024.
C - vehicle limits	Vehicles comply faster with new vehicle emission limits. For the year 2035, the percentages for the six limits are changed as follows. - cars: from 15/15/30/10/9/21% (baseline) to 2/2/26/40/9/21%. - vans: from 15/15/35/14/9/12% (baseline) to 2/2/30/45/9/12%. - buses: from 15/15/25/7.5/10.5/27% (baseline) to 2/2/20/38.5/10.5/27%. - lorries: from 15/20/30/9.5/24/1.5% (baseline) to 5/5/27.5/37/24/1.5%. - heavy trucks: from 15/20/30/9.5/24/1.5 (baseline) to 5/5/27.5/37/24/1.5%.
D - electrification	Electrification is enhanced, with more hybrid and electric vehicles in 2035. The compliance percentages for the six limits in 2035 are changed as follows. - cars: from 15/15/30/10/9/21% (baseline) to 10/10/25/5/19/31%. - vans: from 15/15/35/14/9/12% (baseline) to 10/10/30/9/19/22%. - buses: from 15/15/25/7.5/10.5/27% (baseline) to 10/10/20/2.5/20.5/37%. - lorries: from 15/20/30/9.5/24/1.5% (baseline) to 20/15/25/4.5/34/11.5%. - heavy trucks: from 15/20/30/9.5/24/1.5 (baseline) to 20/15/25/4.5/34/11.5%.
E - barriers	The fractions of roads with noise barriers are increased, for road types 5-8. The length percentages are 12.5% in 2035, which is a factor of 2.5 higher than the baseline value of 5%.
F - speed restriction	Vehicle speeds in all urban areas are reduced. The vehicle speeds in 2035 are changed as follows. - road types 1-4: from 30-50 (baseline) to 30 km//h - road type 5 (main road): from 70-80 (baseline) to 50 km/h - road type 6 (motorway): from 85-115 (baseline) to 80 km/h.
G – car-free zones	New car-free zones in urban areas are created by means of traffic access restrictions and traffic rerouting. In 2035 there is a total of 2500 km^2 new car-free area in EU cities (e.g. 250 zones of 10 km^2); this is about 2.5% of the total area of 400 END cities (average about 250 km^2 per city). This is modelled by direct modification of the exposure distributions for urban agglomerations: exposure is reduced by 2.5%.
H - quiet facades	More quiet façades of dwellings are created. It is assumed that 30% of the dwellings in urban area that have no quiet façade in 2020 will have a quiet façade in 2035. The effect of a quiet façade is a reduction of about 2 dB at the most-exposed façade, so quiet facades are modelled by a 2 dB shift of the exposure distributions. For the calculation of the costs, it is assumed that the 30% of dwellings with a quiet façade is achieved by reducing traffic in 15% of the urban area, modelled as 15% car-free zone.
I - dwelling insulation	More dwellings are insulated. The percentage of dwellings with insulation is increased by 10% in 2035 (compared with baseline), for road types 5-8.

J - reception limits	Reception limits are introduced: 60 dB Lden and 55 dB Lnight in 2035.

7.2 Road traffic noise: results

Calculation results for single-solution scenarios A-J and combined scenarios are presented in Table 7.2 - Table 7.4 and Figure 7.2 - Figure 7.15. The results for the single-solution scenarios A-J are first discussed and the results for the combined scenarios are next discussed.

Scenarios with a single noise solution

In Table 7.2, results for the baseline scenario are given; the annual EU health burden in 2030 is expressed in four quantities:

- number of highly annoyed persons,
- number of highly sleep-disturbed persons,
- number of DALYs (Disability Adjusted Life Years),
- monetized health burden in billion Euros.

In Table 7.2, the reduction of the annual EU health burden in 2030 is given for the scenarios. Table 7.4 shows the results of the cost-benefit analysis for 2020-2035 for the scenarios. Values given in Table 7.3 and Table 7.4 are also presented in the bar diagrams in Figure 7.2. The evolution of monetized health effects, costs, and benefits for scenarios A-J are presented in Figure 7.3 - Figure 7.12.

The focus is on the health burden in 2030 (Table 7.2), and changes of the health burden in 2030 (Table 7.3), but the analysis takes into account the evolution of the health burden in the period 2020-2035, both for the baseline scenario and for the alternative scenarios. As described in Sec. 5.10, the baseline scenario includes autonomous developments as expected for the period 2020-2035 based on existing legislation.

For example, the left graph in Figure 7.4 shows the change of the health burden in 2020-2035 for the baseline scenario (dashed lines) and for scenario B (solid lines). In the baseline scenario, opposing effects of traffic growth and electrification occur (among other effects), resulting in a small overall change of the health burden (see also Figure 5.22).

The results in Table 7.3 show that scenario B (quiet tyres) yields the largest reduction of the health burden. This scenario also has a high benefit-cost ratio, as the costs of quieter tyres are limited. The health reduction for scenario A (quiet roads) is smaller, as the percentage of roads with a quiet surface is assumed to remain limited. The effects of quieter vehicles in scenarios C and D are relatively small, mainly due to the definition of the baseline scenario with 14-25% hybrid and electric vehicles in 2030. For the same reason, the effect of electrification (scenario D) is small. It affects only the powertrain noise, while rolling noise dominates, except at low speed. The effect of barriers (scenario E) is small, as the percentage of roads with a barrier is assumed to remain limited. The benefit-cost ratio for scenario E is very small, because the costs of noise barriers are high. The effect of speed restriction in urban area (scenario F) is large, where it should be noted that the speed restriction is applied to all urban areas, which is rather ambitious. The effect of vehicle access restrictions and car-free zones (scenario G) is small, as it is assumed that this can be achieved in a limited percentage

(2.5%) of the urban areas in the EU. The effects of quiet facades (scenario H) and dwelling insulation (scenario I) are small.

The results of scenario J (reception limits) show the effect of decreasing all levels above the limit to the limit. The fact that the health burden reduction is not very large implies that a large part of the health burden is caused by noise levels below the limits (60 dB L_{den} and 55 dB L_{night}).

The graphs in Figure 7.3 - Figure 7.12 show how the monetized health effects, the costs and the benefits gradually approach the situation in 2035. An exception is scenario B (Figure 7.4), where the effects are assumed to occur in a shorter time period of four years.

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the single-solution scenarios. The reductions for the combined scenarios in Table 7.3 are in the range 15-22%. The difference between the reductions for scenarios ABC and ABCD is small.

Table 7.4 shows the results of the cost-benefit analysis for 2020-2035 for the combined scenarios. The benefit-cost ratio for scenarios ABC and ABCD is considerably smaller than the benefit-cost ratio for scenario B. This suggest that there is room for optimization of combined scenarios such as ABC and ABCD. The benefit-cost ratio for scenario FGHI is small.

The evolution of monetized health effects, costs, and benefits for the combined scenarios are presented in Figure 7.13 - Figure 7.15. For scenarios ABC and ABCD, the effect of the introduction of quiet tyres in the period 2020-2024 is clearly visible in the graphs.

Figure 7.2. Results of calculations for road traffic noise scenarios from Table 7.3 and Table 7.4

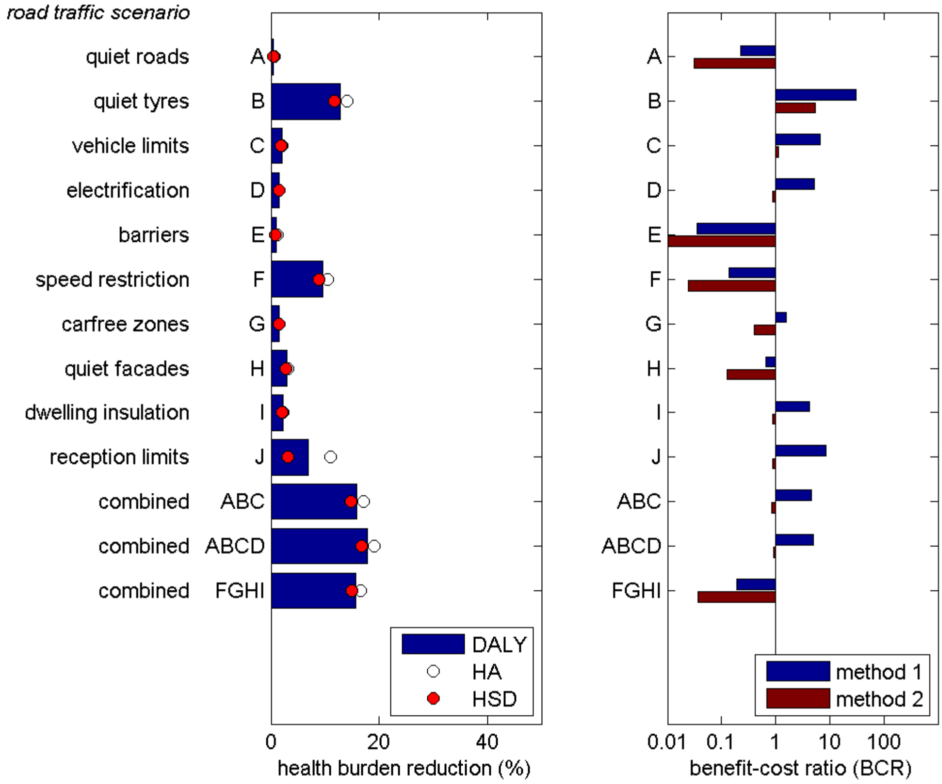


Table 7.2 Annual EU health burden of road traffic noise in 2030, for the baseline scenario

	Annual value in 2030
Highly annoyed persons	31.2 million
Highly sleep-disturbed persons	14.6 million
DALYs	1669 thousand
Monetized health burden (method 1 / 2)	58.4 / 14.6 billion Euro

Table 7.3 Percentage reduction of annual EU health burden of road traffic noise in 2030, relative to the baseline scenario, for single-solution scenarios and combined scenarios

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A quiet roads	0.6	0.4	0.5	1.0 / 0.5
B quiet tyres	14.0	11.8	12.8	17.6 / 12.8
C vehicle limits	2.0	1.9	2.0	2.7 / 1.9
D electrification	1.5	1.5	1.5	2.1 / 1.5
E barriers	1.1	0.8	0.9	1.6 / 0.9
F speed restriction	10.5	8.9	9.6	13.3 / 9.6
G car-free zones	1.5	1.5	1.5	1.5 / 1.5
H quiet facades	3.1	2.8	3.0	3.8 / 2.9
I dwelling insulation	2.3	2.1	2.2	2.6 / 2.2
J reception limits	11.1	3.2	6.9	19.3 / 7.7
ABC combined	17.2	14.8	15.9	21.5 / 15.8
ABCD combined	19.2	16.7	17.9	24.0 / 17.8
FGHI combined	16.6	14.9	15.7	20.0 / 15.7

Table 7.4 Results of cost-benefit analysis of single-solution scenarios and combined scenarios of road traffic noise, for 2020-2035

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) billion Euro	Break-even year (method 1 / 2)
A quiet roads	0.23 / 0.08	-17.1 / -21.5	- / - *
B quiet tyres	30.3 / 5.5	105.3 / 16.0	2021 / 2021
C vehicle limits	6.7 / 1.2	13.1 / 0.3	2021 / 2034
D electrification	5.2 / 0.9	9.6 / -0.3	2022 / -
E barriers	0.03 / 0.01	-240 / -247	- / -
F speed restriction	0.14 / 0.02	-445 / -504	- / -
G car-free zones	1.6 / 0.4	2.8 / -3.0	2026 / -
H quiet facades	0.7 / 0.13	-9.8 / -26	- / -
I dwelling insulation	4.3 / 0.9	10.9 / -0.4	2023 / -
J reception limits	8.6 / 0.9	91.0 / -1.5	2027 / -
ABC combined	4.6 / 0.8	101.3 / -4.5	2021 / -
ABCD combined	5.1 / 0.9	114.2 / -1.9	2021 / -
FGHI combined	0.2 / 0.04	-448 / -534	- / -

* (not reached in 2020-2035)

Figure 7.3. Results of cost-benefit analysis for road traffic noise scenario A (quiet roads), with monetized health effects for scenarios 0 and A (left), and costs and benefits of the scenario (right)

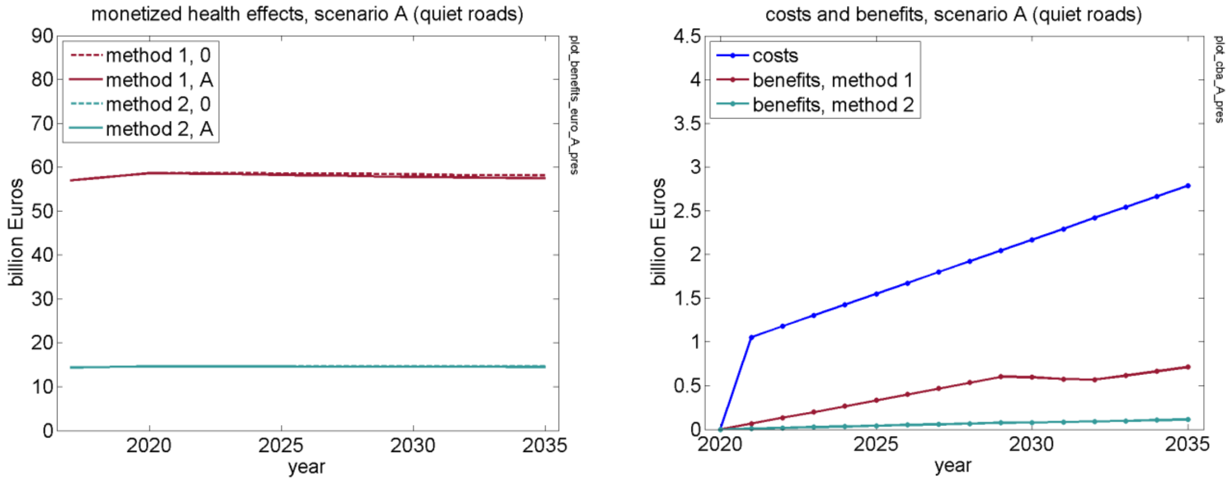


Figure 7.4. Results of cost-benefit analysis for road traffic noise scenario B (quiet tyres).

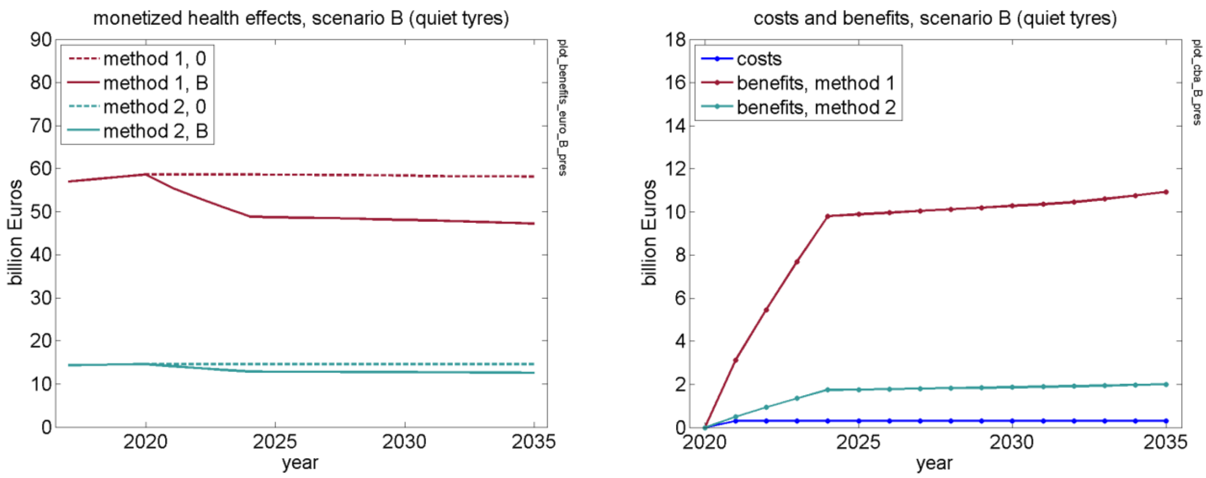


Figure 7.5. Results of cost-benefit analysis for road traffic noise scenario C (vehicle limits)

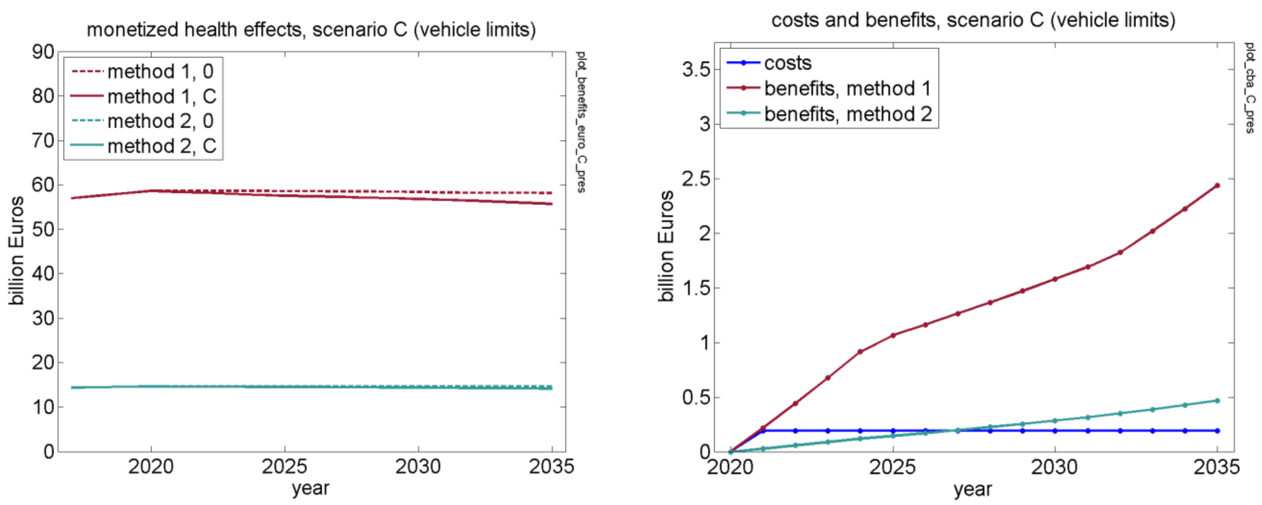


Figure 7.6. Results of cost-benefit analysis for road traffic noise scenario D (electrification).

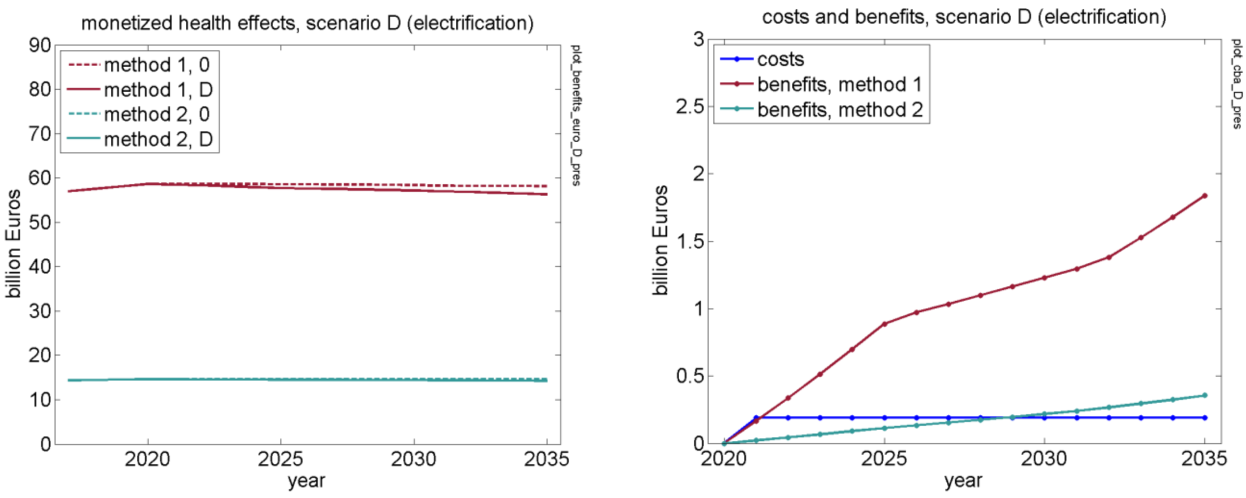


Figure 7.7. Results of cost-benefit analysis for road traffic noise scenario E (barriers).

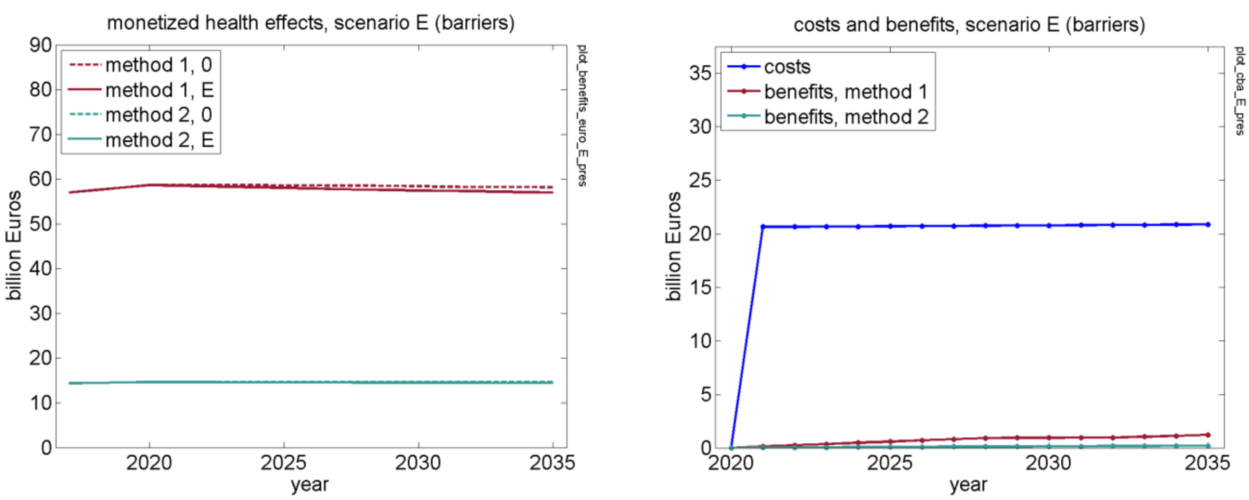


Figure 7.8. Results of cost-benefit analysis for road traffic noise scenario F (speed restriction)

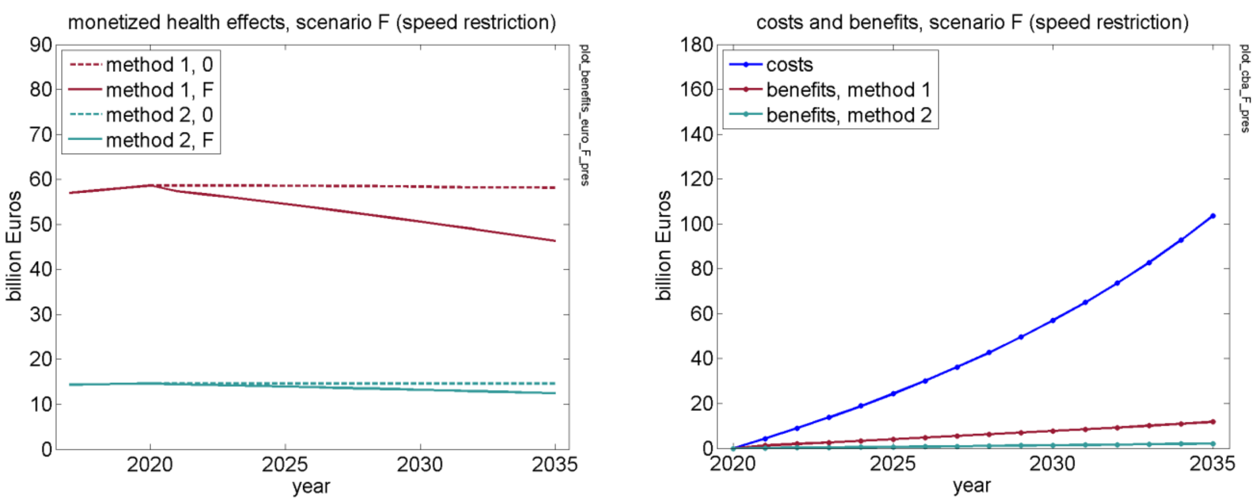


Figure 7.9. Results of cost-benefit analysis for road traffic noise scenario G (car-free zones)

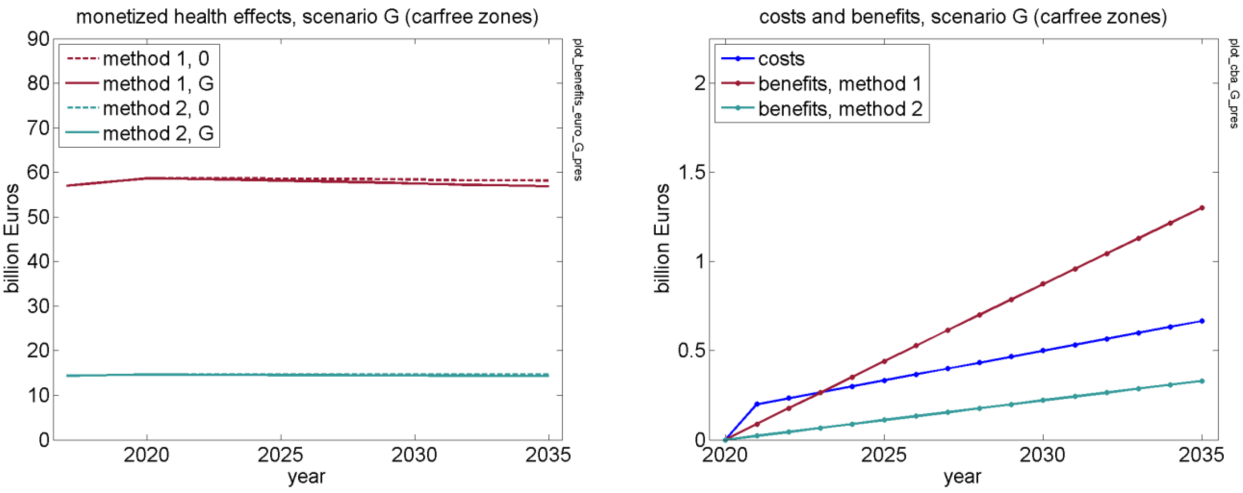


Figure 7.10. Results of cost-benefit analysis for road traffic noise scenario H (quiet facades)

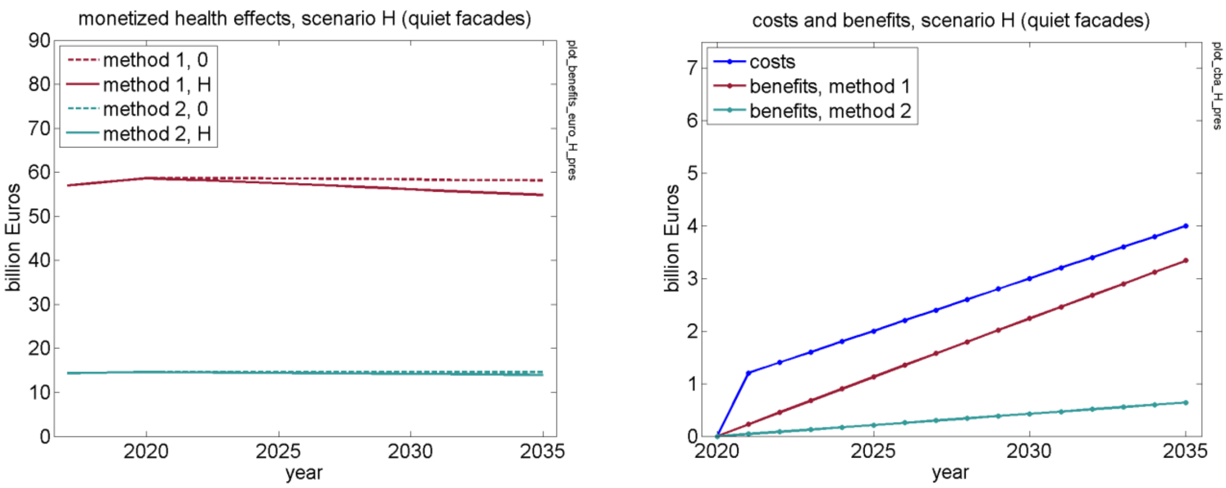


Figure 7.11. Results of cost-benefit analysis for road traffic noise scenario I (dwelling insulation).

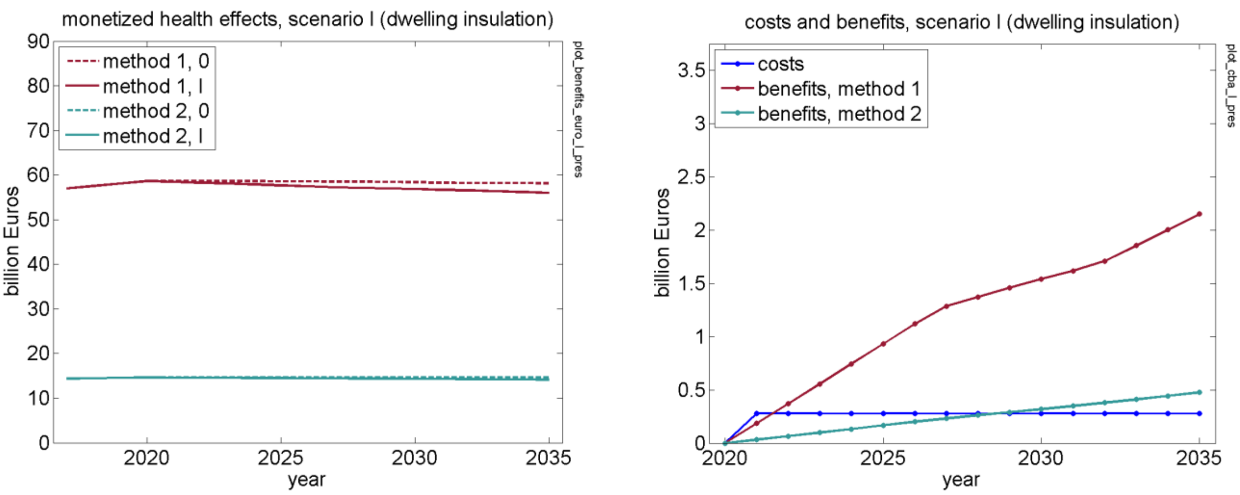


Figure 7.12. Results of cost-benefit analysis for road traffic noise scenario J (reception limits)

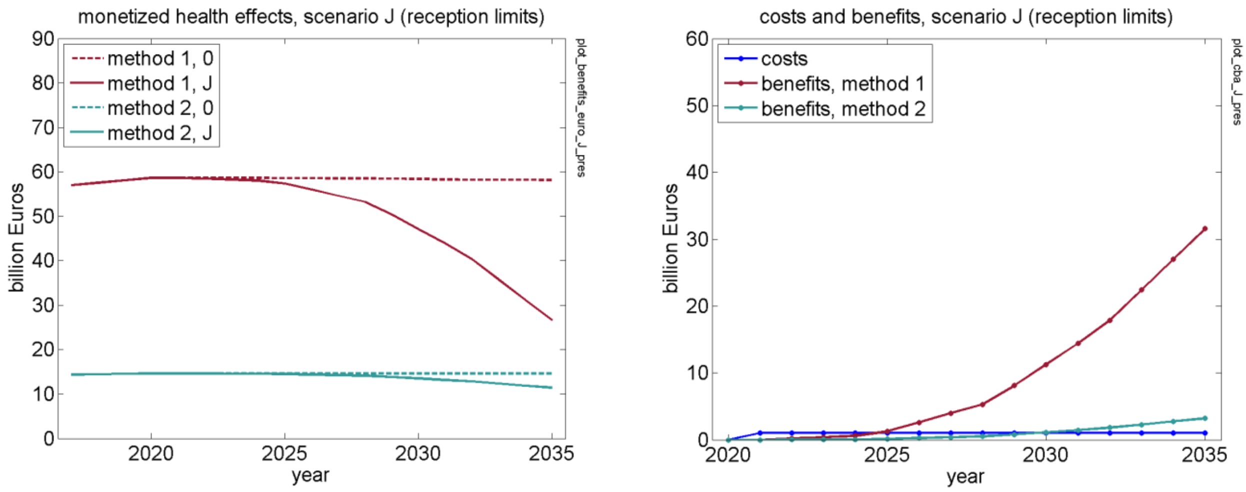


Figure 7.13. Results of cost-benefit analysis for road traffic noise scenario ABC (combined)

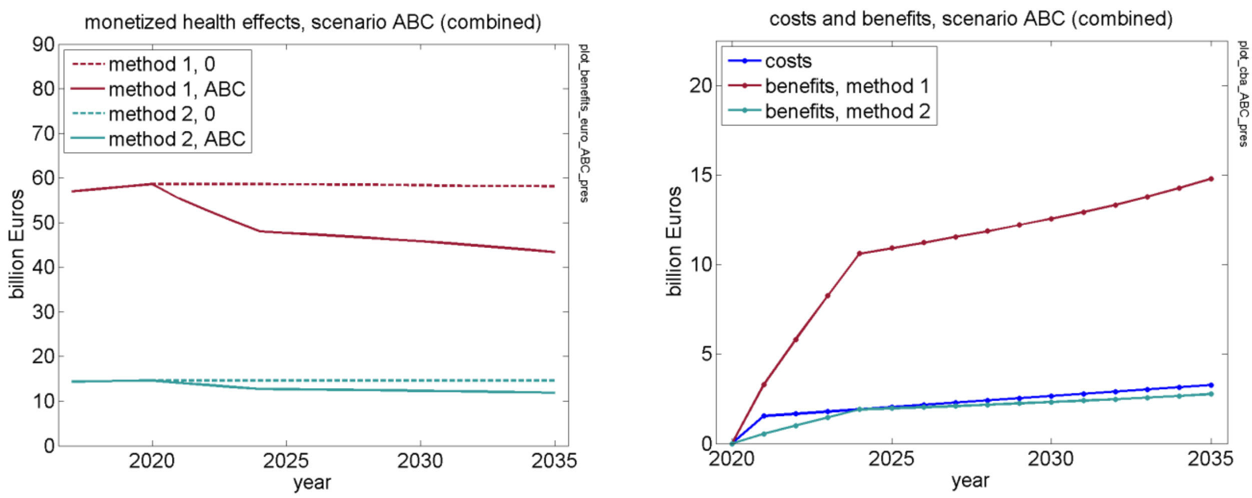


Figure 7.14. Results of cost-benefit analysis for road traffic noise scenario ABCD (combined)

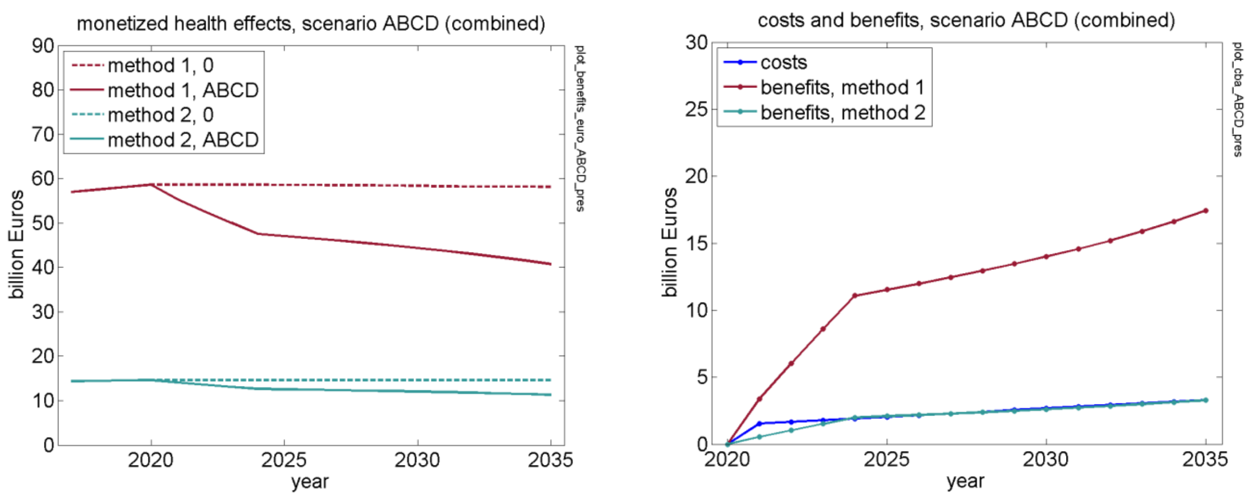
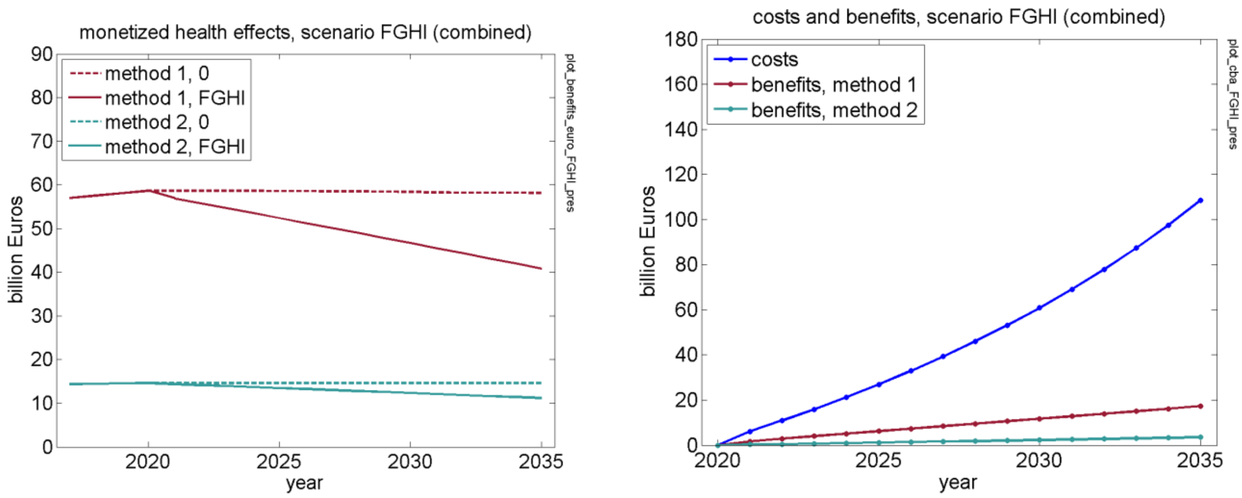


Figure 7.15. Results of cost-benefit analysis for road traffic noise scenario FGHI (combined)



7.3 Road traffic noise: variations

In this section, results are presented for road traffic scenarios described in the previous sections, but now with *modified* input parameters. The input parameters are varied to reflect the uncertainty associated with EU scenarios for the period 2020-2035. For example, a prediction of the amount of quiet road surfaces in the EU is subject to a considerable uncertainty. The results in this section give an impression of the effects of such uncertainties on the results of this study.

The results are presented in Table 7.5 (health burden reduction) and Table 7.6 (cost-benefit analysis). Bar diagrams of the results are shown in Figure 7.16.

For scenario A (quiet roads), three variations are considered, scenarios A1-A3. The length fraction and the type of quiet road surface for the eight road types 1-8 were varied as follows.

	urban residential (1,2)	urban main (3,4)	urban arterial (5)	urban motorway 6	non-urban motorway (7)	non-urban main (8)
fraction of quiet road surface						
baseline	0	0	0.05	0.05	0.05	0.05
A	0	0	0.225	0.225	0.225	0.225
A1	0	0	0.5	0.5	0.5	0.5
A2	0	0.5	0.5	0.5	0.5	0.5
A3	1	1	1	1	1	1
road surface type (1=dense asphalt, 2=thin top layers, 3=porous asphalt, 4=double-layer porous asphalt)						
baseline	1	1	2	2	3	3
A	1	1	2	2	3	3
A1	1	1	2	2	3	3
A2	1	2	2	2	3	3
A3	4	4	4	4	4	4

For scenario A, the fraction of 0.225 in 2035 corresponds with 0.15 in 2030, which is three times higher than the baseline value of 0.05. For scenario A1 the fraction was raised from 0.225 to 0.5, and consequently the health burden reduction for scenario A1 is larger than for scenario A. For scenario A2 urban main roads (types 3 and 4) were included in roads with a quiet road surface, and this increases the health burden reduction by a factor of about 3. This shows that urban main roads have a large contribution to the health burden of road traffic noise. The benefit-to-cost ratio is also higher for scenario A2 than for scenarios A and A1. Scenario A3 is not a realistic scenario but is included here to show the potential effect of quiet road surface. For this scenario, road surface type 4 (double-layer porous asphalt) was assumed for all eight road types. For residential roads (types 1 and 2), this was done to simulate the effect of maintenance or the effect of replacing non-asphalt roads by (dense) asphalt. The effect of road surface type 4 is a reduction of about 4 dB. The health burden reduction for scenario A3 is about 25% and the benefit-cost ratio is 1.05 with method 1 and 0.2 with method 2.

For scenario B (quiet tyres), two variations are considered, scenarios B1 and B2. For scenario B1, the tyre noise reduction of 3-5 dB for scenario B was replaced by 2 dB (see below). Consequently, the health burden reduction is reduced by a factor of about 2. The benefit-to-cost ratio is reduced by the same factor, as the costs are assumed to remain the same as for scenario B. For scenario B2, the same tyre noise reduction was used as for scenario B, but now the introduction is spread out over two periods of 4 years instead of one. Consequently, the health burden reduction in 2030 is exactly the same as for scenario B, but the benefit-to-cost ratio is smaller.

	tyre label vehicle type C1	tyre label vehicle type C2	tyre label vehicle type C3	period
baseline	70	72	75	
B	66	69	70	2020-2024
B1	68	70	73	2020-2024
B2	66	69	75	2020-2024 and 2026-2030

For scenario C (vehicle limits), one variation is considered, scenario C1. The vehicle limits distributions are as follows.

Baseline scenario

	<2015	2016	2020/22	2024/26	hybrid	electric
cars	15	15	30	10	9	21
vans	15	15	35	14	9	12
buses	15	15	25	7.5	10.5	27
lorries	15	20	30	9.5	24	1.5
trucks	15	20	30	9.5	24	1.5

Scenario C

	<2015	2016	2020/22	2024/26	hybrid	electric
cars	2	2	26	40	9	21
vans	2	2	30	45	9	12
buses	2	2	20	38.5	10.5	27
lorries	5	5	27.5	37	24	1.5
trucks	5	5	27.5	37	24	1.5

Scenario C1

	<2015	2016	2020/22	2024/26	hybrid	electric
cars	5	5	20	40	9	21
vans	5	5	24	45	9	12
buses	5	10	25	22.5	10.5	27
lorries	5	5	30	34.5	24	1.5
trucks	5	5	30	34.5	24	1.5

The percentages for limits '2015', '2016', '2020/22', and '2024/26' are different for the three scenarios. The percentages for 'hybrid' and 'electric' are not different. Although the percentages for scenario C1 are not very different from the percentages for scenario C, scenario C1 is included here since during this project the possibility came up that scenario C1 may be considered as an alternative baseline scenario[323]. This implies that all results for the health burden reduction are

[323] This possibility originated from the project 'MN vehicle noise limits' for the European Commission.

subject to an uncertainty that is equal to the health burden reduction for scenario C1, which is about 2% (see Table 7.5).

For scenario D (electrification), one variation is considered, scenario D1. The vehicle limits distributions are as follows.

Baseline scenario						
	<2015	2016	2020/22	2024/26	hybrid	electric
cars	15	15	30	10	9	21
vans	15	15	35	14	9	12
buses	15	15	25	7.5	10.5	27
lorries	15	20	30	9.5	24	1.5
trucks	15	20	30	9.5	24	1.5

Scenario D						
	<2015	2016	2020/22	2024/26	hybrid	electric
cars	10	10	25	5	19	31
vans	10	10	30	9	19	22
buses	10	10	20	2.5	20.5	37
lorries	10	15	25	4.5	34	11.5
trucks	10	15	25	4.5	34	11.5

Scenario D1						
	<2015	2016	2020/22	2024/26	hybrid	electric
cars	0	0	5	5	30	60
vans	0	0	5	5	30	60
buses	0	0	5	5	30	60
lorries	0	0	5	5	60	30
trucks	0	0	5	5	60	30

The summed percentages ‘hybrid’ + ‘electric’ for cars in 2035 are:

- baseline scenario, ‘hybrid’ + ‘electric’ = 30%,
- scenario D, ‘hybrid’ + ‘electric’ = 50%,
- scenario D1, ‘hybrid’ + ‘electric’ = 90%.

Although scenario D1 is not very probable, it is included here to demonstrate the potential effects of electrification. Even for scenario D1, the health burden reduction is only about 6% (see Table 7.5).

For scenario E (barriers), two variations are considered, scenarios E1 and E2. The length fraction of barriers for the eight road types 1-8 was varied as follows.

	urban residential (1,2)	urban main (3,4)	urban arterial (5)	urban motorway 6	non-urban motorway (7)	non-urban main (8)
baseline	0	0	0.05	0.05	0.05	0.05
E	0	0	0.125	0.125	0.125	0.125
E1	0	0	0.5	0.5	0.5	0.5
E2	0	0.5	0.5	0.5	0.5	0.5

For scenario E, the fraction of 0.125 in 2035 is 2.5 times higher than the baseline value of 0.05. For scenario E1 the fraction was raised from 0.125 to 0.5, and consequently the health burden reduction for scenario E1 is larger than for scenario E. For scenario E2 urban main roads (types 3 and 4) were included in roads with noise barriers, and this increases the health burden reduction by a factor of about 3. This shows that urban main roads have a large contribution to the health burden of road traffic noise. Scenario E2 is not very realistic, as it will be difficult to place noise barriers at many locations along urban main roads. The health burden reduction for scenario E2 is larger than for scenario A2, because the effect of a noise barrier is larger than the effect of a quiet road surface.

For scenario F (speed restriction), three variations are considered, scenarios F1-F3. The vehicle speeds for categories light, medium, and heavy are as follows.

Baseline scenario						
	urban residential (1/2)	urban main (3/4)	urban arterial (5)	urban motorway 6	non-urban motorway (7)	non-urban main (8)
light	30 / 30	50 / 50	80	100	115	80
medium	30 / 40	40 / 50	70	85	85	80
heavy	30 / 40	40 / 50	70	85	85	80

Scenario F						
light	30 / 30	**30 / 30**	**50**	**80**	115	80
medium	30 / **30**	**30 / 30**	**50**	**80**	85	80
heavy	30 / **30**	**30 / 30**	**50**	**80**	85	80

Scenario F1						
light	30 / 30	50 / 50	**50**	**80**	115	80
medium	30 / **30**	40 / 50	**50**	**80**	85	80
heavy	30 / **30**	40 / 50	**50**	**80**	85	80

Scenario F2						
light	30 / 30	50 / 50	80	100	115	80
medium	30 / **30**	40 / 50	70	85	85	80
heavy	30 / **30**	40 / 50	70	85	85	80

Scenario F3						
light	30 / 30	50 / 50	80	**80**	115	80
medium	30 / 40	40 / 50	70	**80**	85	80
heavy	30 / 40	40 / 50	70	**80**	85	80

Speeds different from the baseline value are shown bold. The health burden reduction is largest for scenario F, with speed restrictions on all urban roads. Excluding urban main roads (scenario F1) results in a slightly smaller health burden reduction. Speed restriction only on urban residential roads (type 2) still yields a considerable health burden reduction. Speed restriction only on urban motorways (type 6) yields a negligible health burden reduction.

For scenario I (dwelling insulation), one variation is considered, scenario I1. The (extra) percentage of insulated dwellings I for the eight road types 1-8 was varied as follows.

	urban residential (1,2)	urban main (3,4)	urban arterial (5)	urban motorway 6	non-urban motorway (7)	non-urban main (8)
baseline	0	0	0	0	0	0
I	0	0	10	10	10	10
I1	10	10	10	10	10	10

The health burden reduction of 6.7% for scenario I1 is as expected: 10% in 2035 corresponds to 6.7% in 2030.

Figure 7.16. Results of calculations for variations of road traffic noise scenarios from Table 7.5 and Table 7.6

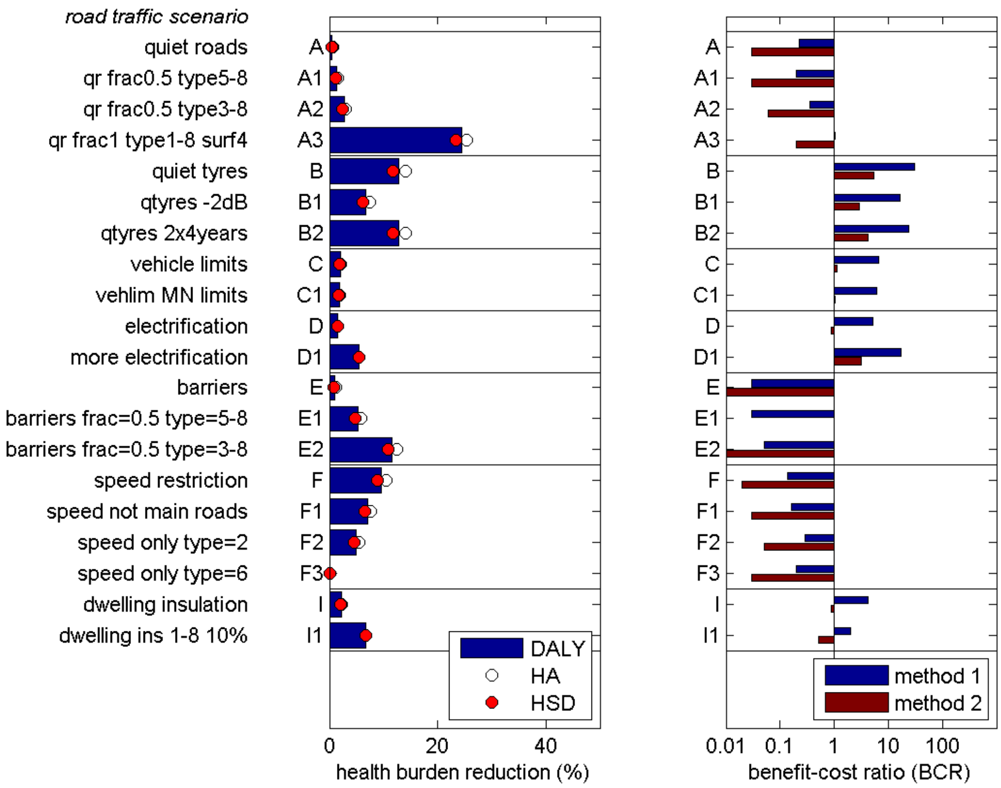


Table 7.5 Percentage reduction of annual EU health burden of road traffic noise in 2030, relative to the baseline scenario, for variations of single-solution scenarios

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A quiet roads	0.6	0.4	0.5	1.0 / 0.5
A1 frac0.5 type5-8	1.5	1.1	1.3	2.1 / 1.3
A2 frac0.5 type3-8	3.0	2.5	2.7	4.0 / 2.7
A3 frac1 type1-8	25.4	23.3	24.4	31.7 / 24.1
B quiet tyres	14.0	11.8	12.8	17.6 / 12.8
B1 -2dB	7.5	6.2	6.8	9.5 / 6.8
B2 2x4years	14.0	11.8	12.8	17.6 / 12.8
C vehicle limits	2.0	1.9	2.0	2.7 / 1.9
C1 MN limits	1.8	1.7	1.8	2.5 / 1.8
D electrification	1.5	1.5	1.5	2.1 / 1.5
D1 more electr	5.5	5.4	5.5	7.2 / 5.4
E barriers	1.1	0.8	0.9	1.6 / 0.9
E1 frac0.5 type5-8	5.9	4.8	5.3	7.4 / 5.4
E2 frac0.5 type3-8	12.4	10.9	11.6	15.5 / 11.5
F speed restriction	10.5	8.9	9.6	13.3 / 9.6
F1 not main roads	7.7	6.5	7.1	9.8 / 7.0
F2 only type2	5.5	4.6	5.0	7.0 / 5.0
F3 only type6	0.1	0.1	0.1	0.2 / 0.1
I dwelling insul.	2.3	2.1	2.2	2.6 / 2.2
I1 type1-8 10%	6.7	6.7	6.7	6.7 / 6.7

Table 7.6 Results of cost-benefit analysis of variations of single-solution scenarios of road traffic noise, for 2020-2035

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) billion Euro	Break-even year (method 1 / 2)
A quiet roads	0.23 / 0.03	-17.1 / -21.5	- / -
A1 frac0.5 type5-8	0.20 / 0.03	-45.4 / -55.3	- / -
A2 frac0.5 type3-8	0.35 / 0.06	-40.5 / -59.1	- / -
A3 frac1 type1-8	1.05 / 0.20	8.1 / -127.8	2034 / -
B quiet tyres	30.33 / 5.45	105.3 / 16.0	2021 / 2021
B1 -2dB	16.57 / 2.89	55.9 / 6.8	2021 / 2022
B2 2x4 years	23.92 / 4/26	82.3 / 11.7	2021 / 2022
C vehicle limits	6.74 / 1.15	13.1 / 0.3	2021 / 2034
C1 MN limits	6.19 / 1.05	11.8 / 0.1	2021 / 2035
D electrification	5.24 / 0.88	9.6 / -0.3	2022 / -
D1 more electr	17.39 / 3.18	37.2 / 5.0	2021 / 2025
E barriers	0.03 / 0.01	-239.7 /-247.0	- / -
E1 frac0.5 type5-8	0.03 / 0.00	-1449.1 /-1482.3	- / -
E2 frac0.5 type3-8	0.05 / 0.01	-1606.8 /-1674.5	- / -
F speed restriction	0.14 / 0.02	-445.0 /-503.8	- / -
F1 not main roads	0.16 / 0.03	-268.5 /-312.0	- / -
F2 only type2	0.29 / 0.05	-93.7 /-125.6	- / -
F3 only type6	0.20 / 0.03	-2.9 / -3.5	- / -
I dwelling insul.	4.29 / 0.87	10.9 / -0.4	2023 / -
I1 type1-8 10%	2.05 / 0.51	17.8 / -8.2	2027 / -

7.4 Railway noise: description of scenarios

For the railway noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Reduced combined wheel-rail roughness
    - Modelled by changing the distribution over the five roughness classes R1-R5.
- Quieter tracks
    - Modelled by changing the distribution over the seven track type classes T1-T7.
- Quieter vehicles
    - Modelled by changing the distribution over the six vehicle type classes V1-V6.
- More noise barriers (low and high barriers)
    - Modelled by increasing the percentages of railway lengths with low and high noise barriers.
- Improved traffic management: alternative routes, mainly for freight.
    - Modelled by changing the numbers of trains on railway lines.
- Noise reduction by urban planning and reconstruction (e.g. tunnelling)
    - Modelled by changing the exposure distributions in urban areas
- Noise reduction by dwelling insulation
    - Modelled by changing the noise exposure distributions.

In addition to the above physical noise solutions, scenarios with reception limits are also considered (in the same way as for road traffic noise).

Scenarios with a single noise solution

In Table 7.7 scenarios A-I with a single solution are specified. In the following, each scenario is briefly described. In the next section, calculation results are presented.

Scenario A is an increase of smooth tracks, by means of rail grinding or milling. The end situation in 2035 is specified in the table: the percentages of the five roughness classes R1-R5 deviate from the initial values in 2017-2020 (which remain constant in the baseline scenario). For intermediate years, linear interpolation is applied. The costs are 3000 Euro per km.

Scenario B is an increase of smooth wheels. In 2035 all wheels are composite/disc braked or better, and wheel flat control is applied. The percentages for R1-R5 in 2035 are specified in the table. The costs are 250 million Euro per year.

Scenario C is an increase of quiet vehicles. The percentages for vehicle types V1-V6 in 2035 are specified in the table. The costs are 250 million Euro per year.

Scenario D is an increase of quiet tracks, by means of a) railpads and b) rail dampers and/or rail shielding. The percentages for track types T1-T7 in 2035 are specified in the table. For the costs, it is assumed that the quiet tracks are achieved for 50% by railpads (3000 Euro per km) and the other 50% by rail dampers and/or shielding (0.5 million Euro per km).

Scenario E is an increase of noise barriers along railways. In 2035, 3% of the (inhabited) railways have high noise barriers (1.75% in the baseline scenario), and 1% have low noise barriers (0% in the baseline scenario). For the costs, a height of 2.5 m is assumed for high barriers and 1 m for low

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barriers. This yields 1.25 million Euros per km of high barrier and 0.5 million Euros per km of low barrier.

Scenario F is traffic management that moves freight trains from urban area to nonurban area. The traffic flow values of freight lines 1-4 for 2035 are specified in the table. For the costs, a fixed 100 million Euro per year is assumed.

Scenario G is urban planning and reconstruction, resulting in 2.5% reduced noise exposure in urban area in 2035. Solutions may include: tunnelling, screening by buildings along lines, and integration of noise abatement in buildings. For the implementation costs, 10 million Euro per km^2 is used.

Scenario H is an increase of dwellings with façade insulation. It is assumed that the percentage of dwellings with façade insulation is increased by 10% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings is so much reduced that these dwellings can be eliminated from the exposure distributions. The costs are 1000 Euro per dwelling.

Scenario I is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated previously, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from 'no limits' to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario an annual cost of 1 billion Euro was assumed. This value was derived by looking at the costs for scenario D (quiet tracks), assuming that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- AB, combination of A and B,
- CD, combination of C and D,
- ABCD, combination of A, B, C, and D,
- EF, combination of E and F,
- GH, combination of G and H.

Scenario AB is a combination of scenario A (smooth tracks) and scenario B (smooth wheels). This is a well know recipe for lower noise emission from railways. The low noise emission from trains with disc- or composite block-braked wheels still depends on sufficiently low rail roughness. By controlling this in noise sensitive areas, and also managing the occurrence of wheel flats, lower noise levels can be achieved. The two single solutions are *not* independent of each other in the model, as both affect the combined wheel-rail roughness. The percentages for roughness classes R1-R5 in 2035 are changed as follows:

- from 20/20/20/20/20% (baseline) to 0/5/55/30/10%.

The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario CD is a combination of scenario C (quiet vehicles) and scenario D (quiet tracks). This scenario focuses on the effect of wheel and track design on noise, disregarding the wheel and rail roughness. Examples are: trains with wheel mounted disc brakes or smaller wheels running on tracks with optimised railpads or rail dampers. The two single solutions are independent of each other in the model, so the effect on the noise emission is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario ABCD is a combination of the four scenarios A, B, C, and D. This combination provides the best potential noise reduction at source. For the emission, the model parameters from scenarios AB, C, and D are combined. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario EF is a combination of scenario E (barriers) and scenario F (traffic management). These scenarios are relatively short term and local. The two single solutions are independent of each other in the model, so the effect on the noise emission is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario GH is a combination of scenario G (urban planning) and scenario H (dwelling insulation). These scenarios are related to urban infrastructure and buildings. The two single solutions are independent of each other in the model, so the effect on the noise levels is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Table 7.7 Scenarios with a single noise solution for railway noise

Scenario	Description
A - smooth tracks	Tracks are made smoother in noise-sensitive areas by rail grinding. The percentages for roughness classes R1-R5 in 2035 are changed as follows: - from 20/20/20/20/20% (baseline) to 5/27.5/20/20/27.5%.
B – smooth wheels	Wheels kept smooth, and in 2035 all wheels are composite/disc braked or better, with wheel flat control. The percentages for R1-R5 in 2035 are changed as follows: - from 20/20/20/20/20% (baseline) to 0/20/30/30/20%.
C – quiet vehicles	Vehicles are quieter. All wheels are 4 dB quieter by design by 2035: 80% damped and/or optimised wheels for passenger trains and 50% improved freight wagons with better bogies and suspension. The percentages for vehicle types V1-V6 are changed as follows: - from 33/20/5/2/30/10% (baseline) to 5/4/3/3/5/80% in 2035.
D – quiet tracks	Tracks are quieter. In 2035 there is a widespread implementation of quieter tracks at sensitive locations, by means of: a) railpads b) rail dampers and/or rail shielding. The percentages for track types T1-T7 in 2035 are changed as follows: - from 14.3/14.3/14.3/14.3/14.3/14.3/14.3% (baseline) to 0/0/43/0/0/43/14)%
E - barriers	The length percentages of railways with low and high noise barriers are increased. For 2035 they are changed as follows: - for high barriers: from 1.75% (baseline) to 3%, - for low barriers: from 0% (baseline) to 1%.
F – traffic management	Traffic management is applied to shift part of the freight train movements from urban area to nonurban area. The traffic flow values (in units/h) of railway types 1-4 for 2035 are changed as follows. - day: from [50 50 50 50] (baseline) to [30 30 70 70] - evening: from [40 40 40] (baseline) to [25 25 55 55] - night: from [20 20 20 20] (baseline) to [10 10 30 30] (note that types 1-2 are in urban area and types 3-4 are in nonurban area).
G – urban planning	Urban planning solutions result in reduced noise exposure in urban area. Solutions may include: tunnelling, screening by buildings along lines, and integration of noise abatement in buildings. This is modelled by direct modification of the EU exposure distributions for urban agglomerations. It is assumed that in 2035 exposure in urban area is reduced by 2.5%.
H – dwelling insulation	More dwellings are insulated. The percentage of dwellings with insulation is changed from 0% (baseline) to 10% in 2035.
I – reception limits	Reception limits are introduced: 60 dB Lden and 55 dB Lnight in 2035.

7.5 Railway noise: results

Calculation results for single-solution scenarios A-I and combined scenarios are presented in Table 7.8 - Table 7.10 and Figure 7.17 - Figure 7.31. The results for the single-solution scenarios A-I are first discussed. Next the results for the combined scenarios are discussed.

Scenarios with a single noise solution

In Table 7.8 results for the baseline scenario are given; the annual EU health burden in 2030 is expressed in four quantities:

- number of highly annoyed persons,
- number of highly sleep-disturbed persons,
- number of DALYs (Disability Adjusted Life Years),
- monetized health burden in billion Euros.

In Table 7.9 the reduction of the annual EU health burden in 2030 is given for the scenarios. In Table 7.10 the results of the cost-benefit analysis for 2020-2035 are given for the scenarios. Values given in Table 7.9 and Table 7.10 are also presented in the bar diagrams in Figure 7.17. The evolution of monetized health effects, costs, and benefits for scenarios A-I are presented in Figure 7.18 - Figure 7.26.

The focus is on the health burden in 2030 (Table 7.8), and changes of the health burden in 2030 (Table 7.9), but the analysis takes into account the evolution of the health burden in the period 2020-2035, both for the baseline scenario and for the alternative scenarios. As described in Sec. 5.11, the baseline scenario includes autonomous developments as expected for the period 2020-2035 based on existing legislation. For example, the left graph in Figure 7.18 shows the change of the health burden in 2020-2035 for the baseline scenario (dashed lines) and for scenario A (solid lines).

On the average, the calculated health burden reductions are a bit higher for railway noise than for road traffic noise. The largest reduction occurs for scenario B (smooth wheels). The effects for scenario A (smooth tracks) are similar, although a bit smaller. The effects for scenario C (quiet vehicles) and scenario D (quiet tracks) are considerably smaller. The effects of noise barriers (scenario E) are small, as they affect only a limited percentage of the railway lengths. Traffic management (scenario F) has a moderate effect. The effect of urban planning in scenario G is small as it affects only a small percentage of the urban area in the EU. The effect of dwelling insulation (scenario H) is moderate.

In the same way as for road traffic noise, the results for scenario I (reception limits) are interesting. The fact that the health burden reduction is not very large implies that a large part of the health burden is caused by noise levels below the limits (60 dB Lden and 55 dB Lnight).

The graphs in Figure 7.18 - Figure 7.26 show how the monetized health effects, the costs and the benefits gradually approach the situation in 2035.

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the single-solution scenarios. The reductions in health burden for the combined scenarios in Table 7.9

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cover the wide range of 5-52%. The largest reductions occur for combined scenario ABCD, with smooth tracks and wheels, quiet vehicles, and quiet tracks. The reductions for scenarios C and D are approximately independent of each other, which means that the reductions for combined scenario CD is equal to the sum of the reductions for scenarios C and D. This is not the case for scenarios A and B, as both affect the combined wheel-rail roughness. The reductions are larger for scenario AB (smooth tracks and wheels) than for scenario CD (quiet vehicles and tracks).

Table 7.10 shows the results of the cost-benefit analysis for 2020-2035 for the combined scenarios. The largest benefit-cost ratio occurs for scenario AB (smooth tracks and wheels), followed by scenario EF (barriers and traffic management).

The evolution of monetized health effects, costs, and benefits for the combined scenarios are presented in Figure 7.27 - Figure 7.31. All graphs show a gradual transition to the situation in 2035.

Figure 7.17. Results of calculations for railway noise scenarios from Table 7.9 and Table 7.10

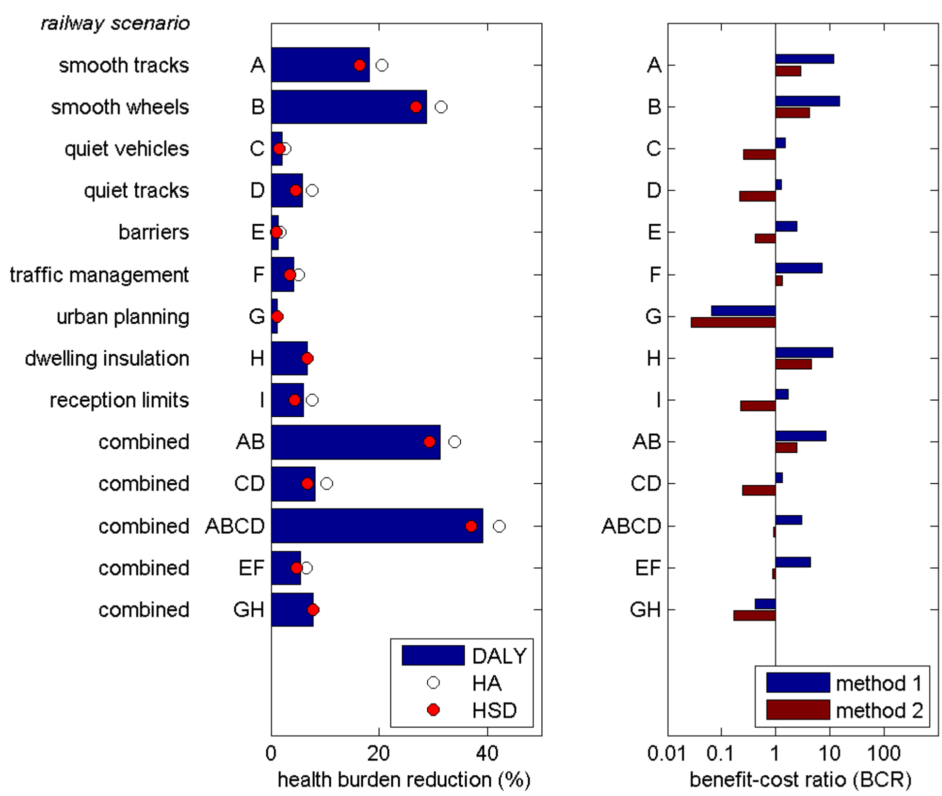


Table 7.8 Annual EU health burden of railway noise in 2030, for the baseline scenario

	Annual value in 2030
Highly annoyed persons	11.0 million
Highly sleep-disturbed persons	4.9 million
DALYs	570 thousand
Monetized health burden (method 1/2)	12.4 / 5.0 billion Euro

Table 7.9 Percentage reduction of annual EU health burden of railway noise in 2030, relative to the baseline scenario, for single-solution scenarios and combined scenarios

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetised health burden (method 1 / 2) (%)
A - smooth tracks	20.5	16.4	18.1	26.9 / 16.7
B – smooth wheels	31.4	26.8	28.7	39.3 / 27.1
C – quiet vehicles	2.7	1.6	2.0	4.1 / 1.7
D – quiet tracks	7.6	4.6	5.8	11.7 / 4.9
E - barriers	1.7	1.0	1.3	2.7 / 1.1
F – traffic management	5.1	3.5	4.2	7.9 / 3.5
G – urban planning	1.2	1.2	1.2	1.2 / 1.2
H – dwelling insulation	6.7	6.7	6.7	6.7 / 6.7
I – reception limits	7.6	4.3	6.0	17.5 / 5.7
AB – combined	33.9	29.2	31.2	42.2 / 29.5
CD - combined	10.3	6.7	8.2	15.4 / 7.0
ABCD - combined	42.2	37.1	39.2	51.5 / 37.3
EF – combined	6.6	4.7	5.5	9.7 / 4.7
GH – combined	7.8	7.8	7.8	7.8 / 7.8

Table 7.10 Results of cost-benefit analysis of single-solution scenarios and combined scenarios of railway noise, for 2020-2035

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A - smooth tracks	11.7 / 2.9	27.9 / 5.0	2021 / 2026
B – smooth wheels	15.2 / 4.2	42.4 / 9.7	2121 / 2025
C – quiet vehicles	1.5 / 0.26	1.6 / -2.2	2030 / -
D – quiet tracks	1.3 / 0.22	2.9 / -7.9	2032 / -
E - barriers	2.5 / 0.41	1.8 / -0.7	2026 / -
F – traffic management	7.1 / 1.3	7.3 / 0.4	2022 /2032
G – urban planning	0.07 / 0.03	-18.6 / -19.4	- / -
H – dwelling insulation	11.3 / 4.6	6.7 / 2.3	2021 / 2023
I – reception limits	1.7 / 0.23	8.8 / -9.2	2032 / -
AB – combined	8.7 / 2.5	42.9 / 8.2	2021 / 2028
CD - combined	1.3 / 0.24	4.0 / -9.9	2031 / -
ABCD - combined	3.1 / 0.90	38.5 / -1.8	2025 / -
EF – combined	4.5 / 0.89	8.3 / -0.3	2023 / -
GH – combined	0.42 / 0.17	-12.0 / -17.1	- / -

Figure 7.18. Results of cost-benefit analysis for railway scenario A (smooth tracks), with monetised health effects for scenarios 0 and A (left), and costs and benefits of the scenario (right)

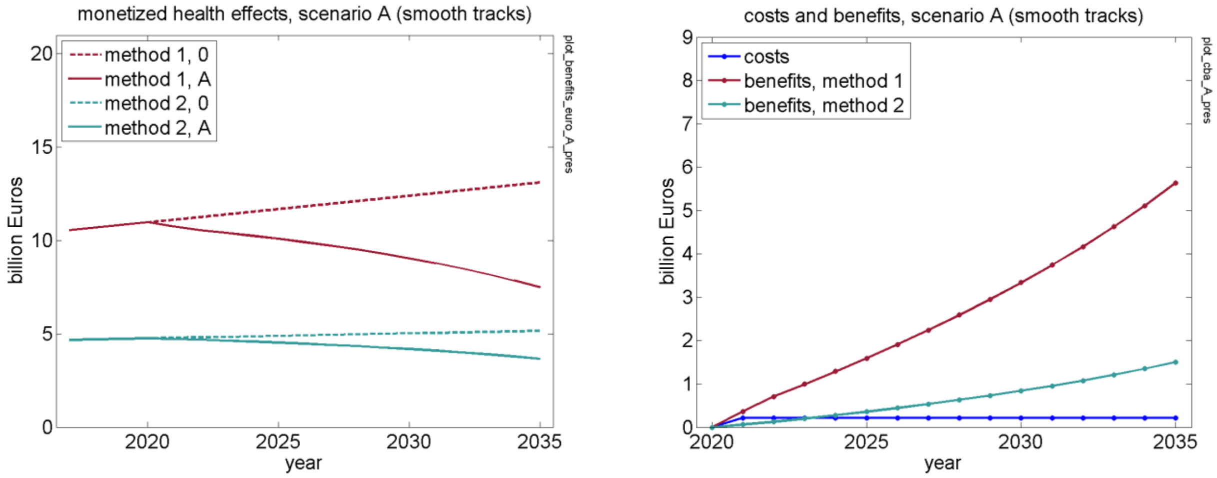


Figure 7.19. Results of cost-benefit analysis for railway scenario B (smooth wheels)

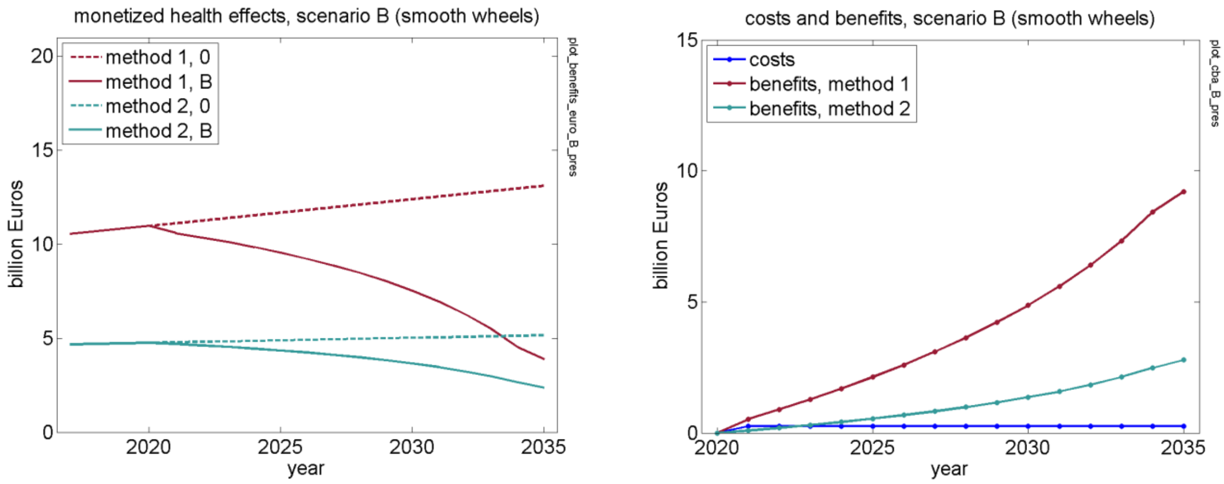


Figure 7.20. Results of cost-benefit analysis for railway scenario C (quiet vehicles)

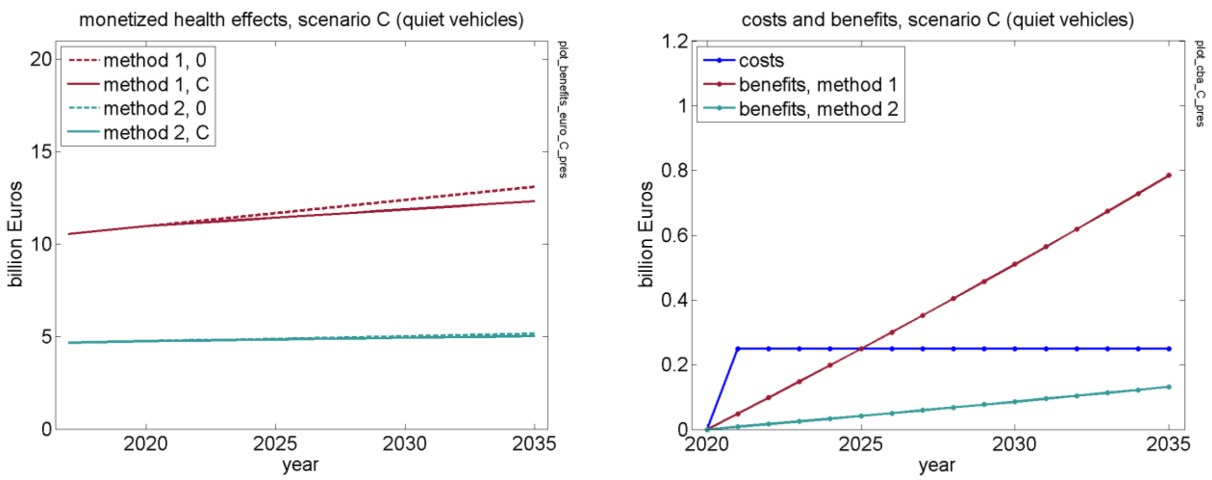


Figure 7.21. Results of cost-benefit analysis for railway scenario D (quiet tracks)

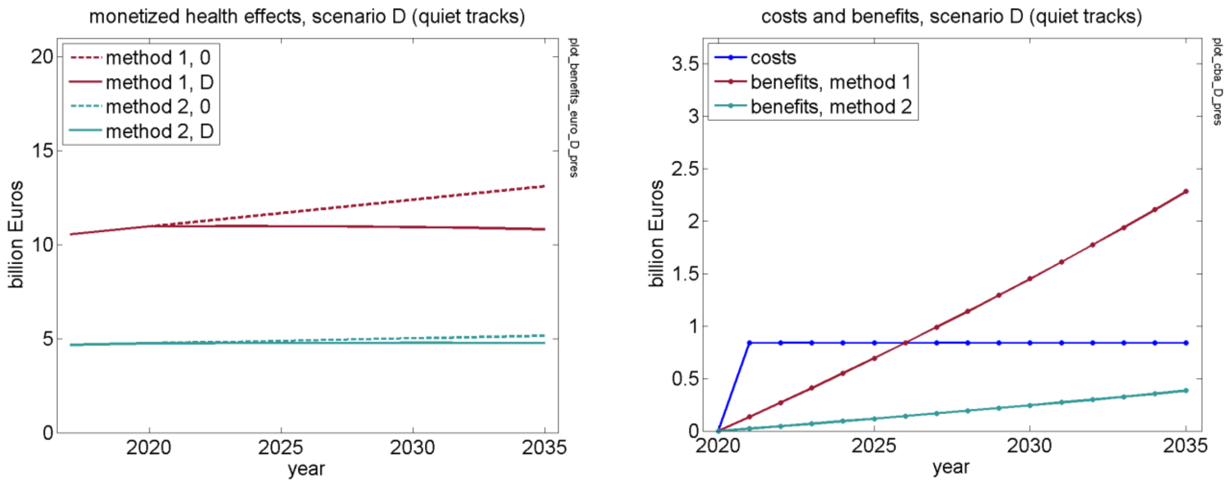


Figure 7.22. Results of cost-benefit analysis for railway scenario E (barriers)

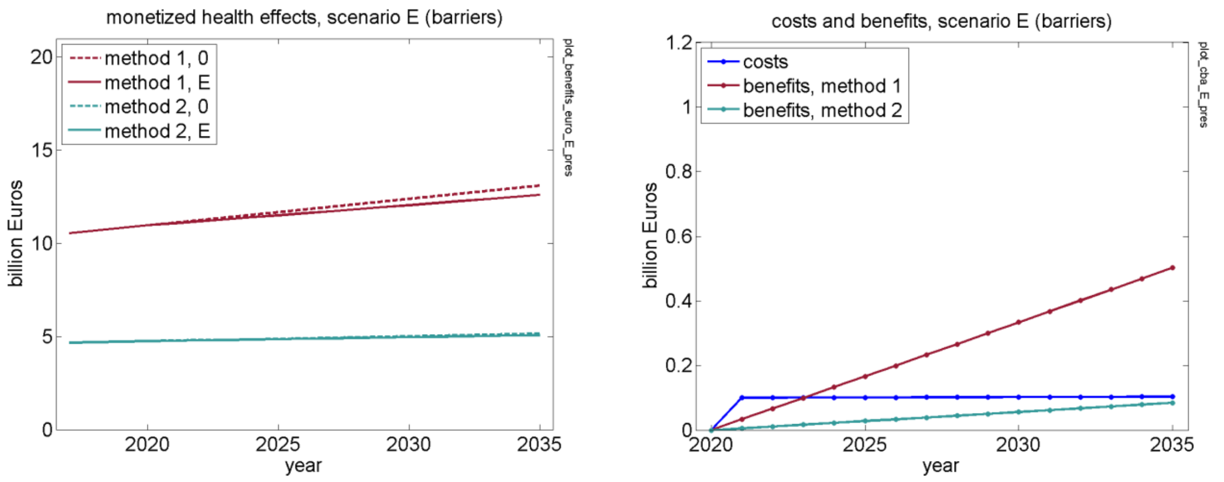


Figure 7.23. Results of cost-benefit analysis for railway scenario F (traffic management)

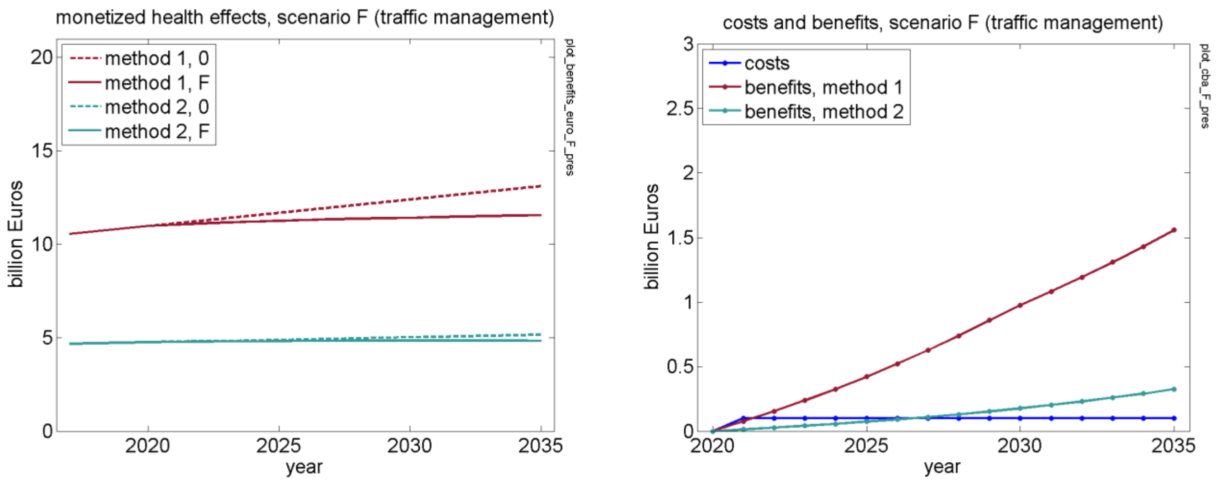


Figure 7.24. Results of cost-benefit analysis for railway scenario G (urban planning)

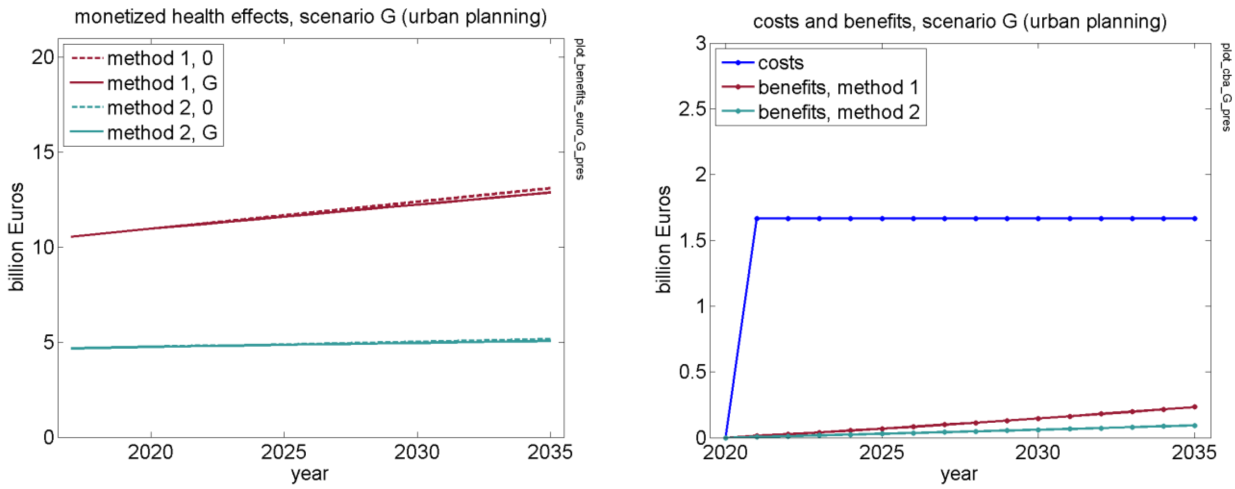


Figure 7.25. Results of cost-benefit analysis for railway scenario H (dwelling insulation)

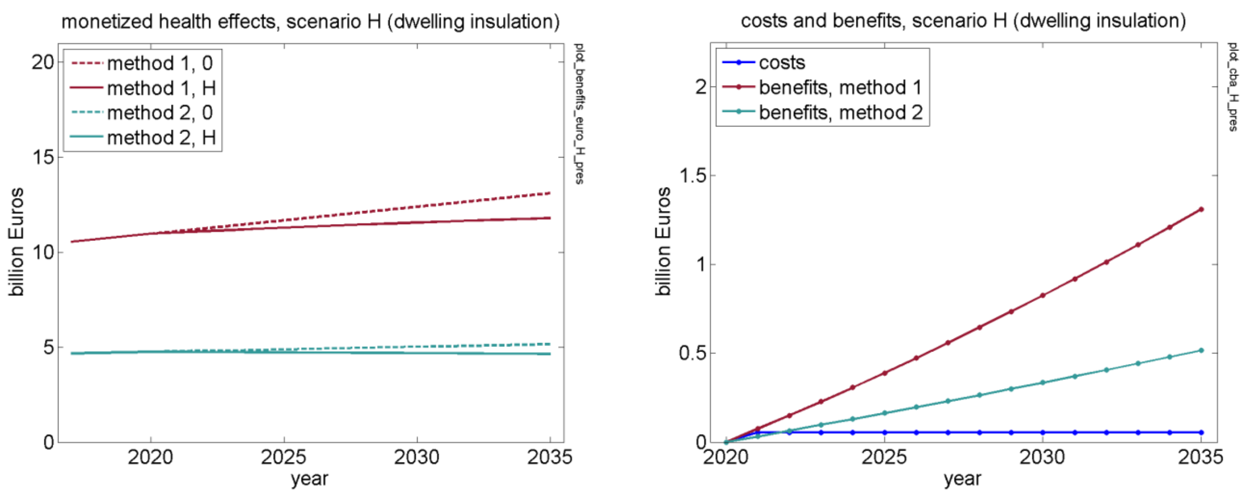


Figure 7.26. Results of cost-benefit analysis for railway scenario I (reception limits)

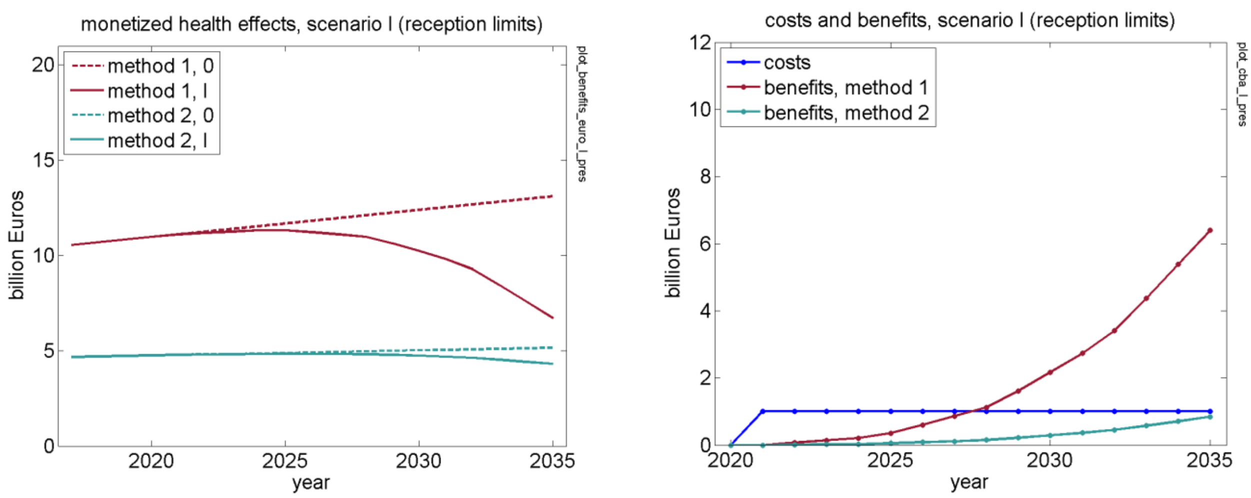


Figure 7.27. Results of cost-benefit analysis for railway scenario AB (combined)

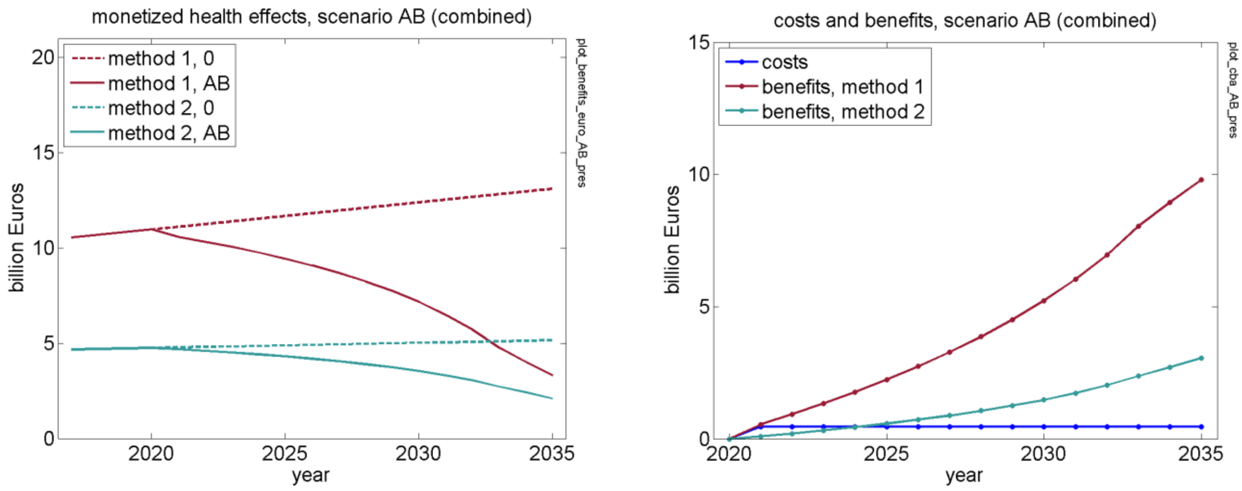


Figure 7.28. Results of cost-benefit analysis for railway scenario CD (combined).

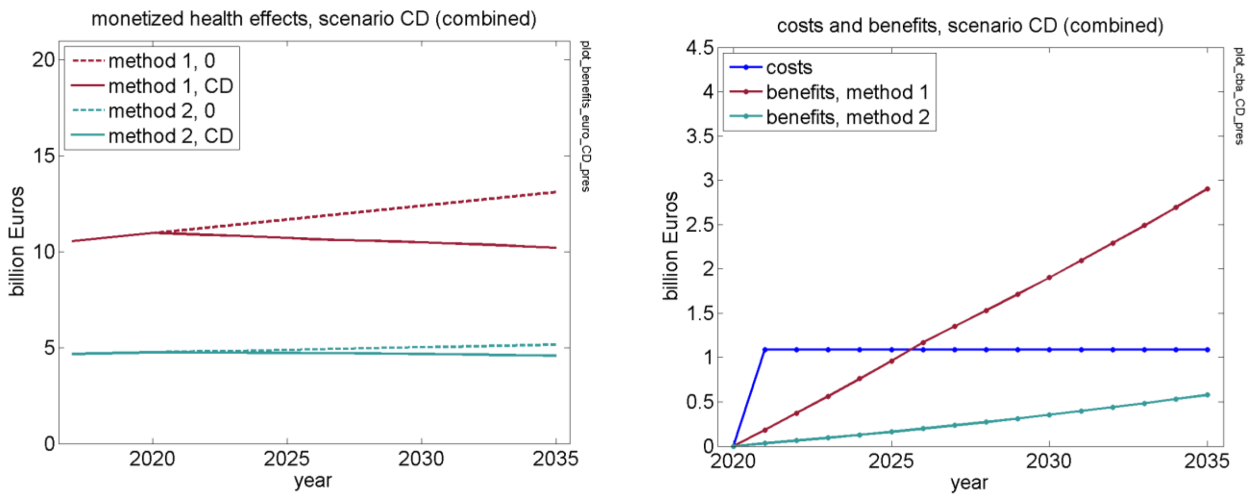


Figure 7.29. Results of cost-benefit analysis for railway scenario ABCD (combined)

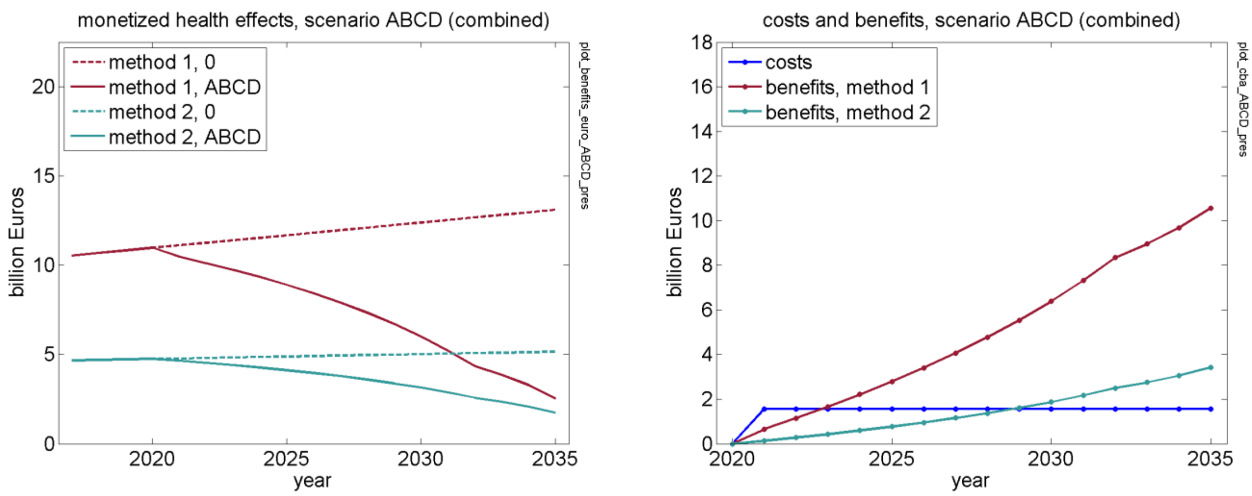


Figure 7.30. Results of cost-benefit analysis for railway scenario EF (combined)

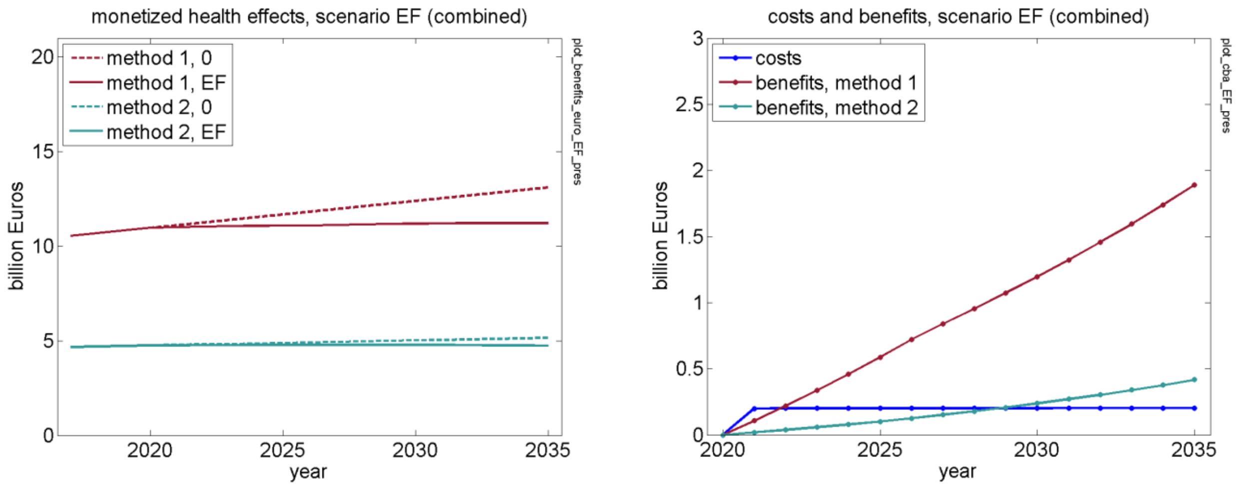
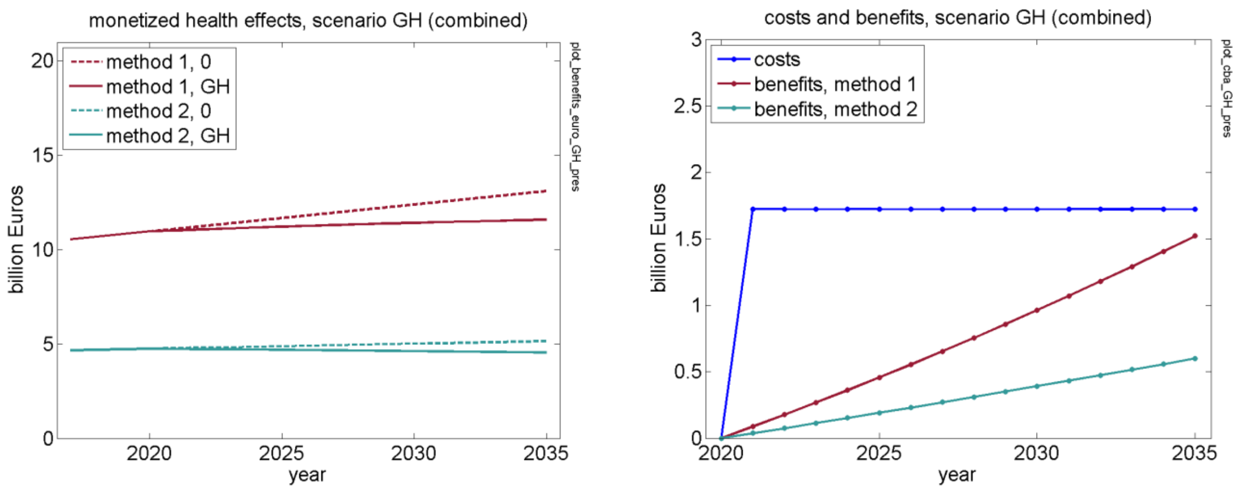


Figure 7.31. Results of cost-benefit analysis for railway scenario GH (combined)



7.6 Railway noise: variations

In this section, results are presented for railway scenarios described in the previous sections, but now with modified input parameters. The results give an impression of the effects of uncertainties in the input parameters on the results of this study.

The results are presented in Table 7.11 (health burden reduction) and Table 7.12 (cost-benefit analysis). Bar diagrams of the results are shown in Figure 7.32.

For scenario A (smooth tracks), one variation is considered, scenario A1. The distributions over the five roughness categories R1-R5 was varied as follows (equal for all ten types of railway lines). The health burden reduction (see Table 7.11) is smaller for scenario A1 than for scenario A.

roughness category*	Baseline	Scenario A	Scenario A1
R1) CI_netrail	0.2	0.05	0.1
R2) disc_netrail	0.2	0.275	0.3
R3) disc_smoothtrack	0.2	0.2	0.15
R4) KB_smoothtrack	0.2	0.2	0.15
R5) srm_cat8	0.2	0.275	0.3

* See Sec. 5.11.

For scenario B (smooth wheels), one variation is considered, scenario B1. The distributions over the five roughness categories R1-R5 was varied as follows (equal for all ten types of railway lines). The health burden reduction for scenario B1 is about the same as for scenario B.

roughness category*	Baseline	Scenario B	Scenario B1
R1) CI_netrail	0.2	0	0
R2) disc_netrail	0.2	0.2	0.1
R3) disc_smoothtrack	0.2	0.3	0.4
R4) KB_smoothtrack	0.2	0.3	0.4
R5) srm_cat8	0.2	0.2	0.1

* See Sec. 5.11.

For scenario C (quiet vehicles), one variation is considered, scenario C1. The distributions over the six vehicle categories V1-V6 was varied as follows (equal for all ten types of railway lines). The health burden reduction for scenario C1 is about the same as for scenario C.

vehicle category*	Baseline	Scenario C	Scenario C1
V1) wheel920	0.33	0.05	0.02
V2) wheel840	0.20	0.04	0.02
V3) wheel680	0.05	0.03	0.02
V4) wheel1200	0.02	0.03	0.02
V5) freight	0.30	0.05	0.02
V6) dampedwheel	0.10	0.80	0.90

* See Sec. 5.11.

For scenario D (quiet tracks), one variation is considered, scenario D1. The distributions over the seven track categories T1-T7 was varied as follows (equal for all ten types of railway lines). The health burden reduction for scenario D1 is slightly larger than for scenario D.

track category*	Baseline	Scenario D	Scenario D1
T1) monosoft	0.143	0	0
T2) monomed	0.143	0	0
T3) monostiff	0.143	0.43	0.5
T4) bibosoft	0.143	0	0
T5) bibomed	0.143	0	0
T6) bibostiff	0.143	0.43	0.5
T7) wooden	0.143	0.14	0

* See Sec. 5.11.

For scenario E (barriers), one variation is considered, scenario E1. The length fractions of high and low barriers was varied as follows (equal for all ten types of railway lines).

- Baseline high barriers 0.0175 low barriers 0
- Scenario E high barriers 0.03 low barriers 0.01
- Scenario E1 high barriers 0.3 low barriers 0.1

The health burden reduction for scenario E1 is much larger than for scenario E. The low fractions for the baseline scenario and scenario E are based on predictions of the railway sector. The fractions for scenario E1 are chosen much higher, to demonstrate the potential effect of noise barriers.

For scenario F (traffic management), one variation is considered, scenario E1. The values of freight traffic flow (in units per hour) were varied as follows.

	Baseline day/eve/night	Scenario F day/eve/night	Scenario F1 day/eve/night
urban freight 50 km/h	50/40/20	30/25/10	20/15/5
urban freight 80 km/h	50/40/20	30/25/10	20/15/5
rural freight 50 km/h	50/40/20	70/55/30	80/65/35
rural freight 80 km/h	50/40/20	70/55/30	80/65/35

In scenario F1, more freight trains are moved from urban area to rural area. The health burden reduction is larger for scenario F1 than for scenario F.

Figure 7.32. Results of calculations for variations of railway noise scenarios from Table 7.11 and Table 7.12

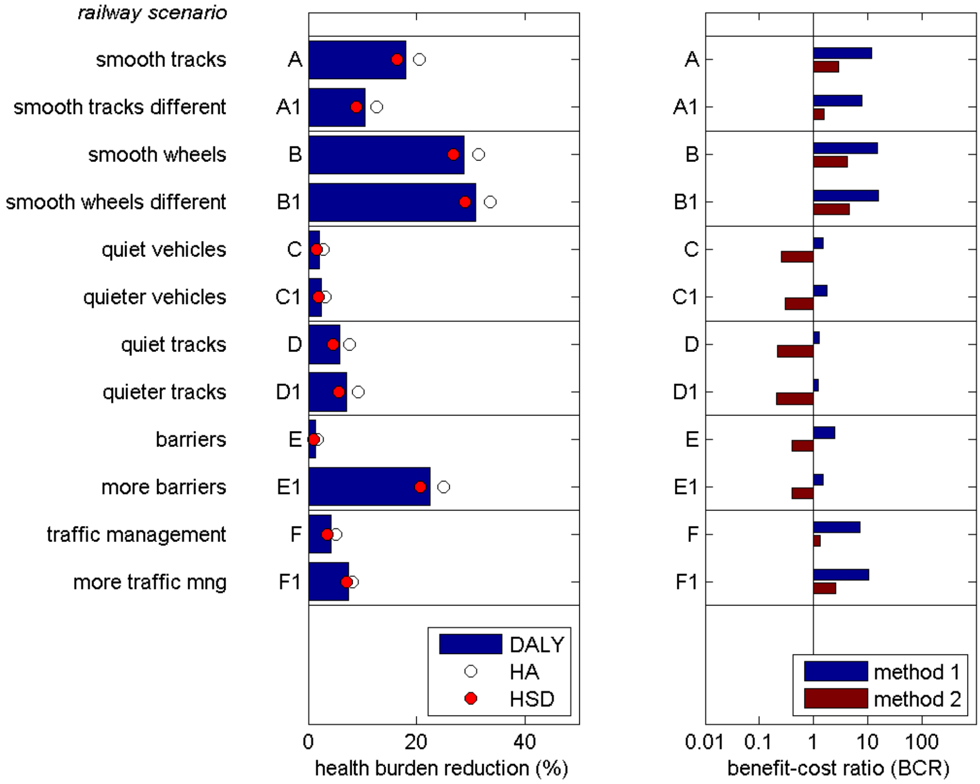


Table 7.11 Percentage reduction of annual EU health burden of railway noise in 2030, relative to the baseline scenario, for variations of single-solution scenarios

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A smooth tracks	20.5	16.4	18.1	26.9 / 16.7
A1 different	12.7	8.9	10.5	18.0 / 9.3
B smooth wheels	31.4	26.8	28.7	39.3 / 27.1
B1 different	33.6	28.9	30.9	41.8 / 29.1
C quiet vehicles	2.7	1.6	2.0	4.1 / 1.7
C1 quieter	3.1	1.9	2.4	4.8 / 2.0
D quiet tracks	7.6	4.6	5.8	11.7 / 4.9
D1 quieter	9.2	5.6	7.1	14.0 / 5.9
E barriers	1.7	1.0	1.3	2.7 / 1.1
E1 more	25.0	20.7	22.5	32.0 / 21.0
F traffic managmt	5.1	3.5	4.2	7.9 / 3.5
F1 more	8.1	7.0	7.5	10.9 / 6.7

Table 7.12 Results of cost-benefit analysis of variations of single-solution scenarios of railway noise, for 2020-2035

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A smooth tracks	11.70 / 2.90	27.9 / 5.0	2021 / 2026
A1 different	7.76 / 1.59	17.6 / 1.5	2021 / 2030
B smooth wheels	15.18 / 4.23	42.4 / 9.7	2021 / 2025
B1 different	16.09 / 4.56	45.1 / 10.6	2021 / 2024
C quiet vehicles	1.52 / 0.26	1.6 / -2.2	2030 / -
C1 quieter	1.77 / 0.30	2.3 / -2.1	2028 / -
D quiet tracks	1.29 / 0.22	2.9 / -7.9	2032 / -
D1 quieter	1.23 / 0.21	2.8 / -9.8	2032 / -
E barriers	2.45 / 0.41	1.8 / -0.7	2026 / -
E1 more	1.51 / 0.40	12.2 / -14.3	2029 / -
F traffic managmt	7.09 / 1.34	7.3 / 0.4	2022 / 2032
F1 more	10.47 / 2.62	11.3 / 1.9	2021 / 2028

7.7 Aircraft noise: description of scenarios

For the aircraft noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Take-off improved profiles (flight procedures)
  - Modelled by changing the flight profiles in Departure
- Dispersion or concentration of flights (route optimization)
  - Modelled by reducing the horizontal dispersion in the flight tracks
- Operating restrictions - curfew
  - Modelled by shifting flights from one period to another and/or reducing the total amount of flights
- Operating restrictions - prohibition of operation for noisier aircraft at night
  - Modelled by changing the fleet composition
- Forced phase out of older aircraft
  - Modelled by changing the fleet composition
- Acquisition of new quieter aircraft (EU or national level incentives for airlines)
  - Modelled by changing the source noise levels
- Sound insulation of residential and communal buildings
  - Modelled by changing the noise exposure distributions.
- Buffer zone
  - Modelled by changing the noise exposure distributions.
- Stakeholder engagement
  - Modelled by changing the noise exposure distributions.

In addition to the above physical noise solutions, scenarios with reception limits are also considered (in the same way as for road and rail traffic noise).

Scenarios with a single noise solution

In Table 7.13 scenarios A-J with a single solution are specified. In the following, each scenario is briefly described. In the next section, calculation results are presented. It is recognised that some of the proposed solutions already may have been implemented at some of the test airports. In this case the solution will not be implemented again, resulting in a zero effect at the corresponding airport(s) for that scenario.

Scenario A is considering the implementation of improved take-off procedures. For departure operations, the noise levels will be reduced by 2 dB, which is the noise reduction that may be expected from optimised procedures with respect to standard profiles. It is assumed that in 2030 all take-off operations will have been replaced. For the intermediate years linear interpolation will be applied. Although for specific situations a tailormade flight profile might be required, when considering more generically applicable procedures, a main driver for airlines to implement them is fuel saving. With an estimated fuel cost saving of 50€ per operation and considering a current implementation of these operations of 30%, around 150 million euros may be saved a year by introducing optimised flight profiles. If cost like additional training etc are included, a total cost reduction of around 125 million per year may be expected.

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Scenario B considers the implementation of Precision-Area Navigation (P-RNAV). This will result in more accurately flown flights, thus minimising horizontal dispersion of especially departures. This scenario will be modelled by imposing that all departures will remain on the backbone of the Standard Instrument Departures (SIDs). Based on available track data from the OpenSky Network database, this technology has already been implemented in around 70% of the airports. It is assumed that in 2030 all operations will have been replaced. For the intermediate years linear interpolation will be applied. This solution is considered budget neutral.

Scenario C is the introduction of an operating restriction, namely a night curfew. This will be simulated by shifting 25% of the night flights to the evening and 25% to the day, and by cancelling the remaining 50%. The effect of an implementation in i) 2025 and ii)2030 will be assessed. The cost of this solution is estimated to be 2.6 billon € yearly. This estimate is based on a profit loss of 6000€ per eliminated operation and an average of 10% night flights in the EU27. This value for profit loss is based on the average profit loss per operation, deduced from studies on night flight restrictions at Heathrow[324], Dublin[325] and Zurich[326] airports. These values varied by around ±15% between these airports. It is noted that only the direct profit loss (i.e. at the airport) is taken into account here. Indirect (incl. supply chain), induced (incl. economic activity related to the transport service such as tourism) and catalytic (all additional effects) impacts have not been considered here, since these are very difficult to quantify.

Scenario D is the introduction of the prohibition of operation for noisier aircraft during a certain period as another operating restriction. This is simulated by replacing all non-chapter 4 aircraft by a chapter 4 equivalent, already in the operators fleet. Considering the relevance of the shoulder hours for sleep disturbance, the period considered will be from 22h to 08h. The effect of an implementation in i) 2025 and ii)2030 will be assessed. The cost of this solution is estimated to be 50M€ for training etc.

Scenario E is considering the forced phase out of older aircraft. In this scenario all non-chapter 4 compliant aircraft will be replaced by chapter 4 compliant equivalents (50% already in the operators fleet, 25% natural replacement and 25% purchase of new aircraft). The effect of an implementation in i) 2025 and ii) 2030 will be assessed. The new aircraft will be more fuel efficient and the purchase/amortisation cost will be fully offset by the benefits of the fuel saving. A resulting total yearly cost saving of 100M€ is assumed.

Scenario F is acquisition of new quieter aircraft. In the baseline scenario a natural renewal of the aircraft fleet is already assumed. This has been simulated by assuming a 0.1 dB noise reduction per year (ICAO/CAEP), effectively resulting in a complete fleet renewal in 20 years. For this scenario an accelerated fleet renewal will be simulated by applying an additional 0.1 dB noise reduction per year, effectively meaning that the fleet will have been completely renewed by 2030. After that, the natural fleet renewal will take over again. The additional cost of new generation aircraft will be offset by a lower fuel consumption. Depending on the methodology used, the estimated cost savings will range from 1 to 5 billion euros per year. For this analysis 2.6 billion euros per year is assumed.

Scenario G is sound insulation of residential and communal buildings. It is assumed that currently 50% of the most exposed (L_{den}>70 dBA, L_{night}>65 dBA) dwellings is already insulated. For this scenario the remaining 50% of the dwellings currently without façade/roof insulation is assumed to be

[324] Ban on night flights at Heathrow Airport - A quick scan Social Cost Benefit Analysis - 2011

[325] Dublin Airport Economic Impact of Operating Restrictions - Update Report – October 2020

[326] Betriebliche Machbarkeit und wirtschaftliche Tragbarkeit einer Vorverlegung der letzten Slots am Flughafen Zürich – May 2019

insulated in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings is so much reduced that these dwellings can be eliminated from the exposure distributions. The costs are 14000 Euro per dwelling.

Scenario H is the creation of a buffer zone. It is assumed that in 2035 no population is living in areas with L_{den}>70 and L_{night}>65dB. With an estimated total of 5000 dwellings in the target zones and a cost of 120k€ per dwelling[327], this solution will have a total cost of 600M€ .

Scenario I is on stakeholder engagement. Since this solution mainly acts on the annoyance, it cannot be calculated directly. However, it can be assumed that a reduced annoyance can be simulated by a reduced sensitivity. It is assumed that in 2035 the %HA of the population due to aircraft noise has been reduced by 2-3%, which, at Lden 65 dBA, is the equivalent of a reduction of 2 dB in noise exposure. Implementation costs for monitoring systems, noise committee, events, consulting, training, etc, is assumed to be 100M€. With a yearly maintenance cost of around 800k€ per airport, the total yearly cost will be around 50M€.

Scenario J is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated previously, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from 'no limits' to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario the cost is assumed to be the sum of the costs of scenarios G, H and I, since it is considered that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) = **3D optimization**
- • **E** (Phase out of noisiest aircraft at night) + **F** (Fleet replacement with quiet aircraft) = **Quietest fleet**
- • **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) + **E** (Phase out of noisiest aircraft) + **F** (Fleet replacement with quiet aircraft) = **Best possible on "aircraft side"**

The cost of the combined scenarios is assumed to be equal to the sum of the costs of the single-solution scenarios.

Table 7.13 Scenarios with a single noise solution for aircraft noise

Scenario	Description
A – flight profiles	Introduction of improved flight profiles. 2 dB reduction for departures.
B – track dispersion	Introduction of P-RNAV, resulting in no horizontal dispersion
C - Operating restrictions - curfew	night curfew, simulated by shifting 25% of the night flights to the evening, 25% to the day and by cancelling the remaining 50%. The effect of an implementation in i) 2025 and ii)2030 will be assessed.

[327] NAP Milan Malpensa airport 2017

D - Operating restrictions - prohibition of operation for noisier aircraft	Prohibition of noisy aircraft during night period. simulated by replacing all non-chapter 4 aircraft by a chapter 4 equivalent in the period from 22h to 08h. The effect of an implementation in i) 2025 and ii)2030 will be assessed.
E - Forced phase out of older aircraft	In this scenario all non-chapter 4 compliant aircraft will be replaced by chapter 4 compliant equivalents. The effect of an implementation in i) 2025 and ii)2030 will be assessed.
F - Acquisition of new quieter aircraft	Accelerated fleet renewal. Apply an additional 0.1 dB/year noise reduction until 2030. After that, natural renewal is assumed
G - Sound insulation of residential and communal buildings	It is assumed that the percentage of dwellings with façade/roof insulation is increased by 50% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings is so much reduced that these dwellings can be eliminated from the exposure distributions.
H – Creation of a buffer zone	It is assumed that in 2035 no population is living in areas with Lden>70 and Lnight>65dB.
I - Stakeholder engagement	Reduction of sensitivity equivalent to 2dB is assumed to be achieved by 2035.
J - reception limits	A scenario with reception limits L_{den} = 60 dB and L_{night} = 55 dB will be considered.

7.8 Aircraft noise: results

Calculation results for single-solution scenarios A-J and combined scenarios are presented in Table 7.14 - Table 7.16 and Figure 7.33 - Figure 7.50. The results for the single-solution scenarios A-J are first discussed. Next the results for the combined scenarios are discussed.

Scenarios with a single noise solution

In Table 7.14 results for the baseline scenario are given; the annual EU health burden in 2030 is expressed in four quantities:

- number of highly annoyed persons,
- number of highly sleep-disturbed persons,
- number of DALYs (Disability Adjusted Life Years),
- monetized health burden in billion Euros.

In Table 7.15 the reduction of the annual EU health burden in 2030 is given for the single-solution scenarios. In Table 7.16 the results of the cost-benefit analysis for 2020-2035 are given for the single-solution scenarios. Values given in Table 7.15 and Table 7.16 are also presented in the bar diagrams in Figure 7.33. The evolution of monetized health effects, costs, and benefits for scenarios A-J are presented in Figure 7.34 and Figure 7.36 - Figure 7.47.

Figure 7.34 shows the results for scenario A – improved flight procedures. Figure 7.35 shows the corresponding exposure distributions for scenarios 0 (baseline) and A. There is a large reduction in exposure of the period 2020-2030, which results in a large reduction of the health burden. The health burden in DALYs is reduced by 28% (see Table 7.15). It should be noted that the costs for scenario A are negative, due to fuel savings. Consequently, the values of benefit-cost ratio BCR are negative for scenario A (negative values of BCR are not shown in Figure 7.33, due to the logarithmic scale).

From all the single solution scenarios, the second largest reduction occurs for scenario A. The largest reduction occurs for scenarios Ci and Cii – night curfew in 2025/2030, with a reduction in DALYs of 71%.

For scenarios Ci and Cii, night flights are partly eliminated and partly shifted to the day and evening periods. Consequently, the reduction in sleep disturbance (HSD) is 100%, while the reduction in annoyance is about 35%. In this situation, monetization methods 1 and 2 give about equal results (see Figure 7.37 and Figure 7.38). Method 1 is based on the Lden level only, while method 2 takes into account both Lden for annoyance and Lnight for sleep disturbance.

Of special interest are scenarios G-J. For these scenarios, monetization method 1 gives a much larger health burden reduction than method 2 does (see Table 7.15). This is a consequence of the fact that for these scenarios the exposure is shifted down to levels around 50 dB, where methods 1 and 2 give different results (method 2 includes exposure down to 45 dB Lden, while method 1 uses a threshold of 50 dB).

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the corresponding single-solution scenarios. The reductions in health burden for the combined scenarios in Table 7.15 cover the wide range of 23-53%. The largest reductions occur for combined scenario ABEF, which is the best possible scenario 'from the aircraft side'.

Figure 7.33. Results of calculations for aircraft noise scenarios

A green dot on the right indicates that the solution is estimated to provide a cost saving

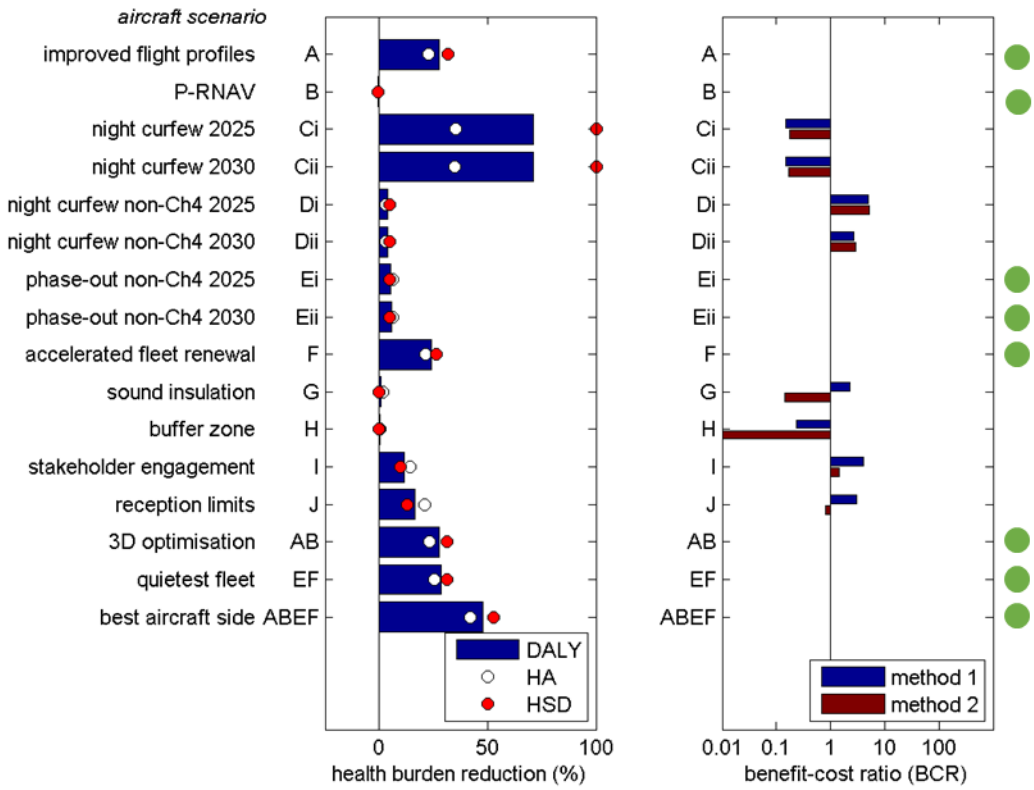


Table 7.14 Annual EU health burden of aircraft noise in 2030, for the baseline scenario

	Annual value in 2030
Highly annoyed persons	1.6 million
Highly sleep-disturbed persons	0.6 million
DALYs	73 thousand
Monetized health burden (method 1/2)	1.0 / 0.8 billion Euro

Table 7.15 Percentage reduction of annual EU health burden of aircraft noise in 2030, for single-solution scenarios

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A – improved flight profiles	22.6	31.5	27.6	24.9 / 25.7
B – P-RNAV	-0.4	-0.4	-0.4	-0.3 / -0.4
Ci – night curfew 2025	35.3	100.0	71.3	37.4 / 59.8
Cii – night curfew 2030	34.8	100.0	71.0	36.8 / 59.5
Di – night curfew non-Ch4 2025	2.9	4.8	4.0	2.7 / 3.7
Dii – night curfew non-Ch4 2030	2.8	4.8	3.9	2.6 / 3.6
Ei – phase-out non-Ch4 2025	6.3	4.8	5.5	5.6 / 5.8
Eii – phase-out non-Ch4 2030	6.3	4.8	5.5	5.7 / 5.8
F – accelerated fleet renewal	21.2	26.1	23.9	22.4 / 22.9
G – sound insulation	1.5	0.1	0.7	5.0 / 0.5
H – buffer zone	0.4	0.1	0.2	1.3 / 0.1
I – stakeholder engagement	14.2	9.6	11.7	20.9 / 10.5
J – reception limits	20.9	12.7	16.4	39.4 / 14.1
AB – 3D optimisation	23.2	31.3	27.7	25.6 / 26.0
EF – quietest fleet	25.6	31.2	28.7	26.4 / 27.6
ABEF – best aircraft side	41.9	52.8	48.0	44.3 / 45.8

Table 7.16 Results of cost-benefit analysis of single-solution scenarios of aircraft noise, for 2020-2035

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A – improved flight profiles	-2.24 / -1.72	2.9 / 2.5	2021 / 2021
B – P-RNAV	-1.10 / -0.46	-0.1 / -0.1	- / -
Ci – night curfew 2025	0.15 / 0.17	-18.2 / -17.7	- / -
Cii – night curfew 2030	0.15 / 0.17	-9.2 / -9.0	- / -
Di – night curfew non-Ch4 2025	5.04 / 5.18	0.2 / 0.2	2027 / 2027
Dii – night curfew non-Ch4 2030	2.71 / 2.90	0.1 / 0.1	2032 / 2032
Ei – phase-out non-Ch4 2025	-0.62 / -0.48	1.5 / 1.4	2021 / 2021
Eii – phase-out non-Ch4 2030	-0.62 / -0.50	1.1 / 1.1	2021 / 2021
F – accelerated fleet renewal	-0.09 / -0.07	22.2 / 21.8	2021 / 2021
G – sound insulation	2.26 / 0.15	0.2 / -0.2	2026 / -
H – buffer zone	0.23 / 0.01	-0.4 / -0.5	- / -
I – stakeholder engagement	4.01 / 1.46	1.4 / 0.2	2021 / 2027
J – reception limits	3.06 / 0.80	2.4 / -0.2	2025 / -
AB – 3D optimisation	-2.42 / -1.82	2.9 / 2.4	2021 / 2021
EF – quietest fleet	-0.10 / -0.08	23.3 / 22.8	2021 / 2021
ABEF – best aircraft side	-0.17 / -0.13	25.6 / 24.7	2021 / 2021

Figure 7.34. Results of cost-benefit analysis for aircraft scenario A (improved flight profiles), with monetized health effects for scenarios 0 and A (left), and costs and benefits of the scenario (right)

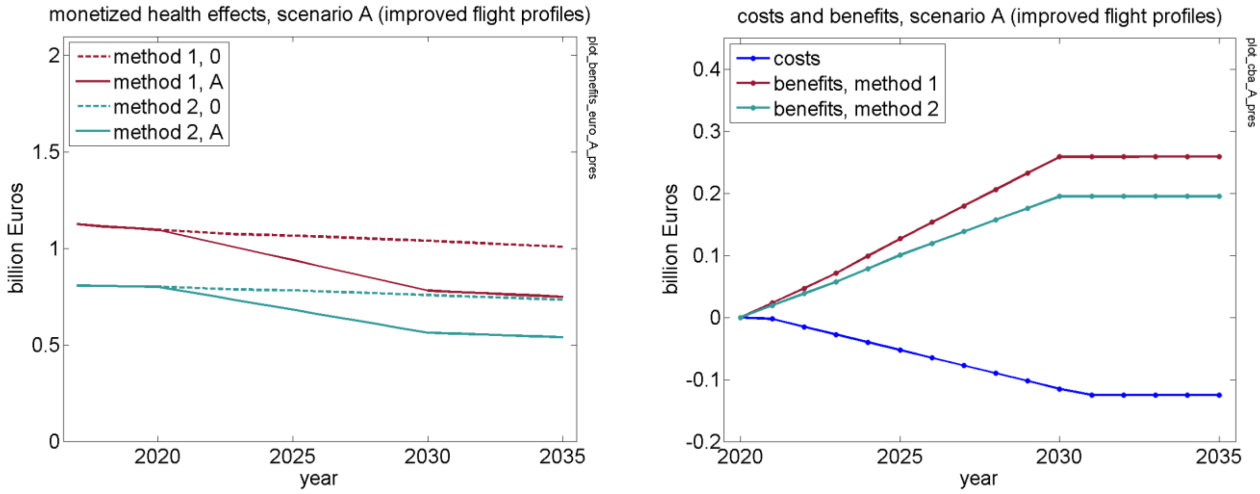


Figure 7.35. Exposure distributions for scenarios 0 and A, over the period 2017-2035. As described in Sec. 5.3, the distributions are extrapolated below the limits of 55 dB Lden and 50 dB Lnight, for the health impact assessment.

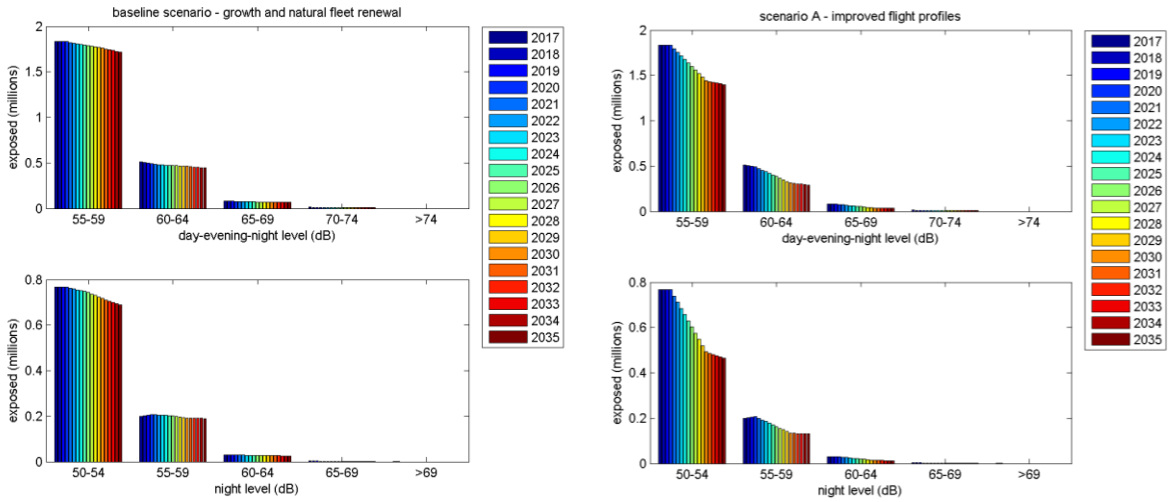


Figure 7.36. Results of cost-benefit analysis for aircraft scenario B.

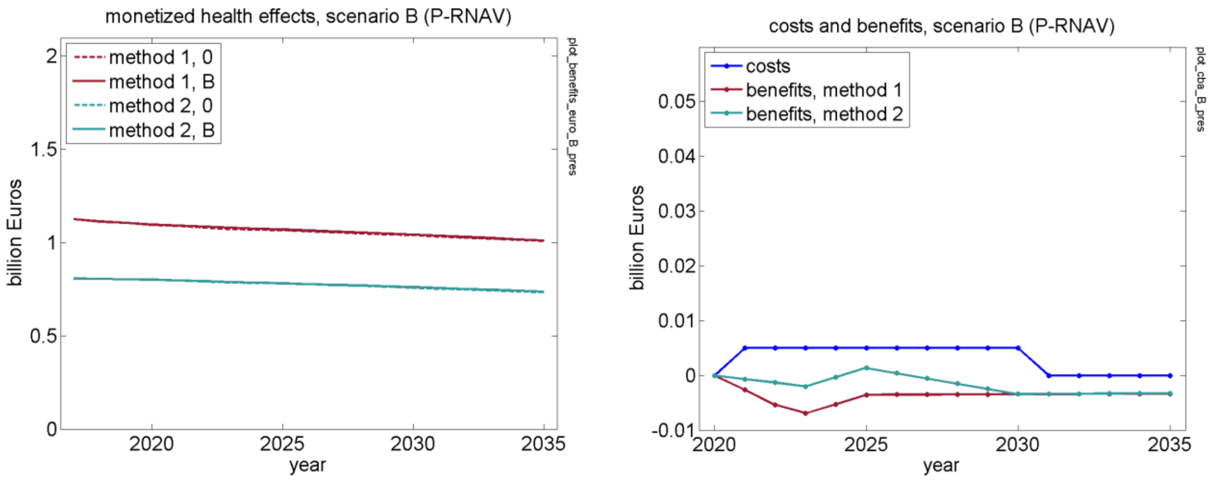


Figure 7.37. Results of cost-benefit analysis for aircraft scenario Ci

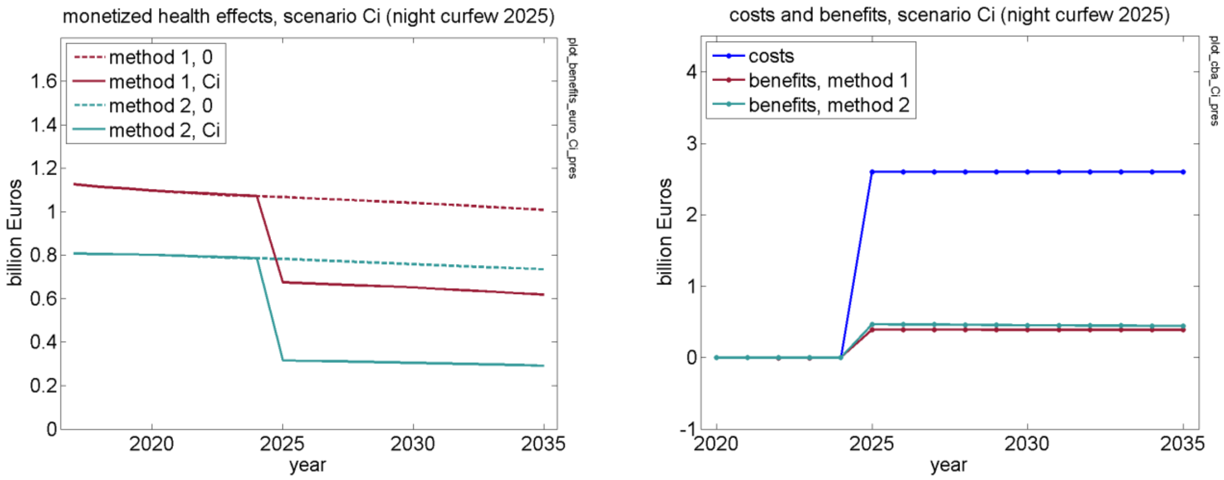


Figure 7.38. Results of cost-benefit analysis for aircraft scenario Cii

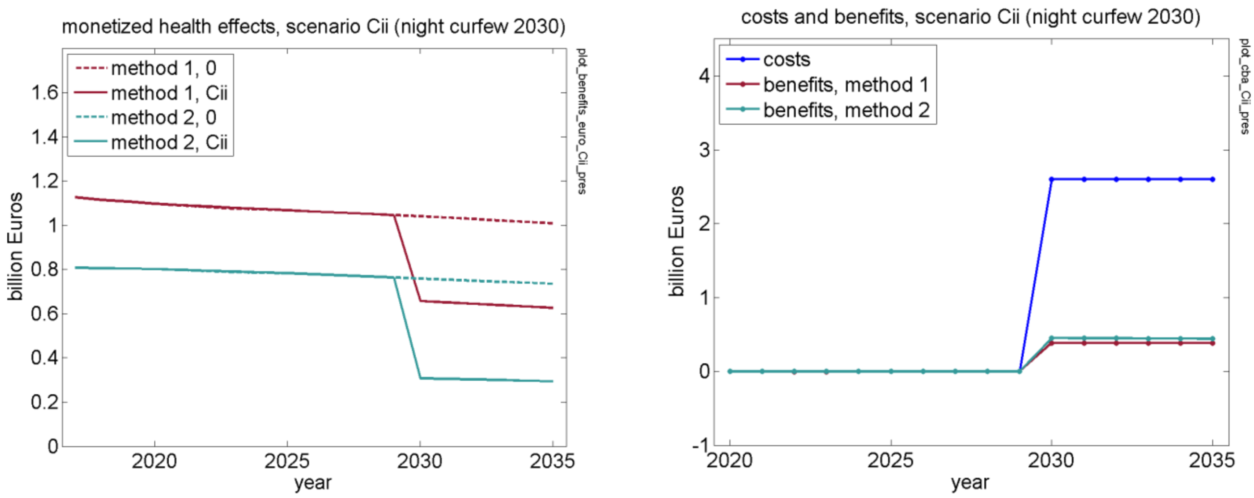


Figure 7.39. Results of cost-benefit analysis for aircraft scenario Di

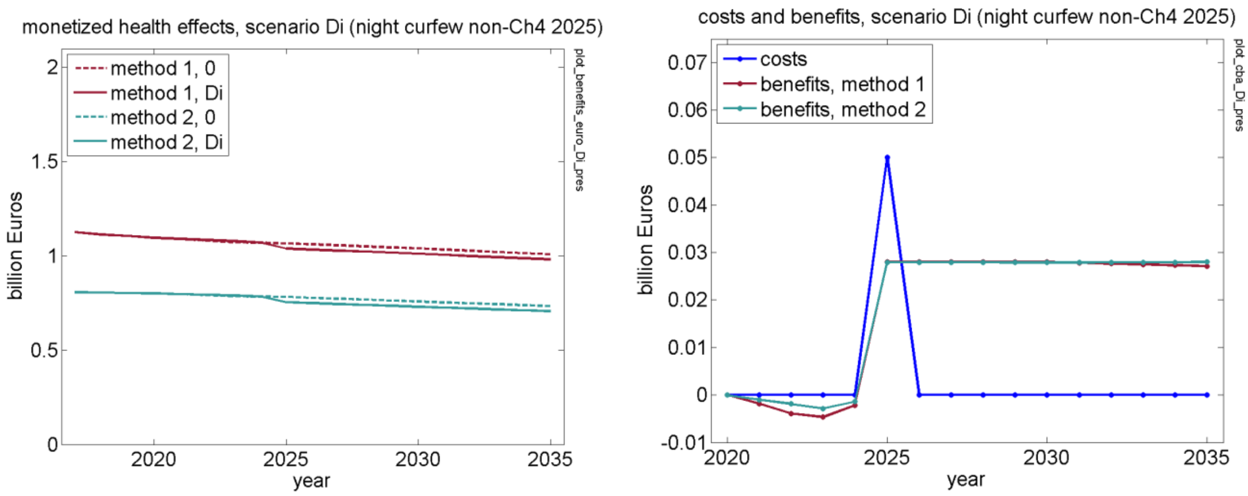


Figure 7.40. Results of cost-benefit analysis for aircraft scenario Dii

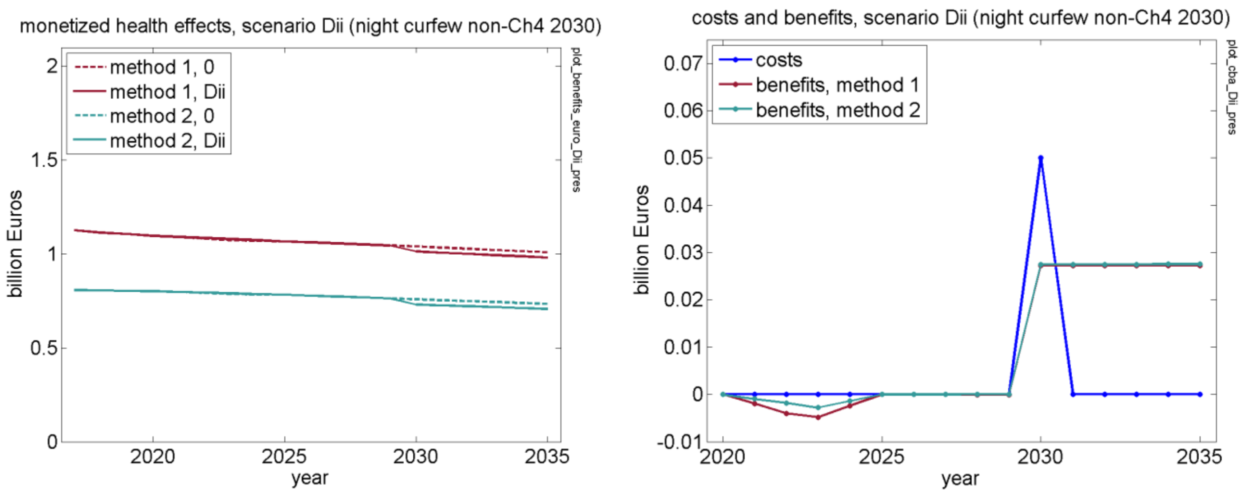


Figure 7.41. Results of cost-benefit analysis for aircraft scenario Ei

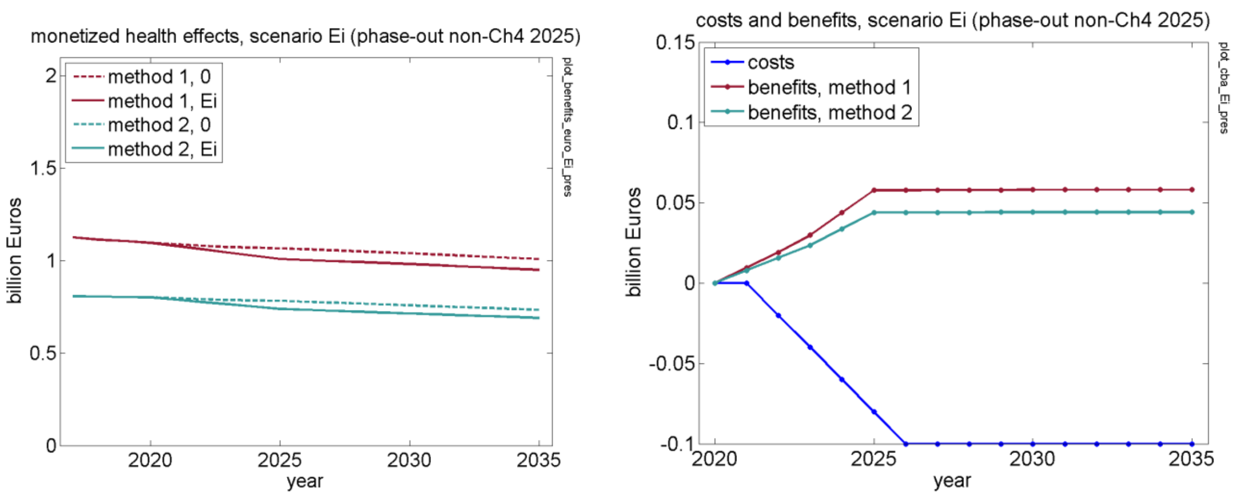


Figure 7.42. Results of cost-benefit analysis for aircraft scenario Eii

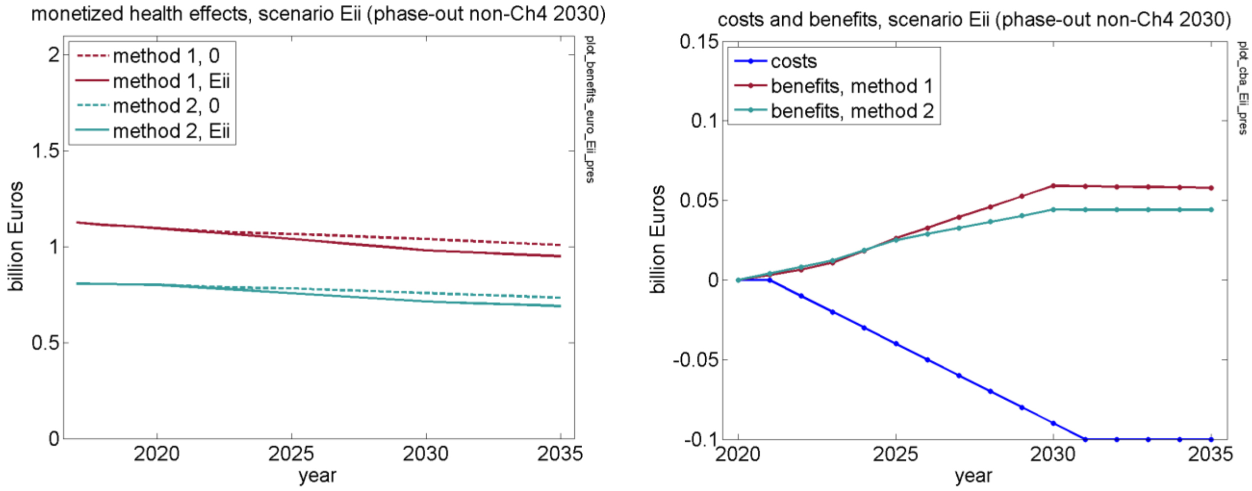


Figure 7.43. Results of cost-benefit analysis for aircraft scenario F

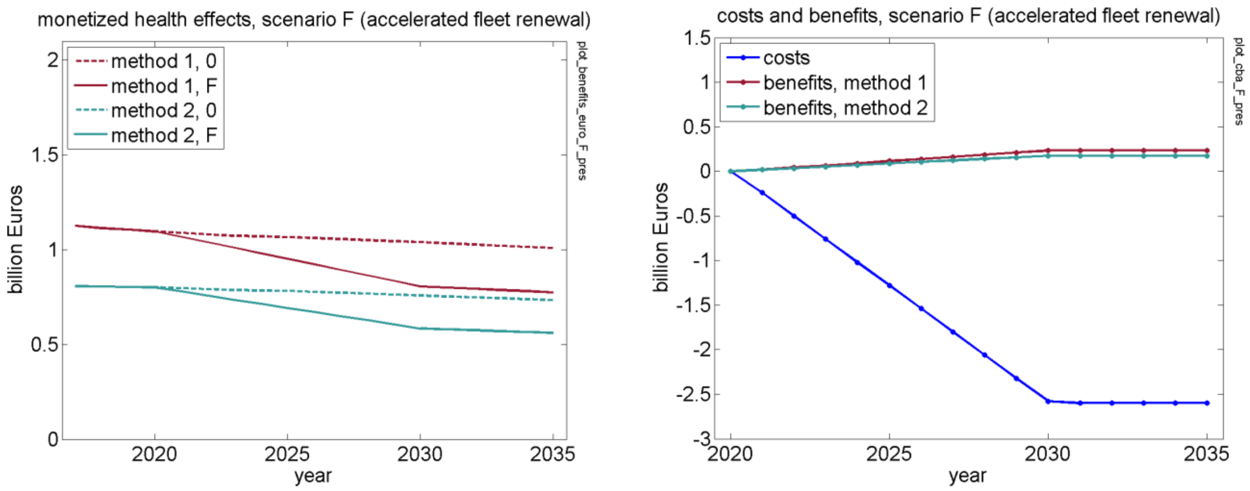


Figure 7.44. Results of cost-benefit analysis for aircraft scenario G

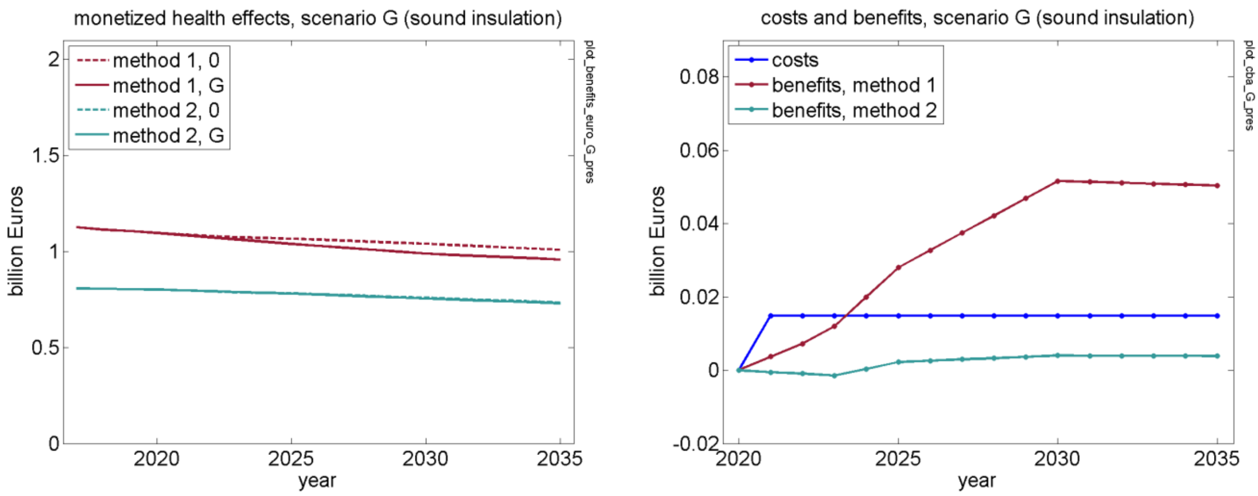


Figure 7.45. Results of cost-benefit analysis for aircraft scenario H

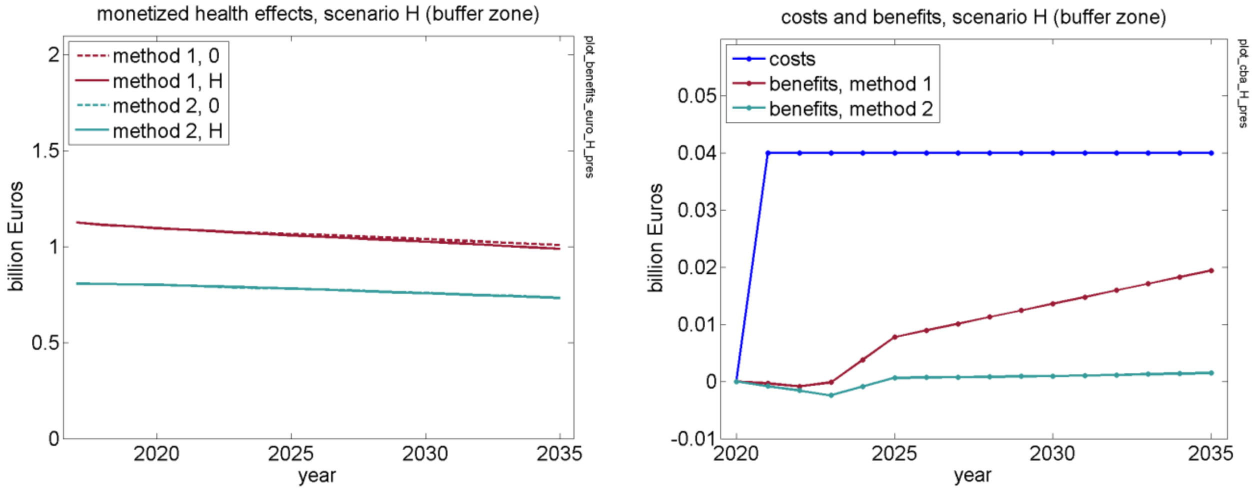


Figure 7.46. Results of cost-benefit analysis for aircraft scenario I

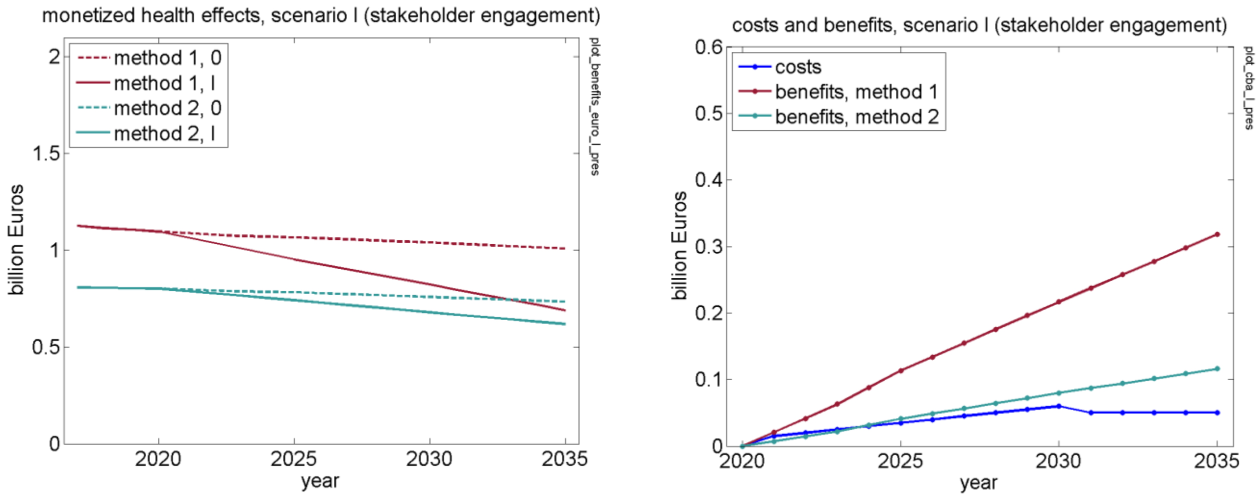


Figure 7.47. Results of cost-benefit analysis for aircraft scenario J

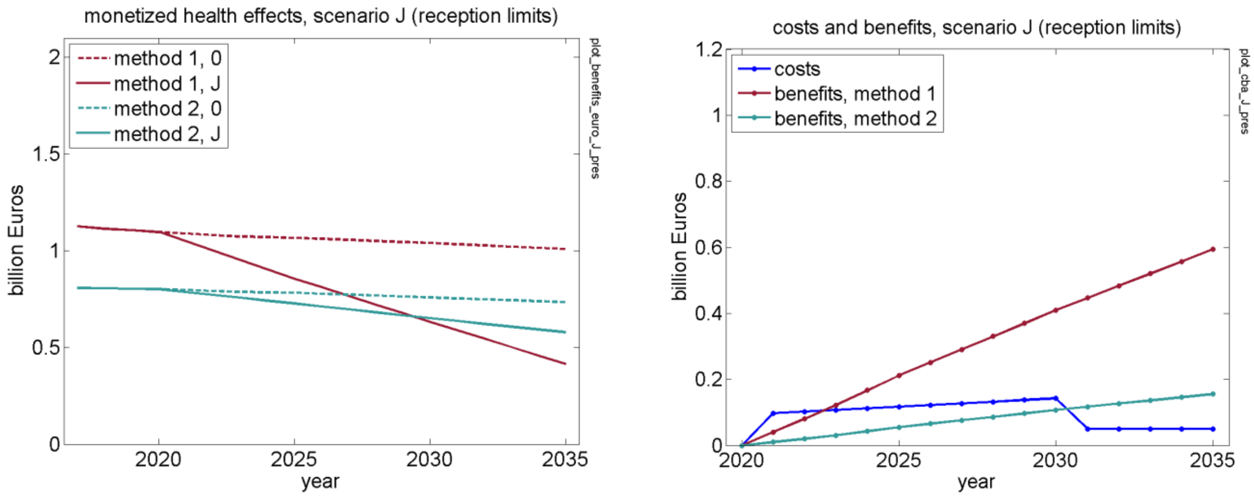


Figure 7.48. Results of cost-benefit analysis for aircraft scenario AB

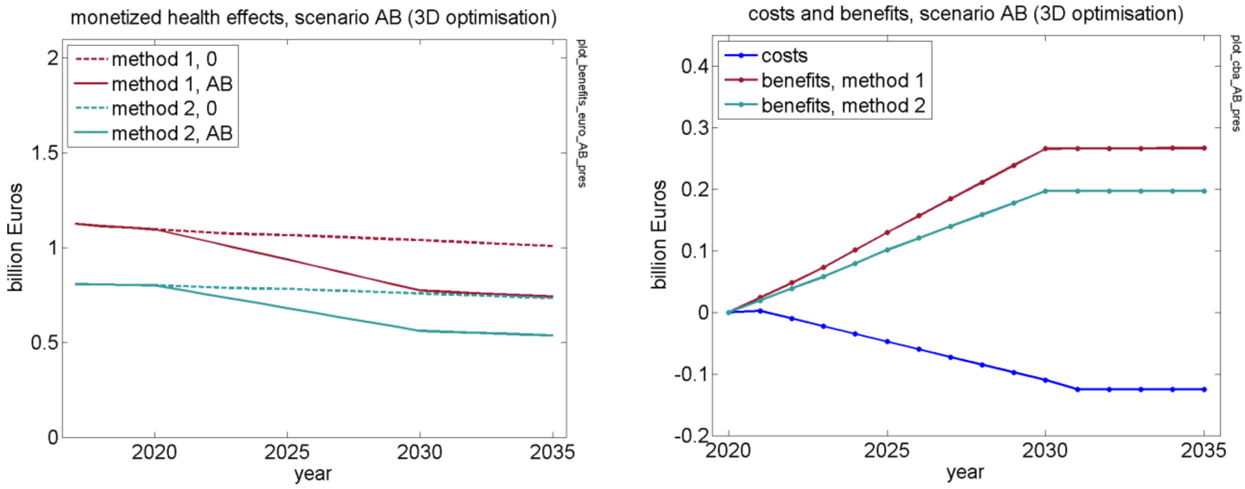


Figure 7.49. Results of cost-benefit analysis for aircraft scenario EF

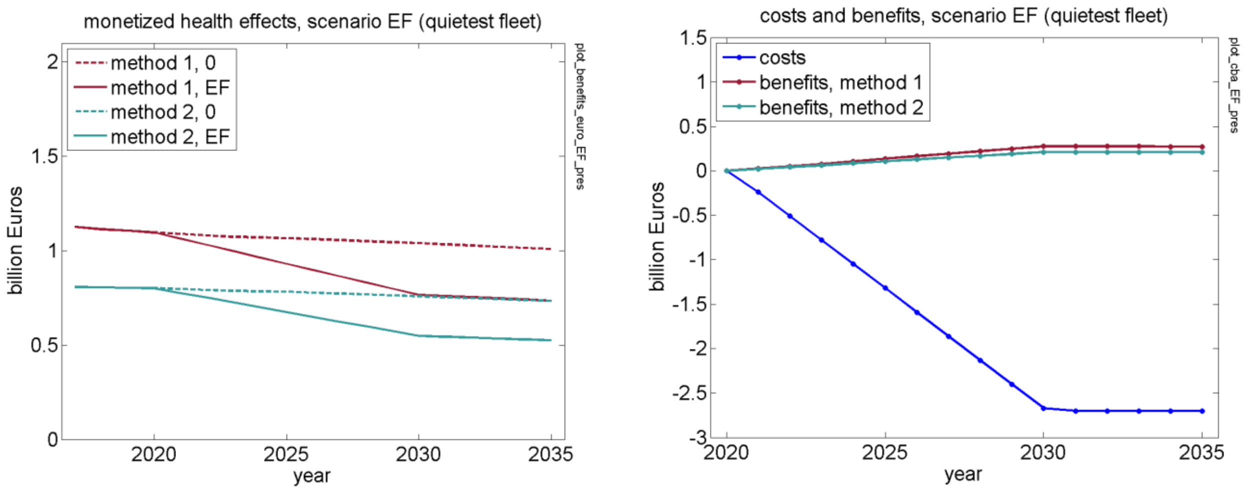
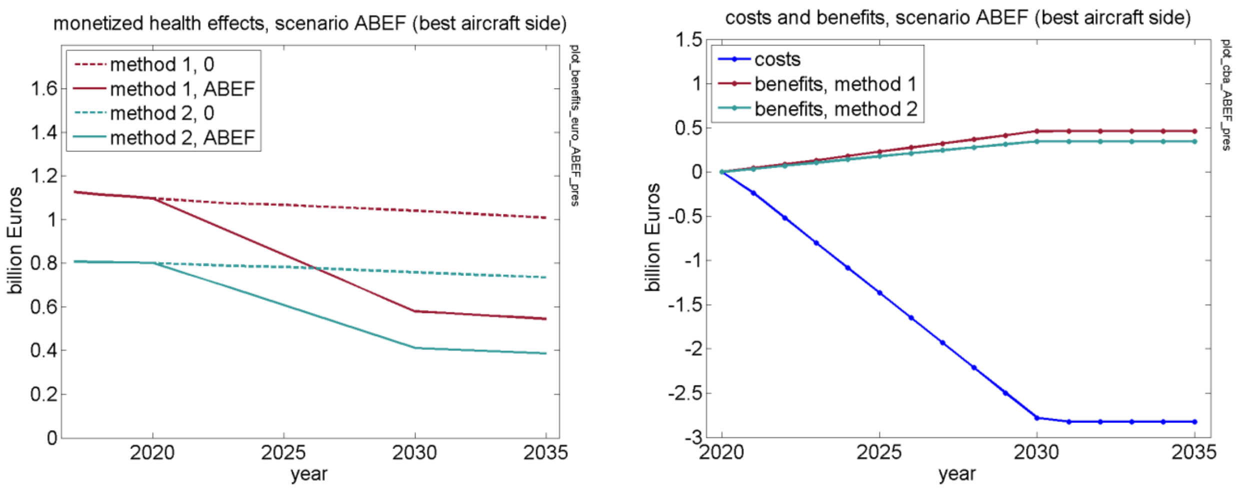


Figure 7.50. Results of cost-benefit analysis for aircraft scenario ABEF



7.9 Aircraft noise: variations

In this section, results are presented for aircraft scenarios described in the previous sections, but now with modified input parameters. The results give an impression of the effects of uncertainties in the input parameters on the results of this study.

The results are presented in Table 7.17 (health burden reduction) and Table 7.18 (cost-benefit analysis). Bar diagrams of the results are shown in Figure 7.51.

For scenario A (improved flight profiles), two variations are considered, scenarios A1 and A2. Scenario A1 changes the assumption of current implementation of improved flight profiles, whereas scenario A2 changes the expected benefit of the improved flight profiles.

- Baseline implementation 2020/2030: 30%/30% Noise effect: -2 dB
- Scenario A implementation 2020/2030: 30%/100% Noise effect: -2 dB
- Scenario A1 implementation 2020/2030: 50%/100% Noise effect: -2 dB
- Scenario A2 implementation 2020/2030: 30%/100% Noise effect: -1 dB

The health burden reduction (see Table 7.17) is smaller for scenarios A1 and A2 than for scenario A.

For scenario Cii (night curfew in 2030), three variations are considered, scenarios C1, C2 and C3. Due to the differences in the character of night operation between the different airports (cargo, express delivery, low-cost carriers, etc), the effect of a night curfew with respect to what will happen with the cancelled night flights will also be very different. Therefore, scenarios C1 and C2 both consider extreme assumptions with respect to the way the night flights are redistributed over the day. Scenario C1 supposes a shift of 50% of the night flights to day-time and 50% to the evening (effectively meaning that no operations are lost). Note that this is a very unlikely scenario, since it doesn't take into account the purpose of night flights (cargo etc) and supposes no capacity constraints during daytime. Scenario C2 considers the opposite, i.e. none of the night flights are shifted to other periods, so all operations are lost. Scenario C3 assumes a lower profit loss per lost operation.

- Baseline Redistribution of night flights to day/evening/lost: 0%/0%/0%
- Scenario Cii Redistribution of night flights to day/evening/lost: 25%/25%/50%
- Scenario C1 Redistribution of night flights to day/evening/lost: 50%/50%/0%
- Scenario C2 Redistribution of night flights to day/evening/lost: 0%/0%/100%
- Scenario C3 Same as Cii, but assuming the profit loss per operation is 3000€

The health burden reduction (see Table 7.17) is smaller for scenario C1 than for scenario Cii. For scenario C2 the health burden reduction is larger. For scenario C3 the health burden reduction is equal to the health burden reduction for scenario Cii but the costs are lower.

For scenario F (accelerated fleet renewal), one variation is considered, scenario F1. This scenario assumes a smaller noise reduction per year than considered in scenario F.

- Baseline Natural fleet renewal
- Scenario F Additional noise reduction -0.1 dB/year
- Scenario F1 Additional noise reduction -0.05 dB/year

The health burden reduction (see Table 7.17) is for scenario F1 is about half the health burden reduction for scenario F.

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Figure 7.51. Results of calculations for variations of aircraft noise scenarios from Table 7.17 and Table 7.18. A green dot on the right indicates that the solution is estimated to provide a cost saving

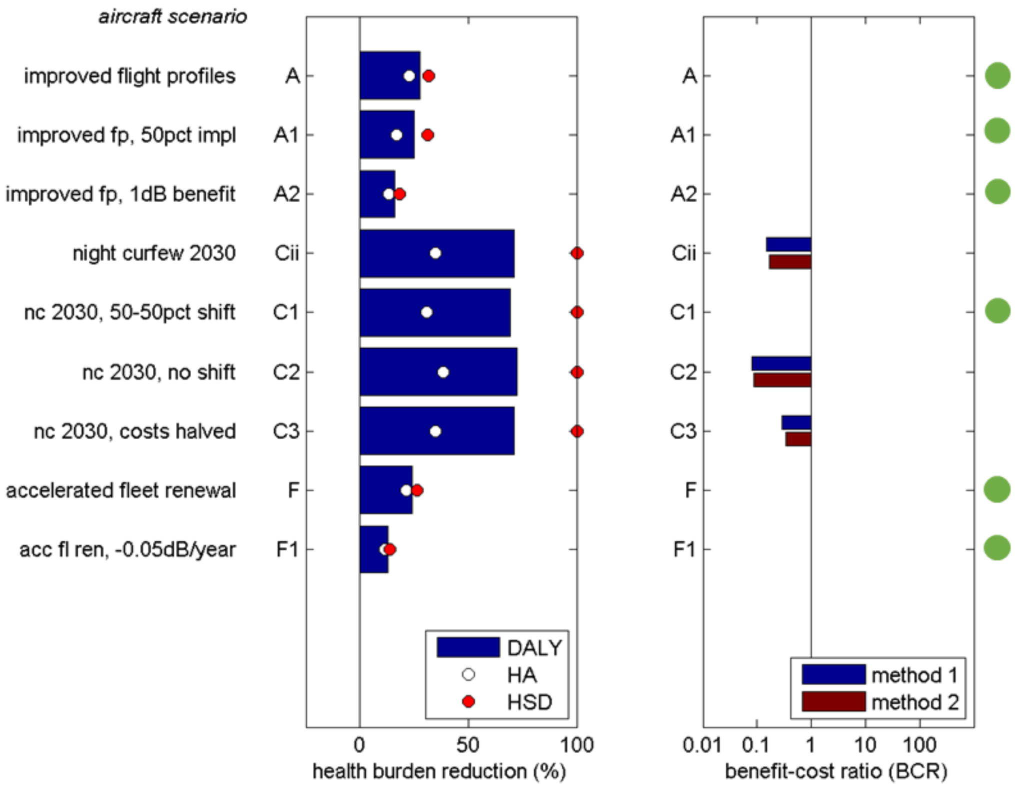


Table 7.17 Percentage reduction of annual EU health burden of aircraft noise in 2030, relative to the baseline scenario, for variations of single-solution scenarios.

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A improved flight profiles	22.6	31.5	27.6	24.9/25.7
A1 improved fp, 50% impl	16.7	31.4	24.9	20.0/21.9
A2 improved fp, 1dB benefit	13.2	18.4	16.1	14.4/15.0
Cii night curfew 2030	34.8	100.0	71.0	36.8/59.5
C1 nc 2030, 50-50% shift	30.8	100.0	69.2	32.7/57.0
C2 nc 2030, no shift	38.4	100.0	72.6	40.4/61.6
C3 nc 2030, costs halved	34.8	100.0	71.0	36.8/59.5
F acc. fleet renewal	21.2	26.1	23.9	22.4/22.9
F1 acc fl ren, -0.05dB/year	11.4	13.9	12.8	11.9/12.3

Table 7.18 Results of cost-benefit analysis of variations of single-solution scenarios of aircraft noise, for 2020-2035.

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A improved flight profiles	-2.24/-1.72	2.9/2.5	2021/2021
A1 improved fp, 50% impl	-1.79/-1.46	2.5/2.2	2021/2021
A2 improved fp, 1dB benefit	-1.33/-1.03	2.1/1.8	2020/2020
Cii night curfew 2030	0.15/0.17	-9.2/-9.0	-/-
C1 nc 2030, 50-50% shift	-/-	1.4/1.8	2030/2030
C2 nc 2030, no shift	0.08/0.09	-19.9/-19.7	-/-
C3 nc 2030, costs halved	0.29/0.34	-3.8/-3.6	-/-
F acc. fleet renewal	-0.09/-0.07	22.2/21.8	2021/2021
F1 acc fl ren, -0.05dB/year	-0.05/-0.04	21.4/21.1	2021/2021

8 The potential of EU and Member State policies to deliver better results on the implementation of noise solutions

8.1 Overview

The aim of this study is to define policy options that could reduce the health burden originating from road, rail and aviation noise by at least 20%, for each transport mode, within the next 10 years. The subsequently suggested policy options take current legislation and other instruments as the baseline at both the EU and Member State level and build on the findings from previous sections including legislation and NAP analysis, scenario analyses and input from stakeholder interviews and workshops.

Despite the WHO's Environmental Noise Guidelines for the European Region and an EU framework for the assessment and management of environmental noise (END), noise thresholds suggested by the END are still widely exceeded, and noise limit values are higher than the intervention level recommended by the WHO (see findings of Chapter 7). The need to take further action is underlined by forecasts and estimates[328] on expected growth in urbanisation and mobility trends for the coming decades, which may result in increased traffic[329] the development of settlements in the proximity of the main infrastructures.

EU Policy Baseline

The identified noise policy framework across the EU consists of EU and national level policy measures. At the EU level, instruments include the END as well as vehicle noise source limits and other transport related measures. The END triggers noise abatement solutions at all levels, at source, in the transmission path, and at the receiver. Noise action plans potentially have a broad scope in terms of types of solutions, including traffic and infrastructure measures at source.

Noise source directives are intended to limit the noise emission of new vehicles under controlled conditions, which do not always fully reflect real world conditions. Furthermore, there is specific EU noise legislation targeted at operations, such as the Balanced Approach Regulation for airports, and the Quiet Routes regulation (from 2024) for railways.

While over the past 20 years, noise emission reductions have been achieved, these have, in part, been offset by traffic growth, urban and infrastructure development and more powerful vehicles. Looking ahead, the European Green Deal is expected to increase the number of low emission vehicles, in particular for road, whereby electric and hybrid vehicles should replace petrol- or diesel-powered vehicles in the coming decades. New limits for road and rail vehicles are also foreseen in the coming years. However, for road and rail, infrastructure also needs further addressing.

Supplementing the policies are financial incentives such as Horizon Europe, the Connecting Europe Facility and, on the national level, the Structural Funds Mechanism. Charges in relation to noise emission are covered by the EU NDTAC regulation for railways and the EU Green Public Procurement criteria.

[328] JRC (2019): The future of cities https://urban.jrc.ec.europa.eu/thefutureofcities/urbanisation#the-chapter

[329] 1% per annum, meaning 10% in 2030.

Based on the information collected from the literature review and stakeholder interviews, the END is the main driver of national and sub-national level regulatory initiatives aiming to reduce noise pollution. However, as demonstrated in Chapter 4, noise levels are often determined and impacted by non-noise policy related instruments (legislative and non-legislative across various policy areas). In fact, one of the recurrent questions raised by stakeholders at the study workshops was whether the current set of EU noise policy measures can effectively tackle real-world noise. Real-world noise in this context was meant to represent the perceived noise from road, rail and aviation. Perceived noise includes both the sources that determine the long-term average noise levels, and those that do so less, due to their limited duration, such as motorcycles, tampered vehicles, helicopters, horns and sirens. In addition, the noise levels predicted by EU or national noise prediction models, can differ from measured noise depending on the inputs and situation modelling. The assessment of health impacts is associated with average Lden and Lnight levels, although a significant part of citizen complaints and surveys are also related to less periodic peak noise sources with high levels. National and local action plans are also in part targeted at reducing peak noise levels where it is an issue.

Figure 8.1 shows the interconnected elements of current transport noise policy at the EU level and includes those relevant policy measures that have a potential impact on the long-term average predicted noise, and real-world noise[330] either as perceived or as measured. Also the input parameters that may lead to differences between predicted and measured noise are indicated.

Figure 8.1 Main EU regulations relevant for transport-specific noise policies (road, rail, aviation) and its management, and its link with real world noise levels and local traffic and infrastructure parameters. (BAR= Balanced Approach Regulation for aircraft noise)

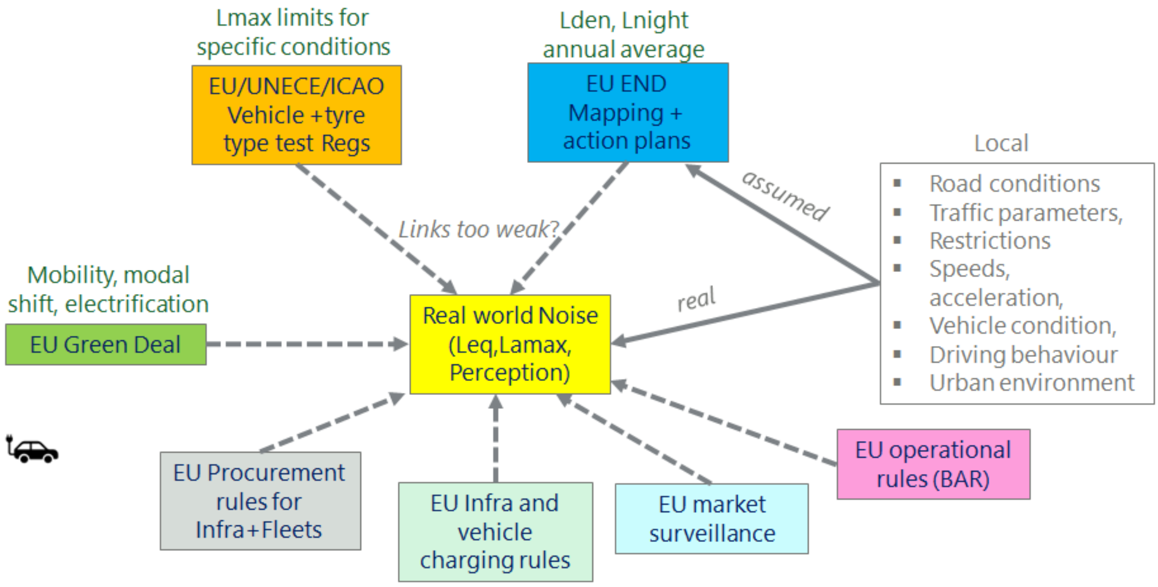


Figure 8.2 shows key policy instruments applied at Member State level. These measures support the effective implementation of relevant policies (as detailed in Chapter 4) and aim to ensure that noise thresholds and limits are met.

330 With respect to 'real world noise levels', it is useful to recall that facade levels at the dwelling are used as approximate representations of the 'true' noise exposure of the inhabitants of the dwelling (see Chapter 5).

Figure 8.2 Key elements of national legislative frameworks relevant for transportation noise and its link with real world noise levels

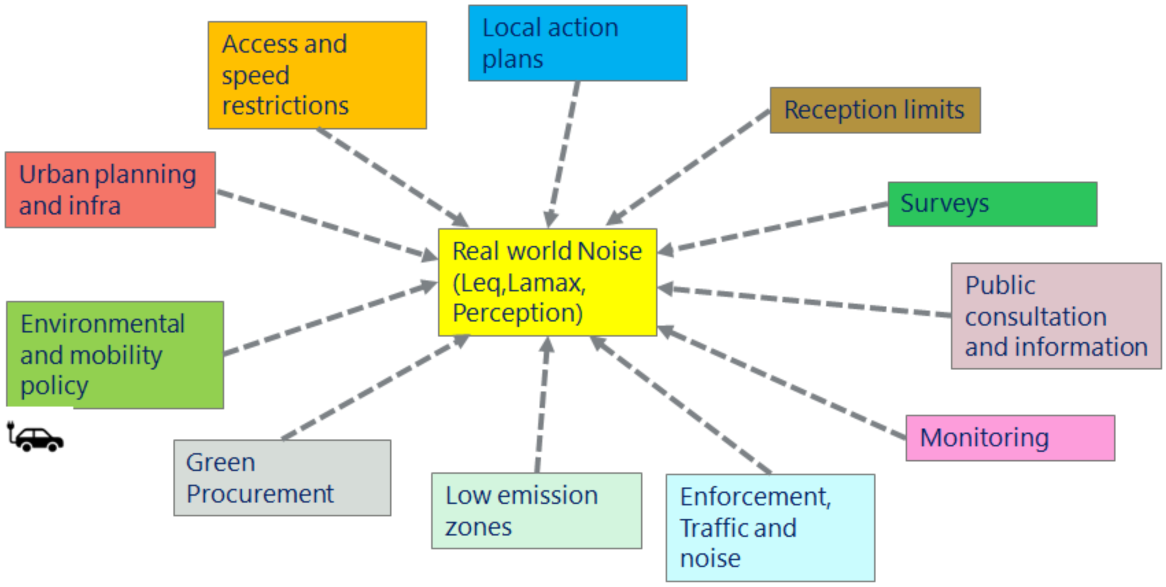
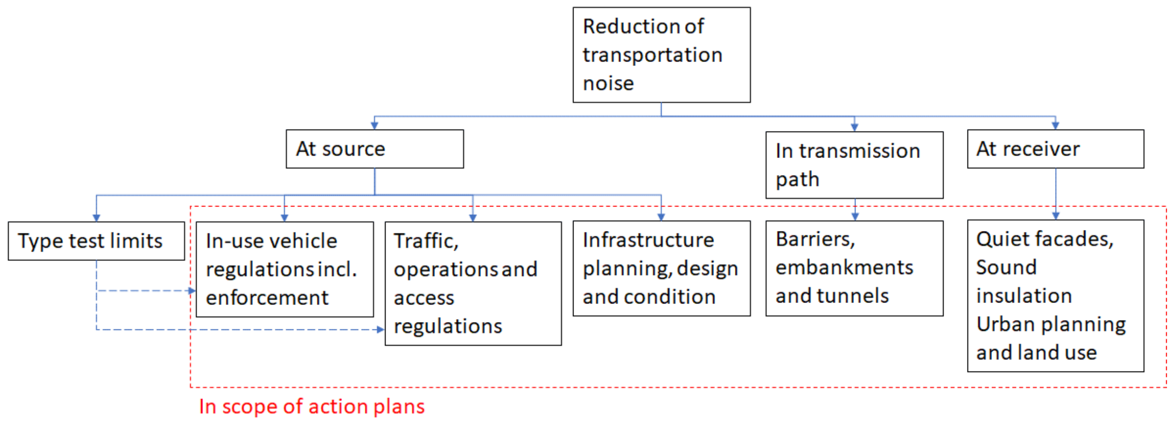


Figure 8.3 shows the generic noise abatement solutions, indicating which of these are potentially in the scope of noise action plans as required by the END. Notably, vehicle type test limits are outside of the scope of the END, as they are only regulated at EU and international level.

Figure 8.3 Main: Generic overview of noise abatement solutions



A general overview of common instruments for reduction of transportation noise is set out in Table 8.1Table 8.1, indicating their level application (EU, national or local level), enforcement, their potential to contribute to an increased implementation of noise abatement solutions and potential improvements. Not all of these are strictly in the scope of this study (major infrastructure or agglomerations), but they are nevertheless included for completeness. Those instruments that are relevant to EU noise policy are coloured.

Table 8.1 Overview of instruments for transportation noise abatement

		Responsible Authority							
	Instrument	Local	National	EU/UNECE	Enforcement	Remarks	Application level	Potential for stronger implementation of noise abatement solutions	Improvements suggested
1	Noise mapping	✓	✓	✓	EU, national, local	Using calculation models or measurement	++	High, if representative results are obtained	Better represent real world noise exposure and including modelling and reporting of source noise abatement measures
2	Noise action plans	✓	✓	✓	EU, National or local authorities	Both END and other	++	High, if followed up	Better guidance on best practice; health impact and CBA assessment, more implementation and verification. A new guidance with an updated data model for reporting information is under discussion with Member States. Better link with urban and infrastructure planning, which is not necessarily in line with EU noise mapping in time or procedurally
3	Cumulative exposure assessment	✓	✓		National or local authorities	Including more than one transport mode	-	For locations with more than one transport noise source	Consider extent and impact, it can resolve double counting in agglomerations and better model real exposure, in line with other pollutants
4	Vehicle source noise limits		(✓)	✓	Vehicle certification authorities	Vehicle type testing (new vehicles)	++	Targeted tighter noise source limits	Targeted tighter noise source limits for road vehicles, tyres, and rail, fleet replacement for aircraft. Limits apply to all operating conditions
5	Noise emission ceilings		✓		National or local authorities	Limited application, wider potential for large infrastructure and to restrict unbounded increase in noise	-	High, depending on emission ceiling limits	Evaluate whether more widely applicable, given traffic growth foreseen. Emission ceilings keep the effects of growth within limits, driving noise control at source and close to source instead of at the receiver. If reception limits are not agreed, this is an alternative
6	Noise access charging or taxation		✓	✓	National or local authorities	Exists for rail and aircraft	++	Medium, depends on the extent	Include for road vehicles combined with emissions
7	Facade noise limits, Lden/Lnight	✓	✓		Local or national authorities	Levels at dwelling facades	++	High, if enforced	
8	Facade noise limits Lamax	(✓)	✓		Local or national authorities	Incl. local acts at dwelling facades	+	High, if enforced	Evaluate whether guidelines are possible at EU level
		Responsible Authority							

	Instrument	Local	National	EU/UNECE	Enforcement	Remarks	Application level	Potential for stronger implementation of noise abatement solutions	Improvements suggested
9	Noise remediation programmes	✓	✓		National and local authorities	Depends on funding and investment levels	++	High, if combined with funding	EU wide coordination and info exchange
10	Noise enforcement (vehicles)		✓	(✓)	Police	UNECE Regulations 51 and 41 specify roadside check method. Meant to control excessive in-use vehicle noise	+	Low for Lden, high for perception and peak noise	Improved and/or automated enforcement methods
11	Monitoring of the noise and the condition of the infrastructure	✓	✓		National or local authorities	In-use infra and vehicles, also combined sources and exposure	++	Possibly high if linked to remediation	Technical and policy guidelines. Better identification of noisier vehicles in use. Guidelines or regulation on track/road maintenance and construction.
12	Noise surveys	✓	✓		n.a	Public perception, also linked to peak noise	++	Low	Potential link to action plans
13	Complaint registration	✓	✓		n.a	Public perception, also linked to peak noise	++	Low	Potential link to action plans
14	Incentives for quieter vehicles including funding		✓		n.a	e.g. tax incentives, access charging	+	Medium	More possible in urban areas to reduce peak noise levels. Consider how EU can encourage this, i.e. indirect incentives for electrification.
15	Innovation/R&D programmes		✓	✓	n.a	National research programmes and/or funding	++	Longer term	More focus on new effective solutions for vehicles, infrastructure, operations and traffic management including user feedback and automated enforcement.
16	Public information	✓	✓	✓	EU, National or local authorities	On noise exposure, urban planning, action planning	++	Low	Information to share based on future END requirements.
17	Public consultation	✓	✓		National or local authorities	On new or upgraded infrastructure or traffic	++	Low	Increase public confidence in commitment to noise abatement.
18	Environmental contract between residents and infra manager	✓	✓		National or local authorities	Binding commitment towards affected citizens	-	Medium	More binding obligation to limit noise exposure. Evaluate what can be done at EU level, such as template.
		Responsible Authority							

	Instrument	Local	National	EU/UNECE	Enforcement	Remarks	Application level	Potential for stronger implementation of noise abatement solutions	Improvements suggested
19	Traffic and operational management	✓	✓		National or local authorities	Other constraints	++	Medium	EU guidelines, include noise
20	Infra Planning procedures and permits	✓	✓		National authorities	Incl. upgrading and land use near dwellings	++	Medium	EU guidelines, include noise
21	Building planning procedures and permits incl. land use	✓	✓		Local and national authorities	Incl. upgrading and land use near infrastructure	++	High, if noise is considered in an early stage	EU guidelines, include noise
22	Public/green procurement	✓	✓	✓	National and EU	Infra or vehicles/fleets	+	High, if noise is included more often	More possible for Infra. Consider Road surface labelling and assessment criteria incl. in use performance
23	(Partial) Access restrictions	✓			Police and local authorities	Incl. night curfew	++	High, If noise is also considered	More possible for noisy vehicles at local level. Include noise and electric vehicles in low emission zones.
24	Speed restrictions	✓	✓		Police and local authorities	Traffic flow considerations	++	High	Wider application possible, synergy with safety
25	Mobility planning and modal shift	✓	✓	(✓)	National and local authorities	Issue of scale	++	High at local level. If at larger scale, also high in the long term	Guidelines on effect on noise and health effects
26	Sound scaping	✓			n.a.	Often little exposure reduction, mainly effective on the perception	+	Low	

The policy options put forth in this chapter have been developed based on the results of the NAP analysis, stakeholder consultations as well as the scenario and cost-benefit analysis presented previously. As indicated in Chapters 4 and 7, an effective and EU-wide reduction of noise emission that would result in at least a 20% decrease of associated health burden within the next 10 years cannot be achieved by individual scenarios but rather by a set of combined and complementary measures. The highest benefits from noise reduction are to be expected from the implementation of the best combined scenarios. Here, the link is made to legislative instruments, which could provide the necessary legal background for a harmonised and measurable implementation of noise abatement measures. This is done for each selected combined scenario, per transport mode, indicating:

- Which current legislation needs to be amended
- Which new legislation could be introduced;
- Causal links to (existing) national legislation;
- Technical and administrative steps required;
- Negative trade-offs;
- Expected reduction in health burden;
- Estimated benefit-to-cost ratio;
- Stakeholder inputs and considerations; and
- Obstacles and likelihood that competent authorities will implement.

To deliver these scenarios, an adequate and coherent legislative framework is required which effectively addresses various aspects linked to noise emission, including urbanisation, public transport, innovation and availability of funding. The desired noise reduction can then be achieved by a series of policy options across these policy areas. This approach follows the principle of horizontally integrating environmental issues into different policy areas. Therefore, it is suggested that the subsequent policy options are developed within the context of a coherent strategy. This will require setting an overall target of the noise reduction across different policy fields. This strategy could be ideally composed of a set of a horizontal (general) and vertical (sector specific) measures. The establishment of such an umbrella approach would streamline the efforts undertaken and ensure their timely application. Therefore, general policy options are discussed in chapter 8.2 and sector-specific policy options are elaborated in the subsequent chapters.

8.2 General policy options

A large number of regulatory measures effect noise emission levels and have an associated health impact. These measures often arise from non-transport related instruments, but nonetheless, as a direct or indirect consequence of their implementation, cause an increase of transport and transportation noise. The health burden reduction and benefit-cost ratio (BCR) of these measures is harder to predict due to the generic nature of these options.

Policy measures resulting in an increase of economic growth and regional development often bring about unintended environmental impacts. These measures include urban and regional development, infrastructure management, finance and investment measures. Often as a consequence of compartmentalisation of policy-making and divided portfolios, identification and in-depth analysis of environmental impacts may only take place once the measures have been implemented. Therefore, an increased **horizontal coordination** between the relevant policy areas of competition, internal market and environment could help clarify the key criteria that would need to be met for

The picture can't be displayed.

the effective and sustainable pairing of dynamic economic growth and sustainability. **An overarching recommendation in this field would be to establish a consultative committee that would update and better define the key environmental criteria to be analysed within the context of impact assessments and part of the Better Regulation Framework.** Additional elements to the environmental criteria under regulatory impact assessment could include quantification of expected changes to noise emission levels.

An example of non-transport related policy with indirect impact on noise is the 2017 update to the EU's General Block Exemption Regulation[331] on state aid which was extended to cover regional airports of up to 3 million passengers per year. In cases where such policies have already been implemented and a revision is not expected, it is vital that adequate financing is provided for the mitigation of indirect environmental and corresponding public health impacts. The proposed general policy options in order of priority are set out in sections 8.2.1-8.2.6.

8.2.1 Standardisation, streamlining and mandatory evaluation of noise action plans

The Environmental Noise Directive 2002/49/EC and its common noise assessment methods defined in Directive 996/2015/EU prescribe noise maps, action plans and their publication.

According to the stakeholders, NAPs are perceived as meaningful tools for identifying noise solutions, driving the implementation of noise abatement solutions in the areas where the noise thresholds have been exceeded. According to Art. 8 of the END, action plans are "designed to manage, within their territories, noise issues and effects, including noise reduction". Hence, these plans **should contain noise abatement measures** to tackle the identified noise issues together with their effect and to protect quiet areas against a potential increase in noise pollution.

As detailed in Chapter 4.3.2.2.2 stakeholders proposed several measures for increasing the effectiveness of noise reduction measures via regulatory instruments. Among the suggestions was the introduction of noise limit values to replace the current non-binding thresholds for NAPs. Although in the context of the END **threshold** values are defined for noise assessment, these are **not mandatory and are to be understood as noise protection levels above which negative health impacts are expected.** Hence, they do not provide a similar level of protection compared with the limit values set by national legislation.

Some areas of improvement have also been identified, primarily to further **clarify the content of the noise action plans** including information on the effectiveness of previously implemented solutions. Art.(8)1, second subparagraph of the END leaves the decision on what noise abatement measures should be taken to address the identified issues to the discretion of the Member States. At the same time, this provision does not oblige Member States to take the measure. Therefore, the effective implementation of the NAPs is often limited and depends on the availability of financial resources and political will. While this provision is applicable for NAPs for roads, rails and agglomeration, this is not the case of aviation which is also driven by the provision of the BAR. Based on Art.5(2) of the BAR the measures adopted in the NAPs for aviation shall be implemented.[332] Information on the **expected benefits of proposed new measures** and a CBA should be requested for aviation, which currently is not compulsory for other sources (according to Annex V of the END).

[331] Commission Regulation (EU) N°651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty

[332] Regulation (EU) No 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC - OJ L 173, 12.6.2014, Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0598.

As noted in Chapter 4 stakeholders suggested that a more effective implementation of the END could be supported by common guidelines and methodologies developed at the EU level. This could help reduce currently fragmented Member State approaches. These common guidelines could support the harmonisation of the NAP content as well as their implementation and evaluation across the EU. Such guidelines could include the specific goals of NAP sections, drafting and monitoring practices (evaluation of implemented measures). In addition, the scope of the guidelines could also include common methodologies for cost-benefit analysis, designation of quiet areas, insulation schemes around airports, or measuring the implementation of past noise reduction measures.

In the NAPs, **clarification** should be requested regarding the description and scale of proposed noise solutions, as these were often found to be lacking. For example, simply knowing that a quiet road surface on a single stretch of road was constructed or that tracks at a particular location were renewed is not sufficient for evaluating the impact – i.e. information would be needed on the achieved noise reduction and the percentage of annoyed or sleep disturbed people benefiting from the measures taken.

This could be implemented by aligning the NAPS with other planning documents. Such a convergence of NAPs with other strategic planning documents could increase their enforceability and increase the overall awareness on noise pollution. Linking the implementation of the noise abatement solution with other relevant policy objectives could shift the resource allocation to the fulfilment of the common goals.

Standardisation refers to **streamlining** and improving the consistency of NAP's content. This requires guidance both on potential best solutions for given situations and the noise reduction to be expected. **Evaluation** means assessing whether the planned measures were actually implemented, and if so, to what extent they appeared to be effective. An evaluation methodology should be drafted on the EU level to serve as a guideline to national authorities. However, action plans may become less ambitious as a consequence. In addition, it should be further considered whether the implementation of NAPs should be mandatory to achieve the overall objective of the END.

Many NAPs focus on reducing noise at hotpots with the highest levels. A **verifiable target to reduce the health burden**, either in terms of the number of people that highly annoyed or highly sleep disturbed, DALYS, or the monetised health burden, would cover a larger number of affected people, rather than only those highly exposed, and offer more flexibility in achieving the target.

Interactions with stakeholders indicated a lack of **shared knowledge** of good practices. Based on multiple exchanges during the interviews and workshops, it was pointed out that the mapping, identification and exchange of best practices could significantly increase effective implementation of noise abatement measures. A regularly updated good practice document, including guidelines on inclusive and effective public consultations, could be prepared as an annex to the END.

Table 8.2 Overview of key impacts for the standardisation, streamlining of noise action plans

Definition	Improved definition, support, verification and evaluation of action plans, including health reduction target
Legislation concerned, new/amended	END guidance document on data reporting, foreseen in 2021. Also include health burden reduction targets.
Causal links to national or EU legislation	National reception limits and planning legislation.
Technical and administrative steps required	Review and impact assessment of the END and its amendments taking into consideration possible policy options for additional mandatory requirements of the action plans as well as the END.

Negative trade-offs	This step has the potential to increase administrative burden at the national as well as the local levels. EU level discussion of the public authorities is needed to facilitate best practices on management of new criteria.
Expected health burden reduction	The estimated reduction in health burden is estimated around 1-3 % with large uncertainty, given that better and more verifiable action plans would be proposed and implemented.
Estimated benefit to cost ratio	The BCR is expected to be well above 1 as the cost for this policy option is rather low compared to the potential benefits.
Stakeholder inputs	Reduction of health burden as a target was recommended by some stakeholders.
Likelihood of implementation by competent authorities	Implementation is likely if prescribed at EU level.
Obstacles	Obstacles to this intervention are the existing differences between member states, some of whom already have in place additional measures.
Timeline	Taking into consideration a revision and impact assessment the implementation of this policy option could take up to five years.

8.2.2 Extend the scope of the END to urban planning, infrastructure planning and land use

As demonstrated in Chapter 4, urban planning, infrastructure and land use planning are important elements for the management of environmental noise. In particular, potential future issues can be avoided where potential noise impact is considered at an early stage. They can have a positive impact on the timely implementation of noise abatement solutions. The analysis of the NAPs identified several links between urban planning instruments and noise abatement measures across Member States. This has mostly been observed in agglomerations. Furthermore, stakeholders consulted during this study pointed out that, given the increasing urbanisation trends across Europe, urban planning alongside mobility and infrastructure plans should include instruments on noise abatement measures. According to a study published in 2017, integrating environmental noise management into plans for upgrading mobility networks could be beneficial on a large scale.[333] For instance, during the modernisation of public transport vehicles, lower noise alternatives could be selected.

During the consultations, stakeholders also pointed out that the scope of the END could be further broadened to include smaller airports than the current range. Furthermore, a possible future END revision should also include the update of several definitions, such as agglomerations.

In its current form the **END** requires **noise mapping** for the purpose of public information and as a basis for health impact assessment. This noise mapping requirement could be extended **to include urban planning, infrastructure planning and land use activities**. Many Member States already use their national prediction models for this requirement, but the **EU prediction model could be upgraded** to fulfil additional requirements for this purpose.

[333] European Commission, Future Brief: Noise abatement approaches, April 2017, Available at: https://ec.europa.eu/environment/integration/research/newsalert/pdf/noise_abatement_approaches_FB17_en.pdf.

Currently, there is a **weak link** between the abovementioned planning instruments, EU noise mapping and the development of NAPs, which all have different timetables and responsible actors. Various authorities are involved in planning procedures, ranging from infrastructure authorities, municipalities to provincial and national authorities. This potentially leads to a **fragmented approach** and is a serious **bottleneck** for the effective implementation of noise abatement measures.

Furthermore, **extending the scope of the END to urban planning** could raise awareness about noise pollution among stakeholders, both citizens and project developers. The convergence between various planning instruments provides a good opportunity to streamline financial resources and reduce administrative burden, as different plans could be developed in a more synchronised manner. This could also help avoid future conflicts when building near roads, railways and airports.

To incentivise EU Member States to use END noise maps for various types of spatial planning, it is vital that the harmonised **CNOSSOS-EU noise model**, which will be used for future END noise maps, gives reliable results and that **initial problems** with the model are eliminated. Spatial planning often requires reception limits at dwellings to be considered, so the calculated noise levels on the END noise maps should be accurate and reliable.

Table 8.3 Overview of impacts for extending the scope of the END

Definition	Improve END calculation models and extend to use for urban, infrastructure and land use
Legislation concerned, new/amended	END amendment
Causal links to national or EU legislation	National reception limits and planning legislation for buildings and infrastructure.
Technical and administrative steps required	A common guidance methodology drawing the link between planning instruments, NAPS and implementation of noise abatement solutions should be developed for this purpose. A review of the END and an impact assessment for its potential update should follow.
Negative trade-offs	Potentially more administrative burden, but also expected savings due to better integration of planning and environmental development.
Expected health burden reduction	There is no estimate available for the reduction in health burden or BCR for this option, but it can be expected that a streamlined approach could help drive up the implementation levels of all noise abatement solutions.
Estimated benefit to cost ratio	
Likelihood of implementation by competent authorities	This policy option offers a more harmonised approach to noise management at national and local levels. Likelihood of implementation is high.
Obstacles	Obstacles to such a scope extension may be national preferences for existing prediction models and precedence and the organisational aspects of noise management.
Timeline	Taking into consideration the time needed for the END review and impact assessment the implementation of this policy option could take up to five years.

8.2.3 Introduction of EU noise reception limits at dwellings

Implementation of the reception limits contained in the WHO's Environmental Noise Guidelines for the European Region would require the roll-out of large-scale noise abatement measures, given that current reception limits in most countries are much higher.[334] Moreover, many stakeholders indicated that indicative noise thresholds included in the END are not sufficiently binding to reach a meaningful reduction of the noise levels.

At the same time, the national noise reception limits are seen by the majority of the stakeholders as the most efficient tool for the reduction of noise pollution. According to the stakeholders, reception limits exist mostly for each transport mode, but given the health impact of noise, setting up recommended limits for cumulative noise could also be considered – i.e. from combined sources such as road and rail or road and aircraft. In this regard, **a stepwise approach at EU level** should be considered to establish EU-wide **uniform reception limits including those of combined noise sources, without degrading existing national limits.**

Noise reception limits at EU level were evaluated as a single scenario for each transport mode in Chapter 7. Given the existence of national limits, a best approach needs to be sought for the EU level. Studies have examined reception limits in different Member States. Given that these are important drivers for noise reduction, such limits would firstly affect Member States with the highest reception limits or none.

The estimated health burden reduction and BCR for reception limits of 60 dB Lden and 55 dB Lnight as described in chapter 7, are as follows:

- for road traffic noise: 8-19%, BCR of 1-9
- for railway noise: 4-8% BCR of 0.2-1.7
- for aircraft noise: 14-39% BCR of 0.8-3.1.

These reductions and BCR figures depend strongly on the level of reception limits in the Member States, and how they are implemented, which may differ significantly for each country. The identified benefits are based on the reduction of the noise distribution down to the chosen reception limit; the costs are based on an overall annual budget of €1 billion per year (see Chapter 7 for each transport mode).

The major obstacles identified with implementation of this policy option are:

- The immediate cost implications especially for Member States with higher or no limits, and insufficient funding for noise abatement;
- Practical constraints in some extreme exposure situations, where often an allowance is applied; and
- Potential restrictions on new infrastructure or housing.

An overview of reception limits in EU Member States is available in an EPAnet report[335]. About 70% of EU countries have noise reception limits for road, rail and aircraft, with different levels such as Lday, Lnight and sometimes Lmax, and different degrees of implementation and enforcement.

A drawback for uniform reception limits is that the **implementation** and responsible authorities can **differ** significantly **between Member States**, including prioritising, funding and enforcement.

[334] European Network of the Head of Environment Protection Agencies, Overview of critical noise value in the European Region, October 2019, available at: https://epanet.eea.europa.eu/reports-letters/reports-and-letters/ig-noise_critical-noise-values-in-eu.pdf/@@download/file/IG%20Noise_Critical%20noise%20values%20in%20EU.pdf.

[335] https://epanet.eea.europa.eu/reports-letters/reports-and-letters/ig-noise_critical-noise-values-in-eu.pdf/view

Specifically, allowances on higher reception limits are often applied in situations where insufficient funding is available or traffic growth is simply given priority.

Another consideration for reception limits is the position of the reception point at the façade, i.e. at 4m height and/or around the whole building. This can result in significant differences in numbers of exposed people and health impacts and is an ongoing discussion point.

An alternative to reception limits is **a target for the reduction of health burden**, which allows more flexibility in how to achieve this.

Table 8.4 Overview of impacts for reception limit changes

Definition	Include minimum noise reception limits in END without degrading national reception limits, or specify targets for health burden reduction
Legislation concerned, new/amended	END amendment
Causal links to national or EU legislation	National reception limits
Technical and administrative steps required	Define stepwise approach for EU-wide reception limits. Lden, Lnight and potentially also LAmax
Negative trade-offs	Administrative burden
Expected health burden reduction	Road: 8-19% / Rail: 4-8% / Air: 14-39%
Estimated benefit-to-cost ratio	Road: 1-9 / Rail: 0.2-7 / Air: 0.8-3
Likelihood of implementation by competent authorities	Implementation is contingent upon availability of financial support, specific guidelines for reception limit and implementation.
Obstacles	High costs: the immediate cost especially for Member States with higher or no limits, and insufficient funding for noise abatement. There are also practical constraints in some extreme exposure situations, where often an allowance is applied. There are potential restrictions on new infrastructure or housing.
Timeline	Depending on the regulatory approach taken and whether reception limit changes introduced separately or together with an update of the END, the implementation could take anywhere between three to five years.

8.2.4 Improve coherence between noise prediction models and vehicle type tests

Although the END refers to the noise source directives, the quantitative link is relatively weak. Whereas the END and its prediction model are based on in-use vehicles, roads and tracks, the source directives refer to type tests of new vehicles under controlled conditions.

Type tests for road and railway vehicles are configured mainly to limit the noise emission level of new vehicles, in a reproducible manner.

Type testing could be expanded to also obtain better data for prediction models, including effects of road surface/tyres and wheels/tracks on rolling noise, operating conditions and design on powertrain noise and aerodynamic noise. If this data is combined with monitoring of in-use vehicles and infrastructure, better quality source data could be obtained for prediction models.

Given the critique on both prediction models and type tests, this measure is strongly reliant upon stakeholder acceptance and support. Stakeholders from the automotive industry have mentioned the mismatch between type testing, prediction models and real world data.

Table 8.5 Overview of the impact of better matching prediction models

Definition	Extend and improve type test procedures to include conditions for more representative data, and improve prediction models where required.
Legislation concerned, new/amended	Amendments to END, EU Source Directives and UNECE legislation.
Causal links to national or EU legislation	National reception limits
Technical and administrative steps required	Inclusion of other road surfaces and more driving conditions in road vehicle tests, track properties for railways, and flight conditions for aviation. Studies supporting the necessity of improving and better matching prediction models will need to be prepared to support the changes.
Negative trade-offs	None foreseen
Expected health burden reduction	Estimated at 1-5%, given better indication towards action plans.
Estimated benefit to cost ratio	Estimated >1, as the main effort is in improving the methods and input data, whereas benefits can be widespread.
Likelihood of implementation by competent authorities	High, if included in EU legislation
Obstacles	Strong stakeholder buy-in is required which could delay implementation
Timeline	Depending on the intensity of stakeholder consultations changes can be implemented in 2-4 years

8.2.5 Include noise requirements in public procurement procedures for vehicles and transport infrastructure

One of the key policy instruments that could benefit from environmental considerations, including noise abatement solutions, is the **Public Procurement Directive.** However, Directive 902/2014 on Public Procurement[336] does not currently require contracting authorities to incorporate points for sustainability and environmental impact among the award criteria. The 2014 review of EU public procurement policies had seen a move from awarding tenders for price-quality ratio to a slightly more complex basis of economic advantageousness. This new term does not explicitly involve

[336] European Commission (2014) Directive 2014/24/EU of the European Parliament and of the Council of 26 February 2014 on public procurement and repealing Directive 2004/18/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014L0024

sustainability considerations, but it does refer to cost effectiveness and life-cycle costing which can include environmental costs of pollution and health burden. More explicit environmental considerations are described in the Commission's **Green Public Procurement**[337] initiative, which is a voluntary instrument containing sustainability criteria that can be used by contracting authorities. The criteria are regularly reviewed and published in a handbook. **Lifting these sustainability criteria and making them part of the Public Procurement Directive** could significantly impact implementation of noise solutions and help increase exchange of sustainability practices among contracting authorities as well as private enterprises. For instance, green public procurement could be linked with mobility planning. As mentioned above, the public procurement could be, for instance, applied during the modernisation of public transport vehicles and drive the uptake of lower noise alternatives.

Changing the procurement legislation would require providing training to the national authorities on the exact implementation of the new requirements. Additionally, a comparative study is required on the extent to which these stronger environmental considerations could impact reciprocal market access to the public procurement market for third countries with which the EU has conducted free trade agreements with relevant provisions.

Table 8.6 Overview of the impacts of public procurement changes

Definition	Include noise emission requirements for vehicle fleets and infrastructure in public procurement
Legislation concerned, new/amended	Amending the EU's Public Procurement Directive
Causal links to national or EU legislation	Green Deal and national climate legislation, EU Procurement Directive and national procurement regulations.
Technical and administrative steps required	Revision of the Public Procurement Directive and corresponding impact assessment would be necessary.
Negative trade-offs	As with all significant changes to public procurement, a training programme would need to update relevant national authorities on the new requirements.
Expected health burden reduction	The potential health burden reduction is expected to be about 5% given that other policies already affect noise emission and in some Member States it is already included.
Estimated benefit to cost ratio	The BCR would be above 1 as the cost for this policy is relatively small.
Likelihood of implementation by competent authorities	High likelihood of implementation
Obstacles	Some Member States may claim that stronger inclusion of environmental considerations can increase costs of public purchases. In order to ascertain the actual costs and benefits of stronger environmental criteria an EU-wide study would be needed.

[337] European Commission (2020) Green Public Procurement https://ec.europa.eu/environment/gpp/index_en.htm

Timeline	Taking into consideration the review and impact assessment of the directive, a four to six-year timeline is foreseen.

8.2.6 Enhance EU financial incentives and increase noise charges

Financial instruments to reduce environmental noise are already in place, such as noise differentiated track access charges (NDTAC) for railways, access charges for aircraft and subsidies or tax benefits for quieter and cleaner vehicles.

Taxation on fuels and vehicles based on other parameters such as weight, power and age also exist, although often not specifically for noise. Given that older vehicles fulfil their older type test and noise limits (which may now be much lower), there is potential to accelerate the uptake of quieter and cleaner vehicles via taxing and access charging. Also, incentives for early withdrawal (scrapping) or a ban on polluting and noisy vehicles could be considered in this respect.

EU funding is available from the Multiannual Financial Framework (MFF) Connecting Europe Facility, innovation and research projects, Cohesion Fund; Regional Development Fund (ERDF); European Social Fund (ESF); and the European Structural and Investment Fund (ESIF). These instruments could be further supplemented by the European Green Deal Investment Plan[338] (EGDIP). Mobilisation of public and private investments are an important element of the EGDIP via InvestEU and the Just Transition Mechanism (JTM)[339]. The JTF was designed to complement the ERDF and ESF+.

In addition, the 2021-2027 Multiannual Financial Framework (MFF) foresees climate mainstreaming across all EU expenditure, dedicating 25% of EU expenditure to climate objectives[340] in combination with elements of 'green' financing in ERDF. Within ERDF[341], the majority of funding must be thematically concentrated on the Green Deal aligned PO 2 and the innovation-focused PO 1[342].
Moreover, new funding opportunities are available, such as the temporary recovery instrument, NextGenerationEU, which have been introduced to address some of the economic and social consequences of the Covid-19 pandemic.[343] This could provide an opportunity to improve transport infrastructure in a way that is more closely aligned with sustainability and the Green Deal objectives.[344]

As noted under Chapter 4.3, stakeholders indicated that access to finance is a key obstacle for the effective implementation of noise abatement measures. Further alignment between noise policy and other relevant areas should be achieved to make better use of available funding opportunities and streamline possible investments.

[338] COM/2019/640 final

[339] COM/2020/22 final

[340] COM(2018) 375 final

[341] COM(2018) 372 final

[342] PO1:"a smarter Europe by promoting innovative and smart economic transformation";

[343] European Commission, Recovery plan for Europe, available at: https://ec.europa.eu/info/strategy/recovery-plan-europe_en

[344] EurActiv, A Green Recovery for Aviation, December 2020, available at: https://www.euractiv.com/section/aviation/opinion/a-green-recovery-for-aviation.

Table 8.7 Overview of potential impacts from increased financing opportunities

Definition	Financial incentives
Legislation concerned, new/amended	National legislation, with EU legislation
Causal links to national or EU legislation	General legislation on infrastructure charging, subsidies and taxation.
Technical and administrative steps required	Review of options for further differentiation in charging and taxation in relation to noise.
Negative trade-offs	Increased financial burden on operators and vehicle owners.
Expected health burden reduction	Expected health burden reduction and BCR is highly dependent upon the amount of direct financial support available and the conditions tied to its use.
Estimated benefit-to-cost ratio	
Likelihood of implementation by competent authorities	Very high likelihood
Obstacles	Political support across Member States
Timeline	This is a measure that can have a relatively short implementation once the political decision has been made to allocate financial support for the reduction of environmental (incl. noise) pollution. Timeline is one to three years

8.3 Policy options to reduce road traffic noise

Based on the solutions/scenarios described in the previous chapters and the good practices derived from the NAPs, reduction of road traffic noise is mostly achievable by reducing tyre-road noise and powertrain noise of vehicles at the source, including increased electrification. Noise barriers are not feasible along many urban roads and always have a significant visual impact besides being relatively costly. In order to achieve significant reductions, quieter road surfaces in combination with quieter vehicles and tyres is considered the most viable solution. At local level, traffic measures such as speed and access restriction are considered effective.

For these reasons, the most effective combined scenarios, as presented in chapter 7, are

- **ABC: more quiet roads, quieter tyres and specific lower vehicle sound limits**
  Health burden reduction in 2030: **16-22%**
  Benefit to cost ratio over 2020-2035: **0.8-4.6**

- **ABCD: as ABC including more electrification than in the baseline scenario**
  Health burden reduction in 2030: **18-24%**
  Benefit to cost ratio over 2020-2035: **0.9-5.1**

- **FGHI: speed restriction, car-free zones, quiet facades, and dwelling insulation**.
  Health burden reduction in 2030: **16-20%**
  Benefit to cost ratio over 2020-2035: **0.04-0.2**

These do not exclude other solutions, but they are considered to be most effective at EU level in the context of this study.

Scenarios ABC and ABCD may be associated with effective noise reduction strategies at EU level (as these measures are governed by EU legislation), and therefore these scenarios are most relevant for noise regulation and actions by the European Commission.

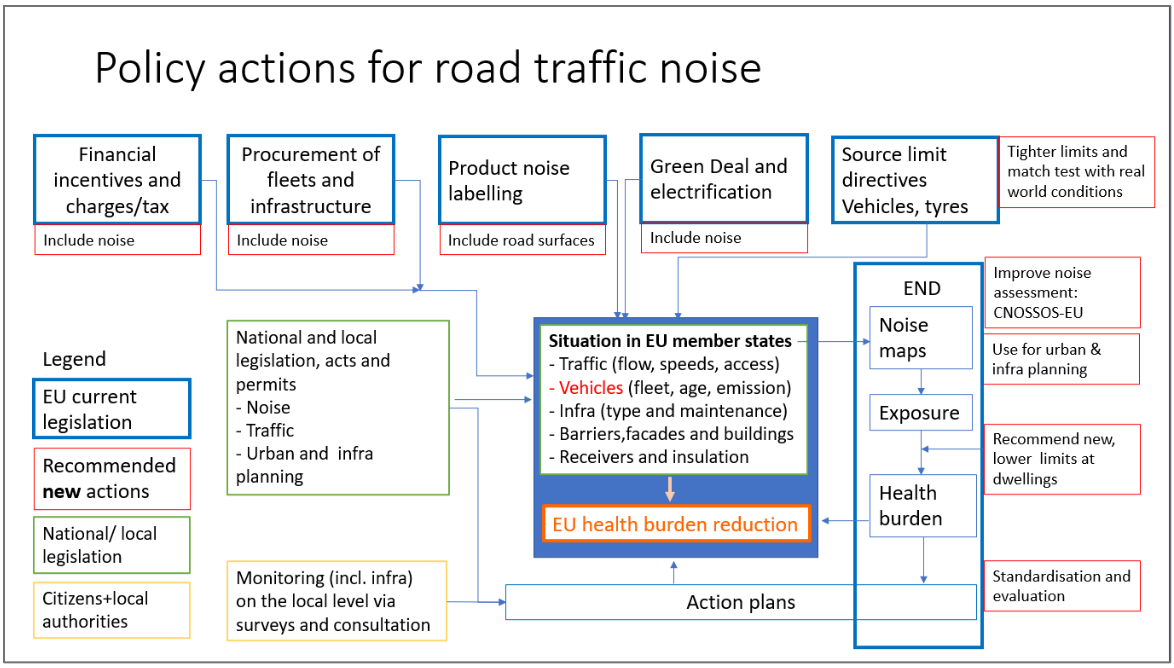
Scenario FGHI is focused more at local level, and therefore less suitable for direct action at EU level. Nevertheless, EU guidance related to scenario FGHI may be useful to stimulate effective noise reduction strategies at local level. An example of such guidance is the recommendation in the END that quiet areas should be protected from noise.

In view of the relevance of ABC and ABCD at EU level, each of the four noise solutions A, B, C, and D are discussed separately in the following subsections. Finally, scenario FGHI is discussed.

To achieve a health burden reduction in the range 20-50%, options ABCD together with FGHI are recommended. This entails both EU source regulations for rolling noise, tighter vehicle limits including increased electrification, together with national actions including speed and access restrictions together with more quiet facades and dwelling insulation.

The specific policy recommendations for road traffic noise are set out in sections 8.3.1-8.3.6 and are visualised in Figure 8.4 below, showing the existing EU legislation (blue) national/local legislation (green/yellow) and potential new actions (red). The arrows show the correlation between current legislation, noise levels in Member States and recommended new actions. Current baseline policies and recommended actions are aligned with the inputs, actions and outputs of the revised intervention logic as presented in chapter 4.

Figure 8.4 EU and national legislation for road traffic noise and potential improvements at EU level (marked red)



8.3.1 A - Increased application of quiet road surfaces

Examining the relevant policy instruments that relate to road works we find that the management of road surfaces is the prerogative of national governments, which includes road development investments and the incorporation of innovative solutions. Nevertheless, competences on road surface improvements are often delegated to regional and local authorities. For instance, as indicated in Chapter 4, in Austria, road traffic noise from motorways is regulated at national level while noise from other major roads is regulated at state level. Consequently, as confirmed by stakeholders, the effective implementation of these measures goes hand in hand with the available sources of financing at the disposal of relevant actors. Relevant European-level policy instruments refer primarily to safety-related issues of road infrastructure, such as the **Road Surface Quality Directive** 2008/96/EC,[345] which focuses on the establishment of road safety impact assessments and road audits.

As the analysis of planned noise solutions had shown, Member States do rely on road surface improvements as a primary noise solution measure, perhaps because noise reduction can easily be integrated into regular road maintenance works. To substantially increase the implementation level of quieter road surfaces, more information and standardisation is required, while constantly improving noise performance and retaining and improving durability. Specifically, for roads with lower speeds (up to 50 km/h), this should lead to broader application, especially if the cost effectiveness is improved. Some new developments in this field already show potential in this respect. In some cases, results are easily achieved simply by better maintenance of standard road surfaces, or even by replacing noisier surfaces such as bricks or cobbles, with quieter ones. Two approaches are recommended: ,

- **Monitoring of road surface quality** at noise sensitive locations where road/tyre noise is the main source, as a basis for action. Such monitoring is already carried out by some authorities but could be applied more widely. In particular, a recent project in Belgium[346] demonstrated the large potential of occasional monitoring of the network; and
- Introduction of a **road surface labelling** system, in analogy with tyre labelling, as proposed in the Netherlands[347] for example.

Both of these interventions could be considered to include in the Road Surface Quality Directive.

In addition, this policy option should rely on **exchange of knowledge, prediction and performance data, cross-border collaboration, EU innovation projects and funding at EU, national and local level**.

Stakeholders, in particular the automotive and tyre industry, have emphasised the large potential of road surface improvement, which has been shown in past and ongoing projects to be effective in terms of noise reduction. A total range of 13dB is mentioned[348], including the extremes of surface quality. The main obstacles for increasing the amount of quieter road surfaces are inevitably the cost and durability, especially in specific conditions such as seasonally very cold (alpine or Northern) or very warm (Southern) regions.

Table 8.8 Overview of impacts of more quiet road surfaces

Definition	Increased application of quiet road surfaces
Solutions triggered	Quiet traffic/lower rolling noise
Legislation concerned, new/amended	Road Surface Quality Directive, amendment
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans
Technical and administrative steps required	Impact assessment study for amending the Road Surface Quality Directive.

[345] Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0096

[346] Mobisense project,, https://pub.dega-akustik.de/ICA2019/data/articles/000696.pdf

[347] https://unece.org/fileadmin/DAM/trans/doc/2017/wp29grb/GRB-65-22e-Add.1.pdf

[348] Cerema Study

Negative trade-offs	More wear and maintenance
Expected health burden reduction	0.5-1% (for assumed increase in implementation). Higher if combined with lower tyre limits.
Estimated benefit to cost ratio	0.08-0.23, Higher if combined with lower tyre limits.
Likelihood of implementation by competent authorities	High, as already in many action plans and at source
Obstacles	Member State coordination due to the fragmented approaches may pose a challenge
Timeline	Depending on the analysis and review of the directive implementation, it could take around five years

8.3.2 B – Quieter tyres via rolling sound limits

Sound emission limits for new tyres are set by UNECE Regulation 117[349] and referred to by EU Regulation 2019/2144. Tyre labelling including the noise level, wet grip and rolling resistance is regulated in 1222/2009/EU, which will be replaced by Regulation (EU) 2020/740[350] in May 2021. This requires manufacturers, vendors and distributers to provide the tyre performance data at the point of sale via the tyre label. It also encourages improvements that go beyond the minimum standards and the use of a database for evaluation.

The **rolling sound emission limits** for new tyres in UN Regulation 117r4 are specified in two stages, 2012 and 2016. These limits should be periodically **reviewed** for further reduction potential, given the impact of tyre-road noise. Keeping in line with the fast pace of vehicle innovations, tyre rolling noise emission limits could be reviewed **every three years** to assess potential reductions, following technical progress and market information. Furthermore, **consumer awareness raising campaigns and financial incentives** could help to speed up the uptake of quieter tyres, as a complementary measure.

Only one campaign, a Dutch initiative to 'Choose the best tyre'[351], was identified in this study. Despite the availability of quieter tyres and the label information on supplier websites, it does not seem to have yet had significant impact on the average noise label. This could be due to consumer focus on price and other characteristics. Further analysis of tyre sales databases should provide further insight into the reduction potential.

Label data is available on tyre websites[352], showing that quieter tyres are available.

The tyre industry is concerned that tighter limits will conflict with other requirements such as safety, but a recent ACEA study[353] on tyre parameters in relation to noise did not clearly support this concern. It may be the case that high performance tyres cannot fulfil all the requirements, but given the available label data, it would seem that a reasonable number of models could do so, especially

[349] Regulation No 117 of the Economic Commission for Europe of the United Nations (UNECE) — Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and/or to adhesion on wet surfaces and/or to rolling resistance [2016/1350] https://op.europa.eu/en/publication-detail/-/publication/48d3ed27-604f-11e6-9b08-01aa75ed71a1

[350] Regulation (EU) 2020/740 of the European Parliament and of the Council of 25 May 2020 on the labelling of tyres with respect to fuel efficiency and other parameters, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2020.177.01.0001.01.ENG&toc=OJ:L:2020:177:TOC

[351] www.kiesdebesteband.nl

[352] https://www.bfe.admin.ch/bfe/de/home/effizienz/mobilitaet/reifen/reifenliste.html

[353] ACEA (2019) Tyre Performance Study https://unece.org/fileadmin/DAM/trans/doc/2019/wp29grb/GRBP-70-25.pdf

for the most numerous vehicle models. Sales websites show that tyres already 2-3dB below the stage 2 limits are available.

As far as there may be a conflict with wet surface performance as stated in the ETRTO study[354], it would be relevant to examine to what extent this can be generalised, and whether specific tyre groups (application type, load/max speed for example) are more prone to this effect, given that tyres with the best noise label are on the road.

Another issue is the degree to which label data and test results are representative, and how well label level relates to in-use noise levels, at different stages of wear, and on different road surfaces. These are partly open questions, but given the potentially large impact of quieter tyres, it is worth investigating to achieve full impact.

In particular, **current tyre test procedures should be extended** to evaluate a range of road surfaces and their tyre noise emissions. This would also help distinguish tyre surface parameters (e.g. profile, void space) from tyre body parameters (e.g. stiffness, vibration and radiation response), that both affect noise emission.

Based on currently available data in tyre databases (Dutch VACO database and Swiss Database), reductions of 2dB from 2022 and 2dB in 2026 seem to be feasible. From the viewpoint of impact, the most numerous tyre groups and those with the largest mileage would be most beneficial for tighter limits.

Considering the variety of tyres, such as winter tyres, HGV traction, trailer tyres and reprofiled tyres, some further investigation is required to quantify the full noise reduction potential. But in general winter tyres and reprofiled tyres do not dominate the mileage and use over time at EU level.

Obstacles to tighter noise limits for tyres will be the resolution of design conflicts where they occur.

Table 8.9 Overview of the impact of noise limits on quieter tyres

Definition	Further reduction of tyre noise limits
Solutions triggered	Quieter tyres and vehicles
Legislation concerned, new/amended	2019/2144/EU, UN R117r4, 2020/740/EU
Causal links to national or EU legislation	National reception limits, noise emission ceilings
Technical and administrative steps required	Review of tyre databases, verification, new limits for tyres in two steps of 2dB
Negative trade-offs	Other tyre performance aspects, however quieter tyres are already available
Expected health burden reduction	13-18%
Estimated benefit to cost ratio	5-30
Stakeholder inputs	Concerns on limitations of other parameters such as wet grip and curve aquaplaning
Likelihood of implementation by competent authorities	High, as further solutions are urgently needed
Obstacles	Buy-in from tyre manufacturers and ensuring that the various designs all meet the new limits
Timeline	Some aspects such as consumer awareness campaigns can be realised within one to two years; review of tyre noise limits can be done within a year;

[354] https://unece.org/sites/default/files/2021-01/GRBP-73-11e.pdf

	new test procedures could take up to three to four years.

8.3.3 C - Lower vehicle sound limits

Road traffic noise can be lowered by reducing the contribution from powertrains and tyres. This is even more effective on quiet road surfaces.

While traffic-related measures appear among to be the most frequently used noise solutions found in the action plans, vehicle emissions were mentioned only sporadically, probably because this issue is **regulated at international level**, and in-use noise levels can differ from the type test levels.

Sound emission limits for new vehicles are governed by the Regulation on **the sound level of motor vehicles**, 540/2014/EU (and UNECE R51), which sets limits for all passenger and freight vehicles (M and N categories). These limits are for specific conditions and do not guarantee low sound levels for the whole range of driving conditions. Sound limits for motorcycles, trikes, quads, minicars and mopeds (L-category vehicles) are regulated via Directive 168/2013/EU and UNECE R41. Although these are less relevant for year-averaged Lden levels, they are important for peak noise levels, especially for the larger motorcycles, which have not substantially changed their limits for many years and remain a major source of complaints. Although motorcycles are not included in the scenario analysis, it should be mentioned that for regions where they are common, they may have a higher health impact than assumed, if higher dose-effect relationships were to be considered such as recently published for Austria[355], where 30dB difference was found compared to current relationships for road traffic.

In a parallel study[356], several scenarios are proposed for limit reduction, taking into account the limit changes already foreseen in 540/2014/EU, but adding to these wherever there is scope to do so. In addition, sound limits need to consider the whole operational range of the vehicle (ASEP), and tyre noise contribution, which is included in the measured vehicle sound level in the type test.

Some stakeholders in the automotive industry oppose further tightening of vehicle sound limits stating that the asymptotes for vehicle limits will be reached, or that in urban areas, most complaints are in relation to excessive noise such as motorcycles, horns and others.

Reduced vehicle sound limits should focus on:

- Available space for new limits derived from type test databases;
- Available technical potential for further reduction;
- Potential of electric and hybrid vehicles; and
- Potential of the reduced tyre contribution, especially in combination with road surfaces.

Obstacles to further reducing vehicle limits include the broader acceptance of industry given the variety of vehicle types. A detailed proposal for adjusted vehicle sound limits will be set out in the upcoming study report mentioned above. Any new or modified limits are suggested to be applicable from beyond 2026 (current 'phase 3'). A further reduction of 1-2dB is expected to be feasible after 2026, depending on the vehicle type. The powertrain noise, in particular, needs to be limited further, specifically via the LWOT quantity (acceleration) or the ASEP[357] provisions (multiple engine conditions).

[355] C. Lechner, D. Schnaiter, U. Siebert, S. Böse-O'Reilly: Effects of Motorcycle Noise on Annoyance—A Cross-Sectional Study in the Alps, International Journal ofEnvironmental Research and Public Health, 2020, 17, 1580

[356] Study on sound limits for M and N-category vehicles, 2020-21 for DG GROW (ongoing)

[357] Additional Sound Emission Provisions in UNECE R51 and R41, covering wider vehicle operating conditions

Table 8.10 Overview of the impact of lower vehicle noise limits

Definition	Further targeted reduction of specific vehicle noise limits including all operating conditions
Solutions triggered	Quieter vehicles
Legislation concerned, new/amended	540/2014/EU, 168/2013/EU, UNECE R51.03, UNECE R41.04
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans
Technical and administrative steps required	Verification of feasibility (e.g. parallel study). Extension of measurement conditions to full range including enforcement.
Negative trade-offs	N.A.
Expected health burden reduction	2-3%, Higher on quiet road surfaces
Estimated benefit to cost ratio	1-7, Higher on quiet road surfaces
Stakeholder inputs	Potential asymptote for cars
Likelihood of implementation by competent authorities	High, if in legislation, but potential gaps in operating conditions need to be addressed to avoid loud new vehicles. Also tampering and vehicle tuning need to be addressed via enforcement.
Obstacles	Ensuring buy-in from vehicle manufacturers
Time limit	The foreseeable time until implementation would be around five to six years.

8.3.4 D - Increased electrification of road vehicles

Electric and hybrid vehicles are gradually increasing their numbers for private and public transport. Despite relevant research papers highlighting the potential of quieter vehicles and the **EU's 2016 Reference Scenario forecasting a 25% stake** for plug-in hybrid and hybrid cars by 2030, the NAPs reviewed only sporadically mention the use of electric and hybrid vehicles. One of the reasons may be that without solutions to reduce tyre noise, electric vehicles may bring marginal reductions, specifically at speeds above 30 km/hour[358]. In addition, not all hybrid vehicles are quiet, when the IC engine is running. For larger vehicles such as busses, lorries, trucks and vans, electric powertrains have a pronounced advantage especially in urban areas.

The powertrain noise of electric vehicles is reduced at lower speeds and on road sections with intermittent traffic, but tyre noise is broadly the same or higher than ICE powered vehicles, as their tyres tend to bear more weight and undergo stronger torque. If electrification is already assumed in

[358] Rasmus Stahlfest Holck Skov og Lykke Møller Iversen, Danish Road Directorate (2015) COMPETT project report, https://www.vejdirektoratet.dk/api/drupal/sites/default/files/publications/noise_from_electric_vehicles_0.pdf

the baseline then little change is to be expected in the health burden without a substantial increase relative to that.

The current share of hybrid and e-vehicles in the total fleet is around 0.8% hybrid and 0.2% electric cars (2018 data). According to the EU reference scenario (see Section 5.10) these figures will increase to 6% hybrid and 14% electric cars in 2030. Without further policy measures and incentives facilitating the uptake of these low emission (noise and fuel) vehicles, the main driving force increasing their share would be the **economic and environmental consideration of the consumers.** Soft policy instruments such as **guidance and communication** coupled with industry initiatives creating a minimum share of manufacturing capacity dedicated to electric and hybrid vehicles could help further decrease noise pollution. Hard policy measures could result in a stronger push towards electric vehicles which could be implemented via **changes to Regulation 540/2014/EU on the sound level of motor vehicles and Regulation 2016/646 on emissions.** Integrating **green procurement** within the Public Procurement Directive could also help drive uptake of electric vehicles, especially in the public transport sector. As the forecasts on autonomous developments are always uncertain, noise emission limits would be an additional way to promote electric vehicles.

The Green Deal can also come into play here, given the ambition of a climate-neutral economy by 2050. In addition, some countries plan to ban the sale of ICE powered cars from 2030.

The full potential of electric vehicles is expected to be a reduction of around 10 dB in terms of powertrain noise, although this is currently limited by automatic warning noise for lower speeds.

According to the interviewed stakeholders, the key obstacles for electrification are the action range and pricing of vehicles. However, the uptake of electric buses is strong due to their fixed routes that permit easy recharging. Some countries are moving faster than others, such as Norway, where policy measures are driving a higher uptake of electric cars.

Table 8.11 Overview of the impact of increased electrification of road vehicles

Definition	Increased electrification of road vehicles
Solutions triggered	Quieter vehicles with lower powertrain noise
Legislation concerned, new/amended	540/2014/EU amendment, 2016/646 on emissions, and Green Deal
Causal links to national or EU legislation	National reception limits, noise emission ceilings
Technical and administrative steps required	Specific noise limits for electric and hybrid vehicles, financial and infrastructure incentives including charging infrastructure and action range increase.
Negative trade-offs	Tyre noise may increase, unless e-vehicles become lighter.
Expected health burden reduction	1-2% (relative to baseline already including some electrification)
Estimated benefit-to-cost ratio	1-5
Likelihood of implementation by competent authorities	High, given pressure from climate change
Obstacles	Price and action range
Timeline	Some elements such as increased awareness raising and allocating financial subsidies to support e-vehicle purchases can be enacted within a few years.

	Others that require legislative changes have a timeframe of four to five years

8.3.5 Scenario FGHI - More local measures including speed and access restrictions, quiet facades and insulation

Scenario FGHI includes speed restrictions, car-free (or limited access) zones, quiet facades, and dwelling insulation, which are all measures coordinated at the local level and potentially elements in action plans. As outlined in chapter 6, all these measures contribute to noise reduction, even if the first two are often applied for other reasons than for noise.

Also, as discussed in Chapter 4, these measures are often included in urban planning tools, which are not always directly linked to noise management. Nevertheless, they can have a potentially significant impact on noise levels. Their combined potential impact at EU level is significant, especially at locations with high noise exposure levels. Whereas quiet facades and dwelling insulation work specifically at the reception point, speed restrictions and car-free zones have a wider effect. The BCR is low due to the costs of such measures, but it can be higher if other benefits, such as quality of life and energy efficiency, are included.

Barriers could also be included here. However, they are less suitable for the majority of urban roads other than motorways and are less cost-effective.

Speed restrictions require local regulation – for example, 30 km/h limits applied to whole urban areas, such as that imposed in Brussels, are becoming more common. Despite some consequences for traffic flow and routing, as well as noise reduction, restrictions have major benefits for road safety, health, quality of life and reduction of emissions. Several stakeholders mentioned the potential of speed reduction as a promising measure in urban areas, with the strong benefit of improved safety. The costs of speed restrictions, as calculated by travel time loss, are high, resulting in a low BCR. But if the other benefits were to be included, the BCR would be much higher.

Car-free zones and other access restrictions are also on the increase in urban areas, having a similar effect to speed restrictions but with a larger impact on traffic and public access. These therefore require planning, consultation and impact assessment at the local level. A special case of access restriction is at night, for example for heavy vehicles.

Quiet facades and dwelling insulation are a last resort for highly exposed dwellings, as there are many such constructions along busy urban roads. However, they are relatively effective in terms of health burden reduction, with dwelling insulation more cost effective. In particular, they play a key role in increasing urbanisation at close proximity to main roads, having synergies with energy saving.

Finally, another initiative with a local dimension that should be considered is the use of **quiet areas** – for instance, the aforementioned greenbelt of Vitoria-Gasteiz and the urban oasis of Bilbao in Spain.

From the EU perspective, best practice guidance including suggestions for inclusive and effective public consultations is the most relevant intervention, not requiring specific legislation. Financial support towards the related costs of measures for agglomerations is also a means to stimulate this action.

Identified obstacles to these local measures include cost, planning and consensus ,traffic management and access issues.

Table 8.12 Overview of impacts from increased local measures relating to FGHI scenario

Definition	Local measures under the FGHI scenario including speed restriction, car-free zones, quiet facades and dwelling insulation.
Solutions triggered	At local level, quieter traffic due to speed and access restrictions, and better insulation.
Legislation concerned, new/amended	Related to the END, action plan guidance.
Causal links to national or EU legislation	National Reception limits, Noise emission ceilings, national requirements for urban planning at the local level including national guidance, national environmental strategies.
Technical and administrative steps required	Local planning and implementation.
Negative trade-offs	Traffic flow, reduced access.
Expected health burden reduction	16-20%
Estimated benefit to cost ratio	0.04-0.2 Due local effect and high cost.
Likelihood of implementation by competent authorities	High, except on roads where main traffic flow is impeded.
Obstacles	Political opposition due to push back from businesses and service providers that use the inner-city roads for commercial purposes.
Timeline	These measures can be enacted relatively quickly within one to two years

8.3.6 Noise barriers

Although noise barriers are not a very cost-effective scenario compared to other solutions at EU level, they are still applied and are therefore mentioned here.

Noise barriers are mainly built along motorways and arterial roads with sufficient numbers of adjacent dwellings. Their design and application depend on the specific geographic and socio-economic characteristics of the given area, including population size and density, building layout, and traffic parameters. For example, both the country size and ground price can be a limiting factor, which was mentioned as an issue in Luxembourg. In the context of this study, additional noise barriers (e.g. doubling the length in the EU) do not produce a large health benefit at EU level due to the limited overall length of motorways compared to other road types.

The results presented in Chapter 7 indicate that the cost-effectiveness of noise barriers is rather low, partly due to the high costs, but also because they are not feasible in many urban situations. Therefore, **noise barriers are not a preferred option for reducing road traffic noise, unless they are integrated in landscape or buildings.** In general, source measures are preferable (as is the case for all transport modes). However, due to high noise source levels for motorways and lack of alternatives, noise barriers will remain relevant for these situations for the foreseeable future.

Noise barriers for roads are applied as roadside walls, between carriageways, as embankments, and using buildings as barriers. While the locations where noise barriers could be deployed are derived from noise mapping, selection and implementation are the responsibility of national and local authorities. Here, **information exchange** particularly among regional and local stakeholders of cross-border areas as well as joint innovation initiatives involving public and private entities could effectively improve results by providing information on good practices, lessons learnt as well as a comparison of costs and benefits delivered.

Table 8.13 Overview of impacts of noise barriers

Definition	Noise barriers
Solutions triggered	Various types of noise barrier including embankments and buildings
Legislation concerned, new/amended	Related to END and national reception limits
Causal links to national or EU legislation	National reception limits, noise emission ceilings
Technical and administrative steps required	Local planning and implementation
Negative trade-offs	No impact at source on noise emission
Expected health burden reduction	0.9-1.6%
Estimated benefit-to-cost ratio	0.01-0.03 cost-effectiveness is low due to high costs and limited feasibility in urban areas
Likelihood of implementation by competent authorities	High, mainly along motorways and arterial roads with space available
Obstacles	Visual obstruction and cost
Timeline	Noise barriers are implemented locally in the absence of alternative measures

8.4 Railway noise

Based on the scenarios analysed, findings from the NAP analysis and stakeholder inputs described in the previous chapters, several combined scenarios are recommended, which are set out here in terms of the required policy options.

Reduction of railway noise as in the baseline is best achievable by reducing wheel/rail rolling noise, which is the most dominant source for the current major lines and in agglomerations. This can be done by management of wheel and rail roughness and quiet design of wheels and tracks including noise control devices. Traction noise and aerodynamic noise are also important, but less so in terms of overall impact and exposed population at EU level. Where traction noise is an issue, sometimes quieter rolling stock can be a solution, for example switching from diesel to electric traction, such as demonstrated in Grenoble Metropole.

Although relatively costly, barriers are a next best solution as they can be positioned near the source and are somewhat easier to apply in an urban environment than for roads. They can also function as a perimeter wall and options such as low barriers or barriers between tracks are more feasible.

Traffic management is also an option either by rerouting or adjusting timetables, if this space is available.

Urban reconstruction including tunnelling, screening by buildings and integrated noise abatement, combined with increased facade and building insulation, also have large potential at local level, especially when included in future projects. There are many examples of new or reconstructed city railway lines underground, but these tend to be long-term projects whose impact, while lasting, is mainly local.

Based on their type (source/path/receiver), legislation and responsible authorities, the following combined scenarios presented in Chapter 7 are recommended:

- **AB, smoother wheels and smoother rails**
  Health burden reduction in 2030: **30-42%**
  Benefit to cost ratio over 2020-2035: **2-9**
- **CD, quieter vehicles and quieter tracks**
  Health burden reduction in 2030: **7-15%**
  Benefit to cost ratio over 2020-2035: **0.24-1.3**
- **ABCD, smoother and quieter vehicles and tracks**
  Health burden reduction in 2030: **37-52%**
  Benefit to cost ratio over 2020-2035: **0.9-3.1**
- **EF, more barriers and traffic management**
  Health burden reduction in 2030: **5-10%**
  Benefit to cost ratio over 2020-2035: **0.9-4.5**
- **GH, urban planning and reconstruction, and more facade insulation.**
  Health burden reduction in 2030: **7.8%**
  Benefit to cost ratio over 2020-2035: **0.2-0.4**

In the policy options below the combined scenarios are split into their components where separate legislation or implementation aspects are addressed.

Scenario ABCD would seem to offer by far the best potential for health burden reduction, which should be **augmented by scenario EF and/or GH**, which are relevant for control at local level.

Within rail infrastructure interventions, rail and wheel surface conditions and their maintenance are key considerations for managing noise emission. Railway lines are often part of strategic national infrastructure and their maintenance is overseen by Member State authorities. Relevant legislative elements pertaining to noise emissions of railways include Directive 2012/34[359] on the Single European Railway Area and its implementing Regulation 2015/429[360]. A review of this implementing Regulation could help identify whether further changes to the current noise charging scheme would be required in order to deliver better results in Member States. Furthermore, an **analysis of the relevant financing schemes,** including the Connecting Europe Facility, Structural and Cohesion Funds, could help identify the **efficacy** of the current support mechanisms.

The specific policy recommendations for railway noise are set out in sections 8.4.1-8.4.6 and are visualised in Figure 8.5, showing the existing EU legislation (blue) national/local legislation (green/yellow) and potential improvements at EU level (red). The arrows show the correlation between current legislation, noise levels in Member States and recommended new actions. Current baseline policies and recommended actions are aligned with the inputs, actions and outputs of the revised intervention logic as presented in chapter 4.

[359] Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02012L0034-20190101

[360] Commission Implementing Regulation (EU) 2015/429 of 13 March 2015 setting out the modalities to be followed for the application of the charging for the cost of noise effects https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R0429

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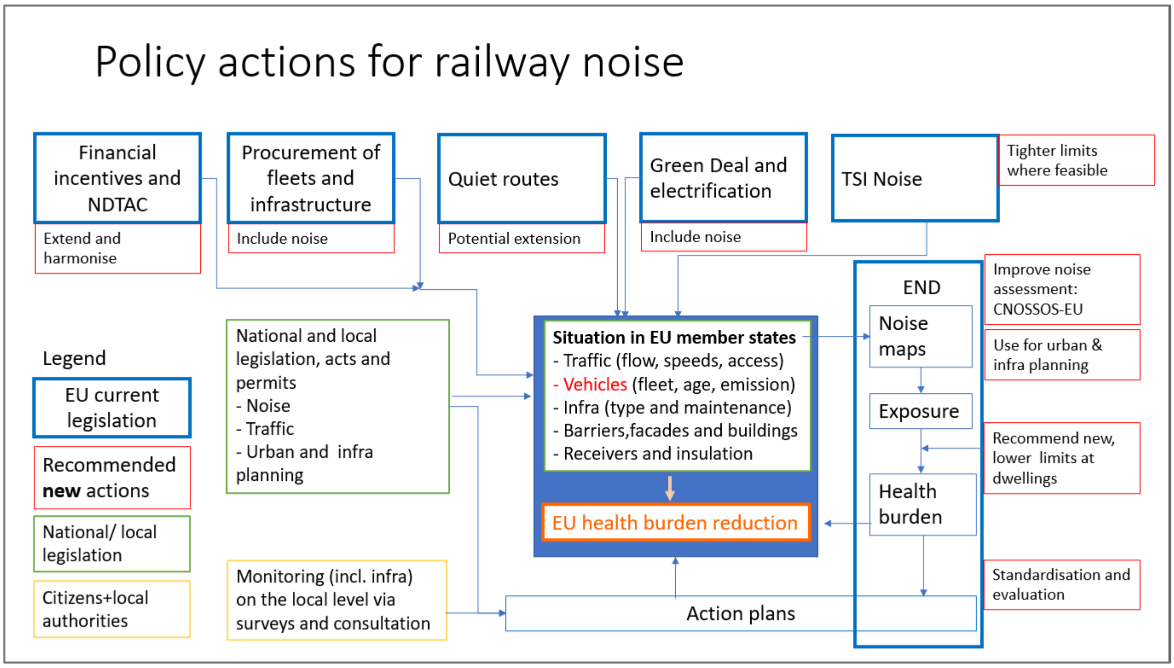
Figure 8.5 EU and national legislation for rail traffic noise and potential improvements at EU level (marked red)



8.4.1 A- Rail roughness management

During the past 10 years, more network monitoring of rail roughness has been undertaken, resulting in a better picture of track sections with higher roughness. This allows targeted maintenance in noise-sensitive areas, restoring the low noise levels similar to the TSI for trains with well-maintained wheels. It has been demonstrated in several countries that preventive milling can not only keep the noise levels low but also extend the life of the rails, which otherwise may be shortened by normal grinding. In terms of legislation, additional requirements could be set to ensure that network maintenance results in sufficiently smooth rails.

According to stakeholders, rail roughness management is already applied on some lines, including to maintain low noise levels as in Denmark and Germany for example. Cost savings on normal track maintenance are expected if preventive milling is applied. Monitoring methods are available but not yet standardised.

For older tracks, in some situations, **upgrading** to newer ones can already produce benefits due to the elimination of impact noise by using welded rail.

Table 8.14 Overview of the impact of rail roughness management

Definition	Include infrastructure quality maintenance in legislation, in relation to noise emission
Solutions triggered	Quieter tracks with reduced rolling noise, by smoother rail and reduced rail impacts.

Legislation concerned, new/amended	TSI or national legislation
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Increase infrastructure monitoring to identify higher roughness locations and target maintenance.
Negative trade-offs	n.a.
Expected health burden reduction	17-27%
Estimated benefit-to-cost ratio	3-12
Likelihood of implementation by competent authorities	High, if cost savings are more widely demonstrated.
Obstacles	Fragmented approaches in Member States
Timeline	Depending on the legislative tool selected (e.g. guidance or policy revision) for harmonising rail roughness management in Member States, the timeline for implementation can range from two to five years.

8.4.2 B- Wheel roughness reduction

The reduction of wheel roughness of rolling stock depends on the type of braking system, but also on wheel maintenance including reduction of wheel flats. At the Member State level, as identified by the 2018 impact assessment[361] of the TSI, the share of silent wagons and braking systems varies considerably between Member States, and consequently, the mitigation actions of the countries are also in stark contrast. According to a report, Germany and Switzerland planned to **restrict operation of noisy wagons** from 2020. While restrictive measures can provide a timely response to noise pollution, exchange of information among Member States can be useful to **avoid obstacles to free movement of goods**. Further **coordinated roll-out** of such operating restrictions could be organised through a European platform of competent authorities.

Further support to **innovative approaches** for silent brake technology, quieter wheels and vehicles could be delivered through EU research financing such as Horizon Europe or the Connecting Europe Facility.

Various legislative instruments to reduce the number of cast-iron block-braked wagons are already in place. But the quality of the wheel surface also depends on wear and tear and maintenance. Additional provisions to minimise wheel flats would yield additional benefits, either by specifying on-board monitoring systems or maintenance procedures. This could be part of the TSI or separate guidelines.

Table 8.15 Overview of wheel roughness reduction

Definition	Finalise retrofitting and better maintain wheel surface quality
Solutions triggered	Quieter rolling stock

[361] European Union Agency for Railways, 2018 Revision of the Noise TSI - Application of NOI TSI requirements to existing freight wagons https://www.era.europa.eu/sites/default/files/library/docs/recommendation/006rec1072_full_impact_assessment_en.pdf

Legislation concerned, new/amended	TSI or national legislation
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans
Technical and administrative steps required	Monitoring of rolling stock at trackside or and/or in workshop. Criteria and regulation to implement this, both for wheel roughness, flats and other defects.
Negative trade-offs	Costs of monitoring and maintenance, but wear of track should be reduced.
Expected health burden reduction	27-39%
Estimated benefit to cost ratio	4-15
Stakeholder inputs	Fleet retrofitting is already well advanced, but still needs completing.
Likelihood of implementation by competent authorities	High, as it is consistent with other maintenance criteria and benefits both environment and track wear.
Obstacles	Fragmented approaches in Member States.
Timeline	Aspects such as closer coordination between Member State authorities and increased EU financing of relevant innovative approaches can be realised within one to two years

8.4.3 C- Quieter vehicles

Current modern rolling stock, in particular EMUs, often have quieter (well damped or smaller) wheels resulting in noise levels well below TSI limits. Even on rougher tracks, such vehicles produce less noise than the previous generations. **This trend could be reflected in future TSI noise limits.**

For freight wagons, further progress beyond the retrofit principle is feasible. Depending on the pattern of usage, freight wagons can be more prone to wheel flats, or run for longer before requiring maintenance. They will also tend to produce higher noise levels on tracks with rough rails. **Design improvements** on wheels, bogies, suspension and superstructure should lead to further reductions in future both for new wagons and potentially also for existing ones. The high axle density, different bogie design and wagon structure compared to passenger trains are areas that could be improved, which also could be encouraged through the TSI or other instruments.

Although traction noise and aerodynamic noise contribute less to the health burden at EU level than rolling noise, they should still be included in terms of lower noise limits for rail vehicles, as this can be effective in the situations concerned. The technology is often available, but not always sufficiently implemented or included in specifications.

Table 8.16 Overview of the impact of quieter train vehicles

Definition	Lower vehicle noise limits where possible to reflect technical progress. Mainly to reduce rolling noise but also traction and aerodynamic noise.
Solutions triggered	Quieter rolling stock including all noise sources
Legislation concerned, new/amended	TSI amendment

Causal links to national or EU legislation	National reception limits, noise emission ceiings
Technical and administrative steps required	Review and impact assessment on TSI noise limits; targeted allocation of EU financing for design improvements.
Negative trade-offs	Cost, but benefits can be higher in the long term.
Expected health burden reduction	1.7-4.1%
Estimated benefit to cost ratio	0.3-1.5
Stakeholder inputs	Fleet retrofitting is already well advanced, but still needs completing.
Likelihood of implementation by competent authorities	High, if in EU legislation
Obstacles	In some cases design constraints.
Timeline	Increased targeted financing could be established within a short timeframe within one to three years, a review and implementation of revised TSI limits could take five years

8.4.4 D - Quieter tracks

In addition to rail roughness, solutions for the reduction of noise emission from the track are available and still being improved.

The most cost effective are **optimised railpads** for tracks with soft pads, followed by **rail dampers** and **rail web shielding**. Assessments of their effectiveness at a given location must be make prior to implementation, but all have the greatest benefits where rolling noise is the strongest source and quieter wheels are present. Here, **standardisation of measurement data** and **methods** still have a role to play, and in terms of the END, input data for calculation models and guidelines for application. In some situations, **upgrading** can reduce noise levels by replacing wooden sleepers by concrete sleepers.

New or existing unballasted tracks (high speed or urban slab tracks) tend to produce more noise due to lack of absorption and soft railpads. Apart from the abovementioned solutions, **absorption plates** can provide additional reduction in this case. All the above solutions should be better disseminated with **guidelines on applications** so they can be included in action plans. Their effectiveness should also be reflected in the **END calculation model**.

Table 8.17 Overview of impacts of quieter tracks

Definition	Guidelines for new and retrofit tracks including noise control devices.
Solutions triggered	Quieter tracks, reducing rolling noise.
Legislation concerned, new/amended	TSI amendment and guidance document for action plans.
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.

Technical and administrative steps required	Quantified impact of track noise control solutions in prediction models.
Negative trade-offs	Potential maintainability or durability
Expected health burden reduction	5-12%
Estimated benefit to cost ratio	0.22-1.3
Stakeholder inputs	Demonstration and further research projects are ongoing for quieter railpads and other track noise solutions.
Likelihood of implementation by competent authorities	High, if solutions are cost effective, and included in action plan guidelines.
Obstacles	Investment cost
Timeline	Guidelines on applications and standardisation of measurement data can be done on a shorter time scale within one to three years, whereas amendments to the TSI are expected to take up to five years.

8.4.5 EF - Barriers and traffic management

These two measures are implemented at the **local level** and can have an immediate effect in the short term, while also being under the authority of railway companies or infrastructure managers. Barrier implementation can also be dependent on national or municipal authorities, for example for planning and funding. Traffic management is not always possible for noise only, but it can have a major effect, for example, if freight trains at night are routed through tunnels or less sensitive areas.

Low noise barriers close to railway tracks have been shown to be effective, although safety issues need to be further addressed. Low close barriers are more cost effective than normal barriers in some situations, due to lower cost, higher effect and no visual obstruction.

Barriers are mainly built or upgraded on existing routes where traffic and/or speeds are increased, and on new lines that must fulfil new requirements. They are a common element in many action plans and new infrastructure plans, and they are also relevant where traction noise and aerodynamic noise determine the noise levels.

The need for noise barriers can be reduced if all the noise sources can be abated at source.

Table 8.18 Overview of impacts for barriers and traffic management

Definition	Further application of barriers including new types, and traffic management
Solutions triggered	Barriers and rerouting/scheduling
Legislation concerned, new/amended	National or local legislation amendment to include close low barriers. Action plan guidelines on new barrier types. EU Quiet Routes is an example of traffic management for noise abatement.
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans

Technical and administrative steps required	Already available. Low/close barriers required further allowances.
Negative trade-offs	Visual obstruction for barriers, operational constraints for traffic management.
Expected health burden reduction	5-10%
Estimated benefit to cost ratio	0.9-4.5
Stakeholder inputs	The Railway sector is less keen on traffic management as a tool for noise control due to operational constraints.
Likelihood of implementation by competent authorities	Already applied, with immediate effect, although cost and operational aspects are restrictive.
Obstacles	Investment costs
Timeline	Implementation can be done within one to two years

8.4.6 GH - Urban planning and dwelling insulation

Urban and infrastructure planning can provide the best opportunity to design the environment in such a way that noise exposure is minimised. In combination with good building insulation, infrastructure and building layout can be designed in a complementary way.

This is a longer term solution due to the duration of such projects, especially when considered at EU level. But if noise is included in the criteria for sustainability, future overexposure to noise can be avoided. This has been seen in some of the insulation schemes presented in the NAPs, where insulation of dwellings is supported for both sound and energy considerations. Common examples include **tunnelling under urban centres and positioning non-residential buildings** along railway lines as barriers.

Here, the territorial limitations and land price can also be mentioned, especially in the case of Luxembourg, as regards noise barriers along the railway. Purchasing of land and relocation of dwellings are seen as a last resort but can happen due to lack of available land for implementing the noise measures. This illustrates the need to include land-use planning and urban planning in noise policy, as well as the need to also have more effective legislation at source. In this regard, the coordination between the two policy areas constitutes a key element. Coordinating noise policy and infrastructure planning may also yield added value, as revealed by the study.

Therefore, urban and land use planning can foster the implementation of noise abatement policies with tools such as infrastructure and building permits and guidelines. These instruments are mostly developed at the local level and are not only relevant for rail but for road and aviation as well.

Table 8.19 Overview of impacts for urban planning and dwelling insulation

Definition	Guidelines for noise in action plans and urban and infrastructure planning including building insulation
Solutions triggered	Better infra and building layout/insulation to minimise noise exposure.
Legislation concerned, new/amended	Related to END but local competence for new projects.

Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Local level implementation can be supported by sharing of good practices at the EU level and targeted financial support.
Negative trade-offs	Long term realisation
Expected health burden reduction	7.8%
Estimated benefit to cost ratio	0.2-0.4
Likelihood of implementation by competent authorities	High, if benefits are clear
Obstacles	Fragmented approaches across Member States.
Timeline	Five to ten years considering urban planning measures at the local level as well as infrastructural development /insulation

8.5 Policy options to reduce aircraft noise

Based on the scenarios described in chapter 7, the NAP analysis and stakeholder inputs, solutions to reduce aircraft noise are mainly related to air traffic management and aircraft innovation. Nevertheless, it should be considered that the management of different environmental policies, in the case of aircraft operations, must inevitably take into account interdependencies between environmental noise, CO_2 emissions/fuel consumption and NOx emissions (air quality). This includes recent policy developments such as the EU Green Deal, Sustainable and Smart Mobility Strategy, and Zero pollution action plan.

The main policy instrument currently for limiting aircraft noise is EU Regulation 598/2014[362] on the introduction of noise-related operating restrictions at Union airports, also called the Balanced Approach Regulation (BAR). The BAR sets the framework for the development of the NAPs for airports, covering all available noise reduction solutions. However, as already mentioned in section 8.2.1, the NAP analysis performed in this study highlighted that there is room for improvement in the way the BAR is applied and how noise solutions are selected. Stakeholder consultation should also be considered here. A review of the BAR is in process and could potentially end up in alignment with the policy options developed in this study.

The methods for calculating aircraft and helicopter noise are contained in the END, along with the noise and performance data of the aircraft. These methods are maintained by the AIRMOD working group of ECAC, and the inclusion of the latest validated methods in the END shall be safeguarded.

In order to avoid future noise issues at small, but fast-growing airports, often situated close to residential areas, changing the definition of airports to be included in the END from 50,000 down to 30,000 movements a year should be considered.

[362] Regulation (EU) No 598/2014 of the European Parliament and of the Council of 16 April 2014 on the establishment of rules and procedures with regards to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32014R0598

Traffic management

According to the noise action plans, air operational and traffic management initiatives are one of the key instruments for meeting noise thresholds in and around airports. Apart from the already mentioned interdependencies between noise and emissions, these solutions are also constrained by flight safety considerations.

The **current regulatory requirements** coupled with the airport outreach and communication initiatives seem to provide the necessary coverage to ensure compliance. Consideration could be given to incorporate noise emission constraints into the **EU Slot Regulation**. In its current form the Regulation does contain reference (Article 3) to environmental factors relating to airport capacity analysis which shall take into consideration environmental constraints. It may be useful to assess whether further references could be made to noise emission limits during specific times (early morning or late evening).

On the Member State level, environmental taxation is also a frequently cited instrument to facilitate compliance of airlines and aircraft operators. **Taxation** is a Member State competence and even though discussions on the introduction of a possible EU-level **green tax** are ongoing, it is not certain that it will happen by 2030. Despite the lack of EU-wide approach, Member States can work together to share good practices and coordinate approaches to improve harmonisation and avoid fragmentation of the internal market.

The BAR also describes the introduction of **operating restrictions** at airports. Operating restrictions may be partial (applicable to a certain period of the day and/or certain aircraft types) or full (complete ban on certain aircraft types). Although these restrictions may be highly effective from a health burden point of view, they usually come at a significant cost (loss of profit, loss of jobs, etc.) and therefore they are only to be considered a last resort solution, once it has been assessed that other solutions are economically and/or technically not viable.

Aircraft Innovation

Perhaps one of the most promising angles for reducing aviation noise is innovation. Research and innovation into low-noise aircraft have delivered significant results over the past three decades. Current research focuses not only on the reduction of jet engine noise but also on aerodynamic noise, caused by turbulence around airframe structures (airframe noise). However, implementation of new technologies in the operational fleet will take a long time. Therefore, continued research and innovation into noise-optimised flight procedures shall also be pursued, since its relatively easy implementation may provide benefits in the short term.

As the industry continues to develop, despite setbacks relating to the COVID-19 pandemic, further incentives could be provided via international research platforms under the umbrella of Horizon Europe. An important driver for continued innovation would be the further reduction of noise certification limits through ICAO.

Selected scenarios

From the results described in Chapter 7 the best single solution with respect to health burden reduction is the introduction of a **night curfew** at all airports – i.e. an EU-wide ban on night flights (scenario C). Although such a move leads to a large reduction in health burden, it would potentially put some carriers out of business.

Health burden reduction in 2030: **37-60%**
Benefit to cost ratio over 2020-2035: **0.1-0.2**

The selected combined scenarios presented in Chapter 7 are:

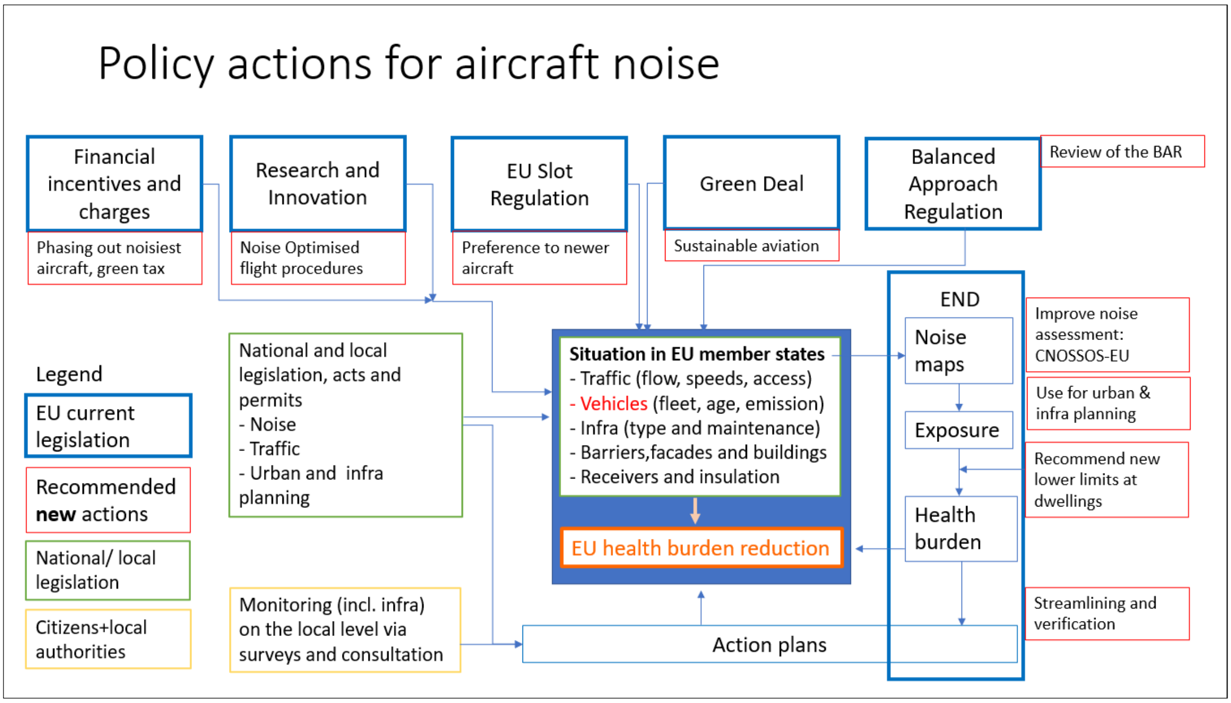
- **3D optimisation**: (AB) Improved take-off procedures and dispersion or concentration of flights
  Health burden reduction in 2030: **25-26%**
  Benefit to cost ratio over 2020-2035: **-2.4 to -1.8** (cost saving)
- **Quietest fleet** (EF) Phase out of noisiest aircraft and accelerated fleet replacement with quiet aircraft
  Health burden reduction in 2030: **26-28%**
  Benefit to cost ratio over 2020-2035: **-0.1** (cost saving)
- **Best possible on 'aircraft side'** (ABEF) Improved take-off procedures, dispersion or concentration of flights, phase out of noisiest aircraft and accelerated fleet replacement with quiet aircraft
  Health burden reduction in 2030: **44-46%**
  Benefit to cost ratio over 2020-2035: **-0.2 to -0.1** (cost saving)

The policy options for achieving these scenarios are described in the sections below.

Scenario ABEF would seem to offer by far the best potential for health burden reduction of 44-46%, which could be **augmented by scenario C** for selective night curfews.

The specific policy recommendations for aircraft noise are set out in sections 8.5.1-8.5.5 and are visualised in Figure 8.6, showing the existing EU legislation (blue) national/local legislation (green/yellow) and potential improvements at EU level (red). The arrows show the correlation between current legislation, noise levels in member states and recommended new actions. Current baseline policies and recommended actions are aligned with the inputs, actions and outputs of the revised intervention logic as presented in chapter 4.

Figure 8.6 EU and national legislation for aircraft noise and potential improvements at EU level (marked red).



8.5.1 C – Night curfew

An **EU-wide ban on night flights** is obviously the best solution to eliminate health burden related to sleep disturbance. However, the related **cost is likely to be very high**, since it will entail a loss of business (and hence jobs and profit), especially for cargo operators for which night operations are essential.

Shifting all night operations to the day/evening is probably not possible, due to capacity constraints during the day/evening period and/or due to the specific nature of night flights (cargo), significantly altering logistics. Another important factor to take into account is the impact of operations in the so-called **shoulder hours** (early morning or late evening). In these periods, when people are just going to sleep or are about to wake up, noise events may cause alterations in sleep patterns (delays in sleep or early awakenings).

Variants of this solution may consider a **ban during a shorter period of the night, taking into account sleep patterns**.

The BAR in principle allows for the introduction of this solution. However, since it is an operating restriction, it should be justified that no other solution (or combination of solutions) is available that can provide a similar health burden reduction at a lower cost. This will require a careful impact assessment, taking into account all involved stakeholders.

Table 8.20 Overview of the impact of night curfew

Definition	Night curfew
Solutions triggered	Operating restriction, banning night flights at EU airports
Legislation concerned, new/amended	BAR
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Careful Impact assessment (CBA)
Negative trade-offs	Potentially high economic and social impact due to loss of jobs and profit
Expected health burden reduction	37 to 60%
Estimated benefit to cost ratio	0.1 to 0.2
Stakeholder inputs	Communities around airports strongly in favour (as main beneficiaries).
Likelihood of implementation by competent authorities	Not very likely to be implemented for the full night period (8 hours). Some possibilities for a ban during shorter periods.
Obstacles	Airlines (especially air cargo) will strongly oppose the measure, due to the likely high economic impact.
Timeline	As the BAR is currently under review, adjusting specific aspects of the instrument related to night-time bans could be implemented within two to four years.

8.5.2 A - Improved take-off procedures

Noise optimised take-off procedures have been in use for more than a decade. Mainly two different procedures have been defined by ICAO: **NADP1 (close-in) and NADP2 (distant)**, aimed at noise reduction near the airport or further away, respectively.

Depending on the location of the most affected population one or the other procedure should be used. However, **often these procedures are not mandatory** at an airport, which may induce pilots to use the same procedure at all airports, even where not optimal from a noise point of view. Factors like **safety (same procedure flown all the time) and fuel consumption will play a big role** in this choice.

More recently **Continuous Climb Operations** are being implemented, which may provide benefits from both a noise and fuel/emissions point of view. It is estimated that currently around 30% of the departures are performed with this type of operation. With the advance of flight automation the safety aspect that currently prevents pilots from flying optimised procedures will become less and less of an issue. This would enable the **possibility to fly take-off procedures that are optimised for each individual airport**, and even taking into account acoustic propagation effects due to actual weather conditions.

Apart from the potential cost savings due to a reduction of fuel consumption, another main driver for implementing these procedures would be to make them mandatory at airports, with a control through the already widespread noise and track monitoring systems for example. This will require a collaborative action between the main stakeholders (airlines, NASPs, airports) at local level. At EU level, the BAR may be an appropriate instrument for imposing noise-optimised flight procedures as a high priority solution to be assessed as part of the NAPs.

Table 8.21 Overview of the impacts for improved take-off procedures

Definition	Improvement of take-off procedures to minimise noise exposure
Solutions triggered	Optimised combination of attenuation due to greater distance and lower noise due to lower power setting.
Legislation concerned, new/amended	BAR
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Safety assessment required
Negative trade-offs	Potentially higher noise at some locations
Expected health burden reduction	25-26%
Estimated benefit to cost ratio	-2.2 to -1.7
Likelihood of implementation by competent authorities	High, if benefits are clear.
Obstacles	Buy-in from airport management
Timeline	Implementation within three to five years

8.5.3 B – Flight dispersion or concentration

During this study it was found that seven of the 10 test airports have already implemented P-RNAV-based routing. It is less clear, also from the available NAPs, whether the current routes are optimised for noise.

It is beyond the scope of this study to redesign airspace, define new routes and assess the corresponding health burden reduction. Nevertheless, it can be inferred that by carefully (re-) designing the routes, it should be possible to avoid, or at least minimise, noise exposure in residential areas. It is recognised that this may result in higher fuel consumption and hence emissions. These trade-offs should therefore be carefully assessed.

The use of P-RNAV also enables the possibility to introduce respite periods, alternating between exposed communities.

As with noise optimised flight procedures, a main driver to implement these procedures would be to make them mandatory at airports, with a control through the already widespread noise and track monitoring systems. This will require a collaborative action between the main stakeholders (airlines, NASPs, airports) at local level. At EU level, the BAR may be an appropriate instrument for imposing noise-optimised routing as a high priority solution to be assessed as part of the NAPs.

Table 8.22 Overview of the impact of flight dispersion or concentration

Definition	Dispersing or concentrating flights in different paths to minimise noise exposure
Solutions triggered	Guide aircraft to follow noise optimised routes.
Legislation concerned, new/amended	BAR
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Widespread consultation with relevant stakeholders. May require a redesign of airspace. Safety assessment required
Negative trade-offs	May cause higher fuel consumption/emissions.
Expected health burden reduction	0.7%
Estimated benefit to cost ratio	-1.1 to -0.5
Likelihood of implementation by competent authorities	High, if benefits are clear.
Obstacles	Collaboration between main stakeholders
Timeline	Implementation within three to five years

8.5.4 E - Phasing out of noisiest aircraft

In this solution the gradual replacement of the noisiest aircraft types is addressed. An example is the ban of all Chapter 2 aircraft from operation in the EU as of 1 April 2002. Due to the international character of aviation, **such a forced phase out should be implemented on an EU-wide scale.** As in this example, the current solution would most likely also be **based on the certification noise levels** of the aircraft types. In this scenario a forced phase-out of **non-Chapter 4 compliant aircraft** has been assessed. Only around 3% of the current EU fleet falls in this class. A more ambitious, but voluntary, fleet renewal is covered by scenario F, described hereafter.

Considering that this solution constitutes an **operating restriction**, the appropriate instrument for implementation will be the BAR.

During the **COVID-19 crisis** many aircraft were grounded, especially the less fuel-efficient ones. Depending on how fast recovery occurs, it could be seen as an **opportunity to scrap these older/noisier aircraft.** Such a move may be **incentivised** by using some of the **EU Recovery Plan** funding, in which sustainability is one of the key elements.

Table 8.23 Overview of the impact of phasing out the noisiest aircraft

Definition	Phasing out noisiest aircraft
Solutions triggered	Quieter aircraft
Legislation concerned, new/amended	BAR
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Direct financial support for the phasing out of noisiest aircraft before the restart of post-pandemic economy; review of the BAR to accommodate forced phase out.
Negative trade-offs	Loss of flight slots and business especially for the air freight sector.
Expected health burden reduction	2.6-3.7%
Estimated benefit to cost ratio	2.7-5.2
Likelihood of implementation by competent authorities	Likely if it also delivers savings such as fuel.
Obstacles	N.A.
Timeline	Targeted financial support could be an immediate solution within a year.

8.5.5 F - Fleet replacement with quiet aircraft

This solution is similar to the previous one (E), with the main difference that its **voluntary and more ambitious**.

The solution simulated resembles a **replacement of the whole fleet,** such that in the period 2030-2035 **a fully Chapter 14 compliant fleet** is achieved. This accelerated fleet replacement appears to be a highly effective solution from an environmental point of view, since both noise and emissions are reduced. The required technology is already available as evidenced by the latest generation of aircraft such as A320neo, A350, B787 and 737MAX. These aircraft provide significant fuel savings compared to their predecessors. Potential overall cost savings will depend on the fuel price, a decisive factor in the direct operating cost of aircraft, which should more than compensate the increased cost of the assets.

As mentioned for E, the current situation due to the **COVID-19 crisis** may be considered an **opportunity** for fleet renewal beyond that which is considered the natural fleet replacement rate.

Promising instruments are economic incentives, maybe as part of the **EU Recovery Plan**, in combination with operational incentives such as **preferential slots for latest generation aircraft**.

An interesting variant would be to consider a **night curfew for non-Chapter 14 aircraft in 2025** as part of this overall accelerated fleet renewal, amending the BAR.

Table 8.24 Overview of the impacts for fleet replacement

Definition	Replacement of the existing fleet with quieter aircraft
Solutions triggered	Quieter aircraft
Legislation concerned, new/amended	BAR, EU Slot Regulation
Causal links to national or EU legislation	National reception limits, noise emission ceilings, END action plans.
Technical and administrative steps required	Stakeholder consultation, BAR review
Negative trade-offs	Partial write-off of investment
Expected health burden reduction	22-23%
Estimated benefit to cost ratio	-0.1
Likelihood of implementation by competent authorities	Likely if it also delivers savings such as fuel
Obstacles	Stakeholder buy-in
Timeline	10-15 years

9 Conclusions

The Phenomena study had two fundamental objectives:

- Define the potential of measures capable of delivering significant reductions (20%-50%) to health burden due to environmental noise from roads, railways and aircraft; and
- Assess how relevant noise-related legislation could enhance the implementation of measures, while considering the constraints and specificities of each transport mode.

The appraisal period for health benefit reduction was 10 years, which included a 1% foreseeable traffic growth in the baseline within the context of the current legislation. The increased implementation of noise abatement solutions and corresponding reduction in health burden were projected onto legislative solutions that could possibly be enacted before 2030.

Long-term noise exposure associated with health impacts is characterised by the yearly average quantities Lden and Lnight. Although noise events with limited duration, not contributing to the yearly average, are a major source of complaints and perceived high noise levels, they are not within the scope of the current EU legislation and this study, and must be addressed separately.

This study combined various qualitative and quantitative methodologies, examined individual and combined noise abatement measures implemented across EU Member States and included extensive stakeholder consultations. Overall, the study found that within the given timeframe the required 20% or more reduction in health burden would only be feasible by using **combined noise abatement solutions**, which are driven and supported by **revised and strengthened EU environmental policies**, including the END, source directives, the Green Deal as well as other legislative measures with a strong environmental impact. There is also a recognition that a revised EU policy framework is only as good as the **national implementation and enforcement** measures. Consequently, in order to harmonise the fragmented approaches currently seen in Member States and drive the dissemination of good practices, increased emphasis should be put on the **consultative participation** of those **national and local authorities** that identify, select and implement noise abatement measures.

The analysis supporting this conclusion consisted of the following methodologies:

- Literature review;
- Analysis of EU and national legislation;
- Analysis of 300 Noise Action plans;
- Bilateral stakeholder consultations and workshops;
- Development of the intervention logic;
- Methodology for health burden analysis and CBA;
- Analysis of a series of test sites;
- Assessment of available noise abatement solutions;
- Scenario analysis of best solutions and combinations; and
- Development of policy options.

EU and national legislation

The study began with an extensive literature review examining all relevant international, EU and Member State level legislation and research that could, directly or indirectly, impact on the reduction of noise source and consequently on the reduction of the associated health burden. The main goal

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of this literature review was to identify and analyse all relevant measures and assessments that could indicate the level of effectiveness of noise abatement solutions and regulatory compliance in Europe as well as internationally. The study found that noise as a policy issue lies at the crossroads of different policy areas (environment, health, transport, urban planning, road safety, construction and product life cycle, etc.) and its efficient management requires broad coordination of policies at the national, local, regional and EU level. Noise mitigation requires **more efficient horizontal coordination** between different policy areas and alignment with the **Green Deal ambitions** in pursuing sustainable development goals (SDGs). In doing so, the EU would put more emphasis on the focal point of its environmental policy: the principle of integrating environmental policy into other sectors. Horizontal coordination can also have cost savings as highlighted by the EEA 2020 report, which states that air and noise mitigation measures combined would give **better cost-benefit results** than each of these areas treated separately.

The role of **national and local** legislation and **enforcement** is of primary importance as urbanisation levels, geographic aspects, local governance mechanisms all have an essential role in determining the selection and implementation of the most adequate noise abatement solutions. Noise abatement practices applicable for various transport modes differ between Member States and relatively little attention is being paid to the sharing of good practices. **Increasing communication and encouraging consultation** between the local authorities of EU Member States in charge of selecting and implementing the noise abatement measures could facilitate an increase in the implementation of effective noise solution measures.

Noise action plans

The study included the review of **300 noise action plans** (NAPs) that aimed to identify the noise abatement measures that have been planned and implemented in Member States. The review included the overarching analysis of 200 and the in-depth analysis of an additional 100 noise action plans. While the overarching analysis identified the types of measures implemented and planned, the in-depth analysis sought to gather more detailed information on the implemented interventions and to ascertain the extent to which national and EU legislations **drive** the implementation of noise abatement measures. Following the preliminary analysis of 21 Member States, based on the availability of action plans, a short list was drawn up of 16 countries that had submitted action plans according to the 2019 requirements.

Information from the analyses of the action plans was also **fed into the drafting of a revised intervention logic** illustrating the wide-reaching impacts of relevant policy measures. Furthermore, the result of the action plan review **provided information for the identification of possible new policies that can strengthen and facilitate the effective implementation** of noise solutions.

Road: The examples reviewed indicated that Member States may prefer noise barriers, quiet road surfaces, and road maintenance as main solutions. These measures are usually combined with various other source interventions, infrastructure interventions, and mobility plans depending on the availability of resources, including finances and technological solutions. A less frequent combination includes the use of education and communication campaigns.

Rail: Common implemented or planned measures included rail grinding, noise barriers, track vibration dampers and embankment solutions. Additionally, innovative or unique solutions were identified during the in-depth analysis.

Aviation: The reviewed action plans indicate that a wide variety of measures are focused on noise mitigation both from the receiver as well as the noise source perspective. These often combine operating restrictions, such as a curfews with a penalty regime, noise monitoring and infrastructure development including lengthening the runway to avoid low flights over residential areas.

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Stakeholder consultation and workshops

Stakeholders were widely consulted throughout the project. Bilateral interviews with Member State officials, private enterprises, NGOs, associations, researchers and EU officials were taking place over the course of 10 months and were concluded in January 2021. The purpose of the interviews was to gather information relating to national or EU level implementation of noise abatement solutions and to clarify stakeholder's position on the effectiveness of noise abatement measures as well as their suggestions for potential improvements. **Altogether 64 stakeholder interviews** were carried out bringing together a balanced set of opinions from the three transport modes and agglomeration representatives of various Member States.

In addition to the interviews, **two remotely organised workshops** were also held in June and November 2020. Combined, the two workshops attracted over 200 participants from across Europe. The workshop provided a platform for consultation and validation of the interim project results and allowed stakeholders to give feedback and offer suggestions for the upcoming stages of the project.

Intervention logic

The intervention logic represents the causal relationship between the needs, objectives and inputs that drives the action of intervention and results in a form of desired outputs, results and impacts. Based on the first interim results of the project, the initial intervention scheme prepared at the proposal stage has been readjusted.

The **revised intervention logic** presents more defined needs and objectives for reducing noise pollution and relates it to the health burden. These needs and objectives can be met by a more effective implementation of a **common approach to noise reduction**, which also takes socio-economic characteristics into account (e.g. population growth and increased urbanisation, share of low-income households, increasing connectivity in densely populated urban areas and transport innovation). The revised intervention logic emphasises those supporting measures which can further enhance the application of the relevant regulatory frameworks, such as financial assistance or stakeholder involvement.

The revised intervention logic emphasises an effective implementation that relies on a **combination of measures** including compliance with relevant EU and national policies as well as innovation and collaboration. Coherence between EU and Member State policies, including those on thresholds and noise emission limits, is essential for achieving cohesion between noise abatement measures in the Member States. Moreover, **increased coherence between noise policy and other various policy areas to enhance co-benefits** (e.g. urban and mobility plans) should be explored to facilitate a more effective implementation of noise abatement measures.

Methodology for analysis of health burden and CBA at EU level

A specific methodology was set up to quantify the health burden and its reduction at EU level over time. The DPSEEA framework was applied, quantifying each step in the chain from source to receiver and health impact. The health burden is quantified by two monetisation methods to account for potential spread, but also in terms of percentage reduction of highly annoyed, highly sleep disturbed people and DALYs (related to heart disease). The existing average noise distribution in the EU, from EEA data, is used for the baseline, including forecast traffic growth and foreseen noise legislation.

The health burden reduction is calculated from the change in this noise distribution resulting from changes to the baseline – for example, due to further reduction of noise at source, in the path or at receiver.

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The cost-benefit analysis is based on the costs for increased implementation of noise abatement measures and the monetised health benefits using two methods. It results in a benefit-to-cost ratio for the period 2020-2035, identifying the net present value and break-even year.

Test site analysis

The methodology for calculating noise exposure in the EU was based on the exposure distributions calculated in the framework of the END. To get an impression of the uncertainty of the distributions, the END results have been compared with the results of local noise-mapping calculations for test sites. The following types of test sites were considered:

- Sub-areas of urban agglomerations with road and rail traffic noise;
- Areas near major roads and major railways; and
- Airports and surrounding areas.

The test site calculations focused on the effects of noise abatement solutions on the noise exposure distributions. This provided input for the effects of noise abatement solutions in the global health impact assessment methodology. Two examples are the following.

- *Noise barrier*. The effect of inserting a noise barrier in a specific situation was investigated for various road and rail test sites; and
- *Rerouting traffic*. This complex noise abatement solution was investigated by a test site calculation for the German city of Karlsruhe.

The test site calculations clearly showed that the effect of (local) traffic measures such as rerouting on the exposure distribution of the entire city is usually quite small. This conclusion also applies to local urban planning solutions such as tunneling. Furthermore, it was found that low-speed urban streets (50 km/h, 30 km/h) have a major effect on the exposure distributions.

Noise abatement solutions

For each transport mode, available noise abatement solutions were selected for this analysis in terms of their potential noise reduction and known effectiveness. Solutions still under development were not included due to the timescale of 2030.

For road transport these include (A) quieter road surfaces, (B) quieter tyres, (C), quieter vehicles (D) more electric vehicles, (E) noise barriers, (F) speed restriction, (G) car-free zones, (H) quiet facades, (I) dwelling insulation and (J) reception limits.

The railway noise abatement solutions include (A) smooth tracks, (B) smooth wheels, (C) quiet vehicles, (D) quiet tracks, (E) barriers, (F) traffic management, (G) urban planning, (H) dwelling insulation and (I) reception limits.

For aircraft, the main noise abatement solutions include (A) improved flight profiles, (B) precision area navigation, (C,D) night curfews, (E) phase-out of noisier aircraft, (F) accelerated fleet renewal, (G) sound insulation, (H) buffer zones, (I) stakeholder engagement and (J) reception limits.

Scenario analysis and required legislation per transport mode

Single and combined scenarios were analysed in terms of their reduction in health burden and benefit-to-cost ratio (BCR). Combined scenarios are generally required to achieve a significant effect. The selection was based on the health burden reduction, feasibility and timescale. In some cases the health burden reduction is high but the BCR rather low, due to the relatively high cost and the limited timescale of 10 years – e.g. the case of urban planning. This should not necessarily disqualify these solutions, as the benefits may actually be much larger if we factor in more parameters than noise, such as reduced pollution, improved access and property value and quality of life.

The strongest scenarios for noise abatement solutions and the required legislation to achieve them for each mode of transport are as follows.

Road traffic

Scenario ABCD: more quiet roads, quieter tyres and specific lower vehicle sound limits, increased electrification:
Health burden reduction in 2030: 18-24%
Benefit to cost ratio over 2020-2035: 0.9-5.1

Scenario FGHI: speed restriction, car-free zones, quiet façades, and dwelling insulation.
Health burden reduction in 2030: 16-20%
Benefit to cost ratio over 2020-2035: 0.04-0.2

Quieter vehicles and tyres are driven by the vehicle sound emission regulation 540/2014/EU and tyre limit regulation 2019/2144, which should foresee tighter limits adopted over the coming decade: 1-2dB for vehicles including an improved ASEP, limitation of the LWOT level, and 4dB tighter tyre limits in two steps. The extent and quality of quiet road surfaces should be increased by a factor of three by 2030, to fulfil the required health burden reduction. Road surfaces in noise critical areas should be monitored to assess the action threshold to replace or maintain the surface. In addition, road surface labelling should be introduced to increase the uptake of quieter surfaces. Both of these actions could be included in the Road Surface Directive.

Speed and access restrictions are effective instruments at local level for reducing noise at source, driven by national and local legislation and linked to END action plans. Façade insulation, quiet facades and barriers are last resort measures where others are not feasible.

Railways

The best railway noise scenario is ABCD, smoother and quieter vehicles and tracks

Health burden reduction in 2030: 37-52%
Benefit to cost ratio over 2020-2035: 0.9-3.1

It can be augmented by local measures including:

- EF, more barriers and traffic management

  Health burden reduction in 2030: 5-10%

  Benefit to cost ratio over 2020-2035: 0.9-4.5

- GH, urban planning and reconstruction, and more façade insulation.

  Health burden reduction in 2030: 7.8%

  Benefit to cost ratio over 2020-2035: 0.2-0.4

Smoother and quieter vehicles and tracks can be driven by the TSI Noise, with additional provisions for maintenance and monitoring of both wheel and rail surface roughness. Maintenance and monitoring of tracks are also linked to national regulations and authorities. The TSI could provide the methodology and criteria for these activities.

Barriers, traffic management and façade insulation are driven by the END and action plans, which prescribe these where measures at source do not suffice.

Urban planning and reconstruction, both of residential buildings and infrastructure, is driven by national legislation and could be better linked to EU legislation via action plans and guidance.

Aircraft

The best single solution with respect to health burden reduction is the introduction of a night curfew at all airports, i.e. an EU-wide ban on night flights. Although this has a large reduction in health burden, it has also a very high cost.

Health burden reduction in 2030: 37-60%

Benefit to cost ratio over 2020-2035: 0.1-0.2

The best possible scenario on aircraft, ABEF, includes improved take-off procedures, dispersion or concentration of flights, phase out of noisiest aircraft and accelerated fleet replacement with quiet aircraft.
Health burden reduction in 2030: 44-46%
Benefit to cost ratio over 2020-2035: -0.2 to -0.1 (cost saving)

These scenarios can be achieved by means of amendments to the BAR.

General Policy options

Policy options have been developed based on the results of the NAP analysis, stakeholder consultations as well as the noise abatement scenarios and cost-benefit analysis. The specific legislative changes for each transport mode have been indicated above.

In addition to these, several general policy options listed in table 9.1 are recommended to enhance the noise policy framework and its coherence.

Table 9.1 General policy options to reduce health burden of transportation noise

	General policy
1	Standardisation, streamlining and verification of noise action plans
2	Extending the scope of the END to urban planning, infrastructure planning and land use
3	EU Recommendation for reception limits or health burden reduction target
4	Better matching of prediction models and type test data
5	Including noise requirements in public procurement for fleets and infrastructure
6	Financial incentives and charges

Standardisation, streamlining and verification of noise action plans

This entails guidance both on potential best solutions for given situations and the noise reduction to be expected. Verification means assessing whether the measures have been implemented and to what extent they appeared to be effective. In addition, it should be further considered whether the implementation of the NAP should be prescribed as mandatory to achieve the overall objective of the END. Many NAPs focus on reducing noise at hotpots with the highest levels. A verifiable target to reduce health burden, either in terms of numbers of highly annoyed, highly sleep disturbed, DALYS or monetised health burden, would cover a larger number of affected people, rather than only those highly exposed, and offer more flexibility in achieving the target.

Extend the scope of the END to urban planning, infrastructure planning and land use

In its current form the END requires noise mapping for the purpose of public information and as a basis for health impact assessment. This noise mapping requirement could be extended to include urban planning, infrastructure planning and land use activities. Many Member States already use their national prediction models for this, but the EU prediction model could be upgraded to fulfil additional requirements for this purpose. Currently, there is a weak link between the abovementioned planning instruments, EU noise mapping and the development of NAPs which all have different timetables and responsible actors. Various authorities are involved in planning procedures, ranging from infrastructure authorities, municipalities to provincial and national authorities. This potentially leads to a fragmented approach and is a serious bottleneck for the effective implementation of noise abatement measures.

EU Recommendation for reception limits or health burden reduction target

National noise reception limits are seen by the majority of the stakeholders as the most efficient tool for the reduction of noise pollution. Reception limits exist mostly for each transport mode, but given the health impact of noise, setting up recommended limits for cumulative noise could be considered – i.e. from combined sources such as road and rail or road and aircraft. In this regard a stepwise approach at EU level should be considered to establish EU-wide uniform reception limits including those of combined noise sources, without degrading existing national limits. Noise reception limits at EU level were evaluated as a single scenario for each transport mode in Chapter 7. Given the existence of national limits, a best approach needs to be sought for the EU level. Should this be insufficiently supported, **a target for the reduction of health burden** should be considered that would allow more flexibility in how to achieve this aim.

Better matching of prediction models and type test data

Although the END refers to the noise source directives, the quantitative link is relatively weak. Whereas the END and its prediction model are based on in-use vehicles, roads and tracks, the source directives refer to type tests of new vehicles under controlled conditions.
Type tests for road and railway vehicles are configured mainly to limit the noise emission level of new vehicles, in a reproducible manner. Type testing could be expanded to also obtain better data for prediction models, including effects of road surface/tyres and wheels/tracks on rolling noise, operating conditions and design on powertrain noise and aerodynamic noise. If this data is combined with monitoring of in-use vehicles and infrastructure, better quality source data could be obtained for prediction models.

Include noise requirements in public procurement for fleets and infrastructure

The **Public Procurement Directive** 902/2014 could be expanded to require contracting authorities to incorporate points for sustainability and environmental impact among the award criteria. More explicit environmental considerations are described in the Commission's **Green Public Procurement**[363] initiative, which is a voluntary instrument containing sustainability criteria that can be used by contracting authorities. The criteria are regularly reviewed and published in a handbook. Lifting these sustainability criteria and making them part of the Public Procurement Directive could significantly impact implementation of noise solutions and facilitate the exchange of sustainability practices among contracting authorities as well as private enterprises. For instance, green public procurement could be linked with mobility planning and new public transport fleets.

[363] European Commission (2020) Green Public Procurement https://ec.europa.eu/environment/gpp/index_en.htm

Financial incentives and noise charges

Financial instruments to reduce environmental noise are already in place such as noise differentiated track access charges (NDTAC) for railways, access charges for aircraft and subsidies or tax benefits for quieter and cleaner vehicles.

Taxation on fuels and vehicles based on other parameters such as weight, power and age also exist, although often not specifically for noise. Given that older vehicles fulfil their older type test and noise limits (which may now be much lower), there is potential to accelerate the uptake of quieter and cleaner vehicles via taxing and access charging. Also, incentives for early withdrawal (scrapping) or ban of polluting and noisy vehicles could be considered in this respect.

EU funding is available from the Multiannual Financial Framework (MFF) Connecting Europe Facility, innovation and research projects, Cohesion Fund; Regional Development Fund (ERDF); European Social Fund (ESF); and the European Structural and Investment Fund (ESIF). These instruments could be further supplemented by the European Green Deal Investment Plan[364] (EGDIP). Mobilisation of public and private investments are an important element of the EGDIP via InvestEU and the Just Transition Mechanism (JTM)[365]. The JTF was designed to complement the ERDF and ESF+.

In addition, the 2021-2027 Multiannual Financial Framework (MFF) foresees climate mainstreaming across all EU expenditure, dedicating 25% of EU expenditure to climate objectives[366] in combination with elements of 'green' financing in ERDF. Within ERDF[367], the majority of funding has to be thematically concentrated on the Green Deal aligned PO 2 and the innovation-focused PO 1[368].
With regards to the Covid-19 pandemic, new funding opportunities are available, such as the temporary recovery instrument – NextGenerationEU – which is designated to repair some of the economic and social consequences of the pandemic.[369] This could provide an opportunity to improve transport infrastructure in a way that is more closely aligned with sustainability and the Green Deal objectives.[370]

As most stakeholders indicated, access to finance is a key obstacle for the effective implementation of noise abatement measures. Further alignment between noise policy and other relevant areas should be achieved to make better use of available funding opportunities and streamline possible investment.

As indicated in Chapters 4 and 7, an effective and EU-wide reduction of noise emission that would result in a 20-50% health burden reduction within the next 10 years cannot be reached by individual scenarios but rather by a set of **combined and complementary measures.** The greatest benefits from noise reduction are to be expected from the implementation of the best combined scenarios outlined above.

Chapter 8 presents **proposed policy measures** that could be implemented within the next 10 years and **includes both mandatory (hard) and optional (soft) policy measures**. Recognising that EU legislation is a key stepping stone in the harmonisation and further implementation of noise

[364] COM/2019/640 final

[365] COM/2020/22 final

[366] COM(2018) 375 final

[367] COM(2018) 372 final

[368] PO1:"a smarter Europe by promoting innovative and smart economic transformation";

[369] European Commission, Recovery plan for Europe, available at: https://ec.europa.eu/info/strategy/recovery-plan-europe_en

[370] EurActiv, A Green Recovery for Aviation, December 2020, available at: https://www.euractiv.com/section/aviation/opinion/a-green-recovery-for-aviation.

solutions across Member States, a significant share of the proposed policy measures relate to the **review and amendment of these policy instruments**. In addition to noise and transport specific instruments such as the END, TSI Noise and the BAR, other **non-noise policy related instruments** (legislative and non-legislative across various policy areas) have also been analysed.

This approach follows the principle of **horizontally integrating environmental issues into different policy areas**. Therefore, it is suggested that the proposed policy options are developed within the context of an **overarching strategy.** This will require setting an **overall target for noise reduction across different policy fields**. This strategy could be ideally composed of a set of a horizontal (general) and vertical (sector specific) measures. The establishment of such an umbrella approach would streamline the efforts undertaken and ensure their timely application.

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Annex 1: NAP Analyses

NAPs – In-depth analysis

Road

Valdani Vicari & Associati
ECONOMICS & POLICY

Contents

1 Austria

1.1 National roads (2013)

1. Background information

- **Major National Roads, Austria (NAP 2013):**

The NAP includes roads with more than 3 million vehicle passages a year, which covers about 2,180km road in Austria.
In 2013, Austria had approximately 8,5 million inhabitants. The number of people affected by national road noise is indicated below:

- >60 Lden threshold value: 101,762 people (1,2% of the population)
- >50 Lnight threshold value: 164,629 people (2,0% of the population)
- >55 dB Lden: 472,829 (6% of the population)
- >45 dB Lnight: 626,466 (7% of the population)

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation.[1] If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law	**YES**	• Federal Environmental Noise Protection Act (BGBl. I No. 60/2005) • Federal Environmental Noise Protection Ordinance (BGBl. II No. 144/2006) • The noise calculations were carried out in accordance with § 4 of the Federal Noise Ordinance (Bundes-LärmV) as per RVS 04.02.11, Environmental Protection, Noise and Air Pollutants, Noise Protection, 2nd amendment March 2009
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**YES**	• Spatial Planning Act. Official publication: State Law Gazette (LGBl.) ; Number: 47/2006 ; Publication date: 2006-09-06
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**YES**	• Section 7a of the Federal Roads Act 1971 (BGBl. I No 34/2013) • Law on an amendment to the Road Act. Official publication: State Law Gazette (LGBl.) ; Number: 22/2006 ; Publication date: 2006-05-11
Buildings regulation	**NO**	

[1] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP does not discuss the main sources of noise.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

Planned measures (by national authorities); main focus of the NAP:

- Construction of road noise barriers and dams
- Promotion of soundproof windows
- Renewal of road surfaces (e.g. low-noise road surfaces)
- Renewal of existing noise barrier elements if necessary (Replacement of the old elements)
- Promotion of noise abatement measures close to residential buildings (e.g. dams in the vicinity of the residential buildings)

Other mentioned measures (responsibility of regional authorities):

- Speed controls
- Spatial planning

1.3. Are there any noise limits mentioned in the NAP?[2]

- L_{den} for road noise: 60dB
- L_{night} for road noise: 50 dB

1.4. Are these new measures or they are continuation of existing measures?

- Continuation of existing measures which were started in first NAP round (2008-2012).

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

2013-2017

1.5.2. Per reduction measure

No data available.

[2] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

- Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMVIT)
- Autobahnen- und Schnellstraßen Finanzierungs-AG (ASFiNAG) – Austrian highway financing stock corporation under the responsibility of the Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology
- Spatial planning and control of speed limits are the responsibility of the regional authorities (due to constitutional laws)

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

- No, but it mentions research to optimize cost-effectiveness:
- An Austrian infrastructure research project to optimize noise barriers develops a method to find the best solution for noise barrier planning regarding costs and effectiveness. In this project, the wall geometry on the basis of the wall costs, limit value exceedances, and secondary conditions are optimised. The mathematical formalism includes the Austrian Regulations, standards and legal foundations for road and rail noise abatement projects. The funcitoning is demonstrated with concrete examples.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

- It is estimated in the NAP that all planned measures will amount to a total of EUR 12-20 million per year on average (2013-2017). ASFiNAG will bear these costs.
- The NAP also mentions that, for the NAP period of 2008-2013, a total of EUR 17-33 million per year was spent on average.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

- The extent of already existing noise measures is mentioned: Noise protection measures are implemented on about 4,1 km^2 of the entire ASFiNAG road network, which amounts to a length of about 1,275 km.

- Planned measures on national roads (name of road section mentioned in brackets); amount of km not mentioned in the NAP:
- A1 West Highway (Pöchlarn – Ybbs)
- A1 West Highway (Preßbaum)
- A1 West Highway (Itzling – Gaglham)
- A2 South Highway (Zubringer Graz East)
- A2 South Highway (Pirka – Unterpremstätten)
- A2 South Highway (Lieboch)
- A2 South Highway (Mooskirchen)
- A8 Innkreis Highway (Weibern – Haag, Haag-Ried)
- A9 Pyhrn Highway (Gratkorn (Eggenfeld und Murfeld))
- A9 Pyhrn Highway (Weitendorf)
- A10 Tauern Highway (Grödig)
- A12 Inntal Highway (Kramsach Nord, Radfeld Süd)

- A12 Inntal Highway (Kufstein)
- A14 Rheintal/Walgau Highway (Hörbranz-Lochau)
- A23 Highway Südosttangente Vienna (Knoten Inzersdorf – Hochstraße Inzersdorf)
- S6 Semmering Expressway (Kindbergdörfl-Aumühl)
- S6 Semmering Expressway (Kindbergbrücke)
- S6 Semmering Expressway (Leoben Ost-Goess)

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes, the draft NAP was accessible for public inspection for six weeks between June 1, 2013 and July 17, 2013 through the website laerminfo.at of the Federal Ministry of Agriculture, Regions and Tourism. Access was also made possible through a visit to the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMVIT), where residents could inspect the noise maps and the draft NAP. Public opinions could be submitted via email or postal mail.

1.11. Does the public consultation include active involvement of stakeholders?

Yes, see Q4.1.

1.12. Are the results of the public consultation integrated in the NAP? How?

Yes, the opinions of the 105 members of the public who submitted their views were summarised and discussed in the NAP.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Yes, it was a one-off event.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

To demonstrate the impact of the measures established over the last 5 years, the NAP compared the percentage of people affected by the below mentioned noise levels in 2007 and in 2012. Due to the implementation of noise abatement measures in the last 5 years, results show that the share of inhabitants exposed to noise above the threshold value of > 50 dB Lnight in relation to the share of inhabitants exposed to noise above 45 dB Lnight has decreased by about 6 % in the last 5 years. The NAP does not refer to individual measures which contributed to that.

~~1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)~~

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

The NAP does not mention how exactly it will be evaluated. However, it discusses research projects to investigate/evaluate noise reduction measures. Research is conducted on: 1) refractive edges (infrastructure research), 2) sound reflection of road noise barriers (infrastructure research), 3) low-noise tyres (infrastructure research), 4) optimisation of road noise barriers (concerning wall geometry) (infrastructure research), 5) long-term behaviour of road surfaces (ASFiNAG)

Furthermore, it is mentioned that the effectiveness of low-noise pavement will be evaluated in the following way: Immission measurements will be carried out after completion of the pavement to ensure the required quality. If necessary, additional immission measurements will be carried out to check compliance with the designated noise protection target.

The NAP also mentions that it appears unlikely that a reduction of the percentage of people affected by noise will be as high as 6% (as mentioned above under Q5.1.2.1.) since many major road sections creating high levels of noise have already been improved. However, it is expected that the planned measures will lead to further reductions.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

7. What are the questions that remained un-answered after reviewing the NAP and consulting respective online sources?

Is there are timeframe for the implementation of measures per reduction measure?

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Renewal of road surfaces and use of low-noise road surfaces
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	• Speed limits (not elaborated much in NAP because this is responsibility of regional authorities)
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	• Spatial planning (not elaborated much in NAP because this is responsibility of regional authorities)
	Path interventions between source and receiver	Road noise barriers	☒	• Construction of road noise barriers and noise protection dams • Renewal of existing road noise barriers (replacement of old elements)
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	• Installation of soundproof windows
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

1.2 Regional roads – Carinthia province (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[3]

Austria – Regional Roads in Carinthia (in German: Kärnten) Province, NAP 2013:

Roads covered by the NAP: All roads except superhighways and highways. The NAPs for the agglomerations of Klagenfurt (capital of province) and Villach (second largest town in Carinthia) were drafted separately and included in the annex of this NAP.

Total area of Carinthia: 9,500 km^2

Total inhabitants of Carinthia: 561,000 inhabitants (status January 2019)

Estimation of number of residents with decreased noise burden due to NAP 2013 measures: 2,204 residents within identified noise hotspots

Most residents are burdened by noise levels up to L_den 70dB and L_night 65dB.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [4]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**YES**	• Federal Environmental Noise Protection Act (BGBl. I No. 60/2005) • Federal Environmental Noise Protection Ordinance (BGBl. II No. 144/2006) • The noise calculations were carried out in accordance with § 4 of the Federal Noise Ordinance (Bundes-LärmV) as per RVS 04.02.11, Environmental Protection, Noise and Air

[3] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[4] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

		Pollutants, Noise Protection, 2nd amendment March 2009
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

No, not directly mentioned.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

Planned measures in the 2013 NAP:

- Protective measures on/in buildings, i.e. passive measures (soundproof windows, soundproof ventilators): The owner of the residential property must apply for the subsidy. The application is examined and approved in accordance with the provisions of the RiLL legislation. The subsidy amount can also be used for a privately erected noise barrier.
- Construction of roadside protection measures by the road maintainer, i.e. active measures (noise barriers, noise protection walls): For the realisation of these measures, the planning of a noise engineering project in accordance with the relevant regulations (RiLL, RVS 04.02.11) is necessary. Under certain conditions, co-financing by third parties is necessary.
- Application of a low-noise road surface in case of future road maintenances in order to keep rolling noise as low as possible.

Discussed future long-term measures, with aim to integrate it into NAP in the future:

- Optimising the use of vehicles for freight transport: freight exchanges to avoid empty runs/trips, modal shift from road to rail for unavoidable freight traffic

- Examination of local and regional traffic network plan and integration of noise measures
- Integration of traffic noise into transport policy
- Improving offer of parking facilities
- Planning of non-motorised traffic
- Planning of stationary traffic
- Promotion of modal shift from road to rail
- Promotion of alternative mobility (e.g. electric transport)
- Promotion of inner-city cycling (e.g. expansion of cycling network)
- Improved land-use planning

3.3. Are there any noise limits mentioned in the NAP?[5]

L_den: 60dB

L_night: 50dB

3.4. Are these new measures or they are continuation of existing measures?

Continuation of existing measures (insulation of windows, noise barriers) and discussion of new important long-term measures.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

2013-2018

3.5.2. Per reduction measure

n/a

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Drafting and implementation of NAP:

- Office of the Carinthian Provincial Government, Division 7 – Competence Center of Business Law and Infrastructure
- City of Klagenfurt (=capital city of Carinthia province), Department for Environmental Protection, Magistrate of the provincial capital Klagenfurt am Wörthersee

[5] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

- City of Villach, Magistrate of the city of Villach, Business group 2 – Construction

Note 1: The city of Klagenfurt and Villach have issued their own NAPs, available in annex 1 and 2 of this Regional Roads NAP.

Note 2: For long-term measures, authorities other than the province government may have to be taken into account. These long-term measures include development planning, zoning plans, other spatial planning measures, measures to optimise freight transport, and shift to rail.

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

No.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

- Total costs of main measures: approx. EUR 9.8 million (for insulation of windows) and EUR 14 million (for noise barriers)
- The cost estimate of noise measures was based on the assumption that there are 2.5 persons per household. The average amount of funding per household is therefore approx. EUR 1,600.
- Total costs of NAP (including noise mapping): EUR 2.04 million
- The government of Carinthia had invested approx. EUR 1 million in regional roads (roads and buildings) in the years before 2013.

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

Not directly mentioned. It is only mentioned that the number of inhabitants with reduced noise burden is approx. 6,500 due to insulation of windows.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

The public was involved in Carinthia's action planning in accordance with the Carinthian Environmental Planning Act (especially §8 and §10) (according to the information in the Carinthian Road Act §62f). The law stipulates that a draft of the action plan is available for public inspection during office hours within the period of 4 weeks and that anyone who can demonstrate an interest can comment on the draft within this period. The start and end of the inspection/circulation period of 4 weeks was published in the Kärntner Landeszeitung on 21.11.2013: 25.11.2013 to 23.12.2013.

Furthermore, the draft action plan was also sent to the public environmental agencies of the province for comments.

4.2. Does the public consultation include active involvement of stakeholders?

Residents and public environmental agencies were given the opportunity to submit their comments and inquiries on the draft action plan. No comments were submitted, however.

4.3. Are the results of the public consultation integrated in the NAP? How?

Since the public did not submit any comments or inquiries, the results of the public consultation could not be integrated in this NAP.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

One-off event

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The NAP only states the following: "The statistical recording of the implemented noise protection measures, which is already being carried out, will be differentiated into measures within the framework of noise action planning and other measures. The degree of implementation of the action planning can be derived from this."

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)	**NO**	

Urban/land use planning legislative acts	**YES**	Regional legislation: • Carinthian Community Planning Act (LGBl. No. 88/2005)
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**YES**	Regional legislation: • Carinthian road law (LGBl. No. 87/2005) – Regional law
Building regulation	**NO**	
Environment acts	**YES**	Regional legislation: • Carinthian Environmental Planning Act (LGBl. No. 89/2005) • Carinthian Environmental Noise Ordinance K-ULV, LGBL No. 76/2006 of 19.12.2006, 7-AL-GVV-321/8/2006 • Carinthian IPPC Plant Act (LGBl. No. 13/2006) • RiLL Guideline for noise protection on provincial roads in Carinthia (01.02.2011)
Other	**NO**	

7. Please provide a brief summary

Remarks on this NAP:

On long-term modal shift from road to rail freight transport:

This goal can only be pursued in the long term, since technical improvements in the noise emissions of rail vehicles are also a long-term prerequisite for this shift.

The responsibility for these strategies lies with a transport policy that is to be implemented in the long term and that covers all modes of transport. To this end, a change in the current legal framework with sectoral responsibility and financing should also be sought.

8. Is there a contact person that we can contact for follow-up questions?

8.1. Please provide the details

Office of the Carinthian Provincial Government

Division 7 - Competence Center Business Law and Infrastructure

Mießtaler Street 1

9021 Klagenfurt am Wörther See

abt7.post@ktn.gv.at

For the city of Klagenfurt:

Department for Environmental Protection

Magistrate of the provincial capital Klagenfurt am Wörthersee

Bahnhofstrasse 35

9010 Klagenfurt am Wörthersee

umwelt@klagenfurt.at

For the city of Villach:

Mr. Werner Kanatschnig

Magistrate of the city of Villach

Business Group 2 - Construction

Town hall square 1

9500 Villach

werner.kanatschnig@villach.at

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Application of quiet road surface in case of future road maintenances *Pending long-term planning:* • Examination of local and regional traffic network plan and integration of noise measures • Planning of non-motorised traffic • Planning of stationary traffic
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	*Pending long-term planning:* • Modal shift from freight and passenger traffic from road to rail *(pending long-term planning)* • Optimising the use of vehicles for freight transport: freight exchanges to avoid empty runs/trips • Promotion of alternative mobility (e.g. electric transport)
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	*Pending long-term planning:* • Improving offer of parking facilities • Promotion of inner-city cycling (e.g. expansion of cycling network) •

	Path interventions between source and receiver	Road noise barriers	☒	• Noise barriers • Noise protection walls
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	• Insulation of buildings (soundproof windows & ventilators)
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

1.3 Regional roads – Salzburg province (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[6]

Austria – Regional Roads in Salzburg province, 2013 (and updated 2015):

Roads covered by the NAP: All major roads except highways and superhighways in Salzburg province outside of Salzburg agglomeration with at least 8, 220 vehicles per day

Length of major roads covered by the NAP: 414.6 km

The total area of Salzburg province if 7,154 km², of which only about 17.6% (1,259 km²) can be used as a permanent settlement area. This permanent settlement area is home to 99.8 % of the resident population, 99.5 % of the employees at their workplace, and 96.8 % of the built-up area. There is a large number of interests in the use of land (settlement areas, traffic areas, technical infrastructures, open space use). Consequently, space is becoming scarce, and resulting environmental problems (sealing of soil, noise, air) arise. Therefore, the planning and securing of areas for future traffic infrastructures is also becoming increasingly difficult.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [7]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**YES**	• Federal Environmental Noise Protection Act (BGBl. I No. 60/2005) • Federal Environmental Noise Protection Ordinance (BGBl. II No. 144/2006) • The noise calculations were carried out in accordance with § 4 of the Federal Noise Ordinance (Bundes-LärmV) as per RVS 04.02.11, Environmental Protection, Noise and Air Pollutants, Noise Protection, 2nd amendment March 2009

[6] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[7] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Transposed into regional level in the MS		
Urban/land use planning legislative acts	**YES**	• Spatial Planning Act. Official publication: State Law Gazette (LGBl.) ; Number: 47/2006 ; Publication date: 2006-09-06
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**YES**	• Section 7a of the Federal Roads Act 1971 (BGBl. I No 34/2013) • Law on an amendment to the Road Act. Official publication: State Law Gazette (LGBl.) ; Number: 22/2006 ; Publication date: 2006-05-11
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP acknowledges that noise is created by numerous sources. It highlights that in the province of Salzburg, which is very mountainous and has several transit routes of national and international importance, residents in valleys are particularly affected by noise. Due to the structure of narrow valleys, sound travels across considerably larger areas than on flat land. This is caused by the reduced or lacking sound absorption by the soil/ground in valleys, particularly on slopes.

Other types of noise burdens are also addressed: good housing/residential area and general satisfaction with living conditions

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

<u>Measures of the NAP:</u>

- Construction of bypasses which include the following activities:

Construction of tunnels, noise protection in the portal areas of the tunnel, noise protection/flood dams

- Construction and maintenance of noise barriers

- Noise insulation of buildings
- Reduction of multiple routes to the A1 junction Salzburg-Nord

Other regional measures mentioned in the NAP:

- Salzburg province cycle network investment programme 2006-2015 (continuation of 2002-2005 programme)
- Subsidy programme of Salzburg state to support those companies that shift their freight transport from road to rail. Province subsidies are up to 10% of the project costs and are complemented by the 30-40% subsidy of the national government.
- Project to raise attractivity of public transport: Rail, bus, and passenger transport as well as cycling and walking paths have lower quality levels than road traffic/transport. Thus, Salzburg aims to raise the service quality standards for all modes of transport (public transport, cycling, roads and freight transport).
- Road surface:
    - New road surfaces
    - Building of road surfaces as uniform/homogenous as possible
    - Covers for manholes on roadways and avoidance of installation of manholes with screwed covers
- Bridges:
    - installation of integral bridge objects without roadway transition constructions in the path of the bridge
    - Noise shielding of the roadway transition constructions downwards
    - Roadway transition constructions: finger constructions instead of lamella constructions
    - Increased use of concrete step barriers (noise shielding)
    - Research project for alternative cover constructions on bridges

3.3. Are there any noise limits mentioned in the NAP?[8]

Noise limits based on "Environmental Protection and Environmental Information Act – UUIG":

L_den: 60dB

L_night: 50dB

3.4. Are these new measures or they are continuation of existing measures?

New measures. Previous noise abatement projects have been concluded in the past.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

[8] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

2013-2018

3.5.2. Per reduction measure

n/a

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Government of Salzburg; Implementing Agency: Department 5 (Nature and Environmental Protection, Trade) of the Office of the Salzburg Provincial Government

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

No.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The following noise measures and related costs are discussed in the NAP:

- B1 Straßwalchen bypass: EUR 50 million
- B159 Langwies bypass: EUR 20 million
- A1 Hagenau half-connection point (first expansion stage): EUR 15 million
- Construction of noise barriers: EUR 2.5 million
- Installation of noise-insulated windows, doors, and soundproof windows: EUR 1.4 million

Cost of previous noise abatement projects:

For the support programme on the construction of noise barriers, a total of EUR 7,200,000 has been invested in the province of Salzburg on major roads over the last 10 years (2003 - 2012). In 53 projects, noise barriers with a total length of approx. 10.3 km were erected to protect approx. 500 residential buildings.

In the budget for 2013, EUR 500,000 was earmarked for the construction of approx. 0.7 km of noise barriers in 3 sub-projects.

For the noise protection campaign on window insulation, a total of EUR 2,820,000.- has been spent on major roads over the last 10 years (2003 -2012). This means that the installation of approx. 6,100 individual elements (windows or doors, sound-absorbing ventilators) was subsidised for approx. 900 projects (houses).

In the province budget for 2013, EUR 270,000 was reserved for this.

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

- Construction of noise barriers: approx. 3.6km in 20 projects
- Installation of noise-insulated windows, doors, and soundproof windows: approx. 3,000 individual elements to install in about 450 houses

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

Public inspection of draft NAP:

The draft of the Salzburg NAP was prepared by the Office of the Salzburg State Government with the involvement of the municipalities and the mayors as representatives of all municipal citizens. In accordance with §§ 23 para. 3, 18 UUIG (LGBl. No. 72/2007 as amended) in conjunction with § 5 para. 1 Salzburger Abfallwirtschaftsgesetz 1998 (LGBl. No. 35/1999 as amended), this draft was open to public inspection for six weeks at the Office of the Salzburg Provincial Government, Michael-Pacher-Straße 36, as well as at the district administrative authorities concerned. It was also published on the internet platform of the state and the Ministry for a liveable Austria.

4.2. Does the public consultation include active involvement of stakeholders?

Yes. Information events on the NAP were held in groups for all 61 municipalities concerned. During each event, the overarching project "EU Environmental Noise" was presented and information was given on the completion of the noise maps and the draft NAP. All affected communities were asked to name the measures they had implemented and panned, as well as the strategies they were pursuing. They were also asked to report their measures to the Department of Nature and Environmental Protection: Division of Industries.

4.3. Are the results of the public consultation integrated in the NAP? How?

The NAP does not give clear indication if and how the results of the consultations influenced the measures of the NAP. The NAP also states that local measures for smaller roads are the responsibility of local municipalities and not regional authorities (=province of Salzburg). However, summaries of the comments on the NAPs and planned local measures are included in the annex of the NAP.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Several parallel one-off events

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The measures and programmes set out in the action plan will be evaluated and assessed every five years when the strategic noise maps and action plans are updated.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**YES**	• The Salzburg Regional Planning Act of 2009, which came into force on 1 April 2009, contains additional instruments for the increased consideration of preventive noise protection in zoning and development planning.
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	

Environment acts	**YES**	• Environmental Protection and Environmental Information Act - UUIG, originally "IPPC Plant Act", LGBl No 72/2007, as amended. (This is an environmental protection law which implements certain directives of the European Union and regulates the communication of environmental information)
		• § Section 18 UUIG refers to Section 5 of the Salzburg Waste Management Act 1998 (S.AWG) with regard to environmental assessment.
		  • § Section 5 para. 2 S.AWG stipulates that plans are to be subjected to an environmental assessment if the planning is suitable:
		  • 1. to be the basis for a project subject to an environmental impact assessment pursuant to Annex 1 of the Environmental Impact Assessment Act 2000 (UVP-G 2000), or
		  • 2. to significantly affect European nature reserves (§ 5 Z 10 of the Salzburg Nature Conservation Act 1999 - NSchG) or wildlife European nature reserves (§ 108a of the Hunting Act 1993 - JG)

Other (please add rows below if needed)	**NO**	

8. Please provide a brief summary

Remarks on this NAP:

Major issues to consider for roads in Salzburg's mountainous areas are indicated below. Lessons can be learned from these for other mountainous regions in Europe:

- Speed limits of below 50km/h are not desirable since they would decrease the road capacity for higher-ranking traffic (freight vehicles, presumably)
- Noise barriers are not desired since they hide local landscape views. And noise barriers also have no effect in areas with narrow street canyons.
- Therefore, the remaining option is sound-insulation of windows. While this may be effective for residents when they stay inside, it is not effective in the open air (balconies, gardens, etc.).

Interesting solution for modal shift from road to rail to reduce noise created by freight traffic:

- Subsidy programme of Salzburg province to support those companies that shift their freight transport from road to rail. Province subsidies are up to 10% of the project costs and are complemented by the 30-40% subsidy of the national government.
    - 2013 status and project details: The "Innoversys" project was launched in 2008 with a view to shifting truck traffic to rail. The aim of this project is to identify the necessary measures (sidings, terminals, etc.) in the province of Salzburg and in the neighbouring Bavarian region together with the business community. Since 2008, the Salzburg connecting railway coach has been in place. This coach creates synergy effects in regional rail freight transport by communicating with companies and municipalities in order to make the operation of connecting railways and of public loading tracks more profitable.

Interesting solution: cross-regional/border legislation on traffic intensity of major projects:

- Guideline for traffic reports on major projects:

Major projects are important traffic generators whose location and design are primarily based on economic calculations and which often have undesirable spatial and traffic effects. On the other hand, there are political objectives of sustainable spatial and settlement development. The available and applied examination and approval procedures were not suitable enough to prevent problematic site developments or undesirable developments.

In a guideline, a procedure is to be standardised across departments and disciplines, with which the traffic effects of large-scale projects can be determined and assessed in a uniform and comprehensible manner throughout the country. The application of these guidelines should also enable the development of measures to achieve traffic compatibility, which are to be agreed with the project applicant.

NAP acknowledges that there is no single source of noise nor a solution for noise abatement in the foreword:

"Is the noise problem really so easy to solve? If it could be solved so easily, why have the necessary steps not been taken long ago? Noise as a side effect or waste product of our technological world has many different forms and sources. There is therefore no simple, isolated and cheap measure that will immediately bring us a quieter environment. Each of the different sound sources requires different changes or noise remediation steps. Our engineered environment was not created overnight. This environment has cost a great deal of money, and it has taken many years to build. A change to a quieter environment therefore takes a lot of time (product life cycles) and/or a lot of money (remediation measures) as well as changes in behaviour."

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Maintenance and construction of new road surfaces • Better manhole constructions (lids/cover of manhole)
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	• Subsidy programme for companies to support modal shift from road to rail for freight traffic • Enhancement of the quality of public transport (rail, bus, passenger)
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	• Construction of bypasses and related construction of o Tunnels o Noise protection in the portal areas of the tunnel o Noise protection/ flood dams • Reduction of multiple routes leading to the same highway • Extension of cycling network • Improvement of quality of walking lanes • Quieter bridge constructions and shielding
		Road noise barriers	☒	• Construction and maintenance of noise barriers

	Path interventions between source and receiver	Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	• Noise insulation of buildings
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

2 Belgium

2.1 Wallonia major roads (2017)

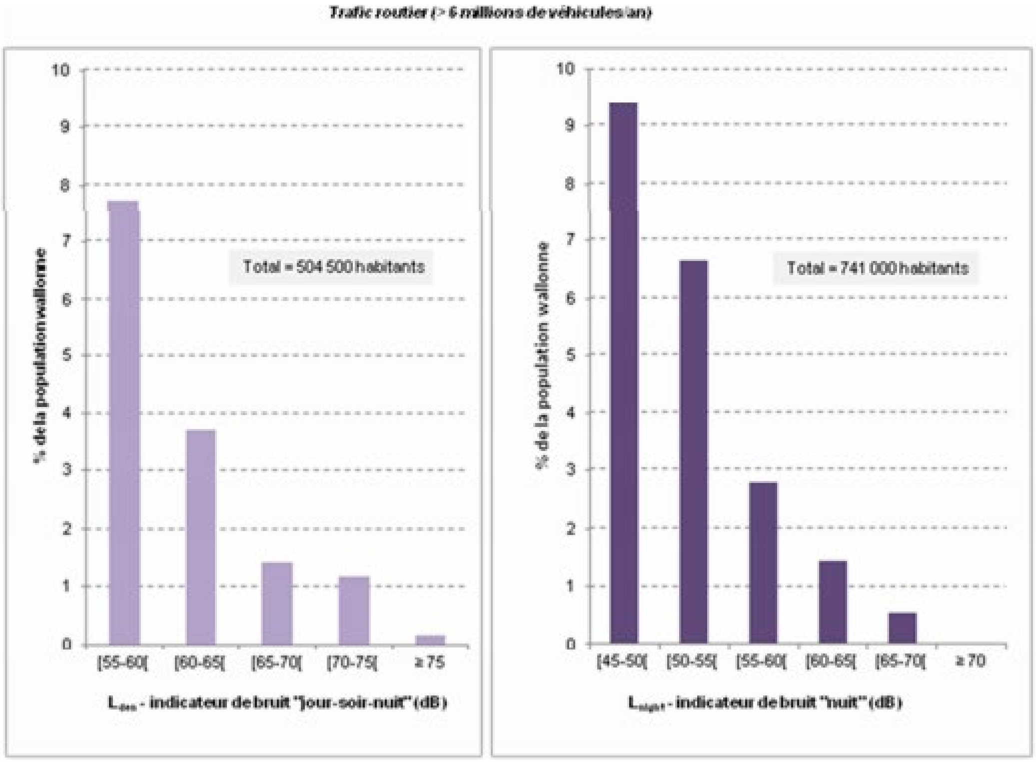
1. Background information

This NAP focuses on the major roads in Wallonia. It focuses on the road network of more than 6 million vehicles per year and between 3 to 6 million vehicles per year and was drafted in 2017. The roads of over 6 millions vehicles were mapped in 2009 and the roads between 3 to 6 million were mapped after 2012 and both maps were adopted in 2017.

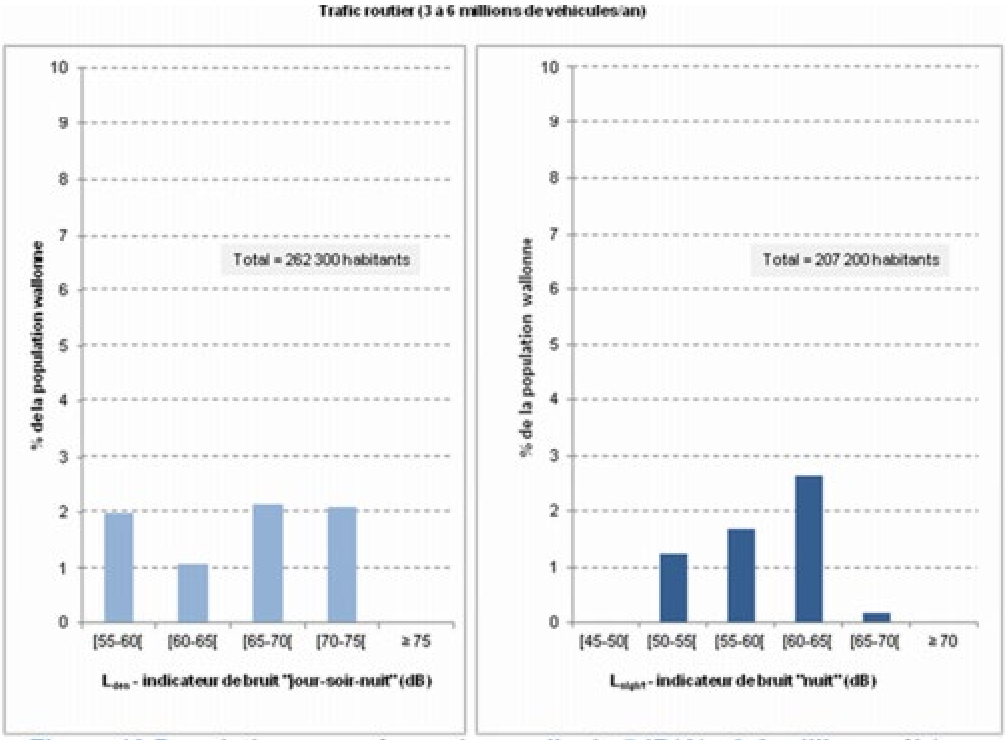
The NAP mentions an additional indicator, *UCEpop* co-developed by Wallonia, bringing together the number of dwellings on a given site; the number of inhabitants in a given dwelling; and the maximum Lden level calculated 2 meters from the façade of a given dwelling.

The NAP also presents the method that was developed, including categories of noise levels and definition and classification of action sites.

The population exposed to higher noise levels from the roads with more than 6 million vehicles per year is as follows:



The population exposed to higher noise levels from the roads with 3 to 6 million vehicles per year is as follows:



2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [9]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law	**Yes**	Order of 1 April 2004 amending the Order of 17 July 1997 on urban noise abatement. Official publication: Staatsblad; Publication date: 26/04/2004; Page number: 34299-34308
Transposed into regional level in the MS	**Yes**	Order of the Walloon Government on the assessment and management of environmental noise. Official publication: Moniteur Belge; Publication date: 12/07/2004; Page number: 54852-54859
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)		

3. NAP noise reduction measures

[9] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP focuses on road traffic noise. It identified 922 action sites (372,2 km) for the roads over 6 million vehicles, defining different degrees of priority. For the roads between 3 to 6 million of vehicles, there are 2 216 action sites (781.9 km).

The different sites are also categorized into silos based on the type of measure they benefit from or on their location (new noise barriers; updated noise barriers; crossing agglomerations; agglomeration in the END directive; to be adapted; works ongoing or planned).

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The NAP refers to several measures:

- Noise barriers (new and upgrade of existing ones). The update includes either renovation of barriers or an upgrade (in size for instance).
- New road pavements
- Silent pavements (bigger decrease of noise impact, but issues with the sustainability of this noise reduction, therefore this solution is being studied)
- Road improvements (break straight lines road to prevent high speed, by using baffle plates or speed limits)
- Land planning (consider integration environmental noise management in land use plans)

1.3. Are there any noise limits mentioned in the NAP?[10]

The limits used are 70 dB(A) Lden and 60 dB(A) Ln.

1.4. Are these new measures or they are continuation of existing measures?

Both. For instance, regarding the noise barriers, both the implementation of new noise barriers and an upgrade/update of existing ones are mentioned.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general
1.5.2. Per reduction measure

Not provided.

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

[10] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

According to the Walloon Government Order of 2004, the Walloon Government is the responsible authority for the mapping and the NAPs for major roads. In the Walloon Public Service, it's the competence of DG01, and more precisely the "noise" unit of the Works Expertise Directorate in the Technical Expertise Department.

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Not provided.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The plan explains that within the Infrastructure Plan for Wallonia (2016-2019), EUR 10 million were allocated to the management of road traffic noise. This covers:

- Structural network and mapping (including new noise abatement measures) : EUR 6 million
- Non-structural network and mapping (including new noise abatement measures) : EUR 1 million
- Upgrade of noise barriers: EUR 3 million

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

The NAP refers to identified action sites and their lengths.

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

1.11. Does the public consultation include active involvement of stakeholders?

1.12. Are the results of the public consultation integrated in the NAP? How?

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

No information provided.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

The plan mentions that a full analysis of the situation at the end of its implementation will be carried out by the competent authorities. The measures implemented within the infrastructure plan will also be evaluated. The implementation of the plan will also be assessed to see which necessary drivers will be needed for future plans.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		
Other (please add rows below if needed)		

7. What are the questions that remained un-answered after reviewing the NAP and consulting respective online sources?

1.17. Please provide a brief summary

The plan lacks information on a timeframe and on public consultation, even though there was one: https://www.plan-bruit-routier-wallonie.be/ and took place between 17 September and 5 November 2018. A budget is given, but no detailed information on cost-effectiveness.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	New road pavements and silent pavements are considered in the plan
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	Speed limits are considered
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	Road transformation is considered
	Path interventions between source and receiver	Road noise barriers	☒	Noise barriers are the core measure
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	
	Noise solutions	Examples	If YES, tick a box	Comments
Rail (major and cities)	Source interventions	Replacing old freight wagons, rail grinding, change in traffic flow on existing railways, reduction of freight transport, relocation of people	☐	
	Mobility plans	Introducing silent wagons, retrofitting wagons, “quieter route”, speed limit	☐	
		Operating restrictions	☐	
	Infrastructure interventions	Railway bridges, tunnels, new railway line, new type of rail pads, acoustic rail grinding, new rolling stock, land and urban planning	☐	
		Noise barriers railway	☐	

	Path interventions between source and receiver	Maintaining rails, buildings insulation	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception	☐	
Airports	Source interventions	Change in number and time of aircraft flights, airport curfew, landing and take-off improved profiles, prohibition of operation for old (noisier) aircrafts, relocation of people	☐	
	Mobility plans	Introducing new aircrafts, closing old airports	☐	
	Noise solutions	Examples	If YES, tick a box	Comments
	Infrastructure interventions	Building new runway, land and urban planning	☐	
	Path interventions between source and receiver	Aviation noise barriers	☐	
		Maintaining pathways, buildings insulation	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perceptions	☐	

3 Croatia

3.1 Split-Dalmatia road section (2019)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[11]

Name: Road Split Dalmatia County, published in 2018 (3rd NAP round)

Population and area covered with NAP: NAP covers the area of 44,54 km2 and 51 562 inhabitants. The road length is 12,7km.

Noise level (L den): 94% of inhabitants (i.e. 48 595) live in areas where noise level is below 55 dB (A) L; 3% of inhabitants (i.e. 1 496) are exposed to noise level between 55 dB (A) and 59 dB (A); 2 % of inhabitants (i.e. 907) are exposed to noise level between 60 dB (A) and 64 dB (A); 1% of inhabitants (i.e. 407) are exposed to noise level between 65 dB (A) and 69 dB (A); less than 1% of inhabitants are exposed to noise level above 70 dB (A)

Noise level (L night): 1% of inhabitants (i.e. 657) are exposed to noise level between 55 dB (A) and 59 dB (A); less than 1% of inhabitants are exposed to noise level above 60 dB (A)

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [12]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)		
Transposed into regional level in the MS		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		

[11] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[12] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Other (please add rows below if needed)	Health	1. Noise Protection Act; Official Gazzette No. 30/2009 2. Rulebook on drafting noise maps, noise action plans and calculation on permissible noise levels; Official Gazzette No. 75/2009 3. Noise Protection Act – Amended; Official Gazzette No. 55/2013 4. Noise Protection Act – Amended; Official Gazzette No. 153/2013 5. Noise Protection Act – Amended; Official Gazzette No. 41/2016 6. Rulebook on drafting noise maps, noise action plans and calculation on permissible noise levels - Amended; Official Gazzette No. 60/2016

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

Road vehicles.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

NAP outlines different noise reduction measures (i.e. listed in the table), and it states that the most appropriate measures for improving noise situation in critical areas are: (1) using ''silent asphalt'' for road reconstruction (2) introducing speed limits (i.e. better control of speed limits thanks to intelligent transport system (ITS) including speed cameras and cooperation with police on vehicles speed surveillance) (3) ''passive measures'': building insulation (i.e. better sound insulation with windows and doors replacement). However, Croatia does not have roads with 'quite' asphalt, yet. Furthermore, there are no laws in Croatia obliging the implementation of ''passive'' noise measures in critical noise situations.

3.3. Are there any noise limits mentioned in the NAP?[13]

According to national rules on maximum permissible noise level in work and residential areas (Official Gazzette No. 145/04), see below the table:

Zone and purpose of space	Highest immission noise level LRAeq	
	L day	L night
Hospital, resting and recovery zone	50	40
Residential zone	55	40
Mixed zones, majorly residential	55	45
Mixed zones, business and residential	65	50
Industrial zone (production, industry, storage and service)	Below 80 dB (A)	

3.4. Are these new measures or they are continuation of existing measures?

In the past 10 years, prior to this NAP (2019), there was no implementation on noise prevention program in this road area.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general: as for timeframe, NAP states: 2020 and further

3.5.2. Per reduction measure: 2020 and further

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

County Road Administration – Split is responsible for implementation and monitoring of prescribed noise measures. At the national level, the responsible institution for the implementation of Law on Noise prevention is Ministry of Health. Ministry of Health issues also licenses for engineers providing noise maps and noise action plans.

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

[13] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

No. The NAP does not give the budget estimation nor the amount of allocated funds for noise reduction.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

N/A

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

N/A

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

The public consultation on NAP was available for one month (03/07/2019-02/08/2019). The comments on NAP should be sent via e-mail. The public consultation event on NAP was organised on 12. July 2019. Furthermore, in the period of consultation, the NAP could be consulted also in administrative premises of County Road Administration – Split, every working day from 9:00-11:00 am. No comments were received from public stakeholders, so NAP was adopted as it was initially proposed. However, as a part of the present NAP, public engagement activities should continue, so the comments and complaints from public stakeholders should be taken into account at any stage of ongoing action plan.

4.2. Does the public consultation include active involvement of stakeholders?

Yes. Public stakeholders can actively take part in public hearings on spatial planning with the reference to noise measures.

4.3. Are the results of the public consultation integrated in the NAP? How?

There is no previous NAP for reference.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

NAP mentions that 'public consultation' will be constantly ongoing process during the duration of this action plan. The cooperation with public, their engagement (i.e. noise complaints, participation in new urban/spatial planning initiatives information on noise action plan implementation) and education on noise.

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. **No :** Not available, as this is the first NAP.

5.1.2. If yes, what are the results?

N/A

5.1.2.1. **Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?**

N/A

5.1.2.2. **Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)**

N/A

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The NAP will be constantly monitored and revised if needed to ensure noise protection.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		
Other (please add rows below if needed)	EU	4 Commission Recommendation 2003/613/EC concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road traffic noise and railway noise, and related emission data
	Health	5 Rulebook on the maximum permissible noise level in work and residential areas Official Gazzette No. 145/04

	Noise calculation for roads is performed according to French noise calculation method	– French national calculation method : NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB) – Law : Arrété du 5 mai 1995 relatif au bruit des infrastructures routiéres, Art. 6. XPS 31-133

7. Is there a contact person that we can contact for follow-up questions?

7.1. Please provide the details

Certified engineers for producing noise maps and noise action plans:

Ivan Bublic: ivan.bublic@hrbi.hr

Ivan Tudor : N/A

Institute for safety improvement, Osijek, representative: Ivan Babic : zzusos@os.t-com.hr (contractor for the present NAP drafting)

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Silent asphalt (4-5 dB reduction)
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	Traffic regulation: speed control, traffic re-routing (up to 3dB reduction) during day or night; reducing numbers of 'heavy' vehicles
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	Need for better laws targeting noise prevention in urban and spatial planning at national and county level ; ensure noise protection for residents during infrastructural interventions
	Path interventions between source and receiver	Road noise barriers	☒	Noise barriers: absorbing and acoustic ensuring average noise decrease between 5-10 dB; wooden walls, metal walls, concrete walls, brick walls, plastic material walls, transparent walls,
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	''Passive measures'': buildings insulation (i.e. windows, doors) (i.e. effective for noise reduction above 5dB)
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☒	Public engagement and education, noise awareness campaigns, public participation in new spatial planning initiatives

6 Denmark

6.1 National roads (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[14]

Denmark, National Roads NAP 2013:

The Danish state road network amounts to approx. 5% of the total public road network of almost 75,000km, but almost half of all road traffic is on the state road network.

The Danish Road Directorate's noise survey shows that along state roads a total of approx. 120,000 homes are exposed to noise above the limit value (58dB). Out of the 120,000 homes, approx. 11,000 have a noise burden of more than 68dB. By comparison, according to the Danish Environmental Protection Agency's statement from 2012, there were a total of approx. 724,000 homes in Denmark there was exposed to a noise level above the recommended limit value at 58 dB. Out of these 724,000 homes, about 141,000 had a noise burden of over 68dB.

Along the state roads are thus approx. 16% of the noise-polluted homes and approx. 8% of those are homes with heavy noise burdens over 68dB. The rest is located by municipal roads.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [15]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**YES**	• Executive Order no. 1309 of 21 December 2011 on mapping of external noise and preparation of noise action plans • Executive Order on mapping of external noise and preparation of action plans (Noise Executive Order) Annex 1: Official publication:

[14] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[15] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

		Lovtidende A; Number: 766 • Executive Order on mapping of external noise and preparation of action plans (Noise Executive Order) Annex 2: Official publication: Lovtidende A; Number: 766 • Executive Order on mapping of external noise and preparation of noise action plans Annex 3: Official publication: Lovtidende A; Number: 717 • Executive Order on mapping of external noise and preparation of noise action plans • Official publication: Lovtidende A; Number: 51
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

Information n/a

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

- Noise barriers
- Noise insulation of homes
- Low-noise asphalt and road maintenance

3.3. Are there any noise limits mentioned in the NAP?[16]

Generally, the Danish Environmental Protection Agency's indicative limit value for road noise in dwellings is set to 58 dB. In Denmark, a home is considered as noisy when the road noise level exceeds the recommended limit value of 58 dB. Above 68dB, it is considered very noisy.

Limit values for different types of areas:

- Recreational areas in the open country, holiday home areas, campsites, etc.: 53dB
- Residential areas, kindergartens, nurseries, schools and educational buildings, nursing homes, hospitals, allotment gardens, outdoor living areas, and parks: 58dB
- Hotels, offices, etc.: 63dB

3.4. Are these new measures or they are continuation of existing measures?

Continuation

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

2013-2018

3.5.2. Per reduction measure

Information n/a in the NAP. Presumably until the beginning of the next NAP round in 2018.

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Danish Road Directorate (an institution of the Ministry of Transport): responsible for planning, design, construction, operation, and maintenance of the state road network, including prevention and control of noise burden from traffic on state roads

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

On the construction of noise barriers: The Danish Road Directorate's criterion for designating possible noise screen projects is to accommodate the residential areas with the heaviest noise burden first (areas in which at least one dwelling is exposed to noise over L_den 68 dB), and that the project has the largest possible cost-effectiveness measured as reduced noise per invested DKK. The projects

[16] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

that give the greatest effect per krone are given the highest priority in the Danish Road Directorate's proposal for the implementation of pool funds.

The Danish Road Directorate places much emphasis on the cost-effectiveness of measures. In order to achieve this, it has planned various projects and studies, the first two of which are already implemented:

1. Development of tool for effective planning of noise barriers (see Directorate's websites: aaa.vd.dk -> Knowledge and data -> Themes -> Noise -> Noise viewer)
2. Analysis of roundabouts: Measurements and analyses in this project have shown that the changed flow of traffic in roundabouts leads to less noise in the road environment compared to ordinary intersections.
3. Testing and optimization of low-noise pavement
4. Ability to reduce noise from road surfaces noise throughout their lifetime: ongoing, annual measurements of noise and road condition to understand durability and noise reduction capabilities over many years.
5. Improvement of system for declaration of low-noise pavement
6. Demonstration projects for low-noise pavements
7. Development of more cost-effective noise barriers with testing of various designs to find most powerful noise protection
8. Development of systematic road maintenance method that takes noise abatement into consideration during ongoing road maintenance

Further, the Danish Road Directorate works with the following international projects:

- PERSUADE ("PoroElastic Road SUrface: an innovation to Avoid Damages to the Environment") to develop and test new pavements with a lot high noise reduction effect.
- COMPETT is a European project which is investigating opportunities and barriers to the introduction of electrical cars. In this project, the Danish Road Directorate is investigating the noise levels effects of using electric cars.
- NordTyre - Tire labeling and Nordic traffic noise; a joint Nordic project that aims to investigate the relationship between car tyre noise emission on typical Nordic asphalt pavements.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

No, but the overall budget of noise barriers is DKK 170. With the agreement on "A green transport policy" of 29 January 2009, a total of DKK 15 million was allocated for noise insulation of homes. Subsequently, by the agreement of 5 May 2011, an additional 7.5 million DKK was granted for noise insulation, of which 2.5 million was reserved for particularly noisy detached homes outside urban areas. The NAP states that the funds are expected to be exhausted in 2013 (year when this NAP was published).

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

The extent of the noise mapped roads in the state road network comprises 3,800km. However, the extent of noise measures is not available.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

Proposal for a noise action plan for the state roads 2013-2018 was in public consultation in the period from 3rd June 2013 to the 25th August 2013. The noise action plan could be downloaded from the consultation portal and the Danish Road Directorate's website. In addition, information on the public consultation was provided to a total of 89 affected municipalities in Denmark. The Danish Road Directorate received a total of 27 consultation responses. A total of 29 municipalities were represented in the consultation responses, while 3 consultation responses were from citizens.

4.2. Does the public consultation include active involvement of stakeholders?

See above.

4.3. Are the results of the public consultation integrated in the NAP? How?

The majority of the responses to the consultation dealt with noise issues at specific locations along the state road network, including questions and wishes about noise reduction measures. The Danish Road Directorate will prepare separate answers to these consultation responses which will be sent to the individual municipalities/citizens. Several municipalities want cooperation or dialogue regarding possible solutions, which the Danish Road Directorate is open to, according to the NAP. A small part of the consultation responses contained comments and proposals for a more general action plan, which is referred to in the NAP, with the comments from the Danish Road Directorate regarding these public responses. These responses addressed the availability of noise mappings online to the public, questions about noise mapping details, and questions about the noise insulation funds.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

One-off

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

The NAP states that in the NAP period 2008-2013, the Danish Road Directorate has completed a number of major road projects that reduced the number of noise-burdened homes through noise barriers, noise insulation of homes, or the use of low-noise asphalt. When constructing new road sections, in many cases a traffic and noise relief of existing residential/urban communities occurred due to the noise abatement projects. Overall, these projects resulted in a reduction of noise-pollution in 1,500 with burdens over 58dB.

Noise pool fund: Was started in 2009 and lasted until 2014. The total sum of the noise pool was DKK 400 million, which, according to estimations, protected about 900 homes from noise and allowed the installation of insulation in about 500 homes (over 58dB). The focus on remedying houses was on homes in heavily noise zones of above 68dB.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

According to the Noise Order, the Danish Road Directorate, an institution under the Ministry of Transport, is obliged to carry out a mapping of the noise along the state roads and to prepare a noise action plan every 5 years.

The Danish Road Directorate outlines its evaluation approach regarding the NAP and effectiveness of measures as follows:

The Danish Road Directorate continuously uses different methods for evaluation of the effect of noise reduction measures, e.g. in the calculation of the noise, or through surveys of citizens who experienced noise nuisance, before and after noise reduction measures. In 2010, the Danish Road Directorate published the report "Residents' perception of the noise at Motorring 3". The report is about the residents' experiences regarding road noise before and after the expansion of Motorring in Copenhagen.

In 2012, the Danish Road Directorate carried out an evaluation of the project for the first part of the noise insulation scheme of the noise pool comprising a total of 592 homes located by the Helsingør motorway (Gentofte), Holbækmotorvejen (Hvidovre) and Roskildevej (Ortved). The evaluation shows, among other things, that the average price for noise insulation of a single-family house is calculated at approx. DKK 77,000 (2011 prices), while the average price for noise insulation of an apartment is approx. DKK 36,000 (2011 prices).

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

7. Please provide a brief summary

Remark on this NAP:

- Very good example of national effort to investigate most cost-effective solutions

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Application of low-noise pavement and road maintenance
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	Noise barriers
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	Insulation of buildings
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

7 Germany

7.1 Regional roads – Bayreuth town (2015)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[17]

Germany, Regional Roads in Bayreuth city, NAP 2015:

Bayreuth city, number of inhabitants: approx. 75,000

Bayreuth city, area: approx. 67 km^2

Noise-affected regional roads: B22 west, B85, B2 northeast, B22 east, B2/B85, Bayreuth city ring road, south bypass. All of these regional roads (B2, B22, B85) lead through the city of Bayreuth.

Number of people affected by noise (the number of people affected in 2010 is indicated in the brackets for comparison):

- L_night:
  - >50-55dB(A): 1,300 (1,400)
  - >55-60dB(A): 700 (900)
  - >60-65dB(A): 200 (300)
  - >65-70dB(A): 0 (0)
  - >70dB(A): 0 (0)
- L_den:
  - >55-60dB(A): 1,500 (1,700)
  - >60-65dB(A): 1,300 (1,300)
  - >65-70dB(A): 700 (900)
  - >70-75dB(A): 200 (300)
  - >75dB(A): 0 (0)

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [18]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES

[17] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[18] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Directly into National law (Directive as it is)	**YES**	• Law on the implementation of the EC Directive on the assessment and management of environmental noise *Official publication: Federal Law Gazette Part 1 (BGB 1) ; Publication date: 2005-06-29 ; Page: 01794-01796*
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**YES**	• Thirty-fourth Ordinance for the Implementation of the Federal Immission Control Act (Ordinance on Noise Mapping - 34th BImSchV) • *Official publication: Federal Law Gazette Part 1 (BGB 1) ; Number: 12 ; Publication date: 2006-03-15 ; Page: 00516-00518*
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

Not really, it only indicates that motorised traffic is a source of noise and noise burdens.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

- Maintenance of road surface
- Maintenance and new construction of road
- Application of low-noise pavement
- Speed limits
- Construction of roundabouts
- Noise barriers
- Expansion and improvement of public transport system

- Expansion of cycling network
- Improved land use planning
- Optimisation of traffic light control
- Park guidance system
- Speed limits and 30km/h-zones

3.3. Are there any noise limits mentioned in the NAP?[19]

General orientation limits for noise action planning:

- Day: 67dB(A)
- Night: 57dB(A)

The Federal Immission Control Ordinance from 12.06.1990 (16. BImSchV, BGBI. I S. 1036) stipulates the following noise limits:

- Hospitals, schools, health resorts, retirement homes:
  - Day: 57dB(A), Night: 47dB(A)
- Residential areas, small residential estate areas:
  - Day: 59dB(A), Night: 49dB(A)
- Mixed use areas, central areas, villages:
  - Day: 64dB(A), Night: 54dB(A)
- Commercial/industrial areas:
  - Day: 69dB(A), Night: 59dB(A)

Noise abatement measures are (financially) supported if noise levels surpass the following limits:

- Hospitals, health resorts, retirement homes, residential areas, small residential estate areas:
  - Day: 70dB(A), Night: 60dB(A)
- Mixed use areas, central areas, villages:
  - Day: 72dB(A), Night: 62dB(A)
- Commercial/industrial areas:
  - Day: 75dB(A), Night: 65dB(A)

3.4. Are these new measures or they are continuation of existing measures?

Both. Many of the measures were already realised or are being implemented as part of this NAP. This NAP is a continuation of the NAP of the previous (first) round.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

[19] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

Not specifically stated in the NAP. The NAP is from 2014/2015 and acknowledges that noise maps and action plans should be reviewed and updated every 5 years.

3.5.2. Per reduction measure

n/a

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

City of Bayreuth: Office of Environmental Protection

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

It only refers to the reduction of dB, which varies from a 2dB to a 5dB reduction through pavement maintenance.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

Maintenance of pavement/road surface: ranging from EUR 41,000 to EUR 1 million

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

n/a

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes. The draft NAP was announced in the official gazette of the city of Bayreuth on 11.12.2015. The public had the opportunity to inspect the draft NAP from 14.12.2015 to 25.01.2016 at the local office for environmental protection and the internet homepage of the city of Bayreuth. The public was given the opportunity to submit comments until two weeks after the end of the above deadline.

4.2. Does the public consultation include active involvement of stakeholders?

No, since the public did not submit any comments. No other involvement of stakeholders is mentioned.

4.3. Are the results of the public consultation integrated in the NAP? How?

No. See Q4.2. above.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

One-off event

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

The number of people affected shifted towards the lower levels as a result of the measures implemented since 2010 and those still planned for the coming years in this NAP. In the level range 70 to 75 dB(A), at value of the 24-hour assessment level L_den decreased by about 100 persons. In the 65 to 70 dB(A) level range, the number of people affected was about 300 people less. At the 8-hour night assessment level L_night, the number of persons affected decreased similarly, but naturally at a slightly lower level. It should also be noted that the effects of general traffic-reducing or traffic-directing measures (e.g. expansion of the cycle path network, optimisation of public transport, etc.) could not be directly assessed, according to the NAP. However, the NAP acknowledges that these measures also contribute to an increasing improvement in the traffic noise situation.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The NAP does not go into detail, but it makes the general statement that noise maps and action plans will be reviewed every five years, following the requirements of the END.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

7. Please provide a brief summary

Remarks on this NAP:

- No special comments on this NAP, it is relatively standard and does not offer any innovative solutions or insights.
- Notably, regional road NAPs in Germany are not developed on a federal or regional level, but by local (city, municipality) authorities. Therefore, Germany has a high number of different local NAPs drafted by local city/town authorities.

8. Is there a contact person that we can contact for follow-up questions?

8.1. Please provide the details

City of Bayreuth: Office of Environmental Protection:

Email: Umweltamt@stadt.bayreuth.de

Telephone numbers for noise protection:

- 0921 251118
- 0921 251385

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Road surface maintenance • Application of low-noise pavement • Maintenance and new construction of road
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	• Speed limits and 30km/h zones • Expansion and improvement of public transport system
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	• Construction of roundabouts • Expansion of cycling network • Improved land use planning • Optimisation of traffic light control • Park guidance system
	Path interventions between source and receiver	Road noise barriers	☒	• Noise barriers
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

8 Ireland

8.1 Cork County roads (2013)

1. Background information

Cork County Major Roads (NAP 2013-2018): The results of the noise mapping reveal that 1% of the population of Cork County are exposed to road noise levels above 70L_{den}, which is the onset level for the assessment of noise mitigation. According to the 2011 census, the total population of Cork County was approx. 520,000.

Major roads in the NAP is defined as "Sections of road with a flow threshold of 3,000,000 vehicle passages per year (or 8,220 AADT)". The total length of road in the Cork County Council jurisdiction is approx. 12,000 km. The total length of roads in the Cork County Action Plan area is approx. 11,700 km (300 km is contained within the Cork Agglomeration). Of this road network, about 330km exceed the threshold of 3 million vehicles/year.

This NAP covers national roads and regional roads with a total flow of above 3 million vehicle passages per year, which includes the following roads:

- **Motorway Roads**
- • M8
- **National Roads**
- • N8, N22, N25, N71 & N72
- **Regional Roads**
- • R600 – Kinsale Road
- • R608 – Ballincollig
- • R617, R579 – Tower / Blarney
- • R639 – Fermoy / Glanmire
- • R623 – Little Island
- • R624 – Cobh Road
- • R630 – Midleton
- • R611, R612, R613 – Carrigaline
- • R620 – Mallow
- • R880 – Clonakilty
-
- **Population affected by road noise in Cork County:**
- For Lden<55: 302,011
- For Lden 55-59: 14,931
- For Lden 60-64: 5,401
- For Lnight<50: 314,229
- For Lnight 50-54: 9,072
- For Lnight 55-59: 6,064

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation.[20] If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law	**YES**	• ENVIRONMENTAL NOISE REGULATIONS 2006 . Official publication: Iris Oifigiúl ; Publication date: 2006-04-21
Transposed into regional level in the MS	**NO**	• Currently there is no regional or local legislation relating to noise in Cork County (as stated in the NAP)
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP only indicates that road traffic is a source of noise but does not provide a conclusive discussion on noise sources.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

Mitigation measures:

- Speed controls and speed limit reductions
- Traffic signals co-ordination (minimization of braking/acceleration at junctions)
- Alternative modes of transport (model short to public transport, bicycles, walking)
- Lower Noise Vehicles (policies to support hybrid and electric vehicles)
- Removal of rumble strips (traffic calming)
- Low noise surfaces
- Noise barriers/screens
- New tyre technologies

Land use mitigation measures:

- Set-back from roads rail
- Use of commercial development buildings as noise screens

[20] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

- Location of non-sensitive areas such as stairwells, kitchens, bathrooms on high noise side
- Enhanced façade sound insulation air tightness

1.3. Are there any noise limits mentioned in the NAP?[21]

- Day limit: 70 dB L_{den}
- Night Limit: 57dB, L_{night}

1.4. Are these new measures or they are continuation of existing measures?

Yes, continuation of existing measures.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

2013-2018

1.5.2. Per reduction measure

Data not included.

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

- Environmental Protection Agency (EPA): responsible for supervision of noise-mapping bodies and action planning authorities; provides guidance where necessary
- Cork County Council: responsible for action planning in Cork County
- National Roads Authority (NRA): responsible for noise mapping in Cork County

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Discussing cost-effectiveness, the NAP refers to a paper published on the Valuation of Noise by the Working Group on Health and Socio-Economic Aspects, which suggests an interim value of EUR 25 per dB (Lden), per household per year.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The NAP does not indicate any specific costs for noise measures. It only mentions that "[t]he effectiveness and cost of the proposed measures will be assessed to determine the most cost effective measure or combination of measures for the relevant locations requiring remediation." The following Cork Roads NAP for 2018-2023 includes the same sentence but does not mention any specific costs either.

[21] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

It does not refer to any number of km, however it mentions the roads affected by the measures:

- • N22 Ballvourney to Macroom Road Scheme
- • N25 Dunkettle Interchange Improvement Motorway Scheme
- • Cork Northern Ring Road
- • N28 Upgrade

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes, the draft NAP was available for inspection from the public for a period of six weeks from May 20, 2013 to June 28, 2013. Another two weeks was allowed for the receipt of submissions/observations on the draft action plan; the closing date for submissions was July 12, 2013.

1.11. Does the public consultation include active involvement of stakeholders?

Except for the consultation, no active involvement is mentioned.

1.12. Are the results of the public consultation integrated in the NAP? How?

A total of 5 public opinions were submitted during the period of the public inspection of the draft NAP in 2013. A summary of submissions and responses were included in Appendix F of the NAP.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Yes, the NAP describes it as a one-off event.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

The NAP only briefly discusses the Cork County NAP 2008-2013, giving no information on whether noise reduction measures were effective and by how much noise levels were reduced.

However, the NAP states that noise reduction measures have been implemented on "the M8, N20 and the N22 Ballincollig Bypass, which include mitigation measures such as noise barriers, low noise road surfacing, earth bunds etc." Other measures include traffic calming programmes, which have the effect of reducing driver speeds. Green route works are continuing in Cork County, including bus routes and corridors, cycle lanes and improving pedestrian facilities. Cycle networks have been implemented in the areas/towns of 1) Crosshaven to Carriagline Cycleway, 2) Carriageline Town, 3) Passage West to Rochestown linking with the Blackrock city route, and 4) Eyries.

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

While the NAP does not provide information on by how many dB noise was reduced (if at all), it does offer general information of noise reduction scope for each noise mitigation measure:

- Speed controls and speed limit reductions: 1-3 dB
- Traffic signals co-ordination (minimization of braking/acceleration at junctions): 1-3 dB within 50m of junction
- Alternative modes of transport (model short to public transport, bicycles, walking): 0,5 dB per 10% reduction
- Lower Noise Vehicles (policies to support hybrid and electric vehicles): 1-3 dB (if substantial changeover)
- Removal of rumble strips (traffic calming): 3-5 dB within 20m
- Low noise surfaces: 2-3 dB
- Noise barriers/screens: 3-5 dB (at 1st floor windows)
- New tyre technologies: 1-2 dB
- Set-back from roads rail: 3 dB per doubling of distance
- Use of commercial development buildings as noise screens: 10 dB on quiet façade, and screened outdoor areas
- Location of non-sensitive areas such as stairwells, kitchens, bathrooms on high noise side: 10 dB in bedrooms
- Enhanced façade sound insulation air tightness: 5-10 dB relative to current standard construction
-

~~1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)~~

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

The NAP states that the noise action planning authority will review the effectiveness of the NAP regularly by performing an annual review of the progress and effectiveness regarding noise reduction/mitigation measures.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	**YES**	**EU/Government policy:** • "Directive 70/157/EEC - relates to the permissible sound level and the exhaust system of motor vehicles and gives requirements for their measurement. This directive is continually evolving with the latest amendments up to and including 2007/34/EC, which limit maximum values between the range 74 dB(A) to 80 dB(A) depending on the vehicle category."

		• "Directive 2002/30/EC – relates to establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports. This compliments the EU key objective of the common transport policy of sustainable development." • "Directive 2008/57/EC – relates to the interoperability of the rail system within the community." • "EU Regulation 661/2009 sets out much of the detail in relation to type approval requirements for the general safety of motor vehicles, which feeds into regulation 1222/2009 [which aims at reducing fuel consumption]."
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	

Sector specific acts (aviation, rail, road)	**YES**	• Roads: "The National Roads Authority (NRA) is designated as the NMB [Noise Mapping Body] for major roads, in the Environmental Noise Regulations 2006, where such roads are classified as national roads in accordance with Section 10 of the Roads Act 1993 (No. 14 of 1993)."
		• Roads: Section 77 of the Roads Act 1993 allows the minister to "[...] make regulations requiring road authorities or the Authority to carry out works or take such other measures as are necessary to mitigate the effects of road traffic noise in respect of such types of public road constructed or improved after the commencement of this section as are specified in the regulations".
		• Guidelines relating to development affecting national roads (including motorways, national primary and national secondary roads) outside the 50/60 km/h speed limits zones for cities, towns, and villages:
		  ○ National Spatial Strategy
		  ○ Smarter Travel - A Sustainable Transport Future
		  ○ A New Transport Policy for Ireland 2009-2020

Building regulation	**NO**	• **"**Part E of the Building Regulations 1997 (S.I. no. 497 of 1997) relates to the mitigation of sound transfer between dwellings and rooms within a building. This document, updated in 1998, gives some guidance in relation to the achievement of reasonable sound insulation insofar as it relates to

		noncomplex buildings of normal design and construction."
Environment acts	**NO**	
National legislation on noise	**YES**	• Environmental Protection Agency (EPA) Act 1992: In Ireland, the principal law relating to noise is Sections 106, 107, and 108 of Part VI of the Environmental Protection Agency (EPA) Act 1992.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Traffic calming measures: removal of road bumps • Application of low noise road surface • Encouragement of environmentally friendly transport such as cycling & walking; development of pedestrian and cyclist facilities • Low noise car tyres
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	• Encouragement of use of public transport • Speed limits and controls • Encouragement of use of electric and hybrid vehicles
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	• Improved traffic management: construction of bridge crossings (road bridges and accommodation bridges), direct road links, roundabouts
	Path interventions between source and receiver	Road noise barriers	☒	• Installation of noise barriers
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	• Installation of noise insulation in buildings
	Other physical interventions	Green areas, quiet areas	☒	• Identification of quiet areas
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

9 Italy

9.1 Highway dei Fiori (2013)

1. Background information

In 2011, highway Fiori A10 Savona-Ventimiglia-French border registered between 7.6-16.3 million. It covers 113,3 km of road in Liguria region crossing 47 municipalities in Savona and Imperia. This is category A highway extra-urban.

Noise range	>55 L den	>65 L den	>75 L den
Territory km2	49	7,5	2
Buildings	3801	230	2

Highway Fiori A10	55-59 L den dBA	60 - 65 L den dBA	65 – 70 L den dBA	70 – 75 L den dBA	> 75 L den dBA
Population	23 069	6 587	1 443	144	5

Highway Fiori A10	45-49 L night dBA	50-55 L night dBA	55-59 L night dBA	60 - 64 L night dBA	65 – 70 L night dBA	> 70 L night dBA
Population	39 617	12 161	2 917	486	51	0

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [22]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)		
Transposed into regional level in the MS		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)	Adoption of Directive is proposed by different Ministries (EU Affairs,	Legislative Decree 194/05 on Implementation of Directive 2002/49 / EC relating to the

[22] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

	Environment and Territorial protection, Transport, Infrastructure, Health, Justice, Economy and Finance, Foreign Affairs, Regional Affairs)	determination and management of environmental noise; amended with Legislative Decree 42/17

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

Noise originate mostly from the source. This is A – Highway road so there are no many residential areas that interfere with noise from main highway road.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

- replacement of traditional asphalt with 'quiet' asphalt (ensuring 3dBA noise reduction): this practice is 'taken' from the nearby French pavement anti-noise practice, where traditional pavements were totally substituted with 'quieter' asphalt pavements. This is long term noise action plan strategy. Furthermore, there is also long-term plan for upgrading measuring appliances for better monitoring of noise level and the effects of implemented measures.

-noise barriers: constructed 4972m, mostly towards the part of the highway close to the French border; the height of noise barriers varies between 1m to 5m. the majority of noise barriers have the height between 2m-3m.

1.3. Are there any noise limits mentioned in the NAP?[23]

Yes: Decree of the President of the Council of Ministers (PCM) 142/04 on noise limits for certain areas and noise immision level (i.e. noise reception inside buildings).

Road	Relevant acoustic zone	Day dBA	Night dBA
A – Highway	Area A: 100m from road	70	60
	Area B: 100m - 150m from road	65	55
B – main extra-urban road	Area A: 100m from road	70	60
	Area B: 100 – 150m from road	65	55

[23] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

C – minor extra-urban road	Area A: 100m from road	70	60
	Area B: 100 – 150m from road	65	55
	Area B: 50m from road	65	55
Schools, hospitals, care and pension houses	Any area from above	50	40

Before PCM Law 142/04, the reference law was PCM law 447/95 and PCM Law of 14.11.1997. on noise classification territories in residential areas:

Zone	Leq night dBA
Schools, hospitals, care and pension houses	35
Other residential areas	40

Zone	Lday dBA
School	45

Furthermore, regarding permitted noise levels in quite zones, NAP refers to ''*Report on the definition, identification and preservation of urban and rural quiet areas*'' as recommended document in 2003 in EU Steering Group.

- 40 dBA L den for relax, contemplation and nature
- 47-53 dBA L den for pleasant conversation
- 52 dBA L den for moderate disturbing of residential area

Recommended noise limits for agglomeration:

50 dBA L den

40 dBA L den for ''best practice/ gold standard'' area

As for the identification of 'quite zones', noise maps are not detailed enough to detect 'quiet areas'.

For noise mapping, the Italian law does not use L den and L night, but the measurements in Leq (6-22) and Leq (22-6).

1.4. Are these new measures or they are continuation of existing measures?

The NAP confirms the continuation of the past measures particularly in regards to the construction of new noise barriers (2m - 5m height) nearby residential areas with highway road noise issue.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general: 2013-2017

1.5.2. Per reduction measure: no

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Highway Association Fiori SpA is responsible for drafting and implementation of this NAP. NAP is also sent for comments to the Region of Liguria and Ministry of Environment.

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Financing for noise measures for the period of this noise action plan (2013-2017) is estimated at EUR 10 million for new noise barriers installations.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

NAP does not mention costs of noise measures per dwelling or inhabitant, but

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

N/A

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

The public consultation lasted 45 days and the call for the participation for public consultation was published in 2 newspapers (i.e. La Stampa, Il Corriere mercantile). Draft NAP could be consulted at the premises of Highway Association Fiori SpA or electronically though website. Suggestions and complains on draft NAP should be submitted in written form.

As for the type of stakeholder who participated with opinions on draft NAP are majorly citizens (87%) and public institutions (13%). As for the type of request: half of request referred to the installation of noise barriers (53%), verification if permitted sound limits are respected (28%) and request for removal of heavy vehicles from some parts (i.e. viaduct bridge, stopover places) (19%). Some public stakeholders requests/suggestions are considered and included in final NAP.

1.11. Does the public consultation include active involvement of stakeholders?

No.

1.12. Are the results of the public consultation integrated in the NAP? How?

Yes. Some suggestions and complains are taken into consideration and integrated in NAP (i.e. noise control of certain areas, installing noise barriers).

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

It is 'one-off' event that lasts 45 days before the adoption of final NAP.

2. Evaluation of the NAP

2.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

2.1.1. No

2.1.2. If yes, what are the results?

National noise action plans have the duration of 15 years, so the EU NAP reporting is 'intermediary' benchmark point for the progress of national noise action plan that contains long term noise planning. As for the evaluation of past measures (2008-2012), the NAP mentions the number of km replaced with sound-absorbing asphalt (190,386km).

2.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

2.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

2.2. Is there any information how current NAP will be evaluated?

2.2.1. No

2.2.2. Yes – please provide details

Yes. The success of implemented measures should be identified though the comparison of noise maps between two consecutive rounds. As this NAP is focusing on installing noise barriers nearby critical residential areas, the future evaluation should report whether there is noise decrease in given area.

5. Legislative framework

2.3. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	Measuring description (L day, L evening, L night)	ISO 1996-2: 1987 on annual day, evening and night noise
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts	Yes	Decree Law of Ministry of Environment of 21 November 2000 obliging big infrastructure companies to write noise abatement plans including technical aspects and timeframe
		Decree Law of the President of the Republic 142/2004 on territories and applicable limit values
Other (please add rows below if needed)	French law on road noise calculation	NMPB-Routes-96 (SETRACERTU-LCPC-CSTB) as referred in Law for 10 May 1995 on road noise infrastructure and law XPS 31-133 and "Guide on land transport noise and predicted sound levels, CETUR 1980''

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☐	
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	Road noise barriers of different height (2m-5m)
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	Replacement of traditional asphalt with 'quiet' asphalt; investments in noise measuring technology
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

9.2 Torino-Alessandria-Piacenza (2013)

1. Background information

The Road section A21 Torino-Alessandria-Piacenza is connecting 3 Italian regions: Piedmont, Lombardy and Emilia Romagna and it is the part of highway Torino – Brescia. It covers 165 km. In 2011, the road traffic volume was between 10.5 – 13.4 million. The road crosses 28 municipalities in Piedmont, 20 municipalities in Lombardy and 5 municipalities in Emilia Romagna.

Region	Population – L den					
	55 - 54	55- 59	60 - 64	65- 69	70 - 74	>75
A21 Piedmont	15 741	8 199	2 654	855	412	8
A 21 Lombardy	9 387	1 963	560	138	36	6
A 21 Emilia Romagna	1 768	602	304	54	0	0
Total	26 896	10 764	3 518	1 047	448	14

Region	Population – L night							
	40 - 44	45 - 49	55 - 54	55- 59	60 - 64	65- 69	70 - 74	>75
A21 Piedmont	19 367	10 871	4 143	1 062	282	47	0	0
A 21 Lombardy	11 656	5 630	1 094	268	62	6	0	0
A 21 Emilia Romagna	3 543	759	518	135	8	0	0	0
Total	34 566	17 260	5 755	1 465	352	53	0	0

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [24]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law		
Transposed into regional level in the MS		
Urban/land use planning legislative acts		
Mobility related legislative acts		

[24] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)	Legislative Decree 194/05 on Implementation of Directive 2002/49 / EC relating to the determination and management of environmental noise	The Decree establishes the criteria for defining the noise produced by the main transport infrastructures, including airports, according to the acoustic indicator Lden, as well as the actions planned by the infrastructure managers, aimed at reducing and managing the noise produced.

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

In the public consultation, the complains from citizens referred to the noise from heavy vehicles traffic on bridge viaducts.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The Noise Action Plan (2008-2012) mentions the installation of noise barriers in different municipalities in three different regions Piedmont (54%), Emilia Romagna (25%) and Lombardy (21%) across the road section A21. The Noise Action Plan (2013-2017) also mentions the installation of new noise barriers. The other long-term measures refer to quiet noise pavements, the road maintenance and continuous noise monitoring of the effectiveness of ongoing measures.

1.3. Are there any noise limits mentioned in the NAP?[25]

In the absence of conversion of national laws on noise limits (L eq) in L den and L night, the following national laws are considered as a reference to noise limit values required by the END:

(1) Decree of the President of the Council of Ministers 142/04 on noise limits for certain areas

Road	Day	Night
Area A – 100m from road	70 dBA	60 dBA

[25] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (the combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

Area B – 100 – 250m from road	65 dBA	55 dBA

1.4. Are these new measures or they are continuation of existing measures?

Both. However, old and new measures refer to noise barriers.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general: it refers to 5 years plan

1.5.2. Per reduction measure

1.6. What actors are responsible for the implementation of the measures?

Competent authorities for drafting action plan for road section A21 refer to region Piedmont (Municipality of Torino assists in plans drafting other interested municipalities in the region) , the Lombardy region (Municipality of Milan) and the region Emilia Romagna.

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

No cost-benefit analysis for the present NAP, but it mentions that the implementation of the NAP will allocate € 12,590,000 for the installation of new noise barriers accroas the road section A21 between 2013-2017.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant. N/A

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc. N/A

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes. Three groups of stakeholders have presented their opinions: citizens, NGOs and public authorities (municipality, province, region). The majority of opinions were presented by citizens (72%) and then by public authorities (28%). The main request is the installation of noise barriers (89%) and then annoyance for passing heavy vehicle on viaduct bridges (11%).

1.11. Does the public consultation include active involvement of stakeholders?

Yes. The public consultations were published in 4 national journals (La Repubblica Nazionale, La Repubblica Torino, La Repubblica Milano, La Repubblica Bologna). The web page SATAP (www.satapweb.it) , section "Acoustics" and phone call consultations to Technical Office in Torino were available channels for gathering documents for consultations. The consultation period was 45 days. The documents were sent via post.

1.12. Are the results of the public consultation integrated in the NAP? How?

The requests deriving from the public consultations are firstly assessed in relations to planned actions and the state of National Noise Abatement Plan and then considered for European Noise Action Plan in order to avoid the duplication of effort.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

The public consultations for NAP lasts 45 days. However, there are other periodical revisions for the assessments of national Noise Abatement Plans.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. **Yes.** For NAPs (2008-2012) there are two phases of evolution on single planned noise intervention (i.e. noise barrier). The first phase is referring to NAP and which measures were implemented. The second (experimental) phase is referring to evaluating effectiveness of measures coming from national laws (tests).

1.14.2.1. The noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

No mention in dB reduction per single measure. However, NAP provides table of the situation in 2013 and expected reduction in the number of people in 2017.

1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

No mention in evaluation part.

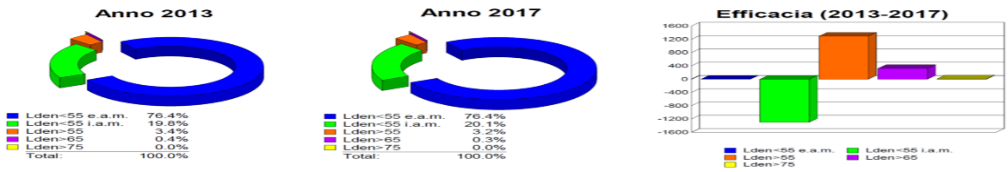
1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. **Yes**. It will be evaluated in two phases (as in the previous round). In evaluation part, the NAP presents different tables per categories territorial synthesis: resident population, dwellings. Each table, chart and graph contains different L den and L night noise categories in relation to (1) the number of people exposed to environmental noise in 2013, (2) expected results following new measures in 2017 and (3) expected efficiency (increase or decrease of people exposed to environmental noise.). The data are represented for the whole road section, as well as , for each region (Piedmont, Lombardy and Emilia Romagna).

Efficacia del piano d'azione

Popolazione Esposta	Lden < 55 Esterno a.m.	Lden < 55 Interno a.m.	Lden > 55	Lden > 65	Lden >75
Anno 2013	321680	83463	15790	1508	14
Anno 2017	321680	84758	14495	1185	6
Efficacia (2013-2017)	0	-1295	1295	323	8



NAP table in evaluation part (2013-2017)

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES

International regulations/standards (especially in aviation)			
Urban/land use planning legislative acts			
Mobility related legislative acts			
Sector specific acts (aviation, rail, road)			
Building regulation			
Environment acts	Yes	Decree Law 447/1995 on Noise Pollution	
		Decree Law of Ministry of Environment of 21 November 2000 obliging big infrastructure companies to write noise abatement plans including technical aspects and timeframe	National noise abatement plans is written for the period of 15 years, but it can be periodically revised.
		Decree Law of the President of the Republic 142/2004 on territories and applicable limit values	
		Decree Law of Ministry of Environment and Protection of Land and Sea of 25 March 2008 on noise abatement plan relevant to road A21 Torino-Alessandria - Piacenza	SATAP SpA (a branch of National Company for Roads - ANAS) prepared the national noise abatement plan for 15 years period. There are two phases. The first phase ends on 1 January 2014. The second phase starts after the evaluation of the first phase and runs in parallel with the END 2nd round
		Decree Law of Ministry of Environment and Protection of Land and Sea of 11 March 2011 on noise abatement plan relevant to road A21 Torino-Alessandria - Piacenza	SATAP SpA (a branch of National Company for Roads - ANAS) prepared the noise abatement plan.

Other (please add rows below if needed)	Regional law	
	The Emilia Romagna	Regional Law 15 of 9 May 2001 Provisions on environmental protection from noise pollution
	Piedmont	Regional Law 52 of 20 October 2000 Provisions on environmental protection from noise pollution
		Regional Council Decree number 85 – 3802 of 6 August 2001 Acoustic criteria for territory's classification
	Lombardy	Plans for Acoustic Zones for municipalities in the Lombardy region are in the adoption phase

Type	Noise solutions	Examples	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	
		Restricted access zone, traffic restrictions, truck restrictions	
	Infrastructure interventions	Building tunnels, the transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	
	Path interventions between source and receiver	Road noise barriers	Noise barriers
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	Quiet road surfaces (asphalt), road maintenance
	Other physical interventions	Green areas, quiet areas	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	

10 Latvia

10.1 National roads (2014)

1. Background information

Major/National Roads Latvia (NAP 2014):
In 2014, Latvia had approximately 2 million inhabitants. Following the END, noise action plans were developed for sections of major/national roads with a total length of 191.5 km; preparing new action plans for sections with a total length of 156.3 km and reviewing the action plans developed in 2009 for sections amounting to a length of 35.2 km.

Number of people living in dwellings exposed to a certain noise level (based on 2012 noise mapping):

Noise indicator	Noise level in dB(A)					
	50-54	55-59	60-64	65-69	70-74	>75
L_day	14 942	6 426	3 105	760	167	16
L_evening	9 324	5 324	1 365	484	65	0
L_night	5 434	1 704	495	87	0	0
L_den	Noise zone not evaluated according to methodology	8 031	4 307	969	351	31

Number of dwellings exposed to a certain noise level (based on 2012 noise mapping):

Noise indicator	Noise level in dB(A)					
	50-54	55-59	60-64	65-69	70-74	>75
L_day	2192	926	419	200	35	1
L_evening	1481	624	293	111	9	0
L_night	620	299	126	15	0	0
L_den	Noise zone not evaluated according to methodology	1248	536	259	80	5

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation.[26] If possible, arrange it in the following table:

[26] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law	YES	• Cabinet Regulation No. 16 of 7 January 2014 "Procedures for Noise Assessment and Management" (prescribing the procedure for the development of action plans). Official publication: Latvijas Vēstnesis; Number: 16 (5075); Publication date: 2014-01-23. • Law on Pollution (stipulating that the development of action plans for roads is ensured by the Ministry of Transport). Official publication: Latvijas Vēstnesis; Number: 51; Publication date: 2001-03-29 • Law on Administrative Procedures. Official publication: Latvijas Vēstnesis; Number: 164; Publication date: 2001-11-14 • Cabinet Regulation No. 579 of 13 July 2004 Procedures for Environmental Noise Assessment. Official publication: Latvijas Vēstnesis; Number: 112; Publication date: 2004-07-16 • Cabinet Regulation No. 983 of 30 November 2004 "Amendments to Cabinet Regulation No. 597 of 13 July 2004" Procedures for Environmental Noise Assessment "". Official publication: Latvijas Vēstnesis; Number: 193; Publication date: 2004-12-06 • The law (Likums). Official publication: Latvijas Vēstnesis; Number: 25; Publication date: 2005-02-15 • Amendments to Cabinet Regulation No. 597 of 13 July 2004 "Procedures for Environmental Noise Assessment". Official publication: Latvijas Vēstnesis; Number: 23; Publication date: 2006-02-08 • Amendments to Cabinet Regulation No. 597 of 13 July 2004 "Procedures for Environmental Noise Assessment". Official publication: Latvijas Vēstnesis; Number: 37; Publication date: 2010-03-05
Transposed into regional level in the MS	NO	
Urban/land use planning legislative acts	NO	
Mobility related legislative acts	NO	
Sector specific acts (aviation, rail, road)	NO	

Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The main sources of road noise are traffic intensity, speed, vehicle composition, and the quality of the road surface, according to the NAP.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here.

The NAP outlines the following points regarding the implementation of measures:

- Referring to the information provided by SJSC "Latvijas Valsts ceļi" on the available state budget funds and the list of maintenance and renovation works of priority roads, the implementation of noise reduction measures in the next five years is not planned. The implementation of the noise reduction measures specified in the NAPs is possible only within the framework of the long-term plan, provided that funds for the implementation of the measures will be allocated from the state budget.
- The "National Road Improvement Program for 2014-2020" includes the improvement of the quality of road surfaces on several road sections within the next 5 years. Maintaining the quality of road surfaces within the framework of these action plans has not been assessed as a noise reduction measure, but it is considered a priority measure to avoid the deterioration of the noise situation.

Noise abatement measures that Latvia will take are (as mentioned in the NAP):

- Construction of road bypasses (in Baltezers, Sigulda, Ķekava and Iecava)
- Construction of noise barriers and ground embankments (in Salaspils, Saulkalne, Ikšķile, Vangaži)
- Information events: Informing construction planners of the impact of noise and their responsibility to reduce noise levels
- Research on quiet pavement: conducting research on available silent pavement materials, suitability analysis, testing, and development of regulatory framework of use for pavement conditions in Latvia (pavement durability and properties in winter conditions, acoustic efficiency, maintenance, and construction costs)

1.3. Are there any noise limits mentioned in the NAP?[27]

[27] Typology of noise units:
- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)

Noise limit values specified in Cabinet Regulations No. 16 of 7 January 2014:

- Areas with residential houses (detached houses, low-rise or single-family houses), children's institutions, medical treatment, health and social care institutions:
    - L_day 55dB(A), L_evening 50dB(A), L_night 45dB(A)
- Multi-storey residential building areas:
    - L_day 60dB(A), L_evening 55dB(A), L_night 50dB(A)
- Areas with public buildings (public and administrative buildings, including cultural, educational, scientific, state, and municipal administrative institutions, and hotels; with residential buildings):
    - L_day 60dB(A), L_evening 55dB(A), L_night 55dB(A)
- Mixed construction area, including trade and service construction area (with residential construction):
    - L_day 65dB(A), L_evening 60dB(A), L_night 55dB(A)
- Quiet areas in populated zones:
    - L_day 50dB(A), L_evening 45dB(A), L_night 40dB(A)

Moreover, according to the NAP, the Cabinet Regulation No.16 of 7 January 2014 stipulates that in protection zones along motorways and areas which are closer than 30 m from stationary noise sources, the established noise limit values shall be considered as target values.

1.4. Are these new measures or they are continuation of existing measures?

Yes, continuation of the NAP of 2009.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

2013-2018

1.5.2. Per reduction measure

After an analysis of the noise abatement measures, it was found that the measures of the NAP could reduce high noise levels significantly and improve the situation for over 4,600 dwellings, affecting a population of 41,000.

The NAP additionally specifies the following: If the construction of the Kekava bypass is commissioned in the next five years, the noise impact level would decrease for approximately 3,000 residents.

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

State Joint Stock Company (SJSC) Latvian State Roads (VAS Latvijas Valsts ceļi)

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

It is only mentioned that a planned measure should ensure the maximum possible noise level reduction. Additionally, the implementation costs of the measure should not exceed the average price level of the implementation of similar measures.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

- L_den (average noise during the day_evening_night)

The NAP states that in order to implement all the planned measures, approx. EUR 26 million will be needed, of which EUR 20.8 million is state funding and EUR 5.2 million municipal financing.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

In accordance with the set objectives of noise solution planning, noise barriers with a total length of 35.4 km and ground embankments with a total length of 4.2 km are planned in high noise zones.

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes, on 11 February 2014, a public consultation of the draft action plans was commenced. The public was informed about this through an announcement in the newspaper "Latvijas Vēstnesis". Information on the draft NAP and the public consultation was posted on the website of the Ministry of Transport and sent to regions and territories affected by the NAP. The draft NAP was also available on the website of SJSC Latvijas Valsts ceļi during the public consultation.

1.11. Does the public consultation include active involvement of stakeholders?

Yes, to some extent. During the public consultation, 20 proposals on the developed action plans were received from residents, municipalities, and congregations. Comments were made on the content, planned noise abatement measures, and their implementation described in the draft NAP.

1.12. Are the results of the public consultation integrated in the NAP? How?

An overview and discussion of the received comments by the public was included in the full version of the NAP.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Yes, it was a one-off event.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

Noise action plans are reviewed at least once every five years and revised in the event of changes affecting the existing noise situation. The evaluation of the results of the NAP implementation will be performed in 2018 by SJSC Latvian State Roads (Latvijas Valsts ceļi). During this assessment, the implementation of planned measures, their current status, and the results of implemented measures will be summarised. The information gained from this evaluation will be taken into account during the review of the 2014 NAP and the following NAP period.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**YES**	• Cabinet of Ministers Regulation No. 240 "General Regulations for Spatial Planning, Use and Building", adopted on 30 April 2013, Paragraph 147 stipulates that when planning new residential and public building territories, they shall be provided in places where the impact of roads, railways and airfields, as well as other polluting objects does not exceed the pollution limit values specified in regulatory enactments in the field of pollution.
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

7. What are the questions that remained un-answered after reviewing the NAP and consulting respective online sources?

- Was a cost-benefit or cost-effectiveness analysis made? If yes, what were the calculations?
- What were the costs of each noise measure (per km, dwelling, or inhabitant)?
- Is there any information on the evaluation of previous NAPs and individual noise reduction measures?
- (What was the timeframe for implementation of the above-mentioned measures per reduction measures?)

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Maintenance & improvement of road surface
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	• Construction of 4 bypasses (in Baltezers, Sigulda, Ķekava and Iecava)
	Path interventions between source and receiver	Road noise barriers	☒	• Construction of noise barriers and ground embankments (in Salaspils, Saulkalne, Ikšķile, Vangaži)
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☒	• Information events/initiative for construction planners regarding the importance of noise reduction • Research on low-noise pavement to find optimised pavement solution for Latvia

11 Lithuania

11.1 National roads (2014)

1. Background information

Major Roads Lithuania (2014-2018 NAP):

- The noise mapping for the second round was conducted in 2011 and covered 570.25 km of all major roads, i.e. the network of roads with more than 3 million vehicle passages per year (28 road sections).

  Results of strategic noise mapping (situation in 2011):

  Estimated area of exposure to excess noise according to L den (> 65 dB):

- Area - 82.28 km2 (including:> 75 dB - 16.52 km2).
- Approximately 1,200 people live in this area (500 dwellings). 12% of them live in noise-insulated dwellings (replaced windows; noise barriers).
- There are no schools or hospitals in this area.

  Estimated number of people exposed to excessive noise exposure according to the L night indicator (> 55 dB):

- Approximately 2,000 people. 7% of them live in noise-insulated dwellings (replaced windows; noise barriers).
- There are no hospitals in the zone according to the Lnight indicator (> 55 dB).

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation.[28] If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law	YES	• Law of the Republic of Lithuania on Noise Management, 2004 October 26 No. IX – 2499 (Official Gazette, 2004, No. 164–5971 with subsequent amendments Official Gazette, 2006, No. 73-2760; Official Gazette, 2010, No. 51-2479; Official Gazette, 2013, No. 79- 3988). • Law of the Republic of Lithuania on Noise Management No. Law IX-2499 Amending Articles 2, 5, 7, 8, 9, 11, 13, 14, 17, 18, 24, 26, 27, 29 and repealing Articles 19, 20 XII-2341 Official publication: Register of Legislation; Number: 2016-13907; Publication date: 2016-05-24 • Government of the Republic of Lithuania 2018 April 4 Resolution no. 321 "On the Implementation of the Law on Noise Management of the Republic of Lithuania". Official publication: Register of Legislation; Number: 2018-06179; Publication date: 2018-04-18

[28] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

		• Government of the Republic of Lithuania, 2004 August 18 Resolution no. 967 "On the Approval of the Description of the Procedure for Strategic Environmental Assessment of Plans and Programs". Official publication: State News; Number: 130; Publication date: 2004-08-21 **Noise mapping:** • State Strategic Noise Mapping Program. Resolution of the Government of the Republic of Lithuania No. 581, 2006 June 14 (Official Gazette, 2006, No. 68-2508; Official Gazette, 2006, No. 71 (correction)). • Government of the Republic of Lithuania, 2008 July 16 Resolution no. 719 "On the Implementation of the State Strategic Noise Mapping Program for 2008-2012. approval of the plan of measures" (Official Gazette, 2008, No. 84-3356). • Minister of Transport and Communications of the Republic of Lithuania 2006 July 24 Order No. 3-304 "On the Implementation of the State Strategic Noise Mapping Program and Approval of the List of Responsible Executors". **Noise action plans:** • Government of the Republic of Lithuania 2007 June 6 Resolution no. 564 "On the State Noise Prevention Actions for 2007-2013. approval of the program" (Official Gazette, 2007, No. 67-2614). • Government of the Republic of Lithuania 2009 March 4 Resolution no. 157 "On the State Noise Prevention Actions for 2007–2013. implementation of the program for the period 2009-2013 approval of the plan of measures" (Official Gazette Valstybės žinios, 2009, No. 28-1087). **Reporting to the EU and Implementation:** • Minister of Health of the Republic of Lithuania, Minister of Environment of the Republic of Lithuania and Minister of Transport and Communications of the Republic of Lithuania October 25 order no. V-787 / D1- 507 / 3-467 "On the Approval of the Rules for Reporting on the Implementation of the Requirements of the Legislation of the European Union Noise Management Sector to the Commission of the European Communities" (Official Gazette Valstybės žinios, 2005, No. 128-4621). • Government of the Republic of Lithuania 2007 December 5 Resolution no. 1305 "On Approval of the Rules for Provision of Initial and Summary Noise Management Information to the Noise Prevention Council, State and Municipal Institutions and the Public" (Official Gazette Valstybės žinios, 2007, No. 132-5380 with subsequent amendments Official Gazette Valstybės žinios, 2010, No.:59-2897; ., 2010, No. 64-3154; Official Gazette 2012, 58-2898).

		• Minister of Health of the Republic of Lithuania, 2007 July 19 order no. V-616 "On the approval of information formats for reporting to the Commission of the European Communities on the implementation of Directive 2002/49 / EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise" (Official Journal 2007, No 83-3406). • Government of the Republic of Lithuania 2006 March 27 Resolution no. 299 "On the Government of the Republic of Lithuania April 7 Resolution no. Amendment 388 "On the approval of the procedure for submission of reports to the European Commission on the implementation of the legislation of the European Union in the field of environment and submission of the information required for the preparation of reports to the European Environment Agency". Official publication: State News; Number: 35; Publication date: 2006-03-30 • Resolution No. 938 of the Government of the Republic of Lithuania of 24 September 2008 On Resolution No. 388 "On the Approval of Procedures for the Submission of Reports Relating to the Implementation of European Union Environmental Legislation to the European Commission and for the Preparation of Information Required for Reporting to the European Environment Agency". Official publication: State News; Number: 112; Publication date: 2008-09-30 • Minister of Health of the Republic of Lithuania 2017 May 16 order no. V-558 "On Order No. V-616 of the Minister of Health of the Republic of Lithuania of 19 July 2007" On Information Required for Reporting to the Commission of the European Communities on Directive 2002/49 / EC of the European Parliament and of the Council of 25 June 2002 on the preparation of the implementation of the assessment and management of environmental noise, the "amendment" of the approval of submission forms. Official publication: Register of Legislation; Number: 2017-08230; Publication date: 2017-05-16 • Minister of Health of the Republic of Lithuania, Minister of Environment of the Republic of Lithuania and Minister of Transport and Communications of the Republic of Lithuania 2017 June 21 order no. V-787 / D1-541 / 3-279 "On Order No. V-787 / D1-507 / 3-467 of the Minister of Health of the Republic of Lithuania, the Minister of Environment of the Republic of Lithuania and the Minister of Transport and Communications of the Republic of Lithuania of 25 October 2005" "Amendment" to the approval of the rules for reporting to the European Commission on the implementation of the requirements of the legislation of the European

		Union noise management sector. Official publication: Register of Legislation; Number: 2017-10622; Publication date: 2017-06-23 **Environmental Assessment:** • Resolution No. of the Government of the Republic of Lithuania of 23 December 2014 1467 on Resolution No. 1467 of the Government of the Republic of Lithuania of 18 August 2004 967 "On Amendment to the Description of the Procedure for Strategic Environmental Assessment of Plans and Programs". Official publication: Register of Legislation; Number: 02014-20928; Publication date: 2014-12-30 **Noise limit values:** • Lithuanian Hygiene Standard HN 33: 2011 "Noise Limit Values in Residential and Public Buildings and Their Environment", approved by the Minister of Health of the Republic of Lithuania on 13 June 2011. by order no. V-604 (Official Gazette, 2011, No. 75-3638).
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP does not refer to any specific sources of noise except road traffic.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

- Construction of bypass routes around towns
- Road noise barriers
- Replacement of windows for individual residential buildings
- Greenery/green spaces for the protection of individual residential buildings
- Application of quiet road pavement
- Traffic management (restriction of heavy goods vehicles, diversion; speed)

1.3. Are there any noise limits mentioned in the NAP?[29]

For residential buildings (houses) and public buildings (excluding catering and cultural buildings) in an environment exposed to traffic noise:

- L_den: 65 dB(A)
- L_day: 65 dB(A)
- L_evening: 60 dB(A)
- L_night: 55 dB(A)

1.4. Are these new measures or they are continuation of existing measures?

Yes, continuation of existing measures (1st round of NAP).

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

2014-2018

1.5.2. Per reduction measure

No data available.

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Lithuanian Road Administration under the Ministry of Transport and Communications of the Republic of Lithuania

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

The NAP does not refer to the cost-effectiveness of the measures.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

- It mentions the cost of the following planned measures in Lithuanian litas (Lt.) (Euro was introduced only in 2015, after release of this NAP):
- Palanga bypass:123 574,880 Lt.
- Priekulė bypass: 41 403,157 Lt.
- Radviliškis noise barrier: 2 589,960 Lt.
- Žiežmariai noise barrier: 2 311,100 Lt.
- Biruliškių village noise barrier: 695,240 Lt.
- Giraitė village noise barrier: 3 379,936 Lt.
- Ilgakiemio village noise barrier: 1 109,328 Lt.
- Išlaužo village noise barrier: 1 900,068 Lt.
- Juragių village noise barrier: 3 453,280 Lt.

[29] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

- Moluvėnų village noise barrier: 2 674,000 Lt.
- Nemėžio village noise barrier: 1 680,800 Lt.
- Pakumprio village noise barrier: 440,064 Lt.
- Stanaičių village noise barrier: 1 528,000 Lt.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

The NAP mentions the assessment of traffic noise and preparation of recommendations on the need to repair existing road noise barriers along the A1 Vilnius-Kauna-Klaipeda section (37-40km) near Vievis city.

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

No information on public consultations included in the NAP.

1.11. Does the public consultation include active involvement of stakeholders?

Information not available.

1.12. Are the results of the public consultation integrated in the NAP? How?

Information not available.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Information not available.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

The NAP states that measures such as quiet asphalt, noise barriers, and remedies for homes exposed to noise have been planned and/or implemented in the context of the 2009-2013 NAP. It is not indicated whether these measures have led to a reduction of noise.

1.14.2. If yes, what are the results?

~~1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.~~

~~1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)~~

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

It does not mention how exactly the NAP will be evaluated, but it does mention that an estimated 43% of people exposed to excessive noise levels will be protected as a result of the 2014-2018 NAP.

~~1.15.2. Yes – please provide details~~

6. Legislative framework

1.16.Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	NO	
Urban/land use planning legislative acts	NO	
Mobility related legislative acts	NO	
Sector specific acts (aviation, rail, road)	NO	
Building regulation	NO	
Environment acts	NO	
Other	NO	

7. What are the questions that remained un-answered after reviewing the NAP and consulting respective online sources?

- Was there a public consultation in the 2014-2018 round? If yes, please provide details.
- Was a cost-benefit analysis of the measures created? If yes, what were the calculations and assessments?

Sources:

NAP round 3 (2019-2023): http://lakd.lrv.lt/lt/veiklos-sritys/triuksmo-valdymas/triuksmo-prevencijos-veiksmu-planai/iii-etapas-1

NAP round 2 (2014-2018; only NAP summary available on official website): http://lakd.lrv.lt/lt/veiklos-sritys/triuksmo-valdymas/triuksmo-prevencijos-veiksmu-planai/ii-etapas

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Construction of bypasses going around towns • Application of quiet road pavement
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	• Restriction of permissible speed limits
		Restricted access zone, traffic restrictions, truck restrictions	☒	• Traffic manage ment: restricti on of heavy goods vehicles, diversio n
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	• Installation of road noise barriers
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	• Replacement of windows in individual residential buildings for noise protection
	Other physical interventions	Green areas, quiet areas	☒	• Installation of greenery/green spaces for noise protection of individual residential buildings
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

12 Malta

12.1 General noise action plan focusing on mainly on roads (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[30]

Malta, NAP 2013:

Since in Malta only the major roads fall within the criteria for the first reporting round, the strategic noise maps do not include agglomerations, railways, or major airports.

For the second reporting round, it was identified that Malta does not have an agglomeration with more than 250,000 inhabitants, no major airports having more than 50,000 movements per year, and no railways. Malta's agglomeration is made up of 243,746 inhabitants and covers an area of 65.8km^2. Therefore, this agglomeration will be used for the second and subsequent rounds. Information available from the airport indicates that in 2006 there were a total of 24,711 aircraft movements.

Total population: 514,564 (2019 data)

Total area: 316 km^2

Malta's NAP implementation timeline:

- Year 1: Extent of noise exposure when assessment is considered necessary
- Year 2: Review strategic noise maps to identify priorities
- Year 3: Confirming extent of impact
- Year 4: Review possible mitigation measures and cost-benefit analysis undertaken for each mitigation measure
- Year 5: Recommendations for action

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [31]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**YES**	• Regolamenti ta' l-2004 dwar Valutazzjoni u Maniggjar ta' Hsejjes fl-Ambjent taht l-ATT TA' L-2001 DWAR IL-HARSIEN

[30] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[31] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

		TA' L-AMBJENT (KAP. 435) *Official publication: The Malta government gazette; Number: 17,571*
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

No, it does not.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

According to the NAP, there are no specific noise abatement measures that Maltese authorities plan to implement in this round. Since the noise action planning is in its early stages in Malta, the NAP discusses the various measures that could be applied to reduce noise.

The reduction measures focus primarily on 1) noise reduction at source, 2) operating restrictions to reduce noise emissions and 3) any procedures to reduce noise impacts.

The lists below indicate potential measures that Maltese government may implement.

<u>A non-exhaustive list of measures may include:</u>

- Vehicle noise emissions and tyre noise regulations based on EU levels
- National planning guidance or noise regulations based on a national level
- Transport policy objectives may be set at national level;
    - Improving public transport;
    - Getting people out of cars; and
    - Increasing bus and bicycle journeys.

<u>On a national and local level, the designated authority has powers to:</u>

- Replace diesel vehicles with Compressed natural gas / electric;
- Control truck routes;
- Restrict night-time deliveries;
- Issue planning permissions keeping in mind noise effects;
- Enforce speed limits;
- Close roads and/or re-route traffic;
- Re-surface roads;
- Control planning zones;
- Impose façade insulation;
- Erect noise barriers;
- Form public liaison groups; and
- Have long-term targets.

Roads authorities could undertake the following:

- Traffic management – routes and HGVs;
- New road construction (bypass);
- Re-surface roads;
- Vehicle speed management;
- Noise screening measures; and
- Façade insulation measures.

3.3. Are there any noise limits mentioned in the NAP?[32]

- Prior and after to the adoption of the Environment Noise Directive 2002/49/EC there are no limit values in force or under preparation.
- The proposed onset levels, for assessment of noise mitigation measures due to exposure to road traffic noise are:

L_den = 65dB

L_night = 55dB

- The identification and noise preservation of the quiet areas in the vicinity of a major road is considered to be below the proposed onset level at:

L_den: 55dB

L_night: 45dB

The preservation of relatively quiet areas in open countryside will also be considered.

[32] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

3.4. Are these new measures or they are continuation of existing measures?

New measures

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

- For short-term objectives (=finalization of all reporting obligations under the first round of the END): implementation by 2012
- For medium-term objectives (=strategic noise mapping for second round, improvement of stakeholder engagement, NAP planning): 2012-2017
- For long-term objectives (=improve quality of datasets and mapping results, developing of planning guidance, introducing noise limits, increase institutional capacity for implementation of strategic noise mapping and noise action planning, report results of noise mapping to the EC on 5-year cycle): within 10 years

3.5.2. Per reduction measure

n/a

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The Malta Environment and Planning Authority (MEPA) is responsible for the drafting and implementation of the NAP. MEPA collaborated with the noise consultants (Acustica Ltd) for the noise mapping and with Transport Malta for the management of traffic networks.

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Considering that the Maltese government does not refer to any specific measures it plans to implement, data on the cost-effectiveness of specific measures is not available.

Generally, the NAP states that "a cost benefit analysis is currently the best procedure considered to maximise good value for money and to benefit from investment. This analysis will be achieving the targets of lifetime construction and that of maintenance cost against noise reduction benefit."

According to the NAP and noise mapping report carried out by Acustica, studies show that monetisation of noise is the most common approach to process this analysis. These studies show that the monetary assessments of noise levels are based on two different approaches: (a) impact upon property market value and (b) whether residents are willing to pay for noise mitigation measures. Both approaches may lead to differing suggested levels of financial benefit. When the cost-benefit analysis is undertaken, the appropriate valuation and research will be reviewed using the best available research data.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

n/a

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

n/a

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes. The Draft Noise Action Plan was published for public consultation on the MEPA website www.mepa.org.mt. The general public was invited to submit comments on this plan for 4 weeks starting on June 1, 2020.

The public consultation initiative also included a number of presentations with key stakeholders. A presentation organised for the general public by the Malta Environment and Planning Authority in collaboration with the Malta-EU Steering and Action Committee (MEUSAC) was also held on June 13, 2011. Furthermore, a number of media events were organized targeting information on the Draft Noise Action Plan.

4.2. Does the public consultation include active involvement of stakeholders?

Yes, see Q4.1.

4.3. Are the results of the public consultation integrated in the NAP? How?

Not mentioned in the NAP.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

Series of different events over the course of a limited time period

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

A committee composed of representatives from three authorities in Malta; Transport Malta, Department of Health and headed by Malta Environment and Planning Authority (including environment / planning directorate and mapping unit) is expected to be set up and tasked with overseeing the implementation of this plan. The objectives of this committee is (a) to review the effectiveness of noise action planning activities on on-going activities by performing an annual review of the progress made in relation to programmed activities (b) to improve stakeholder engagement and improve the collaboration on strategic noise mapping and noise action planning and (c) to consider the effectiveness of the proposed measures for combating local environmental noise exposure.

In an effort to ensure the proper achievement of the objectives of the plan, it may be opportune to adjust the timing of planned activities in order to optimise delivery.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	
Environment acts	**NO**	
Other (please add rows below if needed)	**NO**	

7. Please provide a brief summary

Remarks on this NAP:

- The table below is not applicable for this NAP, since noise action planning is in its infancy in Malta. Therefore, no particular noise abatement measures are planned in the 2013 NAP (second round). The NAP for the third round is in progress and not yet published by the government of Malta.
- Round two closed consultation update (2019):
- https://meae.gov.mt/en/Public_Consultations/MSDEC/Pages/Consultations/IntentandObjectivesUpdatetoMaltasNoiseActionPlan.aspx

8. Is there a contact person that we can contact for follow-up questions?

8.1. Please provide the details

Any communication regarding the Noise Action Plan should be addressed to:

Malta Environment and Planning Authority (MEPA)

Unit D: Waste, Air, Radiation and Noise

Unit Manager

Email: noiseplan@mepa.org.mt

Telephone: 00356 2290 7200

Fax: 00356 2290 2281

(contact details potentially outdated)

MEPA's address is:

St Francis Ravelin,

Floriana,

FRN1230.

13 Netherlands

13.1 National roads (2013)

1. Background information

National Roads, Netherlands (2014 NAP, round 2013-2018):

The Netherlands had approx. 17 million in habitants in 2014. More than 95% of the total Dutch national road network has an intensity of more than six million vehicles per year.

Noise and annoyance levels on national road during 24-hour period measured in 2011:

Noise levels in dB	**Number of dwellings**	**Number of people**	**Number of people annoyed by the noise**	**Number of people that find the noise highly annoying**
55 - 59	56.200	129.400	27.200	10.300
60 - 64	14.500	33.300	10.000	4.300
65 - 69	3.600	8.300	3.400	1.700
70 - 74	400	1.000	600	300
75 and above	0	0	0	0

Comparison of number of dwellings (including dwellings in agglomerations) in noise classes for the 24-hour period (Lden):

Noise exposure (in dB)	**Noise map 2006**	**NAP 2008**	**Noise map 2011**
55 - 59	76.100	69.400	56.200
60 - 64	21.100	18.000	14.500
65 - 69	5.200	3.500	3.600
70 - 74	1.000	600	400
75 and above	100	0	0

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation.[33] If possible, arrange it in the following table:

HOW END IS TRANSPOSED	**YES/NO**	**NOTES**
Transposition in the national law	**YES**	• Dutch Noise Abatement Act; • Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of Directive No 2002/49/EC of the European Parliament and of the Council of the European Union of 25 June 2002 relating to the assessment and management of environmental noise, OJEC L

[33] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

		189 (noise maps and action plans). Official publication: Official Journal (Bulletin des Lois et des Décrets royaux) ; Number: 2004/338 ; Publication date: 2004-07-15 ; Page: 00001-00008
Transposed into regional level in the MS	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Buildings regulation	**NO**	
Environment acts	**YES**	• The action plan has been drawn up within the framework of Section 11.2 of the Environmental Management Act. • Article 11.14 of the Environmental Management Act describes the procedure for adopting the action plan. Preparation is carried out in accordance with the procedure laid down in Section 3.4 of the General Administrative Law Act. Contrary to Article 3:15 of the General Administrative Law Act, 'anyone' may submit an opinion (public consultation). • Decree of 6 July 2004, containing rules relating to the representation and management of environmental noise and entry into force of the Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of the Environmental Noise Directive (Environmental Noise Decree). Official publication: Official Journal (Bulletin des Lois et des Décrets royaux) ; Number: 2004/339 ; Publication date: 2004-07-15 • Environmental noise control. Official publication: Government Gazette (Journal Officiel néerlandais) ; Number: 134 ; Publication date: 2004-07-16 • Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings). Official publication: Official Journal (Bulletin des Lois et des Décrets royaux) ; Number: 2012, 266 ; Publication date: 2012-06-20 • Decree of 6 June 2012, establishing the date of entry into force of the Act of 24 November 2011

		amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings), the Noise Production Ceilings Implementation Act, the Environmental Management Decree and the Noise Production Ceilings Implementation Decree. Official publication: Official Journal (Bulletin des Lois et des Décrets royaux) ; Number: 2012, 268 ; Publication date: 2012-06-20
Other (please add rows below if needed)	**NO**	

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

No specific main sources of noise are mentioned in the NAP.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

Measures that can be taken mainly consist of quieter road surfaces and noise screens (or noise barriers), possibly supplemented with the insulation of houses, quiet tyres, quiet areas, and potential relocation of homes. During major road maintenance, at least a quiet road surface with the sound quality of Very Open Asphalt Concrete (ZOAB) is used and, if necessary, quieter joint transitions (connections at bridges and viaducts) are installed.

1.3. Are there any noise limits mentioned in the NAP?[34]

The maximum noise limit on noise-sensitive objects from 2012 has been reduced from 68 to 65 dB. In this action plan, a plan threshold has been chosen for the next five years that is in line with the maximum value of 65dB. If the noise reduction measures required to continue to comply with the noise production ceilings are not (sufficiently) possible or ineffective, the competent authority can decide to modify the noise production ceilings (setting limits above 65dB).

Legislation and noise policy in the Netherlands are entirely aimed at controlling the value of Lden. If the Lden values continue to comply with the standards, the value of Lnight will also be sufficiently limited, as Lnight is a component of the L from Lden.

When a road is newly constructed, efforts must be made to ensure that the noise at the surrounding noise-sensitive objects (homes, schools, etc.) does not exceed the preferred value of 50 dB. Exceeding this

[34] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

preferential value is permissible when measures to achieve the preferential value are ineffective and as long as the maximum value is not exceeded.

1.4. Are these new measures or they are continuation of existing measures?

Continuation of existing measures. Previous NAP round was 2008 to 2013.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

2013-2018

1.5.2. Per reduction measure

Decrease in numbers of noise affected dwellings anticipated from 2011 to 2016:

55-59dB range: 16% decrease from 56,200 to 47,200 dwellings

60-64dB range: 14% decrease from 14,500 to 12,500 dwellings

65-69dB range: 17% decrease from 3,600 to 3,000 dwellings

Above 70dB range: 25% decrease from 400 to 300 dwellings

The NAP states that after the implementation of the planned measures, it is expected that in 2016 there will be approximately 18% fewer dwellings above the plan threshold of 65 dB.

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

Manager of national highways from the Directorate-General for Public Works and Water Management (Rijkswaterstaat), which is part of the Ministry of Infrastructure and Water Management of the Netherlands. The manager is responsible for the control of noise levels so that they do not exceed established noise limits. The manager must report on compliance with the noise production ceilings.

Chapter VI of the Noise Abatement Act lays down rules for the protection against noise nuisance of national roads when a municipality is preparing a new zoning plan in which (new) noise-sensitive buildings are included within the sphere of influence ('zone') of a national road.

Depending on the situation, the Mayor and Aldermen of the municipality or Provincial Executives are the competent authority.

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

The NAP states that in the future, the implementation of local noise measures will become less and less cost-effective. The most effective measures have already been taken at many locations. With unchanged circumstances, the decrease in the number of noise-exposed dwellings will therefore become smaller in the long term and may even turn into an increase with further traffic growth. It is therefore increasingly important that the traffic itself produces less noise.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The planned measures in the period 2013-2018 will total approximately €300 million. No specific costs for individual measures are mentioned.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

In the past five years (2008-2013), about 250 km of noise barriers have been installed, about 250 km of noisier road surfaces have been replaced by ZOAB quiet road surface and more than 600 km by two-layer ZOAB (lane lengths).

For the period of 2013-2018, the Directorate-General for Public Works and Water Management (Rijkswaterstaat) will construct about 100 km of noise screens and barriers, replace about 450 km of noisier road surface with ZOAB quiet road surface and about 180 km of road surface with two-layer ZOAB (lane lengths).

Until the planning period of this action plan, the following noise measures have been taken or are being prepared on or along national roads in the Netherlands:

- 950 km of noise screens or barriers;

- 5,100 km of quiet road surface (all road surfaces with ZOAB acoustic quality or better).

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

Yes, public consultation was implemented with residents. The public consultation lasted from 12 July to 22 August 2013.

1.11. Does the public consultation include active involvement of stakeholders?

Three written opinions by the public have been put forward on the draft NAP during the consultation period from July to August 2013. No oral opinions were submitted.

Appendix F contains the integral Memorandum of Reply to the opinions submitted.

1.12. Are the results of the public consultation integrated in the NAP? How?

Apart from addressing the submitted public views in Chapter 5 and Appendix F (which contains the integral Memorandum of Reply to the opinions submitted) of the NAP, the content of the draft Environmental Noise Action Plan was not amended as a result of the opinions submitted.

Some views also related to a provincial or municipal NAP. A copy of the complete opinions has then been sent to the province or municipality in question.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

It was a one-off event.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

In the period between the first (2007) and the second (2012) noise map, the number of noise-exposed dwellings decreased significantly. Furthermore, the number of noise-exposed dwellings was reduced by approximately 40% in 2011 compared to the situation in 2006. This reduction is largely the result of the noise measures taken. A small portion of the decrease can be attributed to the transfer of national roads to other (municipal or provincial) road authorities and to changes in the methods used to determine the input data for the calculations (such as traffic intensities and screen files).

The NAP mentions general noise reduction measures expected from different types of measures:

- In general, noise screens or barriers reduce noise levels by 5 to sometimes more than 10 dB.
- The effect of quieter road surfaces such as ZOAB, two-layer ZOAB (fine) or thin top layer is 2 to 6 dB compared to the 'reference road surface' of dense asphalt concrete (DAB).
- A reduction of a few dBs can also be achieved using quiet tyres.
- Facade insulation measures only have an effect on lowering the interior noise level.
-

~~1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)~~

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

The NAP does not directly mention how measures from the second round (2013-2018) will be evaluated, but it contains information on how the first round was evaluated (2008-2013). This may indicate how the analysed NAP measures will be evaluated:

The NAP states that a comparison was made between the noise map for the situation 2006 (the noise map was determined in 2007) and the situation 2011 (determination 2012). For this purpose, the tables with noise-exposed dwellings in a 24-hour period (Lden) were used. Noise classes (based on dB) were established, and the total number of dwellings in the Netherlands that fall within a noise class was recorded.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)	**NO**	
Urban/land use planning legislative acts	**NO**	
Mobility related legislative acts	**NO**	
Sector specific acts (aviation, rail, road)	**NO**	
Building regulation	**NO**	
Environment acts	**YES**	• Dutch 2006 Noise Abatement and Measurement Regulations • Dutch 2012 Noise Abatement and Measurement Regulations

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	• Use of quiet tyres • Application of quiet asphalt/road surface • Maintenance of roads and application of quiet road surface • Relocation of homes • Use of quieter joint transitions (connections at bridges and viaducts)
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	• Construction of road noise barriers; screen or earth embankments
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☒	• If source interventions and other measures do not provide sufficient protection, insulation of homes and building will be implemented
	Other physical interventions	Green areas, quiet areas	☒	• Quiet areas, which will be determined by provinces and municipalities
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

Other (please add rows below if needed)	**NO**	

13.2 North Holland province roads (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[35]

The NAP targets the provincial roads for North Holland between 2014 and 2018. The plan covers a total of 630 km of provincial road. This also includes the roads within Amsterdam and Alkmaar. It has 2 775 617 inhabitants for a surface area of 4 091,76 km^2.

It identifies noise sensitive destinations (buildings, dwellings, schools) and quiet areas. 39 quiet areas are identified in Noord Holland.

A consultancy has drafted a report for the province entitled "Action Plan for Noise in the Province of North Holland – technical substantiation with a scenario study", which determined the effect of measures according to various scenarios and tested the effectiveness of the measures.

The NAP presents a GES score calculated with noise to describe environmental health, and DALYs.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [36]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**YES**	- Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of Directive No 2002/49/EC of the European Parliament and of the Council of the European Union of 25 June 2002 relating to the assessment and management of environmental noise, OJEC L 189 (noise maps and action plans).
Transposed into regional level in the MS		
Urban/land use planning legislative acts		
Mobility related legislative acts		

[35] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[36] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts	**Yes**	- Decree of 6 July 2004, containing rules relating to the representation and management of environmental noise and entry into force of the Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of the Environmental Noise Directive (Environmental Noise Decree). - Environmental noise regulation, 16 July 2004 - Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings). - Decree of 6 June 2012, establishing the date of entry into force of the Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings), the Noise Production Ceilings Implementation Act, the Environmental Management Decree and the Noise Production Ceilings Implementation Decree.
Other (please add rows below if needed)		

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

As a provincial road NAP, the NAP identifies road traffic as source of noise. Below, the results of the mapping on the number of annoyed and sleep disturbed inhabitants:

- Annoyed

Type	55-60 dB	60-65 dB	65-70 dB	70-75 dB	75 dB and more	Total
Dwellings	6 901	3 833	1 666	394	0	12 794
Persons	15 872	8 816	3 832	906	0	29 426
Number of annoyed persons	3 333	2 645	1 571	489	0	8 038
Number of severely annoyed persons	1 270	1 146	766	272	0	3 454
DALYs	25	23	15	5	0	69

- Sleep disturbed

Type	50-55 dB	55-60 dB	60-65 dB	65-70 dB	70 dB and more	Total
Dwellings	4 438	2 317	554	86	0	7 395
Persons	10 207	5 329	1 274	198	0	17 009
Number of sleep disturbed persons	715	533	166	36	0	1 449
DALYs	45	34	12	3	0	93

Based on the GES indicator, the NAP proposes data on the environmental health quality:

Environmental health quality	Number	Share
Good	259 542	88%
Reasonable	17 604	6%
Moderate	13 066	4%
Insufficient	2 487	1%

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

Annex 4:

There is a national remediation scheme for dwellings that had a noise level of more than 60 dB before 1986, which provides, under conditions, a subsidy for noise reduction measures (quiet road surfaces, noise barriers, walls and façade insulation). Municipalities are responsible for applying for such a subsidy. Along the provincial roads in Noord Holland, 1 948 dwellings are concerned, and the remediation for 1 612 dwellings still has to be done.

The NAP also presents a list of possible measures (silent motors, silent tires, silent asphalt, thin coatings, speed reduction, sound screens, sound insulation of dwellings). They explain for instance that with experience, quiet asphalt has led to higher additional costs than initially assumed, because it has to be replaced more often.

Below is the list of chosen measures in the NAP:

- Silent asphalt. The NAP provides a cost-benefits analysis and a map where it can most efficiently be implemented. The first selection provides 10 km of efficient and technically possible quiet asphalt for a budget of EUR 0.24 million. They provide information on starting points for the implementation of the quiet asphalt. The assessment shows that on four road sections the construction of quiet asphalt is efficient and technically possible, and is in line with the maintenance and reconstruction plans. 3 of the 4 road sections with quiet asphalt can be realized in the coming planning period. The NAP therefore suggests the construction of three road sections with a total length of 5.5 km of quiet asphalt.
- Quiet areas. Putting quiet asphalt next to quiet areas is reconsidered as the costs are high. A selection was made of road sections where investment in quiet asphalt for provincial roads has a relevant influence on the quality of the quiet area. Two criteria were considered: quality of the quiet area and efficiency of the construction of quiet areas. A significant part of the quiet area must have excessive noise levels as a result of the provincial road, to be in proportion with the investment. Efficient areas make up to 16 km of road sections, with EUR 167 735. 4 road sections are eligible for 12.3 km and EUR 124.194. This overlaps with the other road sections targeted by quiet asphalt, and the added costs would be of EUR 22 000. The total would amount to EUR 102 000. However, the province has chosen not to implement this in the coming planning period.

The expected effect of the plan is as follows:

	Noise maps 2011	**NAP 2014-2018**	**Difference**
Number of dwellings >65 dB with effect	n/a	52	n/a
Seriously annoyed	8 716	8 691	25
Seriously sleep disturbed	5 961	5 949	12
DALY's	592	591	1

The NAP indicates that the province will seek innovative measures in the following planning period. This would include physical measures at the roadside (diffractors and (low) noise screens) or physical measures on the road itself (mixture of quiet asphalt that are more resistant).

3.3. Are there any noise limits mentioned in the NAP?[37]

The NAP explains that the Dutch legislation has implemented the European "relevant limit value" as "planning threshold", which is the policy basis in the planning period (here, 2013-2017). It does not replace the legal limit values in the Noise Abatement act. Each road authority can choose the height of the plan threshold.

In the first NAP, the plan threshold was set at 65 dB Lden. For the second NAP, the province also carried out an analysis. They took into consideration that health effects already occurred at levels such as 40 dB(A) to which a lot of people are exposed. They tried to focus both on high noise levels (above 63-65 dB(A) Lden) but also on noise levels above 45-55 dB(A) Lden.

Limit values for suburban areas:

	Preferred limit value	Maximum limit value	Highly admissible indoor level
New house, existing road	50 dB	55 dB	33 dB
Existing house, new road	50 dB	60 dB	33 dB

The NAP develops a reasoning for the choice of these thresholds, with several scenarios, including the planning threshold of 65 dB Lden. 1 500 dwellings currently exceed this threshold. Here, quiet asphalt is suggested.

3.4. Are these new measures or they are continuation of existing measures?

Both, as measures implemented in the previous NAP are mentioned. For instance, quiet asphalt was built along all quiet areas. This is reconsidered in the NAP as part of the reassessment of the quiet area policy. Noise barriers were not implemented in the first plan. However, noise barriers had been implemented in the past. The previous plan also implemented speed reduction on a number of road sections. At the time of the new NAP, they had all been implemented.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

The planning period is defined as 2014-2018.

3.5.2. Per reduction measure

[37] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The province of Noord-Holland is the administration for the provincial roads. The delegated state of Noord-Holland adopts the plan.

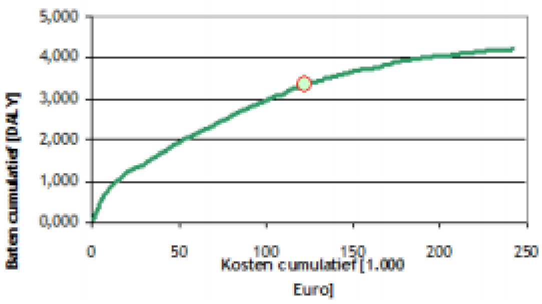
3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

The measures listed are chosen for a theoretical budget of EUR 1 million.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The NAP refers to EUR 10 000 of extra costs per year for the new quiet asphalt. The costs of dwelling insulation are estimated to EUR 10 000 per dwelling and can reach a reduction of noise levels to approximately 20 dB only indoors.

The NAP presents a costs benefits analysis on quiet asphalt. It is not possible to apply it on 41% of the road (intersections), and then 35% of the roads fall off the plan due to other reasons. Therefore, the planned investment drops to EUR 240 000. The figure below shows the development on costs benefits (cumulated DALYs vs cumulated costs):



It shows that the additional benefits are gradually decreasing with the increasing costs. The dot shows the point at which 79% of the total benefits are realized against 51% of the costs of the total package of possible measures of EUR 240 000. The cost-benefit ratio is estimated at 0.14 at the dot. This value was retained as the cut-off point for the road selection qualifying for quiet asphalt.

Moreover, the costs are kept as low as possible as introducing quiet road surfaces are associated with road maintenance.

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

The quiet asphalt will be implemented on three road sections for a total of 5.5 km, and a budget of EUR 55 321, structurally and cumulatively per year, from 2016 to 2018.

The annual additional costs for quiet asphalt already in place amount to EUR 1.3 million. For the planned quiet asphalt, an increase in the maintenance budget of EUR 55 321 cumulative per year will be required by the end of the 2014-2018 period.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

4.2. Does the public consultation include active involvement of stakeholders?

4.3. Are the results of the public consultation integrated in the NAP? How?

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

The NAP explains that in the adoption process there is a deadline of six weeks to express views and opinions on the draft NAP. A month after the adoption, the action plan is made public.

7 views were received from residents during the consultation process. Most of them were focused on the increased noise nuisance, requesting to apply more noise reduction measures than what is planned, such as adding noise barriers to the quiet asphalt. Questions on the noise mapping were also raised. Maintaining the maximum speed allowed was also mentioned. The NAP indicates that these have been answered in the Response Draft NAP 2014-2018.

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

There was an interim evaluation of the NAP 2009-2013 in December 2011. The results were as follows:

- In 2009 and 2010 quiet asphalt was implemented in 14 road sections.
- After that, 15 road sections were still programmed for 2011 and 2012, and the remaining ones for after 2012.
- Not one of the noise barriers mentioned in the first action plan had been realised, because of physical limitations on the 5 road sections, or objections from the residents.
- Speed reduction is in force where it was proposed.
- Approximately 120 km of quiet asphalt were realised.

Annex 5:

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

Compared to the previous mapping, there was an increase of 12% in noise levels as a result of traffic growth. However, for 48% of the population, there was a decrease in noise levels due to the use of quiet road surfaces. For 39% the noise levels remained roughly similar.

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The action plan will be evaluated during the drafting of the following plan.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts	**Yes**	- Provincial Environmental Ordinance contains rules aimed at preserving the quality of quiet areas by keeping out activities that can cause nuisance. - Future noise legislation/Working Together on the Implementation of New Noise Policy (SWUNG) to replace the Noise Abatement Act. SWUNG 1: new regulation for national infrastructure. This has been implemented since 1 July 2012 in the Environmental Management Act. It sets a noise production ceilings system for national highways and main railways. SWUNG 2: noise regulation for provincial and municipal roads and is currently under preparation. SWUNG 2 will introduce the same notion of ceilings for provincial roads.
Other (please add rows below if needed)		

7. Please provide a brief summary

The plan provides detailed insights on the use of quiet asphalt and on the selection method of the road sections where it will be implemented. It also provides comprehensive information on costs and cost-effectiveness.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Road surface is the core measure of the NAP
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	Speed limit is mentioned
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☐	
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☒	Quiet areas are mentioned
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

13.3 South Holland province roads (2013)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[38]

This NAP outlines the actions taken at the regional level in the province of South Holland (Zuid Holland) for the second round of mapping in the END Framework, as the actions are planned for the 2013-2018 period. The region had 3 577 032 inhabitants in 2013, with a surface area of 3 418, 50 km^2.

The plan seeks to improve the living environment quality in Zuid Holland with less annoyance from noise levels. It is based on the noise mapping from 2012.

The plan outlines a selection of roads sections for which measures will be considered. There is as well a priority setting. This was done by examining the plan threshold of 55 dB and where in the province this threshold, set in the Policy Vision on Sustainability and the Environment (2013-2017), is exceeded. There was also an assessment of efficiency of measures on some road sections. The NAP selected 60 road sections amounting to 110 km of length for which the measures should be efficient. This includes 5 085 houses or 11 700 people. Within this, about 3 600 are severely annoyed or disturbed in their sleep.

Within these road sections, further were selected to observe acoustic quality of the living environment of the dwellings along the road sections. These are the noise section considered for noise abatement measures. It is 31 road sections, with 49.3 km of length, concerning 4 000 dwellings and other buildings sensitive to noise, with approximately 9 200 residents.

The road mapped are roads with more than 6 million motor vehicle passages per year.

Finally, the NAP identifies an enforcement gap, supporting the revision of noise regulations (SWUNG).

The data on people annoyed by provincial roads are as follows:

Noise range	Annoyed	Seriously annoyed
55-59 dB	21%	8%
60-64 dB	30%	13%
65-69 dB	41%	20%
70-74 dB	54%	30%
75 dB or higher	61%	37%

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [39]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	**YES/NO**	**NOTES**

[38] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[39] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Directly into National law (Directive as it is)	**YES**	- Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of Directive No 2002/49/EC of the European Parliament and of the Council of the European Union of 25 June 2002 relating to the assessment and management of environmental noise, OJEC L 189 (noise maps and action plans).
Transposed into regional level in the MS		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts	**Yes**	- Decree of 6 July 2004, containing rules relating to the representation and management of environmental noise and entry into force of the Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of the Environmental Noise Directive (Environmental Noise Decree). - Environmental noise regulation, 16 July 2004 - Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings). - Decree of 6 June 2012, establishing the date of entry into force of the Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernisation of noise policy instruments, noise production ceilings), the Noise Production Ceilings Implementation Act, the Environmental Management Decree and the Noise Production Ceilings Implementation Decree.

Other (please add rows below if needed)		

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The first selection of areas followed these three criteria:

- Exceedance of the planned threshold
- Application of the efficiency test
- Technical and operational framework conditions

In the second selection, the acoustic quality of the living environment of the dwellings were considered, seriousness of noise impact and the corresponding number of affected persons.

Road sections already prioritized in the previous NAP have not been considered.

The first selection resulted in lengths of approximately 100 km of provincial roads, with 5 000 dwellings and 11 700 persons. The second selection led to a list of 31 road sections, with an order of priority. The measures implemented will then be implemented on given road sections. These 31 sections represent 50 km of provincial road, along with 4 000 noise sensitive buildings and 9 200 residents.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The NAP presents all the possible noise measures in detail (noise screens and barriers, quieter asphalt, traffic management) and their advantages or disadvantages.

- Noise barriers and screens can allow a 10 dB reduction (up to) right behind the screen, and less with more distance.
- Quieter asphalt: stone mastic asphalt (SMA) is providing more noise reduction that the one previously used (dense asphalt concrete DAB). But the noise reduction capacity of SMA is too limited for provincial roads. Another quieter road surface was developed for provincial and municipal roads, it contains a thin wear-resistant and noise reducing top layer (DGD). It allows an average noise reduction of 3 to 4 dB compared to regular asphalt. After construction, a higher noise reduction can be observed (7 to 8 dB). After 8 to 9 years, it offers a 2-3 dB reduction. Maintenance costs are high.
- Traffic management can be linked to reduction of air pollution. A halving of the traffic intensity leads to a noise reduction of approximately 3 dB. Provincial traffic management options to direct traffic on other roads are often limited. Other measures could include dynamic speed limits, rush hour lanes and traffic information, but little is done on noise with these.
- Developments such as ultra-quiet road surface are monitored and followed, as well as other technological developments.

The plan lists the areas eligible for these measures, and will be followed by an implementation plan.

3.3. Are there any noise limits mentioned in the NAP?[40]

[40] Typology of noise units:

The NAP mentions the noise limit of 55 dB within the Policy Vision on Sustainability and the Environment (2013-2017). This Policy Vision also sets the noise threshold at 50 dB night-time. The maps should include areas above these thresholds. These are the noise thresholds also used in the NAP, which are stricter than in the previous NAP. The roads above these thresholds were taken into account for noise reduction in the plan. The NAP adds that in terms of budget and feasibility, further selection and priority setting was necessary. These thresholds do not relate to quiet areas.

3.4. Are these new measures or they are continuation of existing measures?

Both are mentioned, as the NAP presents what has been done between 2008 and 2013, therefore in the previous round of reporting. This plan outlined a threshold of 65 dB, with no specific limit for nighttime. Only dwellings with very high noise levels and other noise-sensitive buildings were considered. It took into account 27 road sections, with a length of 52.8 km. Quieter asphalt was applied to almost all road sections as a noise-reduction measure during the planning period.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

The plan sets the measures for the period 2013-2018.

3.5.2. Per reduction measure

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The Infrastructure and Environment Ministry is responsible for the adoption of noise maps and national NAPs (highways, main railways, Schiphol airport and other major airports). Mayors of agglomerations of more than 250 000 inhabitants have this responsibility for roads, railways, facilities and airports in or near the agglomeration. In South Holland, three agglomerations are considered, gathering several municipalities:

- Gouda
- The Hague/Leiden
- Rotterdam/Dordrecht

Environmental noise rules require the provinces to periodically draw up noise maps and action plans for the roads they manage.

The delegated state of the region adopts the NAP (South Holland).

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

The budget for the action plan is of EUR 10 million from the Provincial Infrastructure Multi-Year Programme.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

N/A

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

The noise abatement measures laid out in the plan were narrowed down to 31 road sections, with 49.3 km of length, and concern 4 000 dwellings and other buildings sensitive to noise, with approximately 9 200 residents.

Quiet areas are not part of the action plan as they are usually within the municipalities' responsibilities.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

4.2. Does the public consultation include active involvement of stakeholders?

4.3. Are the results of the public consultation integrated in the NAP? How?

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

The NAP indicates that it is subject to a public participation procedure.

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

The NAP presents the result of the measures applied to the focus road sections between 2008 and 2013 (mainly quieter asphalt):

Year	Dwellings exposed to more than 65 dB	Inhabitants exposed to more than 55 dB	Annoyed, more than 55 dB
2006	1 250	18 100	4 700
2011	835	13 400	3 440
Results from NAP 1 (2008-2013)	415	4 700	1 260

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

The NAP lays out legal steps to be carried out every 5 years:

- Inventory of the extent of environmental noise with the noise maps
- Actions, implementation of NAP with a view on prevention and reduction of noise

- Noise threshold to be taken into account
- Communication and public consultation
- Community evaluation. The NAP is sent to the minister who sends a summary to the Commission.

Then, monitoring of the results of the NAP is carried out every two years, starting from 2014.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	**YES/NO**	**NOTES**
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts	**Yes**	- Sustainability and Environment Policy Vision 2013-2017 adopted by the Provincial Council on 27 March 2013. It seeks the prevention of environmental bottlenecks and the improvement of the quality of the living environment. - Working Together on the Implementation of New Noise Policy (SWUNG). SWUNG 1: new regulation for national trunk roads and main railways within the framework of Chapter XI of the Environmental Management Act. These regulations relate to noise production ceilings, setting a maximum on the permitted emissions of national roads and main railways. SWUNG 2 will introduce the same notion of ceilings for provincial roads.
Other (please add rows below if needed)		

7. Please provide a brief summary

The NAP provides a comprehensive methodology of selecting the priority areas for action and knowledge on the noise measures applicable in provincial roads. It however fails to indicate which measures will be taken into consideration, as it is to be followed by an implementing plan.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Several types of quieter asphalt are presented
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☒	Traffic management is mentioned
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	Barriers and screens are presented
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

14 Poland

14.1 Lubuskie Voivodship (Swiebodzin and Nowa Sol) (2011)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[41]

NAP for areas outside agglomerations located alongside national and provincial roads in the Warmińsko-Mazurskie Voivodeship with a load of over 3 million vehicles per year, the operation of which has caused a negative acoustic impact as a result exceeding the permissible noise levels determined by the LDWN and LN indices. The NAP was drafted based on the noise map developed for this region in 2012. The Warmińsko-Mazurskie voivodship is situated in the north-eastern part of the country and covers an area of 24 173.47 km^2, and in 2012 had 1.45 million inhabitants. It is the fourth voivodeship in terms of area in the country. The Voivodeship contains a number of national, express, and regional roads.

The objective of the NAP Program is to indicate actions which the consistent implementation will bring the noise level to the permissible thresholds and provides a descriptive list of roads' sections being a subject to the NAP. The total length of roads included in the scope of the acoustic maps and the NAP is approx. 30 km.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [42]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)		

[41] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[42] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Transposed into regional level in the MS	Rozporządzeniem Ministra Środowiska z dnia 1 października 2012 r. zmieniającym Rozporządzenie w sprawie dopuszczalnych poziomów hałasu w środowisku zostały ustalone nowe normy dla hałasu komunikacyjnego Obecnie w Rozporządzeniu Ministra Środowiska z dnia 14 czerwca 2007 r. w sprawie dopuszczalnych poziomów hałasu w środowisku (Dz. U. z 2014 r., poz. 112) przyjęto mniej restrykcyjne dopuszczalne poziomy hałasu (por. Tabela 6).	***Ustawa z dnia 27 kwietnia 2001 r. Prawo ochrony środowiska (Dz. U. z*** ***2013 r., poz. 1232 ze zm.)*** ***Ustawa dnia 3 października 2008 r. o udostępnianiu informacji*** ***o środowisku i jego ochronie, udziale społeczeństwa w ochronie*** ***środowiska oraz o ocenach oddziaływania na środowisko (Dz. U. z 2013 r.,*** ***poz. 1235 ze zm.)*** **Rozporządzenie Ministra Środowiska z dnia 14 października 2002 r.** **w sprawie szczegółowych wymagań, jakim powinien odpowiadać** **program ochrony środowiska przed hałasem (Dz. U. z 2002 r., nr 179,** **poz. 1498)** **Rozporządzenie Ministra Środowiska z dnia 14 czerwca 2007 r.** **w sprawie dopuszczalnych poziomów hałasu w środowisku (Dz. U. z** **2014 r., poz. 112)** **Rozporządzenie Ministra Środowiska z dnia 1 października 2007 r. w** **sprawie szczegółowego zakresu danych ujętych na mapach** **akustycznych oraz ich układu i sposobu prezentacji (Dz. U. z 2007 r., nr**

		187, poz. 1340)
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)		***Program ochrony środowiska województwa warmińsko-mazurskiego na lata*** ***2011-2014 z uwzględnieniem perspektywy na lata 2015-2018.*** ***Strategia Rozwoju Społeczno-Gospodarczego Województwa Warmińsko-*** ***Mazurskiego do 2025 r.***

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

It does not.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The NAP provides two types of the reduction measures under three separate tasks: main, supportive measures and performance of ecological review.

1. **Main tasks (anti-noise investments)**

- Modernization of the road surface
- Introduction of speed limits

2. **Supportive tasks (preventive measures)**

- Traffic control (compliance with traffic speed regulations);
- Road surface inspection
- Considering the principles of space management in the vicinity of noise sources for newly created spatial development plans.

In addition, second and third part of the NAP provides a detailed description per each road section and outlines the directions and scope of necessary action to restore the permissible noise levels.

3. **Performing of ecological review** aiming to evaluate if in a given area should be establish the limited use area.

3.3. Are there any noise limits mentioned in the NAP?[43]

No. Only the exceed of the permissible noise levels is mentioned as follows:

a) 0 – 5 dB,

b) 5 – 10 dB,

c) 10 –15 dB,

d) 15 – 20 dB,

e) Above 20 dB

3.4. Are these new measures or they are continuation of existing measures?

The NAP does not provide clearly this information.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

The measures are planned in a short (2015-2019) and long (post-2020) term perspective.

Period	Tasks	Years
Short term measures	- Main tasks: Modernization of the road surface where the permissible levels above 5 dB were exceeded.. - Performance of ecological review where the anti-noise investment measures could not be implemented.	2015-2019
Long term measures together with the future up-date of the NAP	Tasks which the implementation was not possible in the short term, as	Post-2020

[43] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

	well as the continuation of tasks from the previous period.	

3.5.2. Per reduction measure

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The administration bodies responsible for issuing local legal acts in the scope related to the NAP implementation are: municipal councils in the areas covered by the NAP (local spatial development plans) and poviat councils (possibly establishing restricted use areas). The control responsibilities in relation to the railway line manager are performed by the Voivodship Inspector for Environmental Protection.

The actors responsible for the implementation of the NAP are infrastructure managers. The infrastructure managers are required to prepare and submit by end of March to the Voivodeship Marshal annual reports for the previous year with regard to the progress of work on the NAP implementation.

In addition, infrastructure managers of the relevant sections of roads identified in the NAP should perform noise measurements on these sections, after the completion of the tasks indicated in the NAP. Measurement results should be reported annually to the competent authorities. They will demonstrate the purposefulness and effectiveness of the proposed measures. The submitted reports will constitute the basis for the evaluation of the implementation of the activities proposed under the NAP when preparing the NAP update.

The table below show the obligation and limitation of responsible bodies under the NAP.

	Description	Actor responsible
1.	Implementation of corrective actions under the NAP	The infrastructure manager
2.	Adoption of local legal acts in the scope related to the NAP implementation	Municipal councils, city councils, poviat councils, voivodship councils
3.	Control of the analyzed sections of road by the infrastructure manager	Voivodship Inspector of Environmental Protection
4.	Policy development in the field of spatial planning	City councils, municipal councils
5.	Drafting and submitting to the Marshal of the Region of annual reports on the progress of work on the NAP implementation (by the end of March for the previous year)	The infrastructure manager, village heads, city mayors and presidents etc.
6.	Performance of the noise measurements before and after implementation of measures as foreseen in the NAP.	The infrastructure manager

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Annex 6:

No.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

Yes. However the NAP provides only and approximative estimation of these costs. costs of the main ant-noise investment measures as provided in the table below/:

Task	Unit cost (net)
Modernization of the road surface	150 PLN/m^2
Performance of the ecological review	10 000 PLN/ km
Speed limitation	5 000 PLN/ section

However, most of the proposed anti-noise measure do not incur additional costs (spatial planning, road surface inspections, traffic control of compliance with speed regulations). Therefore, they were not listed in the above table.

The estimated cost of the NAP of implementing is estimated around:

- modernization of the road surfaces: approx. PLN 3 million
- speed limitation: PLN 5 000
- Performance of the ecological review: PLN 20 000

The estimated total cost of the NAP implementation in the years 2015-2019 is estimated to approximatively PLN 3.25 million.

In addition, the NAP provides information on main source of funding of these measures: specific bank loans, polish funding mechanism (national and regional) and operational funds of the EU.

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

No.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

No.

4.2. Does the public consultation include active involvement of stakeholders?

4.3. Are the results of the public consultation integrated in the NAP? How?

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

Yes. Responsible bodies for implementation of the NAP should draft and submit to the Marshal of the Region annual reports on the progress of work on the NAP implementation (by the end of March for the previous year) for evaluation.

5.1.1. No

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		
Other (please add rows below if needed)		

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☒	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☐	
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

14.2 National road in Warminsko Mazurskie (2014)

1. Background information

NAP for areas outside agglomerations located alongside national and provincial roads in the Warmińsko-Mazurskie Voivodeship with a load of over 3 million vehicles per year, the operation of which has caused a negative acoustic impact as a result exceeding the permissible noise levels determined by the LDWN and LN indices. The NAP was drafted based on the noise map developed for this region in 2012. The Warmińsko-Mazurskie voivodship is situated in the north-eastern part of the country and covers an area of 24 173.47 km², and in 2012 had 1.45 million inhabitants. It is the fourth voivodeship in terms of area in the country. The Voivodeship contains a number of national, express, and regional roads.

The objective of the NAP Program is to indicate actions which the consistent implementation will bring the noise level to the permissible thresholds and provides a descriptive list of roads' sections being a subject to the NAP. The total length of roads included in the scope of the acoustic maps and the NAP is approx. 30 km.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [44]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)		

[44] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Transposed into regional level in the MS	By the Ordinance of the Minister of the Environment of October 1, 2012, amending the Ordinance on permissible noise levels in the environment, new standards for traffic noise were established. Currently, in the Regulation of the Minister of the Environment of June 14, 2007 on permissible noise levels in the environment (Journal of Laws of 2014, item 112), less restrictive permissible noise levels were adopted (see Table 6).	***Act of April 27, 2001, Environmental Protection Law (Journal of Laws of 2013, item 1232, as amended)*** ***Act of 3 October 2008 on the provision of information on the environment and its protection, public participation in environmental protection and on environmental impact assessments (Journal of Laws of 2013, item 1235, as amended)*** ***Regulation of the Minister of the Environment of October 14, 2002.*** ***on the detailed requirements that it should meet*** ***environmental protection program against noise (Journal of Laws of 2002, No. 179,*** ***item 1498)*** ***Regulation of the Minister of the Environment of June 14, 2007.*** ***on permissible noise levels in the environment (Journal of Laws of*** ***2014, item 112)*** ***Regulation of the Minister of the Environment of October 1, 2007 in*** ***on the detailed scope of data included in the maps*** ***acoustic and their layout and presentation method (Journal of Laws of 2007, No. 187, item 1340)***
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows		***Environmental protection program for the Warmińsko-Mazurskie***

below if needed)		***Voivodeship for 2011-2014, taking into account the perspective for 2015-2018.*** ***Strategy for Socio-Economic Development of the Warmińsko-Mazurskie Voivodeship until 2025***

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

It does not.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The NAP provides two types of the reduction measures under three separate tasks: main, supportive measures and performance of ecological review.

1. **Main tasks (anti-noise investments)**
- Modernization of the road surface
- Introduction of speed limits
2. **Supportive tasks (preventive measures)**
- Traffic control (compliance with traffic speed regulations);
- Road surface inspection
- Considering the principles of space management in the vicinity of noise sources for newly created spatial development plans.

In addition, second and third part of the NAP provides a detailed description per each road section and outlines the directions and scope of necessary action to restore the permissible noise levels.

3. **Performing of ecological review** aiming to evaluate if in a given area should be establish the limited use area.

1.3. Are there any noise limits mentioned in the NAP?[45]

No. Only the exceed of the permissible noise levels is mentioned as follows:

a) 0 – 5 dB,
b) 5 – 10 dB,
c) 10 –15 dB,
d) 15 – 20 dB,
e) Above 20 dB

[45] Typology of noise units:
- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

1.4. Are these new measures or they are continuation of existing measures?

The NAP does not provide clearly this information.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

The measures are planned in a short (2015-2019) and long (post-2020) term perspective.

Period	Tasks	Years
Short term measures	- Main tasks: Modernization of the road surface where the permissible levels above 5 dB were exceeded.. - Performance of ecological review where the anti-noise investment measures could not be implemented.	2015-2019
Long term measures together with the future up-date of the NAP	Tasks which the implementation was not possible in the short term, as well as the continuation of tasks from the previous period.	Post-2020

1.5.2. Per reduction measure

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The administration bodies responsible for issuing local legal acts in the scope related to the NAP implementation are: municipal councils in the areas covered by the NAP (local spatial development plans) and poviat councils (possibly establishing restricted use areas). The control responsibilities in relation to the railway line manager are performed by the Voivodship Inspector for Environmental Protection.

The actors responsible for the implementation of the NAP are infrastructure managers. The infrastructure managers are required to prepare and submit by end of March to the Voivodeship Marshal annual reports for the previous year with regard to the progress of work on the NAP implementation.

In addition, infrastructure managers of the relevant sections of roads identified in the NAP should perform noise measurements on these sections, after the completion of the tasks indicated in the NAP. Measurement results should be reported annually to the competent authorities. They will demonstrate the purposefulness and effectiveness of the proposed measures. The submitted reports will constitute the basis for the evaluation of the implementation of the activities proposed under the NAP when preparing the NAP update.

The table below show the obligation and limitation of responsible bodies under the NAP.

	Description	Actor responsible
1.	Implementation of corrective actions under the NAP	The infrastructure manager
2.	Adoption of local legal acts in the scope related to the NAP implementation	Municipal councils, city councils, poviat councils, voivodship councils
3.	Control of the analyzed sections of road by the infrastructure manager	Voivodship Inspector of Environmental Protection
4.	Policy development in the field of spatial planning	City councils, municipal councils
5.	Drafting and submitting to the Marshal of the Region of annual reports on the progress of work on the NAP implementation (by the end of March for the previous year)	The infrastructure manager, village heads, city mayors and presidents etc.
6.	Performance of the noise measurements before and after implementation of measures as foreseen in the NAP.	The infrastructure manager

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

No.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

Yes. However the NAP provides only and approximative estimation of these costs. costs of the main ant-noise investment measures as provided in the table below/:

Task	Unit cost (net)
Modernization of the road surface	150 PLN/m^2
Performance of the ecological review	10 000 PLN/ km
Speed limitation	5 000 PLN/ section

However, most of the proposed anti-noise measure do not incur additional costs (spatial planning, road surface inspections, traffic control of compliance with speed regulations). Therefore, they were not listed in the above table.

The estimated cost of the NAP of implementing is estimated around:

- modernization of the road surfaces: approx. PLN 3 million
- speed limitation: PLN 5 000
- Performance of the ecological review: PLN 20 000

The estimated total cost of the NAP implementation in the years 2015-2019 is estimated to approximatively PLN 3.25 million.

In addition, the NAP provides information on main source of funding of these measures: specific bank loans, polish funding mechanism (national and regional) and operational funds of the EU.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

No.

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

No.

1.11. Does the public consultation include active involvement of stakeholders?

1.12. Are the results of the public consultation integrated in the NAP? How?

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

Yes. Responsible bodies for implementation of the NAP should draft and submit to the Marshal of the Region annual reports on the progress of work on the NAP implementation (by the end of March for the previous year) for evaluation.

1.14.1. No

1.14.2. If yes, what are the results?

1.14.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that?

1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	X☐	
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	X☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☐	
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		
Other (please add rows below if needed)		

15 Portugal

15.1 IC2 Batalha Sul – IC1 Porto road section (2015)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[46]

This NAP targets the road section IC2 Batalha Sul – Porto (IC1). This section is about 182 km long and has differentiated areas:

- Transverse profile 2x1 ways
- Transverse profile 1x1 way in one direction and 1x2 in the other direction
- 2x2 way profile (highway type)

The road IC2 overlaps in some areas with the highway EN1. Along the road, several roundabouts and traffic lights exist, especially for the first two types of areas. There are as well different surface layers along the road section in terms of noise emission (different types and state).

The road starts in Batalha, until Nova de Gaia and crosses 4 districts, 14 councils and 97 municipalities. It crosses quite densely populated areas, alternated with areas of sensitive occupation even with lower population density. The type of dwellings can vary along the road section.

The document is the summary of the NAP.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [47]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**Yes**	- Ministry of the Environment, Town and Country Planning and Regional Development - transposes into national law Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. - Presidency of the Council of Ministers-Decree Law no. 146/2006, which transposes Directive no. 2002/49/EC of the European Parliament and of the Council, of 25 June, on the assessment and management of environmental noise, published in the Diário da República, 1st series, no. 146, of 31 July 2006, has been rectified.

[46] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[47] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Transposed into regional level in the MS	**Yes**	- Autonomous region of Azores - Legislative Assembly- Approves the general regulation on noise and noise pollution control and transposes into regional law Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, Directive Noise Directive and Directive Noise Directive. 2002/30/EC of the European Parliament and of the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports and Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise. - Presidency of the Council of Ministers - Legal Centre - Rectifies the Regional Legislative Decree No. 23/2010/A, of 30 June, of the Legislative Assembly of the Autonomous Region of the Azores, which approves the general regulation on noise and noise pollution control and transposes into the regional legal order Directives No. 23/2010/A, of 30 June, of the Autonomous Region of the Azores. 2002/49/EC of the European Parliament and of the Council of 25 June relating to the assessment and management of environmental noise, 2002/30/EC of the European Parliament and of the Council of 26 March on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports, and 2003/10/EC of the European Parliament and of the Council of 6 February on the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise.
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)		

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP provides a table of the average traffic on the road section at different times:

Average hourly traffic/hour								**Average speed (km/h)**	
Year	**Counting station**	**Day time**		**Sunset time**		**Nighttime**		**Light**	**Heavy**
		Light	**Heavy**	**Light**	**Heavy**	**Light**	**Heavy**		
2006	481U – km 116,9	1 411	356	954	241	360	86	60	50
	474O – km 144	954	255	645	172	242	64	90	80
	474A – km 155	749	234	506	158	189	59	90	80
	419O – km 173,2	492	205	333	139	126	53	90	80
	419B – km 183,9	1 301	105	880	71	338	25	90	80
	400U – km 195,4	2 552	170	1 726	115	666	40	110	100
	AO19 – km 204,2	824	127	558	86	231	27	90	80
	294O – km 212,4	840	120	568	81	211	29	80	70
	289B – km 225,8	424	95	287	64	106	23	80	70
	287O – km 237,4	767	76	519	51	193	28	70	60
	270U – km 252,5	822	117	556	79	206	27	70	60
	265O – km 264,2	814	102	551	69	205	24	100	90
	260O – km 271	1 069	116	723	79	273	27	80	70
	AO16 – km 278,85	1 474	118	997	80	535	27	80	70
	245O – km 288,6	1 280	95	865	64	326	21	70	60

This changed significantly by 2012. The NAP provides a table with the most significant changes:

Average hourly traffic/hour							
Year	Counting station	Day time		Sunset time		Nighttime	
		Light	Heavy	Light	Heavy	Light	Heavy
2012	481U – km 116,9	967	244	654	165	247	59
	474A – km 155	520	163	351	110	131	41
	400U – km 195,4	2 040	136	1 380	92	532	32
	AO16 – km 278,85	974	78	659	53	354	18
	245O – km 288,6	814	60	550	41	207	13

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

5 noise barriers were already implemented (see 3.4).

Road surfaces with noise absorbing properties is considered and should allow a reduction of about 4 dB(A). It will be implemented at the time of rehabilitation of the different sections (182 km).

Speed limits will also be implemented.

Noise barriers are planned to be implemented where possible and where non-compliance (to the noise limits) remain. They will be put where feasible, as in the short term it is not possible to upgrade the entire section and as in some areas the noise levels are very high. Populated areas with higher levels than the noise limits in 2012 were therefore identified first as target intervention areas:

- Priority intervention area grade 1: overpassing by more than 5 dB(A)
- Priority intervention area grade 1: overpassing by 5 dB(A) or lower.

The barriers will be first implemented on the grade 1 areas. These are 44 barriers, for which the start and end kilometers are given, as well as height. The panels are either absorbing metals or acrylic reflectors.

Within the improvement project between Leira and Coimbra, a surface with acoustic absorption characteristics is considered. The project is to be implemented in 2014.

The NAP provides information on population exposed, with and without noise abatement measures:

Range of exposure dB(A) Lden	Population exposed x10^2	
	Without noise measures	With noise measures
55 < Lden ≤ 60	200	127
60 < Lden ≤ 65	137	78
65 < Lden ≤ 70	90	71
70 < Lden ≤ 75	77	77
Lden > 75	10	5

Range of exposure dB(A) Ln	Population exposed x10^2	
	Without noise measures	With noise measures
45 < Ln ≤ 50	220	166
50 < Ln ≤ 55	176	100
55 < Ln ≤ 60	105	65
60 < Ln ≤ 65	98	69
65 < Ln ≤ 70	26	12
Ln > 70	2	0

There are still people exposed to higher noise levels even with the noise abatement measures.

3.3. Are there any noise limits mentioned in the NAP?[48]

The table below shows the noise exposure limits provided by the municipal councils, applied to sensitive receptors:

Municipality	**Sensitive area**	**Mixed area**	**Absence of zoning or absence of information**
	Lden ≤ 55 dB(A); Ln ≤ 45 dB(A)	**Lden ≤ 65 dB(A); Ln ≤ 55 dB(A)**	**Lden ≤ 63 dB(A); Ln ≤ 53 dB(A)**
Batalha	-	-	Km110+779 to Km116+600
Leira	-	-	Km116+600 to Km136+700
Pombal	-	Km136+800 to Km163+600	-
Soure	-	-	Km163+600 to Km167+800
Condeixa-a-Nova	-	Km167+800 to Km177+000	-
Coimbra	-	Km177+000 to Km201+900	-
Mealhada	Km200+900 to Km201+100	Km201+900 to Km203+300	-

[48] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

	Km202+750 to Km202+850		
	Km202+950 to Km203+100		
	Km207+800 to Km207+900		
	Km208+300 to Km210+350		
	Km213+400 to Km213+450		
	Km214+500 to Km214+700		
	Km214+500 to Km214+700		
	Km215+200 to Km215+300		
	Km219+800 to Km219+900		
	Km220+300 to Km220+350		
Anadia	Km213+400 to Km213+450	Km211+800 to Km223+450	-
	Km214+500 to Km214+700		
	Km214+500 to Km214+700		
	Km215+200 to Km215+300		
	Km219+800 to Km219+900		
	Km220+300 to Km220+350		
Águeda	-	-	Km223+600 to Km244+900
Albergaria-a-Velha	-	Km242+800 to Km255+800	-
Oliv. de Azeméis	-	Km255+800 to Km269+200	-
S. João da Madeira	Km269+700 to Km273+700	Km269+200 to Km273+700	-

Sta Maria da Feira	-	-	Km273+700 to Km288+800
Vila Nova de Gaia	Km289+450 to Km289+550	Km287+550 a 294+277	-
	Km293+500 to Km297+277		

3.4. Are these new measures or they are continuation of existing measures?

Both, as the NAP mentions that part of the IC2 section was the target of two projects by the West Coast Subconcession, including a project of noise minimization implementing noise barriers. On one of the barriers, top diffusers were added and allow a 3 dB reduction.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

The measures are to be implemented by 2014.

3.5.2. Per reduction measure

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The plan was drafted by EP - Estradas de Portugal, S.A.

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

The NAP explains that implementing low-noise surface as a noise abatement measure cost approximately EUR 803 per capita, for a noise reduction below 55 dB(A) Ln. this targets population exposed but also benefits to all receivers located nearby the road section. The implementing costs of the barriers amount to EUR 3 140 250.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

See above.

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

For the noise barriers, the start and end kilometers as well as height are indicated. Their components too (absorbing metals, acrylic reflectors).

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

No information.

4.2. Does the public consultation include active involvement of stakeholders?

No information.

4.3. Are the results of the public consultation integrated in the NAP? How?

No information.

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

No information.

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

5.1.2. If yes, what are the results?

See question 3.4.

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

Yes, the efficiency of the reduction measures will be assessed through noise monitoring campaigns after its implementation.

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		
Other (please add rows below if needed)		

7. Please provide a brief summary

The NAP provides a detailed overview of the noise barriers to be implemented and detailed information on the road section. Information on timeline and public consultation are lacking.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Road surface measures
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☐	
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☐	
	Path interventions between source and receiver	Road noise barriers	☒	Noise barriers are the core measure of the NAP
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

16 Spain

16.1 Seville roads (2014)

1. Background information

1.1. NAP for which MS and which city/airport/road/rail and provide basic information (see footnote – e.g. City X with population of Y inhabitants and Z noise levels)[49]

This is the road NAP for the province of Seville in Spain. The province has a surface area of 14 036 km2[50], and a population of 1 957 197 inhabitants in 2020[51].

The NAP targets the following roads:

Number	Name	Length (km)
SE-3304	San-Juan de Aznalfarache-Palomares del Rio	4.8
SE-3205	Link from the N-IV to the SE-3206 (via the Palmorillo)	5.7
SE-3206	Branch of the A-4 to Isla Menor	5.8

SE-3304: The mapping considers a population of 71 082 inhabitants around a range of 1.5 km around the road. The population affected by noise levels is as follows:

	Population affected (in hundreds)							
Range	**Evaluation at 4m high**				**Evaluation at any height**			
	Lday	**Levening**	**Lnight**	**Lden**	**Lday**	**Levening**	**Lnight**	**Lden**
50-55 dB(A)	19	20	11	28	14	14	7	20
55-60 dB(A)	12	11	**5**	9	9	8	**5**	11
60-65 dB(A)	6	6	**14**	11	5	5	**1**	6
65-70 dB(A)	**15**	**15**	**0**	16	**3**	**2**	**0**	5
70-75 dB(A)	**0**	**0**	**0**	2	**0**	**0**	**0**	0
>75 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0

[49] The scope of this study is, in the EU, the roads and railways inside agglomerations of more than 100.000 inhabitants, the locations around major roads of more than 3 million vehicles a year, around major railway lines of more than 30.000 trains a year and around major airports of more than 50.000 movements a year. Specifically for the last three cases (major roads, major railways and major airports) the scope is: for major roads, where noise levels are above 53 dB Lden; for major railways, where noise levels are above 54 dB Lden; for major airports, where noise levels are above 45 dB Lden. In this call for tenders this is what is meant when the expression 'EU level' is used.

[50] https://www.ine.es/inebaseweb/pdfDispacher.do?td=154090&L=0

[51] https://www.ine.es/jaxiT3/Tabla.htm?t=31304&L=0

Dwellings exposed:

	Dwellings affected (in hundreds)			
Range	**Lday**	**Levening**	**Lnight**	**Lden**
50-55 dB(A)	7	7	4	11
55-60 dB(A)	4	4	**2**	3
60-65 dB(A)	2	2	**5**	4
65-70 dB(A)	**6**	**6**	**0**	6
70-75 dB(A)	**0**	**0**	**0**	1
>75 dB(A)	**0**	**0**	**0**	0

The values in bold are those were the regulatory thresholds are exceeded.

Five sensitive education buildings are exposed to noise levels above 55 dB(A) Lden. The NAP provides the noise levels for each of these 5 buildings.

Based on calculations integrating the different elements presented, the NAP concludes that this road has a high level of noise affection.

SE-3205: The mapping considers a population of 46 695 inhabitants, for a range of 1.5 km around the road. The population affected by noise levels is as follows:

	Population affected (in hundreds)							
Range	**Evaluation at 4m high**				**Evaluation at any height**			
	Lday	**Levening**	**Lnight**	**Lden**	**Lday**	**Levening**	**Lnight**	**Lden**
50-55 dB(A)	1	2	1	3	1	1	0	2
55-60 dB(A)	1	1	**0**	1	0	0	**0**	1
60-65 dB(A)	0	0	**0**	0	0	0	**0**	0
65-70 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0
70-75 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0
>75 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0

Dwellings exposed:

	Dwellings affected (in hundreds)			
Range	**Lday**	**Levening**	**Lnight**	**Lden**

50-55 dB(A)	1	1	0	1
55-60 dB(A)	0	0	**0**	0
60-65 dB(A)	0	0	**0**	0
65-70 dB(A)	**0**	**0**	**0**	0
70-75 dB(A)	**0**	**0**	**0**	0
>75 dB(A)	**0**	**0**	**0**	0

As shown by the values in bold, no inhabitants are exposed to noise levels above the regulatory thresholds. No sensitive buildings are affected by higher noise levels from this road.

Based on calculations taking into account the different elements presented, the NAP concludes that this road has a low level of noise affection.

SE-3206: The mapping considers a population of 12 072 inhabitants, located in a range of 1.5 km around the road. The population affected by noise levels is as follows:

	Population affected (in hundreds)							
Range	**Evaluation at 4m high**				**Evaluation at any height**			
	Lday	**Levening**	**Lnight**	**Lden**	**Lday**	**Levening**	**Lnight**	**Lden**
50-55 dB(A)	1	1	1	2	1	1	0	2
55-60 dB(A)	1	1	**1**	1	0	0	**1**	1
60-65 dB(A)	0	1	**0**	0	0	0	**0**	0
65-70 dB(A)	**1**	**1**	**0**	1	**0**	**0**	**0**	1
70-75 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0
>75 dB(A)	**0**	**0**	**0**	0	**0**	**0**	**0**	0

Dwellings exposed:

	Dwellings affected (in hundreds)			
Range	**Lday**	**Levening**	**Lnight**	**Lden**
50-55 dB(A)	0	0	0	1
55-60 dB(A)	0	0	**0**	0
60-65 dB(A)	0	0	**0**	0
65-70 dB(A)	**0**	**0**	**0**	0
70-75 dB(A)	**0**	**0**	**0**	0

>75 dB(A)	**0**	**0**	**0**	0

The values in bold show the population exposed to noise levels above the thresholds. No dwellings are exposed to higher levels of noise.

One sensitive education building is exposed to noise levels above 55 dB(A) Lden.

Based on calculations integrating the different elements presented, the NAP concludes that this road also has a low level of noise affection.

The NAP then defines areas for the application of the noise measures and describes the decision-making process to make the measures as efficient as possible, and know where to act. This defines research criteria and scenarios of study to define the points of conflict. Indicators of priority are also calculated. The NAP defines two points of conflict.

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [52]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Directly into National law (Directive as it is)	**Yes** Law 37/2003 of November 17th on Noise. BOE-A-2003-20976[53] Royal decree 1513/2005, December 16, for the development of Law 37/2003 of November 17 on Noise, referring to the evaluation and management of environmental noise. BOE 301/2005[54] Royal Decree 1038/2012	The legislation on environmental noise in Spain is defined by the Ley 37/2003 on noise and implemented by the royal decrees RD.1513/2005 and 1367/2007. This law outlines the requirement to establish and approve strategic noise maps before June 30th 2012 for agglomerations above 100.000 inhabitants. To be approved the maps have to be publicly available for a month. It outlines how to approve the acoustic zoning on which relies the objectives of sound quality. It also outlines the adoption of NAPs within the same time frame as the noise mapping. The RD1513/2005 outlines the minimum requirements that have to be included in the NAPs. The Law 37/2003 also outlines what aims and content should be in the NAPs. Royal Decree 1038/2012 of 6 July amending Royal Decree 1367/2007 of 19 October implementing Law 37/2003 of 17 November on noise, with regard to noise zoning, quality objectives and noise emissions

[52] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

[53] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=NIM:117200 and https://www.boe.es/buscar/pdf/2003/BOE-A-2003-20976-consolidado.pdf

[54] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=NIM:126822 and https://www.boe.es/buscar/pdf/2005/BOE-A-2005-20792-consolidado.pdf

Transposed into regional level in the MS	**Yes** Decree 6/2012	17 January. The decree approves the noise regulation for the Autonomous Community of Andalusia.
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts		
Other (please add rows below if needed)		

3. NAP noise reduction measures

3.1. Does the NAP outline the main sources of noise? (e.g. in airports it could be airplanes on take-off and landing)

The NAP only targets road noise and identifies road traffic as the main source of noise. For some of the roads, it is explained that noise exposure is higher at night.

3.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

The NAP presents what can be done to tackle road noise in terms of:

- Noise emitter
- Mode of transmission (example of noise barriers)
- Receiver (increasing insulation)

The NAP used the SILENCE and SMILE projects to define the measures to be implemented. The measures can therefore be of the following types:

- Corrective measures
- Preventative measures
- Control measures

The chosen measures include corrective and preventative measures.

- Corrective measures: in conflict areas that are residential and education conflict areas.
    - Area 1 (residential conflict area):
        - Pedestrian overpasses have been implemented
        - Raising 4 existing crosswalks
        - Limit speed to 30 km/h in the vicinity of the Mater et Magistra centre (education)
        - Optimisation of the existing traffic light control, applying short cycles so that the speed of passage through the crossing is moderated

        - **Not implemented** tools: noise barriers, insulation, acoustic surface, modification of road, regulation of night traffic
    - Area 2 (education conflict area):
        - Speed limits
        - Reducing the speed to 30 km near the education building
        - **Not implemented** tools: noise barriers, insulation, acoustic surface, modification of road, regulation of night traffic, action on the regulation of traffic
- Preventative measures: prioritize the use of sound-absorbing pavements in new works to be carried out in the provincial road network on residential areas.

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3.3. Are there any noise limits mentioned in the NAP?[55]

National limits in urban areas:

Type of acoustic area		Noise indicators dB(A)		
		Ld	**Le**	**Ln**
E	Areas of the territory with predominance of land use for sanitary, educational and cultural purposes which requires special protection	60	60	50
A	Areas of the territory with predominance of land use for housing purposes	65	65	55
D	Areas of the territory with predominance of land use for with predominance of land use for tertiary purposes	70	70	65
C	Areas of the territory with predominance of land use for recreational and show purposes	73	73	63
B	Areas of the territory with predominance of land use for industrial purposes	75	75	65
F	Affected to general systems of transport infrastructures or other equipment (1)	(2)		

(1) In these areas, appropriate measures to prevent noise pollution will be adopted, in particular through the application of technologies with the lowest acoustic resistance from among the best available technique.

(2) At the limit of these sectors of the territory, the acoustic quality objectives for noise applicable to the rest of the acoustic areas adjacent to them.

In the decree for Andalusia:

[55] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

Type of acoustic area		Noise indicators dB(A)		
		Ld	**Le**	**Ln**
E	Areas of the territory with predominance of land use for sanitary, educational and cultural purposes which requires special protection	60	60	50
A	Areas of the territory with predominance of land use for housing purposes	65	65	55
D	Areas of the territory with predominance of land use for with predominance of land use for tertiary purposes	70	70	65
C	Areas of the territory with predominance of land use for recreational and show purposes	73	73	63
B	Areas of the territory with predominance of land use for industrial purposes	75	75	65
F	Affected to general systems of transport infrastructures or other equipment	Not determined		
G	Natural spaces that require a special protection against noise pollution	Not determined		

3.4. Are these new measures or they are continuation of existing measures?

There are only new measures as the provincial roads were not eligible for the END criteria in the first round. They were indeed below the six million rides threshold, which has been lowered to three million for the second round.

3.5. Is there a timeframe for implementation of the above-mentioned measures?

3.5.1. In general

3.5.2. Per reduction measure

The NAP aims to implement the corrective measures in a period of 2 years, and the preventative one over 5 years.

3.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The maps were realized by the provincial council of Seville, and it is as well responsible for the elaboration of the NAP, through the roads and mobility service. The company SINCOSUR Ingeneria Sostenible also supported this work.

3.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

No information.

3.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

The total estimated budget for the actions on the conflict areas is of EUR 41 082,65.

The detailed budget for the measures in area 1 (residential conflict area) is:

Code	Description	Quantity	Price (unit)	Total

1	Quieter traffic – Pedestrian overpass	4	EUR 4 000	EUR 16 000
2	Traffic regulation - Program calculation, development and load on existing traffic controller	1	EUR 1 600	EUR 1 600
3	Signalling Installation of new limitation signs for speed Repainting of road markings	 1 1	 EUR 1 200 EUR 2 100	 EUR 1 200 EUR 2 100
	Sum	**EUR 20 900**		
	15 % Contingency and Health & Safety	EUR 2 135		
	Execution material	**EUR 24 035**		
	16% General expenses	EUR 3 845,60		
	6 % Industrial Profit	EUR 1 442,10		
	Base bidding budget	**EUR 29 322,70**		
	21% VAT	EUR 6 157,77		
	Total budget	**EUR 35 480,47**		

The detailed budget for the measures in area 2 (education conflict area) is:

Code	Description	Quantity	Price (unit)	Total
1	Signalling Installing new signs for speed limit Repainting of road markings	 1 1	 EUR 1 200 EUR 2 100	 EUR 1 200 EUR 2 100
	Sum	**EUR 3 300**		
	15 % Contingency and Health & Safety	EUR 495		
	Execution material	**EUR 3 795**		
	16% General expenses	EUR 607,20		
	6 % Industrial Profit	EUR 227,70		
	Base bidding budget	**EUR 4 629,90**		
	21% VAT	EUR 972,28		
	Total budget	**EUR 5 602,18**		

3.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

Not specified.

4. Public consultation

4.1. Is there any information on the public consultation? (with residents, NGOs, etc.)

4.2. Does the public consultation include active involvement of stakeholders?

4.3. Are the results of the public consultation integrated in the NAP? How?

4.4. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

The NAP indicates that no comments were received on the maps during the period of public information.

5. Evaluation of the NAP

5.1. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

5.1.1. No

As indicated above, there is no previous NAP as the provincial roads were only eligible for the END from the second round.

5.1.2. If yes, what are the results?

5.1.2.1. Noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

5.1.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

5.2. Is there any information how current NAP will be evaluated?

5.2.1. No

5.2.2. Yes – please provide details

6. Legislative framework

6.1. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)		
Urban/land use planning legislative acts		
Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Building regulation		
Environment acts		

Other (please add rows below if needed)		

7. Please provide a brief summary

The NAP provides a very detailed picture of the roads and the conflict areas it targets. It also develops a very comprehensive explanation of the methodology followed for the selection and prioritisation of areas where to act. Detailed information on costs is also provided, even though cost-effectiveness is lacking, as well as information on evaluation.

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	prioritize the use of sound-absorbing pavements in new works
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	Speed limits
		Restricted access zone, traffic restrictions, truck restrictions	☐	
	Infrastructure interventions	Building tunnels, transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	Land and urban planning
	Path interventions between source and receiver	Road noise barriers	☐	
		Maintaining road surfaces and old buildings, insulation, sound-proof windows for new buildings	☐	
	Other physical interventions	Green areas, quiet areas	☐	
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise free movement (walk, bicycle)	☐	

17 Sweden

17.1 National roads (2015)

1. Background information

The Swedish Transport Administration has mapped the busiest roads, railways and airports in Sweden. The survey covers 400 km of state road. The survey shows that a total of approximately 1,000,000 people are exposed to noise levels exceeding Lden 55 from road and rail traffic from the mapped roads, including residents in the 13 municipalities.

L den	Number of people exposed during the day (outside the thirteen municipalities)
55 - 59	226 100
60 - 64	90 400
65 - 69	27 700
70 - 74	6 100
> 75	600
Total	351 000

L night	Number of people exposed during the day (outside the thirteen municipalities)
55 - 54	119 600
55 - 59	39 800
60 - 64	9 400
65 - 69	1 600
> 70	30
Total	170 430

2. Transposition of the END Directive into National Law

Please follow the link and look for the National legislation. [56]If possible, arrange it in the following table:

HOW END IS TRANSPOSED	YES/NO	NOTES
Transposition in the national law		
Transposed into regional level in the MS		
Urban/land use planning legislative acts		

[56] https://eur-lex.europa.eu/legal-content/EN/NIM/?uri=CELEX:32002L0049

Mobility related legislative acts		
Sector specific acts (aviation, rail, road)		
Buildings regulation		
Environment acts	Yes	Regulation (2004: 675) on environmental noise
Other (please add rows below if needed)		

3. NAP noise reduction measures

1.1. Does the NAP outline the main sources of noise?

The most important noise sources are the contact between the tire and the roadway, as well as engine noise. Road traffic noise depends on also on other circumstances such as the number of cars on the streets, vehicle types, speed, driving style (a fast driving with fast braking and powerful accelerations produce more noise than quiet driving at steady speed), tires and road surfaces. The noise from heavy vehicles (e.g. trucks etc..) is higher than from light vehicles (cars, motorbikes etc.). Light vehicles (under 3.5 tones) were 93% of traffic, and they had accounted for 60% of noise emissions. Furthermore, heavy vehicles (above 3.5 tones) were 7% of traffic, and they had represented 40% of noise emissions. The limit values for motor and tiers are important and should be regulated for noise reduction. Engine noise is a dominant source of noise at the lower speed (30 – 50 km/h for a car and 50-70 km/h for a heavy vehicle) while the noise from tire and roadway contact is dominant at higher speeds. Targeting the noise reduction at a lower speed for passenger car, the use of electric and hybrid engines is less noisy than gasoline, diesel and ethanol engines. The speed of vehicles is of great importance for emitted noise levels. Another important aspect for noise reduction is the choice of tires and coating. Coating with a large stone size is noisier than a smaller stone size. The noise also depends of weather conditions, winds and the surrounding area. Given the long winter period and the use of 'double tires', the Scandinavian coatings emits more noise compared to other countries. The green surrounding and natural landscape sound barriers next to road help noise reduction. The noise during snowy weather conditions is lower than during the rainy conditions.

1.2. What are the reduction measures mentioned in the NAP? (please indicate in the table of noise reduction measures at the end of this document). Please write the main ones/summary here

(1) Early stages of planning

• Community planning (in dialogue with Ministry of Transport, municipalities, business and other stakeholders) of mobility (e.g. greater use of the public transport in urban areas, as well as, bicycles and walking so that car traffic can be reduced) ;

- The four-step principles: (1) influence transport needs and the choice of transport (2) better use of existing roads (3) limited use in some circumstances (4) new investment and developments

(2) Planning support

- Specified objectives, guidelines and overall rules
- Support for quality assurance of rules for the road transport system
- Review plans for construction and physical planning based on transport and environmental policy objectives.

- Knowledge and information about conditions, environmental and health effects
- Support for research and knowledge development on noise widely available (particularly traffic noise)
- Support for façade measures along municipal roads

(3) Quiet and vibration-free sources

- Vehicles, tires, road surfaces
- Promote the use and development of energy-efficient, clean, quiet and traffic-safe vehicles
- Ensure that stricter noise requirements will be applied on new vehicles and tires
- Include noise requirements in procurement criteria
- Enhance the consumer information on noisy properties of vehicles and cars
- Support for increased control of vehicles with regard to noise
- Mobility plans (speed control, shift to other mobility organization that allows the reduction of cars on streets)
- Infrastructure maintenance

(4) Protective measures

- Noise-canceling measures (noise barriers, façade and windows insulation)
- Vibration-dampening measures
- Purchase of noise- or vibration-exposed properties

(5) Protection of quite areas

- The quite areas (parks, recreation areas, outdoor areas and other natural and cultural environments) should be noise protected if there is a plan for road reconstruction or building of a new road. Future intervention should consider this. However, there are no particular noise measures for quite areas, as they are not considered in the priority for action.

1.3. Are there any noise limits mentioned in the NAP?[57]

Yes.

Guidelines values for residential buildings (Infrastructure Bill 1996/97):

- 30 dB (A) indoor equivalent level
- 45 dB (A) indoor night time
- 55 dB (A) outdoor equivalent
- 70 dB (A) outdoor maximum level ratio in connection with housing

Furthermore, the National Plan for the Transport System 2014-2025, priorities noise intervention if noise guidelines are breached more than 5 times in the given period:

[57] Typology of noise units:

- L_day (noise during the day)
- L_night (noise during the night)
- LAeq, 16hr (the combination of day and evening, 0700-2300hr)
- L_den (average noise during the day_evening_night)

- A value of 45 dB (A) maximum level indoor night time may be exceeded a maximum of five times per night (22–06)
- A value of 70 dB (A) maximum level outdoor ratio in connection with housing may be exceeded a maximum of five times per hour

This applies to the existing infrastructure and buildings that have not been renovated by 1997.

The guideline values are recommended values that depend on technical possibilities and available funds for noise reduction. If the values for outdoor noise cannot be respected than the intervention priority is that recommended indoor noise values are not exceeded. The priority of intervention depends on the level of noise (from the highest to lower).

1.4. Are these new measures or they are continuation of existing measures?

Both.

1.5. Is there a timeframe for implementation of the above-mentioned measures?

1.5.1. In general

1.5.2. Per reduction measure

1.6. What actors are responsible for the implementation of the measures? (e.g. in the airports some measures need to be implemented by the airlines, others by the airports)

The Swedish Transport Administration and relevant municipalities

1.7. Does NAP refer to cost-effectiveness of the measures? If yes, what are they and what are the calculations?

Regarding the existing noise problem, the most cost-effective measure is the reduction of noise from the source. However, on the longer-term basis, the preventing noise of occurring from prior planning is the most cost-efficient long term measure.

1.8. Does NAP mention costs for noise measures, i.e. per km or per dwelling or inhabitant.

No.

1.9. Does NAP mention amount or extent of the noise measures, i.e. xx km on motorways, railways or xx extra dwellings insulated, relocated, km of traffic-calmed areas, etc.

No.

4. Public consultation

1.10. Is there any information on the public consultation? (with residents, NGOs, etc.)

The public consultations shall include public authorities, municipalities, organizations, operators, the general public and others affected subjects by the action program. The consultation is announced through the publication in a local newspaper and should last two months for gathering opinions on the proposal.

1.11. Does the public consultation include the active involvement of stakeholders?

No.

1.12. Are the results of the public consultation integrated in the NAP? How?

No data on that.

1.13. Was public consultation a "one-off" event or is it a constantly ongoing process (e.g. there is a monthly meeting of airport management with residents of neighbourhoods around the airport)

It was "one-off" event that had lasted 2 months.

5. Evaluation of the NAP

1.14. Is there any information on the evaluation of previous NAPs and individual noise reduction measures?

1.14.1. No

1.14.2. If yes, what are the results?

For the past period (2009-2012), the noise reduction measures along state roads have reduced the noise for 14 000 people, including 8 400 people who had benefited from the noise reduction more than 10 dB (A). Furthermore, 6 300 people felt the reduction of noise along municipal streets due to the measures that were co-financed between the Swedish Transport Administration and municipality. The measures implemented in these interventions are: noise barriers, façade measures and road coating.

1.14.2.1. The noise level was reduced (by how much). Is there a reference to individual measures that contributed to that.

The changes in traffic management (2012 survey) have contributed to indoor noise reduction from the road for approximately 4 800 people.

Decreased speed on average roads have contributed to a decrease of outdoor noise (around 4%; the measure has targeted 3 000 people annually between 2004 and 2012)

The façade insulation is implemented in circumstances when the indoor noise level is 10 dB above guidelines values. This measure has targeted 10 000 people.

Noise barriers and ramparts (> Leq 65 dBA) have benefited around 8 000 people.

A speed change of 10 km / h, in the interval 30-70 km / h, roughly changes the noise level by 2 dBA..

1.14.2.2. Noise level increased. What are the reasons (e.g. aircraft noise went down, but new neighbourhoods were built in the proximity of the airport)

1.15. Is there any information how current NAP will be evaluated?

1.15.1. No

1.15.2. Yes – please provide details

No information on the current NAP evaluation; however, the national action plan for transport infrastructure for the period 2014-2025 has an annual review.

6. Legislative framework

1.16. Does NAP refer to International, National or local legislative framework (besides END) that inspired measures in the NAP:

Legislative framework	YES/NO	NOTES
International regulations/standards (especially in aviation)	EU law	Regulation, No 540/2014 on new vehicles, limit values that will come in force from 1 July 2016 (phasing out motors with high noise emissions)
Urban/land use planning legislative acts		
Mobility related legislative acts		

Sector specific acts (aviation, rail, road)		
Building regulation	Yes	Infrastructure Bill 1996/97 (indoor house noise levels)
		In 2012, the Swedish Transport Administration adopted an internal guideline for buildings planning taking into consideration noise and vibrations. The purpose of the guideline is to create a common and uniform way of working in collaboration with municipalities in community planning when there is a risk of problems with noise or vibration.
Environment acts		Environmental code
Other (please add rows below if needed)		

Type	Noise solutions	Examples	If YES, tick a box	Comments
Road (major and cities)	Source interventions	Tyres, motor vehicles (cars, motorbikes etc.), road surface, change in traffic flow on existing roadways, heavy vehicle curfew, relocation of people	☒	Vehicles, tires, road surfaces; Ensure that stricter noise requirements will be applied on new vehicles and tires; Include noise requirements; support for increased control of vehicles with regard to noise procurement criteria;
	Mobility plans	Introducing new vehicles: electric vehicles, renewal of public transport fleet with better noise standards, speed limit	☒	Greater use of public transport in urban areas, as well as, bicycles and walking so that car traffic can be reduced; speed reduction and control;
		Restricted access zone, traffic restrictions, truck restrictions	☒	Limit car transport in certain areas;
	Infrastructure interventions	Building tunnels, the transformation of crossroads to roundabouts, building cycling lanes, subway-expansion, new road by-pass, land and urban planning	☒	Early stages of planning including the dialogue between different stakeholders (e.g. Ministry of Transport, municipality etc.); Infrastructure maintenance;
	Path interventions between source and receiver	Road noise barriers	☒	Noise-cancelling measures (noise barriers, façade and windows insulation); vibration-dampening measures; purchase of

				noise- or vibration-exposed properties
		Maintaining buildings, insulation, sound-proof windows for new buildings	☒	Façade and windows insulation
	Other physical interventions	Green areas, quiet areas	☒	The quite areas (parks, recreation areas, outdoor areas and other natural and cultural environments) should be noise protected if there is a plan for road reconstruction or building of a new road. Future intervention should consider this. However, there are no particular noise measures for quite areas, as they are not considered in the priority for action.
	Education and communication	Community education and communication, public consultations, noise perception, campaigns encouraging noise-free movement (walk, bicycle)	☒	Promote the use and development of energy-efficient, clean, quiet and traffic-safe vehicles; Enhance the consumer information on noisy properties of vehicles and cars

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Annex 2: Transposition of END in Member States

Country	Action plan	END transposition	Notes
Austria	Major national roads Vienna agglomeration Vienna airport National railways Regional Road: Salzburg Regional Road: Carinthia	Environmental/land use planning/sectoral acts	Federal Environmental Noise Protection Act (BGBl. I No. 60/2005), Official publication: *Bundesgesetzblatt für die Republik Österreich (BGBl.)* Ordinance of the Federal Minister for Agriculture and Forestry, Environment and Water Management on the Methods and Technical Specifications for the Assessment of Environmental Noise (Federal Environmental Noise Protection Ordinance – Bundes-LärmV) (BGBl. II No. 144/2006) Noise calculations were carried out in accordance with § 4 of the Federal Noise Ordinance (Bundes-LärmV) Federal law amending the Industrial Code 1994, the Mineral Raw Materials Act and the Emission Control Act for Boiler Plants Spatial Planning Act. Official publication: State Law Gazette (LGBl.) ; Number: 47/2006 ; Publication date: 2006-09-06 Section 7a of the Federal Roads Act 1971 (BGBl. I No 34/2013). Law on an amendment to the Road Act. Official publication: State Law Gazette (LGBl.) ; Number: 22/2006 ; Publication date: 2006-05-11
Bulgaria	Sofia airport	Environmental acts	Environmental Noise Protection Act, National Gazette published on 2005-09-13 Regulation on environmental noise indicators, taking into account the degree of discomfort over the various parts of the day, the ambient noise benchmarks, the methods for assessing the values of the noise indicators and the adverse effects of noise on the health of the population, National Gazette published on 2006-07-18 Regulation on the requirements for the development and content of strategic noise maps and action plans, National Gazette published on 2006-08-29
Belgium	Charleroi agglomeration Flanders rail Wallonia road	Environment acts	Order of 1 April 2004 amending the Order of 17 July 1997 on urban noise abatement. Official publication: Staatsblad; Publication date: 26/04/2004; Page number: 34299-34308 Order of the Walloon Government on the assessment and management of environmental noise. Official publication: Moniteur Belge; Publication date: 12/07/2004; Page number: 54852-54859 Decree of the Flemish Government of 22 July 2005 on the evaluation and management of environmental noise and amending the Decree of the Flemish Government of 1 June 1995 on the general and sectoral provisions on environmental hygiene. Official publication: Administrative measures; Publication date: 31/08/2005; Page number: 38020-38029
Croatia	Croatia rail	Health acts	Noise Protection Act; Official Gazzette No. 30/2009;

	Split-Dalmatia road		Rulebook on drafting noise maps, noise action plans and calculation on permissible noise levels; Official Gazzette No. 75/2009 Noise Protection Act – Amended; Official Gazzette No. 55/2013 Noise Protection Act – Amended; Official Gazzette No. 153/2013 Noise Protection Act – Amended; Official Gazzette No. 41/2016 Rulebook on drafting noise maps, noise action plans and calculation on permissible noise levels - Amended; Official Gazzette No. 60/2016
Cyprus	Major agglomerations (Nicosia and Limassol)	Environmental acts	The 2004 Law on Environmental Noise Assessment and Management. Official publication: Cyprus Gazette; Publication date: 2004-07-30 The Law on Environmental Noise Assessment and Management (Amending) Law of 2006. Official publication: Cyprus Gazette; Number: 4076; Publication date: 2006-03-17; Page: 00587-00589 The Law on Environmental Noise Assessment and Management (Amending) Law of 2007. Official publication: Cyprus Gazette; Number: 4130; Publication date: 2007-06-29; Page: 00673-00673
Czechia	Prague agglomeration Prague airport Prague rail	Health/Environment acts	Law No. 76/2002 on integrated pollution prevention and control, integrated pollution register and amending certain laws Law No. 222/2006 amending Law No. 76/2002 on integrated pollution prevention and control, integrated pollution register and amending certain laws (Integrated Prevention Law) as amended, and certain other laws Law No. 25/2008 on integrated register of pollution caused by the environment and an integrated system for fulfilling environmental reporting obligations and amending certain laws Law No. 69/2013 amending Act No. 76/2002 on integrated pollution prevention and control, integrated pollution register and amending certain laws (Integrated Prevention Law) as amended, and certain other laws Law No. 267/2015 amending Law No. 258/2000 on the protection of public health and amending certain related acts, as amended, and other related acts Decree No 523/2006 laying down limit values for noise indicators, their calculation, basic requirements on the content of strategic noise maps and action plans and conditions for public participation in their preparation (Decree on noise mapping) Decree No. 315/2018 on strategic noise mapping Law No. 258/2000 on the protection of public health and amending certain related laws
Denmark	Copenhagen agglomeration Copenhagen airport (2013 + 2018) National rail (2013 + 2018) National roads	Environment acts	(1) Executive Order no. 1309 of 21 December 2011 on mapping of external noise and preparation of noise action plans (2) Executive Order on mapping of external noise and preparation of action plans (Noise Executive Order) (3) Official publication: Lovtidende A; Number: 766 (4) Executive Order on mapping of external noise and preparation of noise action plans (5) Official publication: Lovtidende A; Number: 717 (6) Executive Order on mapping of external noise and preparation of noise action plans (7) Official publication: Lovtidende A; Number: 51
Estonia	Tallinn agglomeration	Environmental acts	(1) Ambient Air Protection Act - Official publication: Elektrooniline Riigi Teataja; Number: RTI 2004, 43, 298 (2) Minimum requirements for the content of the strategic ambient noise map and the action plan for the reduction of ambient noise - Official publication: Elektrooniline Riigi Teataja; Number: RTL 2005, 87, 1092

Finland	Helsinki agglomeration Helsinki airport Oulu agglomeration	Environment/Regional acts	(1) Act on the protection of the environment and the environment (30/2001) (2) Environmental Protection Act (527/2014) (3) Act amending the Environmental Protection Act (327/2016) (4) Government Decree on noise surveys and noise abatement action plans (823/2018) (5) Provincial Decree on application in Åland of the Government Decree on noise investigations and noise action plans provided for by the European Community (51/2005)
France	Paris CDG airport Grenoble agglomeration Grenoble Metropole agglomeration Lyon agglomeration Paris agglomeration Greater Paris Metropole agglomeration Bordeaux Metropole agglomeration Nice Côte d'Azur agglomeration	Environment acts	Ordinance n° 2004/1199 of 12 November 2004 taken in order to transpose directive 2002/49/CE of the European Parliament and Council of 25 June 2002 referring to the evaluation and management of noise in the environment, Decree of 4 April 2006 relating to the establishment of noise maps and environmental noise prevention plans
Germany	Berlin agglomeration Cologne agglomeration Hamburg agglomeration Berlin Tegel airport Cologne airport Frankfurt airport National rail (2015 + 2018) Regional roads – Bayreuth	Environmental law	(1) Law on the implementation of the EC Directive on the assessment and management of environmental noise, Official publication: Bundesgesetzblatt Teil 1 (BGB 1) ; Publication date: 2005-06-29 ; Page: 01794-01796 (2) Thirty-fourth Ordinance for the Implementation of the Federal Immission Control Act (Ordinance on Noise Mapping - 34th BImSchV), Official publication: Bundesgesetzblatt Teil 1 (BGB 1) ; Number: 12 ; Publication date: 2006-03-15 ; Page: 00516-00518 (3) Sixteenth Federal Immission Control Ordinance. 16. BImSchV – 16. Bundes-Immissionsschutzverordnung
Hungary	Pecs agglomeration (2013 + 2019) Budapest airport National rail	Environmental acts	(1) Modification of Law LIII. Of 1995 on environmental protection and Government regulation 280/2004 (X.20) on environmental noise assessment and management (2) Environmental Ministry's Act of 25/2004 on strategic noise maps and noise action plans
Ireland	Cork county major roads Dublin agglomeration Limerick agglomeration Dublin airport (2013 + 2018) National rail	Environment acts	Environmental Noise Regulations 2006, Statutory Instrument 140 of 2006, Official publication: Iris Oifigiúl ; Publication date: 2006-04-21
Italy	Milan agglomeration	Environment acts	

	Milan Malpensa airport (2013 + 2017) Italy rail Italy road Highway dei Fiori Italy road Torino-Alessandria-Piacenza Bologna agglomeration Bologna airport		Legislative Decree 194/05 on Implementation of Directive 2002/49 / EC relating to the determination and management of environmental noise
Latvia	Major national roads Latvia rail (section Salaspils – Aizkraukle) Riga agglomeration Riga airport	Environmental law	(1) Cabinet Regulation No. 16 of 7 January 2014 on the “Procedures for Noise Assessment and Management”, Official publication: Latvijas Vēstnesis ; Number: 16 (5075) ; Publication date: 2014-01-23 (2) Law on Pollution (stipulating that the development of action plans for roads is ensured by the Ministry of Transport), Official publication: Latvijas Vēstnesis ; Number: 51 ; Publication date: 2001-03-29 (2) Law on Administrative Procedures. Official publication: Latvijas Vēstnesis; Number: 164; Publication date: 2001-11-14 (3) Cabinet Regulation No. 579 of 13 July 2004 Procedures for Environmental Noise Assessment. Official publication: Latvijas Vēstnesis; Number: 112; Publication date: 2004-07-16 (4) Cabinet Regulation No. 983 of 30 November 2004 "Amendments to Cabinet Regulation No. 597 of 13 July 2004" Procedures for Environmental Noise Assessment "". Official publication: Latvijas Vēstnesis; Number: 193; Publication date: 2004-12-06 (5) The law (Likums). Official publication: Latvijas Vēstnesis; Number: 25; Publication date: 2005-02-15 (6) Amendments to Cabinet Regulation No. 597 of 13 July 2004 “Procedures for Environmental Noise Assessment”. Official publication: Latvijas Vēstnesis; Number: 23; Publication date: 2006-02-08 (7) Amendments to Cabinet Regulation No. 597 of 13 July 2004 "Procedures for Environmental Noise Assessment". Official publication: Latvijas Vēstnesis; Number: 37; Publication date: 2010-03-05

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<td rowspan="3">Lithuania</td>
<td>Major national roads</td>
<td rowspan="3">Environmental law</td>
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Law of the Republic of Lithuania on Noise Management, 2004 October 26 No. IX – 2499 (Official Gazette, 2004, No. 164–5971 with subsequent amendments Official Gazette, 2006, No. 73-2760; Official Gazette, 2010, No. 51-2479; Official Gazette, 2013, No. 79- 3988).
Law of the Republic of Lithuania on Noise Management No. Law IX-2499 Amending Articles 2, 5, 7, 8, 9, 11, 13, 14, 17, 18, 24, 26, 27, 29 and repealing Articles 19, 20 XII-2341
Official publication: Register of Legislation; Number: 2016-13907; Publication date: 2016-05-24
Government of the Republic of Lithuania 2018 April 4 Resolution no. 321 "On the Implementation of the Law on Noise Management of the Republic of Lithuania". Official publication: Register of Legislation; Number: 2018-06179; Publication date: 2018-04-18
Government of the Republic of Lithuania, 2004 August 18 Resolution no. 967 "On the Approval of the Description of the Procedure for Strategic Environmental Assessment of Plans and Programs". Official publication: State News; Number: 130; Publication date: 2004-08-21

Noise mapping:

State Strategic Noise Mapping Program. Resolution of the Government of the Republic of Lithuania No. 581, 2006 June 14 (Official Gazette, 2006, No. 68-2508; Official Gazette, 2006, No. 71 (correction)).
Government of the Republic of Lithuania, 2008 July 16 Resolution no. 719 "On the Implementation of the State Strategic Noise Mapping Program for 2008-2012. approval of the plan of measures" (Official Gazette, 2008, No. 84-3356).
Minister of Transport and Communications of the Republic of Lithuania 2006 July 24 Order No. 3-304 "On the Implementation of the State Strategic Noise Mapping Program and Approval of the List of Responsible Executors".

Noise action plans:

Government of the Republic of Lithuania 2007 June 6 Resolution no. 564 "On the State Noise Prevention Actions for 2007-2013. approval of the program" (Official Gazette, 2007, No. 67-2614).
Government of the Republic of Lithuania 2009 March 4 Resolution no. 157 "On the State Noise Prevention Actions for 2007–2013. implementation of the program for the period 2009-2013 approval of the plan of measures" (Official Gazette Valstybės žinios, 2009, No. 28-1087).

Reporting to the EU and Implementation:

Minister of Health of the Republic of Lithuania, Minister of Environment of the Republic of Lithuania and Minister of Transport and Communications of the Republic of Lithuania October 25 order no. V-787 / D1- 507 / 3-467 "On the Approval of the Rules for Reporting on the Implementation of the Requirements of the Legislation of the European Union Noise Management Sector to the Commission of the European Communities" (Official Gazette Valstybės žinios, 2005, No. 128-4621).
Government of the Republic of Lithuania 2007 December 5 Resolution no. 1305 "On Approval of the Rules for Provision of Initial and Summary Noise Management Information to the Noise Prevention Council, State and Municipal Institutions and the Public" (Official Gazette Valstybės žinios, 2007, No. 132-5380 with subsequent amendments Official Gazette Valstybės žinios, 2010, No.:59-2897; ., 2010, No. 64-3154; Official Gazette 2012, 58-2898).

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<td>National rail</td>
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<td>Vilnius agglomeration</td>
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			• Minister of Health of the Republic of Lithuania, 2007 July 19 order no. V-616 "On the approval of information formats for reporting to the Commission of the European Communities on the implementation of Directive 2002/49 / EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise" (Official Journal 2007, No 83-3406). • Government of the Republic of Lithuania 2006 March 27 Resolution no. 299 "On the Government of the Republic of Lithuania April 7 Resolution no. Amendment 388 "On the approval of the procedure for submission of reports to the European Commission on the implementation of the legislation of the European Union in the field of environment and submission of the information required for the preparation of reports to the European Environment Agency". Official publication: State News; Number: 35; Publication date: 2006-03-30 • Resolution No. 938 of the Government of the Republic of Lithuania of 24 September 2008 On Resolution No. 388 "On the Approval of Procedures for the Submission of Reports Relating to the Implementation of European Union Environmental Legislation to the European Commission and for the Preparation of Information Required for Reporting to the European Environment Agency". Official publication: State News; Number: 112; Publication date: 2008-09-30 • Minister of Health of the Republic of Lithuania 2017 May 16 order no. V-558 "On Order No. V-616 of the Minister of Health of the Republic of Lithuania of 19 July 2007" On Information Required for Reporting to the Commission of the European Communities on Directive 2002/49 / EC of the European Parliament and of the Council of 25 June 2002 on the preparation of the implementation of the assessment and management of environmental noise, the "amendment" of the approval of submission forms. Official publication: Register of Legislation; Number: 2017-08230; Publication date: 2017-05-16 • Minister of Health of the Republic of Lithuania, Minister of Environment of the Republic of Lithuania and Minister of Transport and Communications of the Republic of Lithuania 2017 June 21 order no. V-787 / D1-541 / 3-279 "On Order No. V-787 / D1-507 / 3-467 of the Minister of Health of the Republic of Lithuania, the Minister of Environment of the Republic of Lithuania and the Minister of Transport and Communications of the Republic of Lithuania of 25 October 2005" "Amendment" to the approval of the rules for reporting to the European Commission on the implementation of the requirements of the legislation of the European Union noise management sector. Official publication: Register of Legislation; Number: 2017-10622; Publication date: 2017-06-23 Environmental Assessment: • Resolution No. of the Government of the Republic of Lithuania of 23 December 2014 1467 on Resolution No. 1467 of the Government of the Republic of Lithuania of 18 August 2004 967 "On Amendment to the Description of the Procedure for Strategic Environmental Assessment of Plans and Programs". Official publication: Register of Legislation; Number: 02014-20928; Publication date: 2014-12-30 Noise limit values:

			Lithuanian Hygiene Standard HN 33: 2011 "Noise Limit Values in Residential and Public Buildings and Their Environment", approved by the Minister of Health of the Republic of Lithuania on 13 June 2011. by order no. V-604 (Official Gazette, 2011, No. 75-3638).
Malta	General (mainly roads)	Environmental act	Regolamenti ta' l-2004 dwar Valutazzjoni u Maniggjar ta' Hsejjes fl-Ambjent taht l-ATT TA' L-2001 DWAR IL-HARSIEN TA' L-AMBJENT (KAP. 435). *Official publication: The Malta government gazette; Number: 17,571*
Netherlands	Amsterdam agglomeration Utrecht agglomeration National rail Major national roads North Holland province roads South Holland province roads Amsterdam Schiphol airport	Environmental acts Aviation act Railways act	(1) Law of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railways Act in connection with the implementation of Directive No 2002/49 / EC of the European Parliament and of the Council of the European Union of 25 June 2002 on evaluation and the control of environmental noise, PbEG L 189 (noise maps and action plans), Official publication: Staatsblad (Bulletin des Lois et des Décrets royaux) ; Number: 2004/338 ; Publication date: 2004-07-15 ; Page: 00001-00008 (2) Decree of 6 July 2004, containing rules with regard to the reproduction and control of environmental noise as well as the entry into force of the Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of the Environmental Noise Directive (Decree environmental noise), Official publication: Staatsblad (Bulletin des Lois et des Décrets royaux) ; Number: 2004/339 ; Publication date: 2004-07-15 (3) Environmental noise control, Official publication: Staatscourant (Journal Officiel néerlandais) ; Number: 134 ; Publication date: 2004-07-16 (4) Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Nuisance Act to the Environmental Management Act (modernization of sound policy instruments, noise production ceilings), Official publication: Staatsblad (Bulletin des Lois et des Décrets royaux) ; Number: 2012, 266 ; Publication date: 2012-06-20 (5) Decree of 6 June 2012, establishing the date of entry into force of the Act of 24 November 2011 amending the Environmental Management Act in connection with the introduction of noise production ceilings and the transfer of Chapter IX of the Noise Abatement Act to the Environmental Management Act (modernization) instruments for noise policy, noise production ceilings), the Noise Production Ceilings Implementation Act, the Environmental Management Noise Decree and the Noise Production Ceilings Implementation Decree, Official publication: Staatsblad (Bulletin des Lois et des Décrets royaux) ; Number: 2012, 268 ; Publication date: 2012-06-20
Poland	Major roads in Lubuskie voivodeship Wielkopolska rail	Environmental acts	Environmental Protection law from 27th April 2001 and Law of 30 August 2019 amending the act - Environmental protection law; Related regulations e.g: - The Regulation of the of Ministry of Environment dated 14 October 2002 on detailed requirement for a system of protection against noise; - The Regulation of the of Ministry of Environment dated 4 June 2007 on the determination of the noise

	Warminsko Mazurskie road		indicators; - The Regulation of the Ministry of Environment dated 12 June 2007 on allowable environmental noise levels; - The Regulation of the Ministry of Environment dated 12 June 2007 on the detailed scope of data included in noise maps and their layout and presentation; - The Regulation of the Ministry of Environment dated 14 June 2007 on permissible sound levels;
Portugal	Lisbon agglomeration Lisbon airport Linha do Minho rail Linha do Sul rail Batalha-Porto road	Environment/regional acts	Ministry of the Environment, Town and Country Planning and Regional Development - transposes into national law Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Presidency of the Council of Ministers-Decree Law no. 146/2006, which transposes Directive no. 2002/49/EC of the European Parliament and of the Council, of 25 June, on the assessment and management of environmental noise, published in the Diário da República, 1st series, no. 146, of 31 July 2006, has been rectified. Autonomous region of Azores - Legislative Assembly-Approves the general regulation on noise and noise pollution control and transposes into regional law Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise, Directive Noise Directive and Directive Noise Directive. 2002/30/EC of the European Parliament and of the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports and Directive 2003/10/EC of the European Parliament and of the Council of 6 February 2003 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise. Presidency of the Council of Ministers - Legal Centre - Rectifies the Regional Legislative Decree No. 23/2010/A, of 30 June, of the Legislative Assembly of the Autonomous Region of the Azores, which approves the general regulation on noise and noise pollution control and transposes into the regional legal order Directives No. 23/2010/A, of 30 June, of the Autonomous Region of the Azores. 2002/49/EC of the European Parliament and of the Council of 25 June relating to the assessment and management of environmental noise, 2002/30/EC of the European Parliament and of the Council of 26 March on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports, and 2003/10/EC of the European Parliament and of the Council of 6 February on the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise.

Romania	Bucharest Henri Coanda Airport Bucharest-Brazi rail	Transport/environment acts	Order of the Minister of Transport, Construction and Tourism, to establish the units responsible for drawing up noise maps for railways, their roads and airports in their administration, strategic noise maps and their action plans, within their field of activity and their respective limits of competence. Official publication: Monitorul Oficial al României; Number: 766; Publication date: 23/08/2005; Page number: 00026-00027 Order of the Minister of Environment and Sustainable Development, of the Minister of Transport, of the Minister of Public Health and of the Minister of Interior and Administrative Reform for the approval of the Guide to the adoption of limit values and of their application when drawing up the action plans, for Lden and Lnight, for road traffic noise on major roads and agglomerations, rail traffic on major roads and in agglomerations, rail traffic on major and/or urban airports and on noise from large and/or urban airports and noise produced in areas within agglomerations where industrial activities listed in Annex 1 to Government Emergency Ordinance No 152/2005 concerning integrated pollution prevention and control, approved with amendments and supplements by Law No 84/2006, are carried out. Official publication: Monitorul Oficial al României; Number: 531; Publication date: 15/07/2008; Page number: 00009-00011 Law No 121/2019 on assessment and management of environmental noise. Official publication: Monitorul Oficial al României; Number: 604; Publication date: 23/07/2019; Page number: 00002-00082 Order No 1090 of 6 December 2019 concerning the transposition into national law of Appendices A to I of the Annex to Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council Official publication: Monitorul Oficial al României; Number: 1031; Publication date: 23/12/2019; Page number: 00012-00012 Annexes 1-9 to Order No 1090 of 6 December 2019 concerning the transposition into national law of Appendices A to I of the Annex to Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council. Official publication: Monitorul Oficial al României; Number: 1031bis; Publication date: 23/12/2019; Page number: 00003-00682 Decision on the assessment and management of environmental noise. Monitorul Oficial al României; Number: 358; Publication date: 27/04/2005; Page number: 00001-00008 Decision amending Government Decision No 321/2005 on the assessment and management of environmental noise . Official publication: Monitorul Oficial al României; Number: 485; Publication date: 19/07/2007; Page number: 00007-00019
Spain	Barcelona agglomeration Madrid agglomeration Bilbao agglomeration (2014 + 2019) Madrid airport (2014 + 2019) Vitoria-Gasteiz agglomeration Basque country rail Autonomous community of Valencia rail Sevilla road	Health/Environment acts	Law 37/2003 of November 17th on Noise. BOE-A-2003-20976 Royal decree 1513/2005, December 16, for the development of Law 37/2003 of November 17 on Noise, referring to the evaluation and management of environmental noise. BOE 301/2005

Sweden	Major national roads	Environment act	Ordinance (2004: 675) on ambient noise. Official publication: Swedish Constitution (SFS); Number: 2004/675
	Stockholm airport		
	National rail (2015 + 2018)		

Annex 3: Stakeholder interviews as of January 2021

Country	Stakeholder group	Stakeholder Interviewed	Focus
EU	Sector organisation	Airports Council International (ACI)	**Aviation**
	Sector organisation	Airport Regions Council (ARC)	**Aviation**
	Sector organisation	European Express Association (EEA)	**Aviation**
	Sector organisation	DHL Brussels	**Aviation**
	Sector organisation	FedEx	**Aviation**
	Sector organisation	UPS	**Aviation**
	Sector organisation	UECNA	**Aviation**
	Sector organisation	Conference of European Directors of Roads	**Road**
	Sector organisation	European Road Federation	**Road**
	Sector organisation	European Tyre and Rim Technical Organisation (ETRTO)	**Road**
	Sector organisation	Michelin	**Road**
	Sector organisation	European Automobile Manufacturers' Association (ACEA)	**Road**
	Sector organisation	Scania	**Road**
	Sector organisation	Renault	**Road**
	Sector organisation	Porsche	**Road**
	Sector organisation	International Union of Railways	**Rail**
	Sector organisation	European Railway Agency	**Rail**
	Sector organisation	Community of European Railway and Infrastructure Companies	**Rail**
	Sector organisation	Shift2Rail Joint Undertaking	**Rail**

Country	Stakeholder group	Stakeholder Interviewed	Focus
	Local authorities	Network of European cities and regions cooperating for innovative transport solutions (POLIS)	**Agglomeration**
	Local authorities	Eurocities	**Agglomeration**
	European authorities	European Commission (DG Move)	**Air**
	European authorities	European Commission (DG Move)	**Rail**
Austria	National authority or public health/environmental organisation	Federal Ministry of Climate Action	**All**
	National authority or public health/environmental organisation	Government of Tyrol	**All**
	National authority or public health/environmental organisation	Environment Agency	**All**
Belgium	Research	University of Ghent Department of Information Technology Research Group Waves	**All**
	National authority or public health/environmental organisation	Wallonia Public Service	**Road**
	National authority or public health/environmental organisation	Agency for Roads and Traffic Flanders	**Road**
Bulgaria	National authority or public health/environmental organisation	Expert, Department: EIA and environment	**All**
Denmark	National authority or public health/environmental organisation	Danish Environmental Protection Agency	**All**
Estonia	National authority or public health/environmental organisation	Ministry of the Environment	**All**

Country	Stakeholder group	Stakeholder Interviewed	Focus
	National authority or public health/environmental organisation	Road administration	**Road**
Ireland	Sector organisation	Transport Infrastructure Ireland	**Road**
Italy	Sector organisation	National Union of Metal Construction and Building Envelope Industries	**Road**
Czechia	National authority or public health/environmental organisation	National Reference Laboratory for Environmental Noise, Public Health Institute	**All**
Finland	National authority or public health/environmental organisation	Ministry of the Environment, Department of the Built Environment	**All**
	Sector organisation	Centre for Economic Development, Transport and the Environment	**All**
	Sector organisation	Finnish Transport and Communication Agency Traficom	**All**
	Sector organisation	Finavia	**Aviation**
France	National authority or public health/environmental organisation	Ministry of an Ecological and Solidarity Transition	**All**
	Sector organisation	SIA – Organisation of French carmakers	**Road**
	Local authorities	Bordeaux Metropole	**Agglomeration**
	Local authorities	Nice Côte d'Azur Metropole	**Agglomeration**
	NGO	Acoucité	**Agglomeration/ Road**
	Association/research	Bruitparif	**All**
Greece	National authority or public health/environmental organisation	NEG Member	**All**
Germany	Sector organisation	Flughafenverband ADV	**All**
Hungary	National authority or public	Ministry of Agriculture	**All**

Country	Stakeholder group	Stakeholder Interviewed	Focus
	health/environmental organisation		
Latvia	National authority or public health/environmental organisation	Ministry of Environmental Protection and Regional Development	**All**
Lithuania	National authority or public health/environmental organisation	State Enterprise Lithuanian Road Administration	**Road**
	National authority or public health/environmental organisation	AB LTG Infra	**Rail**
Luxembourg	National authority or public health/environmental organisation	NEG members	**All**
	National authority or public health/environmental organisation	National Railway company	**Rail**
Netherlands	Research	Individual expert	**All**
	Local authorities	City of Utrecht	**Agglomeration**
	National authority or public health/environmental organisation	Netherlands National Institute for Public Health and the Environment (RIVM)	**Health**
Malta	National authority or public health/environmental organisation	Environment and Resources	**All**
Romania	National authority or public health/environmental organisation	National Road Company	**Road**
Slovakia	National authority or public health/environmental organisation	Permanent Representation of the EU	**All**
Spain	Local associations	Neighbours association of Chueca (Madrid)	**Agglomeration**

Country	Stakeholder group	Stakeholder Interviewed	Focus
Sweden	National authority or public health/environmental organisation	Swedish Environmental Protection Agency	All
	Research	University of Stockholm	All
Switzerland	National authority or public health/environmental organisation	Federal Office for the Environment	All

Annex 4: Test site calculations for road traffic noise

ANNEX 4
Test site calculations for road traffic noise

Calculations performed by: TNO and Tecnalia

Project: Phenomena

Contents

Overview

Road traffic noise calculations have been performed for ten test sites:

- four areas in urban agglomerations: Amsterdam, Antwerp, Karlsruhe, Zaragoza.
- six areas near major roads outside agglomerations.

The calculations were performed by TNO and Tecnalia. Various *variations* of the test sites have been considered by 'switching on or off' motorways in urban areas, or noise barriers along roads.

In this document, graphs of exposure distributions for the test sites are presented. In the annexes results for all test sites are presented.

Agglomerations

Figure 1 shows the Lden noise maps for the areas in Amsterdam, Antwerp, and Karlsruhe. Each area has a size of of 4 x 4 km. Each area contains a motorway (purple band) and many other roads. Figure 2 shows the exposure distributons. The EU average distributions are also shown in the graphs, as well as the distributions for a 2x2km area of Zaragoza.

The exposure in the 65-69 dB Lden interval is considerably higher in Antwerp than in the other cities. This was attributed to the road network: *nearly all roads* are included in Antwerp, while in Amsterdam and Karlsruhe many minor roads are not included. Separate graphs for the three testsites are given in the three subsections below.

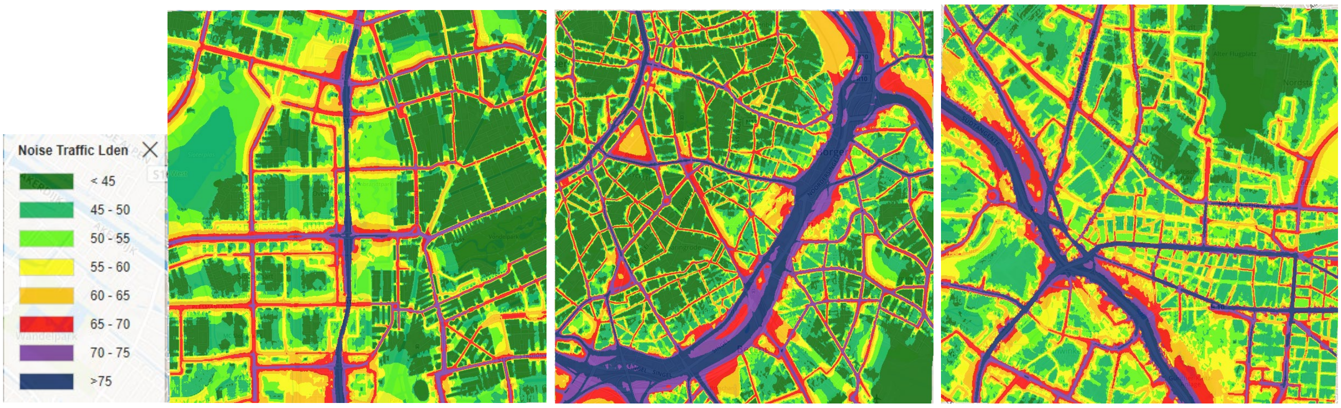


Figure 1. Noise maps for areas of 4 x 4 km in Amsterdam (left), Antwerp (middle), and Karlsruhe (right).

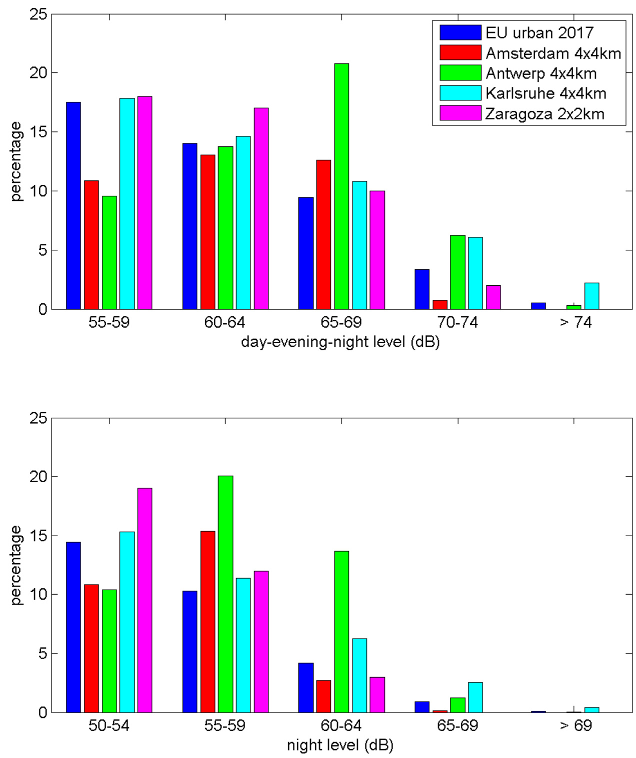


Figure 2. Exposure distributions for four urban areas and the EU average, for Lden and Lnight.

Major roads

Figure 3 shows the distributions for the seven test sites, both for Lden and for Lnight. Figure 4 shows the same distributions, but now normalized so that the sum over the five intervals is unity. In Fig. 4, the average EU distributions for Lden and Lnight are also included. The normalized distributions for the seven test sites are similar to the normalized EU distributions.

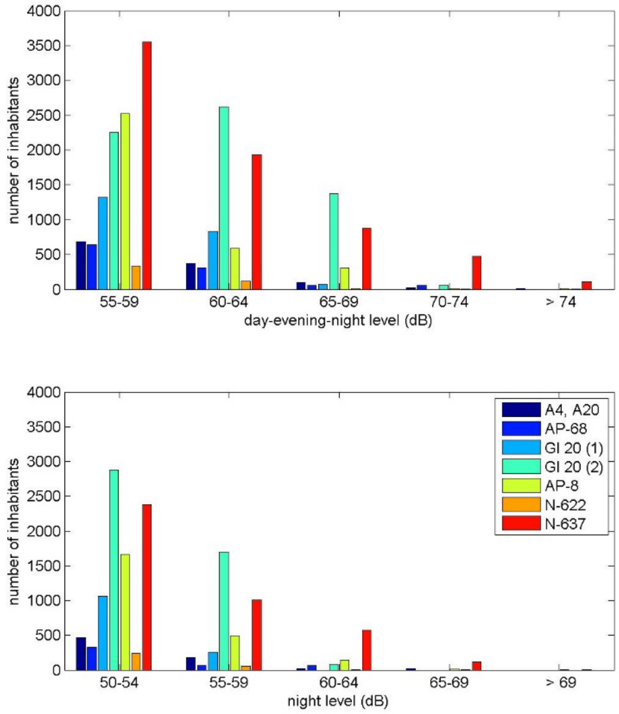


Figure 3. Exposure distributions for the seven test sites, for Lden and Lnight.

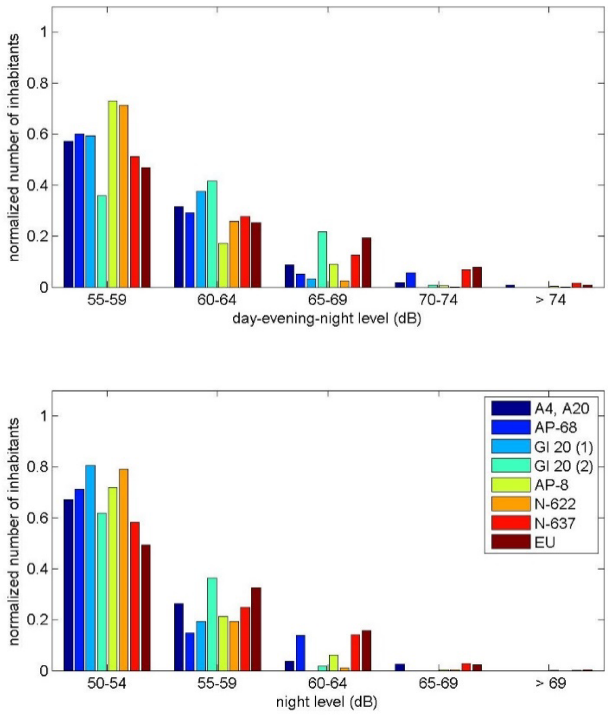


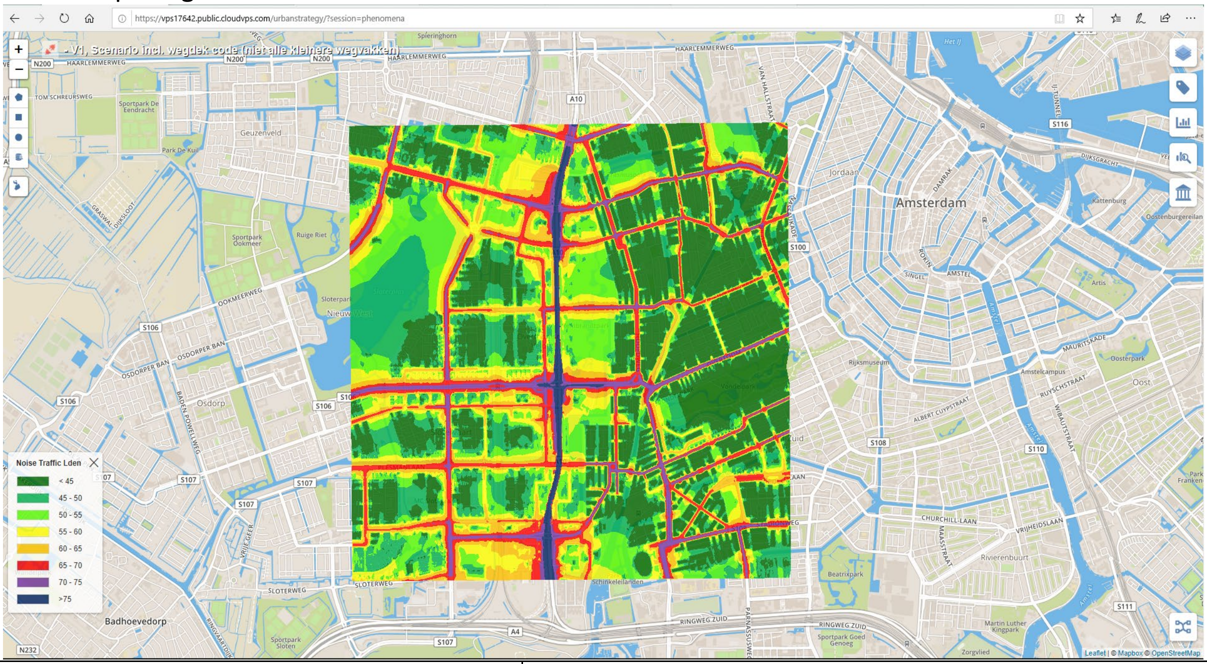
Figure 4. Normalized exposure distributions for the seven test sites, for Lden and Lnight. The EU distributions are included.

Annex A4. Test sites in The Netherlands, Belgium, and Germany

A4.1. Amsterdam

Noise map test site	
City / location / major road	Amsterdam area near A10 West x=112-116km, y=484-488km.

Noise map image



Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	29 Jan 2020
Source of input data used for map	Authority of Amsterdam (2011)
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - Various types of road surfaces. - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - Addresses from BAG. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants and P is the percentage.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	44640	49,4	64103	70,9
L = 50-54 dB	12034	13,3	9797	10,8
L = 55-59 dB	9838	10,9	13902	15,4
L = 60-64 dB	11770	13,0	2462	2,7
L = 65-69 dB	11402	12,6	105	0,1
L = 70-74 dB	685	0,8	0	0,0
L > 75 dB	0	0,0	0	0,0
	90369	100	90369	100

The 4 x 4 km area in Amsterdam includes 90369 inhabitants. The area contains motorway A10 with speed 80 km/h and other roads with speed 30 – 70 km/h. The noise map was calculated with TNO software Urban Strategy. The following variations were performed:

- removing the motorway,
- removing the other roads,
- removing the barrier along the motorway,
- considering only buildings along the roads ('first line' buildings).

For the last variation, buildings were considered within 50 m from the motorway and 15 m from the other roads.

Calculated exposure distributions are shown in Figures 1 and 2, together with EU average distributions. The following conclusions are derived from the results.

- The exposure distribution is dominated by urban roads.
- There is only a small contribution from the motorway.
- Removal of the barriers along the motorway has only a small effect.
- Considering only buildings along the roads (first line) gives an underestimation of the exposure.

It should be noted that the limited effect of the barrier is related to the fact that there are many office buildings along the motorway. These buildings also act as noise barriers.

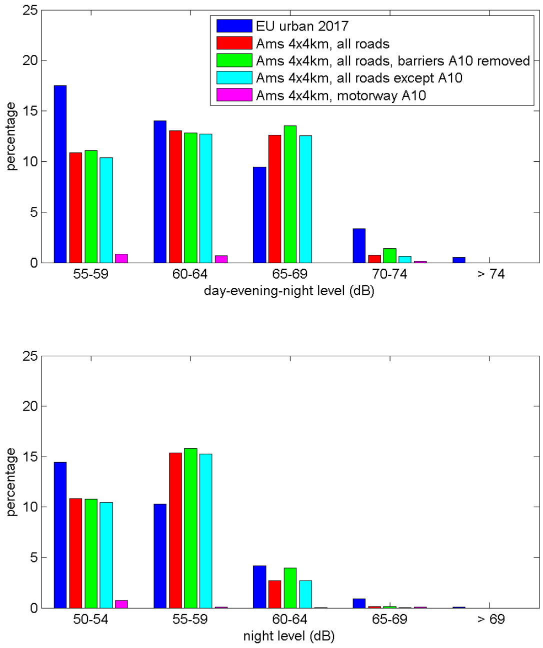


Figure 1. Exposure distributions for the Amsterdam area, and EU average distributions.

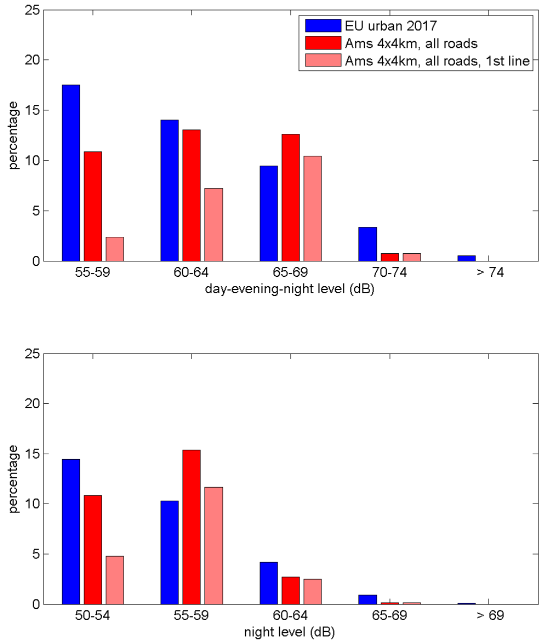
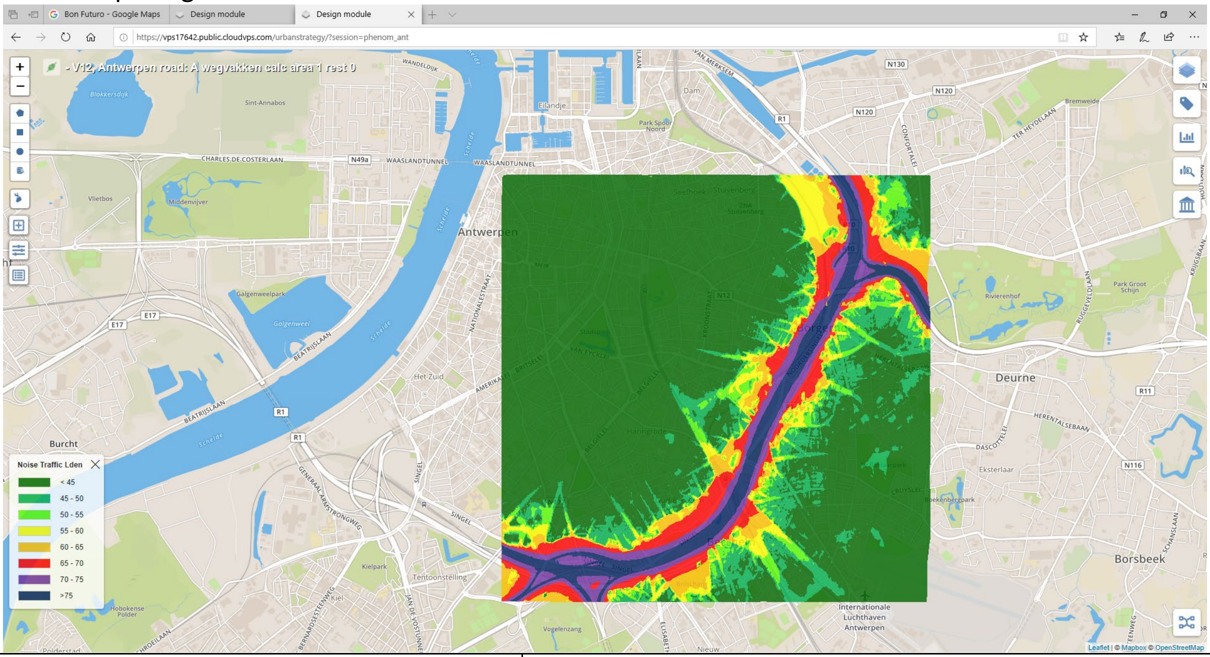


Figure 2. Exposure distributions for all buildings (red) and only first-line buildings (light red). Also shown is the EU average distribution (blue).

Note: First-line percentages are related to the total population; percentages from first-line sub-population are factor 4.5 higher.

A4.2. Antwerp

Noise map test site	
City / location / major road	Antwerpen area x=152.4-156.4km, y=208.7-212.7km.
Noise map image	



Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	19 Mar 2020
Source of input data used for map	Vlaanderen (open data)
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - Various types of road surfaces. - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants and P is the percentage.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	34676,4	36,0	52560,2	54,6
L = 50-54 dB	12903	13,4	10023,2	10,4
L = 55-59 dB	9209,2	9,6	19333,6	20,1
L = 60-64 dB	13224,2	13,7	13178	13,7
L = 65-69 dB	20026,6	20,8	1163,8	1,2
L = 70-74 dB	6008,2	6,2	50,6	0,1
L > 75 dB	266,2	0,3	4,4	0,0
	96314	100	96314	100

The 4 x 4 km area in Antwerp includes 96314 inhabitants. The area contains motorway E19 with speed 120 km/h and other roads with speed 30 – 90 km/h. The noise map was calculated with TNO software Urban Strategy. Similar variations were performed as for Amsterdam:

- removing the motorway,
- removing the other roads,
- *adding* barriers along the motorway,
- considering only buildings along the roads ('first line' buildings).

Calculated exposure distributions are shown in Figures 1 and 2, together with EU average distributions. The conclusions are similar to the conclusions for Amsterdam. In addition, it was found that the high exposure in the 65-69 dB Lden interval is a caused by minor urban roads (many of which were neglected for Amsterdam and Karlsruhe).

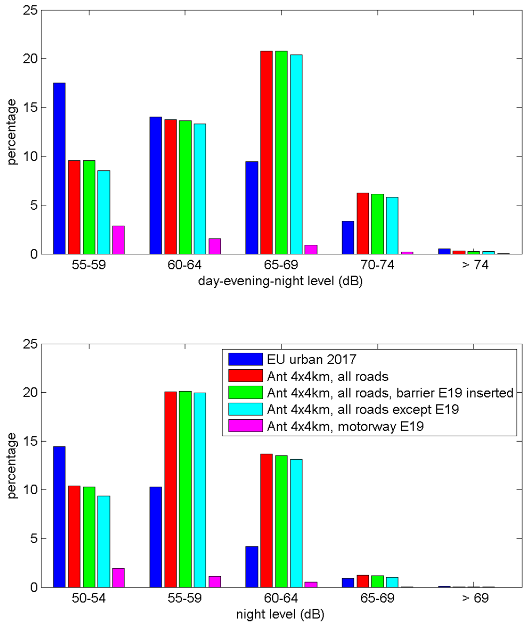


Figure 1. Exposure distributions for the Antwerp area, and EU average distributions.

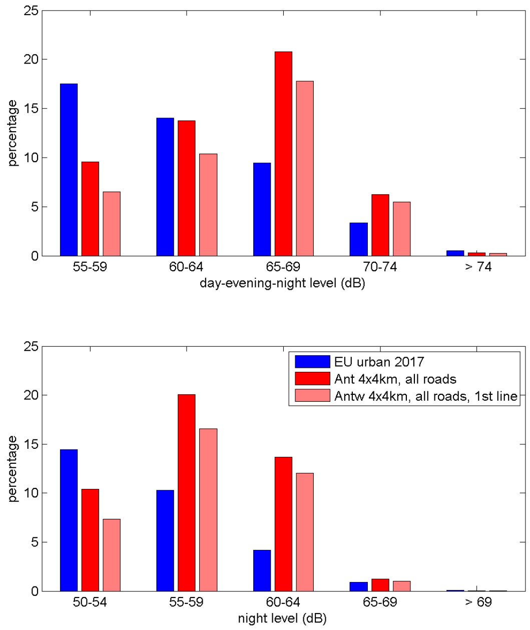
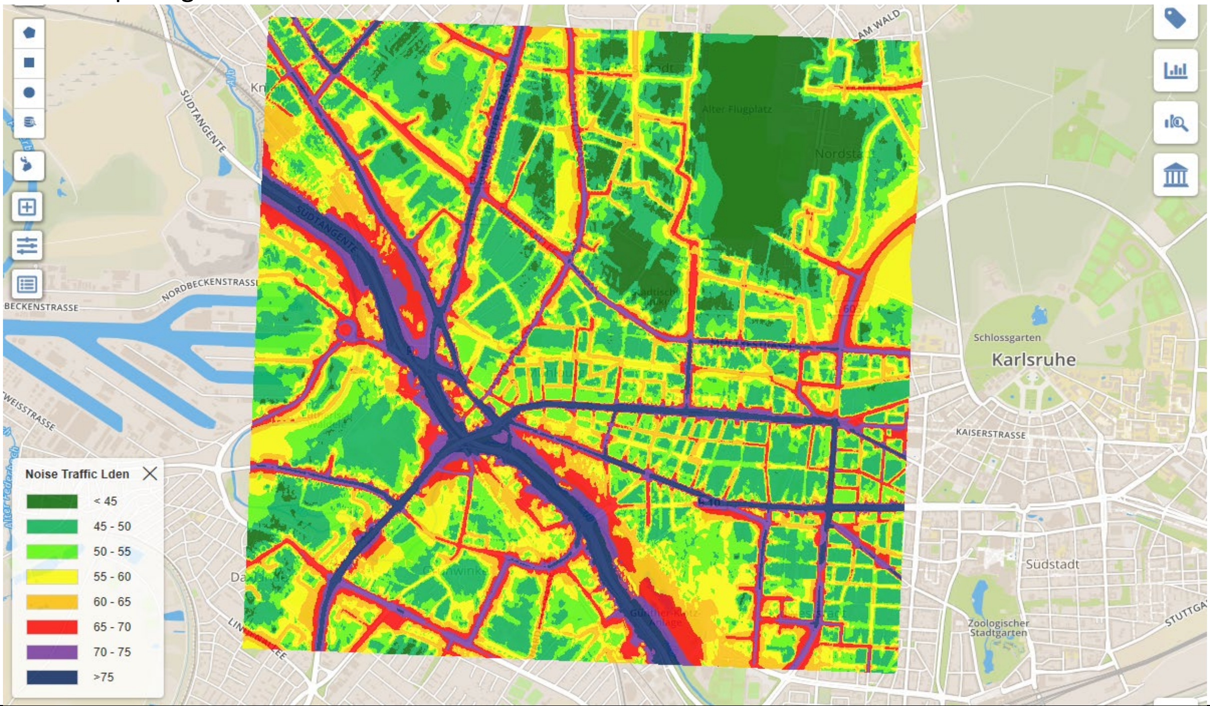


Figure 2. Exposure distributions for all buildings (red) and only first-line buildings (light red). Also shown is the EU average distribution (blue).

A4.3. Karlsruhe

Noise map test site	
City / location / major road	Karlsruhe area x=371-375km, y=116-120km.

Noise map image



Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	14 Apr 2020
Source of input data used for map	Karlsruhe
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - Various types of road surfaces. - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants and P is the percentage.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	10819,6	29,1	23775,4	64,0
L = 50-54 dB	7165,4	19,3	5689,2	15,3
L = 55-59 dB	6617,6	17,8	4228,4	11,4
L = 60-64 dB	5434	14,6	2318,8	6,2
L = 65-69 dB	4010,6	10,8	941,6	2,5
L = 70-74 dB	2263,8	6,1	160,6	0,4
L > 75 dB	809,6	2,2	6,6	0,0
	37121	100	37121	100

The 4 x 4 km area in Karlsruhe includes 37121 inhabitants. The area contains motorway B10 with speed 110 km/h and other roads with speed 30 – 90 km/h. The noise map was calculated with TNO software Urban Strategy. Similar variations were performed as for Amsterdam:

- removing the motorway,
- removing the other roads,
- *adding* barriers along the motorway,
- considering only buildings along the roads ('first line' buildings).

Calculated exposure distributions are shown in Figures 1 and 2, together with EU average distributions. The conclusions are similar to the conclusions for Amsterdam.

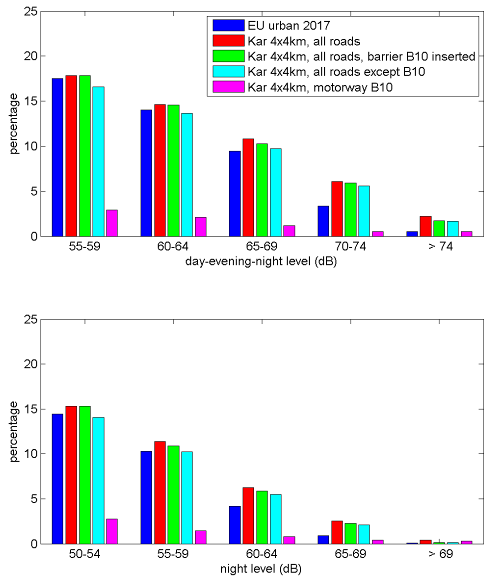


Figure 1. Exposure distributions for the Karlsruhe area, and EU average distributions.

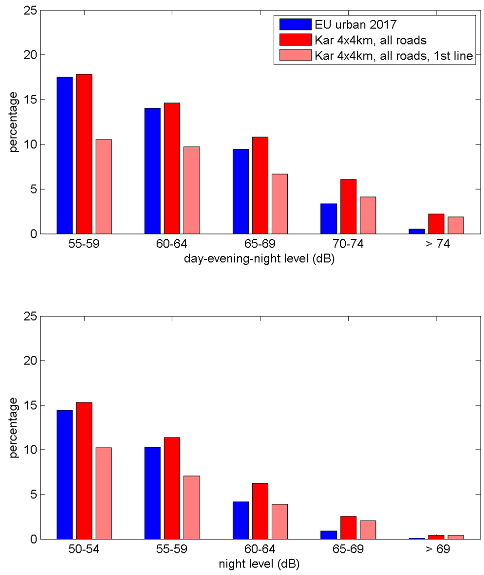


Figure 2. Exposure distributions for all buildings (red) and only first-line buildings (light red). Also shown is the EU average distribution (blue).

Karlsruhe area: traffic measures

In addition to the variations for Karlsruhe studied in the previous, additional variations with traffic measures were studied. In this case the entire city of Karlsruhe was considered. For the traffic measures, the traffic model included in the noise-mapping tool Urban Strategy was used.

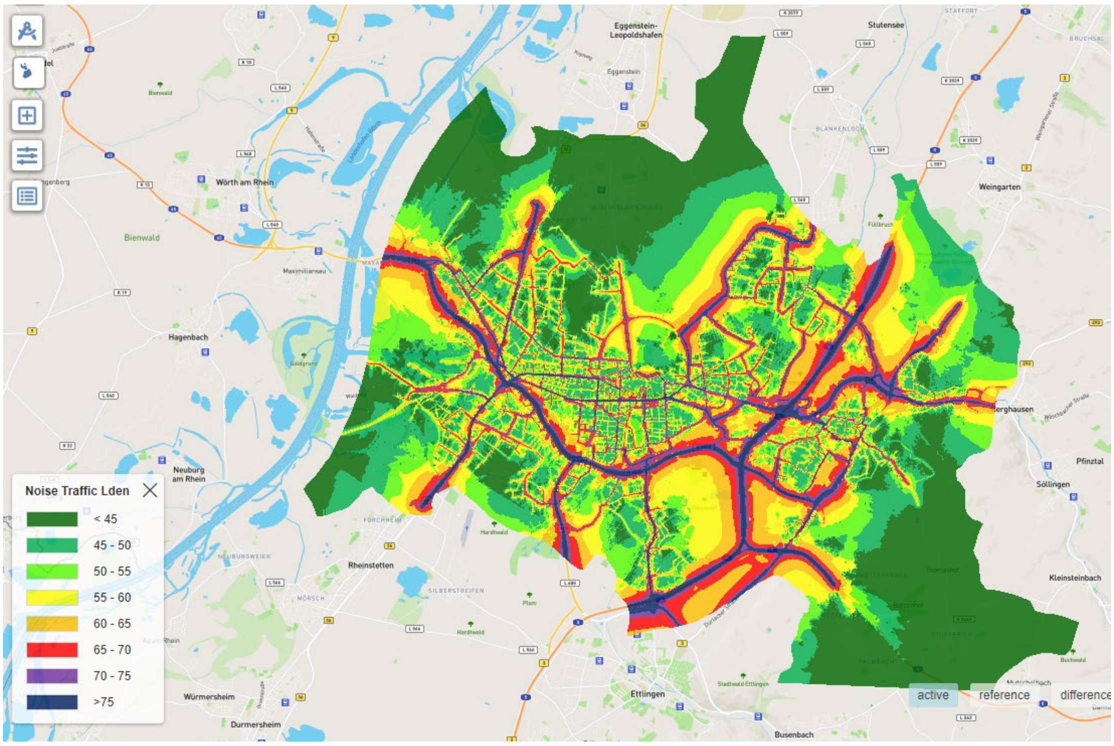


Figure 3. Road traffic noise map (Lden) of Karlsruhe.

The following variations V22-V28 have been considered.

- V22: reference situation
- V23: speed in area A (see Fig. 8b) reduced to 30 km/h; no traffic recalculation
- V24: all traffic in area A removed; no traffic recalculation
- V25: traffic on the road Kriegstrasse interrupted, forced to take other roads (see Fig. 5)
- V26: as V23 but now a traffic recalculation was performed
- V27: as V24 but now a traffic recalculation was performed
- V28: combination of V25 and V27.

Figure 6 shows the resulting exposure distributions calculated with Urban Strategy for the variations V22-V28, and the urban EU27 distribution for comparison. In general, the effects of the traffic measures V23-V28 are small, because area A is only a small region of the entire city. The largest effect occurs for scenarios V24, V27 and V28, and is caused by the removal of traffic from area A. The effect of interupting the traffic on the Kriegstrasse (V25) is smaller, because traffic simply takes adjacent roads (indicated in red in Figure 5).

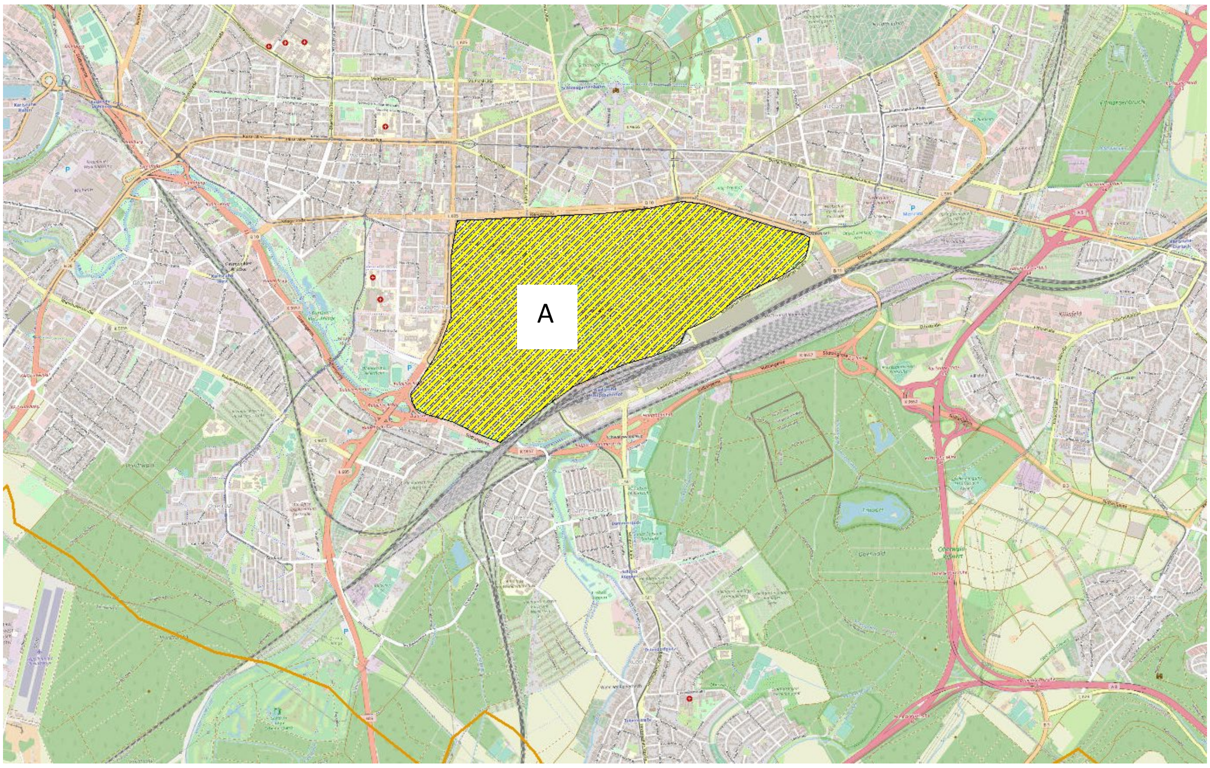


Figure 4. Area A (yellow) were traffic is reduced or eliminated.

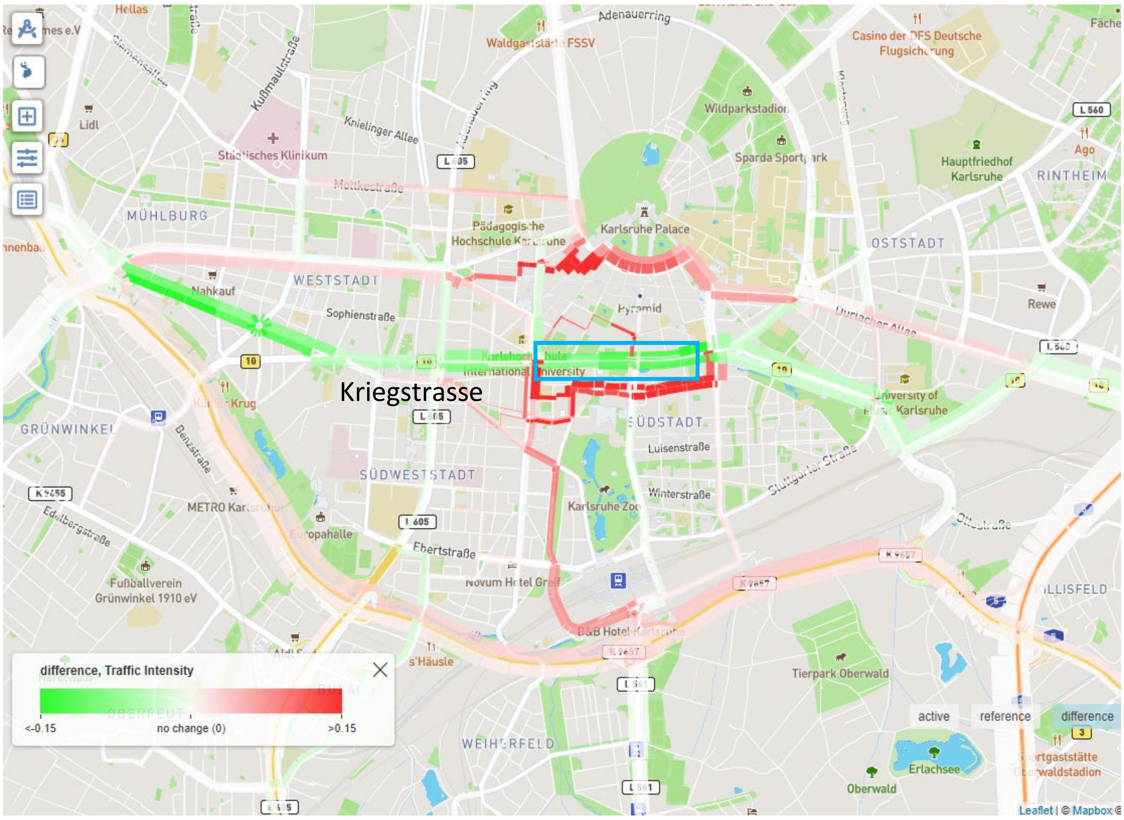


Figure 5. Traffic interrupted on the Kriegstrasse (in the blue rectangle). This reduces traffic on the Kriegstrasse (green) but enhances traffic on adjacent roads (red).

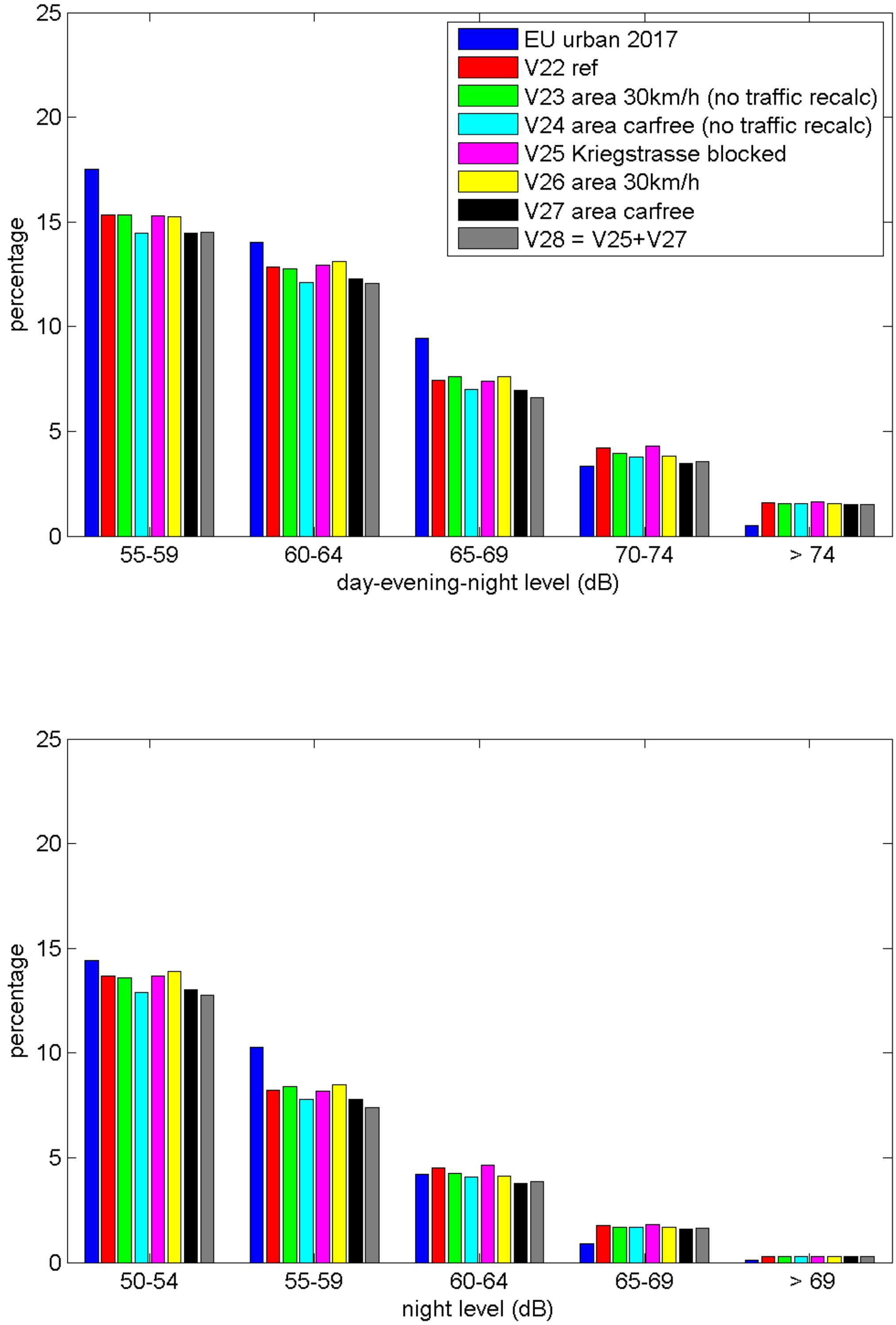
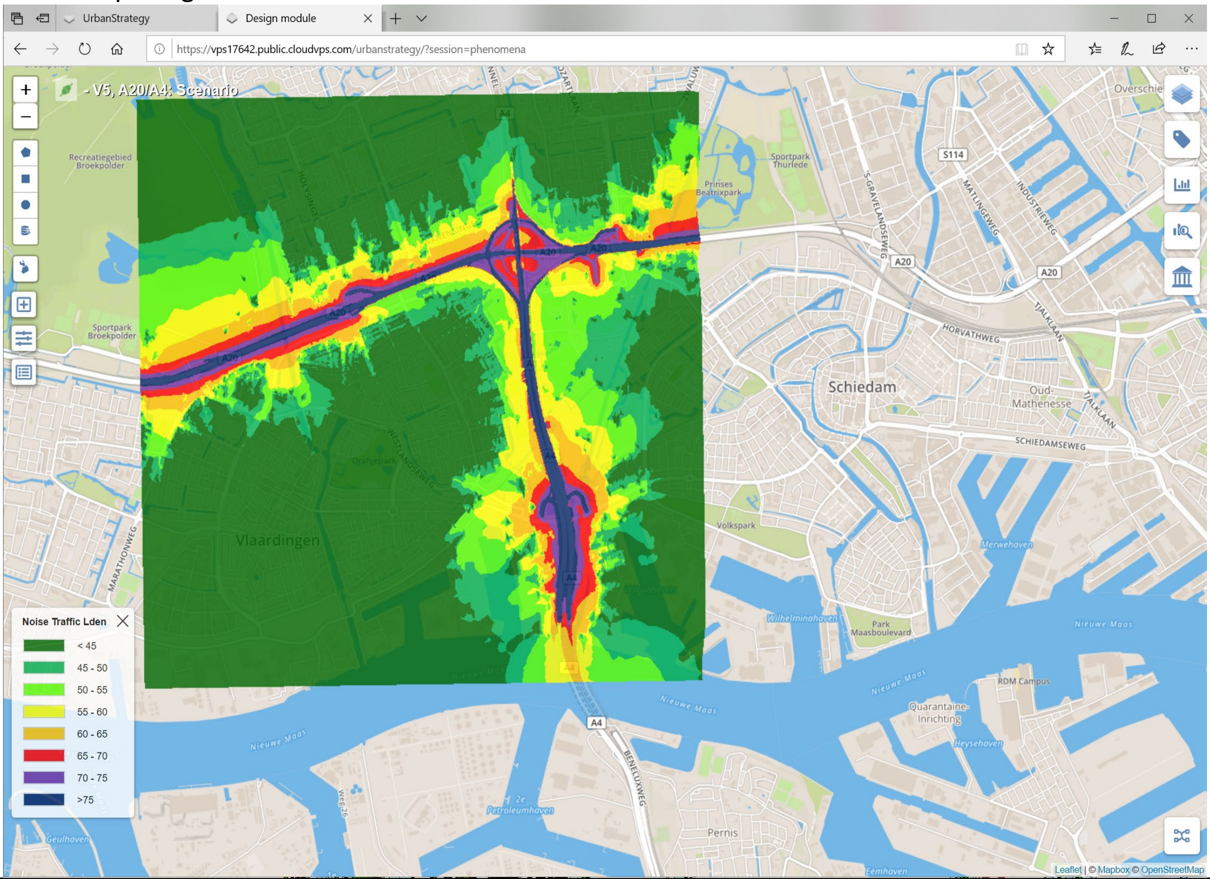


Figure 6. Exposure distributions for urban EU27 (blue), Karlsruhe (red), and Karlsruhe with various traffic measures V23-V28).

A4.4. Motorways A4 and A20, near Vlaardingen

Noise map test site	
City / location / major road	Major roads A20 and A4 near Vlaardingen x=82-86km, y=435-439km.
Noise map image 	
Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	13 Feb 2020
Source of input data used for map	RWS
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - Road surface: porous asphalt (ZOAB 1L, ZOAB 2L) - 22669 buildings and 35939 inhabitants in the area - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - Addresses from BAG. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	33400	92,9	35246	98,1
L = 50-54 dB	1349	3,8	466	1,3
L = 55-59 dB	680	1,9	183	0,5
L = 60-64 dB	374	1,0	26	0,1
L = 65-69 dB	103	0,3	18	0,1
L = 70-74 dB	22	0,1	0	0,0
L > 75 dB	11	0,0	0	0,0
	35939	100	35939	100

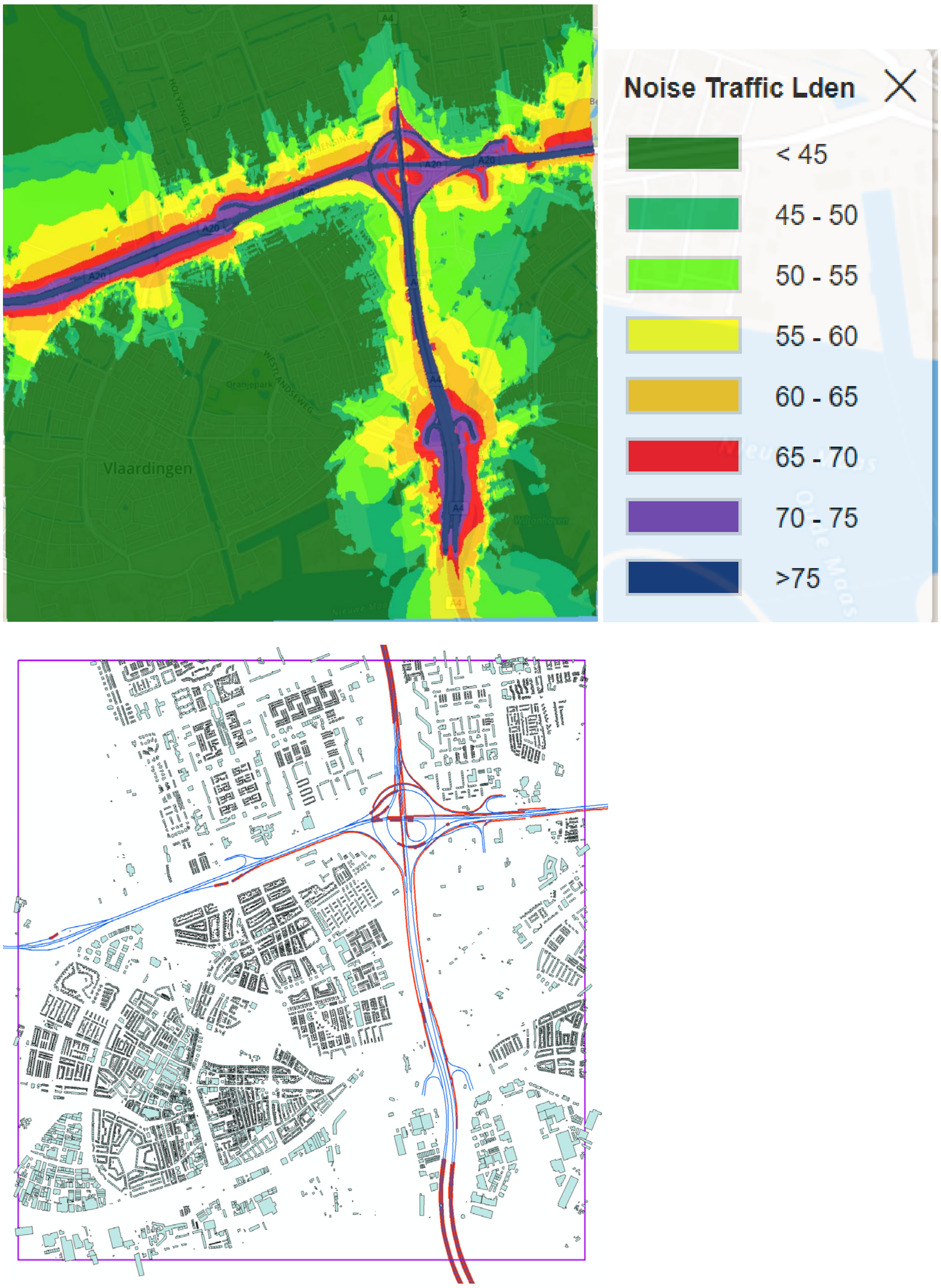


Figure 1. Noise map (top) and road network (bottom) for the 4 x 4 km area around motorways A4 (north-south) and A20 (east-west). Noise barriers along the road network are indicated as red lines.

An area of 4 x 4 km around motorways A4 and A20 (NL) was selected, near the city of Vlaardingen. There are 35939 inhabitants in the area. The noise map was calculated with Urban Strategy.

The noise map and the road network are shown in Figure 1. Noise barriers along the road network are indicated as red lines.

As a variation of the test site calculation, the noise barriers along the motorways were removed. This has a considerable effect on the exposure distribution, as shown in Figure 2.

The cyan bars represent an approximate calculation, based on the observation that about 50% of the roads in the original network had noise barriers. Therefore the cyan distribution was calculated from the red distribution (without noise barriers) as follows: 50% of the red bars was shifted by -10 dB (barrier attenuation) and 50% of the red bars was shifted by 0 dB (no barrier). The cyan distributions agrees well with the dark blue distribution from the noise map calculation. This confirms that the assumption of 10 dB barrier attenuation is a reasonable approximation in this case.

Another conclusion is that the shape of the exposure distributions is similar to the shape of the EU average distributions for major roads outside agglomerations.

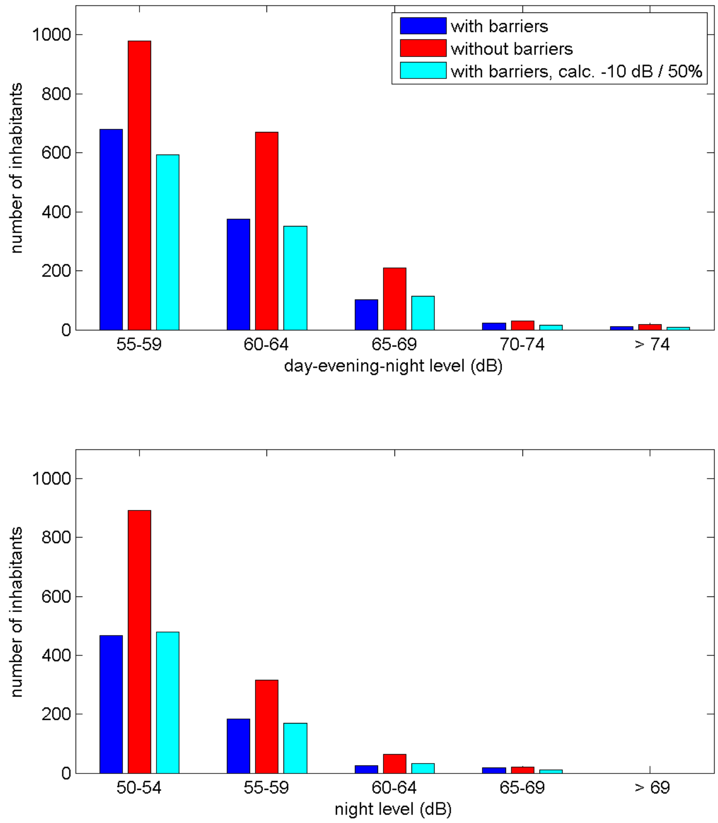


Figure 2. Exposure distributions for 4x4 km area around motorways A4 and A20, with and without noise barriers. The cyan bars represent an approximate calculation.

Annex B4. Test sites in Spain

B4.1. Introduction

In this annex results calculated for different scenarios in selected Road Test Cases are presented, being the reference the baseline scenario and several scenarios with one or more noise abatement solutions.

There are 7 Test Cases selected

Source	***City***
Motorway and National road	Galdakao
Trunk road	Renteria
Motorway	Zarautz
Motorway and Road	Barakaldo
Motorway	San Sebastian
Motorway	Murgia
Agglomeration	Zaragoza

The noise solution for road traffic noise defined in PHENOMENA project are

Solutions	Description
A	Roads with quiet surface
B	Improvement in tyres
C	General improvement in vehicles
D	Enhanced electrification
E	Noise barriers
F	Traffic speed restrictions
G	Traffic management: access restrictions, traffic rerouting
H	Urban planning
I	Enhanced dwelling insulation
J	More restrictive reception limits

The Test Cases simulate the effect on population exposure of each solution compared to the Baseline. The effect is quantified by calculating noise levels outdoor on the facades of residential buildings, receivers located at 4m from the ground. Abatement solutions I and J are not quantified, since measure I does not reduce the noise level outdoors and J is not a technical measure.

Different abatement solutions are applied in each Test Case, depending on their potentiality to be real and to reduce exposure. Among the 7 Test Cases all abatement solutions are applied.

	Variations Calculated		Galdakao: Motorway and Road	Renteria: Trunk road	Zarautz: Motorway	Barakaldo Motorway and Road	San Sebastian Motorway	Murgia Motorway	Zaragoza: Motorway, road and streets
Single Solutions	A or B Quiet Surface or tyres								
	E Barrier								
	F Speed reduction			Night	Night				
	G1 Traffic management: No heavy vehicles at night								
	G2 Traffic management: Rerouting								
	H Urban Planning								
Combined scenarios:	ABD Quiet Surface + Quiet tyres + Electrification								
	Barrier + Solutions at the source:	AE or BE							
		ABDE							
		EF		Night	Night				
		EG2							
	Planning + Solutions at the source:	AH or BH							
		ABDH							
		FH							
		G1H							

In these Test Sites the effects of the abatement solutions at the sources, either in the road surface, tyres or type of engine, are simplified in the following way:

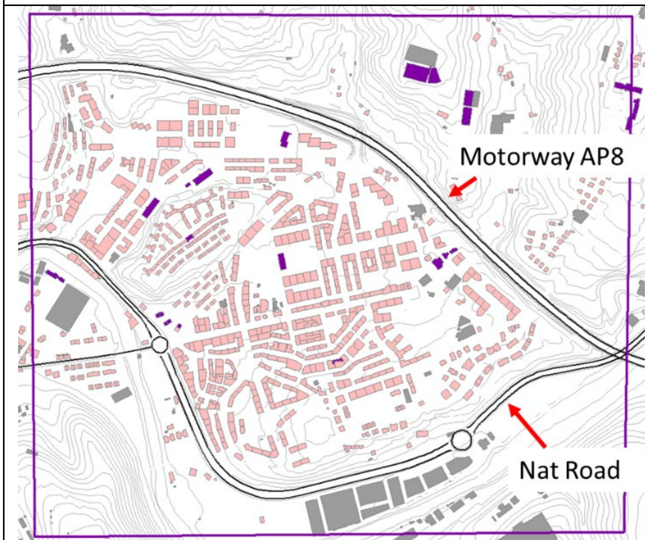
- Measure A: quiet road pavements. This measure only affects the rolling noise, so its effect depends on the running speed.
    - In motorway or speeds above 50 km/h: its effect is considered as a reduction of 3dB,
    - Meanwhile its effect in streets is a reduction of 1 dB.

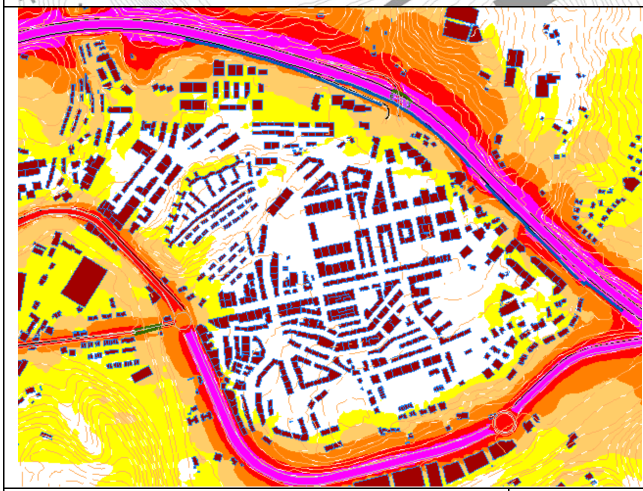
- Measure B: quiet tyres This measure only affects the rolling noise, so its effect depends on the running speed.
    - In motorway or speeds above 50 km/h: Its effect is considered as a reduction of 3dB,
    - Meanwhile the effect in streets is a reduction of 1 dB.

- Combined measures ABD Quiet Surface and Quiet tyres and Electrification: As said, the effect of measures A and B only reduces rolling noise, meanwhile measure D reduces engine noise. Therefore, the effect depends on the type of traffic (speed):
    - Motorway or speeds above 50 km/h: the combined effect of Quiet Surface and Quiet tyres is 2 dB, and there is no effect of the electrification policy. Therefore, the total effect is a reduction of 4 dB.
    - Streets or speeds below 50 km/h: the combined effect of Quiet Surface and Quiet tyres is 2 dB, and the electrification policy reduces the emission in 2 dB. Therefore, the total effect is a reduction of 4 dB.

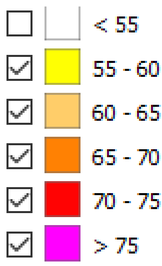
B4.2. Motorway (AP 8) and National road (N-634), near Galdakao

Baseline





Strategic Noise Map (Lden) of actual situation, different from the baseline.



City / location / major road	AP8 Motorway and N634 Road affecting Galdakao city
Compiled for	AP8 and N634 Strategic Noise Maps
Date map was calculated	2014
Source of input data used for map	Regional Road manager-Diputación Foral de Bizkaia
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered. - Noise barriers in AP8 (h=4m)
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected by two roads, the motorway AP8 and the national road main access to the city. The impact of urban traffic in the city has not been calculated.

The national road impact implies higher exposure levels, since the residential buildings are closer to the traffic.

Most of the affected buildings are residential and its heights are between 4,5m and 34 mts height.

Road Authority built noise barriers to reduce the effect of the motorway, and this is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barrier is real and therefore it can be considered as optimized in terms of cost-benefit.

The Baseline for this study is the situation without the noise barrier.

Variations

<table>
<tr><th>Motorway AP 8
and
Road N-634,
near Galdakao</th><th>Calculated Variations</th><th>Comments</th></tr>
<tr><td colspan="3">BASELINE: Existing situation without the noise barriers, considered as an abatement solution</td></tr>
<tr><td rowspan="6">Single Solutions</td><td>A or B Quiet Surface or tyres</td><td>The effect of those measures is considered as a reduction of 3dB in both roads.</td></tr>
<tr><td>E Barrier</td><td>Existing barriers in the motorway
See figure below</td></tr>
<tr><td rowspan="2">F Speed reduction</td><td>Int the Motorway
From
120 km/h light and 90 km/h heavy
To
80 km/h light and 80 km/h heavy</td></tr>
<tr><td>Same reduction only at night (analysed separately)</td></tr>
<tr><td>G2 Traffic management: Rerouting</td><td>Move 50% of traffic from national road to motorway.
See figure below.</td></tr>
<tr><td>H Urban Planning</td><td></td></tr>
<tr><td rowspan="4">Combined scenarios</td><td>ABD Quiet Surface + Quiet tyres + Electrification</td><td>The effect of those measures is considered as a reduction of 4dB in both roads.</td></tr>
<tr><td rowspan="3">Barrier + Solutions at the source:</td><td>AE or BE Quiet Surface or tyres</td></tr>
<tr><td>ABDE Quiet road Surface+ Quiet tyres + Electrification</td></tr>
<tr><td>EF Speed reduction</td></tr>
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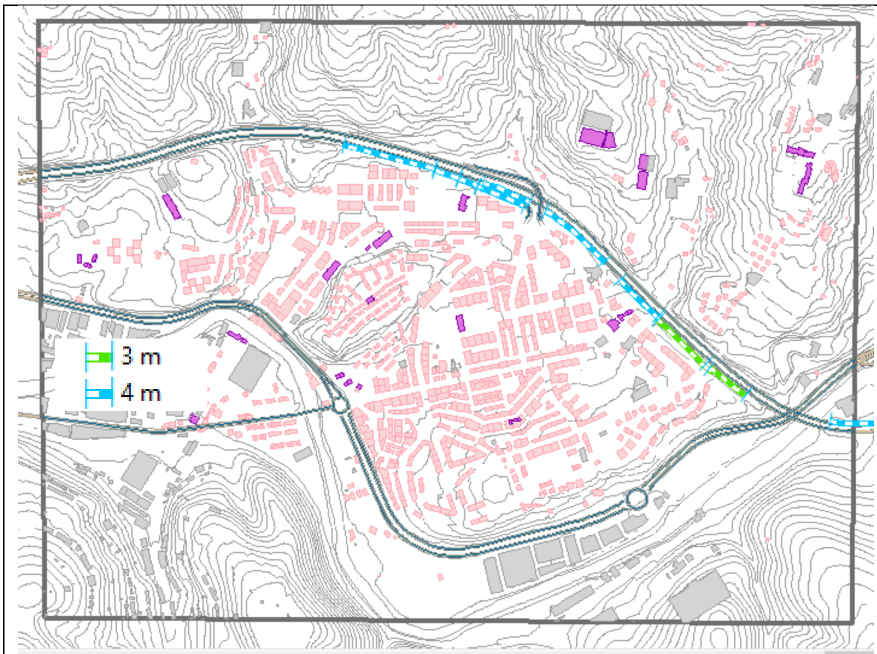
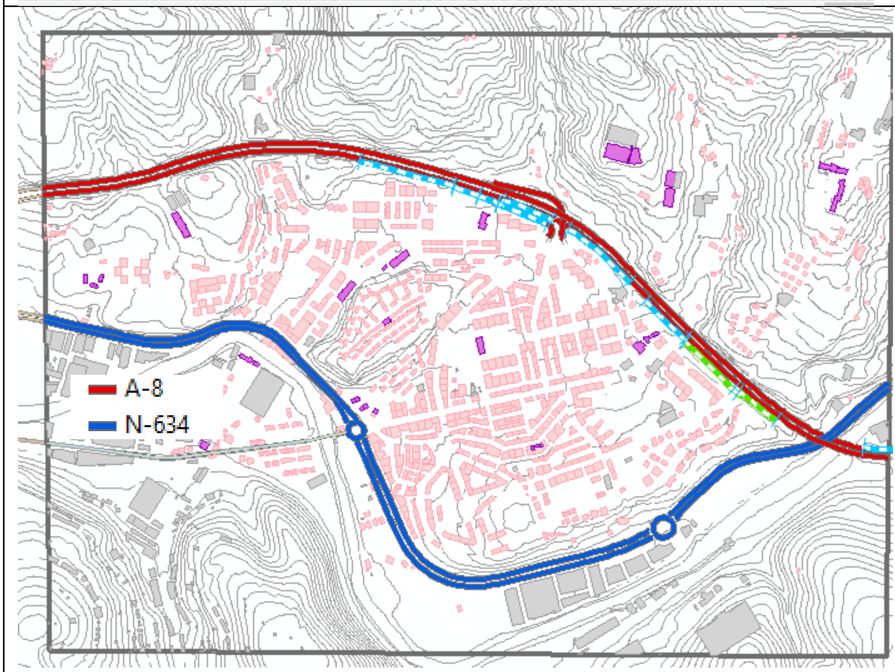
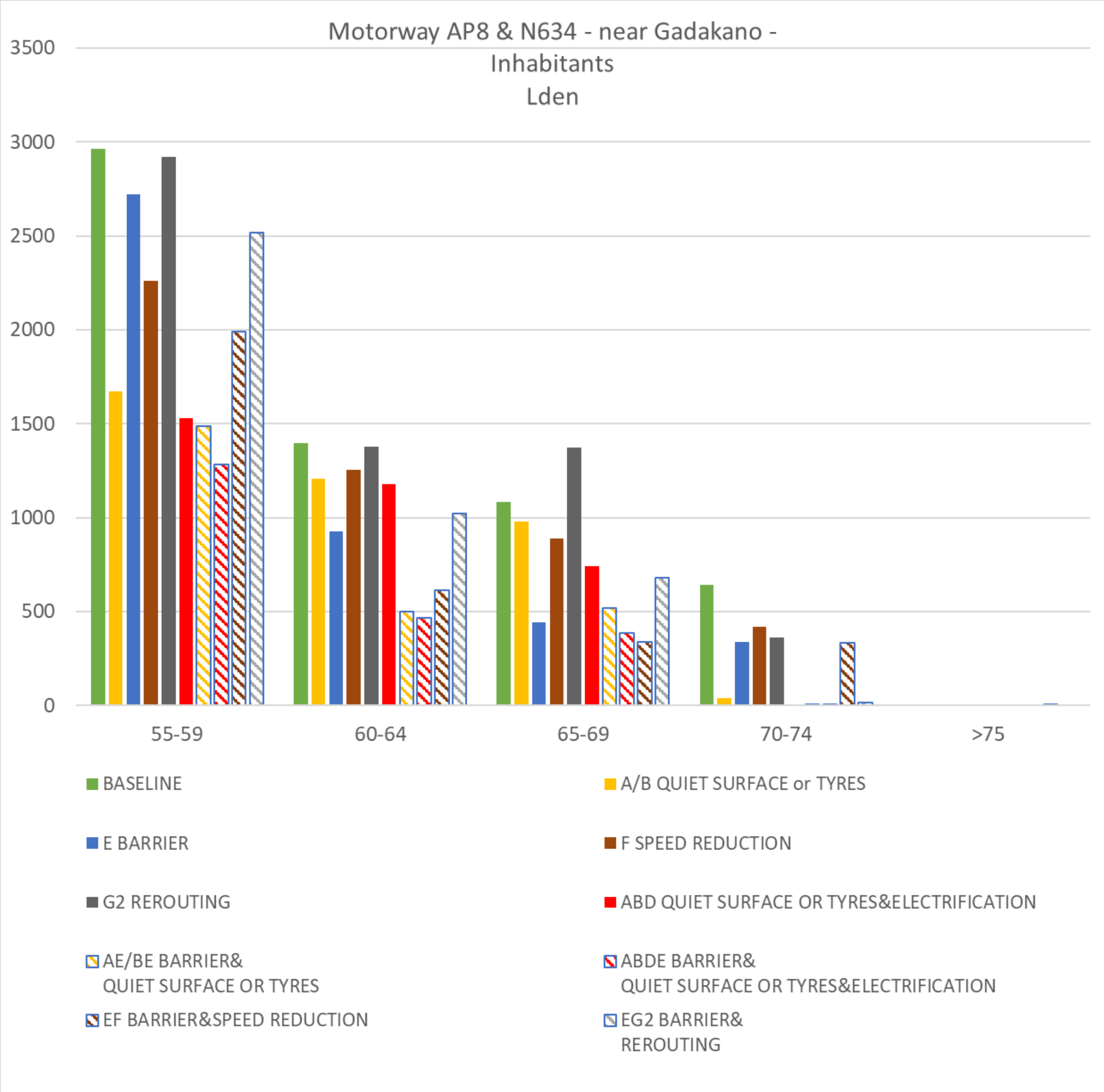
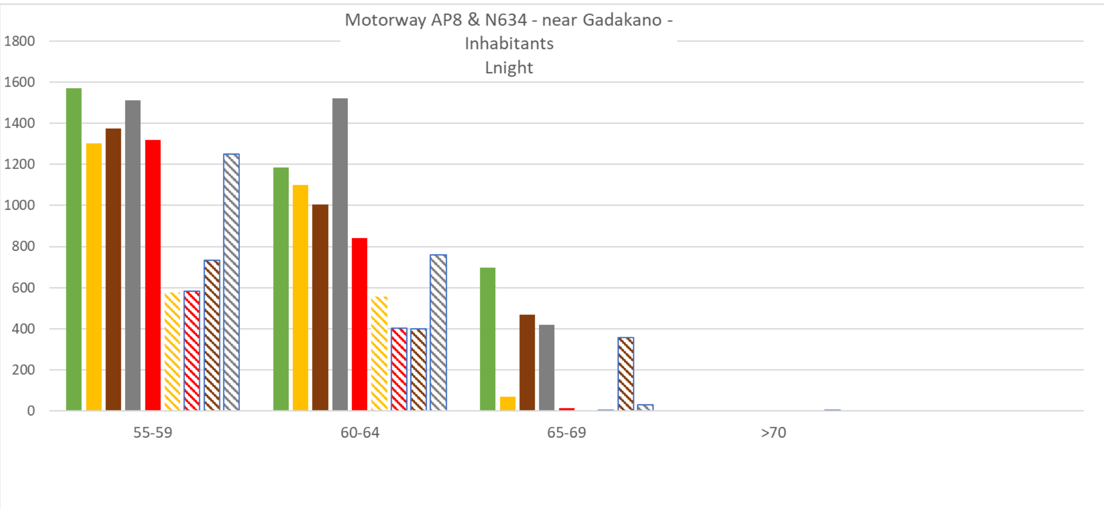
<td>
</td>
<td>Single Solution considered: Noise Barrier in the Motorway</td>
</tr>
<tr>
<td>
</td>
<td>Rerouting solution suppose that there are measures to optimize the access to the city and reduce traffic on the national road. The theoretical result is that 50% of the traffic in the national road (N-634) is moved to the motorway (A-8).</td>
</tr>
</table>

Change in population exposure:

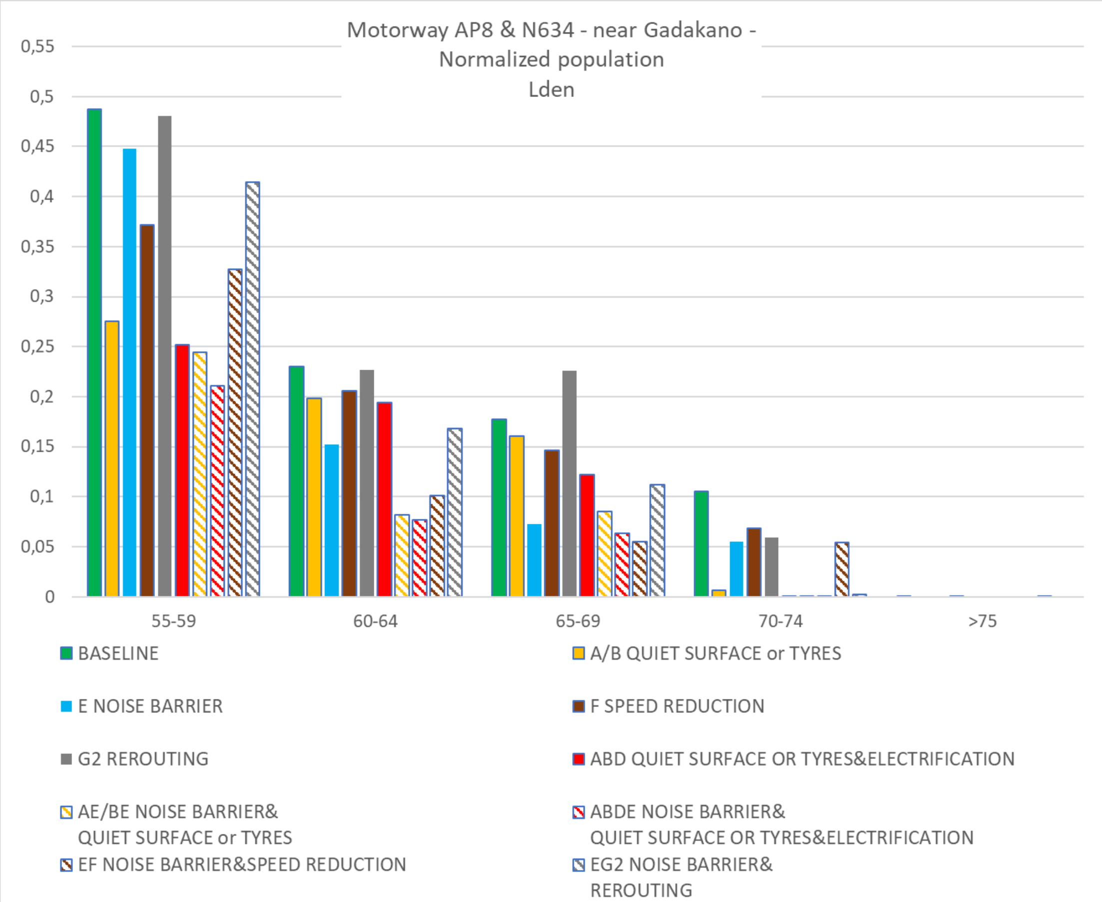


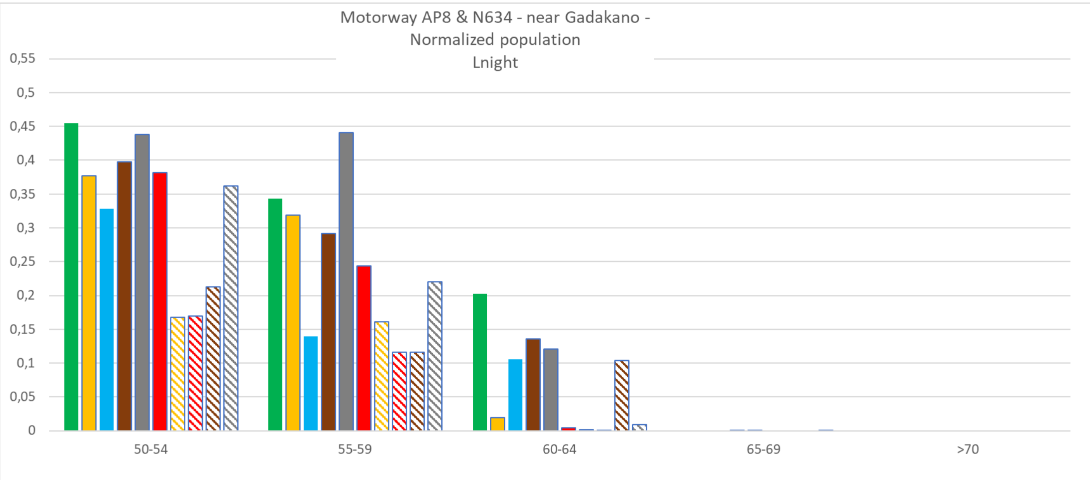


Lden	B	SINGLE SOLUTIONS					COMBINED SOLUTIONS Barrier &			
		A/B	E	F	G2	ABD	AE/BE	ABDE	EF	EG2
	BASE	QUIET ROAD OR TYRE	BARRIER	SPEED	REROUTING	QUIET ROAD OR TYRE & ELECT	QUIET	QUIET & ELECTR	SPEED	REROUTING
55-59	2.961	1.674	2.722	2.260	2.919	1.529	1.486	1.280	1.992	2.519
60-64	1.397	1.208	925	1.253	1.378	1.178	500	467	616	1.021
65-69	1.081	977	443	888	1.372	741	519	387	336	679
70-74	640	38	337	419	361	3	3	3	331	15
> 75	1	0	1	1	0	0	0	0	1	0

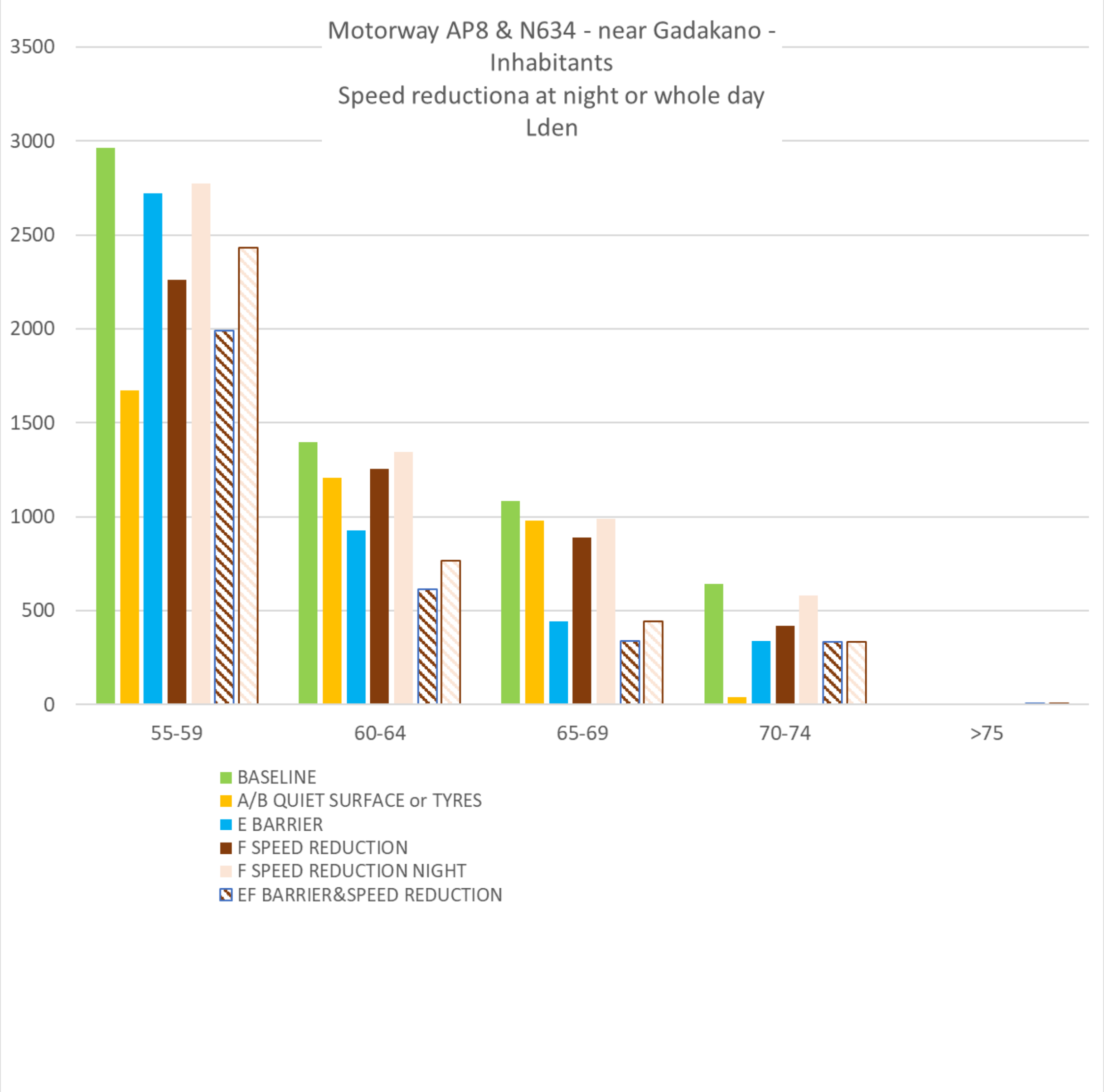
Lnight	B	SINGLE SOLUTIONS					COMBINED SOLUTIONS Barrier &			
		A/B	E	F	G2	ABD	AE/BE	ABDE	EF	EG2
	BASE	QUIET ROAD OR TYRE	BARRIER	SPEED	REROUTING	QUIET ROAD OR TYRE & ELECT	QUIET	QUIET & ELECTR	SPEED	REROUTING
50-54	1.570	1.302	1.132	1.374	1.512	1.318	578	584	733	1.251
55-59	1.184	1.100	481	1.005	1.522	841	557	402	400	760
60-64	697	68	363	467	418	14	5	3	357	30
65-69	2	0	1	1	0	0	0	0	1	0
>70	0	0	0	0	0	0	0	0	0	0

Normalized population exposure:





ANALYSIS OF SPEED REDUCTION ONLY AT NIGHT



Conclusions of Test Site

Take into account in this Test Case that the area is affected by two sources of different behaviour: national road and highway.

Considering all the ranges, the solution that seems most effective are the measures at the source, A (road surfaces) or B (tyres). Those measures reduce emission of the two sources, so in all the areas and at exposure ranges.

The barrier solution (E) offers similar general reductions, but above all in the 60-69 Lden and 55-59 Lnight ranges, and not the higher ones. The barrier (E) does not reduce so much the most exposed inhabitants, since the barrier is positioned close to the motorway and not on the national highway, that generates high levels of exposure. It is neither physically nor socially viable to install a barrier in this area, since the buildings are excessively close to the road. Therefore, the effectiveness of the barrier in the higher exposure ranges is not that high.

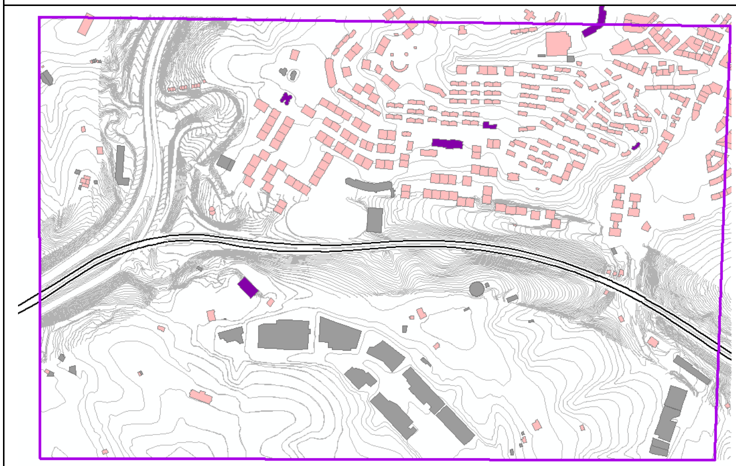
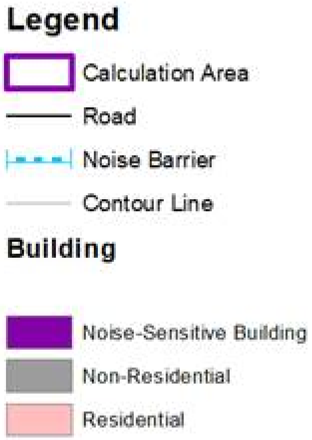
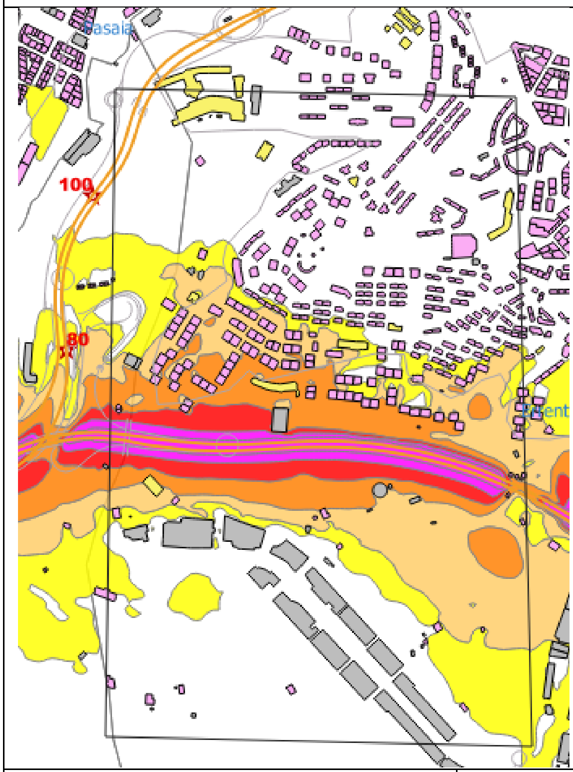
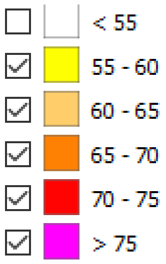
In contrast, the rerouting solution (G2) focuses its effectiveness on that exposure range.

However, as a single solution, the greatest effect in this range are those of emission reduction, A or B or ABD, only comparable to the effect of the combined solution of rerouting and barrier (EG2), which would act on both noise sources: national road and motorway.

As a curiosity, it can be observed that when considering effects on health, the effectiveness of the Noise barrier seems greater in HSD than in HA, since given the ranges analyzed at night, the increase in people with less exposure is outside the study range, meanwhile in HA those people are in the lowest range.

Finally, the effect of reducing speed only in the night period has been analyzed, comparing its effect with the reduction throughout the day. The difference between the two solutions is important in the exposure to the Lden parameter. This solution could be interesting in those cases in which the problem is only focused on the night period. One of the advantages of this solution is that it would imply a lower incidence in the service conditions of the road and therefore in the traffic at rush hours, but as a disadvantage, the need to technically solve the establishment of a dynamic limitation of the speed.

B4.3. Trunk road GI 20, near Renteria

Baseline	
	
	Strategic Noise Map (Lden) of actual situation. Baseline 
City / location / name of major road	GI 20 trunk road affecting Renteria city
Compiled for	GI-20 Strategic Noise Map
Date map was calculated	2016
Source of input data used for map	Regional Road manager-Diputación Foral de Gipuzkoa
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected by a regional road, with an infrastructure similar to a motorway. The impact of urban traffic in the city has not been calculated.

The Baseline for this study is the actual situation.

Road Authority has defined a Noise Action Plan that includes the design of a noise barrier to reduce the effect of the road in this area, and this is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barrier has been initially designed and therefore it can be considered as acoustically optimized.

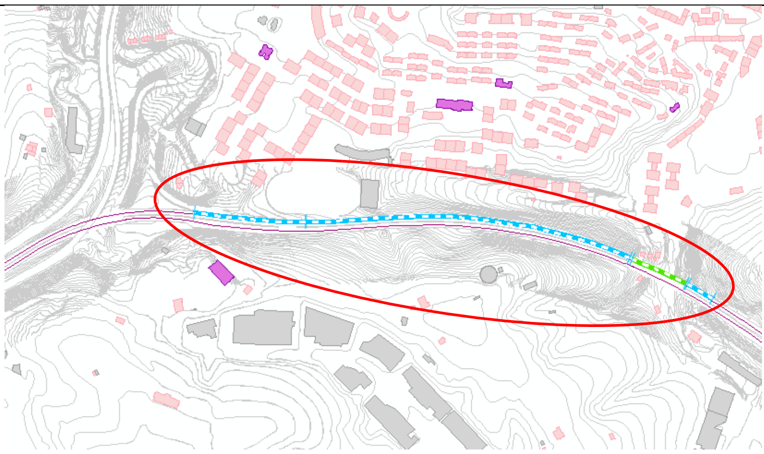
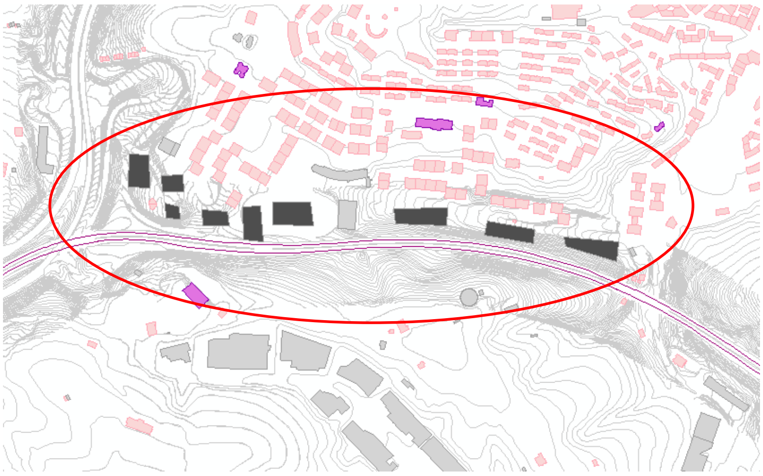
According to the legal noise limits the acoustic impact is mainly at night period.

Most of the affected buildings are residential at an average distance of 70 m from the road. Residential building heights are between 4,5m and 35 m height.

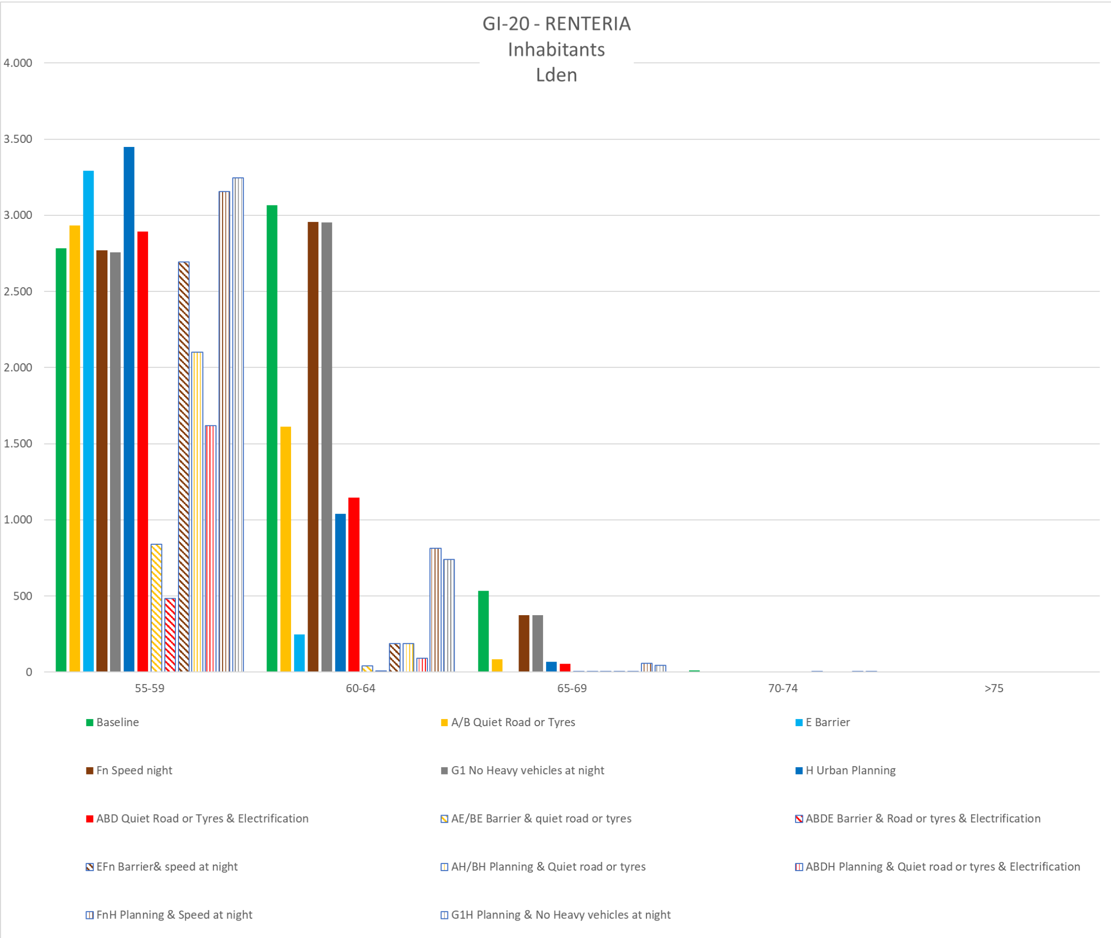
The area allows simulating an abatement measure on urban planning adding non residential buildings close to the road, creating an acoustic shadow behind.

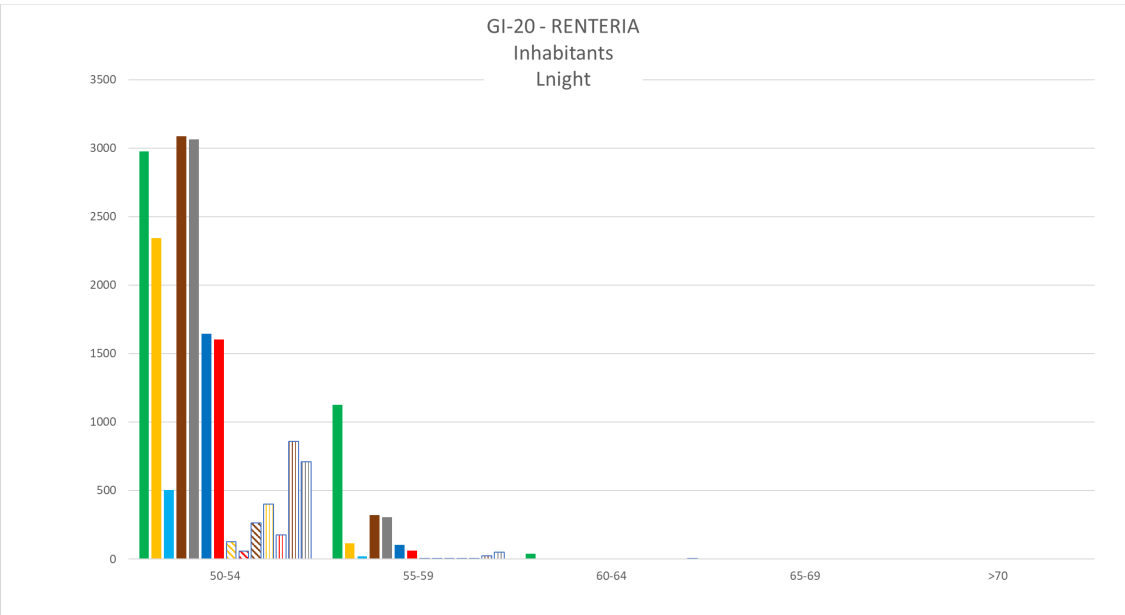
Variations

Trunk road GI 20, near Renteria	Calculated Variations	Comments
BASELINE: Existing situation		
Single Solutions	A or B Quiet Surface or tyres	The effect of those measures is considered as a reduction of 3dB
	E Noise barrier:	Designed in the NAP (4m height). See figure
	F Speed reduction	Applied only at night From 120 km/h light and 80 km/h heavy vehicles To 80 km/h light and 80 km/h heavy vehicles
	G1 Traffic management	Heavy traffic restrictions at night, thar implies a reduction of total traffic. Simulation with no heavy traffic at night period
	H Urban Planning	Non residential buildings added close to the road. See figure
Combined scenarios	ABD Quiet Surface + Quiet tyres + Electrification	The effect of those measures is considered as a reduction of 4dB in both
	E Noise barrier + Noise solutions at the source:	EA or EB Quiet Surface or tyres
		EABD Quiet road Surface+ Quiet tyres + Electrification
		EF Speed reduction
		EG1 Traffic management: Restrictions to heavy vehicles
	H Urban Planning + Noise solutions at the source:	HA or HB Quiet Surface or tyres
		HABD Quiet road Surface+ Quiet tyres + Electrification
		HF Speed reduction
		HG1 Traffic management: Restrictions to heavy vehicles

Noise barrier:	 1022m length; about 122m 2m (in the bridge- in green at the figure) height and about 1000m 4m height (in blue at the figure)
Urban Planning	Add industrial buildings close to the road. See figure  Industrial buildings: about 12m height (2 floors) next to the road

Change in population exposure:

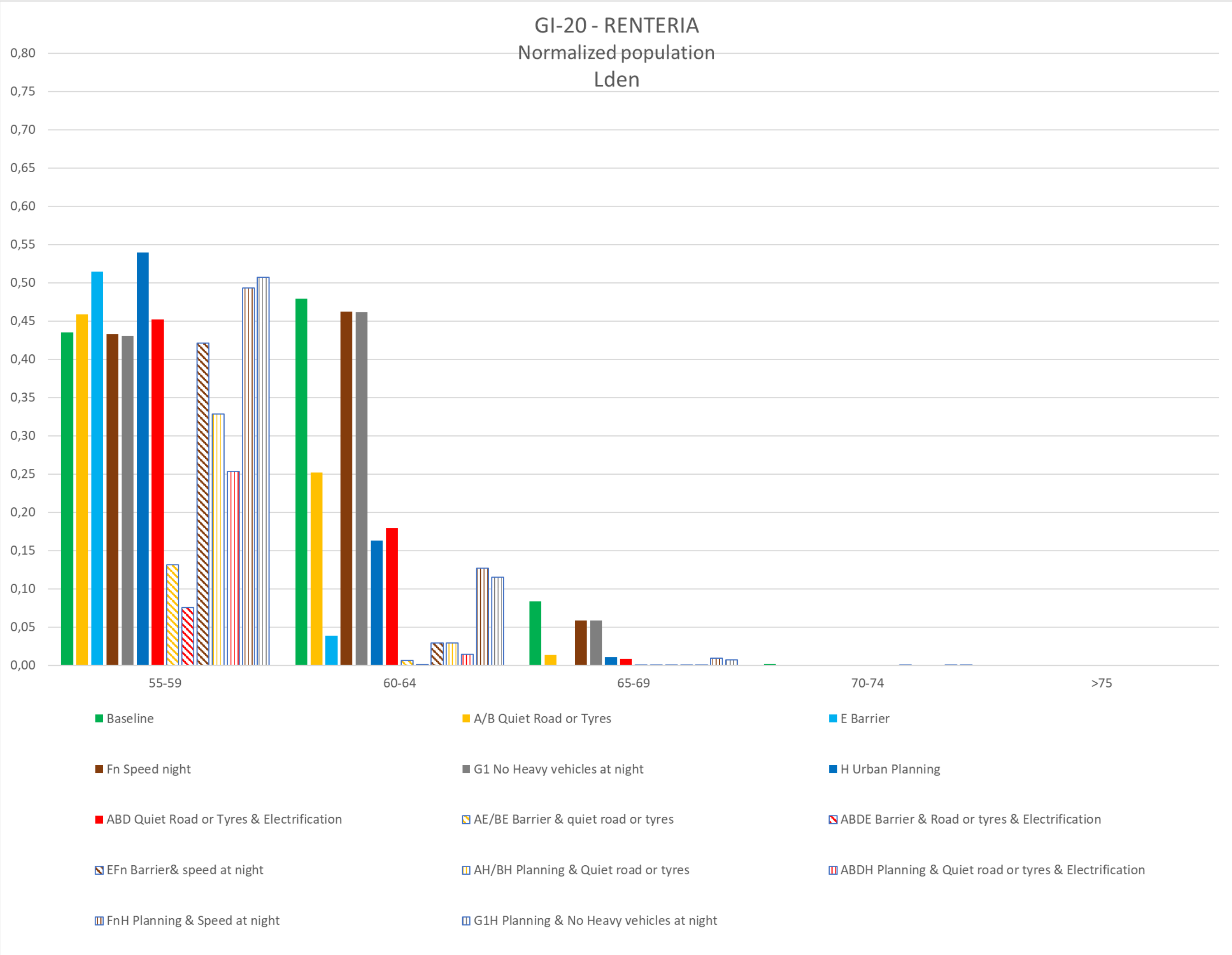


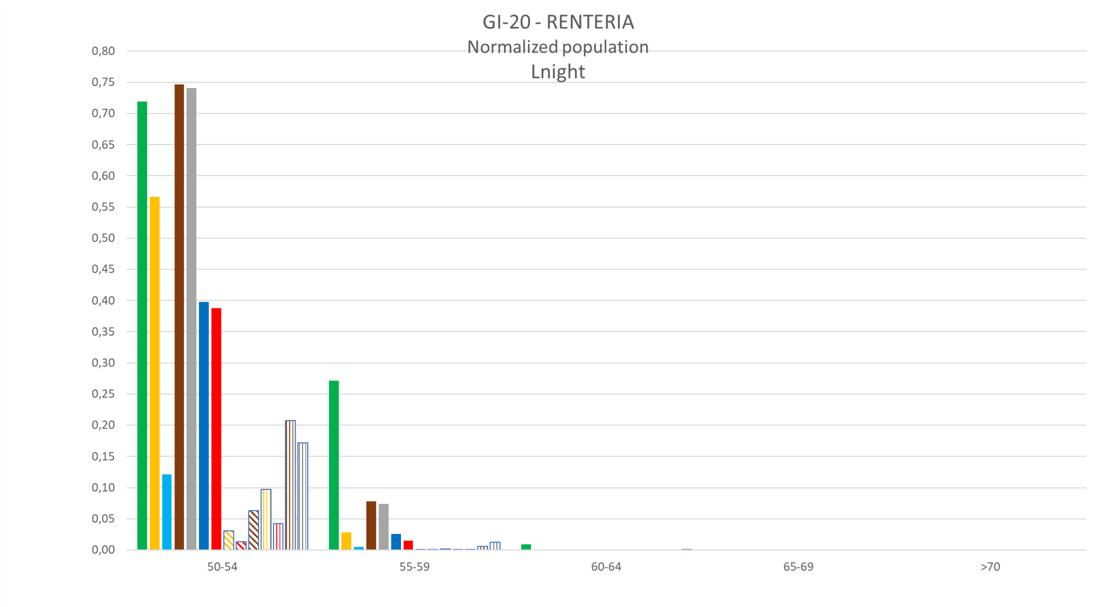


Lden	B	Single Solutions						Combined Solutions						
								Barrier &			Planning &			
		A/B	E	Fn	G1	H	ABD	AE/ BE	ABDE	EFn	AH/ BH	ABDH	FnH	G1H
	Baseline	Road or tyres	Barrier	Speed at night	No Heavy at night	Planning	Road or tyres & Electrification	Road or tyres	Road or tyres & Electrification	Speed at night	Road or tyres	Road or tyres & Electrification	Speed at night	No Heavy at night
55-59	2.785	2.933	3.294	2.771	2.756	3.450	2.892	840	482	2.693	2.101	1.620	3.156	3.245
60-64	3.067	1.613	247	2.957	2.955	1.041	1.146	41	6	187	186	91	813	738
65-69	534	85	4	373	373	68	53	4	4	4	5	4	59	45
70-74	12	0	4	2	2	4	0	0	0	2	0	0	4	4
> 75	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Lnight	Baseline	Single Solutions						Combined Solutions						
								Barrier &			Planning &			
		A/B	E	Fn	G1	H	ABD	AE/BE	ABDE	EFn	AH/BH	ABDH	HFn	HG1
		Road or tyres	Barrier	Speed at night	No Heavy at night	Planning	Road or tyres & Electrification	Road or tyres	Road or tyres & Electrification	Speed at night	Road or tyres	Road or tyres & Electrification	Speed at night	No Heavy at night
50-54	2.974	2.344	503	3.088	3.062	1.645	1.602	127	56	262	402	175	857	709
55-59	1.124	116	20	322	306	105	61	4	4	5	5	4	23	51
60-64	37	0	4	0	2	4	0	0	0	0	0	0	0	2
65-69	0	0	0	0	0	0	0	0	0	0	0	0	0	0
>70	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Normalized population exposure:





Conclusions of Test Site

The Noise barrier (E) designed in the Noise Action Plan is very effective, providing greater efficiency than the measures at the source (A / B / ABD). The action in urban planning (H) is also effective, although especially in the higher exposure range.

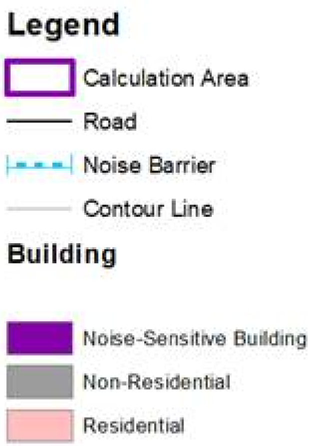
Anyhow, must be considered that the noise barrier would not be equally effective if we considered all heights.

In this Test Case the solutions of speed reduction (Fn) and heavy restriction (G1) are focused on the night period. Therefore, they have little influence on Lden, and in the night period they manage to lower the exposure a range, which in cases of impact only at night can be a good alternative. Although the designed screen is still more effective.

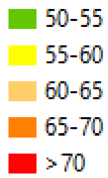
As in the previous case, when considering health effects, the effectiveness of the screen seems to be higher in HSD than in HA, since given the ranges analyzed at night, the increase in people with less exposure in Lnight is outside the study range.

B4.4. Motorway AP 8, near Zarautz

Baseline



Strategic Noise Map (night) of actual situation. Baseline.



City / location / major road	AP8 Motorway affecting Zarautz city
Compiled for	AP8 Strategic Noise Maps
Date map was calculated	2016
Source of input data used for map	Regional Road manager-Diputación Foral de Gipuzkoa
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered. - Noise barriers designed by the Road authorities in AP8 (h=4m) and study of speed limits
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected the motorway AP8. There is a tolling station in the area. The impact of urban traffic in the city has not been calculated.

Most of the affected buildings at one side are residential and there are also some schools in the area. Most of the closest residential building have two stores.

There are two barriers already built and considered in the baseline.

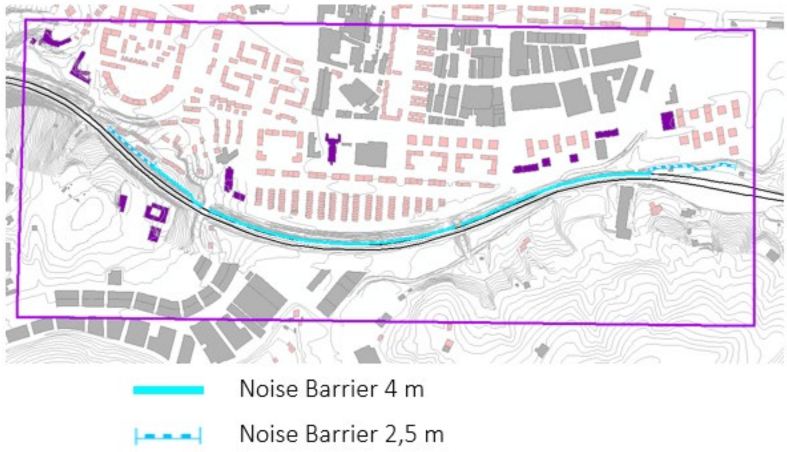
Road Authority has included this area in the Noise Action Plan for the next period. The NAP proposed a noise barrier as abatement solution to reduce the effect of the motorway, and this is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barrier can be considered initially acoustically optimized.

According to the legal noise limits the acoustic impact is mainly at night period.

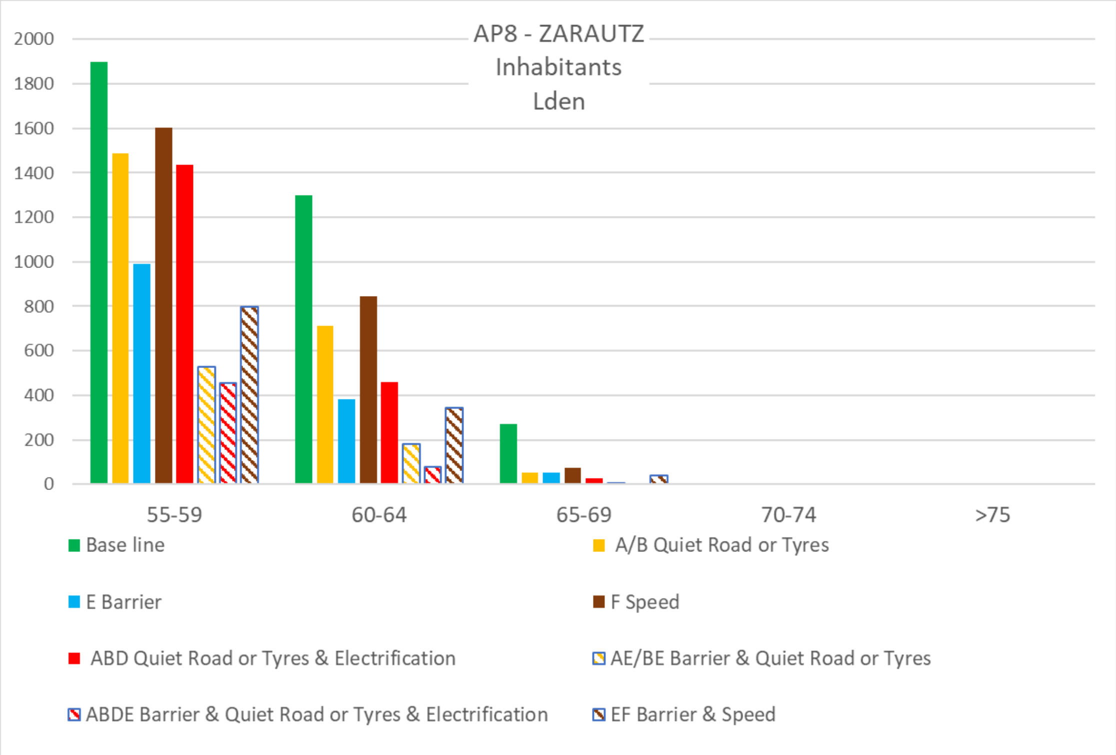
In addition to this, before installing the noise barrier, the potential effect of speed reduction is being analysed, since the presence of the tolling could facilitate the acceptance of this measure in the drivers.

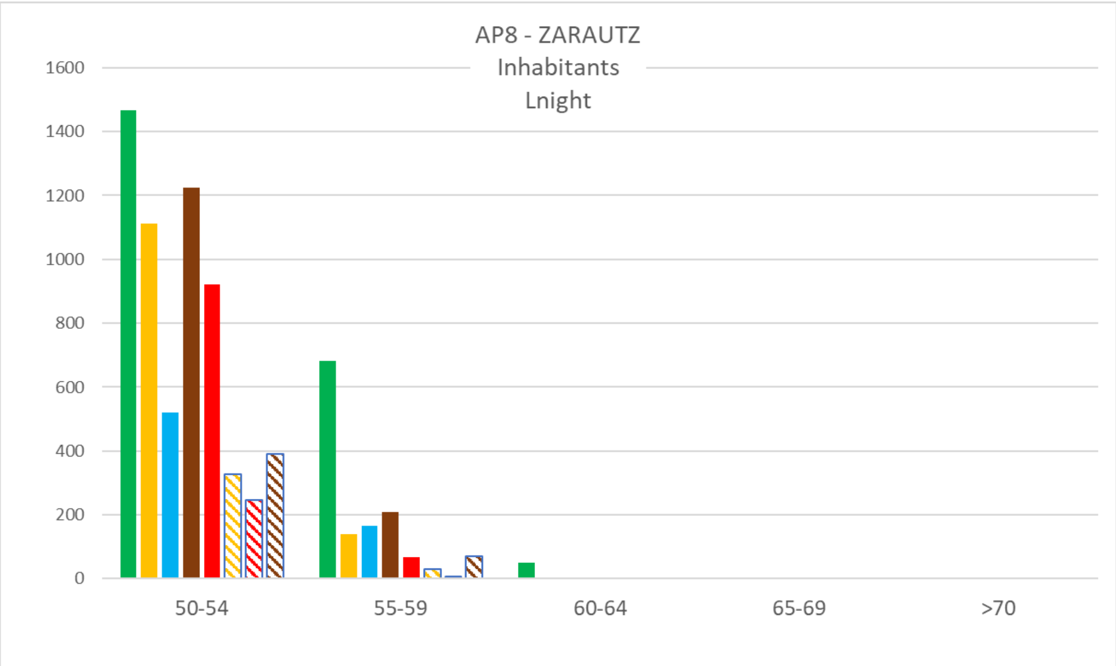
Variations

<table>
<tr><th>Motorway AP 8, near Zarautz</th><th colspan="2">Calculated Variations</th><th>Comments</th></tr>
<tr><td colspan="4">BASELINE: Existing situation</td></tr>
<tr><td rowspan="3">Single Solutions</td><td colspan="2">A or B Quiet Surface or tyres</td><td>The effect is considered as a reduction of 3dB.</td></tr>
<tr><td colspan="2">E Noise barrier:</td><td>Designed in the NAP.
See figure</td></tr>
<tr><td colspan="2">F Speed reduction:</td><td>From
120 km/h light and 80 km/h heavy vehicles
To
80 km/h light and 80 km/h heavy vehicles</td></tr>
<tr><td rowspan="4">Combined scenarios:</td><td>ABD Quiet Surface + Quiet tyres + Electrification</td><td colspan="2">The effect is considered as a reduction of 4dB.</td></tr>
<tr><td rowspan="3">Noise barrier + Noise solutions at the source:</td><td colspan="2">EA or EB Quiet Surface or tyres</td></tr>
<tr><td colspan="2">EABD Quiet road Surface+ Quiet tyres + Electrification</td></tr>
<tr><td colspan="2">EF Speed reduction</td></tr>
</table>

Noise Barrier: Blue Line	

Change in population exposure:

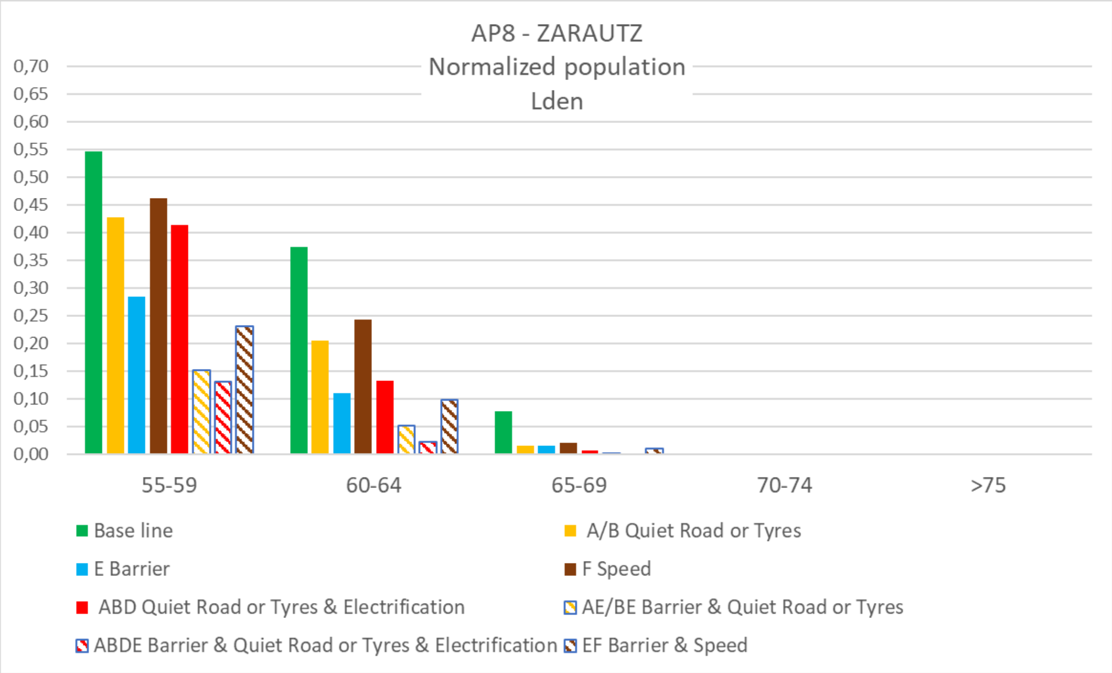


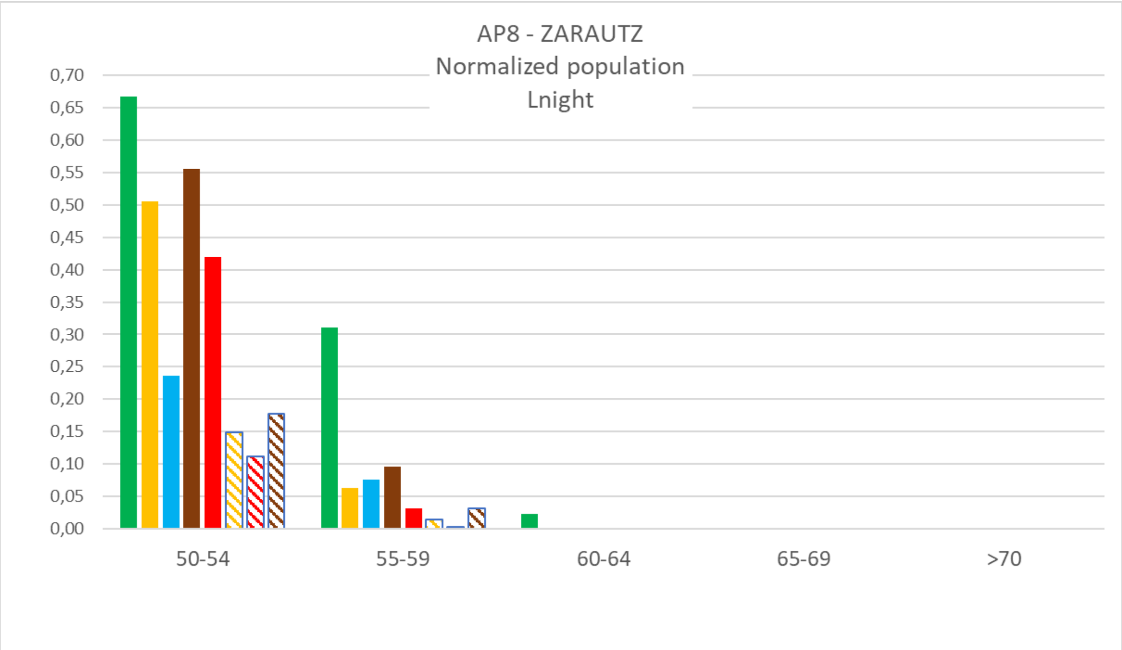


Lden	B	SINGLE SOLUTIONS				COMBINED SOLUTIONS: BARRIER +		
		A/B	E	Fn	ABD	AE/BE	ABDE	EFn
	BASE	QUIET ROAD OR TYRE	BARRIER	SPEED AT NIGHT	QUIET ROAD OR TYRE & ELECTRIFICATI ON	QUIET ROAD OR TYRE	QUIET ROAD OR TYRE & ELECTRIFICATIO N	SPEED AT NIGHT
55-59	1.900	1.488	989	1.602	1.436	529	456	800
60-64	1.297	714	382	844	460	182	80	343
65-69	271	54	55	74	26	4	0	39
70-74	5	0	0	0	0	0	0	0
> 75	0	0	0	0	0	0	0	0

L_{night}			SINGLE SOLUTIONS			COMBINED SOLUTIONS: BARRIER +		
		A/B	E	Fn	ABD	AE/BE	ABDE	EFn
	BASE	QUIET ROAD OR TYRE	BARRIER	SPEED AT NIGHT	QUIET ROAD OR TYRE & ELECTRIFICATI ON	QUIET ROAD OR TYRE	QUIET ROAD OR TYRE & ELECTRIFICATIO N	SPEED AT NIGHT
50-54	1.467	1.112	520	1.223	921	327	246	389
55-59	682	138	166	209	68	30	7	69
60-64	50	1	3	1	0	0	0	0
65-69	0	0	0	0	0	0	0	0
>70	0	0	0	0	0	0	0	0

Normalized population exposure:





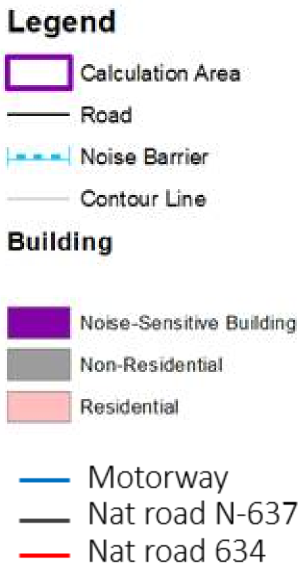
Conclusions of Test Site

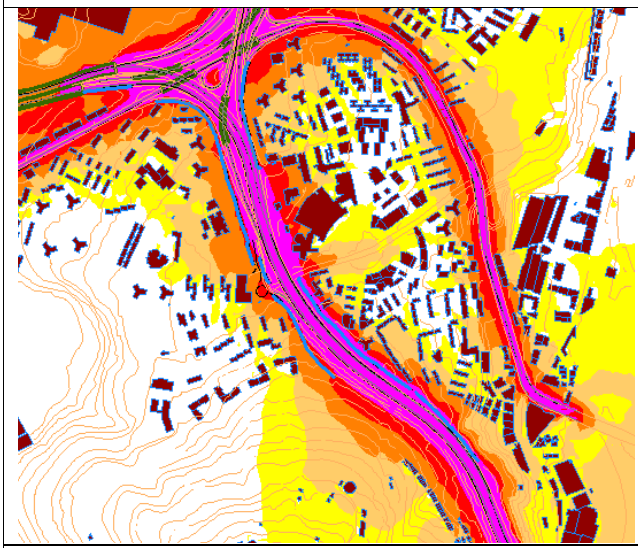
The Noise barrier (E) defined in the Noise Action Plan is very effective, especially to protect exposed inhabitants in the middle ranges 55-65 in Lden and 50-55 in Lnight. Solutions at source A, B or ABD are also effective, being more effective in the more exposed ranges, especially at night.

The speed reduction (Fn) at night is an interesting measure because it reduces the people exposed in the highest ranges, which in this case is enough to reduce the impact focused on the night period. It is being considered as an action of interest, both before installing the screen, and its subsequent maintenance as a complementary measure. The combination of screen and speed reduction at night (EFn) almost eliminates the impact.

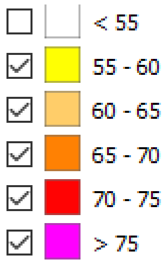
Actions at source, such as pavement change, (A) are somewhat more effective than speed reduction at night (Fn).

B4.5. Motorway N-637 and Road N634, near Barakaldo agglomeration





Strategic Noise Map (Lden) of actual situation, different from the baseline



City / location / major road	N-637 Motorway and N634 Raod affecting Barakaldo city
Compiled for	N-637 and N634 Strategic Noise Maps
Date map was calculated	2014
Source of input data used for map	Regional Road manager-Diputación Foral de Bizkaia
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered. - Noise barriers in A8 (h=4m)
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected by two roads, the motorway N-637 and the Road N634, alternative local route to access neighbourhoods of the city. The impact of urban traffic in the city has not been calculated.

Most of the affected buildings are residential, being also a hospital in the area. Residential building are high, blocks of more than 6 storeys.

The Road Authority built noise barriers to reduce the effect of the motorway, and this is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barrier is real and therefore it can be considered as optimized in terms of cost-benefit.

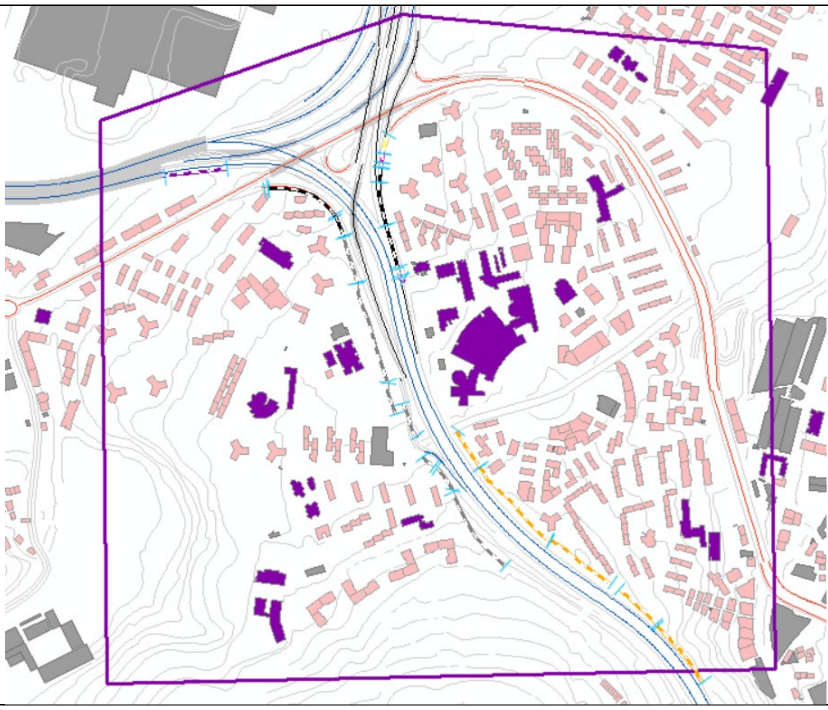
Additionally, the speed is already limited in the motorway to 80 km/h in the whole area, so again this is considered as an abatement solution type F.

The Baseline for this study is the situation without the noise barriers and with speed for light vehicles at 120 km/h in the motorway.

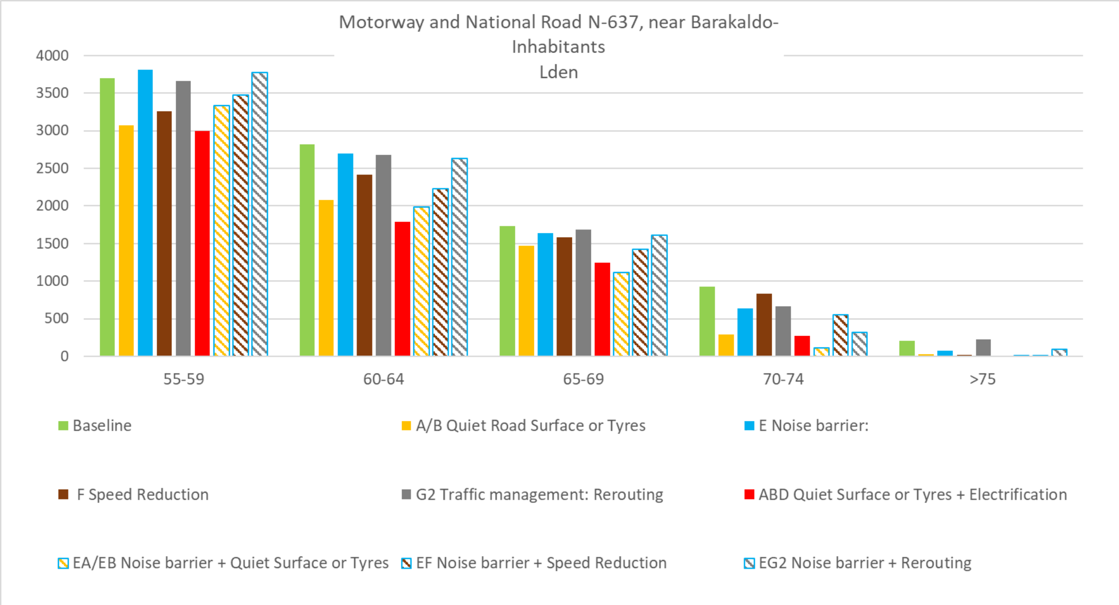
The Road Authority is now studying the option of subsidize façade isolation in some residential buildings in this area.

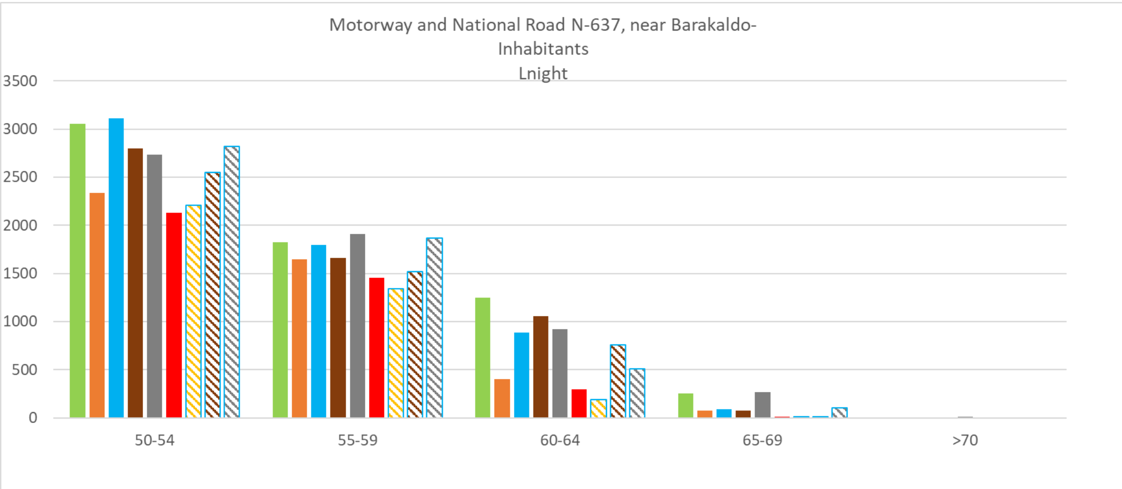
Variations

<table>
<tr><th>Motorway and National Road N-637, near Barakaldo</th><th>Calculated Variations</th><th>Comments</th></tr>
<tr><td colspan="3">BASELINE: Existing situation without the noise barriers and without speed reduction, considered as an abatement solution</td></tr>
<tr><td rowspan="4">Single Solutions</td><td>A or B Quiet Surface or tyres</td><td>The effect is considered as a reduction of 3dB in both roads.</td></tr>
<tr><td>E Barrier</td><td>Existing barriers in the motorway.
See figure.</td></tr>
<tr><td>F Speed reduction</td><td>Only Motorway.
From
120 km/h light and 80 km/h heavy vehicles
To
80 km/h light and 80 km/h heavy vehicles</td></tr>
<tr><td>G2 Traffic management: Rerouting</td><td>Move 50% of traffic from national road to motorway
See figure</td></tr>
<tr><td rowspan="5">Combined scenarios:</td><td>ABD Quiet Surface + Quiet tyres + Electrification</td><td>The effect is considered as a reduction of 4dB in both roads.</td></tr>
<tr><td rowspan="4">E Barrier + Solutions at the source:</td><td>EA or EB Quiet Surface or tyres</td></tr>
<tr><td>EABD Quiet road Surface+ Quiet tyres + Electrification</td></tr>
<tr><td>EF Speed reduction</td></tr>
<tr><td>EG2 Traffic management: Rerouting</td></tr>
</table>

Noise Barrier: Colour line (**height**) 2 2,5 3 3,5 4 4,5	
G2 Traffic management: Rerouting Motorway Nat road N-637 Nat road 634	Rerouting solution suppose that there are measures to optimize the access to the city and reduce traffic on the national road. The theoretical result is that 50% of the traffic in the national road (N-634 red) is moved to the motorway (A-8 Blue). 

Change in population exposure:

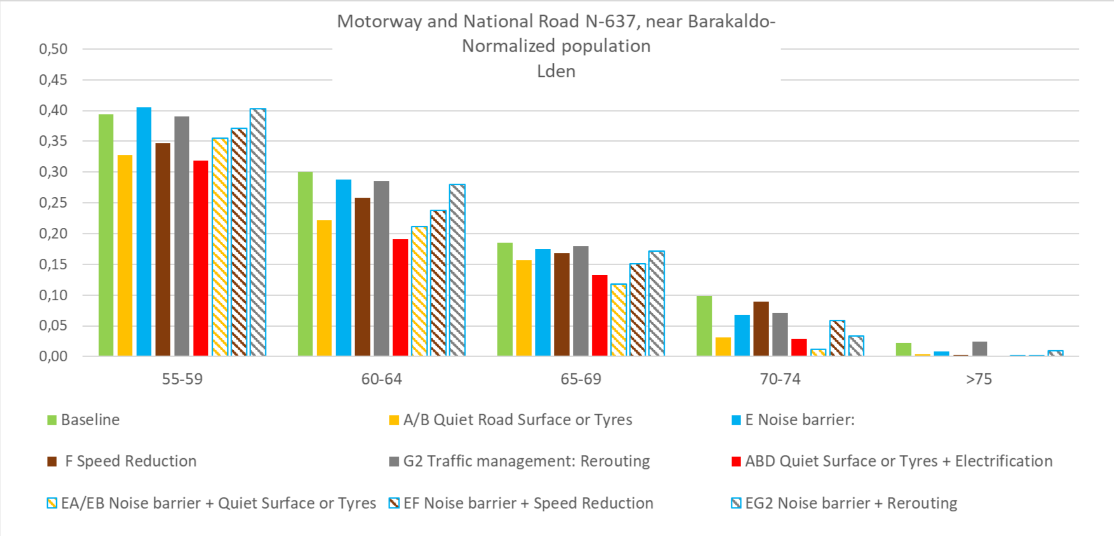


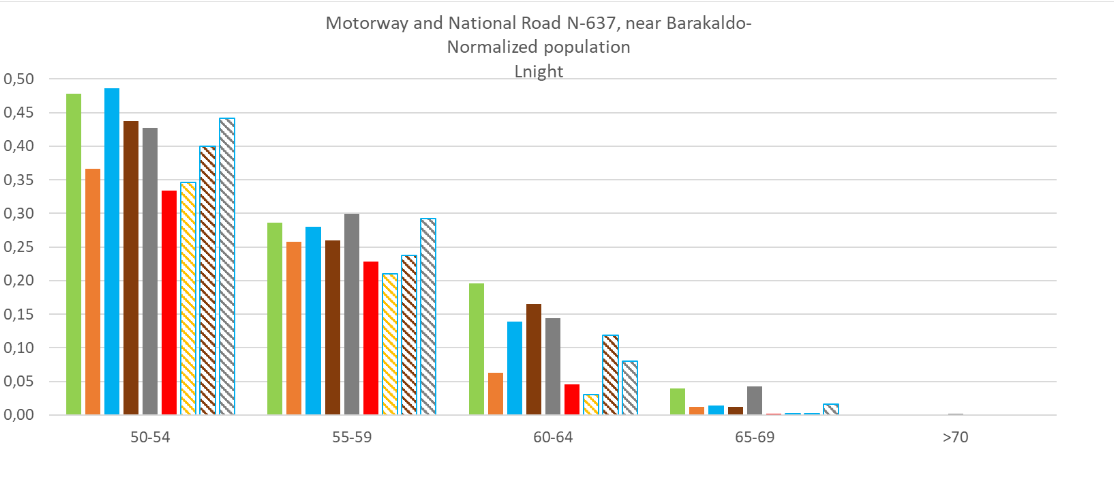


L_{den}	SINGLE SOLUTIONS					COMBINED SOLUTIONS			
						ABD Quiet roads and Tyres and Electrification	BARRIER +		
	BASE	A/B Quiet roads or Tyres	E Barrier	F Speed Reduction	G2 Rerouting		EA/EB Quiet roads or Tyres	EF Speed Reduction	EG2 Rerouting
55-60	3.697	3.075	3.806	3.255	3.662	2.993	3.328	3.478	3.776
60-65	2.819	2.082	2.696	2.420	2.677	1.792	1.989	2.228	2.628
65-70	1.735	1.468	1.638	1.579	1.689	1.249	1.110	1.420	1.607
70-75	922	289	632	834	663	271	113	547	313
>75	209	32	75	23	227	0	7	3	91

L_{night}	SINGLE SOLUTIONS					COMBINED SOLUTIONS			
						ABD Quiet roads and Tyres and Electrification	BARRIER +		
	BASE	A/B Quiet roads or Tyres	E Barrier	F Speed Reduction	G2 Rerouting		EA/EB Quiet roads or Tyres	EF Speed Reduction	EG2 Rerouting
50-55	3.055	2.339	3.107	2.795	2.732	2.131	2.209	2.553	2.822
55-60	1.828	1.646	1.793	1.662	1.912	1.457	1.342	1.516	1.866
60-65	1.251	400	888	1.057	919	294	191	757	512
65-70	255	76	91	76	269	15	15	11	106
>70	0	0	0	0	11	0	0	0	0

Normalized population exposure:





Conclusions of Test Site

First of all, it should be noted that the acoustic situation in the Test Case is very complex. In global terms, the reduction in emission, A or B, seems the most effective, although the improvements achieved are not high.

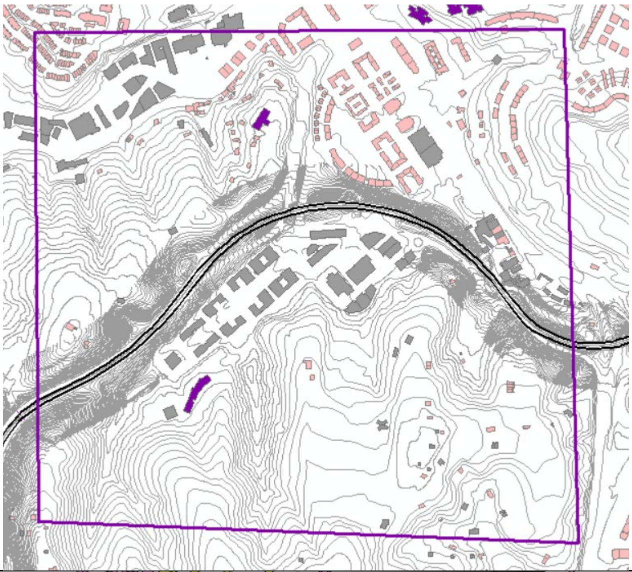
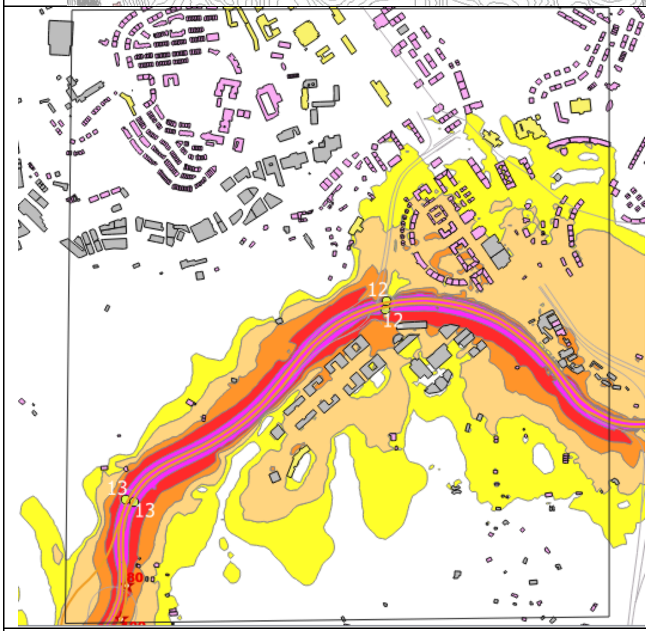
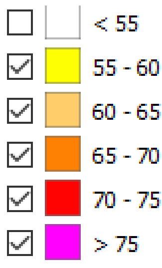
On the other hand, the effect of the Noise barrier on the motorway (E), the speed reduction (F) on the motorway, and the traffic rerouting (G2) are similar, in global terms. Note that rerouting reduces the impact of the national road, while the rest of the solutions compared only act on the motorway.

In addition, it must be taken into account, in this Test Site especially, that the effectiveness of the Noise Barrier is influenced by the methodology defined in the calculation END at 4m above the ground and not at all building heights. Based on this, speed reduction and rerouting solutions would probably be more efficient than screens.

Given the complexity of the situation, only the combination of all the single solutions can bring a clear improvement in the exposure of the population in this area, both from the motorway and from the national road.

It should be remembered that the solution currently implemented in this area is that of Noise Barriers and Speed reduction (EF), not being enough, and reception solutions are being studied.

B4.6. Motorway GI 20, near San Sebastian agglomeration

	
	Strategic Noise Map (Lden) of actual situation. Baseline 
City / location / major road	Donostia- San Sebastian affected by GI 20 motorway
Compiled for	GI-20 Strategic Noise Map
Date map was calculated	2016
Source of input data used for map	Regional Road manager-Diputación Foral de Gipuzkoa
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

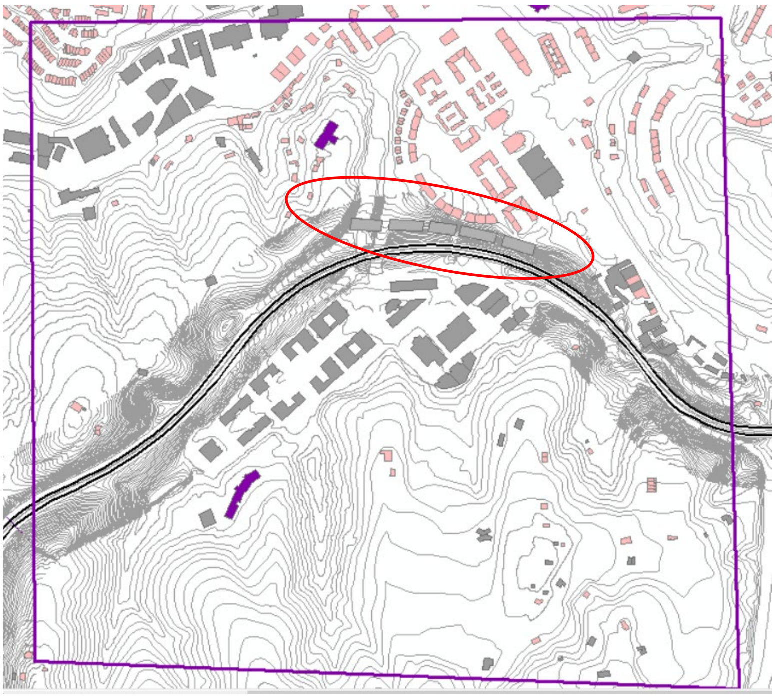
The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected by the motorway. The impact of urban traffic in the city has not been calculated.

Most of the affected buildings are residential, 20 m heights

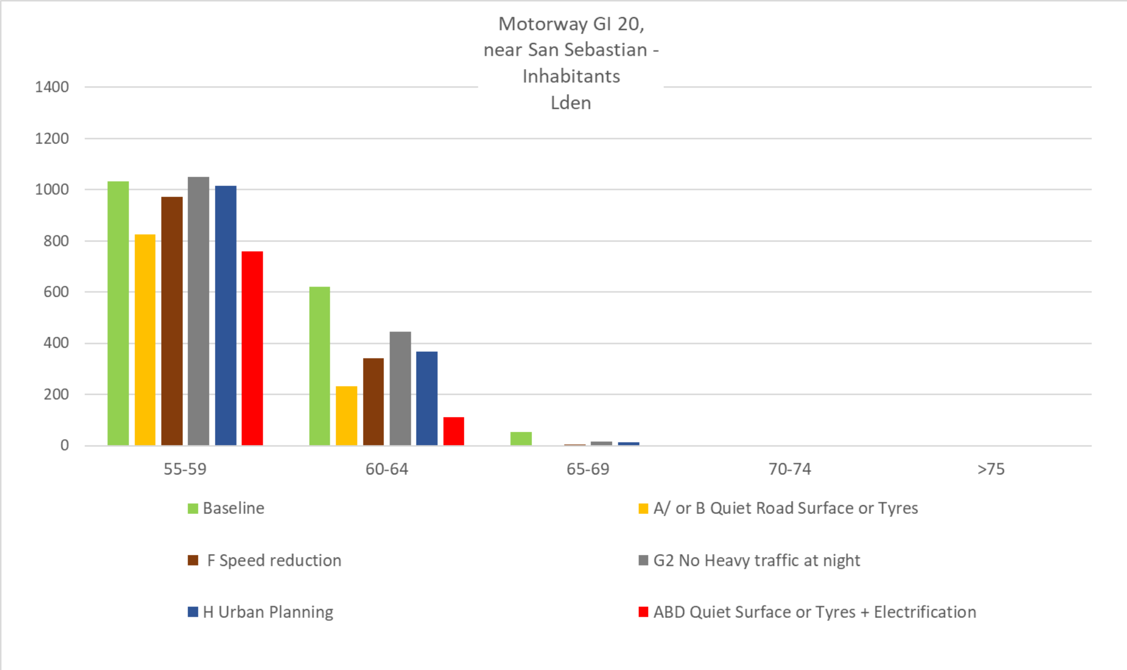
According to the legal noise limits the acoustic impact is mainly at night period. This area is not considered in the Noise Action Plan for the next period.

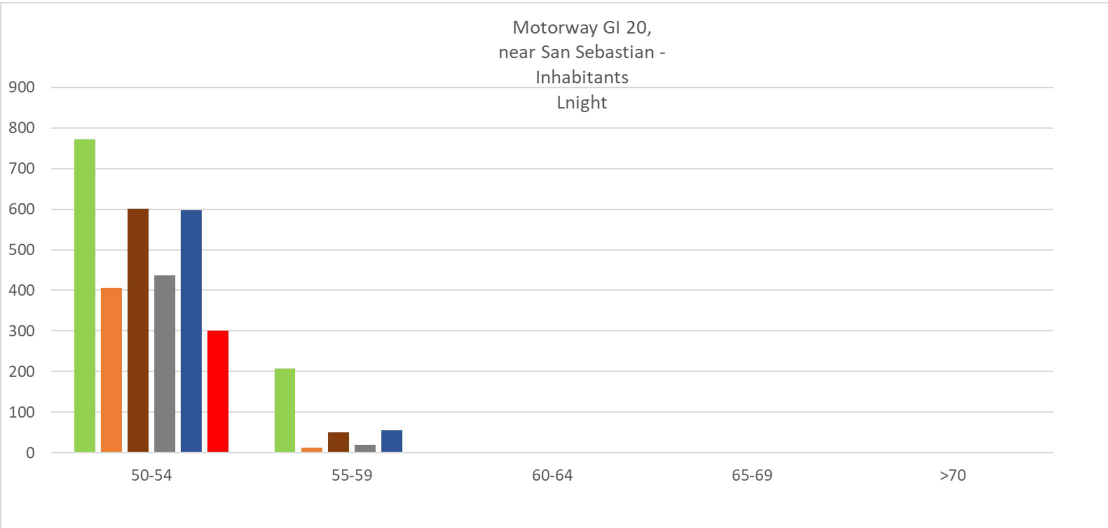
Variations

Motorway GI 20, near San Sebastian agglomeration	**Calculated Variations**	**Comments**
BASELINE: Existing situation		
Single Solutions	A or B Quiet Surface or tyres	The effect is considered as a reduction of 3dB.
	F Speed reduction	From 70 -80 km/h light heavy To 50 km/h light and heavy
	G1 Traffic management	Heavy traffic restrictions at night. Reduction of total traffic.
	H Urban Planning	Add industrial buildings close to the road. See figure.
Combined scenario	ABD Quiet Surface + Quiet tyres + Electrification	The effect is considered as a reduction of 4dB

Urban Planning	Add industrial buildings close to the road.  Industrial buildings: about 20 m height (3/4 floors) next to the road

Change in population exposure:

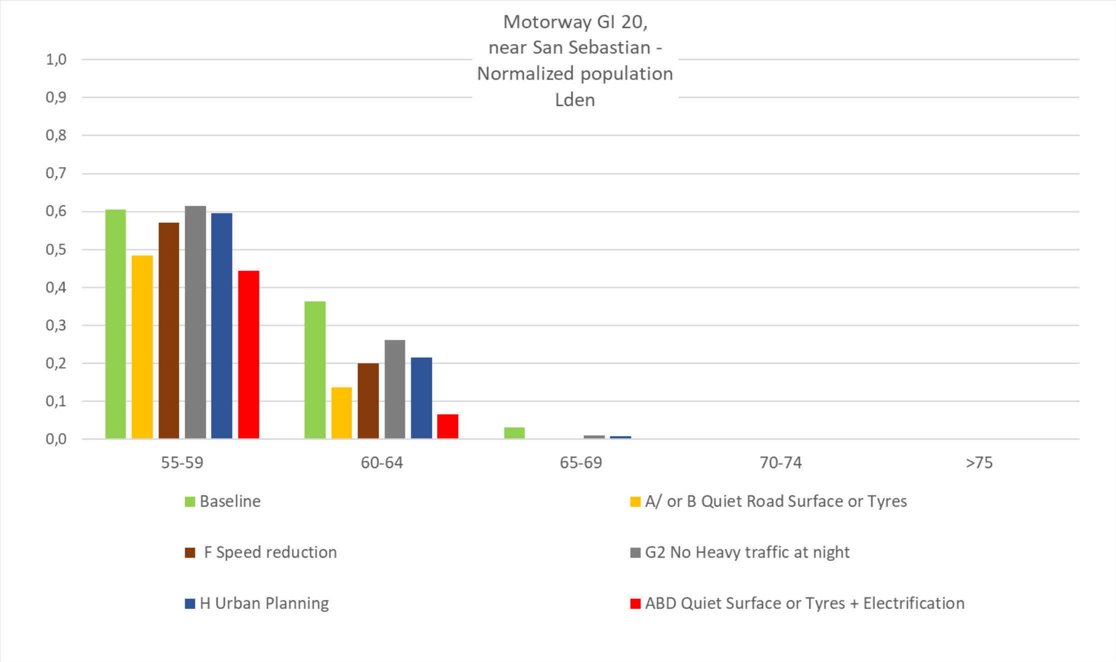


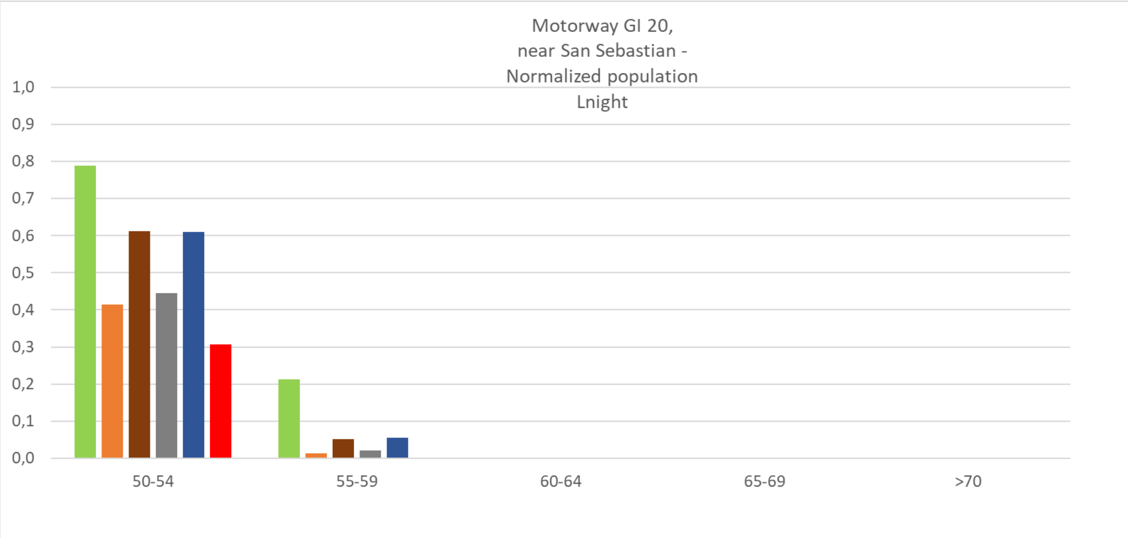


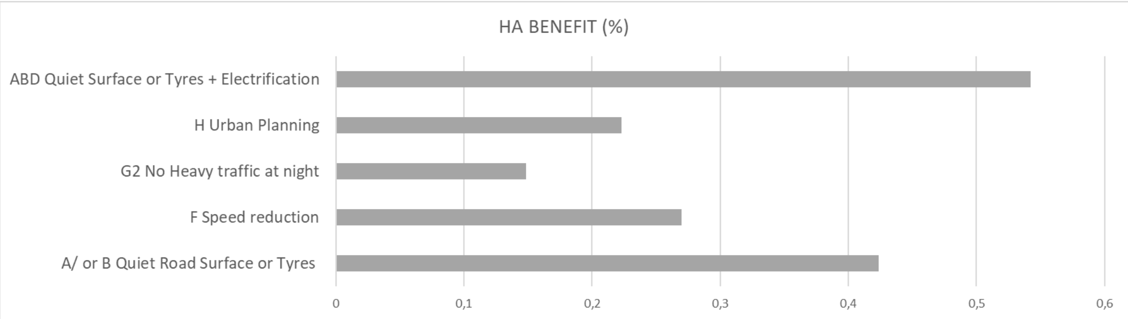
Lden	BASE	A/B Quiet roads or Tyres	F Speed Reduction	G1 No heavy vehicles at night	H Urban Planning	ABD Quiet roads and Tyres and Electrification
55-59	1.032	825	972	1.049	1015	757
60-64	621	233	343	444	367	112
65-69	53	0	4	17	13	0
70-74	0	0	0	0	0	0
>75	0	0	0	0	0	0

Lnight	BASE	A/B Quiet roads or Tyres	F Speed Reduction	G1 No heavy vehicles at night	H Urban Planning	ABD Quiet roads and Tyres and Electrification
50-54	773	405	601	436	598	301
55-59	208	13	50	20	55	0
60-64	0	0	0	0	0	0
65-69	0	0	0	0	0	0
>70	0	0	0	0	0	0

Normalized population exposure:







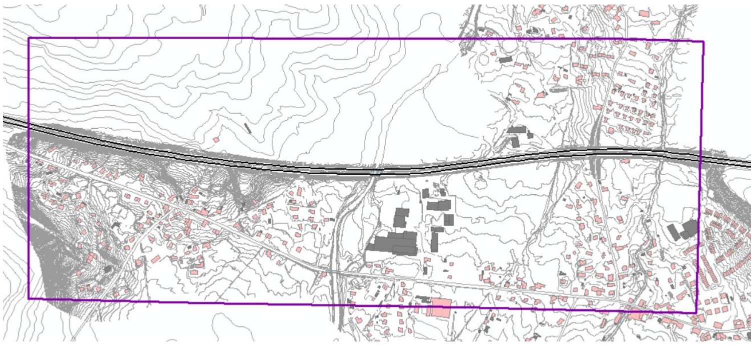
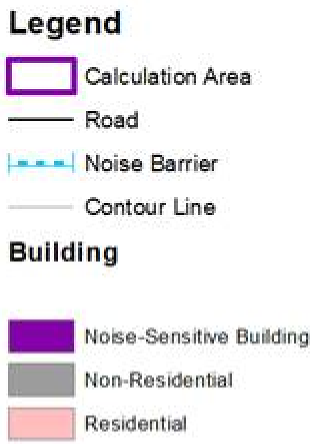
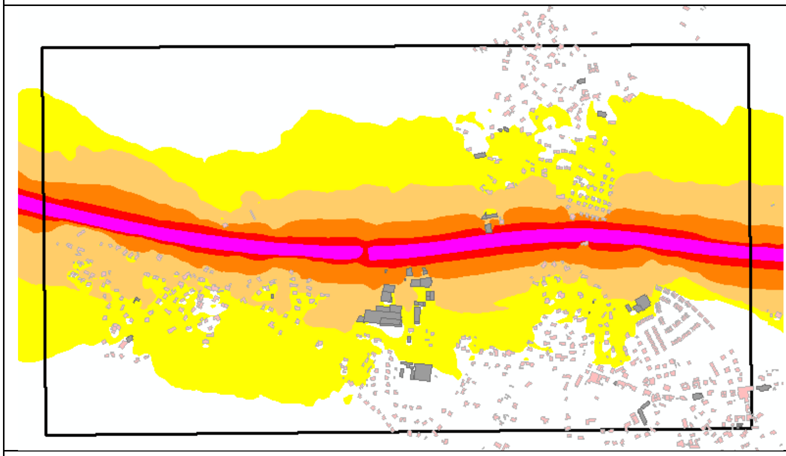
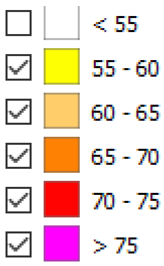
Conclusions of Test Site

The highest efficacy, considering all the parameters and exposure ranges, is achieved with solutions at the source, that reduce acoustic emission (A, B, ABD).

The efficacy achieved with solutions in urban planning (H) and with the reduction of speed (F), in exposure to Lden values is also important, and somewhat less than the restriction of the access of heavy vehicles at night (G1). Note that in this Test Case, speed reduction means limiting speed to 50 km / h, which is very restrictive and difficult to apply.

Observing the exposure of the population to noise at night, which in this case is the most critical variable and night is the only period with legal non-compliance levels, the solution of prohibiting the circulation of heavy vehicles (G1) is the most interesting, with an efficiency similar to the solutions at source (A or B).

B4.7. Motorway N-622, near Murgia

	
	Strategic Noise Map (Lden). Baseline 
City / location / major road	N-622 Motorway affecting Murgia city
Compiled for	N-622 Strategic Noise Map
Date map was calculated	2016
Source of input data used for map	Regional Road manager-Diputación Foral de Alava
Noise prediction model	NMPB-Routes-96 + CETUR 1980
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered. - Noise barriers already designed by the Road authorities
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the regional road authority. This area is part of a city affected by the motorway.

Most of the affected buildings are residential and with low height, two storeys.

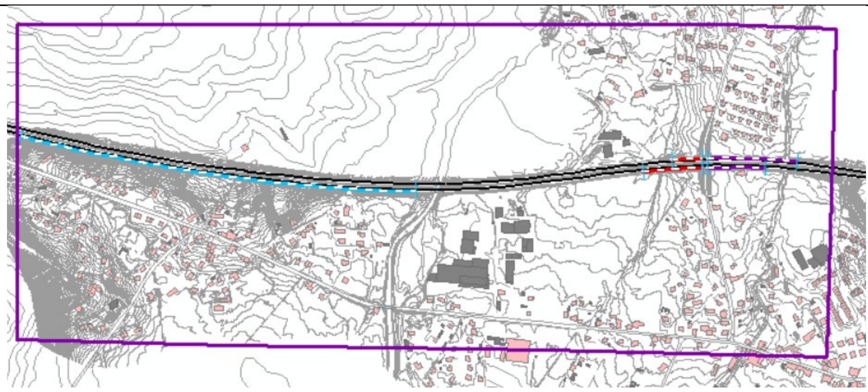
Road Authority has defined abatement measure (two noise barriers) for this area in the Noise Action Plan for this period. In fact, one of the noise barriers is already installed although has not been included in the Strategic Noise Map yet. The design of this barriers is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barriers can be considered as optimized in terms of cost-benefit.

According to the legal noise limits the acoustic impact is mainly at night period. There is a particular residential building close to the road, which protection nowadays is planned improving façade isolation and it is not protected with the designed noise barriers.

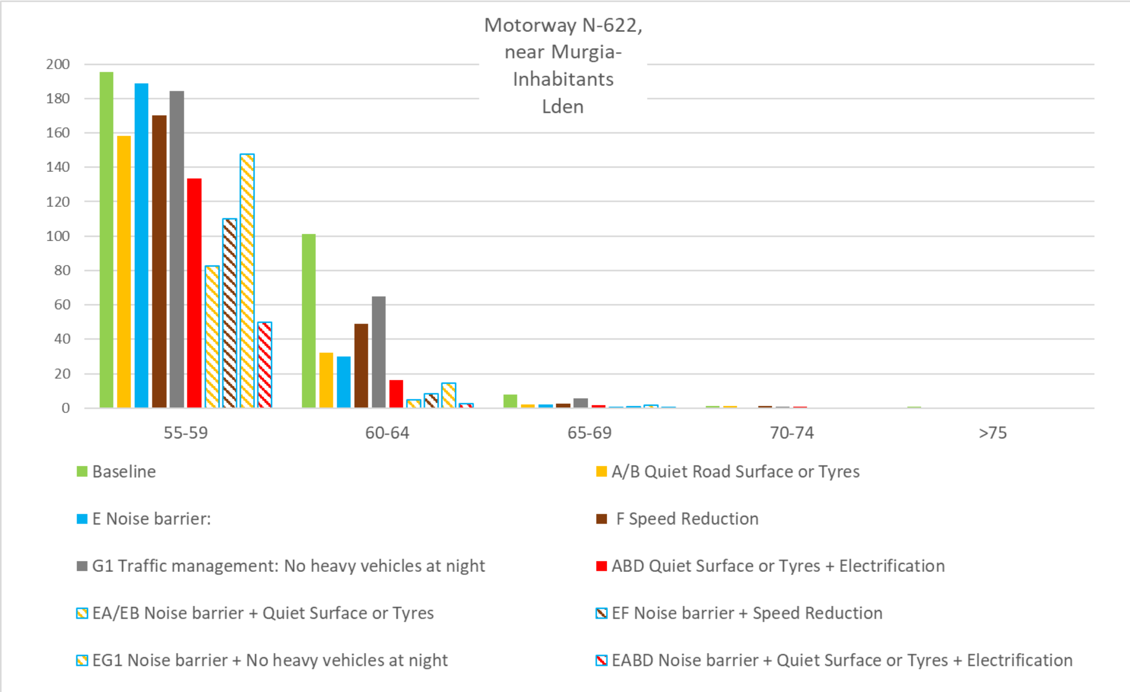
The Baseline for this study is the situation simulated in the last Strategic Noise map, without the noise barrier.

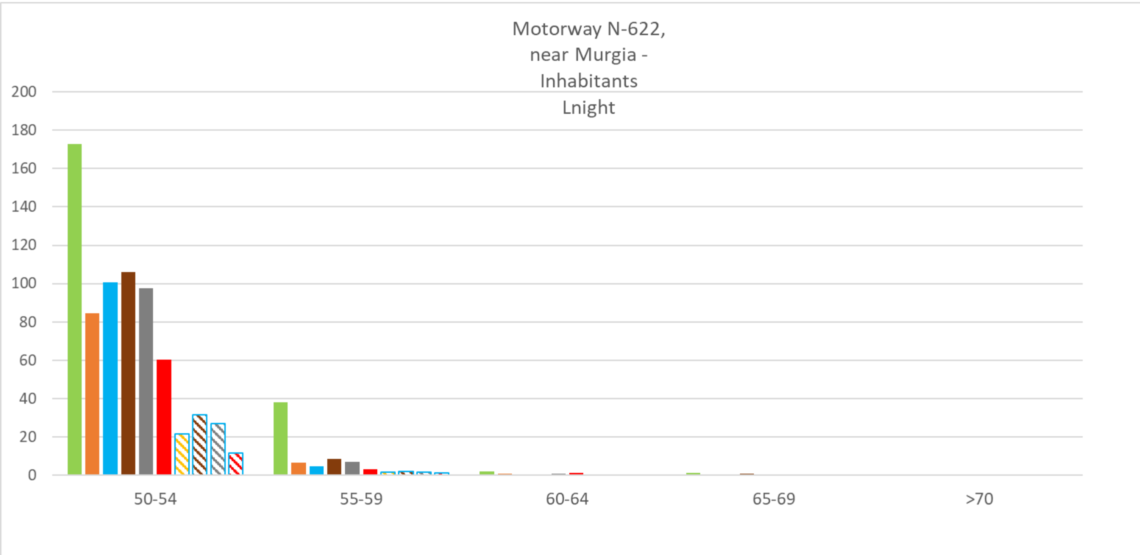
Variations

<table>
<tr><th>Motorway N-622,
near Murgia</th><th>Calculated Variations</th><th>Comments</th></tr>
<tr><td colspan="3">BASELINE: Scenario simulated in the Strategic Noise Map</td></tr>
<tr><td rowspan="5">Single Solutions</td><td>A or B Quiet Surface or tyres</td><td>The effect is considered as a reduction of 3dB</td></tr>
<tr><td>E Noise barrier:</td><td>Designed in NAP.
See figure</td></tr>
<tr><td>F Speed reduction</td><td>From
120 km/h light and 80 km/h heavy
To
80 km/h light and 80 km/h heavy</td></tr>
<tr><td>G1 Traffic management</td><td>Heavy traffic restriction at night</td></tr>
<tr><td>H Urban Planning</td><td></td></tr>
<tr><td rowspan="5">Combined scenarios:</td><td>ABD Quiet Surface + Quiet tyres + Electrification</td><td>The effect is considered as a reduction of 4dB</td></tr>
<tr><td rowspan="4">Noise barrier + Noise solutions at the source:</td><td>EA or EB Quiet Surface or tyres</td></tr>
<tr><td>EF Speed reduction</td></tr>
<tr><td>EG1 Traffic management: No Heavy at night</td></tr>
<tr><td>EABD Quiet road Surface+ Quiet tyres + Electrification</td></tr>
</table>

Noise Barrier: 	

Change in population exposure:

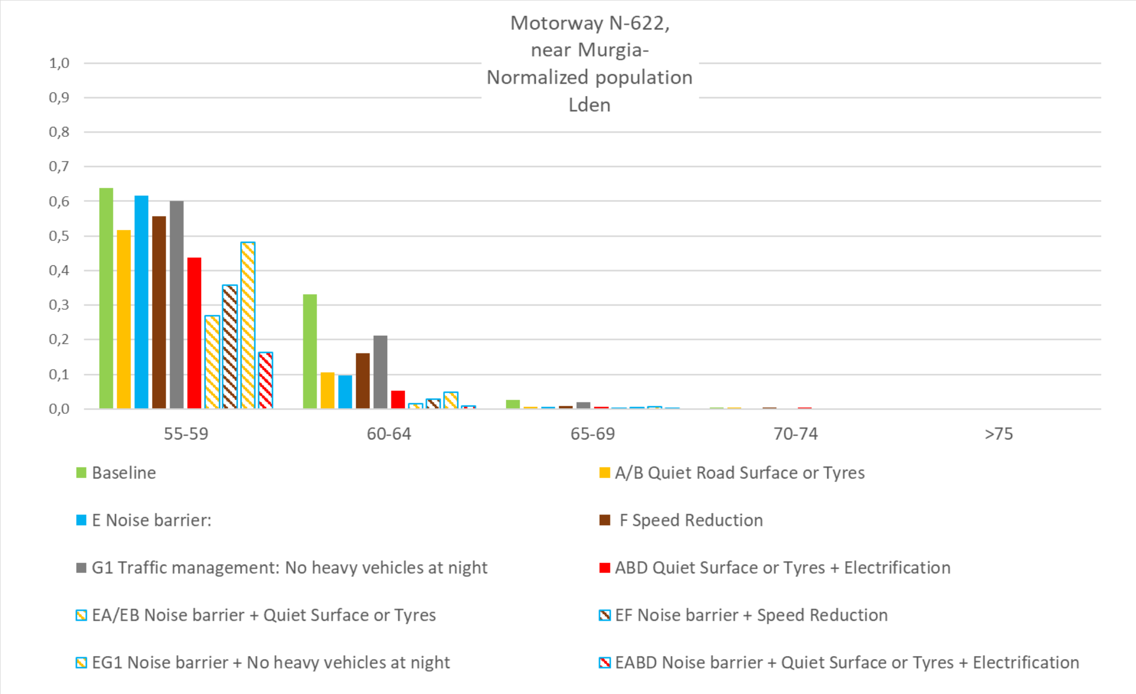


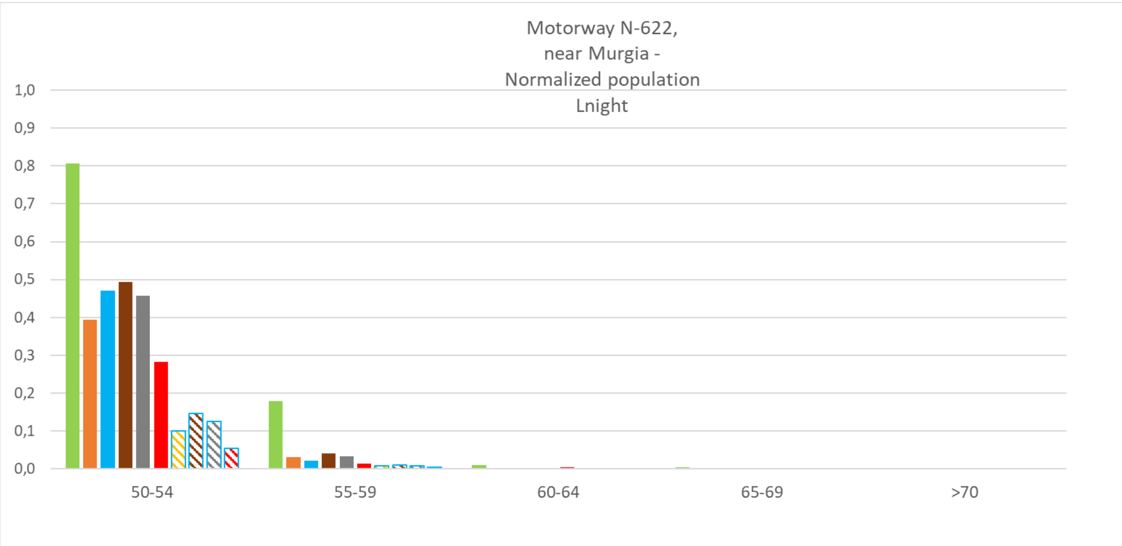


L_{den}		SINGLE SOLUTIONS				COMBINED SOLUTIONS:				
							BARRIER +			
	BASE	A/B Quiet roads or Tyres	E Barrier	F Speed Reduction	G1 No heavy vehicles at night	ABD Quiet roads and Tyres and Electrification	EA/EB Quiet roads or Tyres	EF Speed Reduction	EG1 No heavy vehicles at night	EABD Quiet roads and Tyres and Electrification
55-59	195	158	189	170	184	134	83	110	148	50
60-64	101	32	30	49	65	16	5	8	15	3
65-69	8	2	2	3	6	2	1	1	2	0
70-74	1	1	0	1	1	1	0	0	0	0
>75	1	0	0	0	0	0	0	0	0	0

L_{night}		SINGLE SOLUTIONS				COMBINED SOLUTIONS:				
							BARRIER +			
	BASE	A/B Quiet roads or Tyres	E Barrier	F Speed Reduction	G1 No heavy vehicles at night	ABD Quiet roads and Tyres and Electrification	EA/EB Quiet roads or Tyres	EF Speed Reduction	EG1 No heavy vehicles at night	EABD Quiet roads and Tyres and Electrification
50-54	173	84	101	106	98	60	21	31	27	11
55-59	38	7	5	9	7	3	2	2	2	1
60-64	2	1	1	1	1	1	0	0	0	0
65-69	1	0	0	1	1	0	0	0	0	0
>70	0	0	0	0	0	0	0	0	0	0

Normalized population exposure:





Conclusions of Test Site

The most effective solutions are the solutions that act on emission (A or B) or the Noise barriers (E) proposed (real effect given the type of buildings in the area). This implies that an improvement in the road surface that attenuates the emission in 3 dB would have been a similar solution to the noise barrier.

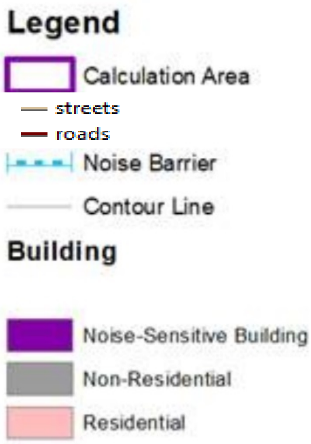
The combination of barriers with speed reduction (EF) doubles the efficacy of the barrier.

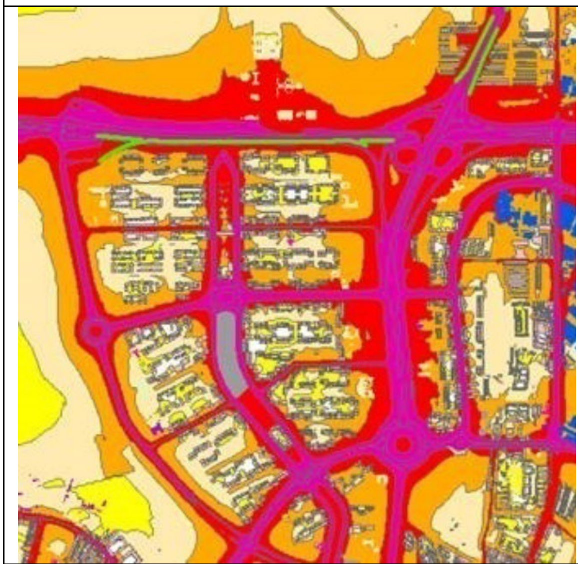
Focusing on the night period, where the main problem is, any isolated solution can solve the problem in the highest range of exposure; either the barriers (E), the solution at the source (A/B), speed reduction (F) or the limitation of access to heavy vehicles at night (G1).

On the other hand, the particular case of the isolated house located on the side of the motorway cannot be satisfactorily solved with any of the solutions studied, nor their combinations. So, the decision to act at the reception seems appropriate.

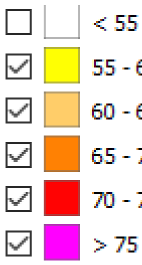
B4.8. Zaragoza agglomeration: A2 motorway, N330 road and streets

Baseline





Strategic Noise Map (Lden) of actual situation, different from the baseline



Compiled for agglomeration	Zaragoza
Author/Owner of noise map	Itziar Aspuru (Tecnalia)
Date map was calculated	2007
Source of input data used for map	Ayuntamiento de Zaragoza
Noise prediction model	NMPB-Routes-96 + CETUR 1980”. Interim Method
Software	CADNA
Details of noise calculation	- Maximum 1 reflection per sound path. - Reference road surface. - Receivers at facades of dwellings separated by 10 m. - Topography considered. - Noise barrier installed
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the Strategic Noise Map of the agglomeration. This area is part of the city affected by the motorway with two access to the city and the urban traffic in the neighbourhood. The impact of urban traffic in the city has been calculated.

Most of the affected buildings are residential with heights corresponding to more than 4 storeys.

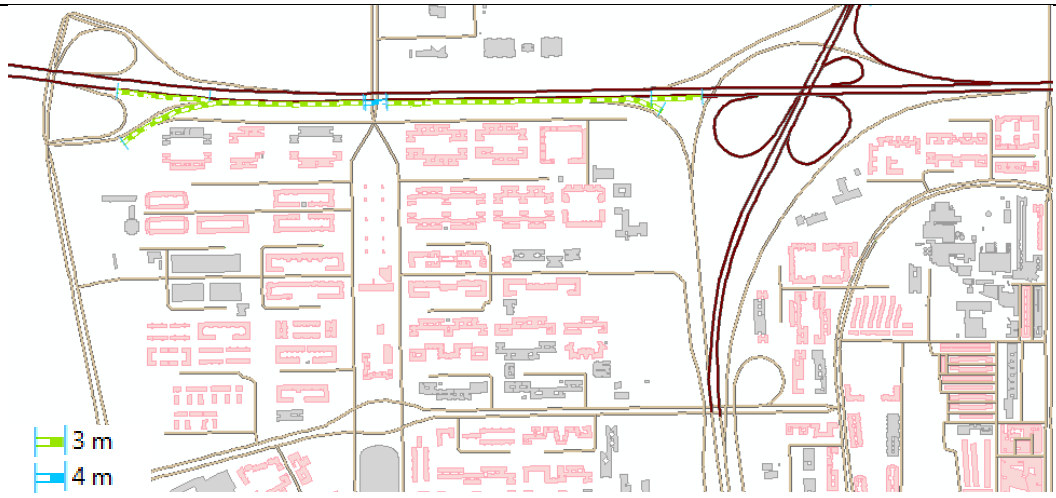
Nowadays, there are noise barriers to reduce the effect of the motorway, and this is the base to study the effect of abatement measure E Noise Barrier. Therefore, in this Test Case the Noise barrier is real and therefore it can be considered as optimized in terms of cost-benefit.

The Baseline for this study is the situation without the noise barrier.

Variations

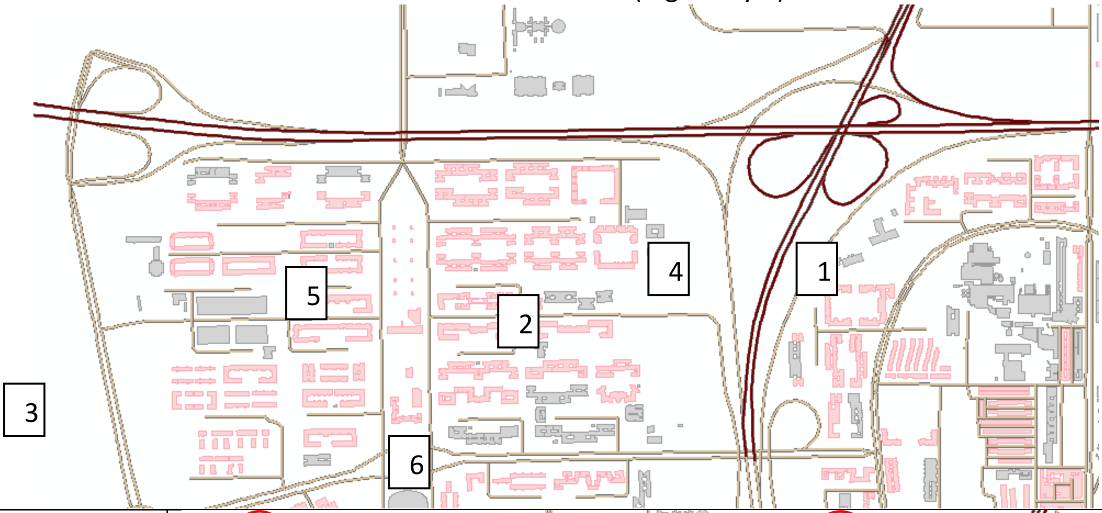
Strategic Noise Map Zaragoza agglomeration: A2 motorway, N330 road and streets	**Calculated Variations**	**Comments**
BASELINE:	Existing situation without the noise barriers, considered as an abatement solution	
Single Solutions	A or B Quiet Surface or tyres	The effect in A2 motorway and N330 road is considered as a reduction of 3dB. The effect in streets at 50 km/h is considered as a reduction of 1dB. See figure
	E Noise barrier:	Existing. See figure
	F Speed reduction	Motorway and Roads from 120 km/h light and 80 km/h heavy To 80 km/h light and 80 km/h heavy Streets from 50 to 30 km/h
	G2 Traffic management	Rerouting between main roads. See figure
	H Urban Planning	Add industrial buildings close to main roads See figure
Combined scenario	ABD Quiet Surface + Quiet tyres + Electrification	The effect in in A2 motorway and N330 road is 4dB. Effect in streets is 4dB.

<table>
<tr><td colspan="2">A or B Quiet Surface or tyres
Reduction of 3dB in emission in roads and 1dB reduction in streets

</td></tr>
<tr><td>E Noise Barrier:
Blue and green Line</td><td>
</td></tr>
</table>

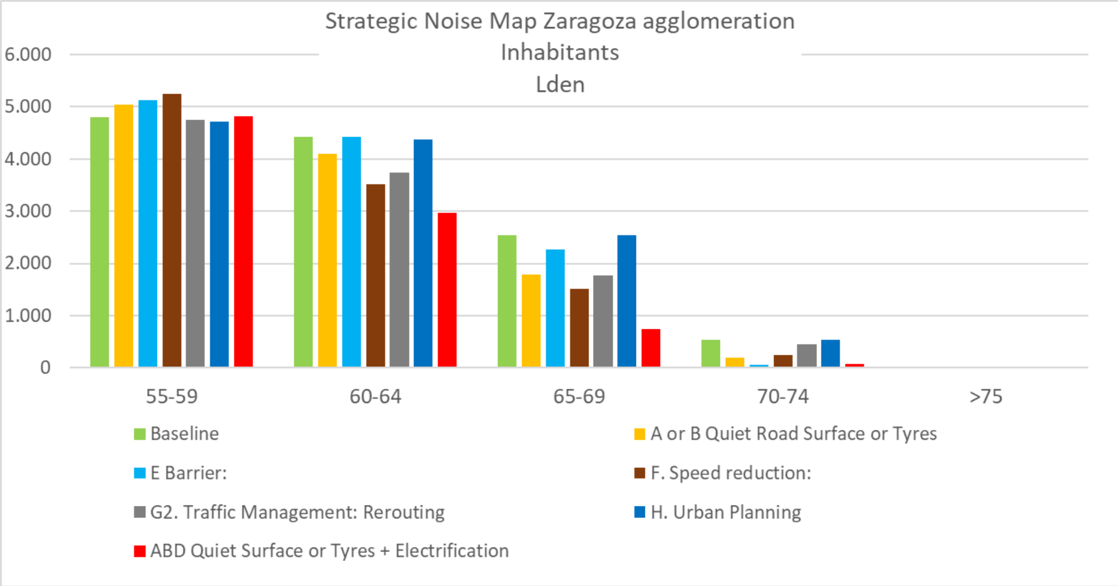
G2 Traffic management: Rerouting

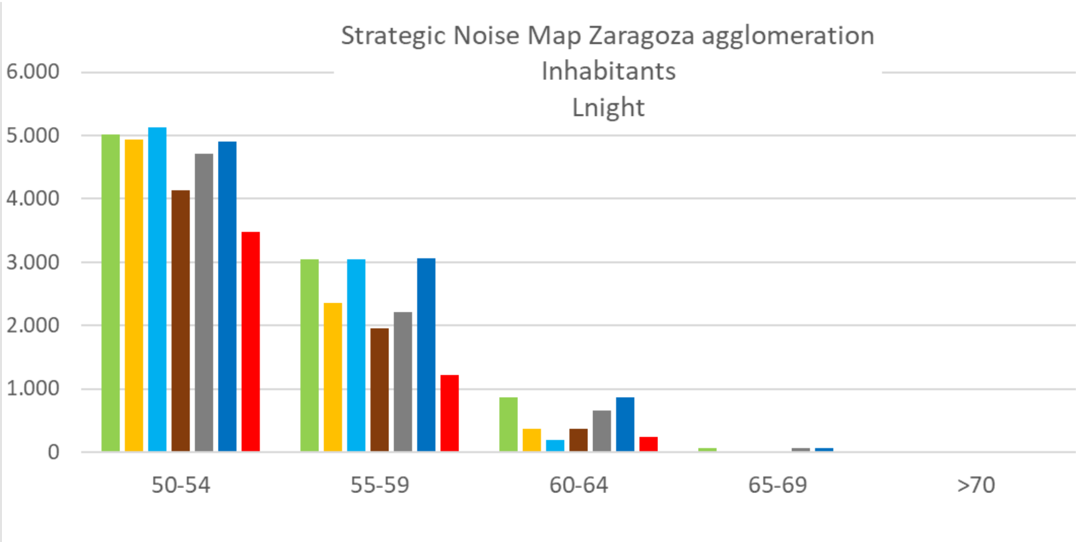
- Reduce the traffic of 1 until has similar traffic as 2. (it goes by the industrial aera outside the calculation area)
- Change the traffic from 4 to 3 and vice versa.
- Convert 5 in pedestrian road (the traffic goes by 3).
- Reduce the traffic of 6 until has similar traffic as 2 (it goes by 3).



H Urban Planning: New industrial buildings (6m height)

Change in population exposure:



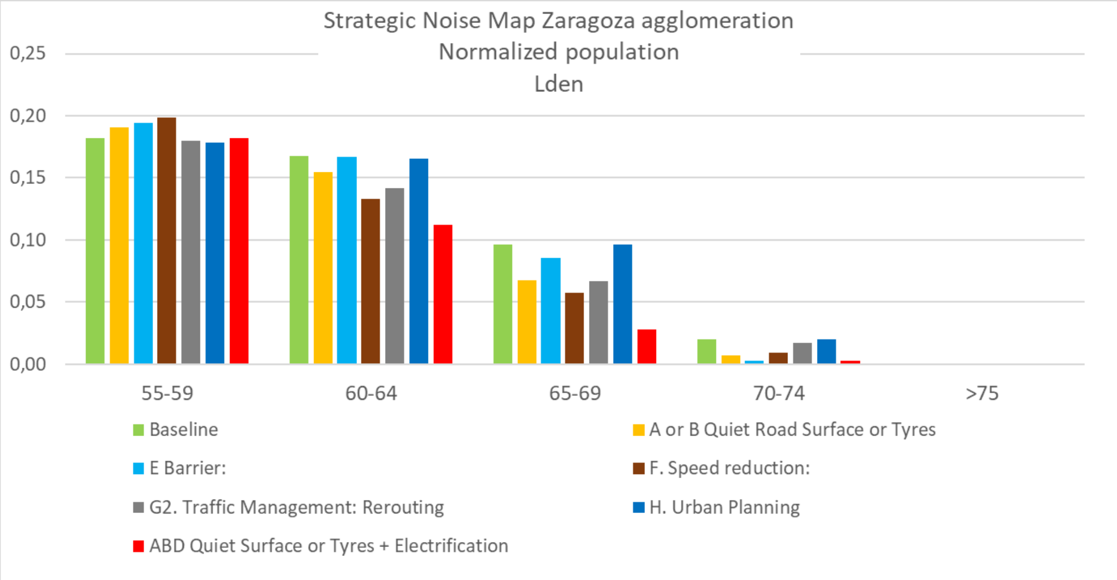


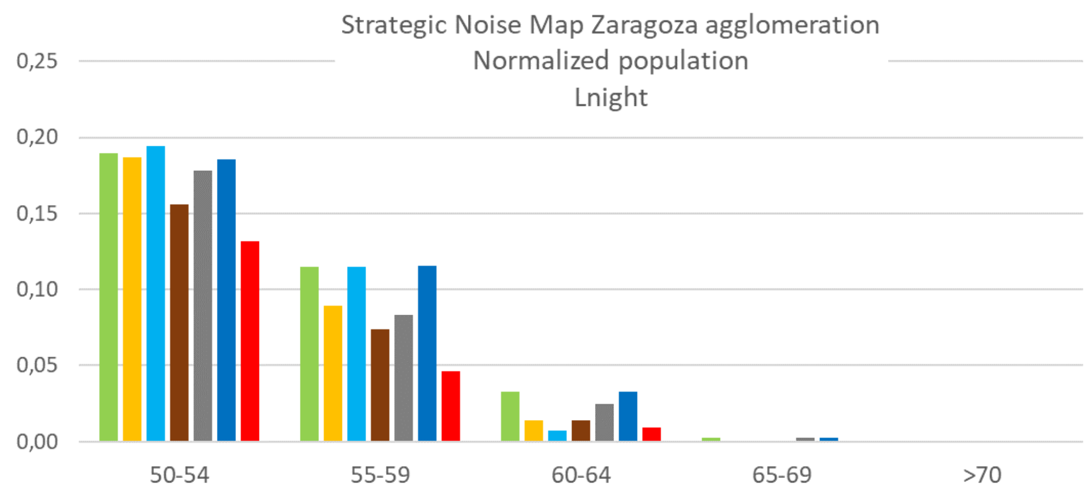
Lden	Baseline	A or B Quiet Road Surface or Tyres	E Barrier:	F. Speed reduction:	G2. Traffic Management: Rerouting	H. Urban Planning	ABD Quiet Surface or Tyres + Electrification
55-59	4.808	5.038	5.134	5.253	4.753	4.709	4.812
60-64	4.424	4.093	4.419	3.518	3.749	4.377	2.968
65-69	2.550	1.795	2.262	1.512	1.773	2.549	748
70-74	532	193	65	249	457	532	72
>75	0	0	0	0	0	0	0

Lnignt	Baseline	A or B Quiet Road Surface or Tyres	E Barrier:	F. Speed reduction:	G2. Traffic Management: Rerouting	H. Urban Planning	ABD Quiet Surface or Tyres + Electrification
50-54	5.017	4.937	5.133	4.129	4.708	4.904	3.483
55-59	3.041	2.359	3.039	1.951	2.209	3.054	1.218
60-64	871	377	194	373	659	871	236
65-69	72	0	0	0	72	72	0
>70	0	0	0	0	0	0	0

Normalized population exposure:

This Test Site is part of an agglomeration and the normalization is referred to the total population living at the area.





Conclusions of Test Site

It should be taken into account that in this Test Case there are two sources of different behavior: the motorway and the access road or the urban streets.

The Noise barrier (E) protects the most exposed inhabitants, but in general the highest effect is achieved with the reduction of speed on all traffic (F), especially noticeable in the intermediate ranges, 60-69 Lden and 50-59 Lnight.

The rerouting solution (G2) also focuses its effect on those same ranges and has little effect at high exposure ranges, as there are no reductions on the motorway.

The solutions acting at the source (A or B or ABD) have generally more effect than the Noise barrier (E) and the rerouting (G2).

As was the case in other Test Cases with the quantification of the health effects of the effect of the Noise Barrier, in this Test Case it occurs with the effect of the speed reduction, which seems to be higher in HSD than in HA, since the increase in people with less exposure is outside the range of the study analyzed at night.

Annex 5: Test site calculations for rail traffic noise

ANNEX 5
Test site calculations for railway noise

Calculations performed by: TNO and Tecnalia

Project: Phenomena

Contents

Overview

Railway noise calculations for have been performed for eight test sites:

- two areas near railway lines in NL,
- six areas near railway lines in ES.

The calculations for NL were performed by TNO. The calculations for ES were performed by Tecnalia. For the two test sites in NL, variations have been performed by adding or removing a noise barrier.

In this document, graphs of exposure distributions for the test sites are presented. In the annexes, the results for each test site are presented.

Figure 1 shows the exposure distributions for the eight test sites, for Lden and Lnight. Figure 2 shows the same distributions, but now normalized so that the sum over the five intervals is unity. In Fig. 2, the average EU distributions for major railways outside agglomerations are also included. The normalized distributions for the eight test sites are similar to the normalized EU distributions.

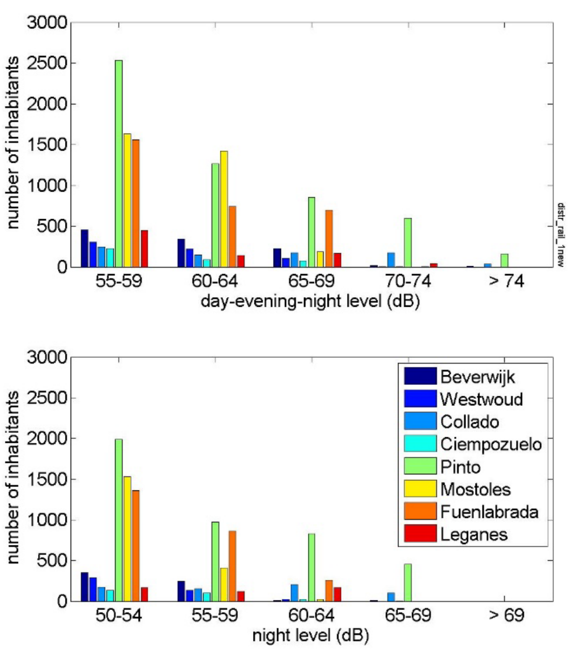


Figure 1. Exposure distributions for the eight railway noise test sites, for Lden and Lnight.

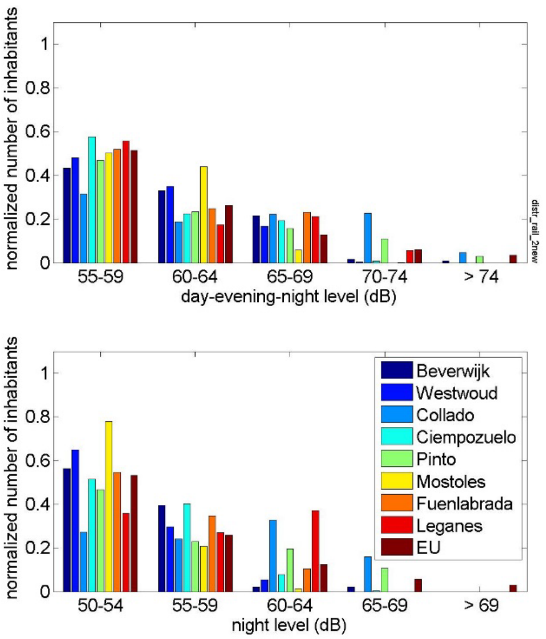
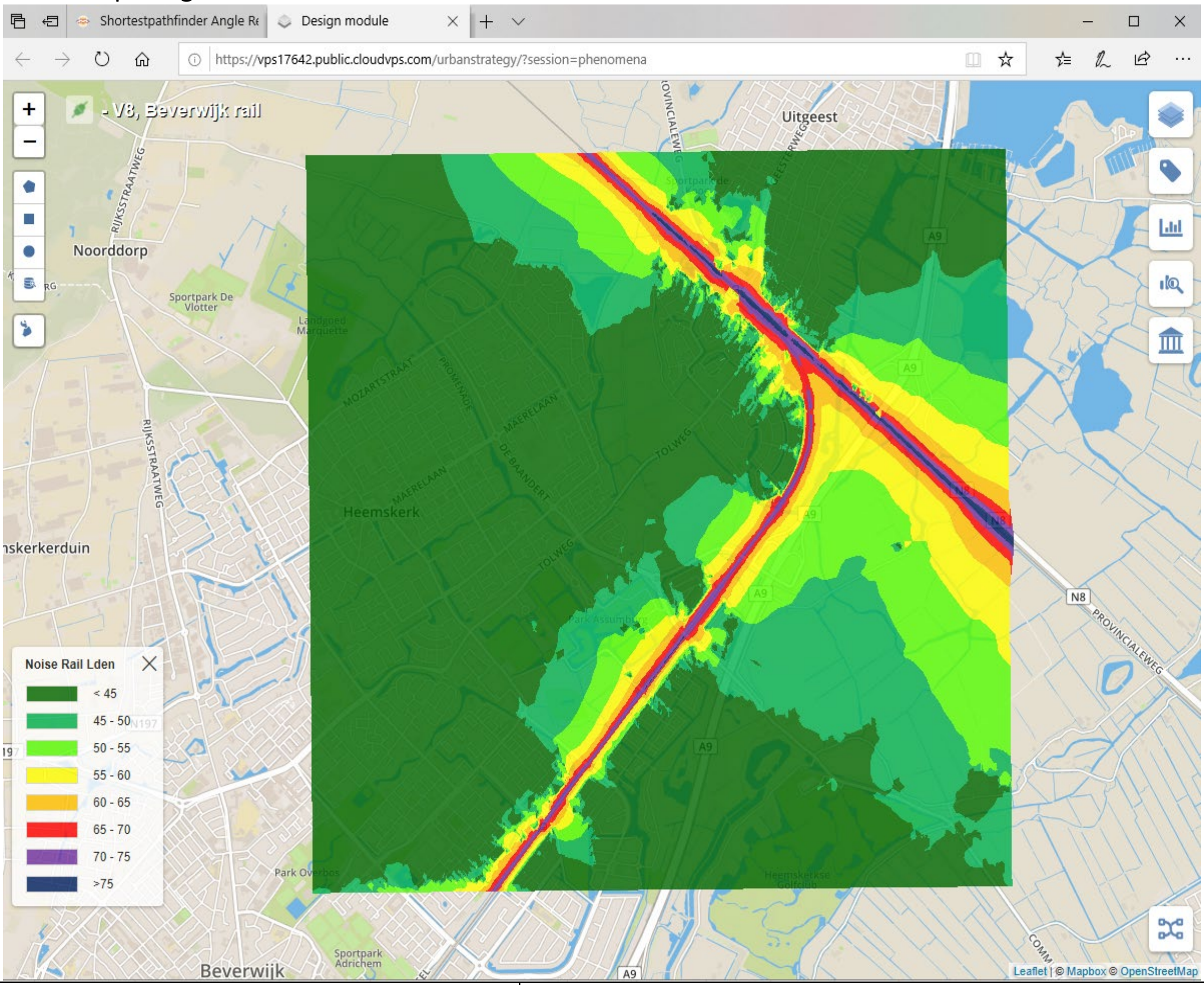


Figure 2. Normalized exposure distributions for the eight test sites, for Lden and Lnight. The EU distributions are included.

Annex A5. Test sites in The Netherlands

A5.1. Beverwijk

Noise map test site	
City / location / major road or railway	Railway through Beverwijk (North-Holland, NL) x=106.1-110.1km, y=500.7-504.7km.
Noise map image 	
Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	19 Feb 2020
Source of input data used for map	Aswin (2009), BAG (2017)
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - 22685 buildings and 31379 inhabitants in the area - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - Addresses from BAG. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	29315	93,4	30760	98,0
L = 50-54 dB	1021	3,3	348	1,1
L = 55-59 dB	451	1,4	244	0,8
L = 60-64 dB	343	1,1	13	0,0
L = 65-69 dB	224	0,7	13	0,0
L = 70-74 dB	15	0,0	0	0,0
L > 75 dB	9	0,0	0	0,0
	31379	100	31379	100

The calculation for test site Beverwijk is illustrated in Figure A1. Two variations of the test site calculation were performed

1) the noise barriers along the railway were removed,
2) buildings that are not (partly) within 100 m from the railway were removed.

The exposure distributions are shown in Fig. A2, for the original calculation and for the two variations. The effect of removing the barrier is limited.

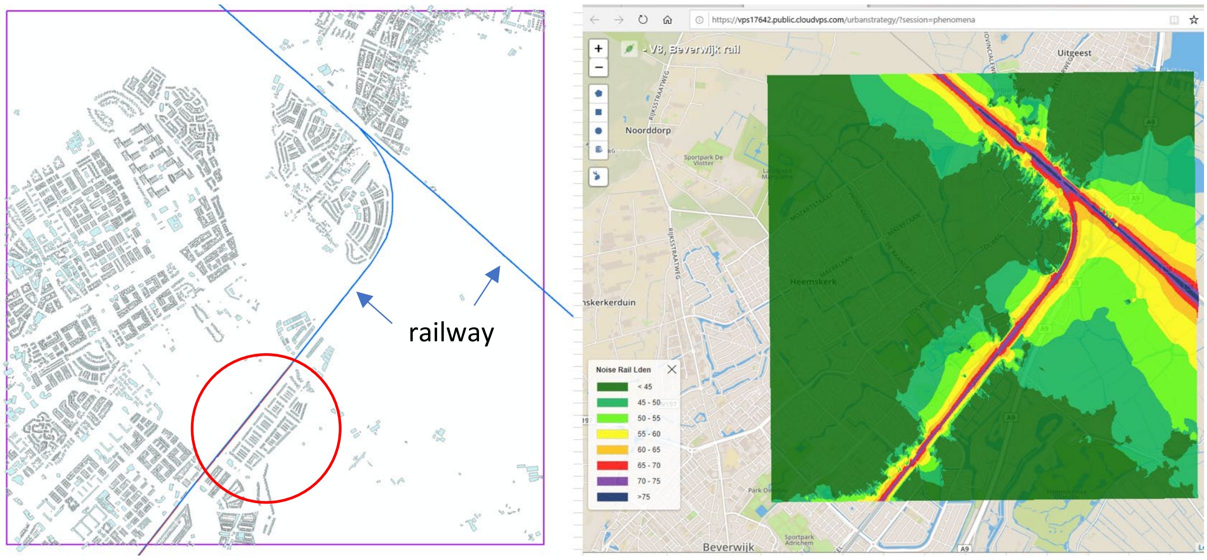


Figure A1. Illiustration of the calculation for test site Beverwijk. The graph on the left shows the railway line (blue) and the dwellings. The dwellings in the red circle are screened by a noise barrier along the railway line. The noise map is shown on the right.

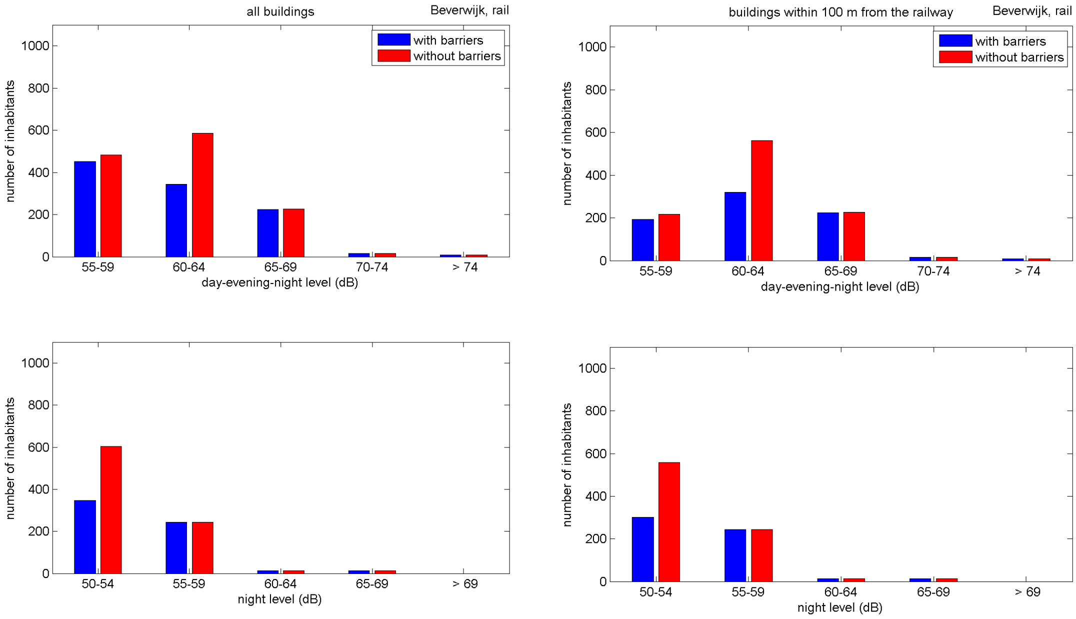
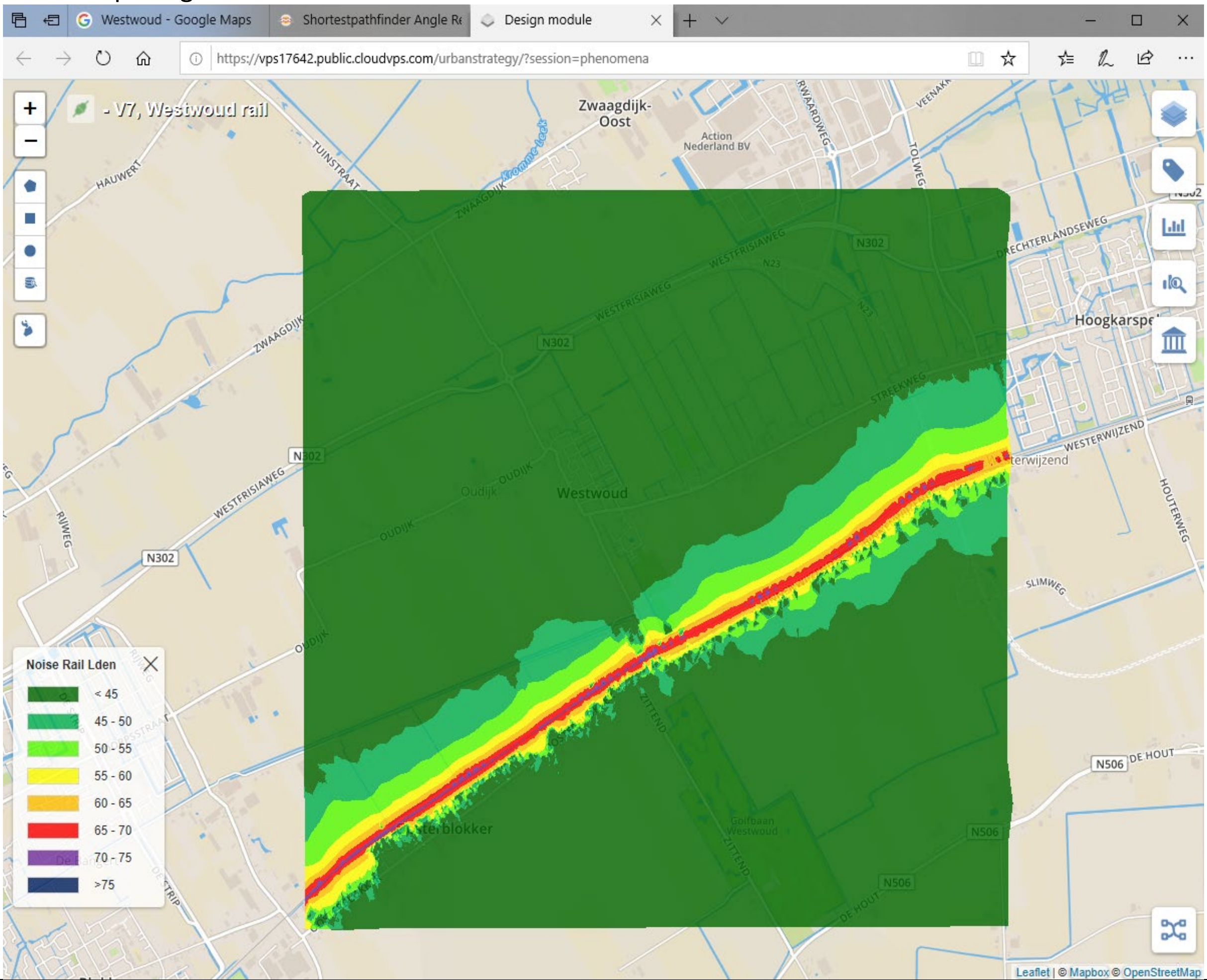


Figure A2. Exposure distributions for Beverwijk. The left graph shows the effect of removing the barrier. The right graph is similar, but now only the buildings within 100 m from the railway are considered.

A5.2. Westwoud

Noise map test site	
City / location / major road or railway	Railway near Westwoud (North-Holland, NL) x=136.1-140.1km, y=519.7-523.7km.

Noise map image



Compiled for agglomeration/road/rail/airport	-
Author/Owner of noise map	TNO
Date map was calculated	19 Feb 2020
Source of input data used for map	Aswin (2009), BAG (2017)
Noise prediction model	Dutch noise model RMG2012
Software	Urban Strategy
Details of noise calculation	- Maximum 1 reflection per sound path. - 2475 buildings and 4699 inhabitants in the area - Receivers at facades of dwellings to calculate façade level at the most-exposed façade. - Addresses from BAG. - No topography (flat ground).
Noise level calculated	Lden and Lnight

Exposure distributions, where N is the number of inhabitants.

	N(Lden)	P(Lden)	N(Lnight)	P(Lnight)
L < 50 dB	3654	77,8	4253	90,5
L = 50-54 dB	409	8,7	290	6,2
L = 55-59 dB	306	6,5	132	2,8
L = 60-64 dB	222	4,7	24	0,5
L = 65-69 dB	106	2,2	0	0,0
L = 70-74 dB	2	0,0	0	0,0
L > 75 dB	0	0,0	0	0,0
	4699	100	4699	100

The calculation for test site Westwoud is illustrated in Figure A3. Two variations of the test site calculation were performed:

1) a 4 m high noise barrier was ADDED at 11 m from the railway (south side),
2) buildings that are not (partly) within 100 m from the railway were removed.

The exposure distributions are shown in Fig. A4, for the original calculation and for the two variations. The effect of adding the barrier is very large, as the majority of buildings lies near the railway on the south side.

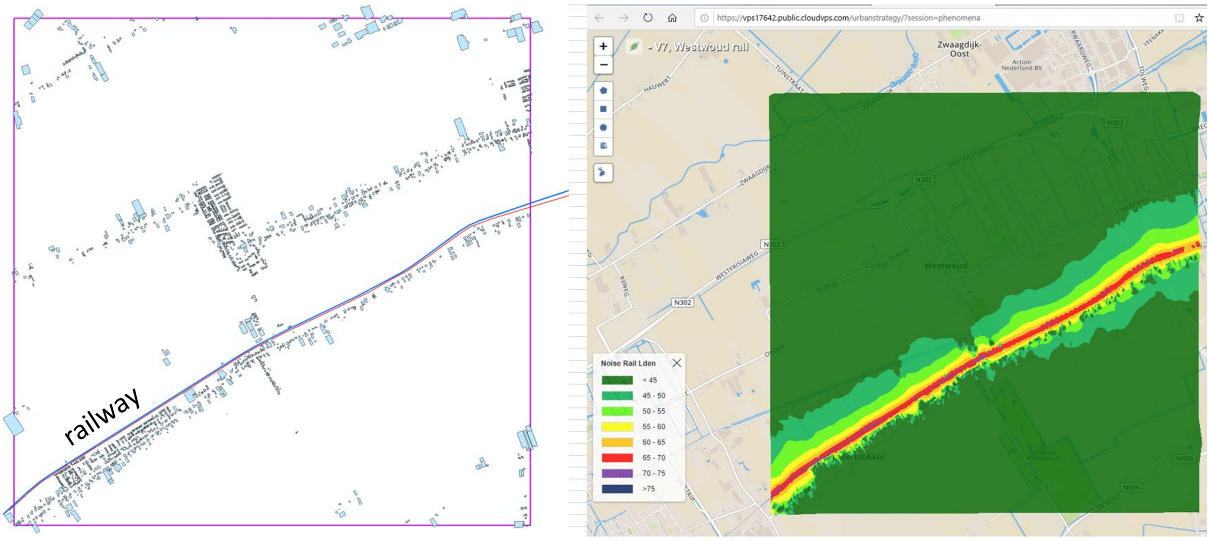


Figure A3. Illiustration of the calculation for test site Westwoud. The graph on the left shows the railway line and the dwellings. The noise map is shown on the right.

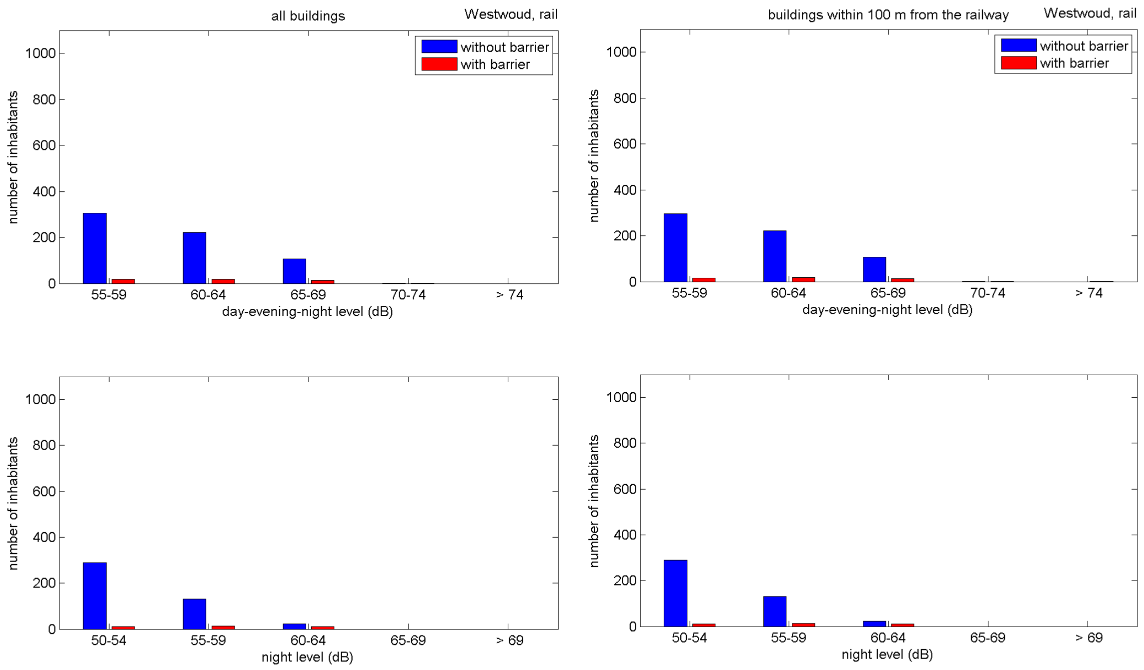


Figure A4. Exposure distributions for Westwoud. The left graph shows the effect of adding the barrier. The right graph is similar, but now only the buildings within 100 m from the railway are considered.

Annex B5. Test sites in Spain

B5.1. General introduction

In this annex results calculated for different scenarios in selected Railway Test Cases are presented, being the reference the baseline scenario and several scenarios with one or more noise abatement solutions.

There are 6 Test Cases selected

	Total Population of the city (inhab)	*Railway Line*
Collado	63.679	Madrid Chamartin- El Escorial
Mostoles	207.095	Mostoles El Soto-Humanes
Leganes	189.861	Mostoles El Soto-Humanes
Ciempozuelo	24.592	Madrid Atocha Cercanias-Aranjuez
Pinto	51.541	Madrid Atocha Cercanias-Aranjuez
Fuenlabrada	193.700	Mostoles El Soto-Humanes

The noise solution for railway traffic noise defined in PHENOMENA project are

Solutions	Description
A	Smooth tracks, grinding
B	Smooth wheels: composite/disc braked or better, and wheel flat control.
C	Quieter vehicle design: optimised wheels, better bogies and suspension
D	Quieter track design: railpads, rail dampers and/or rail shielding.
E	Noise barriers
F	Traffic management: move freight trains outside urban area
G	Urban planning;
H	Enhanced dwelling insulation
I	More restrictive reception limits

The Test Cases simulate the effect on population exposure of each solution compared to the Baseline. The effect is quantified by calculating noise levels outdoor on the facades of residential buildings, receivers located at 4m from the ground. Abatement solutions I and J are not quantified, since measure I does not reduce the noise level outdoors and J is not a technical measure.

Different abatement solutions are applied in each Test Case, depending on their potentiality to be real and to reduce exposure. Among the 6 Test Cases all abatement solutions are applied.

		Variations calculated:	*Collado*	*Mostoles*	*Leganes*	*Ciempozuelo*	*Pinto*	*Fuenlabrada*
Single Solutions		AB/CD Either Roughness wheel and track OR Design vehicle and track Reduce emission in 3dB in 50% of the line	■	■	■	■	■	■
		E Noise barrier:	■	■	■	■		■
		F Traffic management: Remove freight trains	■		■		■	
		H Urban Planning. Add buildings close to the Line.	■		■	■		■
Combined scenarios		AB&CD Both Roughness wheel and track AND Design vehicle and track Reduce emission in 6dB in 50% of the line	■	■	■	■		■
	E Noise Barrier +	ABCDE Roughness AND Design	■	■	■	■		
		EF Traffic management	■		■			
	G Urban Planning +	ABG or CDG Roughness OR Design	■		■	■		
		ABCDG Roughness AND Design	■		■	■		
		EGF Noise barrier + Urban Planning + Traffic restriction	■		■			

The abatement solutions at the sources, either in the wheel or in the track, are the followings:

- AB Improving the roughness of the wheels or the track: the effect is estimated as a reduction in the emission in 3dB.
- CD Improving the design of the vehicle or of the track: the effect is estimated as a reduction in the emission in 3dB.
- ABCD it is a combination of the two, that means improving both the roughness of the wheel or the track and applying improved designs to the vehicle or to the track. the effect is estimated as a reduction in the emission in 6dB.

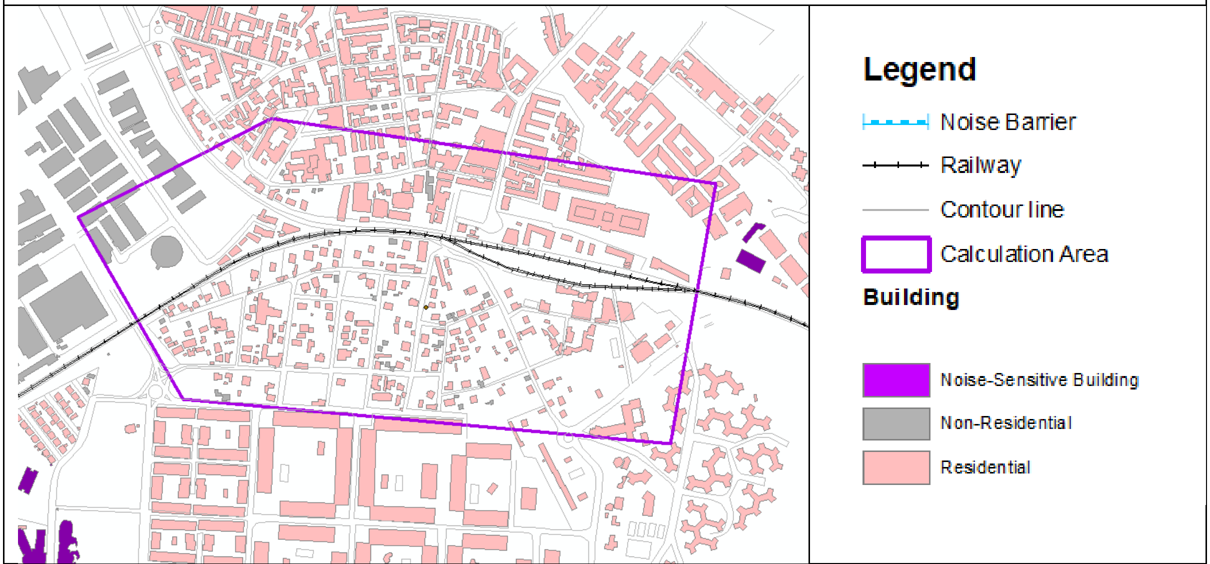
This test sites are calculated with the Dutch method (SRM 96) and these effects in the emission are applied reducing the two lowest sources (0 and 0,5m high), since they only reduce the rolling noise.

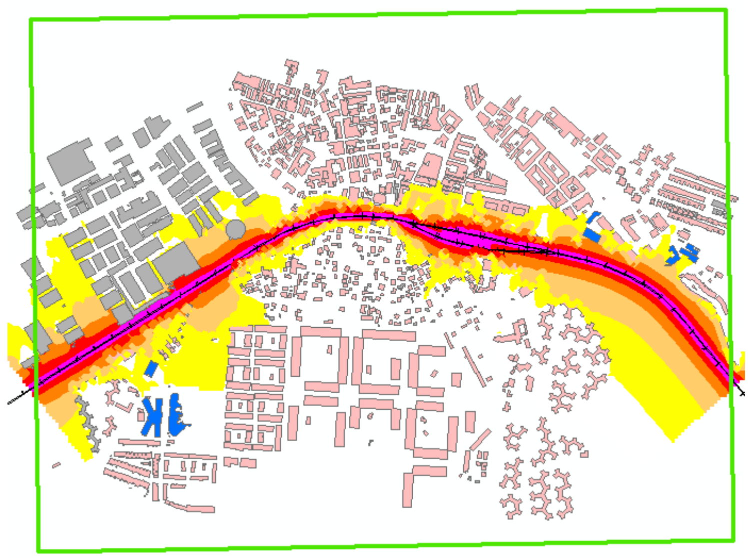
The scenarios presented consider that those measures are partially implemented. Therefore, the reduction is applied to 50% of the line in the area. In the description of each Test Site a figure shows the area were these solutions are applied and an estimation of the population allocated in that area.

The measure F - Traffic management supposes that the freight trains are moved to another railway lines. Considering the size of the Test Sites the negative effect on other lines cannot be considered in the calculations and there is only the reduction of noise due to the freight trains removed.

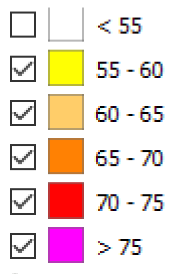
B5.2. Line: Madrid Chamartin- El Escorial in Collado

Baseline





Strategic Noise Map (Lden) of actual situation. Baseline.



City / location / major railway	Collado (63 679 hab) affected by railway line: Madrid Chamartin- El Escorial
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	Spanish Railway Manager ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of a city affected by the railway line.

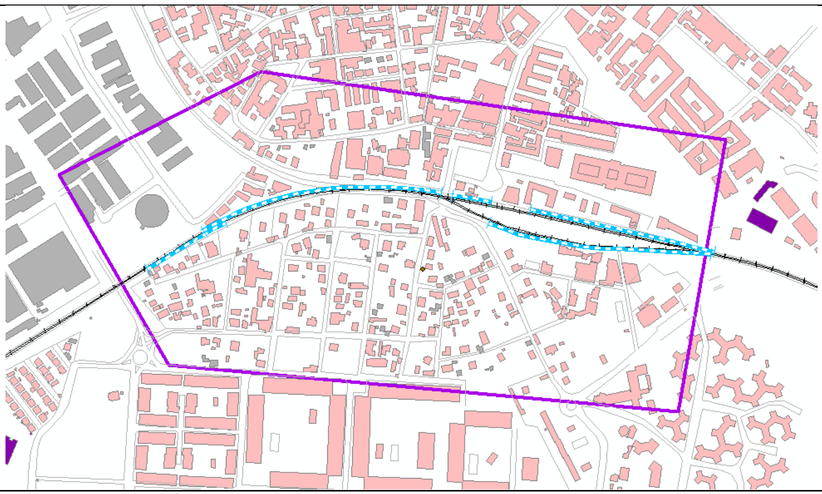
Most of the affected buildings are residential and their height is above 12 m.

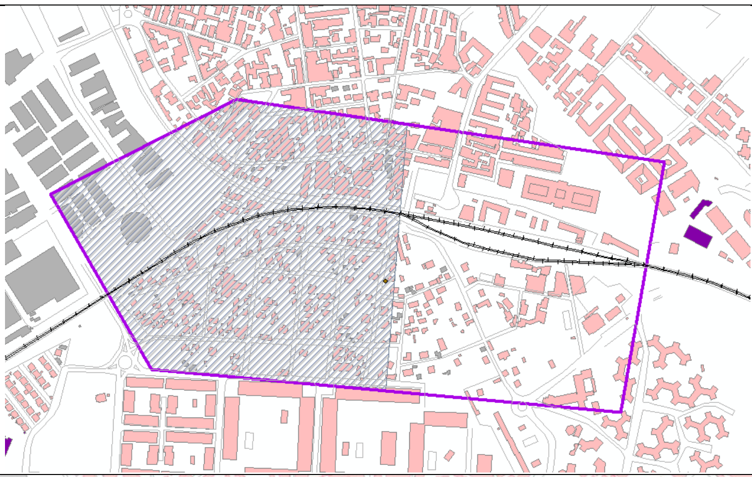
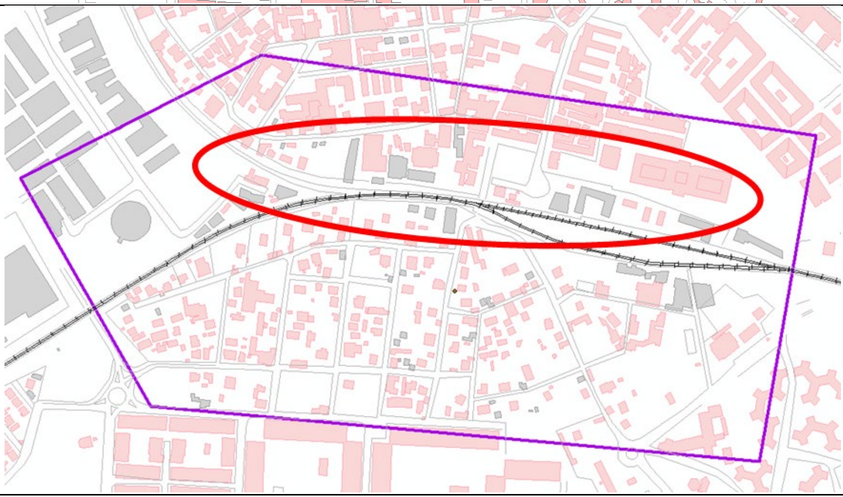
The Test Site includes the station of Collado and there is an area where the railway line is in an embankment.

Variations

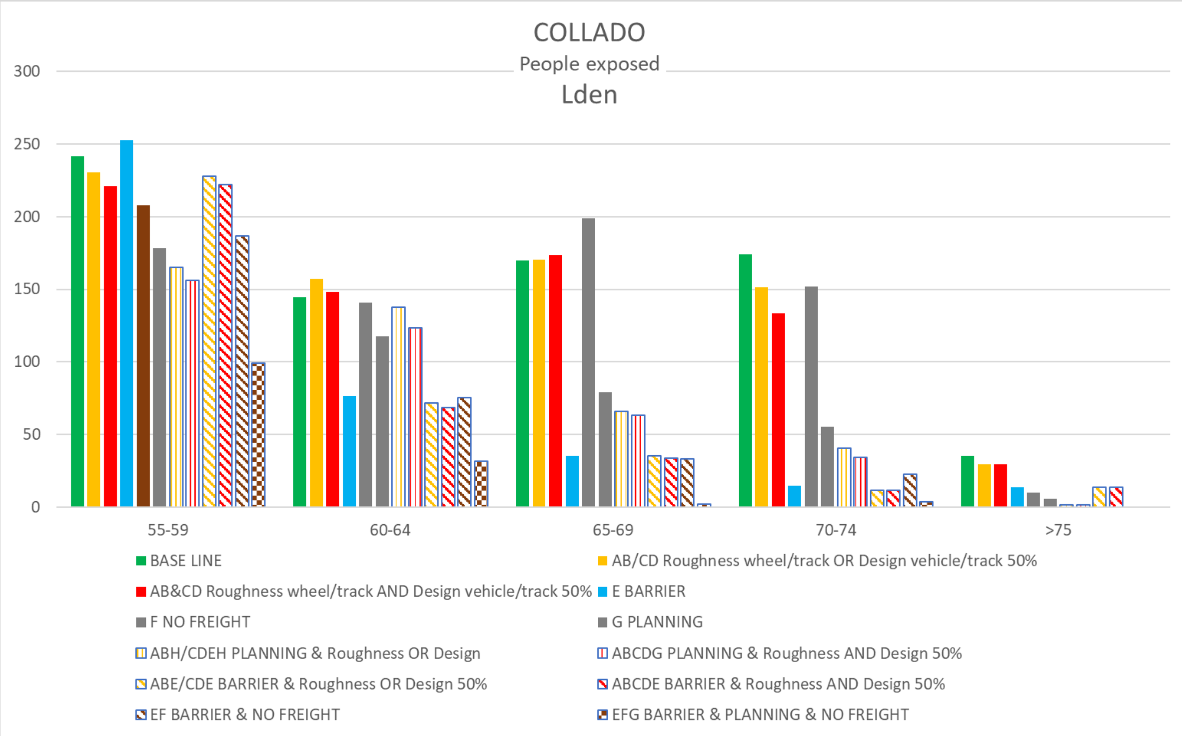
<table>
<tr><th>Collado</th><th colspan="2">Variations calculated:</th><th>Comments</th></tr>
<tr><td rowspan="4">Single Solutions</td><td colspan="2">AB/CD Either Roughness wheel and track or Design vehicle and track</td><td>Reduce emission in 3dB in 50% of the line.
See figure.</td></tr>
<tr><td colspan="2">E Noise barrier:</td><td>Theoretical solution (4m).
See figure.</td></tr>
<tr><td colspan="2">F Traffic management:</td><td>Remove freight trains</td></tr>
<tr><td colspan="2">G Urban Planning</td><td>Change the typology of buildings close to the line.
See figure.</td></tr>
<tr><td rowspan="7">Combined scenarios:</td><td colspan="2">AB&CD Both Roughness wheel and track and Design vehicle and track</td><td>Reduce emission in 6dB in 50% of the line.
See figure.</td></tr>
<tr><td rowspan="3">E Noise barrier + Noise solutions at the source:</td><td colspan="2">ABE or CDE Roughness OR Design</td></tr>
<tr><td colspan="2">ABCDE Roughness AND Design</td></tr>
<tr><td colspan="2">FG Traffic management</td></tr>
<tr><td rowspan="2">G Urban Planning + Noise solutions at the source:</td><td colspan="2">ABG or CDG Roughness OR Design</td></tr>
<tr><td colspan="2">ABCDG Roughness AND Design</td></tr>
<tr><td colspan="3">EGF Noise barrier + Urban Planning + Traffic restriction</td></tr>
</table>

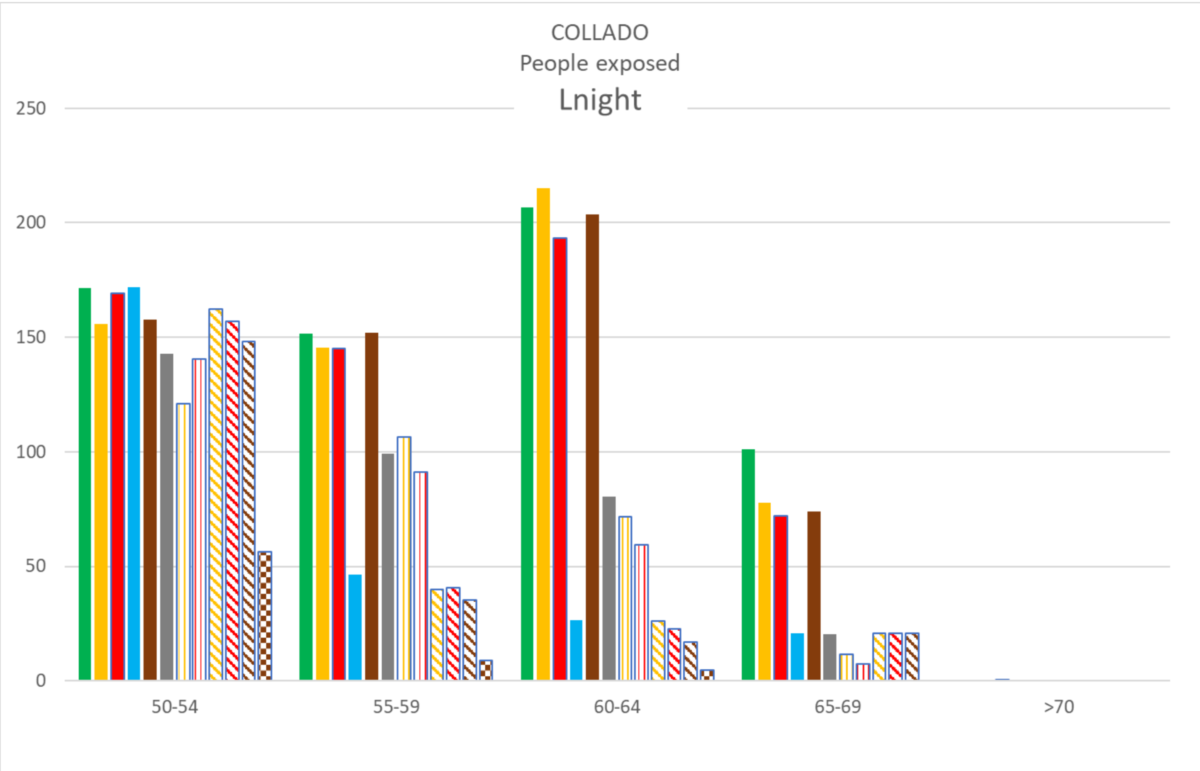
<table>
<tr><td>Noise Barrier:

74 % of the total length
Line in blue</td><td></td></tr>
</table>

Line emission reduction 50% 44 % of total population is allocated in the area where the emission is reduced	
Urban Planning: Change Typology of Buildings close to the road: from residential to non residential. Total population of the area does not decrease.	

Change in population exposure:

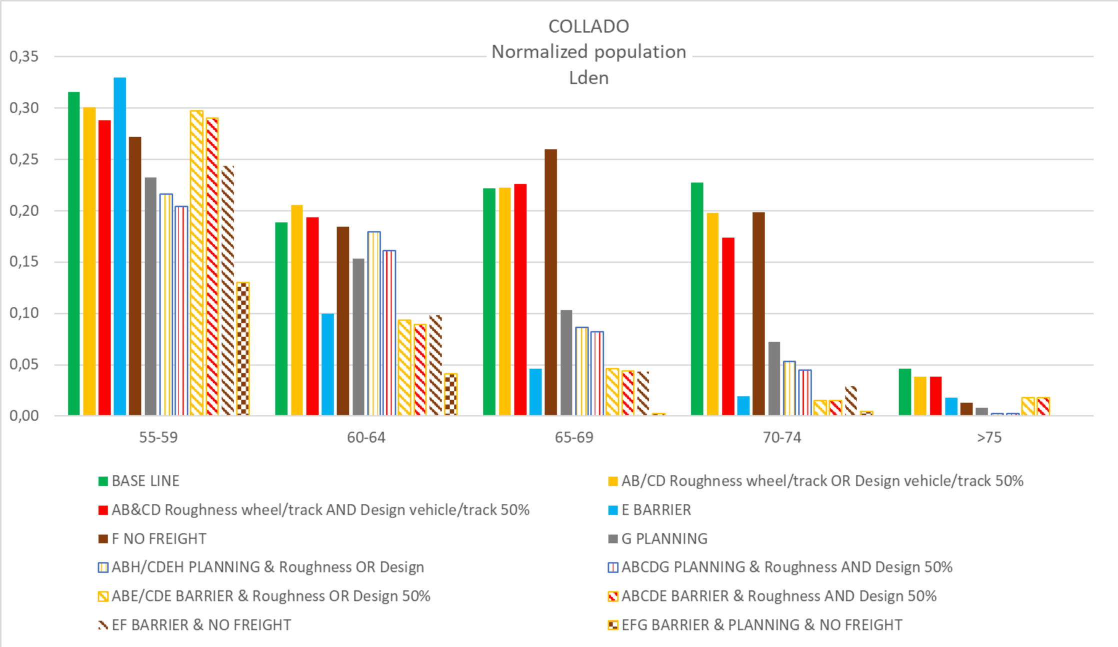


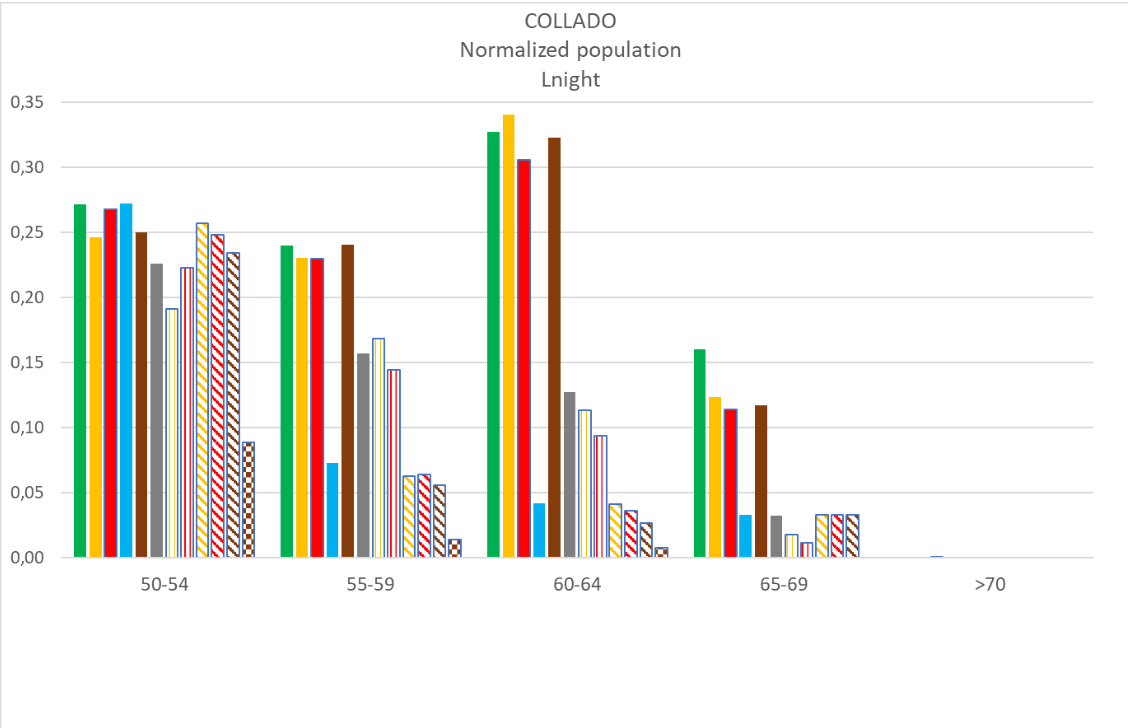


Lden	B	Single Solutions					Combined Solutions					
							Planning &		Barrier &			
	B	AB/ CD	ABCD	E	F	G	ABH/ CDG	ABCDG	ABF/ CDE	ABCDE	EF	EGF
	Base	Roughness Or Design	Roughness And Design	Barrier	No Freight	Planning	Roughness Or Design	Roughness And Design	Roughness Or Design	Roughness And Design	No Freight	Planning & No Freight
55-59	242	231	221	253	208	178	165	156	228	222	187	99
60-64	145	157	148	76	141	118	137	123	72	68	76	32
65-69	170	170	173	35	199	79	66	63	35	34	33	2
70-74	174	152	133	15	152	55	41	34	12	12	22	4
> 75	36	30	30	14	10	6	2	2	14	14	0	0

Lnight	B	Single Solutions					Combined Solutions					
							Planning &		Barrier &			
	B	AB/ CD	ABCD	E	F	G	ABH/ CDG	ABCDG	ABF/ CDE	ABCDE	EF	EGF
	Base	Roughness Or Design	Roughness And Design	Barrier	No Freight	Planning	Roughness Or Design	Roughness And Design	Roughness Or Design	Roughness And Design	No Freight	Planning & No Freight
55-59	172	156	169	172	158	143	121	141	162	157	148	56
60-64	152	145	145	46	152	99	107	91	40	41	35	9
65-69	207	215	193	26	204	80	71	59	26	23	17	5
70-74	101	78	72	21	74	21	11	7	21	21	21	0
> 75	0	0	0	0	0	0	0	0	0	0	0	0

Normalized population exposure:





Conclusions of Test Site

The highest reduction is achieved when applying the Noise Barrier or the Urban Planning solutions (E or G). Although, considering the heights of the buildings in this area, the real effect of the barrier on people exposure would be lower.

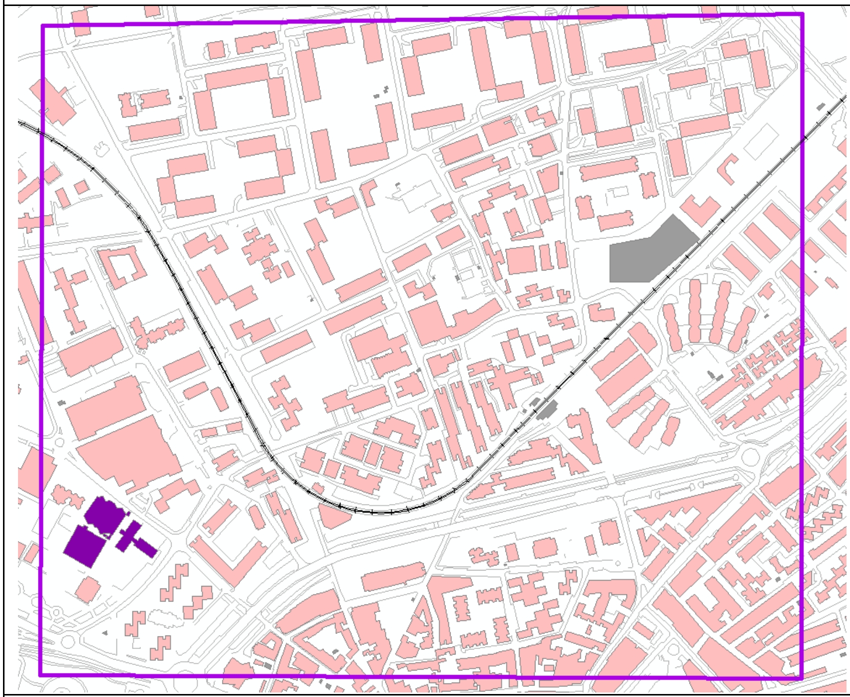
There are few freight trains in this line, so the solution in traffic management (F), restricting their traffic has low effect in this Test Site.

In this Test Site the effect of the measures at the source (ABCD) is less than expected. They only reduce the exposure at ranges 70-74 for Lden and 65-69 for Lnight. This is due to the specific conditions the area where those measures have been applied. In this area the sound propagation is attenuated in the baseline due to the presence of an embankment that implies that railway noise only affects the first line of buildings. Therefore, in the baseline there is less noise exposure where the measures were adopted than in the rest of the Test Site.

Moreover, the comparison of the effectiveness of the theoretical Noise Barrier considered (E) and the measures at the source (ABCD) is somehow unbalanced, since the barrier protects higher portion of the line than the application of the measures at the source.

B5.3. Line Mostoles El Soto-Humanes de Madrid in Mostoles

Baseline



Legend
Noise Barrier
Railway
Contour line
Calculation Area
Building
Noise-Sensitive Building
Non-Residential
Residential

Strategic Noise Map (Lden) of actual situation. Baseline.

- < 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- > 75

City / location / major railway	Mostoles (207.095 inhab) affected by railway line: Mostoles El Soto-Humanes de Madrid
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

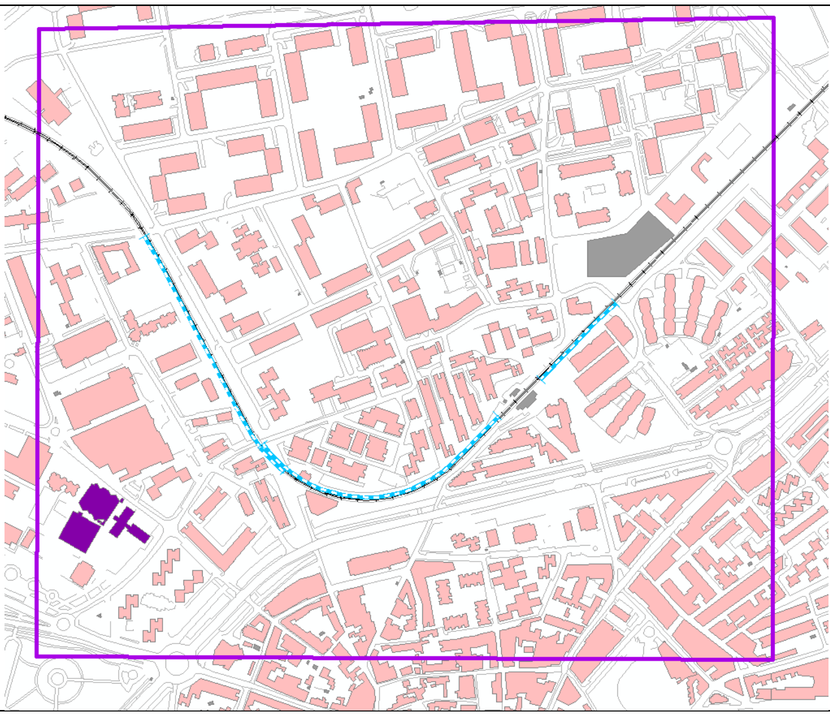
The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of a city affected by the railway line.

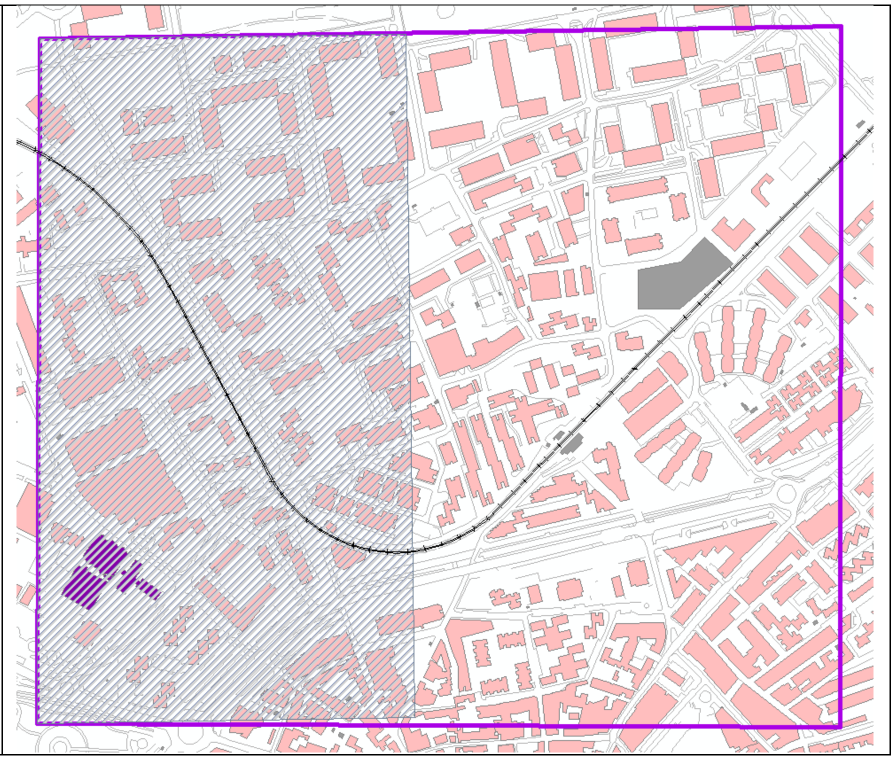
Most of the affected buildings are residential, above 20m high.

Variations

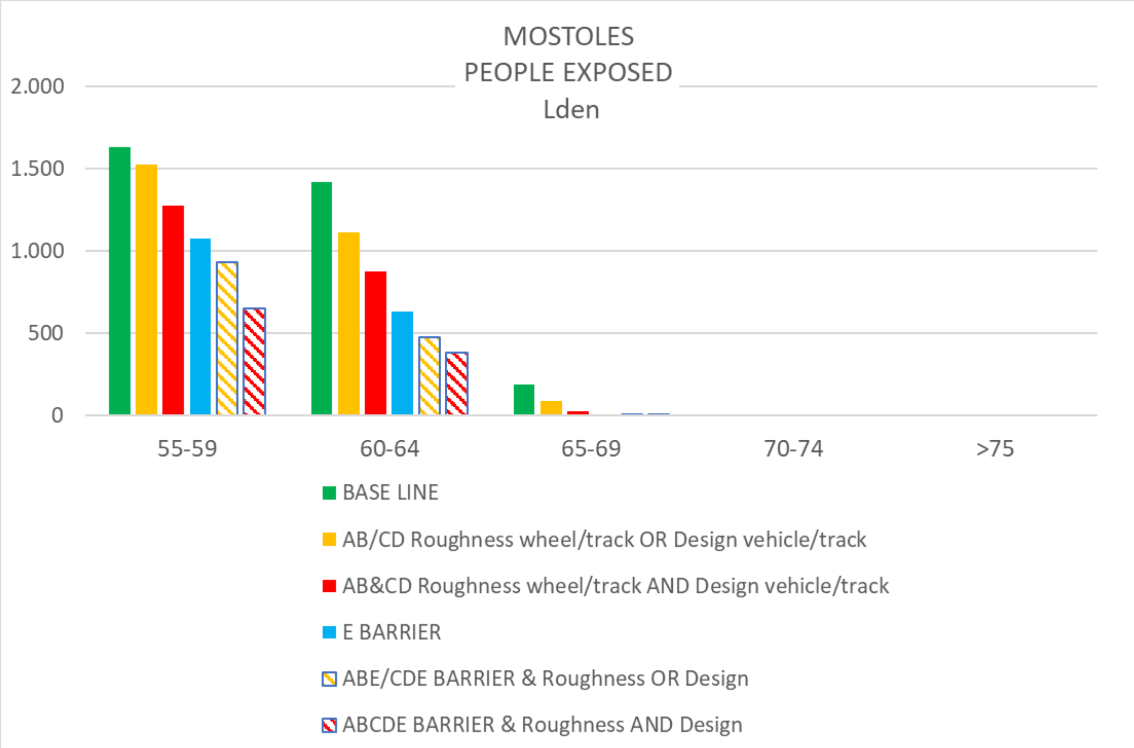
<table>
<tr><th>Mostoles</th><th colspan="2">Variations calculated:</th><th>Comments</th></tr>
<tr><td rowspan="4">Single Solutions</td><td colspan="2">AB/CD Either Roughness wheel and track or Design vehicle and track</td><td>Reduce emission in 3dB in 50% of the line.
See figure.</td></tr>
<tr><td colspan="2">E Noise barrier:</td><td>Theoretical solution (5m).
See figure.</td></tr>
<tr><td colspan="2">F Traffic management:</td><td></td></tr>
<tr><td colspan="2">G Urban Planning</td><td></td></tr>
<tr><td rowspan="3">Combined scenarios:</td><td colspan="2">AB&CD Both Roughness wheel and track and Design vehicle and track</td><td>Reduce emission in 6dB in 50% of the line.
See figure.</td></tr>
<tr><td rowspan="2">E Noise barrier + Noise solutions at the source:</td><td colspan="2">ABE or CDE Roughness OR Design</td></tr>
<tr><td colspan="2">ABCDE Roughness AND Design</td></tr>
</table>

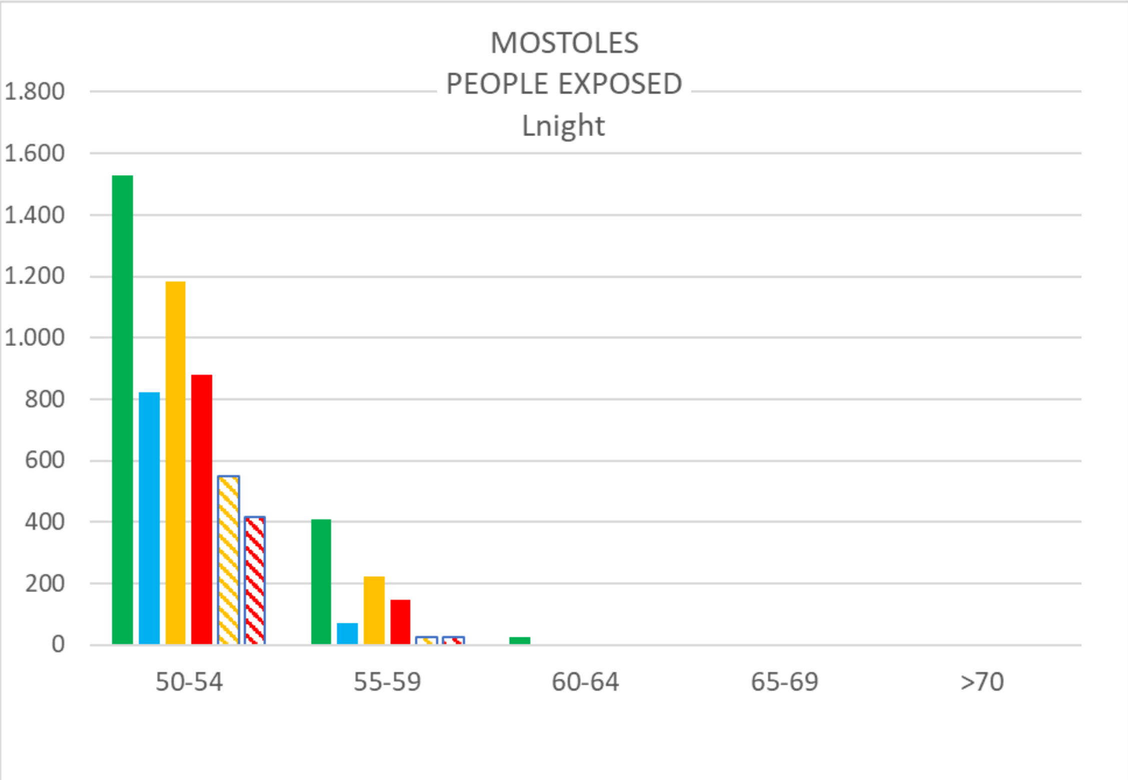
<table>
<tr><td>Noise Barrier: 5 m height Line in blue

57 % of the total length</td><td></td></tr>
</table>

Line emission reduction 50% 36 % of total population is allocated in the area where the emission is reduced	

Change in population exposure:

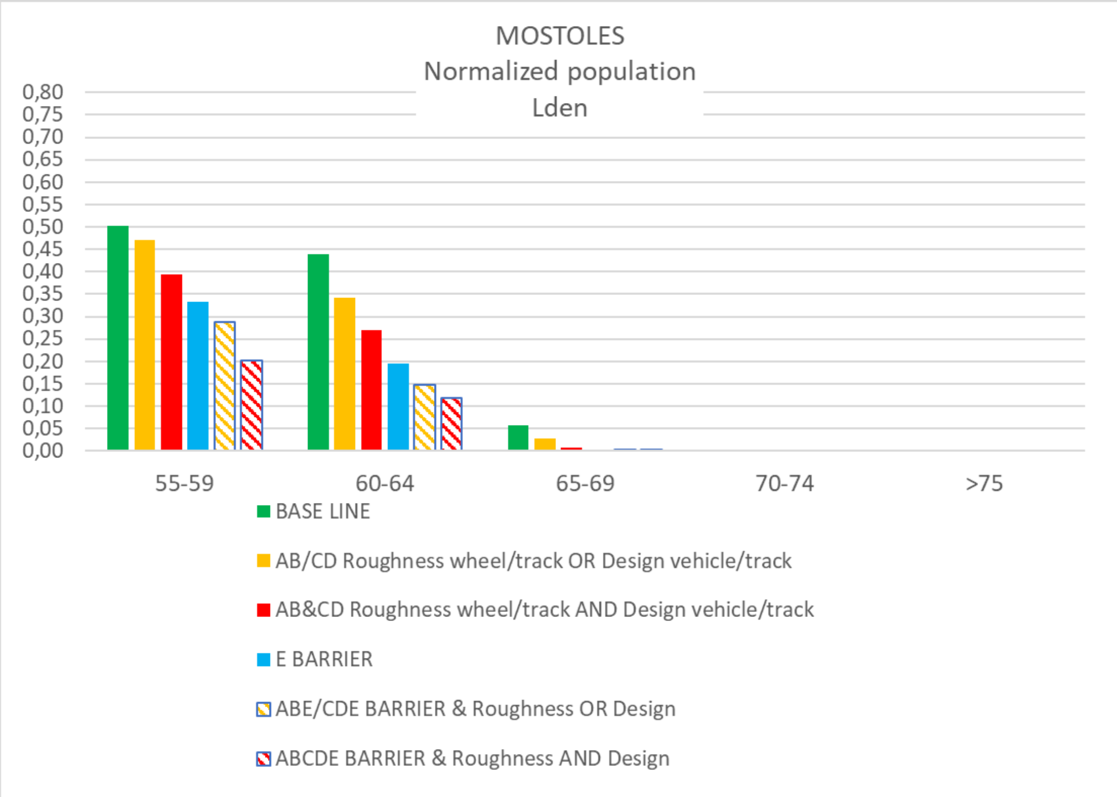


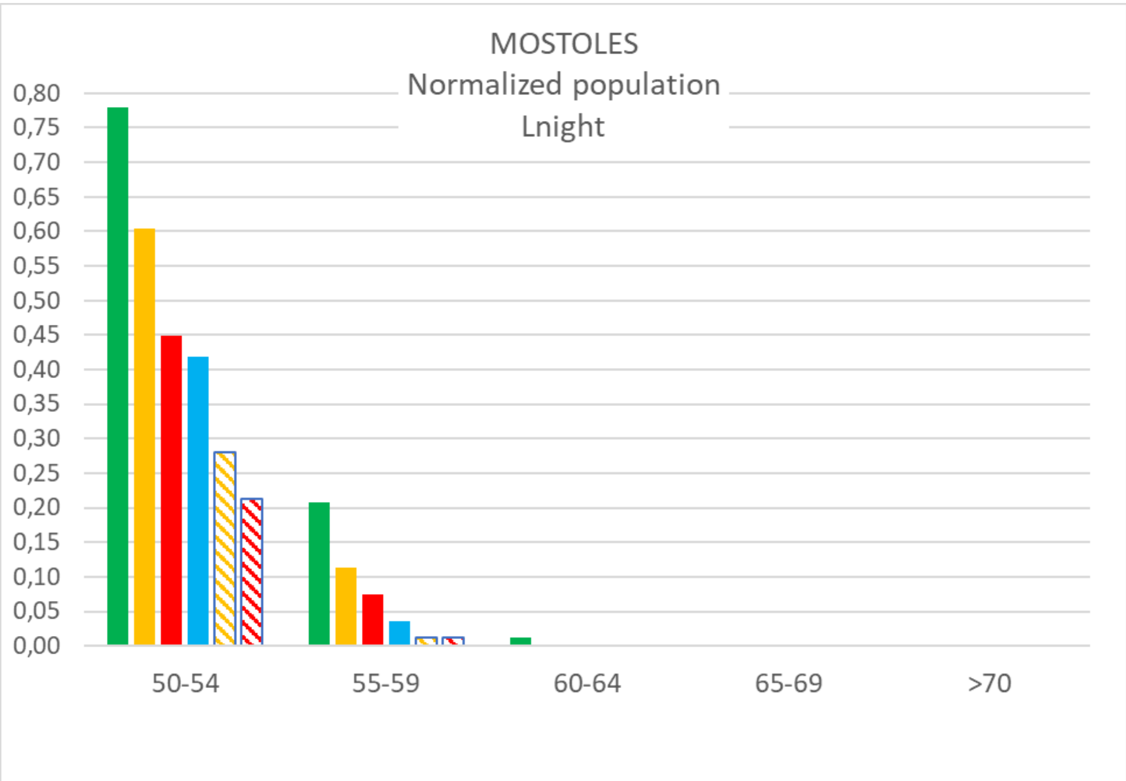


Lden	BASE	SINGLE SOLUTIONS			COMBINED SOLUTIONS Barrier &	
		AB/CD	ABCD	E	ABE/CDE	ABCDE
	BASE	Roughness OR Design	Roughness AND Design	BARRIER	Roughness OR Design	Roughness AND Design
55-59	1.628	1.524	1.272	1.075	930	651
60-64	1.421	1.110	876	631	478	380
65-69	188	92	26	9	9	9
70-74	0	0	0	0	0	0
> 75	0	0	0	0	0	0

L_{night}	BASE	SINGLE SOLUTIONS			COMBINED SOLUTIONS Barrier &	
		AB/CD	ABCD	E	ABE/CDE	ABCDE
	BASE	Roughness OR Design	Roughness AND Design	BARRIER	Roughness OR Design	Roughness AND Design
50-54	1.527	1.184	880	820	549	416
55-59	407	221	147	71	25	25
60-64	26	0	0	0	0	0
65-69	0	0	0	0	0	0
>70	0	0	0	0	0	0

Normalized population exposure:





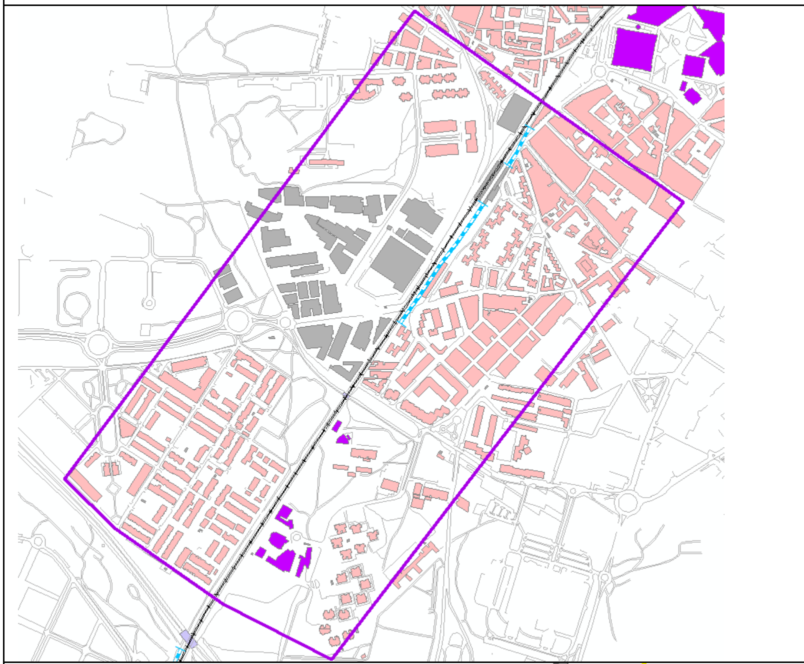
Conclusions of Test Site

The highest exposure reduction is related to the Noise Barrier (E), especially at the highest exposure ranges. Notice that the real effect of the barrier on people exposure would be lower, considering the heights of the buildings in this area.

Reduction achieved by applying measures at the source (ABCD) is not too high. However, it can be considered that more than half of the population is located outside the area where these measures are applied.

B5.4. Line: Mostoles El Soto-Humanes de Madrid in Leganes

Baseline



Legend

Noise Barrier

Railway

Contour line

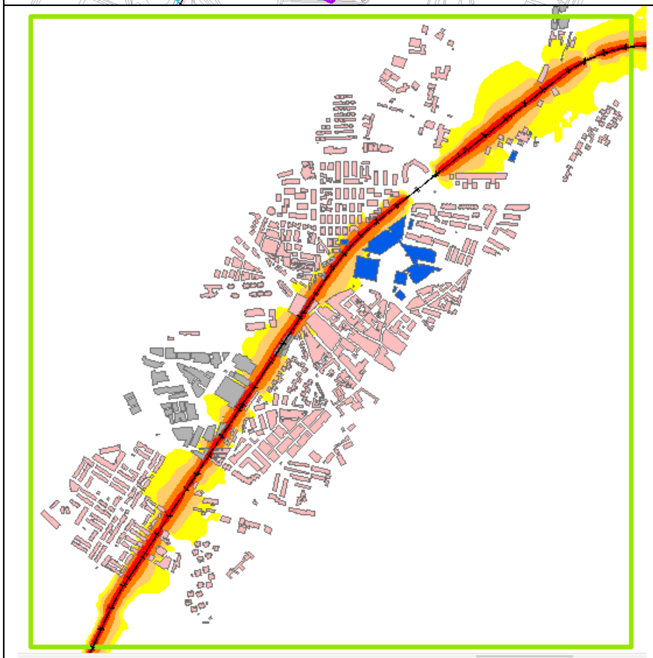
Calculation Area

Building

Noise-Sensitive Building

Non-Residential

Residential



Strategic Noise Map (Lden) of actual situation.
Baseline.

< 55

55 - 60

60 - 65

65 - 70

70 - 75

> 75

City / location / major railway	Leganes (189 861 hab) affected by railway line: Mostoles El Soto-Humanes de Madrid
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of the city affected by the railway line.

Most of the affected buildings are residential, being high block buildings.

Nowadays there is a noise barrier of 3-4 m height to reduce the effect of the railway line, and this is already considered as part of the Baseline in this Test Case.

The study of the effect of the abatement measure E Noise Barrier implies increasing the height of the existing barrier and adding a new one of 5m height.

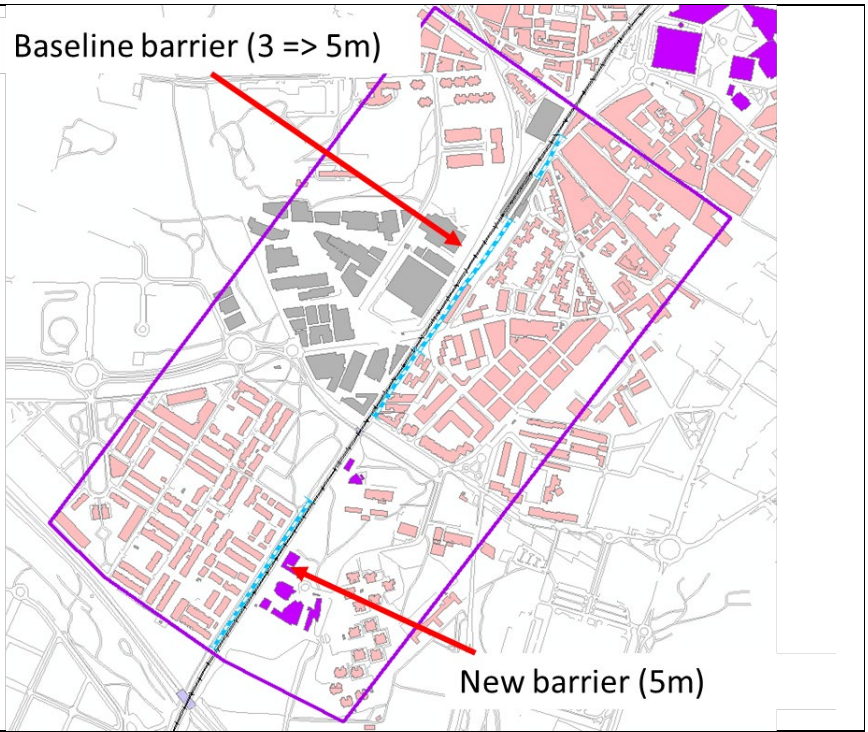
In this line there is high freight traffic: during the day period 3% of the total traffic are freight trains, evening 18% and at night 28%.

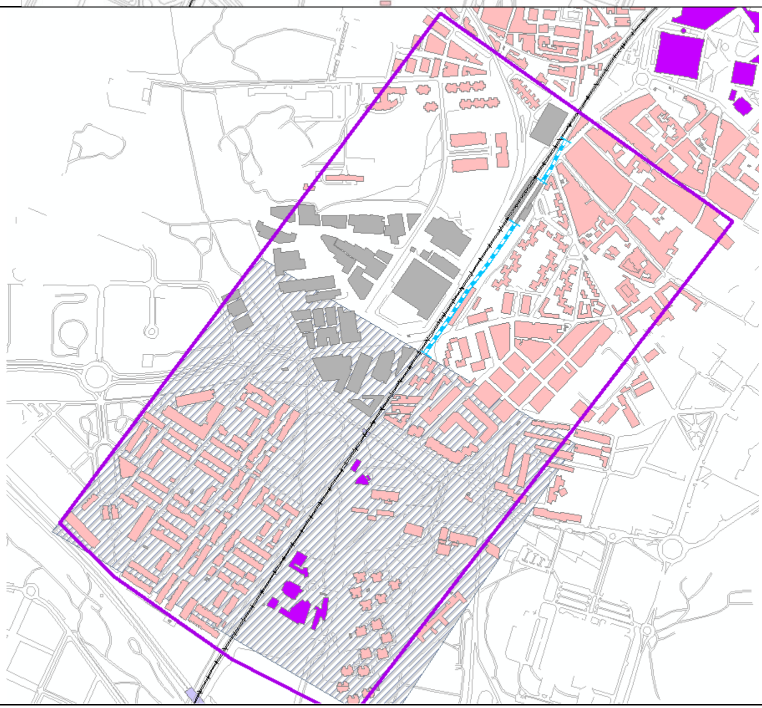
Variations

Leganes	**Variations calculated:**		**Comments**
Baseline: There is a noise barrier (3m and 4 m)			
Single Solutions	AB/CD Either Roughness wheel and track or Design vehicle and track		Reduce emission in 3dB in 50% of the line. See figure.
	E Noise barrier:		Add a new noise barrier (5m) and increase the height of exiting barrier to 5m. See figure.
	F Traffic management:		Remove freight trains
	G Urban Planning		Change the typology of buildings close to the RAIL. See figure.
Combined scenarios:	AB&CD Both Roughness wheel and track and Design vehicle and track		Reduce emission in 6dB in 50% of the line. See figure.
	E Noise barrier + Noise solutions at the source:	ABE or CDE Roughness OR Design	
		ABCDE Roughness AND Design	
		EF Traffic management	
	G Urban Planning + Noise solutions at the source:	ABG or CDG Roughness OR Design	
		ABCDG Roughness AND Design	
	EGF Noise barrier + Urban Planning + Traffic restriction		

<table>
<tr><td>Noise Barrier: Additional noise barrier and height of existing barrier increased to 5 m.

Baseline: 25 % of the total length of the line

Abatement measure: 55 % of the total length</td><td>
</td></tr>
<tr><td>Line emission reduction 50%

39 % of total population is allocated in the area where the emission is reduced</td><td></td></tr>
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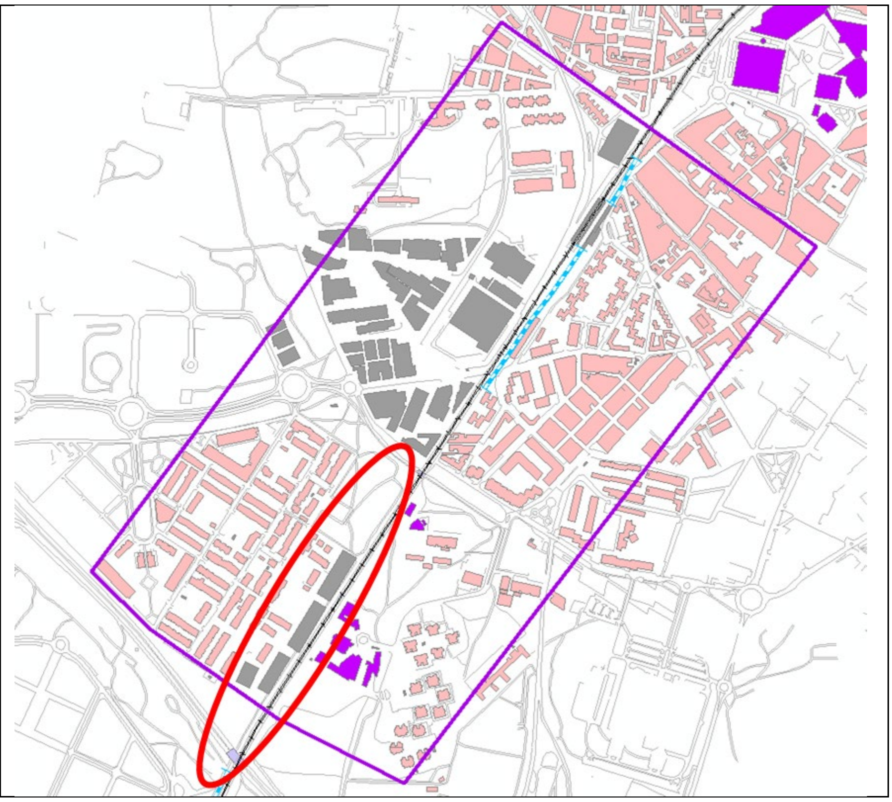
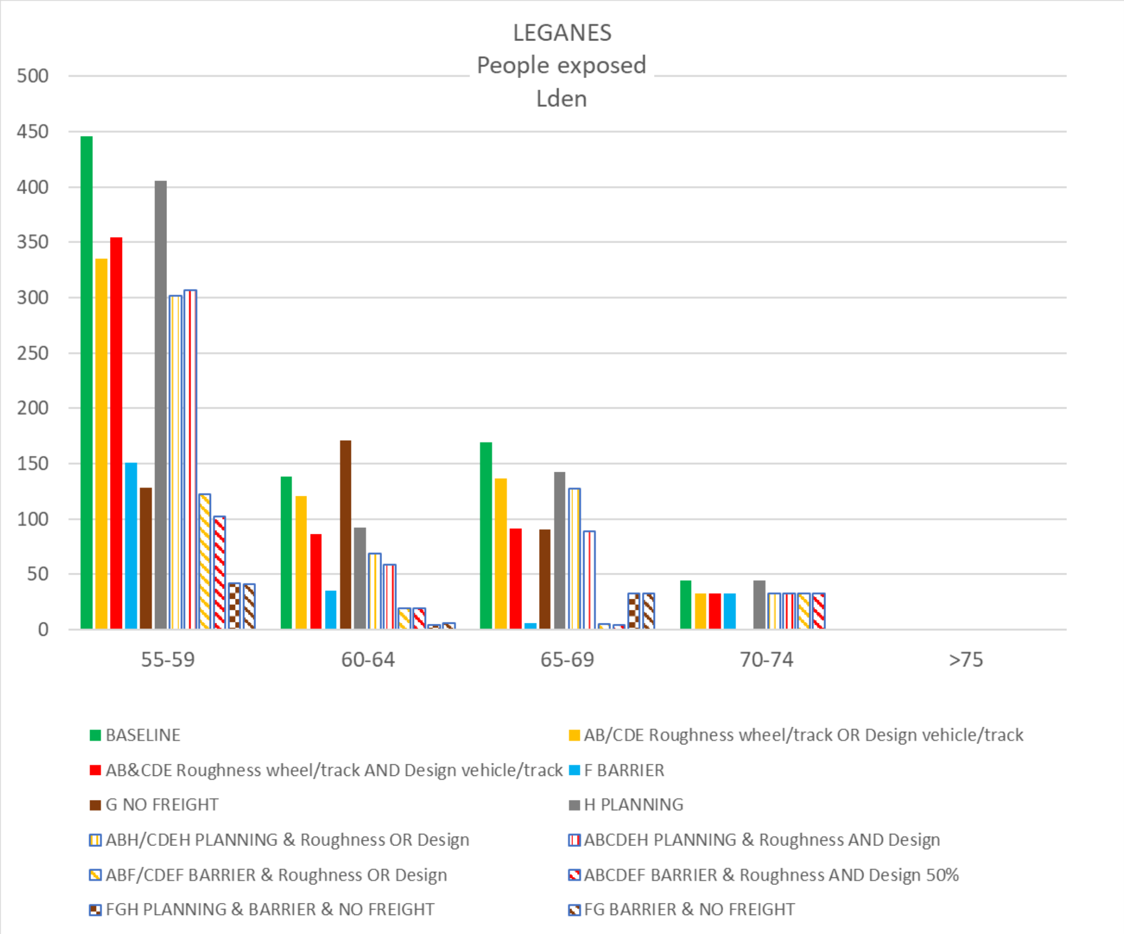
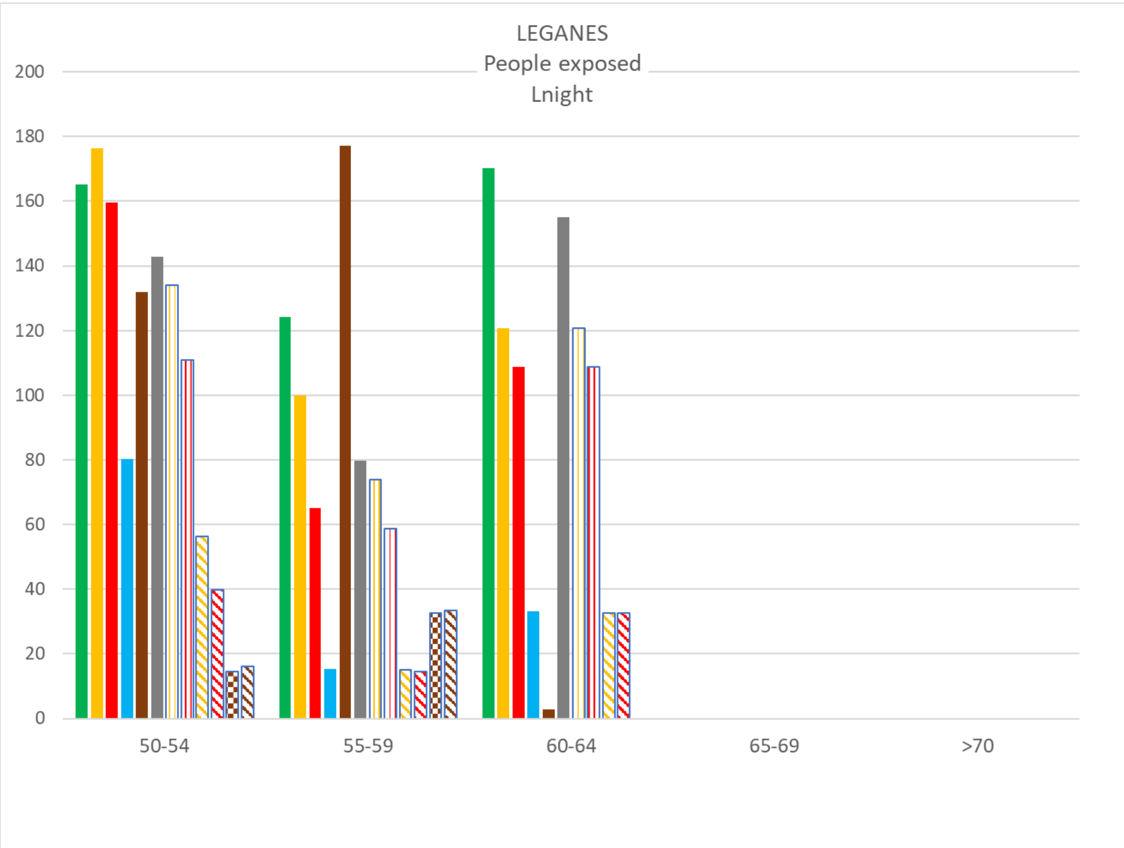
Urban Planning: Change Typology of Buildings close to the road: from residential to non residential. Total population of the area does not change.	

Change in population exposure:

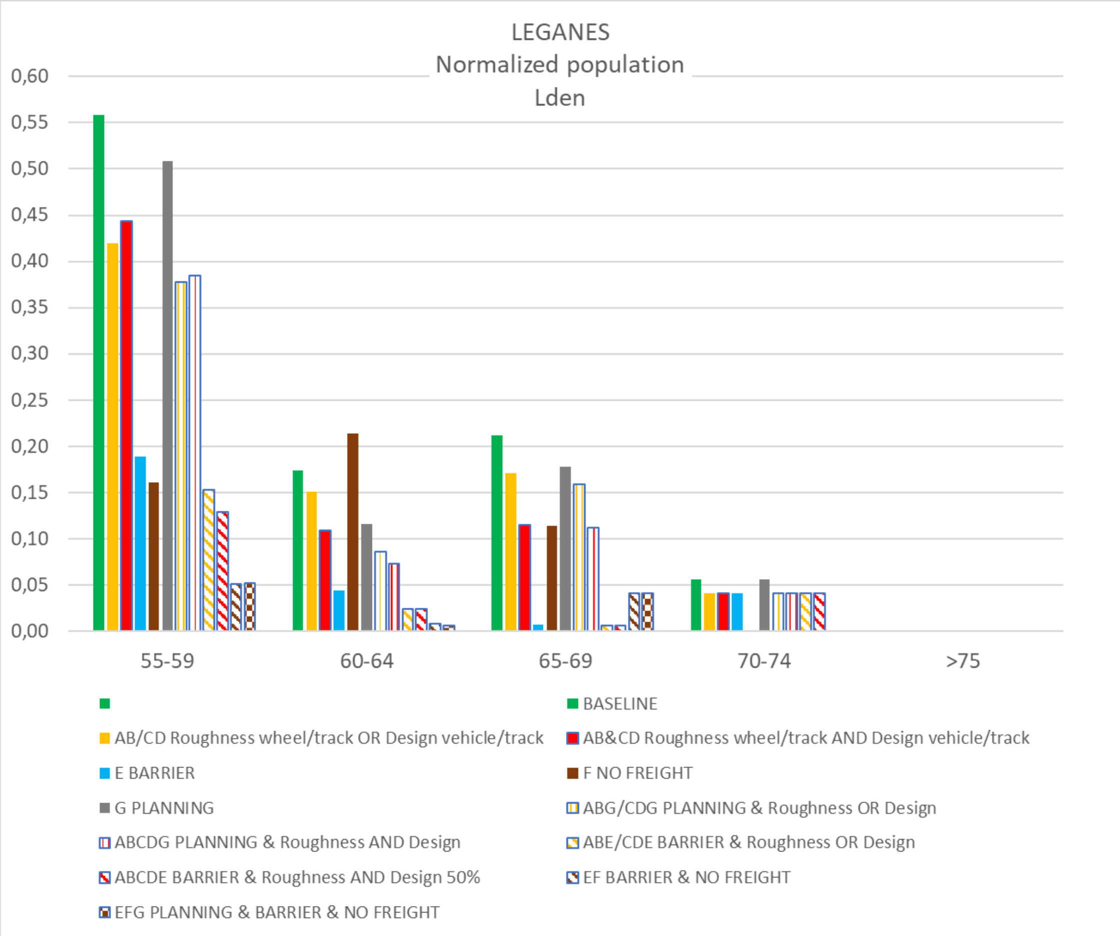


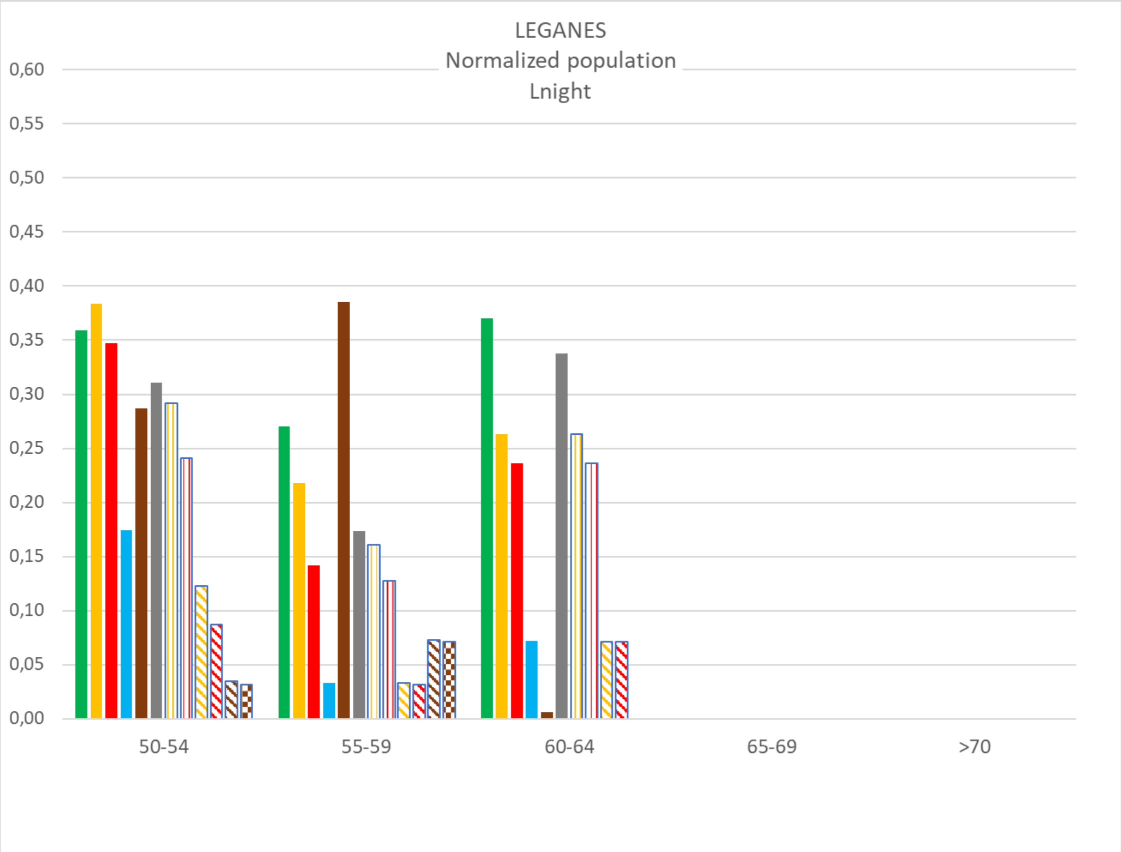


Lden		Single Solutions					Combined Solutions					
							Planning &		Barrier &			
	B	AB/ CD	AB& CD	E	F	G	ABG/ CDG	ABCDG	ABE/ CDE	ABCDE	EF	EGF
	Base	Roughness Or Design	Roughness And Design	Barrier	No Freight	Planning	Roughness Or Design	Roughness And Design	Roughness Or Design	Roughness And Design	No Freight	Planning & No Freight
55-59	446	335	354	151	128	406	302	307	122	103	41	42
60-64	139	121	87	35	171	92	68	59	20	19	6	5
65-69	169	136	91	6	91	142	127	89	5	5	33	33
70-74	45	33	33	33	0	45	33	33	33	33	0	0
> 75	0	0	0	0	0	0	0	0	0	0	0	0

Lnight		Single Solutions					Combined Solutions					
							Planning &		Barrier &			
	B	AB/ CD	AB& CD	E	F	G	ABG/ CDG	ABCDG	ABE/ CDE	ABCDE	EF	EGF
	Base	Roughness Or Design	Roughness And Design	Barrier	No Freight	Planning	Roughness Or Design	Roughness And Design	Roughness Or Design	Roughness And Design	No Freight	Planning & No Freight
50-54	165	176	159	80	132	143	134	111	56	40	16	15
55-59	124	100	65	15	177	80	74	59	15	14	33	33
60-64	170	121	109	33	3	155	121	109	33	33	0	0
65-69	0	0	0	0	0	0	0	0	0	0	0	0
>70	0	0	0	0	0	0	0	0	0	0	0	0

Normalized population exposure:





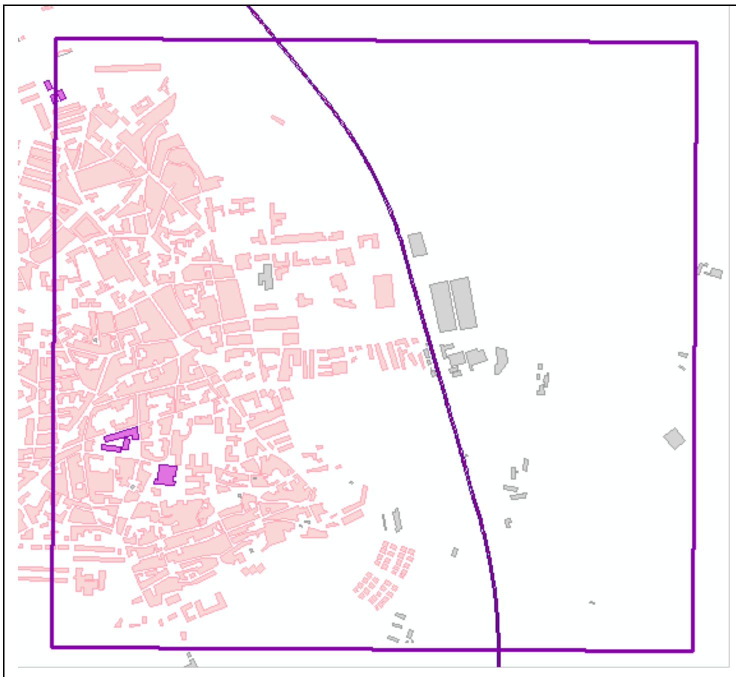
Conclusions of Test Site

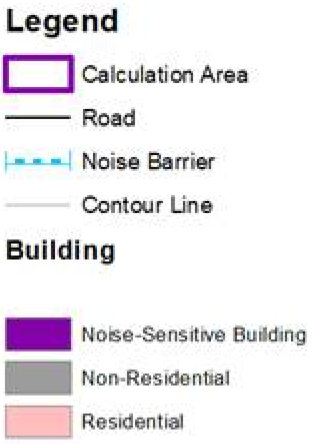
Traffic management that eliminates freight trains (F) is the measure with highest reduction in people exposed at the highest ranges.

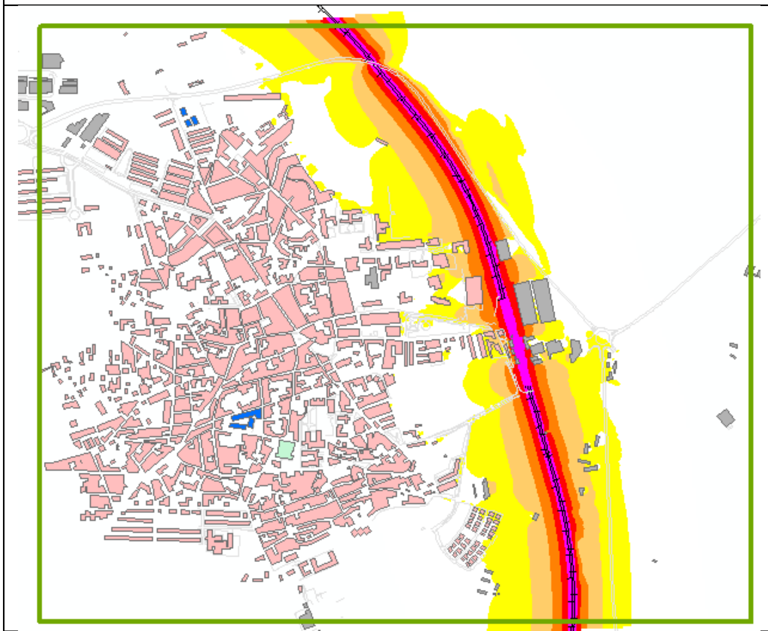
Nevertheless, the highest general reduction is provided by the noise barrier. Notice that the real effect of the barrier on people exposure would be lower, considering the heights of the buildings in this area.

Reduction achieved by applying measures at the source (ABCD) is not too high. However, it can be considered that only 39 % of the population is located in the area where these measures are applied.

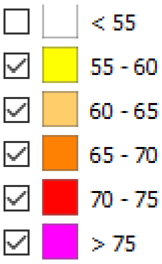
B5. Line: Madrid Atocha Cercanias-Aranjuez in Ciempozuelo







Strategic Noise Map (Lden) of actual situation. Baseline.



City / location / major railway	Ciempozuelo (24.592 hab) affected by railway line: Madrid Atocha Cercanias-Aranjuez
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

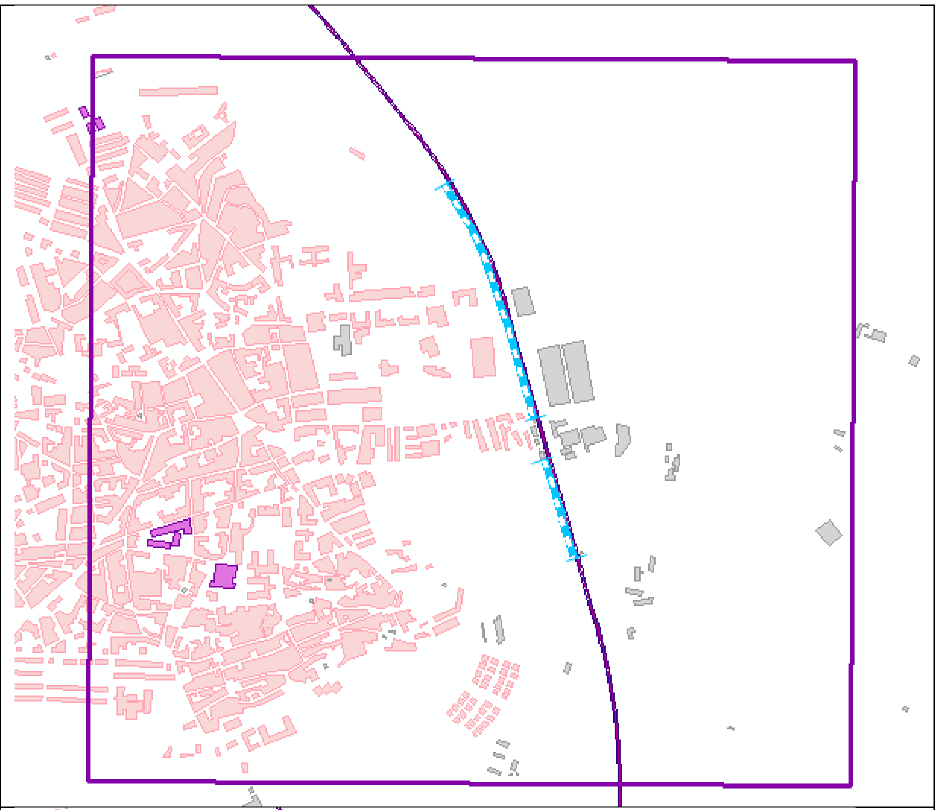
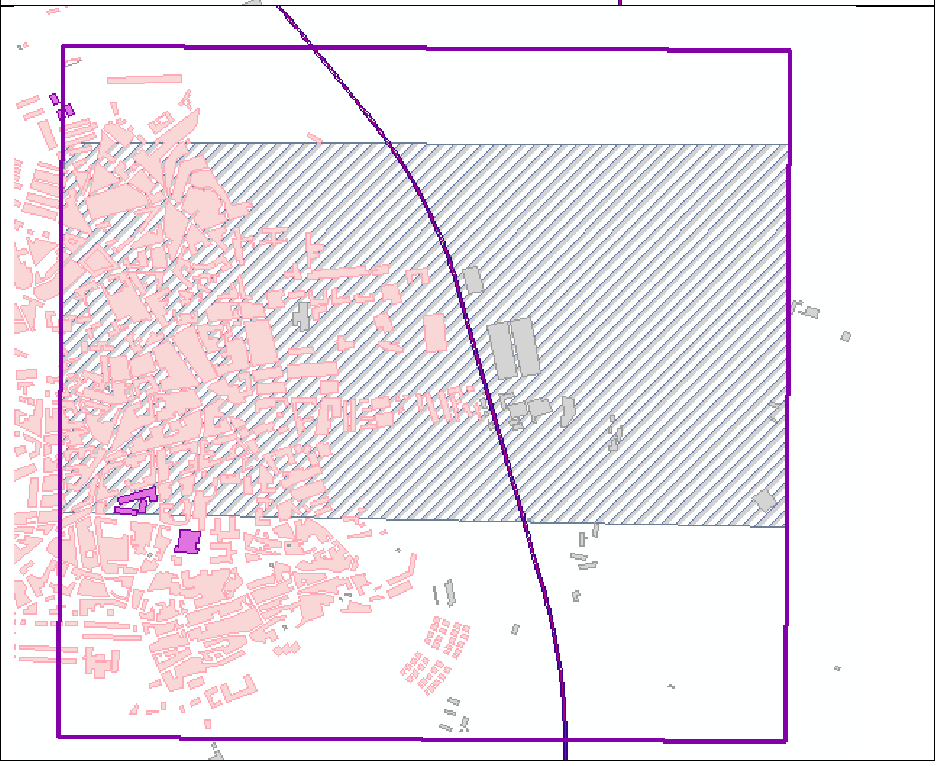
Context

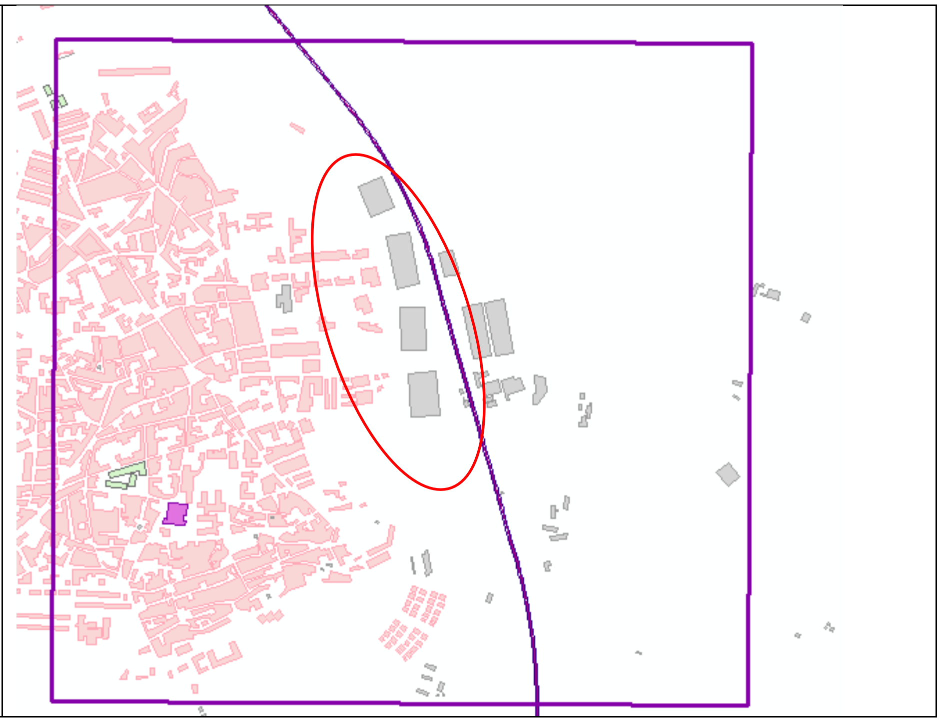
The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of a city affected by the railway line.

Most of the affected buildings are residential, 8m high.

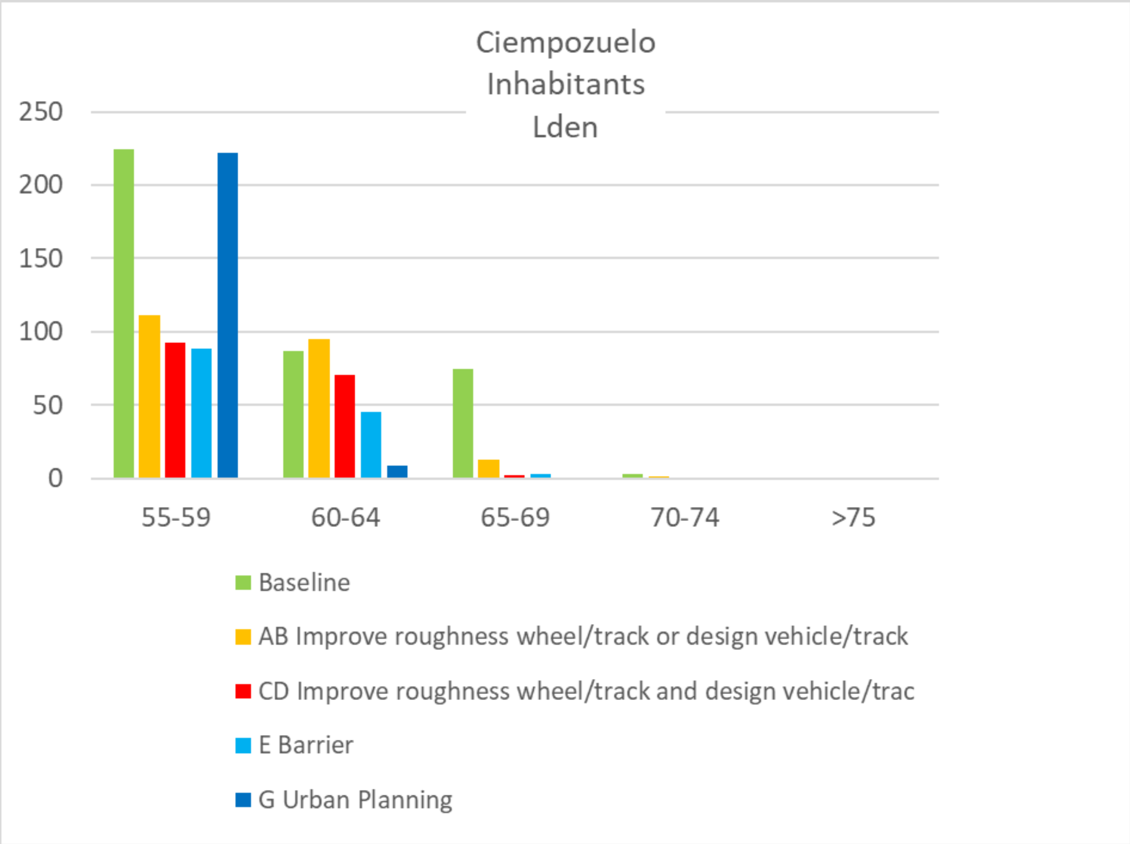
Variations

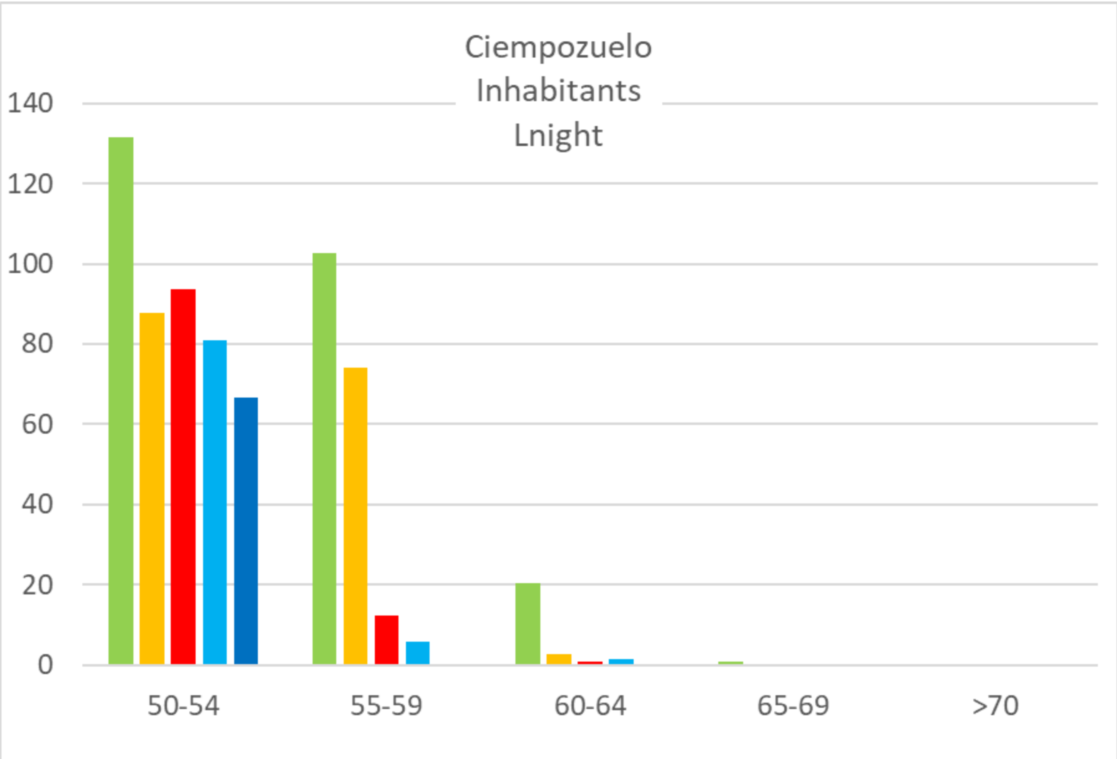
<table>
<tr><th>Ciempozuelo</th><th colspan="2">Variations calculated:</th><th>Comments</th></tr>
<tr><td rowspan="4">Single Solutions</td><td colspan="2">AB/CD Either Roughness wheel and track or Design vehicle and track</td><td>Reduce emission in 3dB in 50% of the line.
See figure.</td></tr>
<tr><td colspan="2">E Noise barrier:</td><td>Add a new noise barrier (5m)
See figure.</td></tr>
<tr><td colspan="2">F Traffic management:</td><td></td></tr>
<tr><td colspan="2">G Urban Planning</td><td>Change the typology of buildings close to the line.
See figure.</td></tr>
<tr><td rowspan="6">Combined scenarios:</td><td colspan="2">AB&CD Both Roughness wheel and track and Design vehicle and track</td><td>Reduce emission in 6dB in 50% of the line.
See figure.</td></tr>
<tr><td rowspan="2">E Noise barrier + Noise solutions at the source:</td><td colspan="2">ABE or CDE Roughness OR Design</td></tr>
<tr><td colspan="2">ABCDE Roughness AND Design</td></tr>
<tr><td rowspan="2">G Urban Planning + Noise solutions at the source:</td><td colspan="2">ABG or CDG Roughness OR Design</td></tr>
<tr><td colspan="2">ABCDG Roughness AND Design</td></tr>
<tr><td colspan="3">EGF Noise barrier + Urban Planning + Traffic restriction</td></tr>
</table>

Noise Barrier: Add new noise barriers of 5 m height (613 m length and 253 m length) 43 % of the total length of the line in the area	
Line emission reduction 50% 65 % of total population is allocated in the area where the emission is reduced	

Urban Planning: Change Typology of Buildings close to the road: from residential to non residential (6m height). Total population of the area does not change.	

Change in population exposure:

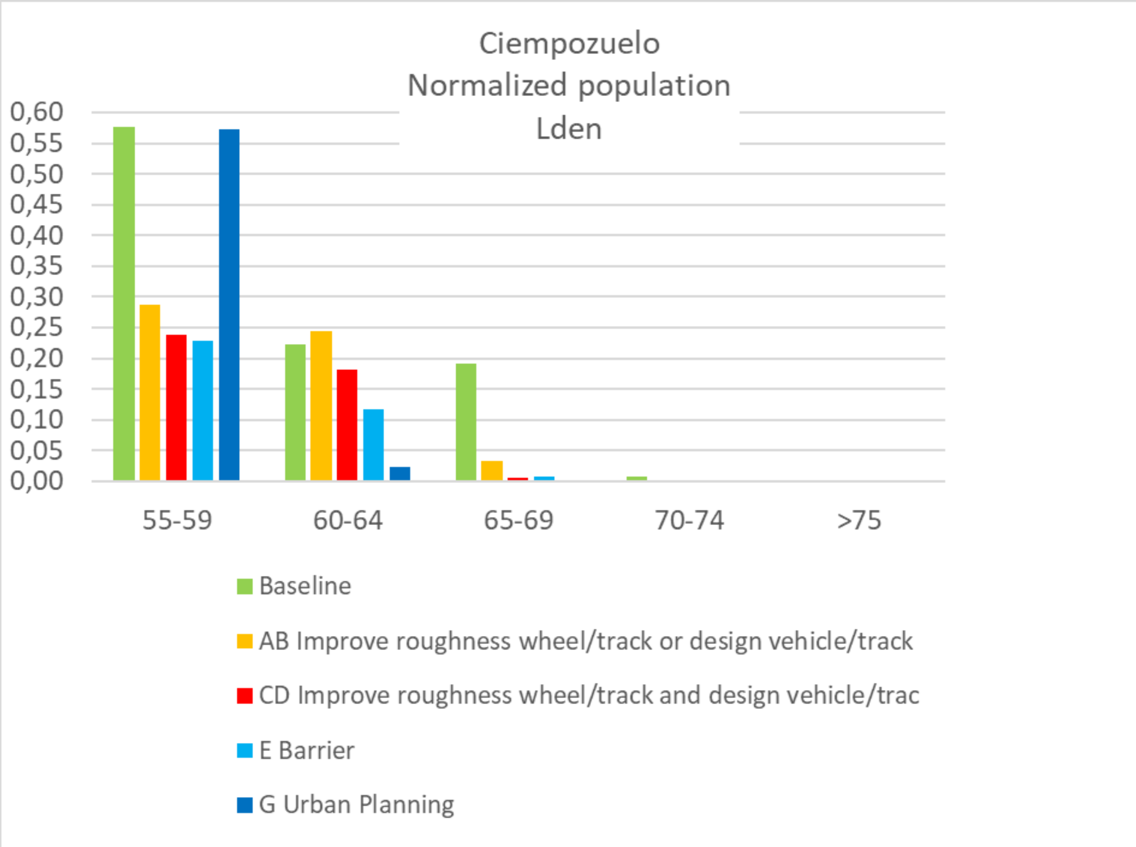


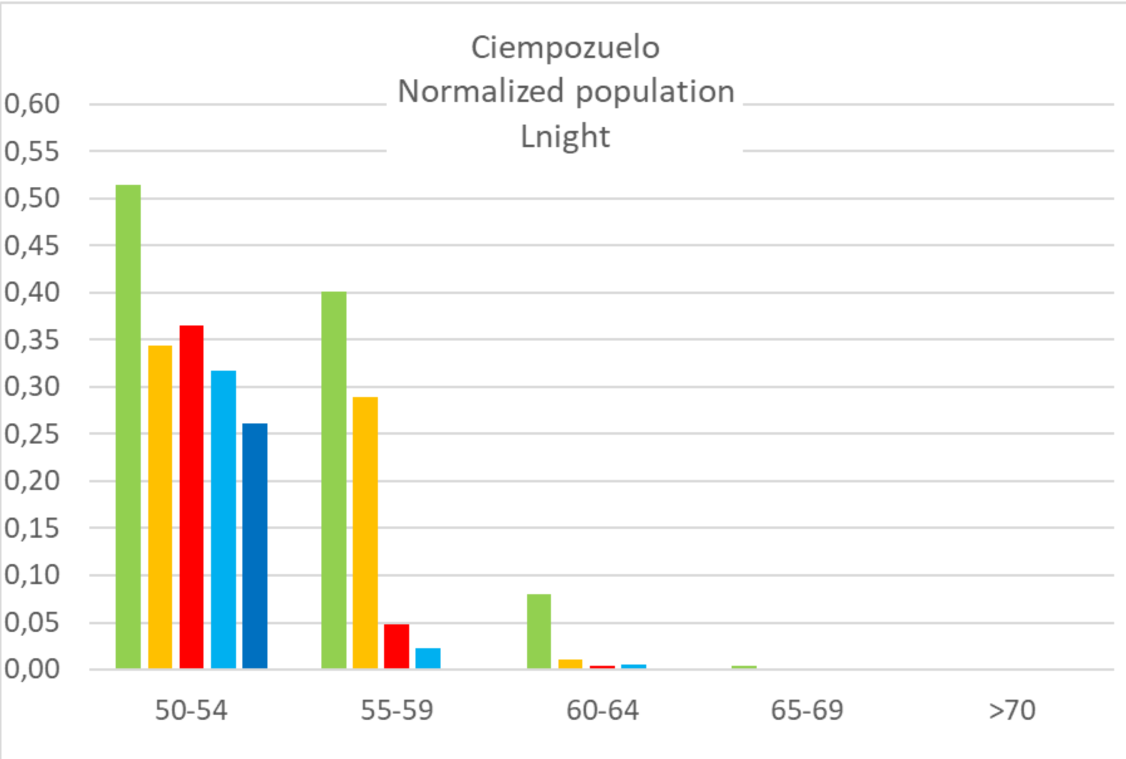


Lden	Baseline	AB Improve roughness wheel/track or design vehicle/track	CD Improve roughness wheel/track and design vehicle/trac	E Barrier	G Urban Planning
55-59	224	111	93	89	222
60-64	87	95	70	46	9
65-69	75	13	2	3	0
70-74	3	1	0	1	0
>75	0	0	0	0	0

Lnight	Baseline	AB Improve roughness wheel/track or design vehicle/track	CD Improve roughness wheel/track and design vehicle/trac	E Barrier	G Urban Planning
50-54	132	88	94	81	67
55-59	103	74	12	6	0
60-64	20	3	1	1	0
65-69	1	0	0	0	0
>70	0	0	0	0	0

Normalized population exposure:





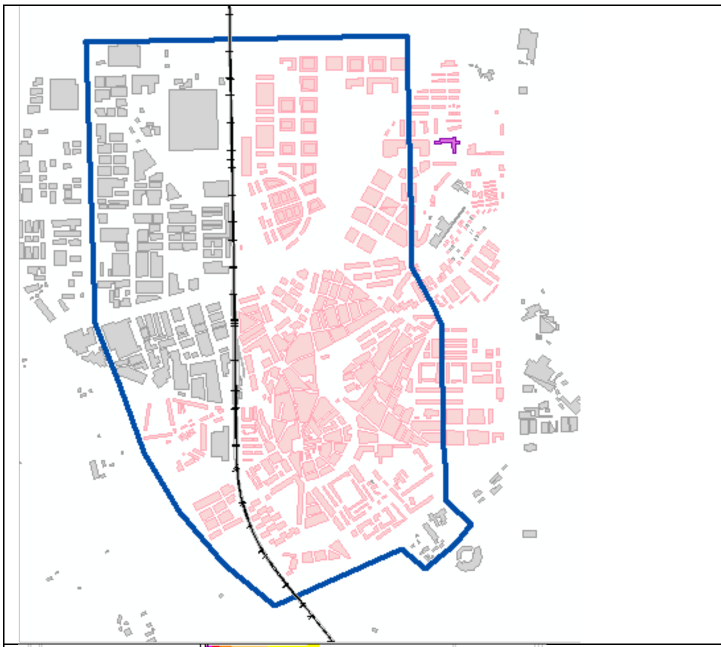
Conclusions of Test Site

The Urban planning measure (G) reduces the exposure more than the Noise barrier (E), both measures acting in the same area. However, the urban planning in this Test Case involves not only adding non-residential buildings near the railway line and protecting the dwellings behind it, but also removing some residential buildings that were highly exposed to rail noise at the baseline.

In this Test Case, considering the height of the buildings the calculation of the effect of the Noise barrier can adequately represent its real effect.

Even though it is not the most effective solution in this Test Case, compared to the rest of the Test Cases presented, the abatement measures in the emission (AB/CD) are the most effective. This is probably due to the fact that 65% of the total population is allocated in the area where emissions are reduced. Anyhow, in the Test Case all action measures are located in the same area

B5.6. Line: Madrid Atocha Cercanias-Aranjuez in Pinto

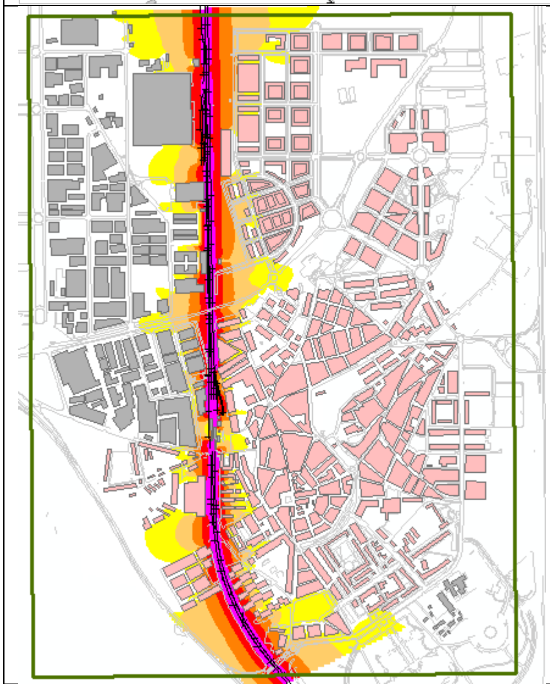


Legend

- Calculation Area
- Road
- Noise Barrier
- Contour Line

Building

- Noise-Sensitive Building
- Non-Residential
- Residential



Strategic Noise Map (Lden) of actual situation. Baseline.

- < 55
- 55 - 60
- 60 - 65
- 65 - 70
- 70 - 75
- > 75

City / location / major railway	Pinto (51.541 inhab) affected by railway line: Madrid Atocha Cercanias-Aranjuez
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of a city affected by the railway line.

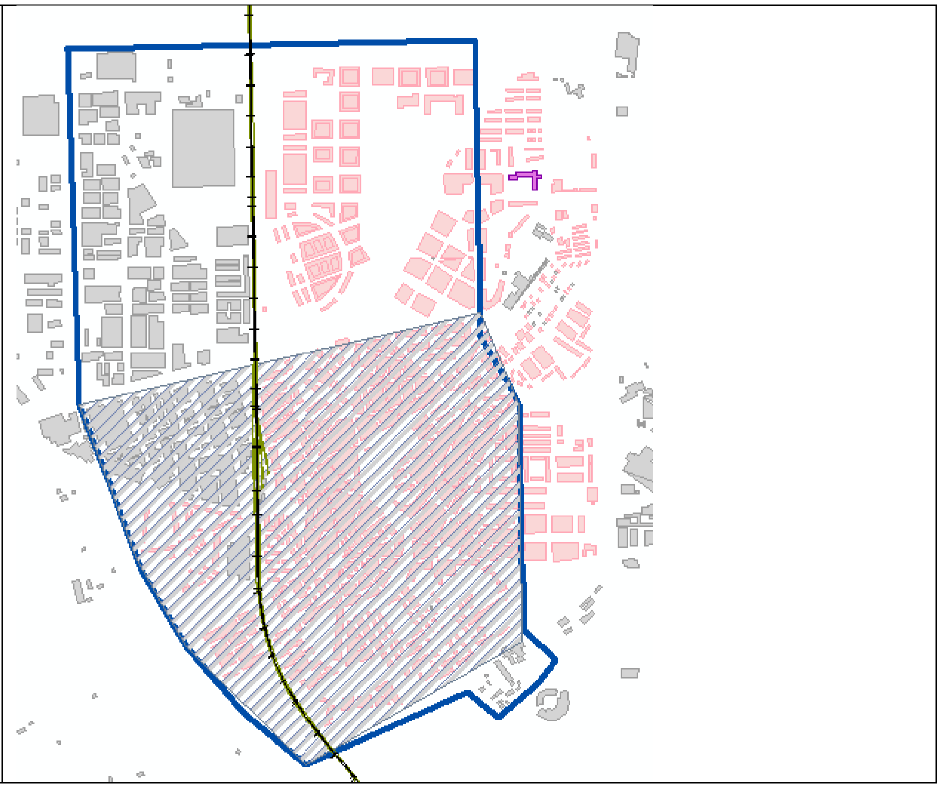
Most of the affected buildings are residential, 10 m high

There is high freight traffic in the line: during the day period 37% of the vehicles are freight trains, and at night 82%.

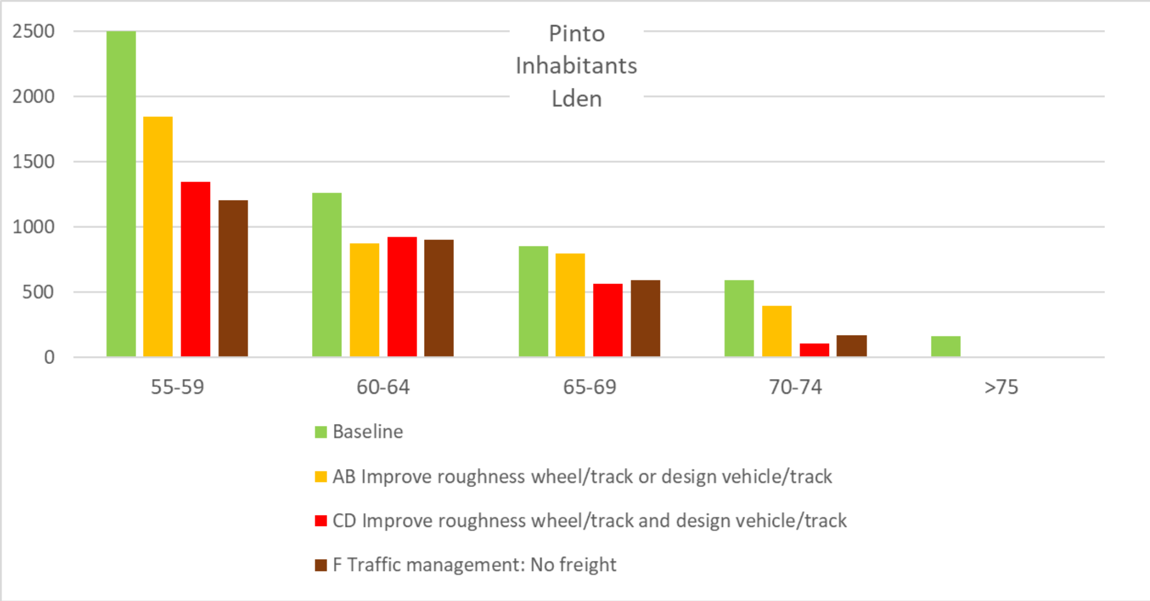
Due to the geometry of the area, abatement measures related to act on the propagation path is not effective. So, not (Noise barrier), nor G (Urban Planning) were calculated.

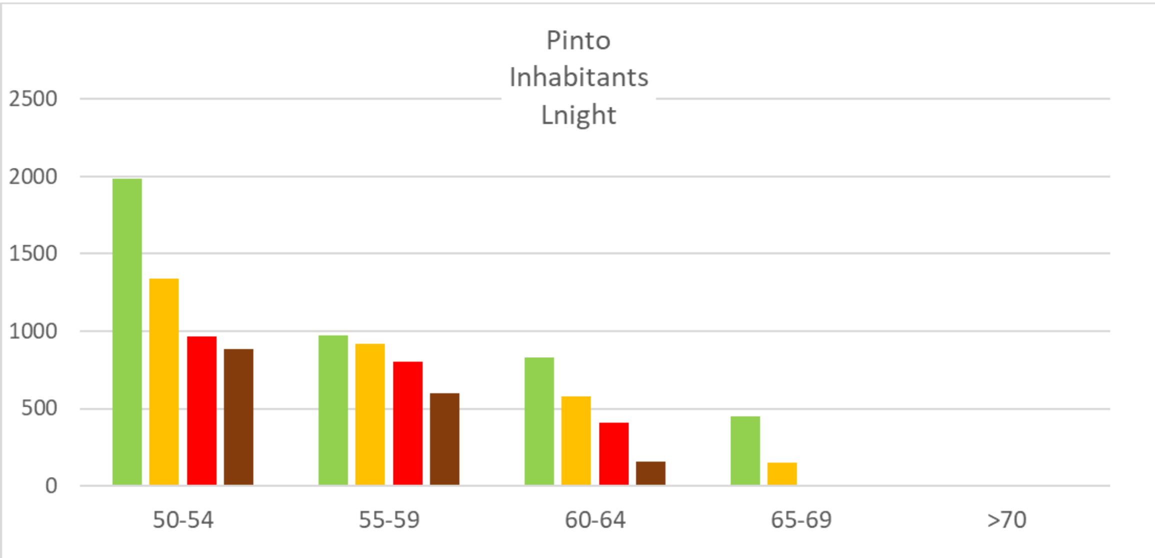
Variations

Pinto	**Variations calculated:**	**Comments**
Single Solutions	AB/CD Either Roughness wheel and track or Design vehicle and track	Reduce emission in 3dB in 50% of the line. See figure.
	E Noise Barrier:	
	F Traffic management:	Remove freight trains
	G Urban Planning	

Line emission reduction 50% 83 % of total population is allocated in the area where the emission is reduced	

Change in population exposure:

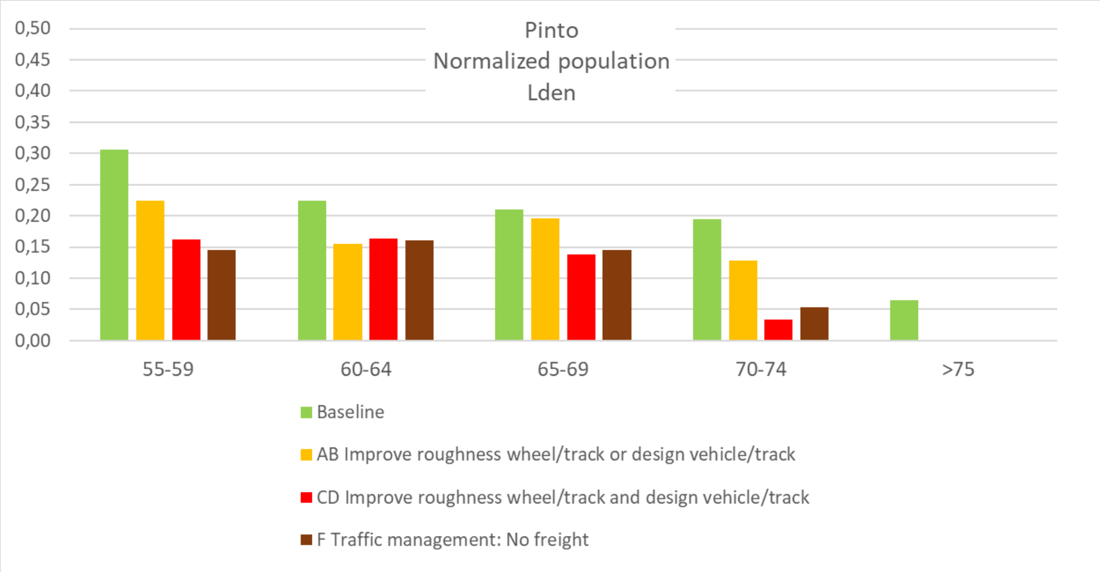


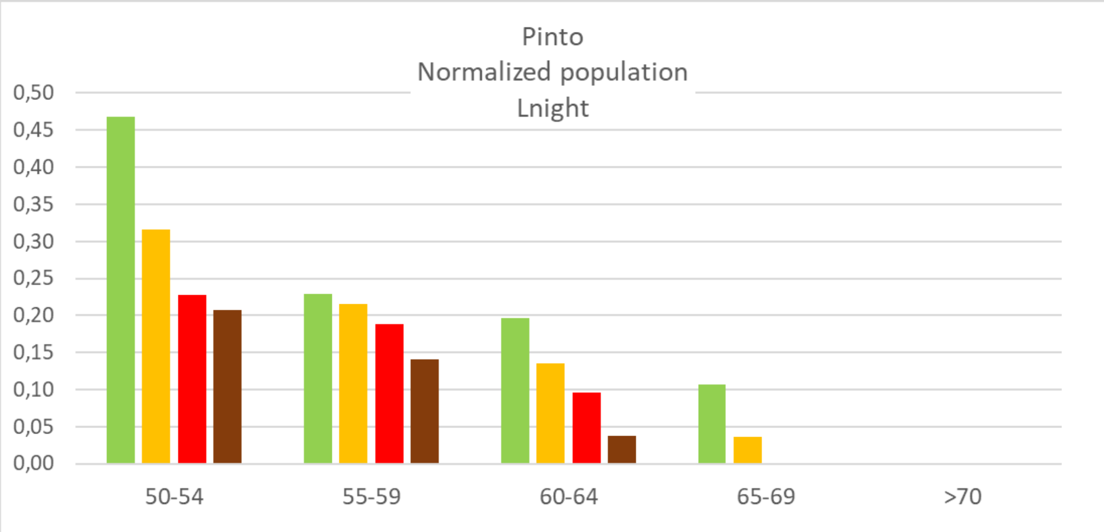


Lden	Baseline	AB Improve roughness wheel/track or design vehicle/track	CD Improve roughness wheel/track and design vehicle/track	F Traffic management: No freight
55-59	2.533	1.848	1.344	1.203
60-64	1.262	873	920	900
65-69	855	795	560	590
70-74	595	395	105	166
>75	161	0	0	0

Lnight	Baseline	AB Improve roughness wheel/track or design vehicle/track	CD Improve roughness wheel/track and design vehicle/track	F Traffic management: No freight
50-54	1.985	1.338	965	882
55-59	972	915	801	599
60-64	831	577	408	156
65-69	452	153	1	0
>70	0	0	0	0

Normalized population exposure:



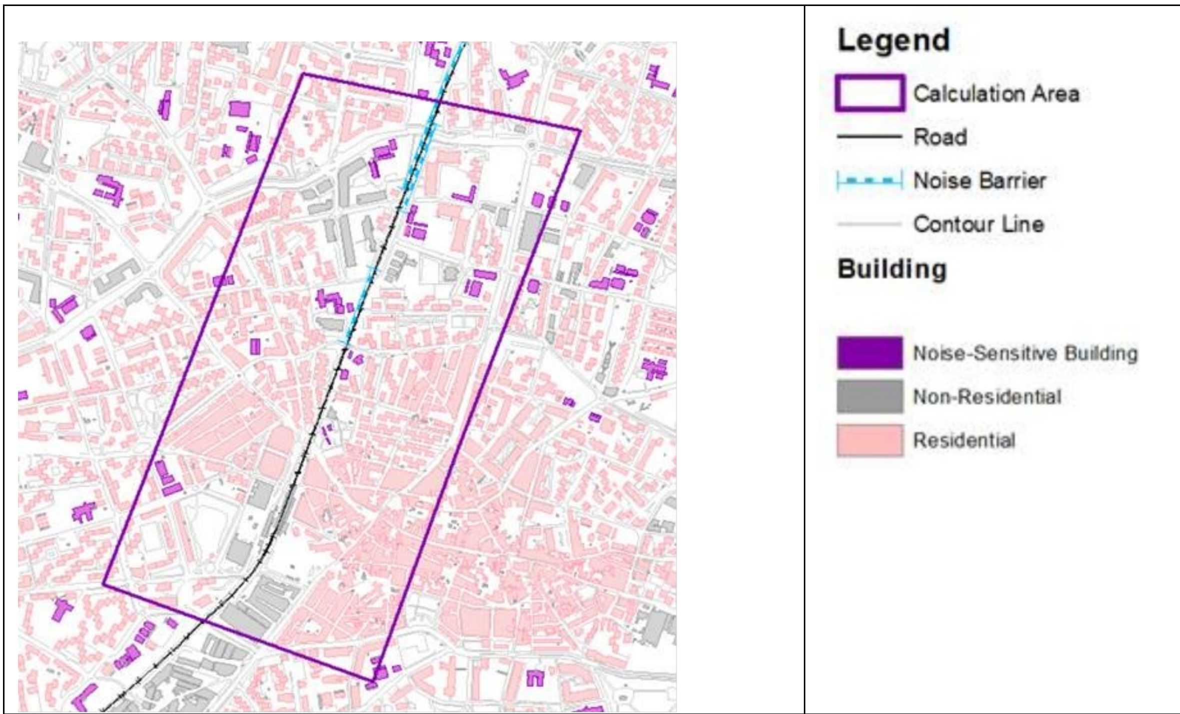


Conclusions of Test Site

In this Test Case, like that of Leganes, the freight traffic restriction measure(F) is very effective. In fact, in Pinto it becomes the measure with highest reduction in people exposure, taking into account that measures in propagation (E or F) have been discarded.

Regarding the emission measures (AB/CD), despite the fact that the vast majority of the population (83%) is in the area where the measures are applied, their effectiveness is only slightly higher than that achieved in other Test Cases (Fuenlabrada, Leganés and Mostoles), being passed by the Test Case in Ciempozuelo.

B5.7. Line: Mostoles El Soto-Humanes in Fuenlabrada



Strategic Noise Map (Lden) of actual situation. Baseline.

City / location / major railway	Fuenlabrada (193.700 hab) affected by railway line: Mostoles El Soto-Humanes
Compiled for rail	ADIF
Date map was calculated	2007
Source of input data used for map	ADIF
Noise prediction model	SRM 96
Software	IMMI
Details of noise calculation	- Maximum 1 reflection per sound path. - Receivers at facades of dwellings separated by 10 m. - Topography considered.
Noise level calculated	Lden, Lnight, Lday, Levening

Context

The Test Site is based on the acoustic study of the Spanish Railway Infrastructure Manage, ADIF. This area is part of a city affected by the railway line.

Most of the affected buildings are residential, 10m hight.

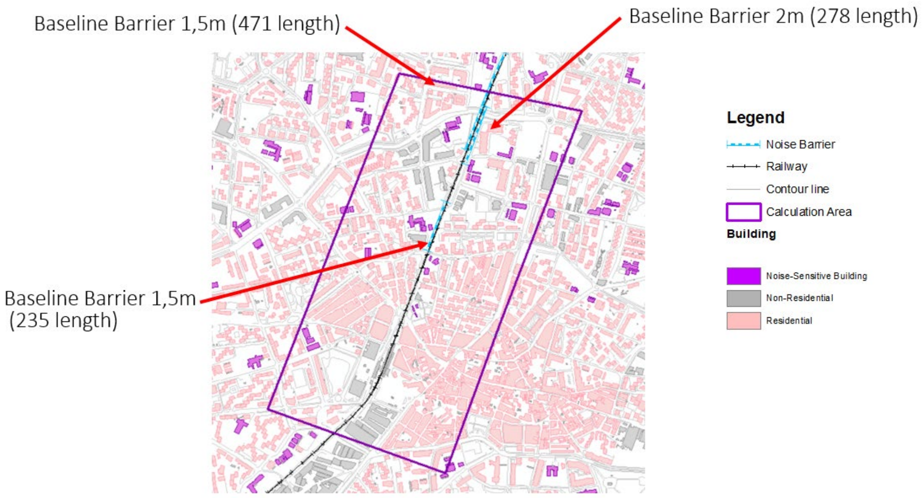
Nowadays there is a noise barrier of 1,5-2 m height to reduce the effect of the railway line, and this is already considered as part of the Baseline in this Test Case.

Moreover, the study of the effect of the abatement measure E Noise Barrier implies adding a new barrier of 5m height at the same side of the line as the existing ones.

Variations

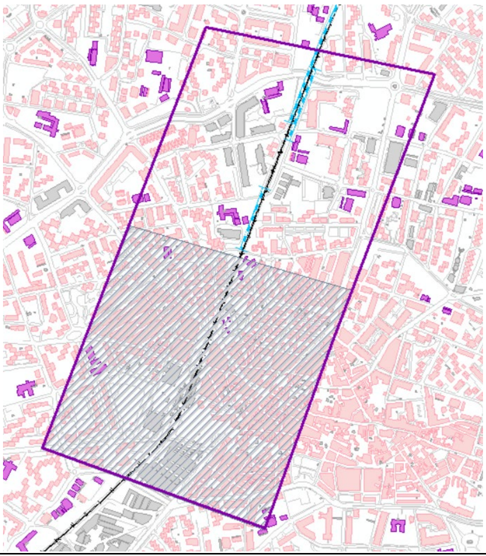
Fuenlabrada	**Variations calculated:**	**Comments**
Baseline: It includes the existing noise barriers. See figure.		
Single Solutions	AB/CD Either Roughness wheel and track or Design vehicle and track	Reduce emission in 3dB in 50% of the line. See figure.
	E Noise barrier:	Add a new noise barrier (5m) See figure.
	F Traffic management:	Remove freight trains
	G Urban Planning	
Combined scenario	AB&CD Both Roughness wheel and track and Design vehicle and track	Reduce emission in 6dB in 50% of the line. See figure.

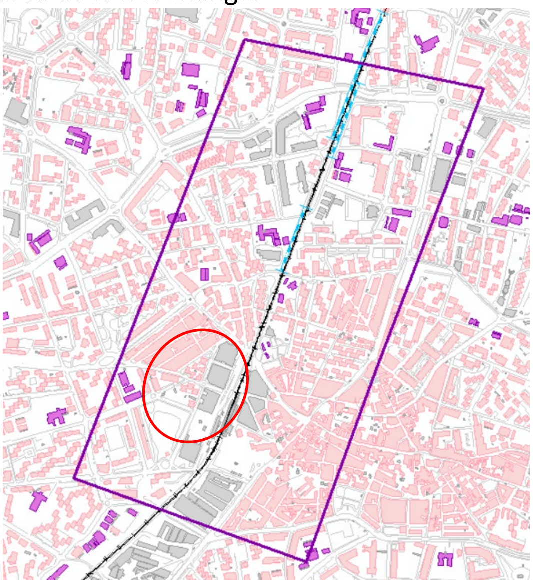
Baseline: existing barriers



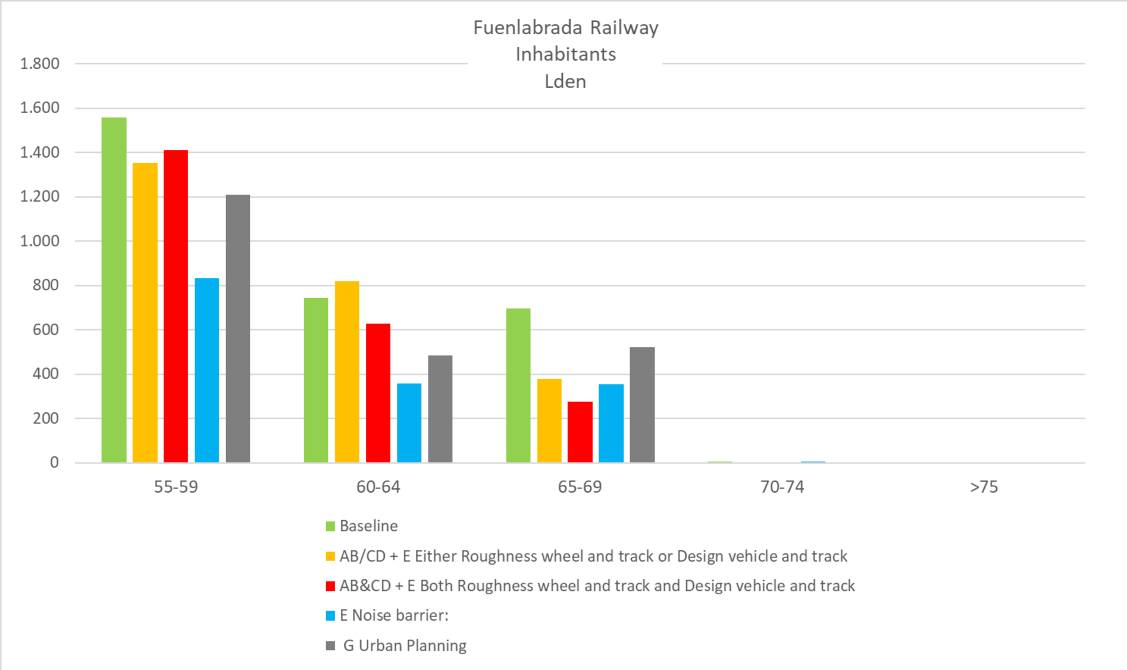
AB Roughness wheel and track
CD Design vehicle and track
It implies reduction in the line emission in 50% of the track.
Shadow area shows the portion of the track where this reduction is applied.

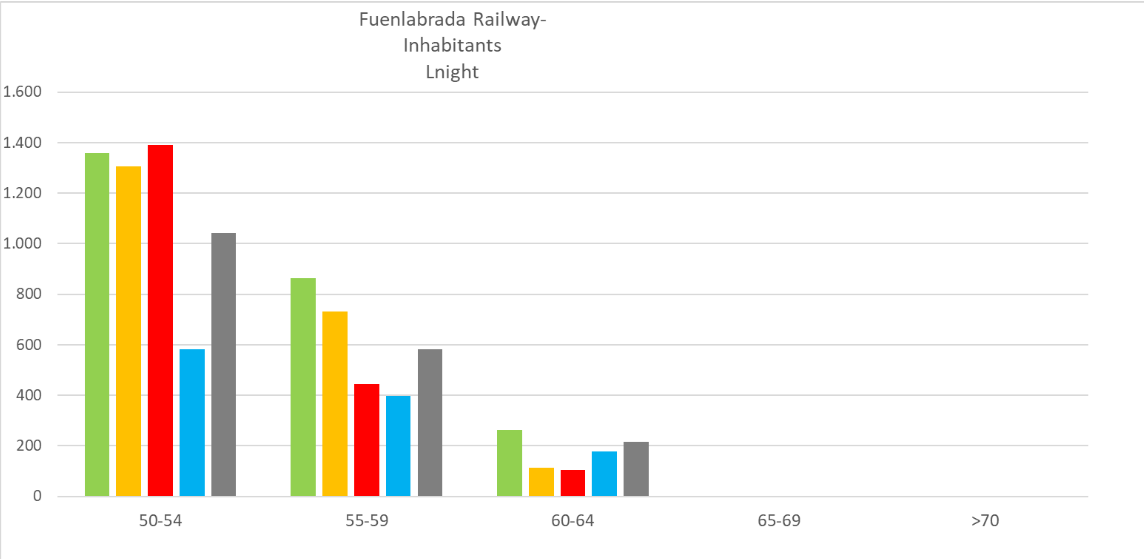
54 % of total population is allocated in the area where the emission is reduced



E Additional noise barrier and height of existing barrier increased to 5 m 44,5% of the total line length 
G Urban Planning: Change Typology of Buildings close to the road: from residential to non residential. Total population of the area does not change. 

Change in population exposure:

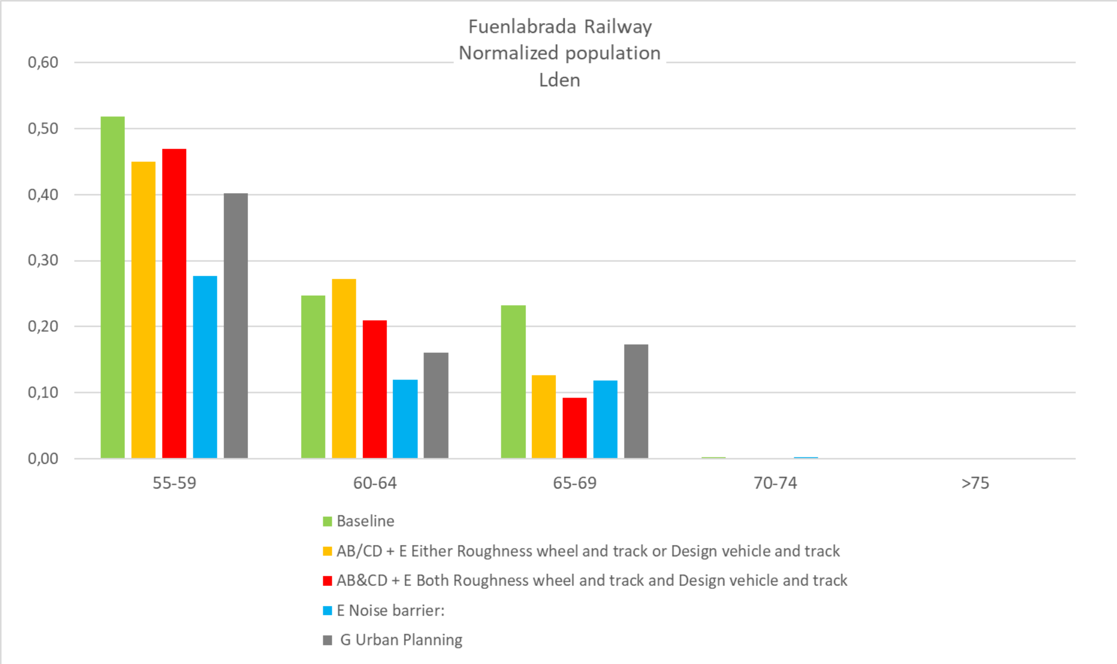


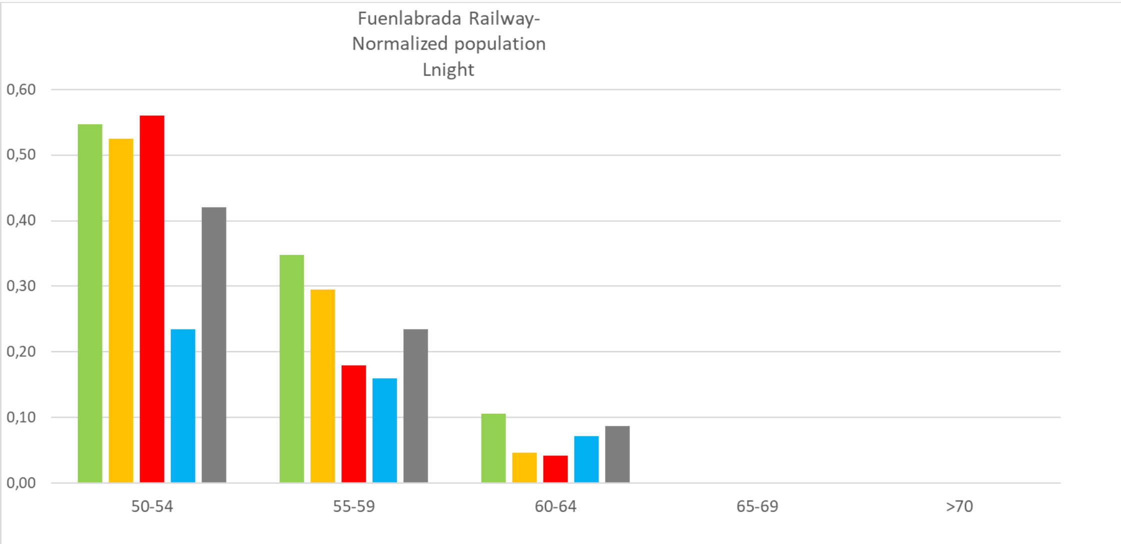


Lden	Baseline	AB/CD + E Either Roughness wheel and track or Design vehicle and track	AB&CDE + E Both Roughness wheel and track and Design vehicle and track	E Noise barrier:	G Urban Planning
55-59	1.559	1.354	1.412	832	1.209
60-64	744	818	629	359	483
65-69	697	380	276	354	520
70-74	5	0	0	5	0
>75	0	0	0	0	0

Lnight	Baseline	AB/CD + E Either Roughness wheel and track or Design vehicle and track	AB&CD +E Both Roughness wheel and track and Design vehicle and track	E Noise barrier:	G Urban Planning
50-54	1.358	1.305	1.390	582	1.044
55-59	863	732	445	397	583
60-64	262	114	105	178	215
65-69	0	0	0	0	0
>70	0	0	0	0	0

Normalized population exposure:





Conclusions of Test Site

The Noise Barrier (E) is, in general, the most effective measure, especially in the intermediate ranges (Lden 55-64 and Lnight 50-59). However, in the higher exposure ranges, the highest reduction is achieved acting on the source emission (AB/CD), since Noise Barrier has only been proposed on one side of the railway line, being the 45% of the total length of the line

Annex 6: Test site calculations for aircraft noise

ANNEX 6
Test site calculations for aircraft noise

Calculations performed by: ANOTEC

Project: Phenomena

Contents

Overview

For Aircraft noise the test site calculations are different from those for road and rail, since both single solution and combined scenarios are fully based on these calculations. The results for the test sites are scaled up to EU level to obtain the noise exposure for the different scenarios.

Aircraft noise calculations have been performed for ten test sites, divided in three classes:

Class	N° of yearly movements	N° of EU airports	Examples (test sites)
Large	> 250.000	8	Amsterdam (AMS) Frankfurt (FRA) Copenhagen (CPH)
Medium	150.000 – 250.000	15	Vienna (VIE) Dublin (DUB) Palma de Mallorca (PMI) Lisbon (LIS)
Small	< 150.000	37	Cologne (CGN) Budapest (BUD) ~~Naples (NAP)*~~ Gothenburg (GOT)

* It was planned to also use Naples airport as a test site, but due to lack of reliable traffic data this airport could not be included in the calculations

Actual 2019 traffic data (nº of operations, fleet and tracks) were extracted from the OpenSky Network database[1] for these 10 airports.

This traffic has been used as input to the SONDEO model, with which the noise maps have been calculated in accordance with ECAC Doc29 4th edition. For each scenario the required changes to the input were made and the noise maps calculated. These noise maps were overlayed on the population map[2] to obtain the noise exposure for the scenario.

Figures 1 to 10 present the traffic maps for a single day at each of the test sites. Figures 11 to 20 provide the noise maps for one of the scenarios in 2030 as an example.

Figures 21 to 33 give the noise exposure distribution for the different scenarios in comparison with the baseline, for which the exposure distribution is given in Table 1.

Table 1. Exposure distribution for the baseline scenario.

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
Baseline, natural fleet renewal	**2017**	7.809	4.393	1.831	0.512	0.082	0.015	0.000	4.609	2.004	0.767	0.200	0.031	0.004	0.001
	2018	7.776	4.374	1.831	0.504	0.080	0.013	0.000	4.615	2.007	0.767	0.202	0.030	0.003	0.001
	2019	7.743	4.355	1.832	0.497	0.079	0.012	0.000	4.621	2.009	0.767	0.205	0.029	0.003	0.000
	2020	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2021	7.665	4.312	1.823	0.485	0.076	0.011	0.000	4.601	2.000	0.763	0.206	0.029	0.002	0.000
	2022	7.621	4.287	1.815	0.481	0.074	0.011	0.000	4.575	1.989	0.759	0.205	0.029	0.002	0.000
	2023	7.576	4.262	1.807	0.477	0.073	0.011	0.000	4.549	1.978	0.754	0.204	0.028	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.011	0.000	4.522	1.966	0.750	0.203	0.028	0.002	0.000
	2030	7.365	4.143	1.759	0.464	0.068	0.010	0.000	4.317	1.877	0.717	0.192	0.027	0.002	0.000
	2035	7.157	4.026	1.718	0.443	0.066	0.010	0.000	4.163	1.810	0.688	0.190	0.025	0.002	0.000

[1] https://opensky-network.org/

[2] GHS population grid, derived from EUROSTAT census data (100m) https://data.jrc.ec.europa.eu/dataset/jrc-ghsl-ghs_pop_eurostat_europe_r2016a

Air traffic maps at test sites

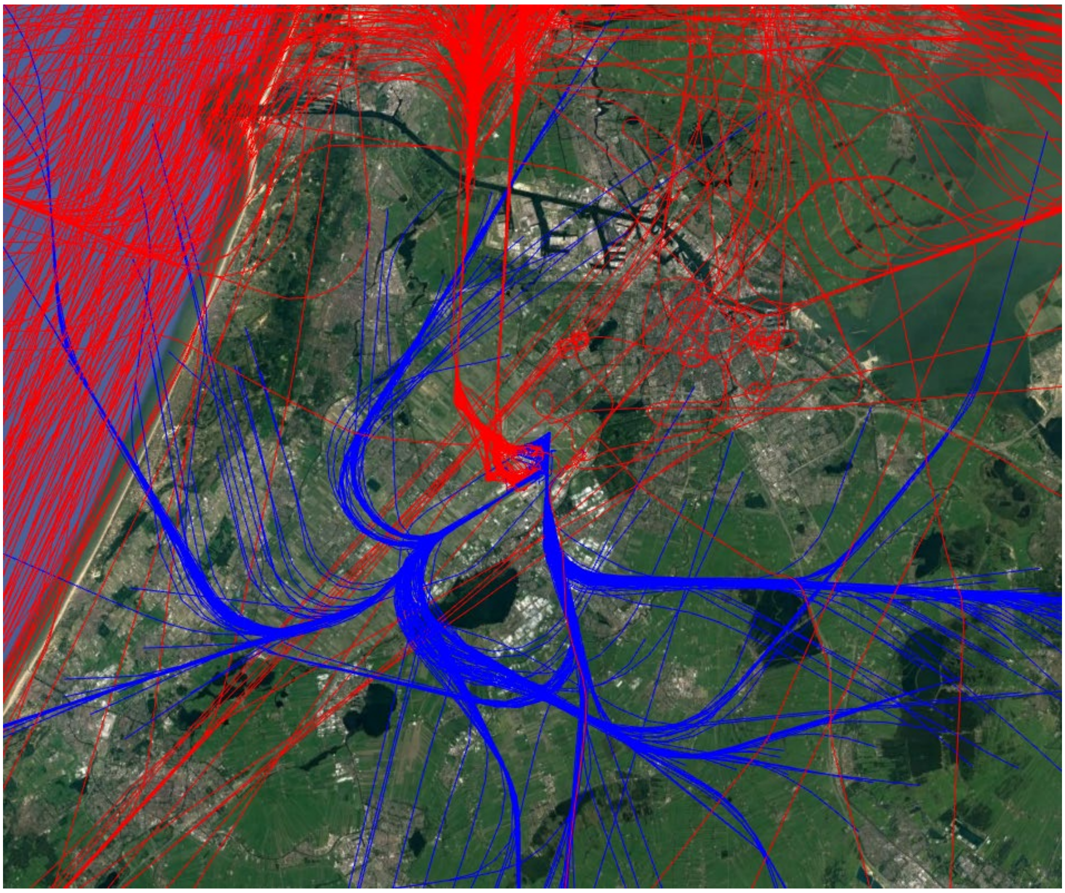


Figure 1. Map of one day of air traffic at AMS

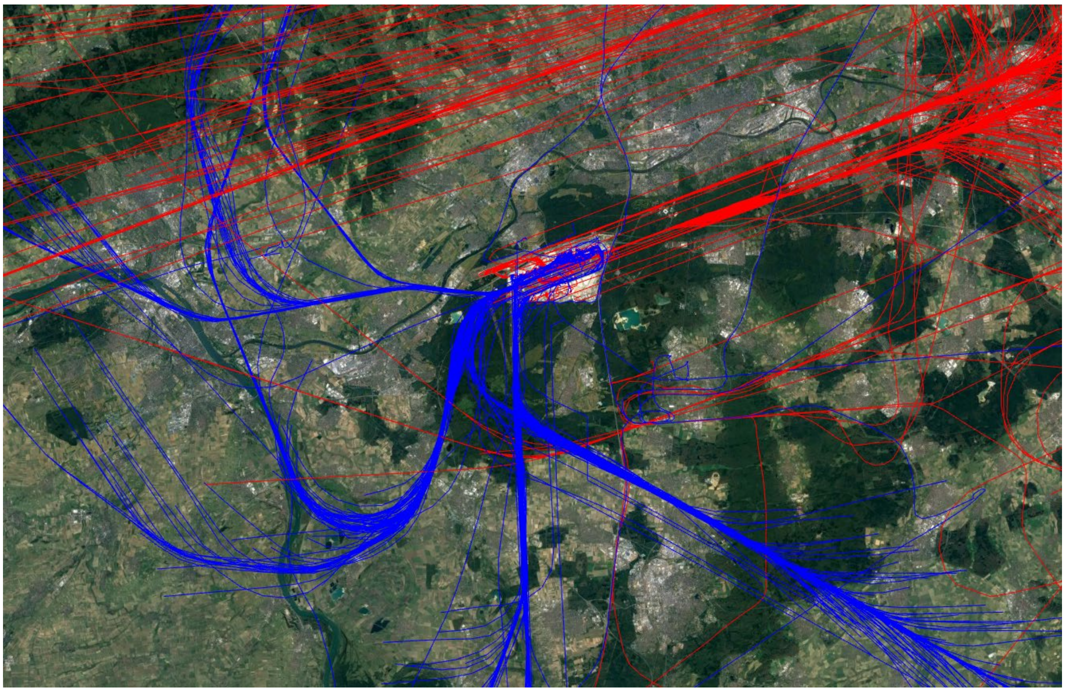


Figure 2. Map of one day of air traffic at FRA

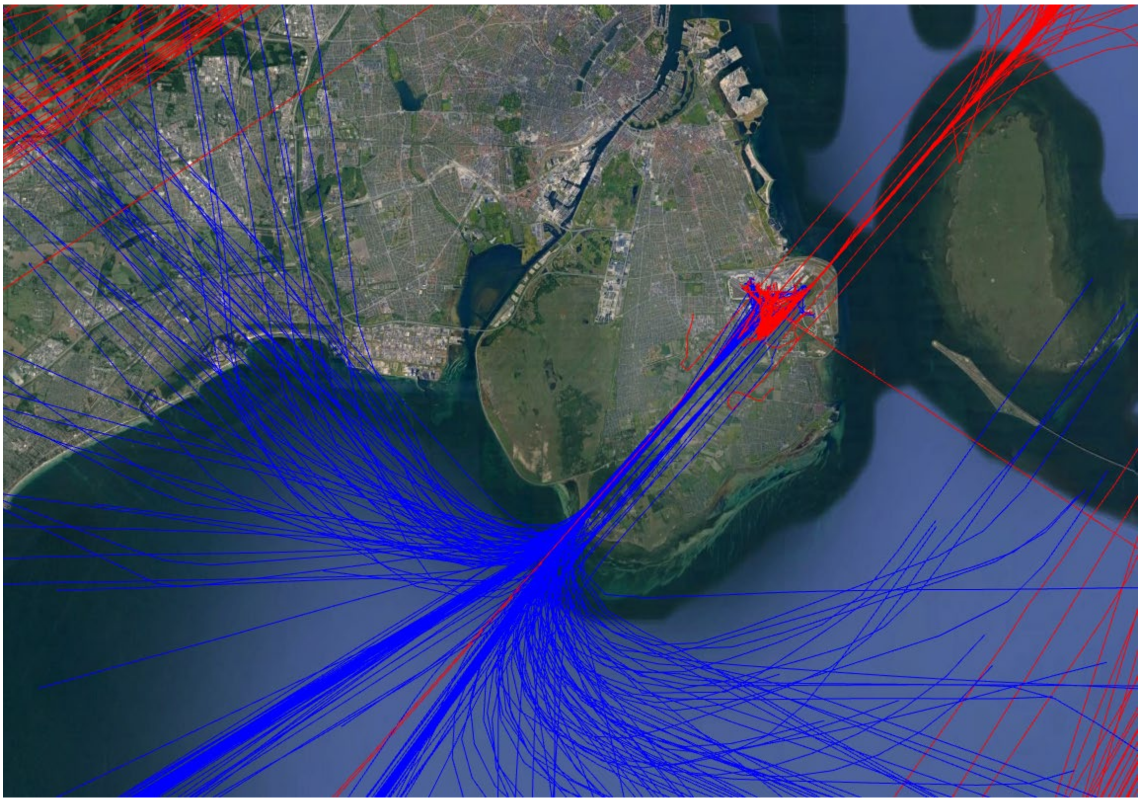


Figure 3. Map of one day of air traffic at CPH

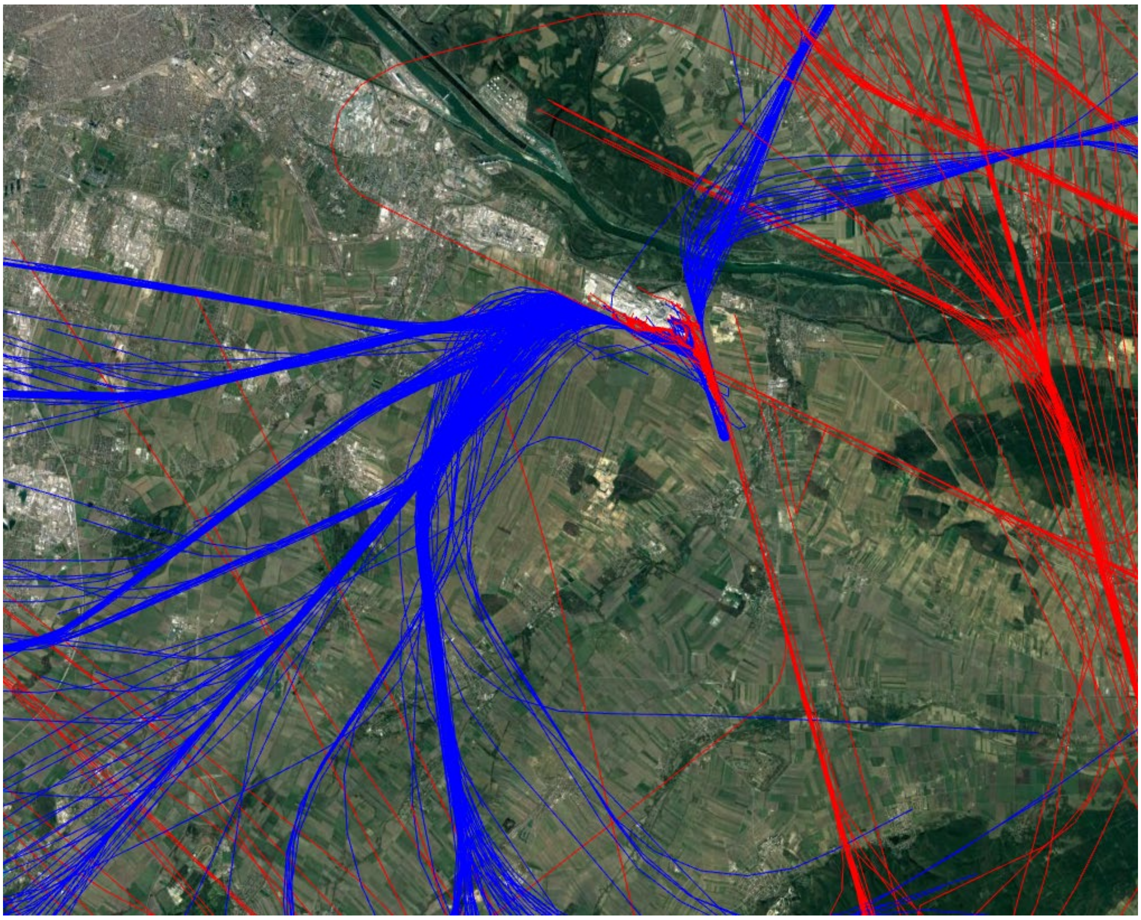


Figure 4. Map of one day of air traffic at VIE

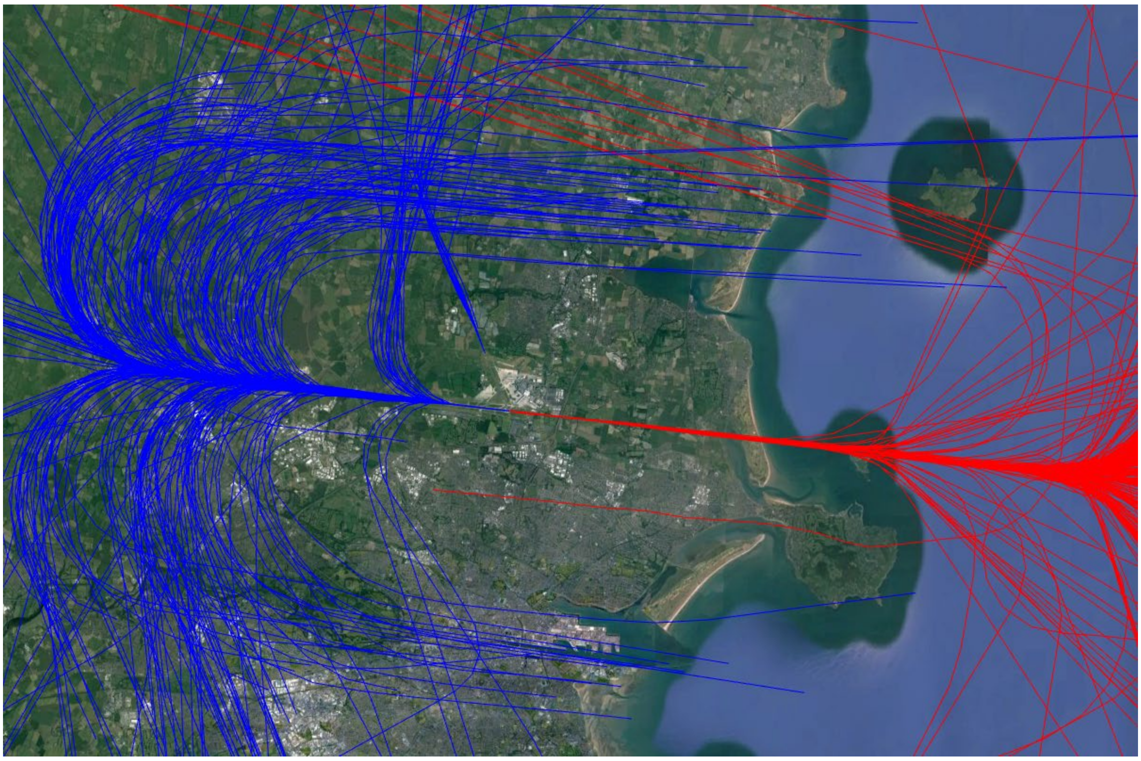


Figure 5. Map of one day of air traffic at DUB

Figure 6. Map of one day of air traffic at PMI

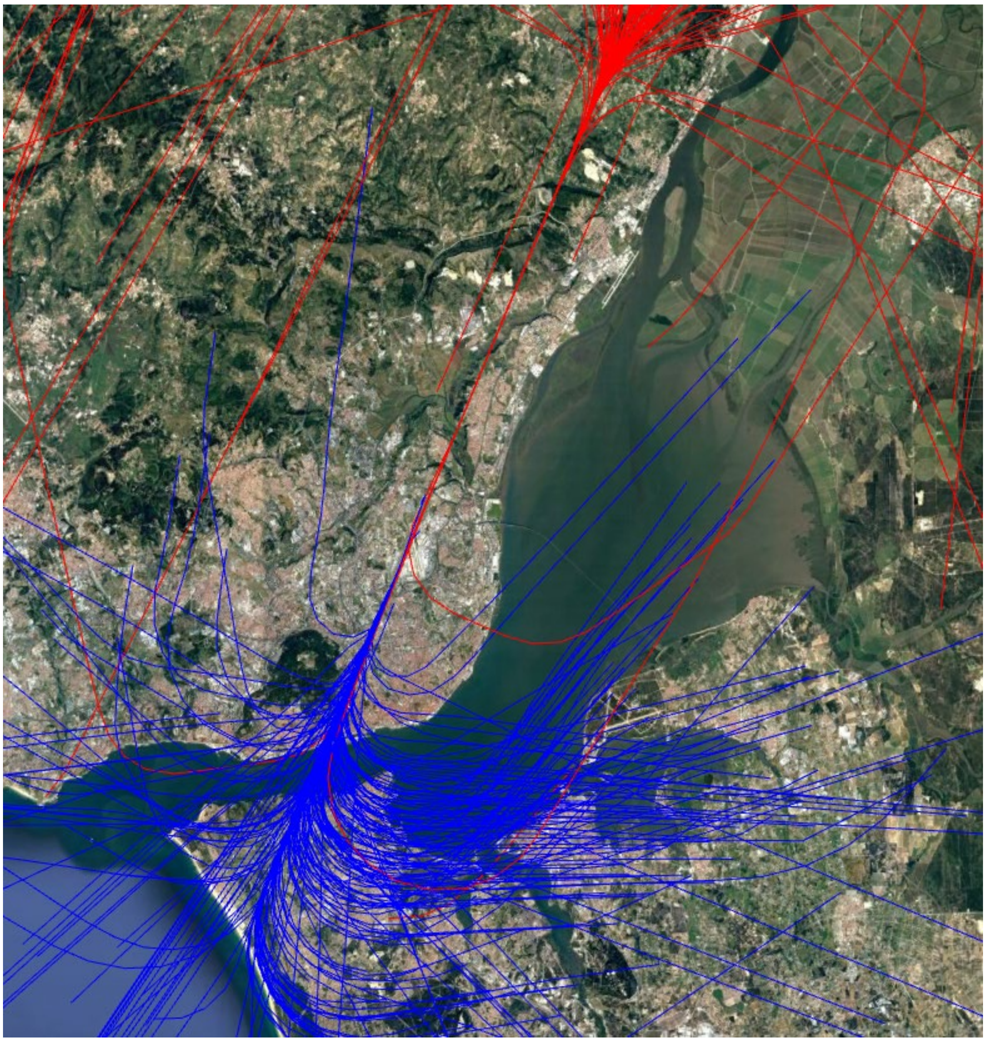


Figure 7. Map of one day of air traffic at LIS

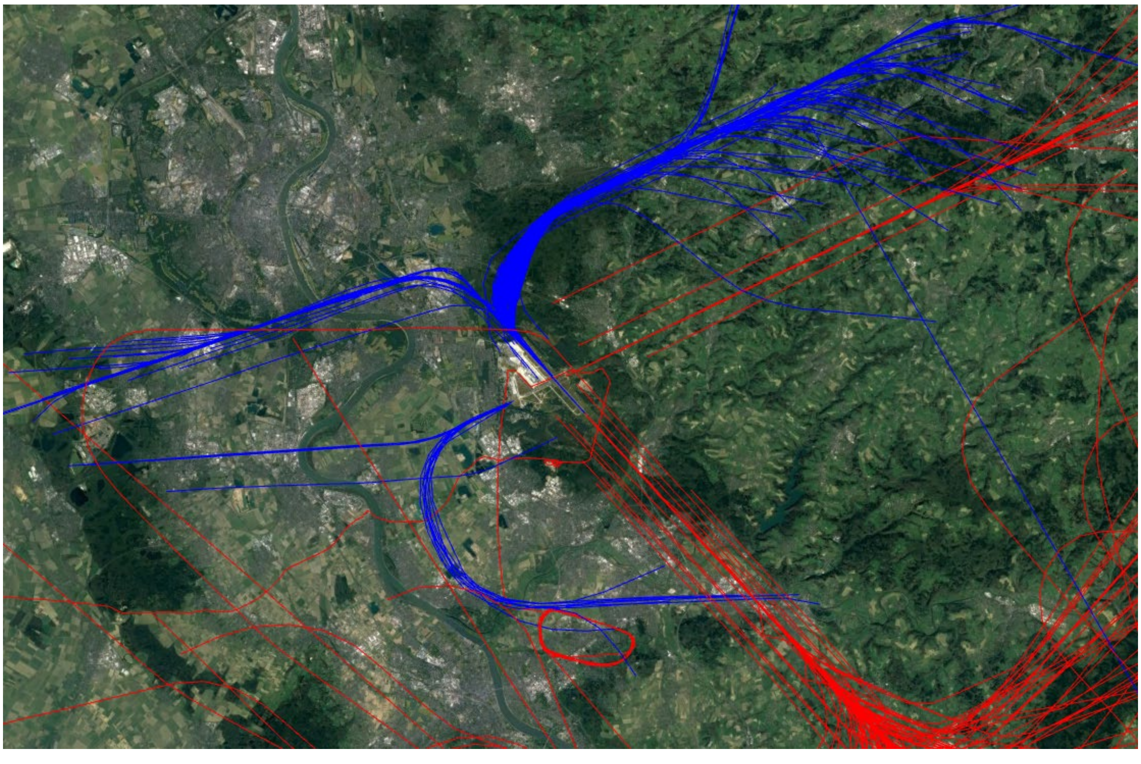


Figure 8. Map of one day of air traffic at CGN

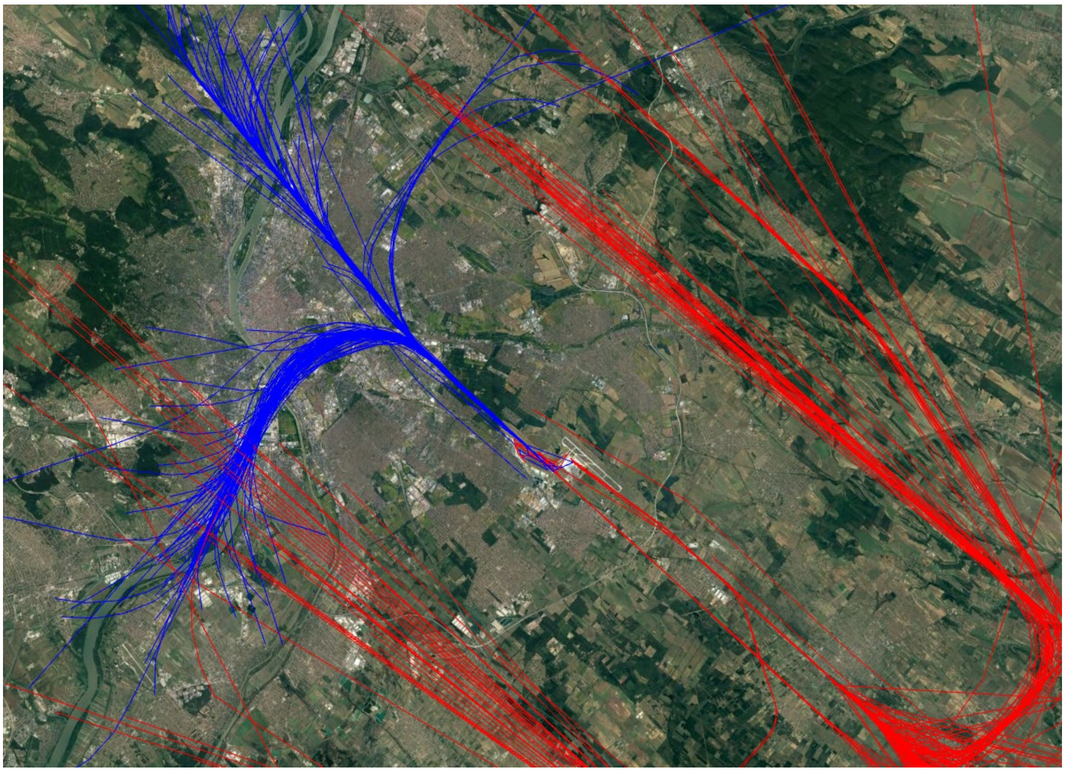


Figure 9. Map of one day of air traffic at BUD

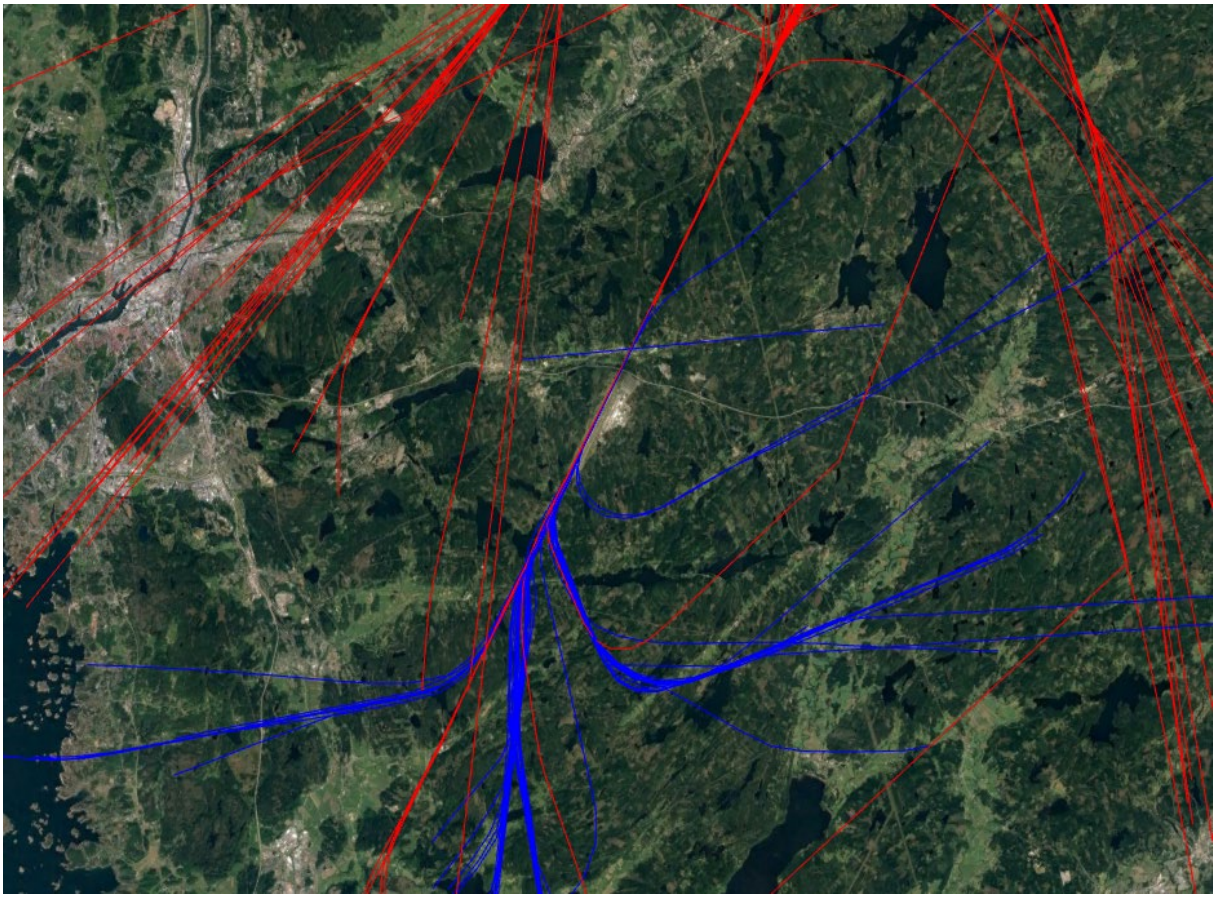


Figure 10. Map of one day of air traffic at GOT

Example noise maps at test sites

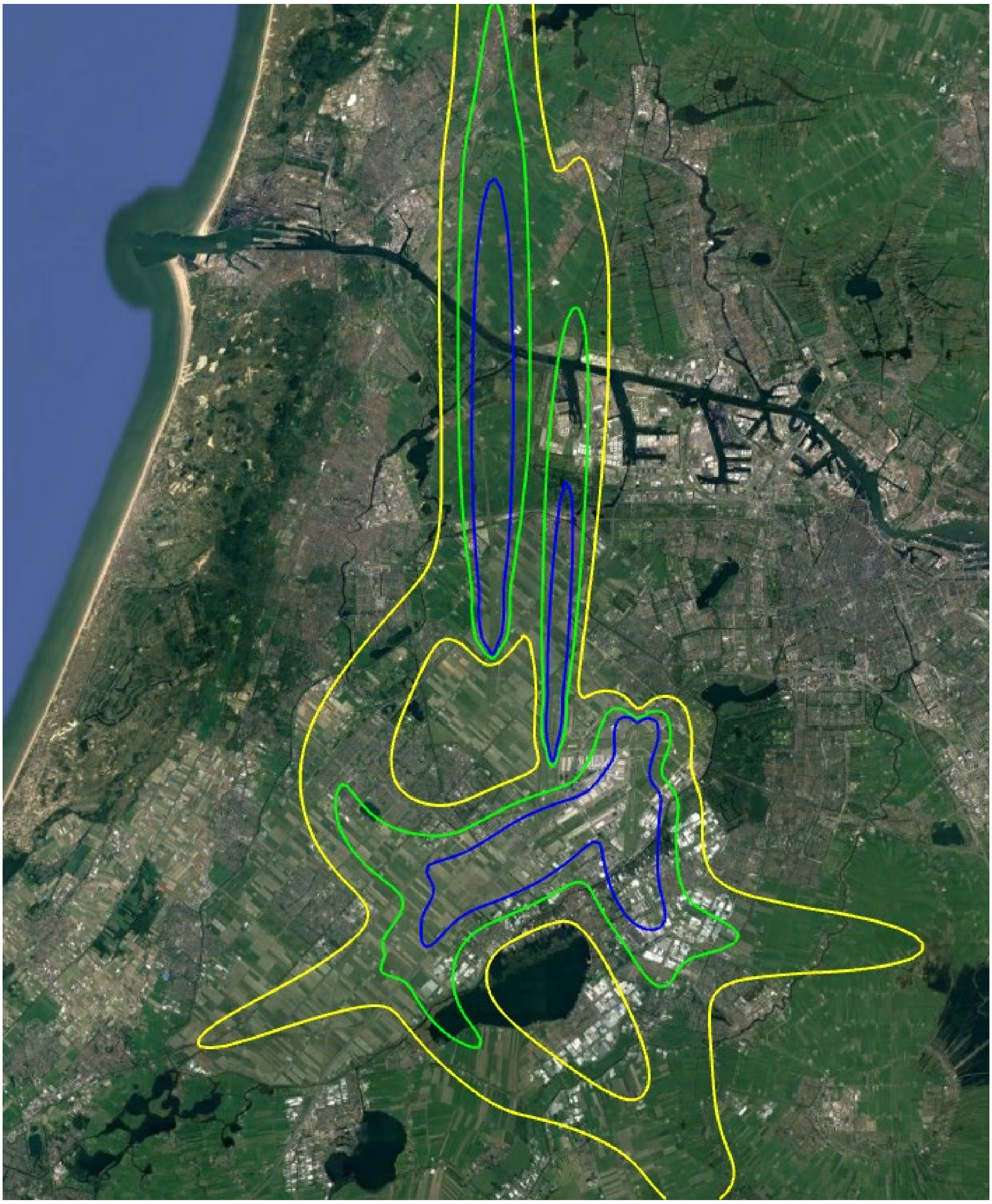


Figure 11. Noise map for Scenario A in 2030 (Lden 50-55-60) at AMS

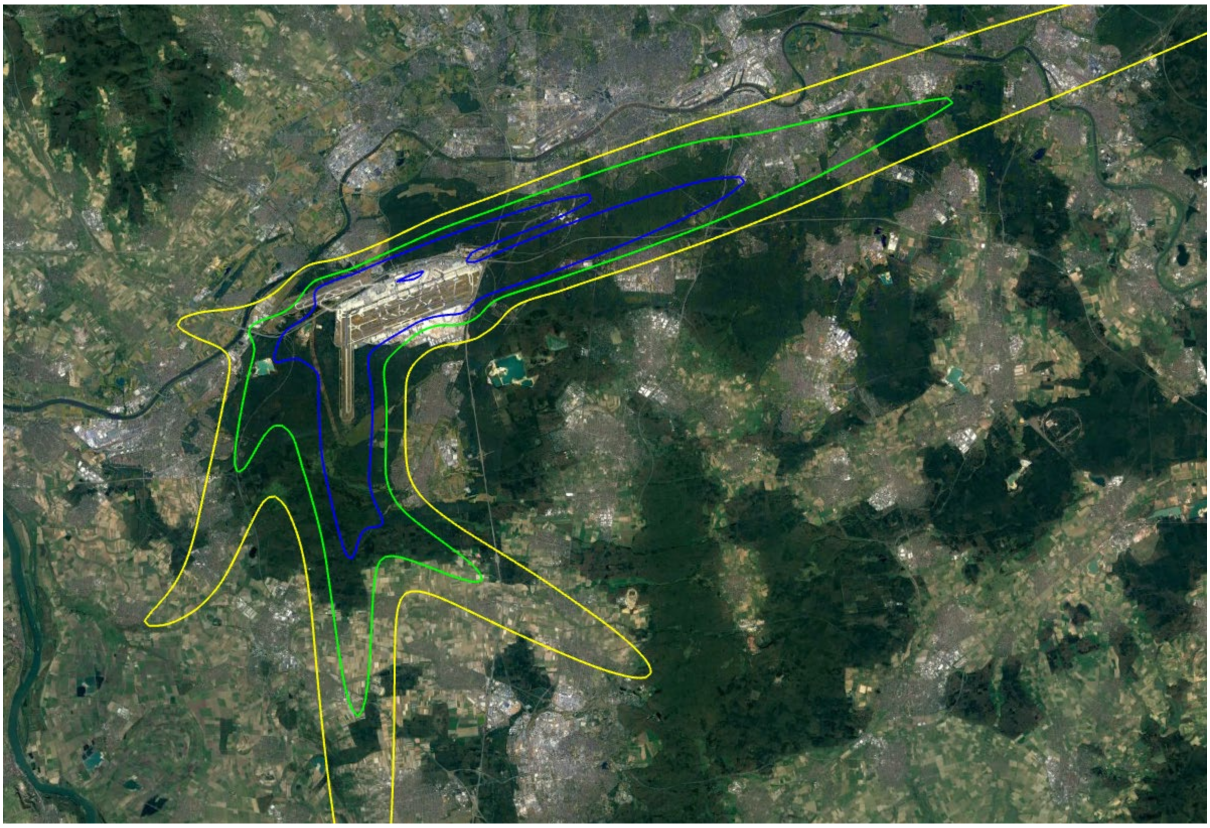


Figure 12. Noise map for Scenario A in 2030 (Lden 50-55-60) at FRA

Figure 13. Noise map for Scenario A in 2030 (Lden 50-55-60) at CPH

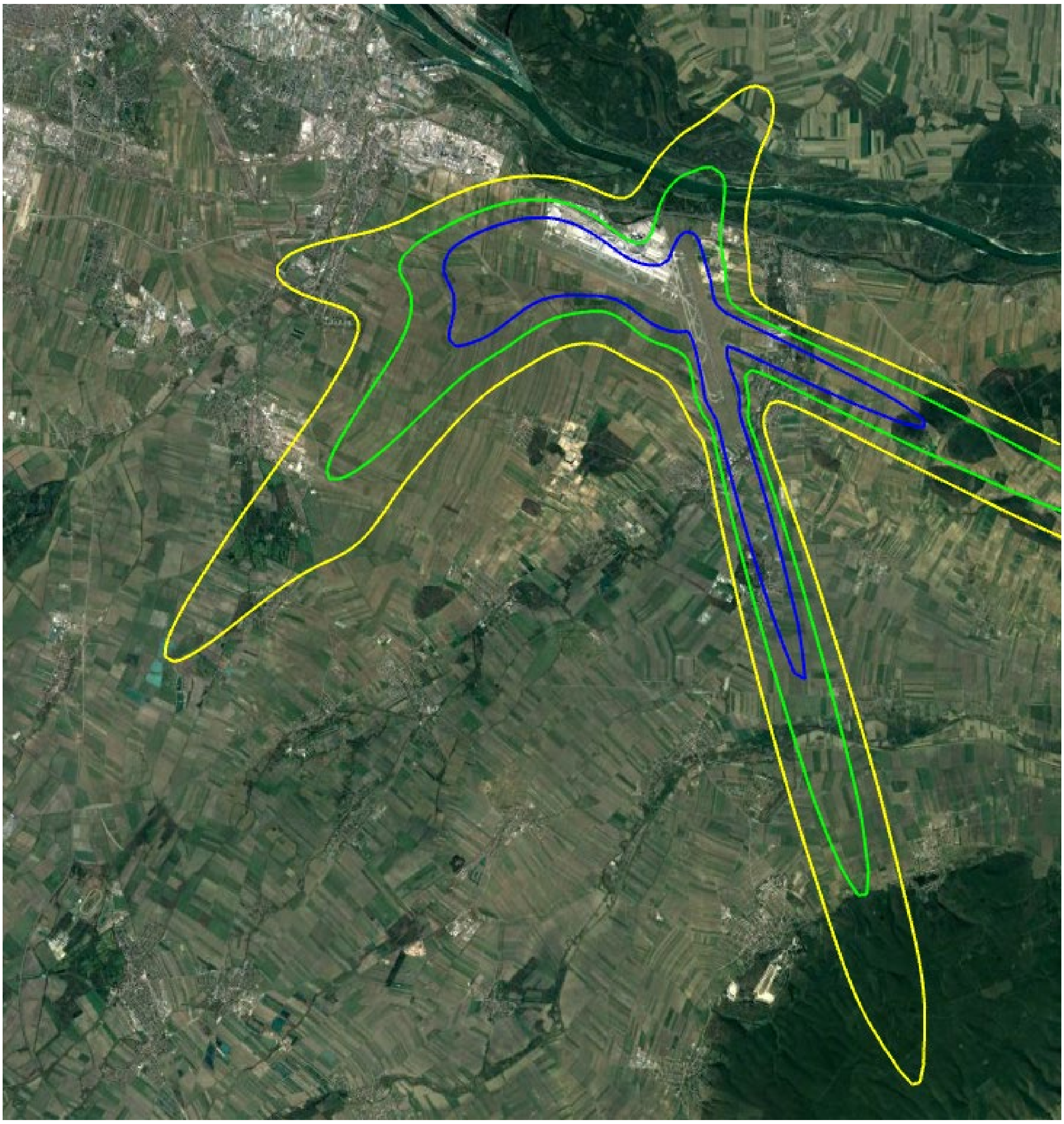


Figure 14. Noise map for Scenario A in 2030 (Lden 50-55-60) at VIE

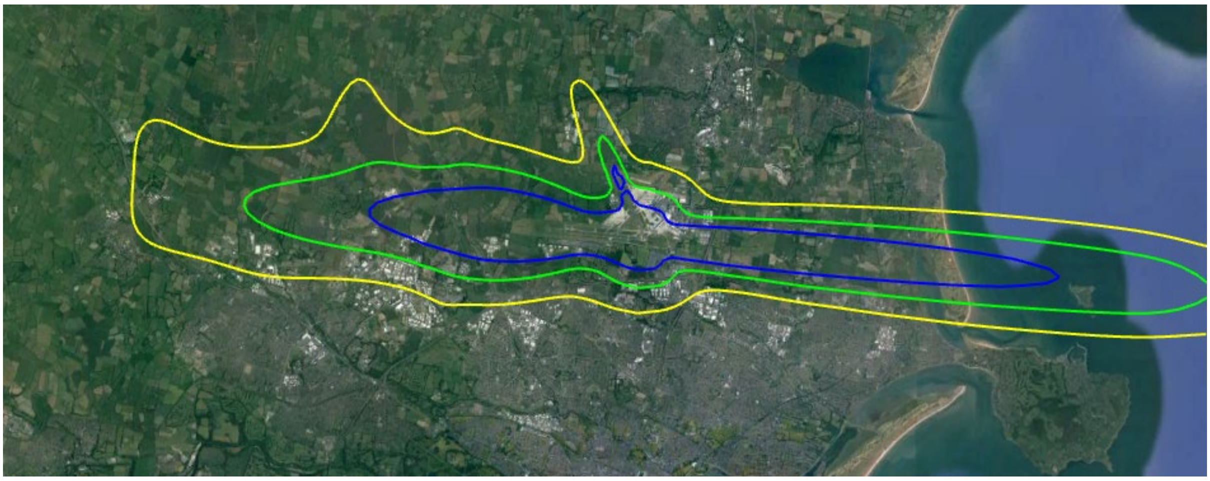


Figure 15. Noise map for Scenario A in 2030 (Lden 50-55-60) at DUB

Figure 16. Noise map for Scenario A in 2030 (Lden 50-55-60) at PMI

Figure 17. Noise map for Scenario A in 2030 (Lden 50-55-60) at LIS

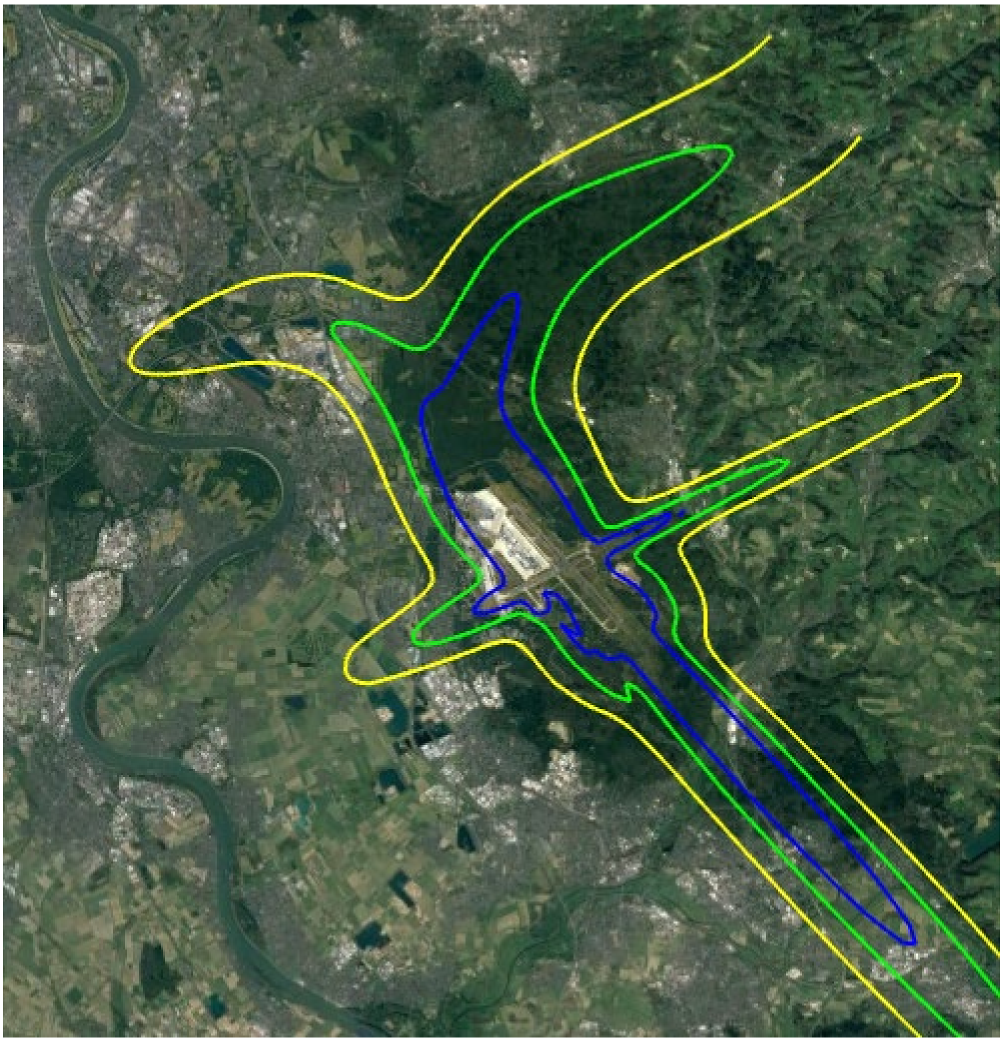


Figure 18. Noise map for Scenario A in 2030 (Lden 50-55-60) at CGN

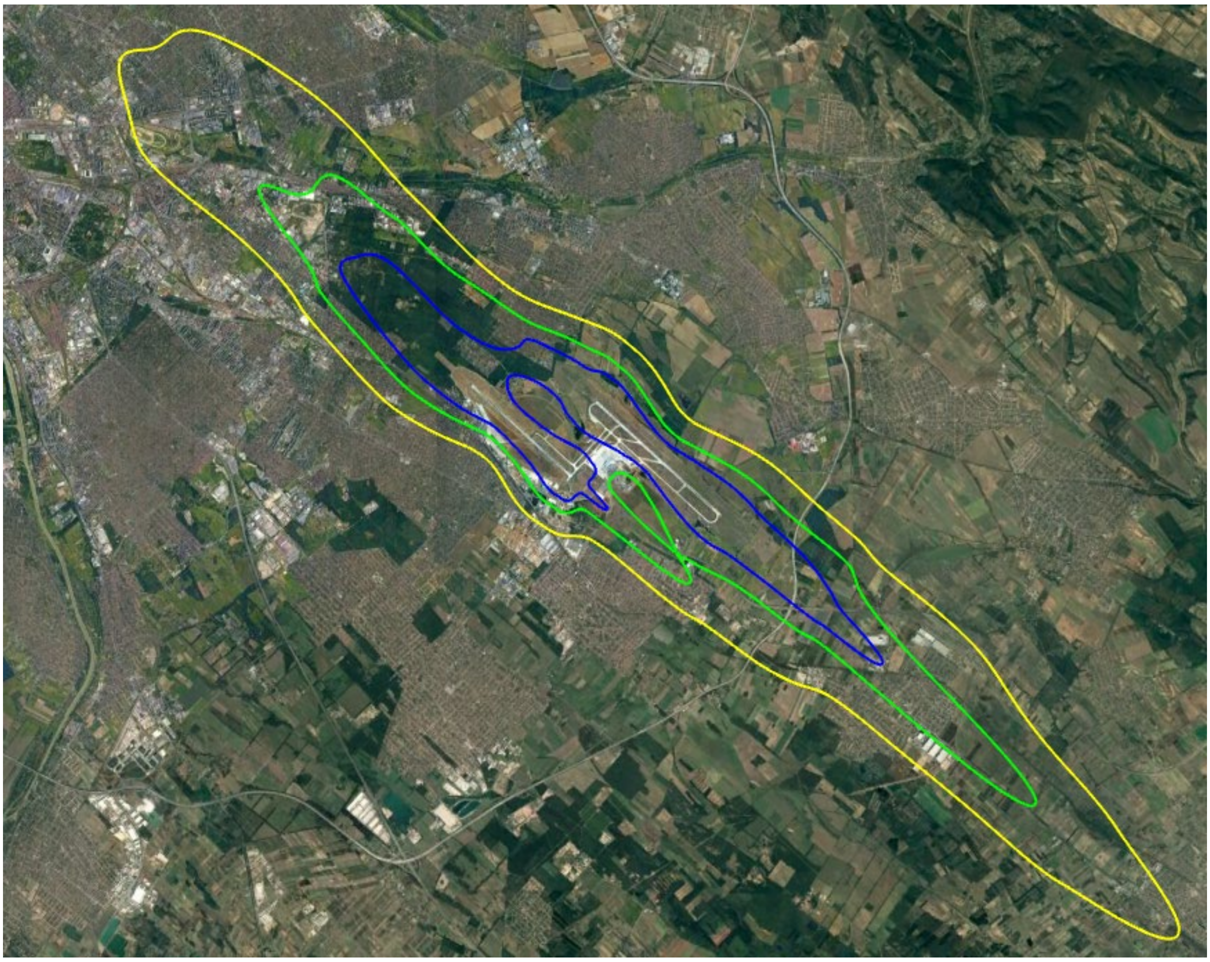


Figure 19. Noise map for Scenario A in 2030 (Lden 50-55-60) at BUD

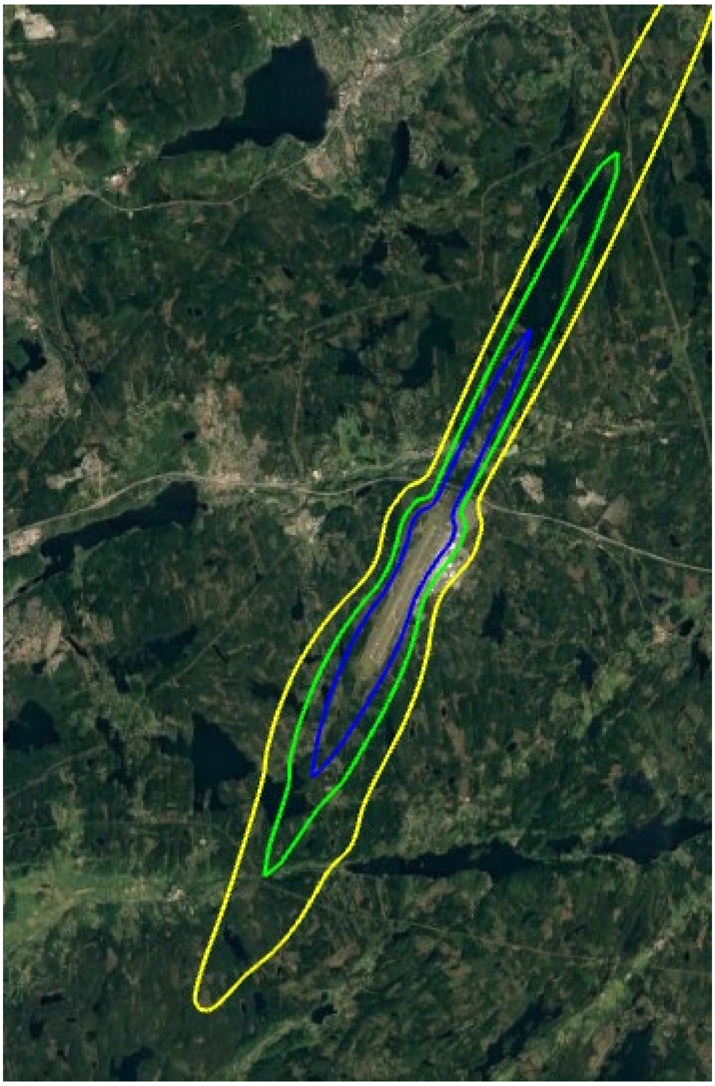
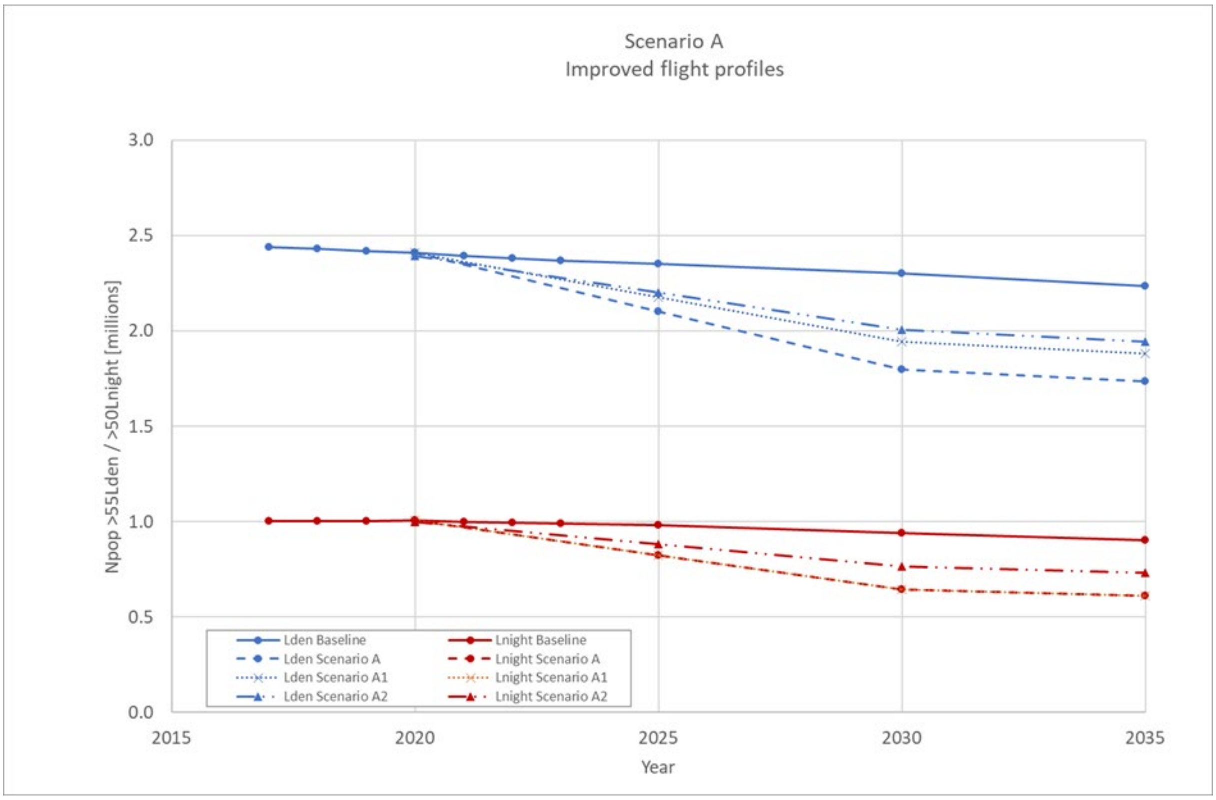


Figure 20. Noise map for Scenario A in 2030 (Lden 50-55-60) at GOT

Noise exposure distributions for scenarios

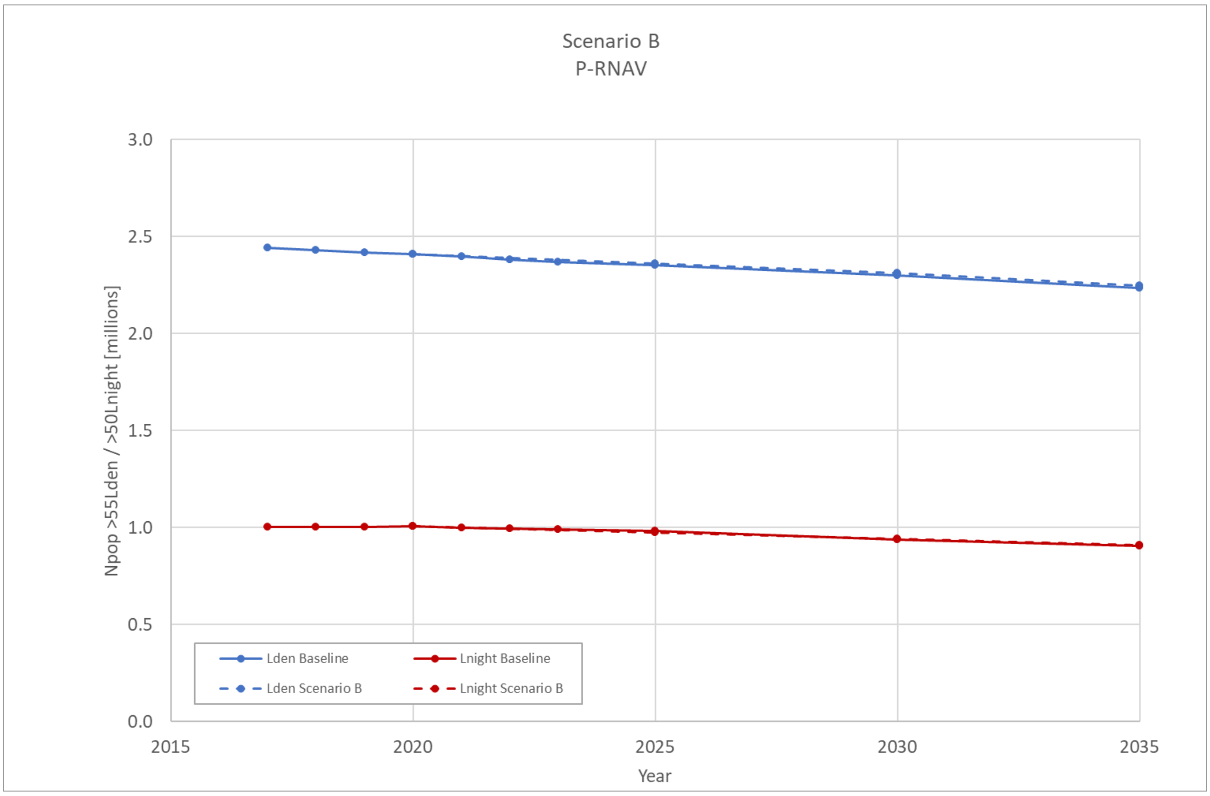


		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	Year	45-49	50-54	55-59	60-64	65-69	70-74	>75	40-44	45-49	50-54	55-59	60-64	65-69	>70
A Improved flight profiles	2020	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.734	3.788	1.636	0.402	0.057	0.010	0.000	3.793	1.649	0.630	0.171	0.022	0.002	0.000
	2030	5.758	3.239	1.441	0.314	0.037	0.008	0.000	2.958	1.286	0.493	0.134	0.014	0.002	0.000
	2035	5.550	3.122	1.399	0.293	0.035	0.008	0.000	2.803	1.219	0.464	0.131	0.012	0.002	0.000

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	Year	45-49	50-54	55-59	60-64	65-69	70-74	>75	40-44	45-49	50-54	55-59	60-64	65-69	>70
A1 Improved flight profiles 50% implem.	2020	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.967	3.919	1.707	0.404	0.058	0.010	0.000	3.796	1.650	0.631	0.171	0.022	0.002	0.000
	2030	6.225	3.501	1.581	0.317	0.038	0.008	0.000	2.964	1.289	0.494	0.134	0.014	0.002	0.000
	2035	6.017	3.384	1.540	0.296	0.036	0.008	0.000	2.809	1.221	0.465	0.131	0.012	0.002	0.000

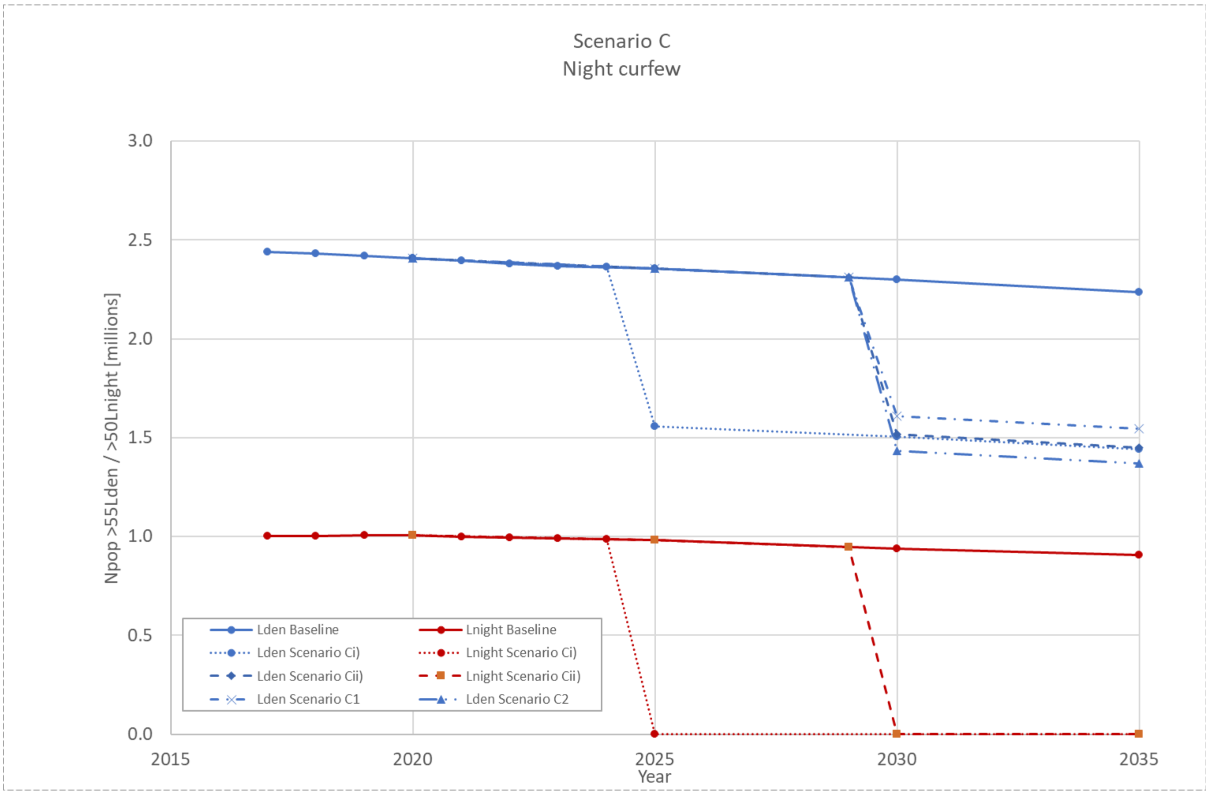
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	Year	45-49	50-54	55-59	60-64	65-69	70-74	>75	40-44	45-49	50-54	55-59	60-64	65-69	>70
A2 Improved flight profiles 1 dB benefit	2020	7.665	4.312	1.823	0.485	0.076	0.011	0.000	4.601	2.000	0.763	0.206	0.029	0.002	0.000
	2025	7.046	3.964	1.695	0.435	0.063	0.010	0.000	4.064	1.767	0.676	0.184	0.022	0.002	0.000
	2030	6.428	3.616	1.566	0.384	0.050	0.008	0.000	3.527	1.534	0.588	0.161	0.015	0.002	0.000
	2035	6.220	3.499	1.525	0.363	0.048	0.008	0.000	3.373	1.466	0.559	0.159	0.014	0.002	0.000

Figure 21. Noise exposure distribution for Scenario A



		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
B P-RNAV	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.555	4.250	1.802	0.476	0.072	0.011	0.000	4.480	1.948	0.742	0.201	0.028	0.002	0.000
	2030	7.401	4.163	1.771	0.463	0.068	0.010	0.000	4.332	1.884	0.717	0.195	0.028	0.002	0.000
	2035	7.193	4.046	1.730	0.442	0.066	0.010	0.000	4.178	1.816	0.688	0.192	0.026	0.002	0.000

Figure 22. Noise exposure distribution for Scenario B



		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
C i) night curfew in 2025	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2024	7.568	4.257	1.805	0.476	0.073	0.011	0.000	4.543	1.975	0.754	0.204	0.028	0.002	0.000
	2025	4.986	2.804	1.239	0.280	0.035	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2030	4.818	2.710	1.200	0.272	0.031	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2035	4.610	2.593	1.159	0.250	0.029	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
C ii) night curfew in 2030	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.011	0.000	4.522	1.966	0.750	0.203	0.028	0.002	0.000
	2029	7.398	4.161	1.767	0.466	0.069	0.010	0.000	4.358	1.895	0.724	0.194	0.027	0.002	0.000
	2030	4.851	2.728	1.204	0.274	0.035	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2035	4.643	2.611	1.163	0.253	0.033	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
C1 night curfew in 2030 50%/50% shift	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.011	0.000	4.522	1.966	0.750	0.203	0.028	0.002	0.000
	2029	7.398	4.161	1.767	0.466	0.069	0.010	0.000	4.358	1.895	0.724	0.194	0.027	0.002	0.000
	2030	5.148	2.896	1.274	0.294	0.037	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2035	4.940	2.779	1.233	0.273	0.035	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
C2 night curfew in 2030 no shift	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.011	0.000	4.522	1.966	0.750	0.203	0.028	0.002	0.000
	2029	7.398	4.161	1.767	0.466	0.069	0.010	0.000	4.358	1.895	0.724	0.194	0.027	0.002	0.000
	2030	4.592	2.583	1.142	0.262	0.029	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	2035	4.384	2.466	1.100	0.241	0.027	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Figure 23. Noise exposure distribution for Scenario C

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
D i) night curfew non Ch4 in 2025	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2024	7.568	4.257	1.805	0.476	0.073	0.011	0.000	4.543	1.975	0.754	0.204	0.028	0.002	0.000
	2025	7.309	4.111	1.736	0.467	0.070	0.011	0.000	4.313	1.875	0.710	0.198	0.027	0.002	0.000
	2030	7.141	4.017	1.697	0.458	0.066	0.010	0.000	4.108	1.786	0.677	0.188	0.026	0.002	0.000
	2035	6.933	3.900	1.655	0.437	0.065	0.010	0.000	3.953	1.719	0.648	0.185	0.024	0.002	0.000

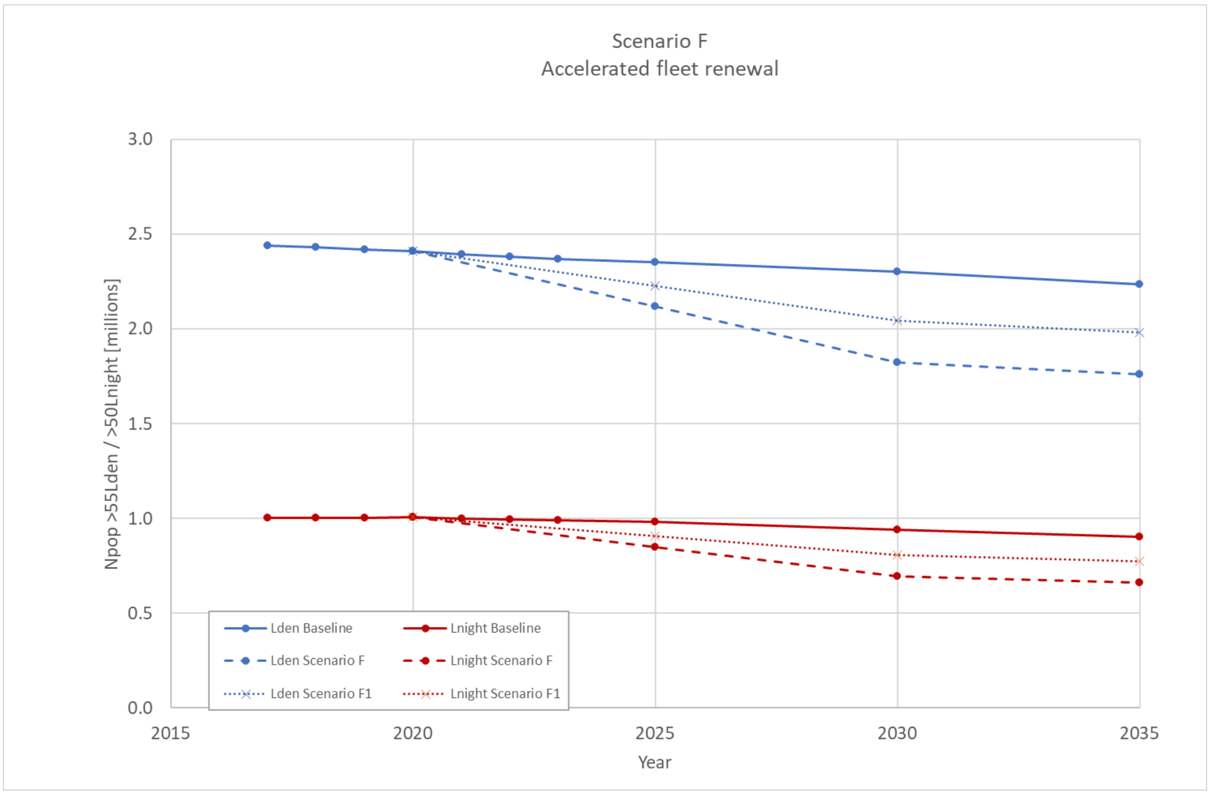
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
D ii) night curfew non Ch4 in 2030	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.011	0.000	4.522	1.966	0.750	0.203	0.028	0.002	0.000
	2029	7.398	4.161	1.767	0.466	0.069	0.010	0.000	4.358	1.895	0.724	0.194	0.027	0.002	0.000
	2030	7.151	4.023	1.702	0.455	0.067	0.010	0.000	4.106	1.785	0.677	0.187	0.026	0.002	0.000
	2035	6.943	3.906	1.661	0.434	0.065	0.010	0.000	3.951	1.718	0.648	0.185	0.024	0.002	0.000

Figure 24. Noise exposure distribution for Scenario D

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	Year	45-49	50-54	55-59	60-64	65-69	70-74	>75	40-44	45-49	50-54	55-59	60-64	65-69	>70
E i)	2020	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
phase-out	2025	7.050	3.966	1.662	0.461	0.070	0.011	0.000	4.313	1.875	0.710	0.198	0.027	0.002	0.000
non Ch4	2030	6.882	3.871	1.622	0.452	0.066	0.010	0.000	4.108	1.786	0.677	0.188	0.026	0.002	0.000
in 2025	2035	6.674	3.754	1.581	0.431	0.064	0.010	0.000	3.953	1.719	0.648	0.185	0.024	0.002	0.000

		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	Year	45-49	50-54	55-59	60-64	65-69	70-74	>75	40-44	45-49	50-54	55-59	60-64	65-69	>70
E ii)	2020	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
phase-out	2025	7.297	4.104	1.728	0.470	0.072	0.011	0.000	4.367	1.898	0.722	0.197	0.027	0.002	0.000
non Ch4	2030	6.884	3.872	1.625	0.449	0.066	0.010	0.000	4.106	1.785	0.677	0.187	0.026	0.002	0.000
in 2030	2035	6.676	3.755	1.584	0.428	0.065	0.010	0.000	3.951	1.718	0.648	0.185	0.024	0.002	0.000

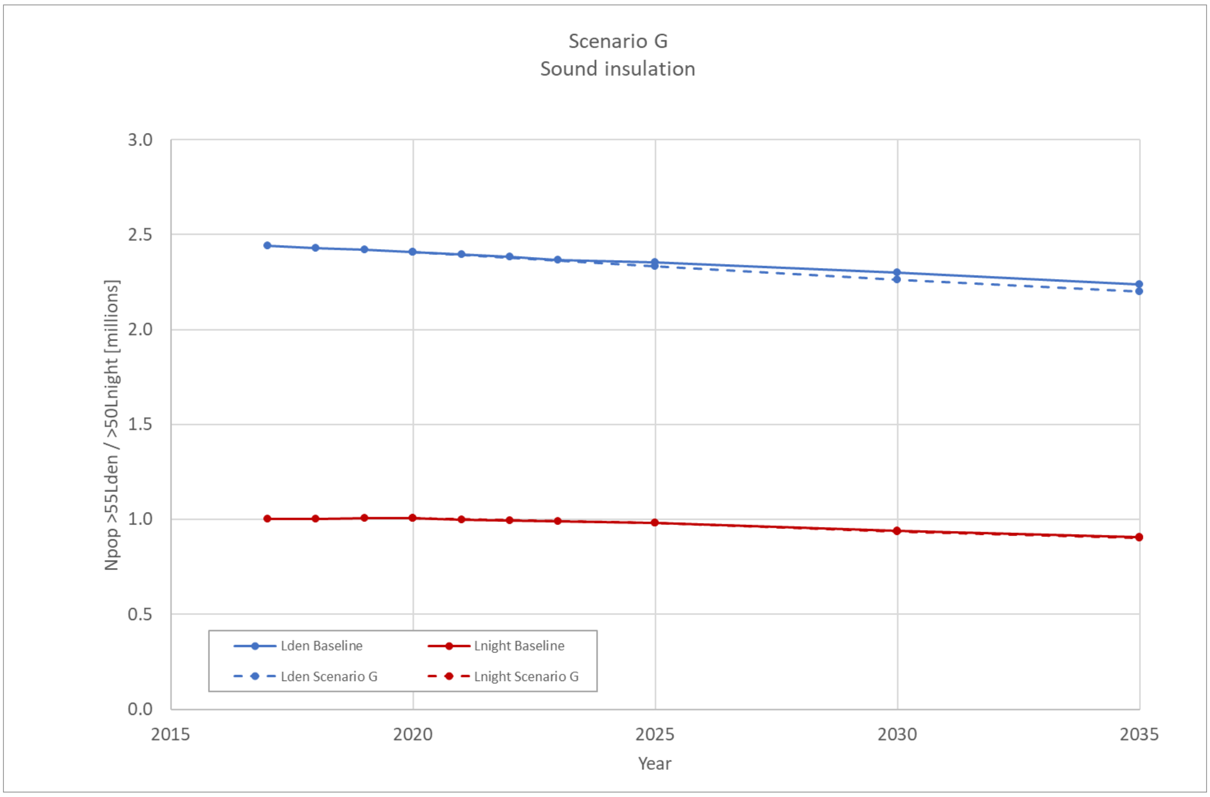
Figure 25. Noise exposure distribution for Scenario E



		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
F accelerated fleet renewal	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.775	3.811	1.628	0.418	0.063	0.008	0.000	3.909	1.699	0.648	0.179	0.021	0.002	0.000
	2030	5.840	3.285	1.424	0.347	0.048	0.005	0.000	3.190	1.387	0.528	0.151	0.014	0.001	0.000
	2035	5.632	3.168	1.383	0.326	0.046	0.005	0.000	3.035	1.320	0.499	0.148	0.012	0.001	0.000

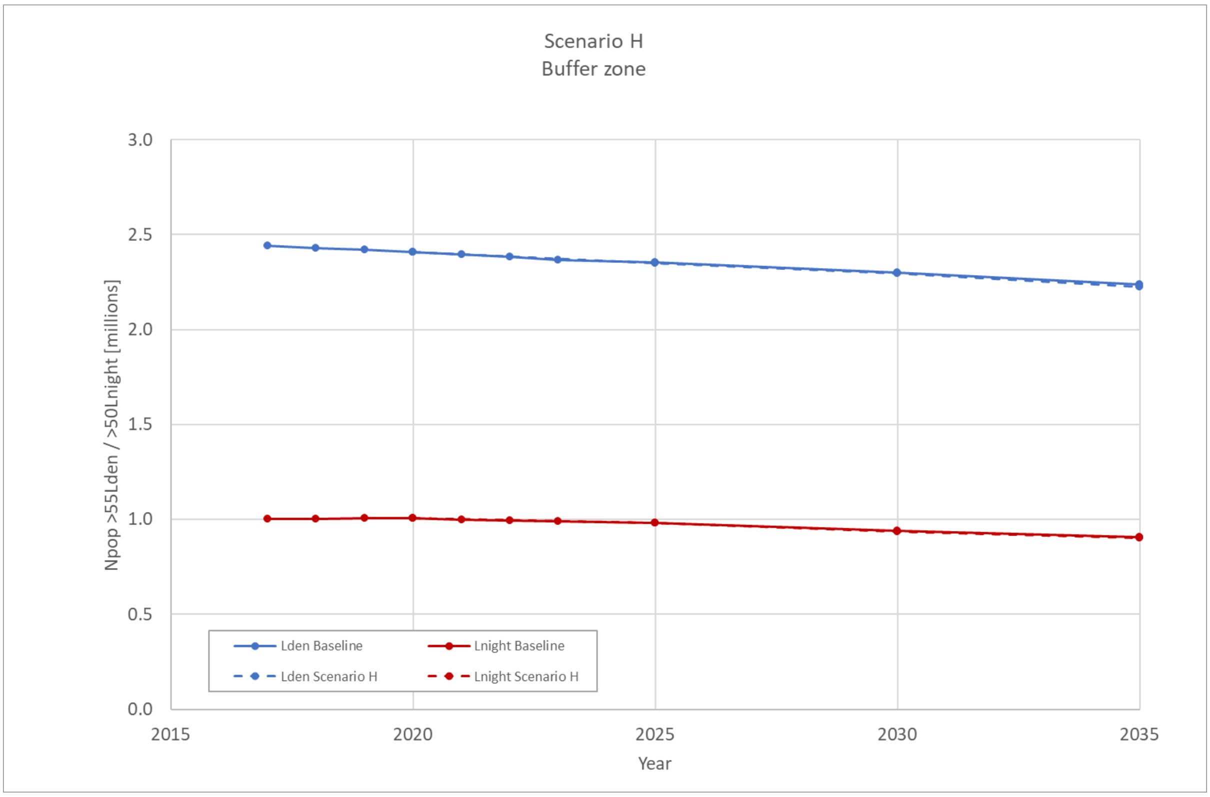
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
F1	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
accelerated	**2025**	7.126	4.009	1.706	0.444	0.068	0.009	0.000	4.171	1.813	0.688	0.192	0.024	0.002	0.000
fleet renewal	**2030**	6.543	3.680	1.580	0.398	0.059	0.008	0.000	3.714	1.615	0.609	0.176	0.020	0.002	0.000
-0.05dB/year	**2035**	6.335	3.563	1.538	0.377	0.057	0.008	0.000	3.559	1.547	0.580	0.174	0.018	0.002	0.000

Figure 26. Noise exposure distribution for Scenario F



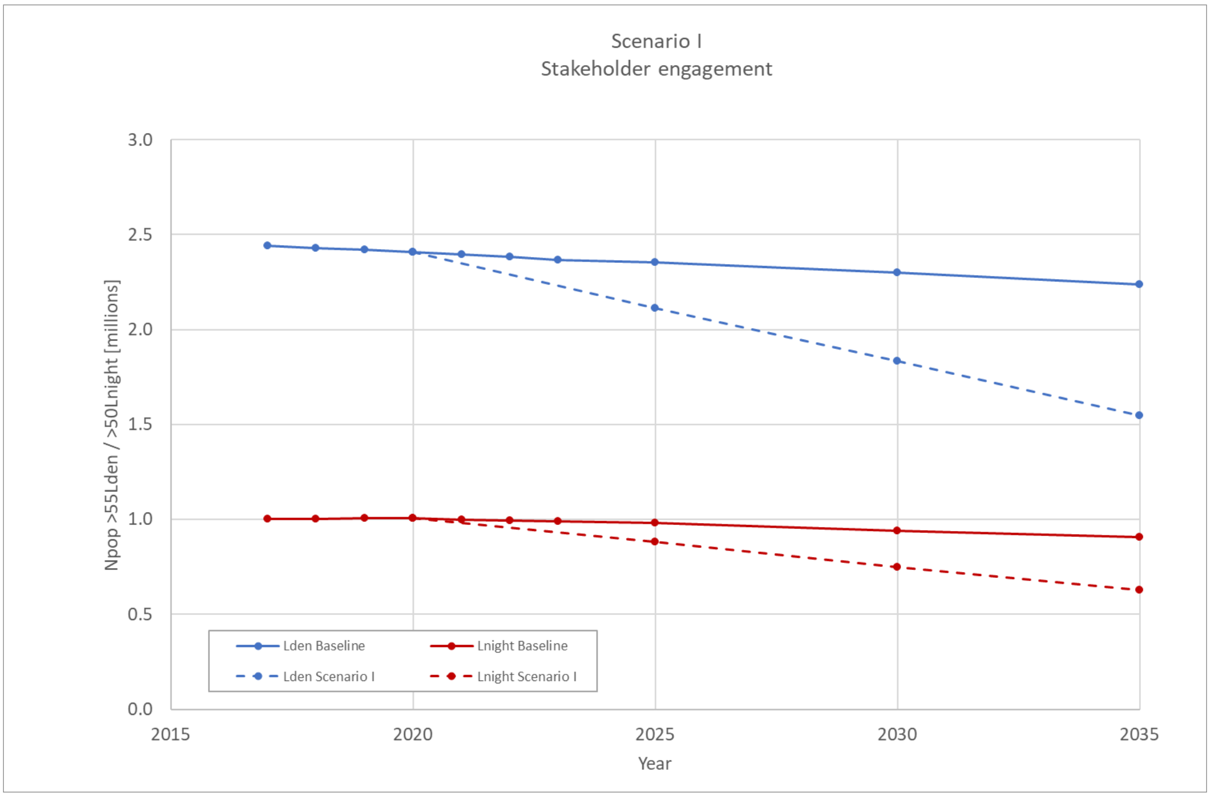
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
G sound insulation	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.054	0.008	0.000	4.522	1.966	0.750	0.203	0.028	0.001	0.000
	2030	7.365	4.143	1.759	0.464	0.034	0.005	0.000	4.317	1.877	0.717	0.192	0.027	0.001	0.000
	2035	7.157	4.026	1.718	0.443	0.033	0.005	0.000	4.163	1.810	0.688	0.190	0.025	0.001	0.000

Figure 27. Noise exposure distribution for Scenario G



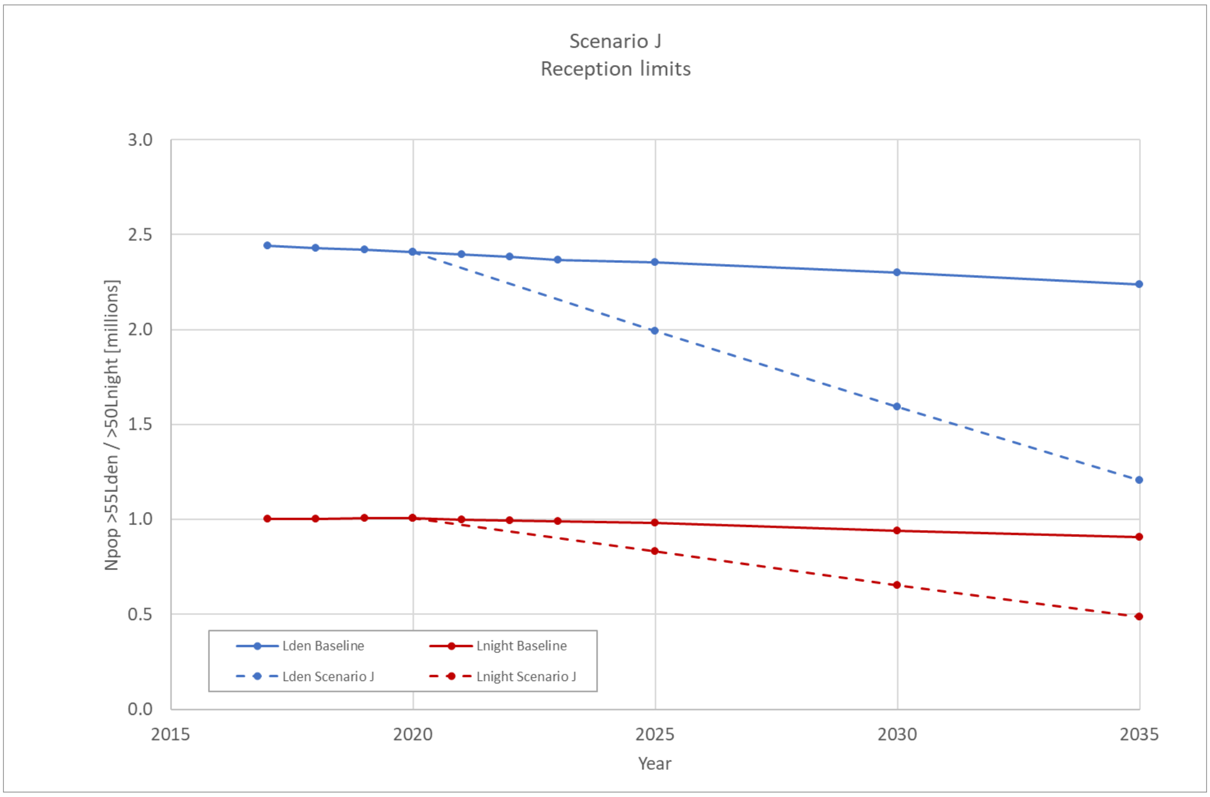
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
H buffer zone	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	4.237	1.798	0.473	0.072	0.007	0.000	4.522	1.966	0.750	0.203	0.028	0.001	0.000
	2030	7.365	4.143	1.759	0.464	0.068	0.003	0.000	4.317	1.877	0.717	0.192	0.027	0.001	0.000
	2035	7.157	4.026	1.718	0.443	0.066	0.000	0.000	4.163	1.810	0.688	0.190	0.025	0.000	0.000

Figure 28. Noise exposure distribution for Scenario H



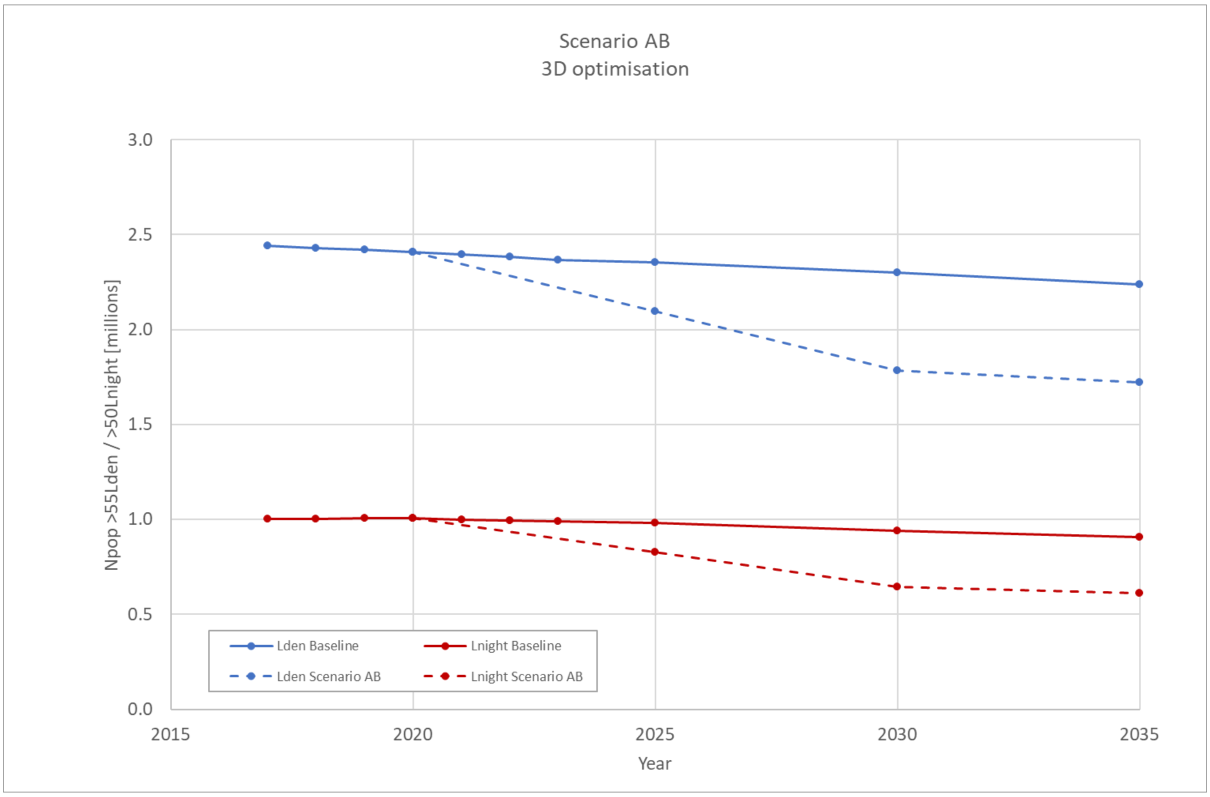
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
I stakeholder engagement	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	3.912	1.621	0.419	0.064	0.009	0.000	4.522	1.804	0.677	0.180	0.025	0.002	0.000
	2030	7.365	3.507	1.414	0.358	0.053	0.008	0.000	4.317	1.568	0.577	0.148	0.020	0.001	0.000
	2035	7.157	3.102	1.208	0.292	0.044	0.006	0.000	4.163	1.361	0.489	0.124	0.016	0.001	0.000

Figure 29. Noise exposure distribution for Scenario I



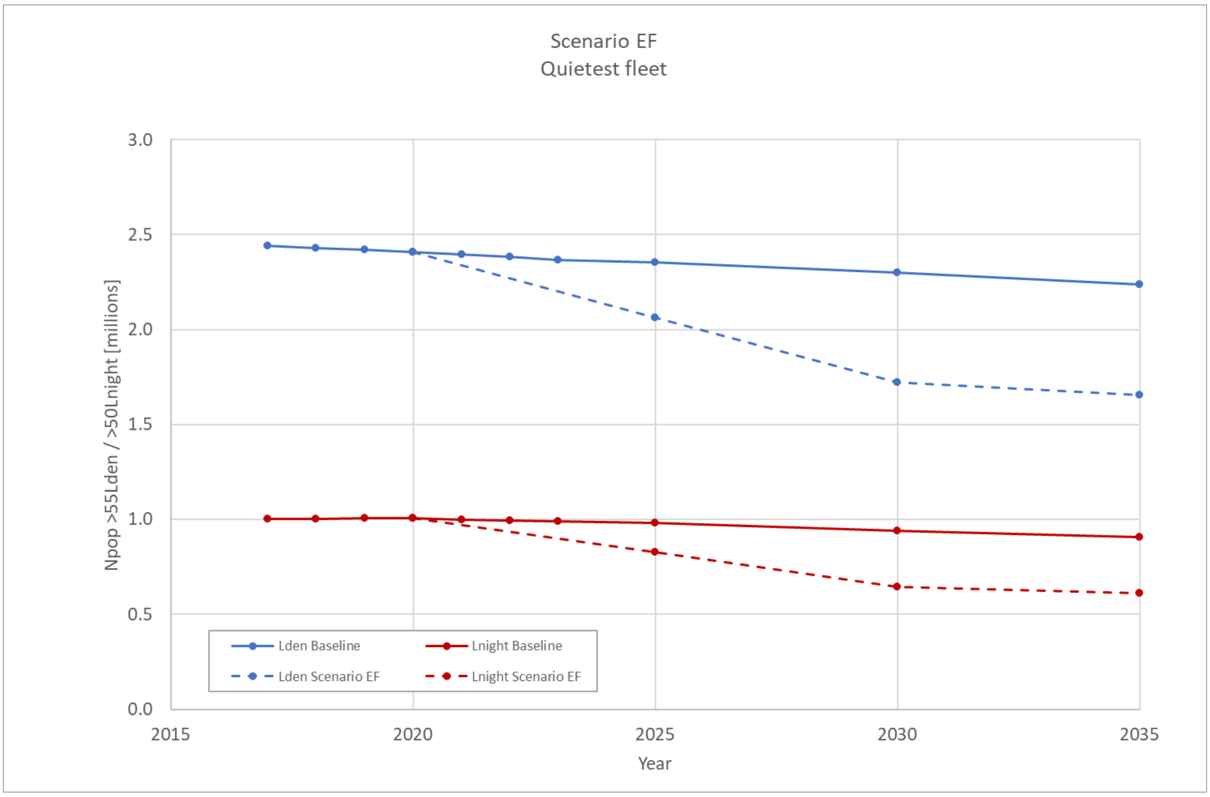
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
J reception limits	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	7.532	3.912	1.621	0.315	0.048	0.007	0.000	4.522	1.804	0.677	0.135	0.019	0.001	0.000
	2030	7.365	3.507	1.414	0.155	0.023	0.003	0.000	4.317	1.568	0.577	0.064	0.009	0.001	0.000
	2035	7.157	3.102	1.208	0.000	0.000	0.000	0.000	4.163	1.361	0.489	0.000	0.000	0.000	0.000

Figure 30. Noise exposure distribution for Scenario J



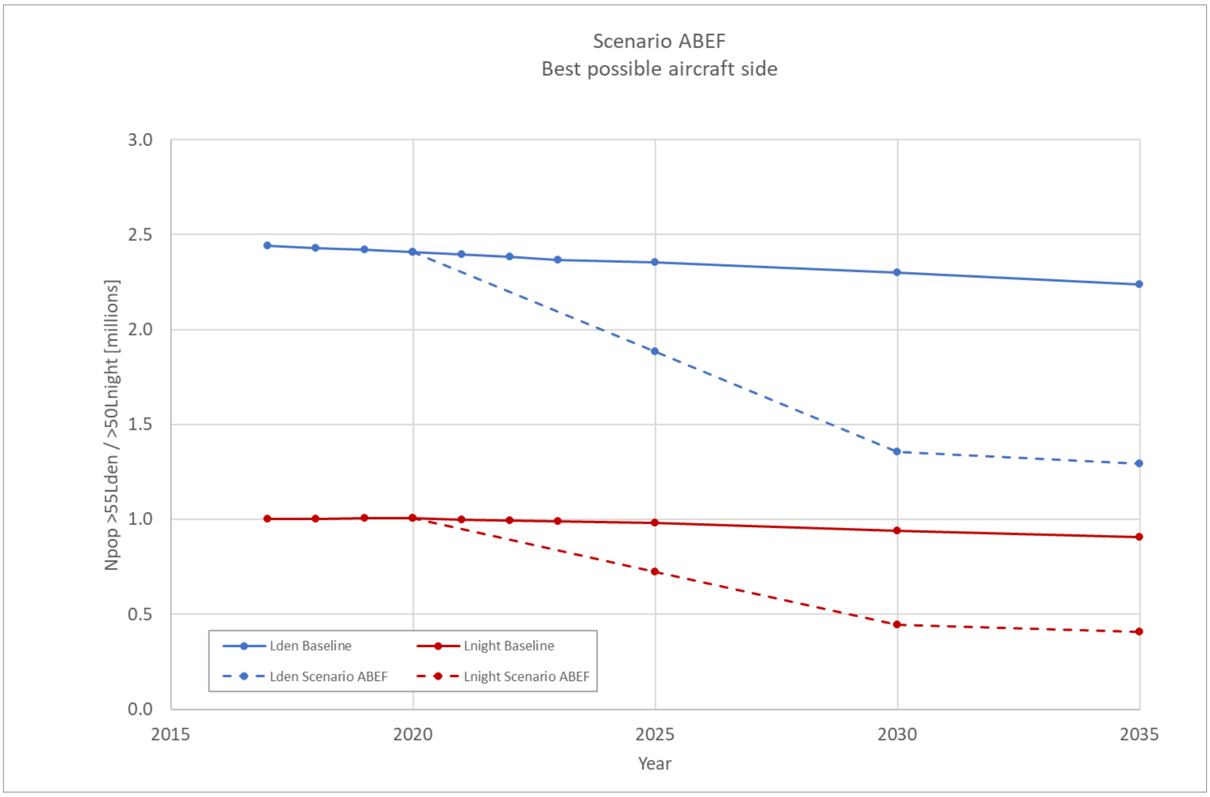
		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
AB 3D optimisation	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.713	3.776	1.632	0.400	0.057	0.010	0.000	3.798	1.651	0.631	0.171	0.022	0.002	0.000
	2030	5.716	3.215	1.432	0.310	0.036	0.008	0.000	2.969	1.291	0.495	0.134	0.014	0.002	0.000
	2035	5.508	3.098	1.391	0.288	0.034	0.008	0.000	2.815	1.224	0.466	0.131	0.012	0.002	0.000

Figure 31. Noise exposure distribution for Scenario AB



		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
EF quietest fleet	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.607	3.716	1.582	0.412	0.062	0.008	0.000	3.799	1.652	0.629	0.175	0.020	0.002	0.000
	2030	5.504	3.096	1.332	0.335	0.047	0.005	0.000	2.971	1.292	0.490	0.142	0.012	0.001	0.000
	2035	5.296	2.979	1.291	0.314	0.046	0.005	0.000	2.816	1.224	0.461	0.140	0.010	0.001	0.000

Figure 32. Noise exposure distribution for Scenario EF



		Population exposed (x10^6)													
		Lden							Lnight						
Scenario	**Year**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**>75**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**>70**
ABEF best possible aircraft side	**2020**	7.710	4.337	1.832	0.490	0.077	0.011	0.000	4.627	2.012	0.767	0.207	0.029	0.002	0.000
	2025	6.026	3.389	1.467	0.357	0.051	0.008	0.000	3.333	1.449	0.554	0.150	0.020	0.002	0.000
	2030	4.342	2.442	1.103	0.225	0.024	0.005	0.000	2.038	0.886	0.340	0.092	0.010	0.001	0.000
	2035	4.134	2.325	1.061	0.204	0.022	0.004	0.000	1.884	0.819	0.311	0.089	0.008	0.001	0.000

Figure 33. Noise exposure distribution for Scenario ABEF

Annex 7: List of legislation and other policy instruments in NAPs

Additional legislation in NAPs						
Sector	**Country**	**NAP**	**Type**	**Legislation/plan/strategy**	**Level**	**Type/policy area**
General environmental noise	BE	Belgian NAPs	Legislations	Order of 1 April 2004 amending the Order of 17 July 1997 on urban noise abatement. Official publication: Staatsblad; Publication date: 26/04/2004; Page number: 34299-34308	National	Environment
Road	BE	Charleroi	Instruments	Communal Mobility Plan (2015-2020)	Local	Transport
Road	BE	Charleroi	Legislations	Environmental permit (in force since 2002)	Regional	Construction
General environmental noise	BE	Charleroi	Legislations	Order of the Walloon Government on the assessment and management of environmental noise. May 13th 2004.	Regional	Environment
General environmental noise	BE	Charleroi	Legislations	Order of the Walloon Government of 13 September 2007 delimiting the agglomerations and infrastructures that must be the subject of acoustic mapping.	Regional	Environment
General environmental noise	BE	Charleroi	Legislations	Order of the Walloon Government of 17 December 2015 adopting the noise limit values in agglomerations of more than 100,000 inhabitants.	Regional	Environment
Several transports	BE	Charleroi	Legislations	The Order of the Walloon Government of 12 March 2009 establishing strategic noise maps of major roads with more than 6 million vehicle passages per year Order of the Walloon Government of 12 March 2009 establishing the strategic noise maps of the main railway lines with more than 60,000 train passages per year	Regional	Transport
Road	BE	Wallonia Roads	Instruments	Infrastructure Plan (2016-2019)	Regional	Infrastructure
Rail	BE	Flanders Rail	Instruments	Flemish railway strategy 2013	Regional	Transport
Rail	BE	Flanders Rail	Instruments	Flemish action plan on railway noise	Regional	Transport
Rail	BE	Flanders Rail	Instruments	Flanders Space Policy Plan	Regional	Land-use planning
Rail	BE	Flanders Rail	Instruments	Vision 2050 Flanders	Regional	Long-term strategy
General environmental noise	BE	Flanders Rail	Legislations	Decree of the Flemish Government of 22 July 2005 on the evaluation and management of environmental noise and amending the Decree of the Flemish Government of 1 June 1995 on the general and sectoral provisions on environmental hygiene.	Regional	Environment
General environmental noise	BE	Flanders Rail	Instruments	Names and contact details of competent authorities in implementation of Directive 2002/49/EC relating to the assessment and management of environmental noise	Regional	Environment
General environmental noise	FR	Paris round 1	Legislations	Order of August 20th 1985 relating to airborne noise emitted into the environment by installations classified for the protection of the environment	National	Infrastructure
Other	FR	Paris round 1	Instruments	Local urban plan (PLU)	Local	Urban Planning
General environmental noise	FR	Paris round 1	Instruments	Certificate of compliance with acoustic regulations. Decree No. 2011-604 of 30 May 2011 and Order of 27 November 2012	National	Construction
General environmental noise	NL	Dutch NAPs	Legislations	Act of 30 June 2004 amending the Noise Abatement Act, the Aviation Act and the Railway Act in connection with the implementation of Directive No 2002/49/EC of the European Parliament and of the Council of the European Union of 25 June 2002 relating to the assessment and management of environmental noise, OJEC L 189 (noise maps and action plans).	National	Transport
Other	NL	South Holland Road	Instruments	Policy vision Sustainability and Environment 2013-2017	Regional	Environment
Several transports	NL	South Holland Road	Instruments	SWUNG Working Together on the Implementation of New Noise Policy	National	Environment
Road	NL	South Holland Road	Instruments	Multi-Year Programme Provincial Infrastructure	Regional	Infrastructure
General environmental noise	ES	Spain	Legislations	Law 37/2003 of November 17th on Noise. BOE-A-2003-20976. Royal decree 1513/2005, December 16, for the development of Law 37/2003 of November 17 on Noise, referring to the evaluation and management of environmental noise. BOE 301/2005	National	Environment
General environmental noise	ES	Vitoria Gasteiz	Legislations	Autonomous legislation decree 213/2012	Regional	Environment
General environmental noise	ES	Vitoria Gasteiz	Legislations	Municipal ordinance on noise and vibration	Local	Environment
Several transports	ES	Bilbao 2019	Instruments	Sustainable Urban Mobility Plan	Local	Transport
General environmental noise	ES	Bilbao 2014	Legislations	Municipal ordinance on noise and vibration	Local	Environment
General environmental noise	ES	Barcelona	Legislations	Decree adopting noise mapping 176/2009	Local	Environment
Aviation	DK	Copenhagen Kastrup Airport	Legislations	Environmental Protection Agency's Guide No 5/1994 on noise from airfields. Noise-limiting regulations can be found in Aeronautical Information Publication Denmark (AIP)	National	Environment
Aviation	DK	Copenhagen Kastrup Airport	Instruments	Environmental Protection Agency's Guide No. 5/1984 "External noise from companies".	National	Environment
Other	DK	Copenhagen agglomeration	Instruments	Sound conditions guidelines “Environment in Construction”	National	Construction
Other	DK	Copenhagen agglomeration	Legislations	Buildings Regulation on noise limit values (2010)	National	Construction
Other	DK	Copenhagen agglomeration	Instruments	City Municipial Plan Copenhagen	Local	Transport
Other	DK	Copenhagen agglomeration	Instruments	City urban renewal strategy (2013-2017)	Local	Construction
General environmental noise	FI	Helsinki agglomeration	Legislations	Provincial Decree on application in Åland of the Government Decree on noise investigations and noise action plans provided for by the European Community (51/2005)	Regional	Environment
General environmental noise	FI	Helsinki agglomeration	Instruments	Plan: Noise is taken into account in land use	Local	Land-use planning
General environmental noise	FI	Helsinki agglomeration	Instruments	Plan: Noise is taken into account in transport system design, traffic planning, increasing attractiveness of public transport, promoting walking and cycling, promote the introduction of hybrid and electric buses, taking noise into account in vehicle procurement criteria for public transport	Local	Transport
Other	FI	Helsinki agglomeration	Instruments	Plan: Explore the possibilities for including quiet areas in the new master plan and develop new so-called urban quiet areas	Local	Urban Planning
Other	FI	Helsinki agglomeration	Instruments	Plan: Increase information on ways to improve the sound insulation of windows	Local	Building
Aviation	FI	Helsinki Vantaa Airport	Instruments	Finavia study of the effects of aircraft noise	National	Health
Aviation	FI	Helsinki Vantaa Airport	Instruments	Finavia study of the effects of aircraft noise	National	Building

Aviation	FI	Helsinki Vantaa Airport	Instruments	The plan of Uusimaa region is reviewed taking into consideration land planning measures and transport system; reference to municipal land use, investment permits	Regional	Land-use planning
Aviation	FI	Helsinki Vantaa Airport	Instruments	Voluntary Code of Practice: "Mitigation of Noise from Arriving Aircra	Local	Transport
Aviation	FI	Helsinki Vantaa Airport	Legislations	Environmental Permit Decision (4 August 2011 No. 49/2011/1)	National	Environment
General environmental noise	FI	Oulu agglomeration	Legislations	Provincial Decree on application in Åland of the Government Decree on noise investigations and noise action plans provided for by the European Community (51/2005)	Regional	Environment
Road	FI	Oulu agglomeration	Instruments	Noise reduction plan between municipalities and transport service for car reduction	Local	Transport
Road	IE	Cork County Major Roads	Instruments	Strategy: Valuation of Noise by the Working Group on Health and Socio-Economic Aspects	National	Health
Road	IE	Cork County Major Roads	Instruments	National Spatial Strategy; Smarter Travel - A Sustainable Transport Future; A New Transport Policy for Ireland 2009-2020	National	Transport
Road	IE	Cork County Major Roads	Legislations	Environmental Protection Agency (EPA) Act 1992	National	Environment
Road	IE	Cork County Major Roads	Legislations	Part E of the Building Regulations 1997 (S.I. no. 497 of 1997)	National	Building
Road	IE	Dublin agglomeration 2014	Instruments	'Smart Travel, a Sustainable Travel Future'	National	Transport
Road	IE	Dublin agglomeration	Instruments	(1) "Urban Design Manual and the Design Manual for Urban Road and Streets 2013" (2) Our Sustainable Future, A Framework for Sustainable Development in Ireland (2012) (3) Sustainable Urban Housing: Design Standards for New Apartments (Guidelines for Planning Authorities) (2007) (4) Sustainable Residential Development in Urban Areas: Guidelines for Planning Authorities (2009) (5) Urban Design Manual: A best practice guide (A companion document to the Draft Planning Guidelines on Sustainable Residential Development in Urban Areas) (2008)	National	Urban Planning
Road	IE	Dublin agglomeration	Legislations	Irish Roads Act 1993	National	Transport
Other	IE	Dublin agglomeration	Legislations	Buildings Regulations 1997 - 2012	National	Building
General environmental noise	IE	Dublin agglomeration	Instruments	'Guidance Note for Noise: License Applications, Surveys and Assessments in Relation to Scheduled Activities (NG4)' (2012)	National	Land-use planning
Other	IE	Dublin agglomeration	Instruments	Regional Planning Guidance for the Greater Dublin Area 2010 – 2022	Regional	Land-use planning
Other	IE	Dublin agglomeration	Instruments	Development Plans and Local Area Plans (transportation, environment and development control policies)	Local	Urban Planning
Road	IE	Dublin agglomeration	Instruments	Transportation Policy for the Greater Dublin Area 2011-2030 (planning for sustainable living, reducing car use, reduce noise and vibration)	Local	Transport
Several transports	IE	Dublin agglomeration	Instruments	Smarter Travel – A Sustainable Transport Future 2009-2020	Local	Transport
Several transports	IE	Dublin agglomeration	Instruments	National Cycle Policy Framework 2009-2020 (10% of all work trips should be made by bicycle)	National	Transport
Other	IE	Dublin agglomeration	Instruments	Wind Energy Guidelines from Department of the Environment, Heritage and Local Government guidance	Local	Other
Other	IE	Dublin agglomeration	Legislations	Environmental Protection Agency Act 1992	National	Environment
Aviation	IE	Dublin airport	Instruments	Guidance : "Environmental Protection Agency Guidance Note for Noise Action Planning"	National	Environment
Aviation	IE	Dublin airport	Instruments	Urban Design Manual and the Design Manual for Urban Roads and Streets 2013	Local	Transport
Aviation	IE	Dublin airport	Instruments	Planning and Development for local authorities (in general)	Local	Land-use planning
General environmental noise	IE	Limerick agglomearation	Instruments	Professional Practice Guidance on Planning & Noise (2017); National Planning Framework 2040; Planning and Development (Strategic Housing Development) Regulations (2017); Professional Planning Guidance (ProPG) on Planning & Noise New Residential Development	National	Urban Planning
Road	IE	Limerick agglomearation	Legislations	Roads Act 1993 (amended in 2015)	National	Transport
Road	IE	Limerick agglomearation	Instruments	Guidelines for the Treatment of Noise and Vibration in National Road Schemes	National	Transport
General environmental noise	IE	Limerick agglomearation	Legislations	Building Regulations 1997-2007; BS 8233-2014: Guidance on sound insulation and Noise Reduction for Buildings	National	Building
General environmental noise	IE	Limerick agglomearation	Legislations	Environmental Protection Agency Act 1992 in particular Section 106 – Regulations for Control of Noise; Section 107 – Power of Local Authority or Agency to Prevent or Limit Noise; Section 108 – Noise as a Nuisance	National	Environment
Road	IE	Limerick agglomearation	Instruments	Transport Infrastructure Ireland Guidelines (TII)	National	Transport
Other	IE	Limerick agglomearation	Instruments	Limerick City Development Plan 2010-2016 (as extended);	Local	Land-use planning
Other	IE	Limerick agglomearation	Instruments	Limerick County Development Plan 2010-2016 (as extended); Castetroy Local Area Plan;	Regional	Land-use planning
General environmental noise	IE	Limerick agglomearation	Instruments	Guidance Note for Noise: Licence Applications, Survey and Assessment in Relation to Scheduled Activities	National	Other
Aviation	IE	Dublin airport 2018	Instruments	A National Aviation Policy for Ireland, 2015	National	Transport
Other	IE	Dublin airport 2018	Instruments	Eastern and Midland Regional Assembly Regional Spatial and Economic Strategy (To replace current Regional Planning Guidelines for the Greater Dublin Area 2010-2022)	Regional	Land-use planning
Other	IE	Dublin airport 2018	Instruments	Fingal Development Plan 2017-2023	Regional	Land-use planning
Aviation	IE	Dublin airport 2018	Instruments	Dublin Airport Local Area Plan, 2006	Local	Land-use planning
Aviation	IE	Dublin airport 2018	Instruments	Dublin Airport Central Masterplan, 2016	Local	Land-use planning
Aviation	IE	Dublin airport 2018	Instruments	Dublin Airport Strategic Issues Paper - Local Area Plan, 2018	Local	Land-use planning
Other	IT	Bologna agglomeration	Legislations	Law 447/1995 on environmental pollution	National	Environment
Road	IT	Bologna agglomeration	Legislations	Decree Law 142/2004 on environmental noise prevention from traffic	National	Transport
Rail	IT	Bologna agglomeration	Legislations	Decree Law 459/1998 on environmental noise prevention from railway traffic and its permitted noise levels	National	Transport
General environmental noise	IT	Bologna agglomeration	Legislations	Regional Council Decision 17/09/2012 N. 1369 on adoption of END relevant to acoustic noise maps for regional roads and agglomerations in Emilia Romagna region	Regional	Other
General environmental noise	IT	Bologna agglomeration	Legislations	Regional Council Decision 23/09/2013 N. 1339 on adoption of END relevant to acoustic noise action plans for regional roads and agglomerations in Emilia Romagna region	Regional	Other
Other	IT	Bologna agglomeration	Legislations	Urban Planning Regulation (RUE)	Regional	Other
Aviation	IT	Bologna airport	Legislations	Decree Law 31/10/1997 on methodology measuring airport noise	National	Other
Aviation	IT	Bologna airport	Legislations	Decree Law n. 496 from 11/12/1997 on reduction of environmental noise pollution from aircraft	National	Other
Aviation	IT	Bologna airport	Legislations	Decree Law 20/05/1999 Criteria for monitoring noise pollution levels nearby airports and airport classification	National	Other
Aviation	IT	Bologna airport	Legislations	Decree Law 476 from 09/11/1999 on the modification of Decree Law 31/10/1997 regarding the prohibition of night flights	National	Transport
Aviation	IT	Bologna airport	Legislations	Decree Law 03/12/1999 on noise abatement procedures and buffer zones nearby airports	National	Other
Other	IT	Bologna airport	Legislations	Framework Law 447 of 26/10/1995 on environmental pollution	National	Environment

Road	IT	Bologna airport	Legislations	Decree Law 29/11/2000 on criteria for organizations and companies responsible for public transport and infrastructure and noise reduction plans	National	Transport
Aviation	IT	Bologna airport	Instruments	Bologna Airport Master Plan 2009 - 2023	National	Land-use planning
General environmental noise	IT	Milan Malpensa 2018	Legislations	Decree Law n. 12 of 17/02/17 on harmonization of national laws on environmental noise with Law n. 161 of 30/10/2014	National	Environment
General environmental noise	IT	Milan Malpensa 2018	Legislations	Regional Council Decision n. 8/808 of 11/10/2005: Guidelines for achieving maximum efficiency of airport noise monitoring systems in Lombardy	Regional	Other
Aviation	IT	Milan Malpensa 2018	Instruments	Guidelines for the design and management of acoustic monitoring networks at the airport, ISPRA	National	Other
General environmental noise	IT	Italy Highway A10 Savona-Ventimiglia-French Border	Legislations	Decree Law of Ministry of Environment of 21 November 2000 obliging big infrastructure companies to write noise abatement plans including technical aspects and timeframe	National	Environment
Road	IT	Italy Highway A10 Savona-Ventimiglia-French Border	Instruments	NMPB-Routes-96 (SETRACERTU-LCPC-CSTB) as referred in Law for 10 May 1995 on road noise infrastructure and law XPS 31-133 and "Guide on land transport noise and predicted sound levels, CETUR 1980''	National	Other
General environmental noise	IT	Milan agglomeration	Legislations	Italian Law Decree of 14 November 1997 "Definition of acoustic limit values from sources"	National	Other
Road	IT	Milan agglomeration	Instruments	Project: Dynamic Acoustic Mapping (DYNAMAP)	Local	Transport
Rail	IT	Rail Sacconago Malpensa	Legislations	The Lombardy Region: Regional Law 13, August 10, 2001 "Rules on noise pollution "	Regional	Other
Rail	IT	Rail Sacconago Malpensa	Legislations	The Lombardy Region: DGRL 8 March 2002 - No. 7/8313 " Approval of the document " Methods and criteria for drafting the documentation for predicting acoustic impact and reviewing the acoustic climate "	Regional	Other
Rail	IT	Rail Sacconago Malpensa	Legislations	Decree Ministry of Environment of 16 March 1998 "Detection and measurement techniques for noise pollution"	National	Environment
Rail	IT	Rail Sacconago Malpensa	Legislations	Presidential Decree 753/80 Chapter 3 on "on distance between buildings and railway headquarters considering operational safety measures" (up to 30m from the track in operation)	National	Building
Other	IT	Rail Sacconago Malpensa	Legislations	Prime Minister Decree of 5.12.1997 on "Determination of the passive acoustic requirements of buildings "	National	Building
Rail	IT	Rail Sacconago Malpensa	Legislations	Presidential Decree 753/80 Chapter 3 on "on distance between buildings and railway headquarters considering operational safety measures" (up to 30m from the track in operation)	National	Building
Rail	IT	Rail Sacconago Malpensa	Legislations	Prime Minister Decree of 5.12.1997 on "Determination of the passive acoustic requirements of buildings "	National	Building
Road	IT	Road section A21: Torino-Alessandria-Piacenza	Legislations	Regional Law 15 of 9 May 2001 Provisions on environmental protection from noise pollution	Regional	Environment
Road	IT	Road section A21: Torino-Alessandria-Piacenza	Legislations	Regional Law 52 of 20 October 2000 Provisions on environmental protection from noise pollution	Regional	Environment
Road	IT	Road section A21: Torino-Alessandria-Piacenza	Legislations	Regional Council Decree number 85 – 3802 of 6 August 2001 Acoustic criteria for territory's classification	Regional	Other
Road	IT	Road section A21: Torino-Alessandria-Piacenza	Instruments	Plans for Acoustic Zones for municipalities in the Lombardy region are in the adoption phase	Regional	Other
Road	IT	Road section A21: Torino-Alessandria-Piacenza	Legislations	Decree Law of Ministry of Environment and Protection of Land and Sea of 25 March 2008 on noise abatement plan relevant to road A21 Torino-Alessandria - Piacenza	National	Land-use planning
Aviation	BG	Sofia Airport	Legislations	Civil Aviation Act , Decision of 02/07/2018;	National	Transport
General environmental noise	BG	Sofia Airport	Legislations	Art. 5 of Ordinance № 6/2006 on environmental noise indicators	National	Environment
General environmental noise	HR	Croatia Road Split-Dalmatia County	Legislations	Rulebook on the maximum permissible noise level in work and residential areas Official Gazzette No. 145/04	National	Health
General environmental noise	HR	Croatia Road Split-Dalmatia County	Legislations	French national calculation method : NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB) Law : Arrété du 5 mai 1995 relatif au bruit des infrastructures routiéres, Art. 6. XPS 31-133	National	Other
General environmental noise	CZ	Prague Agglomeration	Legislations	Government Decree No. 272/2011	National	Health
General environmental noise	CZ	Prague Agglomeration	Legislations	Law 258/2000 on noise limit values	National	Other
General environmental noise	CZ	Prague Agglomeration	Legislations	Quiet areas in the agglomeration Act No. 222/2006	National	Health
Other	CZ	Prague rail	Legislations	Government Decree No. 217/2016 on the condition of ensuring direct ventilation (..buildings..)	National	Building
General environmental noise	CZ	Prague rail	Legislations	Amended Government Decree No. 272/2011 transfer the responsibility for compliance with (indoor) noise limits to buildings owner	National	Building
General environmental noise	SE	Sweden national road	Instruments	Community planning: "A society with a good sound environment without disturbing vibrations"	National	Urban Planning
Road	SE	Sweden national road	Instruments	National Plan for the Transport System 2014-2025	National	Transport
Other	SE	Sweden national road	Instruments	Internal guideline for buildings planning	National	Building
Other	SE	Sweden national road	Legislations	Infrastructure Bill 1996/97 (indoor house noise levels)	National	Building
General environmental noise	SE	Stockholm Arlanda Airport	Legislations	Government's Bill 1996/97 (guidelines on noise limits)	National	Other
Aviation	SE	Stockholm Arlanda Airport	Legislations	Regulation (2004: 501) of the Swedish Transport Agency on the introduction of operating restrictions at airports.	National	Transport
General environmental noise	SE	Stockholm Arlanda Airport	Legislations	Environmental Protection Act / Environmental Code	National	Environment
Other	SE	Stockholm Arlanda Airport	Legislations	Regulation (1998: 896) on land and water management.	National	Land-use planning
General environmental noise	FR	French NAPs	Legislations	Ordinance n° 2004/1199 of 12 November 2004 taken in order to transpose directive 2002/49/CE of the European Parliament and Council of 25 June 2002 referring to the evaluation and management of noise in the environment	National	Environment
General environmental noise	FR	French NAPs	Legislations	Law n°2005-1319 of 26/10/2005 on various provisions for adaptation to Community law in the field of the environment	National	Environment
General environmental noise	FR	French NAPs	Legislations	Decree n°2006-361 of 24 March 2006 relating to the establishment of noise maps and environmental noise prevention plans and amending the urban planning code	National	Urban Planning

Aviation	FR	French NAPs	Legislations	Decree of 3 April 2006 fixing the list of the aerodromes mentioned in the I of the article R.147-5-1 of the urban planning code	National	Urban Planning
General environmental noise	FR	French NAPs	Legislations	French environmental code articles L572-1 and following.	National	Environment
Other	FR	Grenoble 2019	Instruments	Metropolitan Green-Blue Plan	Local	Environment
Other	FR	Grenoble 2019	Instruments	Climate, air and energy territorial plan	Local	Environment
Other	FR	Grenoble 2019	Instruments	Urban Travel Plan 2030	Local	Transport
Road	FR	Grenoble 2019	Instruments	Low-emissions zones	Local	Transport
General environmental noise	FR	Bordeaux 2019	Instruments	Noise black hotspots resorption programme (1999)	National	Environment
General environmental noise	FR	Bordeaux 2019	Legislations	Law 92-1444 of 31 december 1992 on noise management	National	Environment
General environmental noise	FR	Bordeaux 2019	Legislations	Decree No. 95-22 of 9 January 1995 on the limitation of noise from land transport facilities and infrastructures	National	Environment
Other	FR	Bordeaux 2019	Instruments	Territorial Coherence Scheme (SCoT)	Local	Urban Planning
Several transports	FR	Bordeaux 2019	Instruments	Operational master plan for metropolitan transport (SDODM)	Local	Transport
Other	FR	Bordeaux 2019	Instruments	Bicycle Plan 2016	Local	Transport
Other	FR	Bordeaux 2019	Legislations	Decree 30 May 1996 on sound insulation requirements for buildings	National	Construction
Rail	FR	Bordeaux 2019	Legislations	Prefectoral decree of 2 June 2016 on tracks noise classification	Regional	Transport
General environmental noise	FR	Bordeaux 2019	Instruments	Sound plan	Local	Other
Several transports	FR	Nice 2019	Instruments	Administration Mobility Plan	Local	Transport
Other	FR	Nice 2019	Instruments	Code of Conduct for Nightlife	Local	Other
General environmental noise	FR	Nice 2019	Legislations	Municipal decree on noise	Local	Other
Other	FR	Nice 2019	Legislations	Municipal decree on delivery hours	Local	Other
Other	FR	Nice 2019	Legislations	Municipal decree on closing night shops	Local	Other
Other	FR	Nice 2019	Instruments	Environmental Charter of the city of Nice	Local	Environment
Other	FR	Nice 2019	Instruments	2009 Charter on green construction sites	Local	Construction
Other	FR	Nice 2019	Instruments	Environmental charter of the harbour of Nice	Local	Other
Other	ES	Madrid 2014	Instruments	Zonal plans associated to specific target areas	Local	Other
Several transports	ES	Madrid 2014	Instruments	Sustainable Urban Mobility Plan	Local	Transport
General environmental noise	ES	Madrid 2014	Legislations	Ordinance on Protection against Noise and Heat Pollution (OPCAT)	Local	Environment
General environmental noise	ES	Valencia rail	Legislations	Law 7/2002 of 3 December and decrees 266/2004 of 3 December and 104/2006 of the Autonomous Community of Valencia	Regional	Environment
Aviation	FR	CDG airport	Legislations	Urban planning code	National	Land-use planning
Aviation	FR	CDG airport	Legislations	Decree 28 January 2003 setting a representative indicator on sound energy created by airport activity at CDG airport	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 18 February 2003 restricting use by creating environmental protection volumes at Paris-Charles de Gaulle airfield	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 20 June 2003 on operating restrictions at CDG airport	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 8 September 2003 extending the operating restrictions at CDG airport	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 6 November 2003 forbidding unplanned take-offs between 0 am and 5 am at CDG airports	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 6 November 2003 restricting the operation of some aicrafts over take-off nosie limits or landing noise limits at CDG airport	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 6 November 2003 on the attribution of time slots at night at CDG airport	Local	Other
Aviation	FR	CDG airport	Legislations	Decree of 20 September 2011 on operating restrictions at CDG airport	Local	Other
Aviation	FR	CDG airport	Instruments	Airport noise exposure plan	Local	Other
Aviation	FR	CDG airport	Legislations	Law 2014-366 of 24 March 2014 on access to housing and renovated urban planning	National	Building
Aviation	FR	CDG airport	Instruments	Noise annoyance plan	Local	Other
Aviation	FR	CDG airport	Legislations	Law of 11 July 1985 relating to urban planning in the vicinity of aerodromes.	National	Urban Planning
Aviation	FR	CDG airport	Legislations	Law of 12 July 1999 creating ACNUSA, the Airport Nuisance Control Authority	National	Transport
Aviation	FR	CDG airport	Legislations	Decree of 5 September 2012 regulating air traffic over the parisian region	Regional	Transport
General environmental noise	FR	Paris 2019	Legislations	Ministerial decree of 14 April 2017 setting the list of agglomerations to draft NAPs and noise maps (100 000 inhabitants and more)	National	Other
Other	PT	Lisbon airport	Instruments	Municipal Master Plan (PDM) of the City of Lisbon	Local	Urban Planning
General environmental noise	PT	Linha do Minho rail	Legislations	General regulation on noise (RGR) - Decree-law n°9/2007 (17 January), ratified by the declaration of ratification n°18/2007 of 16 March and edited by the Decree-law n°278/2007 of 1 August	National	Environment
General environmental noise	PT	Linha do Minho rail/Portuguese NAPs	Legislations	Decree-law 146/2006 edited by Decree-law 136-A/2019. Presidency of the Council of Ministers-Decree Law no. 146/2006, which transposes Directive no. 2002/49/EC of the European Parliament and of the Council, of 25 June, on the assessment and management of environmental noise, published in the Diário da República, 1st series, no. 146, of 31 July 2006, has been rectified.	National	Environment

General environmental noise	PT	Portuguese NAPs	Legislations	Presidency of the Council of Ministers - Legal Centre - Rectifies the Regional Legislative Decree No. 23/2010/A, of 30 June, of the Legislative Assembly of the Autonomous Region of the Azores, which approves the general regulation on noise and noise pollution control and transposes into the regional legal order Directives No. 23/2010/A, of 30 June, of the Autonomous Region of the Azores. 2002/49/EC of the European Parliament and of the Council of 25 June relating to the assessment and management of environmental noise, 2002/30/EC of the European Parliament and of the Council of 26 March on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports, and 2003/10/EC of the European Parliament and of the Council of 6 February on the minimum health and safety requirements regarding the exposure of workers to the risks arising from noise.	Regional	Environment
General environmental noise	PT	Lisbon agglomeration	Legislations	Basic Law on the Environment n°11/87 11 de Abril	National	Environment
General environmental noise	PT	Lisbon agglomeration	Legislations	General Regulation on noise Decree-law 251/87 of 24 June	National	Environment
General environmental noise	PT	Lisbon agglomeration	Legislations	Legal Regulation on Noise Pollution - Decree-law 292/2000 of 14 November.	National	Environment
Other	PT	Lisbon agglomeration	Instruments	Municipal Plans of Territorial Planning	Local	Urban Planning
Road	PT	Lisbon agglomeration	Instruments	Low-emissions zones	Local	Transport
Other	PT	Lisbon agglomeration	Instruments	Local orders for opening hours of restaurants and bars	Local	Other
Aviation	DK	Copenhagen Kastrup Airport 2018	Instruments	Copenhagen Aiport Development Plan Act no. 271 of 16 June 1980, revised by Act no. 252 of 9.April 1992	Local	Transport
General environmental noise	RO	Henri Coanda Bucharest airport	Legislations	Government Decision no. 321/2005 on the Assessment and Management of Environmental Noise	National	Environment
Several transports	RO	Romania	Legislations	Order of the Minister of Transport, Construction and Tourism, to establish the units responsible for drawing up noise maps for railways, their roads and airports in their administration, strategic noise maps and their action plans, within their field of activity and their respective limits of competence. Official publication: Monitorul Oficial al României; Number: 766; Publication date: 23/08/2005; Page number: 00026-00027	National	Transport
General environmental noise	RO	Romania	Legislations	Law No 121/2019 on assessment and management of environmental noise	National	Environment
General environmental noise	RO	Romania	Legislations	Order No 1090 of 6 December 2019 concerning the transposition into national law of Appendices A to I of the Annex to Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council Official publication: Monitorul Oficial al României; Number: 1031; Publication date: 23/12/2019; Page number: 00012-00012	National	Environment
General environmental noise	RO	Romania	Legislations	Annexes 1-9 to Order No 1090 of 6 December 2019 concerning the transposition into national law of Appendices A to I of the Annex to Commission Directive (EU) 2015/996 of 19 May 2015 establishing common noise assessment methods according to Directive 2002/49/EC of the European Parliament and of the Council. Official publication: Monitorul Oficial al României; Number: 1031bis; Publication date: 23/12/2019; Page number: 00003-00682	National	Environment
Other	RO	Henri Coanda Bucharest airport	Legislations	Law 152/2005 on integrated Pollution Prevention and Control	National	Environment
General environmental noise	RO	Henri Coanda Bucharest airport	Legislations	Order of the Minister of the Environment and Sustainable Development, the Minister of Transport, the Minister of Public Health and the Minister of the Interior and Administrative Reform no. 152/558/1119/532/2008 approving the guide to noise limits setting	National	Environment
Aviation	RO	Henri Coanda Bucharest airport	Legislations	Government Decision no. 1074/2007 regarding the prohibition of the operation at the Romanian airports of civil aircraft that do not comply with the standards specified in Part II, Chapter 3, Volume IAnnex 16 to the Convention on International Civil Aviation	National	Environment
Aviation	RO	Henri Coanda Bucharest airport	Legislations	Order of the Minister of Transport No. 1261/2007 for the approval of the Romanian Civil Aviation Regulation RACR - PM "Environmental Protection", edition 3/2007	National	Transport
Aviation	RO	Henri Coanda Bucharest airport	Instruments	Environmental permit no. 5 of 23 September 2009 of Henri International Airport Coanda-Bucharest	Local	Environment
Aviation	RO	Henri Coanda Bucharest airport	Instruments	strategic programme for the development of the airport infrastructure in Henri Coanda Bucharest International, approved by Government Ordinance no. 64/1999, approved with amendments by Law no. 220/2002	Local	Other
Rail	RO	Bucharest Brazi rail	Legislations	GD 877/2010 on the interoperability of the railway system	National	Transport
Rail	RO	Bucharest Brazi rail	Legislations	Law no. 55/2006 on railway safety	National	Transport
General environmental noise	EE	Tallinn agglomeration	Legislations	Regulation No. 87 of the Minister of Social Affairs of 29 June 2005 strategic Ambient Air Act: minimum requirements for the content of the noise map and the action plan for the reduction of ambient noise	National	Environment

General environmental noise	EE	Estonia	Legislations	Ambient Air Protection Act - Official publication: Elektrooniline Riigi Teataja; Number: RTI 2004, 43, 298	National	Environment
Other	EE	Tallinn agglomeration	Instruments	Tallinn City Master Plan	Local	Land-use planning
Other	EE	Tallinn agglomeration	Legislations	Public Health Act	National	Health
General environmental noise	EE	Tallinn agglomeration	Legislations	Regulation No. 42 of the Minister of Social Affairs of 4 March 2002 “Noise levels in living and recreational areas, residential and communal buildings and noise measurementmethods	National	Environment
General environmental noise	EE	Tallinn agglomeration	Legislations	Regulation No. 75 of the Minister of Social Affairs of 6 May 2002 “Ultrasonic and infrasoundlimit values for sound pressure levels and ultrasonic and infrasound sound pressure levelsmeasurement	National	Environment
General environmental noise	EE	Tallinn agglomeration	Legislations	Regulation No. 124 of the Minister of Economic Affairs and Communications of 16 December 2009"Requirements for noise emitted by equipment used outdoors,noise measurement and labeling and in outdoor conditionsconformity assessment procedures for equipment in us	National	Environment
General environmental noise	EE	Tallinn agglomeration	Legislations	Regulation No. 16 of the Minister of the Environment of 4 March 2011 “Noise in the ambient airrequirements for the preparation of a plan for the purpose of restriction	National	Environment
Other	EE	Tallinn agglomeration	Instruments	Estonian environmental strategy	National	Environment
Several transports	EE	Tallinn agglomeration	Instruments	Transport Development Plan 2006-2013	National	Environment
Other	EE	Tallinn agglomeration	Instruments	General plan of the city of Tallinn and district plans	Local	Urban Planning
Other	EE	Tallinn agglomeration	Instruments	Tallinn street network and soft transport roads (initiated)	Local	Urban Planning
Other	EE	Tallinn agglomeration	Instruments	Location of high-rise buildings in Tallinn	Local	Building
Other	EE	Tallinn agglomeration	Instruments	Planning of recreational opportunities in the Pirita River Valley Landscape Protection Area (initiated) and other similar initiatives	Local	Urban Planning
Other	EE	Tallinn agglomeration	Instruments	Tallinn green areas (initiated)	Local	Environment
Other	EE	Tallinn agglomeration	Instruments	Tallinn Development Plan 2014-2020 and district development plans	Local	Urban Planning

Several transports	EE	Tallinn agglomeration	Instruments	Tallinn Public Transport Development Plan 2011-2020 project (initiated)	Local	Transport
Other	EE	Tallinn agglomeration	Instruments	Strategy "Tallinn 2030"	Local	Long-term strategy
Other	EE	Tallinn agglomeration	Instruments	Tallinn Environmental Strategy until 2030	Local	Environment
Other	EE	Tallinn agglomeration	Instruments	Tallinn Budget Strategy for 2014-2017	Local	Other
Other	EE	Tallinn agglomeration	Instruments	Tallinn Sustainable Energy Action Plan for 2011-2021	Local	Environment
Road	EE	Tallinn agglomeration	Instruments	Development directions of Tallinn traffic for the years 2005—2014	Local	Transport
Road	EE	Tallinn agglomeration	Instruments	Tallinn Program "Traffic Safer in 2008-2014"	Local	Transport
Road	EE	Tallinn agglomeration	Instruments	Tallinn Parking Management Development Plan for 2006—2014	Local	Transport
Several transports	NL	Utrecht agglomeration	Instruments	Municipal Transport Plan 2005	Local	Transport
Other	NL	Utrecht agglomeration	Instruments	Utrecht Attractive and Accessible from June 2012	Local	Long-term strategy
Several transports	NL	Utrecht agglomeration	Instruments	Clean Transport 2010-2014	Local	Transport
Other	NL	Utrecht agglomeration	Instruments	Healthy Air for Utrecht	Local	Environment
Several transports	NL	Amsterdam agglomeration	Instruments	Remediation programme Traffic noise	National	Construction
General environmental noise	NL	Amsterdam agglomeration	Instruments	Environmental Act 2018	National	Environment
Other	NL	Amsterdam agglomeration	Instruments	Sustainability Agenda (2015)	Local	Environment
Several transports	NL	Amsterdam agglomeration	Instruments	Electric Transport Grant Programme	Local	Transport
General environmental noise	NL	Netherlands national roads	Legislations	Environmental Management Act (1979)	National	Environment
General environmental noise	NL	Netherlands national roads	Legislations	Noise Environmental Management Decree (2012)	National	Environment
General environmental noise	NL	Netherlands national roads	Legislations	Noise Nuisance Law (1979)	National	Environment
Several transports	NL	Netherlands national roads	Instruments	multi-annual programme infrastructure, space and transport	National	Infrastructure
General environmental noise	NL	Netherlands national roads	Instruments	multi-annual noise abatement programme	National	Environment
General environmental noise	NL	Netherlands national roads	Instruments	Programme Air and noise measures	National	Environment
Aviation	NL	Amsterdam Schiphol	Legislations	Aviation Law	National	Transport

Aviation	NL	Amsterdam Schiphol	Legislations	Airport Traffic Decree	National	Transport
Aviation	NL	Amsterdam Schiphol	Legislations	Airport zoning decision	Local	Land-use planning
Aviation	NL	Amsterdam Schiphol	Legislations	Schiphol Airport Environmental Information Regulations	Local	Environment
Other	NL	Amsterdam Schiphol	Instruments	regional plans North Holland South (2003) and South Holland West and East (2003)	Regional	Land-use planning
General environmental noise	NL	Amsterdam Schiphol	Legislations	Noise protection regulations 1997	National	Environment
Aviation	NL	Amsterdam Schiphol	Legislations	Aeronautical Environmental Noise Control	National	Environment
Aviation	NL	Amsterdam Schiphol	Instruments	Sound Insulation Programme Schiphol	Local	Construction
General environmental noise	NL	Netherlands national rail	Legislations	Noise Abatement and Measurement Regulations 2006	National	Environment
Rail	NL	Netherlands national rail	Instruments	Structural vision Infrastructure and Space	National	Infrastructure
Rail	NL	Netherlands national rail	Instruments	Programme High Frequency Rail Transport	National	Transport
Several transports	NL	Netherlands national rail	Instruments	Sound innovation programme 2002-2007	National	Transport
General environmental noise	PL	Lubuskie 2011	Legislations	The Regulation of the Ministry of Environment dated 12 June 2007 on allowable environmental noise levels (amending the act - Environmental protection law and related regulations)	National	Environment
General environmental noise	PL	Lubuskie 2011	Legislations	The Regulation of the Ministry of Environment dated 14 June 2007 on permissible sound levels	National	Environment
General environmental noise	PL	Lubuskie 2011	Legislations	The Regulation of the of Ministry of Environment dated 4 June 2007 on the determination of the noise indicators	National	Environment
General environmental noise	PL	Lubuskie 2011	Legislations	The Regulation of the of Ministry of Environment dated 14 October 2002 on detailed requirement for a system of protection against noise	National	Environment
General environmental noise	PL	Lubuskie 2011	Legislations	The Regulation of the Ministry of Environment dated 12 June 2007 on the detailed scope of data included in noise maps and their layout and presentation	National	Environment
Several transports	PL	Lubuskie 2011	Legislations	Environmental Protection law from 27th April 2001	National	Environment
General environmental noise	PL	Wielkopolskie 2014	Legislations	The Regulation of the Ministry of Environment dated 12 October 2001 on the detailed requirements to be met by NAP	National	Environment
General environmental noise	PL	Wielkopolskie 2014	Legislations	The Regulation of the Ministry of Environment dated 1 October 2007 on the detailed scope of data included in noise maps, their layout and presentation	National	Environment
Rail	PL	Wielkopolskie 2014	Legislations	Law of March 28, 2003 on rail transport.	National	Transport
Other	PL	Wielkopolskie 2014	Instruments	The regional development strategy of Greater Poland voivodship untill 2020	Regional	Long-term strategy
General environmental noise	PL	Wielkopolskie 2014	Instruments	The Environmental Protection Program of Greater Poland Voivodeship 2012-2015	Regional	Long-term strategy
Other	PL	Wielkopolskie 2014	Instruments	The Plan of Spatial Development for the Greater Poland Voivodeship	Regional	Long-term strategy
Other	PL	Wielkopolskie 2014	Legislations	Law of October 3, 2008 on the Disclosure of Information on the Environment and Its Protection, Participation of the Public in Environmental Protection, and Environmental Impact Assessments.	National	Environment
Aviation	AT	Schwechat airport, Vienna	Legislations	Federal Act on Noise-related Operating Restrictions at Airports, BGBl. I No. 40/2005	National	Transport
Aviation	AT	Schwechat airport, Vienna	Legislations	Civil Aircraft Noise Abatement Ordinance ZLZV 2005 (BGBl. II No. 425/2005)	National	Transport
General environmental noise	AT	Schwechat airport, Vienna	Legislations	Federal Environmental Noise Protection Act (BGBl I 60/2005)	National	Health
General environmental noise	AT	Schwechat airport, Vienna	Legislations	Federal Environmental Noise Protection Ordinance (BGBl II 144/2006)	National	Environment
General environmental noise	AT	Schwechat airport, Vienna	Legislations	Federal Environmental Noise Protection Ordinance (Bundes-LärmV) BGBl II No. 144/2006 for Civil Air Traffic	National	Environment
General environmental noise	AT	Schwechat airport, Vienna	Instruments	ÖAL (Austrian Working Group for Noise Abatement) Guideline No. 24 Sheet 1 "Noise Protection Zones in the Vicinity of Airports Planning and Calculation Principles"	National	Environment
General environmental noise	AT	Schwechat airport, Vienna	Instruments	ÖAL (Austrian Working Group for Noise Abatement) Guideline No. 36 Sheet 2 "Preparation of noise maps and conflict zone plans and planning of noise abatement measures - Requirements within the scope of the Environmental Noise Directive 2002/49/EC".	National	Health
General environmental noise	AT	Vienna agglomeration	Legislations	Vienna Environmental Noise Protection Act (LGBl. No. 19/2006)	Regional	Health
General environmental noise	AT	Vienna agglomeration	Legislations	Vienna Environmental Noise Protection Ordinance (LGBl. No. 26/2006)	Regional	Health
Several transports	AT	Vienna agglomeration	Legislations	Federal Act on the Regulation of Local and Regional Public Transport (Local and Regional Public Transport Act 1999 - ÖPNRV-G 1999)	National	Transport
Road	AT	National roads	Legislations	Federal Act on the Conveyance and Transfer of Federal Roads (Federal Law Gazette I No. 50/2002)	National	Infrastructure

Road	AT	National roads	Legislations	§ 7a Federal Roads Act 1971 (Federal Law Gazette I No. 34/2013) & Law on an amendment to the Road Act. Official publication: State Law Gazette (LGBl.) ; Number: 22/2006	National	Environment
Rail	AT	National rail 2013	Instruments	ONR 305011:2009 11 15	National	Environment
Rail	AT	National rail 2013	Instruments	ÖNORM ISO 9613-2:2008 07 01	National	Environment
Rail	AT	National rail 2013	Legislations	Rail Traffic Noise Immission Protection Ordinance (SchIV), Federal Law Gazette No. 415/1993	National	Health
Rail	AT	National rail 2013	Instruments	Guideline for the Noise Abatement of Existing Railway Lines for the Uniform Regulation of Noise Protection Measures on Existing Railway Lines (last edition January 2006	National	Health
Rail	AT	National rail 2013	Legislations	Rail Vehicle Noise Permission Ordinance (SchLV), Federal Law Gazette No. 414/1993	National	Health
Other	AT	Regional road: Carinthia 2013	Legislations	Carinthian Community Planning Act (LGBl. No. 88/2005)	Regional	Land-use planning
Road	AT	Regional road: Carinthia 2013	Legislations	Carinthian road law (LGBl. No. 87/2005) – Regional law	Regional	Transport
Other	AT	Regional road: Carinthia 2013	Legislations	Carinthian Environmental Planning Act (LGBl. No. 89/2005)	Regional	Land-use planning
General environmental noise	AT	Regional road: Carinthia 2013	Legislations	Carinthian Environmental Noise Ordinance K-ULV, LGBL No. 76/2006 of 19.12.2006, 7-AL-GVV-321/8/2006	Regional	Environment
Other	AT	Regional road: Carinthia 2013	Legislations	Carinthian IPPC (Integrated Pollution Prevention and Control) Plant Act (LGBl. No. 13/2006)	Regional	Environment
Road	AT	Regional road: Carinthia 2013	Instruments	RiLL Guideline for noise protection on provincial roads in Carinthia (01.02.2011)	Regional	Transport
Other	AT	Regional Road: Salzburg 2013	Legislations	The Salzburg Regional Planning Act of 2009	Regional	Land-use planning
Other	AT	Regional Road: Salzburg 2013	Legislations	Salzburg Waste Management Act 1998 (S.AWG)	Regional	Environment
Other	AT	Regional Road: Salzburg 2013	Legislations	Salzburg Environmental Protection and Information Act (UUIG), LGBl No 72/2007	Regional	Environment
Other	AT	Regional Road: Salzburg 2013	Legislations	Salzburg Spatial Planning Act 2009 (ROG 2009), LGBl Nr 30/2009	Regional	Land-use planning
Other	AT	Regional Road: Salzburg 2013	Legislations	General Provincial Budget Act	Regional	Infrastructure
Other	AT	Regional Road: Salzburg 2013	Legislations	Salzburg Nature Conservation Act 1999	Regional	Environment
General environmental noise	CY	Nicosia & Limassol agglomeration 2015	Legislations	2004 Law on Environmental Noise Assessment and Management	National	Environment
General environmental noise	DK	National rail 2013	Legislations	Executive Order no. 1309 of 21 December 2011 on mapping of external noise and preparation of noise action plans	National	Environment
General environmental noise	DK	National rail 2018	Legislations	Executive noise order no. 1065 of 12 September 2017	National	Environment
General environmental noise	DE	Berlin agglomeration	Legislations	Thirty-fourth Ordinance for the Implementation of the Federal Immission Control Act (Ordinance on Noise Mapping - 34th BImSchV)) . Official publication: Bundesgesetzblatt Teil 1 (BGB 1) ; Number: 12 ; Publication date: 2006-03-15 ; Page: 00516-00518	National	Environment
Rail	DE	Berlin agglomeration	Legislations	German General Railway Act (AEG)	National	Transport
General environmental noise	DE	Berlin agglomeration	Legislations	NATIONAL TRAFFIC NOISE PROTECTION PACKAGE II "Avoiding noise - protecting against noise, 27 August 2009	National	Long-term strategy
Road	DE	Berlin agglomeration	Legislations	Quiet Vehicle Amendment to the Type Approval Ordinance	National	Transport
General environmental noise	DE	Berlin agglomeration	Legislations	Act on Protection against Harmful Effects on the Environment Caused by Air Pollution, Noise, Vibrations and Similar Processes (Federal Immission Control Act - BImSchG)	National	Environment
Aviation	DE	Hamburg Agglomeration	Legislations	Aircraft Noise Act in the version of the announcement of 31 October 2007 (BGBl. I p. 2550)	National	Land-use planning
Other	DE	Cologne Agglomeration	Legislations	Building Utilisation Ordinance	National	Construction
Other	DE	Cologne Agglomeration	Legislations	Construction Code BauGB	National	Construction
General environmental noise	DE	Cologne Agglomeration	Legislations	Decree on environmental noise action planning of Nordrhein-Westfahlen State's Ministry of the Environment, Agriculture, Nature and Consumer Protection	Regional	Environment
Other	DE	Berlin Tegel airport	Instruments	Economic stimulus programme II (based on Act to Secure Employment and Stability in Germany of 2 March 2009, Federal Law Gazette 2009, Part I No. 11)	National	Environment
Aviation	DE	Frankfurt airport	Legislations	Ordinance on the Establishment of the Noise Protection Zone for Frankfurt Main Commercial Airport of 30.9.2011 (GCBI. I p. 438)	Local	Transport
Aviation	DE	Frankfurt airport	Legislations	Ordinance on Data Collection and the Calculation Procedure for the Determination of Noise Protection Areas - 1st FlugLSV) of 27.12.2008 (BGBI I p. 2980)	National	Environment
Aviation	DE	Frankfurt airport	Legislations	Airfield Noise Abatement Measures Ordinance - 2nd FLugLSV) of 8.9.2009 (BGBI. I p. 2992)	National	Environment
Aviation	DE	Frankfurt airport	Legislations	Aircraft Noise Outside Residential Areas Compensation Ordinance - 3rd FlugLSV) of 20.8.2013 (BGBI. I p. 3292)	National	Environment
General environmental noise	DE	Frankfurt airport	Instruments	Guidelines of the State of Hesse for the Promotion of Passive Noise Protection Measures and Sustainable Municipal Development of 31.12.2012, State Gazette of the State of Hesse No. 01/2013 of 31.12.2012, p.67	Regional	Environment
Road	DE	Cologne airport	Legislations	Road Traffic Act StVG	National	Transport
Road	DE	Cologne airport	Legislations	Road Traffic Regulation StVO	National	Transport
Rail	DE	National rail 2015	Instruments	Infrastructure Acceleration Programme II (IBP II)	National	Infrastructure
Other	DE	National rail 2018	Instruments	Future Investment Programme (ZIP)	National	Environment
General environmental noise	DE	National rail 2019	Instruments	I-LENA Programme	National	Environment
General environmental noise	DE	Regional road: Bayreuth town	Legislations	Bavarian Noise Protection Act	Regional	Environment
General environmental noise	LV	National roads	Legislations	Cabinet Regulation No. 16 of 7 January 2014 "Procedures for Noise Assessment and Management"	National	Environment
General environmental noise	LV	National roads	Legislations	Law on Pollution of 2001-03-29	National	Environment
Other	LV	National roads	Legislations	Construction Law	National	Construction
General environmental noise	LV	National roads	Legislations	Cabinet Regulation No. 597 of 13 July 2004 Procedures for Environmental Noise Assessment	National	Environment

General environmental noise	LV	National roads	Legislations	Cabinet Regulation No. 312 of 16 June 2015	National	Construction
Other	LV	National roads	Legislations	Cabinet Regulation No. 240 of 30 April 2013 “General spatial planning,regulations for the use and construction ”	National	Land-use planning
Aviation	LV	Riga airport	Legislations	Cabinet of Ministers Regulation No. 1112 of 15 October 2013 “AircraftProcedures for the Development, Validation, Approval and Maintenance of Flight Procedures "	National	Transport
Aviation	LV	Riga airport	Legislations	Cabinet of MinistersRegulations of 20 June 2006 no. 487 “Regulations on civil subsonic jetrestrictions on the operation of aircraft at aerodromes "	National	Transport
Aviation	LV	Riga airport	Legislations	Cabinet Regulation No. 1041 of 27 December 2005 “Regulations on restrictions on the operation of aircrafts in aerodromes in compliance with environmental protection requirements ”	National	Transport
Aviation	LV	Riga airport	Legislations	Cabinet Regulation No. 507 of June 28, 2011 “Regulations on Airspace Management, Structure and the Civil Aviation Agency"	National	Transport
General environmental noise	LT	National roads	Legislations	Law of the Republic of Lithuania on Noise Management, 2004 October 26 No. IX-2499 (Official Gazette,2004, No. 164–5971 with subsequent amendments Official Gazette, 2006, No. 73-2760; Official Gazette, 2010, No.51-2479; Official Gazette, 2013, No. 79-3988)	National	Environment
General environmental noise	LT	National roads	Legislations	State Strategic Noise Mapping Program. Resolution of the Government of the Republic of Lithuania No.581, 2006 June 14 (Official Gazette, 2006, No. 68-2508; Official Gazette, 2006, No. 71 (correction))	National	Environment
General environmental noise	LT	National roads	Legislations	Government of the Republic of Lithuania, 2008 July 16 Resolution no. 719 “On the State implementation of the Strategic Noise Mapping Program for 2008-2012. action planapproval ”(Official Gazette, 2008, No. 84-3356)	National	Environment
General environmental noise	LT	National roads	Legislations	Minister of Transport and Communications of the Republic of Lithuania 2006 July 24 Order No.3-304 “On Implementation of the State Strategic Noise Mapping Program and approval of the list of responsible operators "	National	Environment
General environmental noise	LT	National roads	Legislations	Government of the Republic of Lithuania 2007 June 6 Resolution no. 564 “On State Noise Prevention Action 2007-2013 approval of the program ”(Official Gazette Valstybės žinios, 2007, No. 67-2614)	National	Environment
General environmental noise	LT	National roads	Legislations	Government of the Republic of Lithuania 2009 March 4 Resolution no. 157 “On the State Noise Prevention Action 2007-2013 implementation of the program for the period 2009-2013 approval of the plan of measures ”(Official Gazette Valstybės žinios, 2009, No. 28-1087)	National	Environment
General environmental noise	LT	National roads	Legislations	Minister of Health of the Republic of Lithuania, Minister of Environment of the Republic of Lithuania and the Minister of Transport and Communications of the Republic of Lithuania in 2005. October 25 order no. V-787 / D1-507 / 3-467 “On the requirements of the legislation of the European Union in the field of noise managementadoption of rules for the submission of implementation reports to the Commission of the European Communities "(Official Journal,2005, no. 128-4621)	National	Environment
General environmental noise	LT	National roads	Legislations	Government of the Republic of Lithuania 2007 December 5 Resolution no. 1305 “On the provision of summary noise management information to the Noise Prevention Council, Statesand municipal institutions and the public ”(Official Gazette Valstybės žinios, 2007, No. 132-5380 with subsequent amendments Official Gazette, 2010, No.:59-2897; Official Gazette, 2010, No. 64-3154; Žin. 2012,58-2898).	National	Environment
General environmental noise	LT	National roads	Legislations	Minister of Health of the Republic of Lithuania, 2007 July 19 order no. V-616 "Information required for reporting to the Commission of the European Communities onJune 25 Directive 2002/49 / EC of the European Parliament and of the Council relating to environmental noiseto prepare the implementation of evaluation and management, approval of submission forms "(Official Gazette Valstybės žinios, 2007, No.83-3406)	National	Environment
General environmental noise	LT	National roads	Legislations	Lithuanian hygiene standard HN 33: 2011 “Noise limits in residential and non-residential areas in public buildings and their surroundings ”, approved by the Republic of LithuaniaMinister of Health 13 June 2011 by order no. V-604 (Official Gazette, 2011, No. 75-3638)	National	Health
General environmental noise	LT	Vilnius agglomeration	Legislations	Regulation of Silent Zones of Vilnius City Municipality, approved in 2011.14 December, Decision no. 1-341 (Decision of the Vilnius City Municipal Council onEstablishment of Vilnius City Municipality Quiet Zones, Vilnius City Municipality Quiet andapproval of noise prevention zones, methodological guidelines and regulations)	Local	Health
Rail	LT	National railwway	Legislations	State railways regulation no. 3-509 of December 27, 2006	National	Transport
General environmental noise	MT	Malta	Legislations	Subsidiary Legislation 435.59 of 2007, Assessment and Management of Environmental Noise Regulations	National	Environment
General environmental noise	MT	Malta	Legislations	LN 193 of 2004, Environment Protection Act, 2001 (CAP 435), Assessment and Management of Environmental Noise Regulations, 2004.	National	Environment
Other	MT	Malta	Legislations	Development Planning Act (2001) of Malta	National	Land-use planning
Other	MT	Malta	Legislations	IPPC (Integrated Pollution Prevention and Control) Regulation (L.N 234 of 2002 as amended by L.N 230 of 2004 and L.N 56 of 2008)	National	Environment
Other	MT	Malta	Legislations	Code of Police Laws of Malta	National	Environment
Other	MT	Malta	Legislations	Environmental Management Construction Site Regulations, 2007 (Legal Notice 295 of 2007)	National	Construction
Other	MT	Malta	Legislations	Draft Building Regulation Act 2009	National	Building
Other	MT	Malta	Legislations	Environment and Development Act 2010	National	Environment
Several transports	MT	Malta	Legislations	Traffic Signs and Carriageway Markings Regulations, SL 65.05	National	Transport
Road	MT	Malta	Legislations	Environmental impact assessment (EIA) regulations	National	Infrastructure
Road	MT	Malta	Legislations	Motor Vehicles Regulations (L.N. 128 of 2004)	National	Transport
General environmental noise	SE	Major railways 2018	Legislations	Ordinance (2004: 675) on ambient/environmental noise	National	Environment
Other	SE	Major railways 2018	Legislations	Ordinance (1998: 905) on environmental impact assessments	National	Environment
General environmental noise	SE	Major railways 2018	Legislations	Ordinance (2015: 216) on traffic noise atresidential buildings	National	Environment

General environmental noise	SE	Major railways 2018	Legislations	Bill 2013/14: 128, Coordinated examination of noise according to the Environmental Code and the Planning and Building Act	National	Environment
Other	SE	Major railways 2018	Legislations	Infrastructure Bill 1996/97: 53	National	Infrastructure
Other	SE	Major railways 2018	Legislations	Swedish Environmental Code 1999	National	Environment
Other	SE	Major railways 2018	Legislations	Planning and Building Act (2010:900)	National	Construction
Aviation	ES	Madrid airport	Legislations	Royal Decree-Law 1257/2003, of 3rd October, regulating the prodecures for the introduction of operative restrictions related to noise in airports	National	Environment
General environmental noise	ES	Sevilla roads	Legislations	Decree 6/201, of 17th January, approving the regulation of protection against noise pollution in Andalusia	Regional	Environment

Annex 8: First workshop proceedings report

1st Workshop Proceedings

Report

Assessment of Potential Health Benefits of Noise Abatement Measures in the EU

Phenomena project

Contract number

07.0203/2019/ETU/815591/ENV.A.3

14 July 2020

Foreword

This report contains the proceedings of the first Interim Workshop of the Phenomena Project. The workshop was designed to introduce the intermediary findings of the study to a wider group of stakeholders at month 8 of the project implementation.

The first Phenomena project workshop was held on the 18th of June 2020 via teleconference with 112 participants. The workshop was co-organised by the European Commission (DG ENVI) Services and the Phenomena project consortium (VVA, TNO, Anotec, Tecnalia, Universitat Autonoma de Barcelona).

The Phenomena project aims to support the European Commission in defining the potential of measures capable of delivering significant reductions (20-50%) of the health burden due to environmental noise. It includes major roads, railways and airports. It will assess which and how legislation at local, national, EU and/or international level could be enhanced to strengthen the implementation of mitigation measures, whilst considering the constraints and specificities of each transport mode. In this light, the Phenomena project seeks to understand what kind of legislative measures could bring added value to the desired outcome, and how likely it is to be undertaken.

Contents

1 Introduction

1.1 General context and objective of the workshop

Phenomena is a 15 month-long research project which started in December 2019. The project aims to support the European Commission in defining the potential of measures capable of delivering significant reductions (20%-50%) of the health burden due to environmental noise. The outcome of the project will provide recommendations for enhanced legislation to achieve the targets for the reduction of health burden. Legislative options to be considered may include mandatory action plans, noise limits at dwellings, vehicle noise limits, the link between END and vehicle legislation.

Following the submission of the preliminary findings in the form of the first interim report at the end of May 2020, the first interim workshop was organised. The workshop was held on the 18th of June 2020 via videoconference and was co-organised by the European Commission (DG ENVI) services together with the Phenomena project consortium (VVA, TNO, Anotec, Tecnalia, Universitat Autonoma de Barcelona). Moreover, a second interim workshop is planned to be organised on November 10th following the submission of the second interim report in mid-October.

The objectives of the workshop are multiple. First, it aims at sharing the preliminary results of the study with the European Commission and the different stakeholders involved in the question of environmental noise (e.g. experts of the Noise Expert Group). Secondly, it also provides a platform for discussion on pending research questions. Finally, allows stakeholders to share their comments and inputs with the consortium and the European Commission. Prior to the first workshop, attendees received background documents to familiarise themselves with the content of the interim report. The background document can be consulted in Annex 4 of this report.

The workshop provided the following elements:

- Consultation and validation of the preliminary results with a wider group of stakeholders by the consortium;
- Insightful feedback and suggestions from the participants to be considered by the consortium in the next stages of the project (e.g. poll results);
- Discussion on specific issues with stakeholders (methodology, analysis, elements to bring into EU legislation, sector specifications);

The workshop resulted in lively discussions, which were supported by a number of on-line polls aiming to gather feedback from the attendees. Suggestions that were made during the workshop will be considered in the second stage of the project. This includes potential noise solutions or innovations or good practices. Stakeholders also shared relevant references with the consortium, as well as suggestions for stakeholder consultations.

1.2 Workshop components

The one-day online workshop was divided into two main sessions (morning and afternoon). During the morning session, the consortium presented the project and its findings in terms of noise legislation, legislative drivers, and its implementation. Subsequently, the consortium introduced the methodology developed to assess health benefits, and the different noise solutions and scenarios defined.

In the afternoon session, the consortium developed on the proposed noise solutions and scenarios for the three different sectors: aviation, rail and road traffic noise. Finally, a plenary session for feedback from the participants was organised.

During the sessions, polls and questions were shared with the participants, and time was dedicated for questions from the stakeholders. The workshop agenda is presented in the box below.

Box 1 Workshop Agenda

Morning session

	Title
10:00 – 10:15	Opening and Introduction (VVA)
10:15 – 11:00	Noise legislation, drivers and implementation (VVA) Q&A
Break	
11:15 – 11:45	Methodology for health benefits (TNO)
11:45 - 12:15	Noise solutions and scenarios (TNO) Q&A

Afternoon session

	Title
13:30 – 13:55 **13:55 – 14:25**	**Aviation**: Anotec (Proposed solutions and scenarios) **Aviation**: Feedback from participants
14:30 – 14:55 **14:55 – 15:25**	**Rail:** TNO (Proposed solutions and scenarios) **Rail**: feedback from participants
15:30 – 16:25 **16:25 – 16:55**	**Road**: TNO (Proposed solutions and scenarios) **Road**: feedback from participants
16:30 – 17:30	***Plenary feedback session (VVA, TNO, DG ENV)***

1.3 Participants

The workshop was attended by 112 stakeholders, including members of the noise expert group (NEG), scientific experts, policy makers from Member States, EC representatives and the consortium members. Stakeholders also included NGOs, European and international industry associations, as well as local citizens' associations. A wide range of stakeholders ensures varied and insightful feedback on the preliminary findings of the study. The complete list of attendees is available in Annex 3.

Experts who were not able to attend the workshop, will be invited to take part in interviews or provide written feedback on the workshop material.

2 General overview of the key findings

The first part of the workshop was designed to present the Phenomena project, its main findings, and to understand the legislative policy and regulatory framework in which current noise abatement measures are applied. In this segment of the workshop, health impacts of different types of noise (rail, road, aircraft) were mapped out, providing an explanation of the health burdens of noise as well as the applied methodology for the health benefits assessment. The session also provided insights into the NAP analyses and presented relevant noise solutions and scenarios. Specifically, participants were asked to discuss the different noise solution types and drivers to which the Cost-Benefit Analysis (CBA) was applied. This part of the workshop aimed to provide a thematic and technical baseline for the second part of the workshop during which sectorial findings were presented and discussed by the participants.

2.1 Project Introduction

2.1.1 Summary of the presentation

This presentation provided an **overview of the project, its general background, context, and objectives**. It also presented the following administrative information on the project:

- Duration of the project: 15-months
- Starting date of the project: December 2019
- Members of the Consortium:
    - Led by VVA in partnership with TNO;
    - Supported by the specialists Anotec Engineering, Tecnalia, and the Universitat Autònoma de Barcelona (UAB);

During this presentation, the **main objectives and scope of the project** were summarised. The key objective of the Phenomena project is, firstly, to outline the potential of measures that can deliver a 20-50% reduction of health burdens caused by environmental noise from roads, railways, and aircrafts. Secondly, the project seeks to evaluate how relevant noise-related EU legislation could enhance the implementation of these measures, while taking into consideration the constraints and specificities of each transport mode. The scope of the project was determined by the number of vehicle movements within a year, the number of inhabitants in and around a location, and the respective noise levels per sector. The project hence covered:

- Roads and railways inside agglomerations with over 100.000 inhabitants
- Locations around major roads of more than 3 million vehicles per year where noise levels exceed 53 dB L_den
- Locations around major railway lines of more than 30.000 trains per year where noise levels exceed 54 dB L_den
- Locations around major airports of more than 50.000 movements per year where noise levels exceed 45 dB L_den

Finally, the **methods of the study** were presented, which include:

- A review of relevant national and EU-level legislation, literature, policies, and noise abatement measures;
- Data collection and analysis of noise action plans (NAPs) and noise maps of Member States;
- A cost-benefit analysis (CBA) for a selected list of noise abatement solutions;
- Scenario developments based on how the current regulatory landscape could be improved in terms of cost-effectiveness and reduction of noise-related health burdens;
- Comprehensive stakeholder consultations, including interviews;
- 2 workshops during which the research findings are presented by the Consortium and participants are encouraged to provide feedback and expert recommendations, giving the Consortium the opportunity to fine-tune the final report ;
- Comparative assessments.

For further reference, the Annex 1 contains the complete PowerPoint presentation of the project introduction.

2.2 Noise legislation, drivers and implementation

2.2.1 Summary of the presentation

The consortium presented the progress to date on the literature review, the analysis of noise action plans, the legislative drivers and the consultation with stakeholders. Moreover, an explanation of the intervention logic used for this project was provided.

First, the main insights obtained from the literature review were introduced. The consortium explained that elements considered included top-down aspects from international frameworks (WHO, UN-SDG, OECD) that support policymaking on national and local levels. Bottom-up elements such as residents and local representatives' initiatives driving the implementation of noise solutions were also identified.

The literature and legislative reviews also examined the environmental noise directive (END). Identified benefits include the development of a coherent management system of environmental noise in all Member States, and, over the years, an increasing number of submitted NAPs and noise maps. However, according to the Regulatory Fitness and Performance initiative (REFIT), which was implemented by the Commission between 2015 and 2019, the END had not fully met its objective because of the long period required for the adoption of a common methodology assessment and did not necessarily enforce active implementation. Taking other policies and cross-policies benefits into account would also be beneficial for the overarching goal of noise reduction, such as urban planning or air pollution. Other criticism targeted the insufficient comparability of data between different reporting rounds which gave a room for different interpretation and implementation.

Subsequently, the consortium presented the main findings of the NAPs analysis, which aimed at identifying noise solution measures implemented across the Member States. The analysis consists of a twofold approach:

- **An overarching assessment** of NAPs (100 already performed, with an additional 100 to be carried out in the second phase);

- **An in-depth analysis** of NAPs (50 performed, with an additional 50 to be carried out in the second phase).

The analysis was presented according to different transport types and agglomerations:

- **Road traffic noise**: in the overarching assessment of NAPs, the most frequently implemented measures were road surface measures, speed limits, and noise barriers. Noise barriers were often used as noise abatement, and they are considered to be the most cost efficient. Other frequently used solutions included traffic restrictions and quiet areas. The in-depth assessment of NAPs found that the solutions are in line with the list of measures predefined at the beginning of the study (see Table 1: List of predefined measures. In addition, road maintenance and continuous monitoring were found to enhance the effectiveness of these measures. Future measures, according to the NAPs analysed, are for the large part a continuation of previous solutions.
- **Railway noise**: the overarching assessment showed that Member States were ambitious in the variety and number of measures implemented in this area. Among the most frequently implemented measures in the NAPs are land-use planning, noise barriers and quiet areas. Additionally, a number of measures also related to rail grinding and infrastructure improvements. Planned solutions in the NAPs analysed focused on rail maintenance and rail track improvement (source interventions). The measures identified in the in-depth assessment of NAPs in the railway sector differed from the predefined list of measures, as the findings from the NAPs indicated a greater variety in planned solutions, such as monitoring and public outreach. The findings demonstrated frequent combinations of various measures with modernization of infrastructure, improving operational procedures (maintenance) and monitoring. Finding the right combination of measures, and the importance of financing support were as well highlighted. Especially, a combination of financial support coming from both national and EU sources were noted as important.
- **Aircraft noise**: the overarching assessment found that the most frequently implemented measures were operational measures as well as curfews, certification limits and complaints systems. The list of planned measures extended this list to building insulation, noise barriers and quiet areas. The in-depth assessment of NAPs showed a trend of implementing a wide combination of measures, with mitigation of noise at the receiver and at the noise source. A continuation of previous noise solutions with improvements resulting from technical implementation and innovation was also observed.
- **Agglomerations**: the research found a great variety of approaches across NAPs for agglomerations. In the overarching assessment, among the most implemented measures were land use planning and noise barriers. Planned measures follow the same trend, adding quiet areas and dispersion of noise. The consortium noted in the in-depth assessment that the balance between measures could be difficult, as people impacted by the generated noise could also benefit from the transport modes being the source of noise. The consortium added that a higher level of public awareness could ensure increased transparency and accountability of those exceeding noise limits.

Table 1: List of predefined measures

Source	Noise solution	Examples
Road	2dB reduction of noise from tyres	Tyres with lower average noise label value
	2dB reduction of noise by road surface	Porous asphalt and/or smooth asphalt
	2 dB reduction of whole, vehicle noise	*New noise limits, electric vehicles*
	Noise barriers	Standard or special, including absorbent or tilted barriers and lane barriers

Source	Noise solution	Examples
	Re-routing or limiting road traffic	*Congestion charge or access restrictions for high dB areas and vehicles*
	Acoustical site planning: increasing the sound attenuation between the noise source and the receiver via parks, courtyards etc	*Urban planning on the national or local level*
	Retrofitting of residential and communal buildings	*Government incentives for homeowners Improved insulation, noise cancelling solutions*
	Extending land barrier, changing land-use	Acquisition of dwellings
Rail	2 dB reduction from infrastructure improvement	Rail grinding, quieter rail pads, rail dampers, rail shielding (> 1 dB can be achieved)
	1 dB reduction from new rolling stock	New generation rolling stock with very smooth wheels, > 2 dB on smooth tracks
	Noise barriers	Standard or special, including absorbent or tilted barriers and low barriers near track
	Retrofitting of residential and communal buildings	*Improved insulation, noise insulation solutions*
	Extending land barrier, changing land-use	Acquisition of dwellings
Aviation	Landing and take-off improved profiles	Flight procedures
	Dispersion/Concentration of flights	Route optimisation
	Operating restrictions/curfew	Airport regulation
	Operating restrictions/prohibition of operation for noisier aircrafts	Airport regulation
	Forced phase out of older aircrafts	Airport regulation
	Acquisition of new, lower noise emission airplanes	*EU or national level incentives for airlines*
	Retrofitting of residential and communal buildings	*Government incentives for home owners improved insulation, noise cancelling solutions*
	Extending land barrier, changing land-use	Acquisition of dwellings

During the analysis the consortium encountered several limitations, such as:

- Uneven quantity of content, structure and information across the NAPs;
- Lack of data on (cost-) effectiveness of measures and absence of harmonised processes for the evaluation of effectiveness;
- Lack of data on costs per measure or overall budget for the NAPs;
- Uneven data on public consultations across NAPs;
- Lack of data on the main sources of noise;
- Lack of data on good practices.

The presentation of the noise legislation drivers and implementation was introduced with a presentation of the baseline intervention logic. The methodological approach for the intervention logic presented below follows general principle of the European Commission used when preparing new initiatives, proposals and when managing and evaluating legislation. This approach is defined in the European Commission's Better Regulation Guidelines.[1] The intervention logic is widely used in a policy context concept of the EU, which defines the objectives of a policy and their expected results. It includes steps, actions, the different actors involved and related interdependencies. To this aim, the study team at the preliminary stage of the project, designed a baseline Intervention Logic to provide a context and narrative highlighting the objectives of the relevant policies and their outputs/impacts. The objective of the intervention logic is to illustrate how the intervention was expected to work (chain of events that should lead to the intended change). An intervention should be understood as a legislative context behind the solution to a problem, which under the present study is noise pollution. The present intervention logic should be perceived as a tool that visualises the different steps, action and actors involved in the intervention, as well as their interdependencies. It demonstrates the cause and effect of these relationships and how both actors and actions were expected to interact to deliver the planned changes over a given lap of time to achieve the objective of the EU intervention behind.

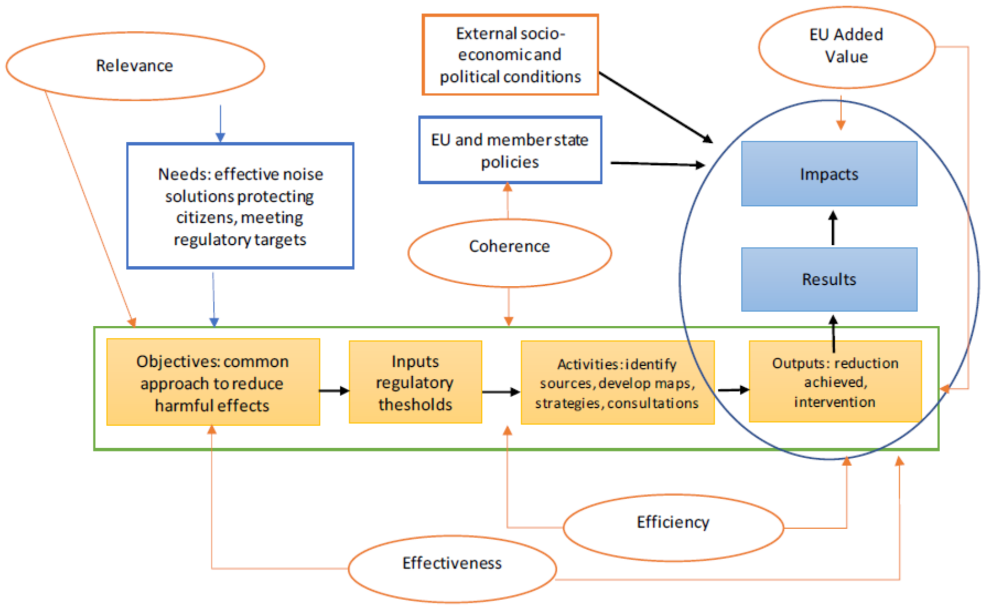
A view of the baseline intervention logic is presented in Figure 1 below. Baseline reflects the situation at the time when the intervention was designed. The elements of the figure represent the following

- Arrows: the causal assumption/relationships between the boxes;
- Needs: needs that triggered the EU intervention, the problem that the EU intervention aimed to solve;
- Objectives: 'a desired situation' that was supposed to be achieved; changes that were expected to be achieved;
- Inputs: inputs that are supposed to be used to achieve the defined objectives (e.g. understood as human resources, equipment, legislation to be adopted);
- Activities: events that were planned to happen (e.g. what obligations were set or what provisions were expected to be put in place);
- Outputs, results and impacts: consideration of changes over times that were supposed to happen and are presented in the expected order of activities;
- External factors: are factors that could influence the performance of the initial EU intervention, alternate it, or generate the same type of effects;
- Other EU policies: other actions/intervention undertaken at the same time at the EU level that can have a positive and negative effect on the impacts and result of the intervention.

In addition, physical inputs are frequently translated into monetary values, leading to a broader consideration of what has been needed to achieve objectives and possibly to considerations of costs and benefits. For example, in the present case, the costs and benefits related to the noise solutions chosen. Cost analyses can include life cycle cost analyses, where relevant, and benefit analyses where health benefits are monetised, costs for hospitalisations are considered, and increase in real estate value.

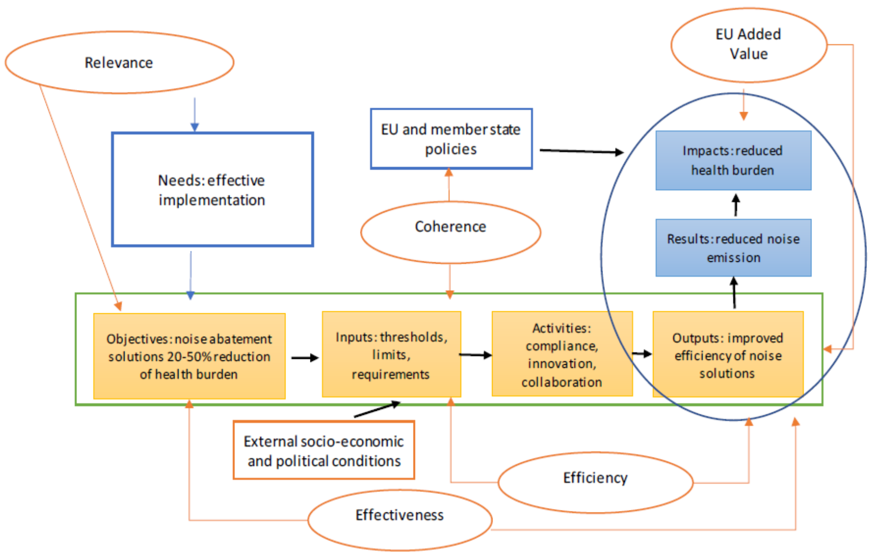
[1] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

Figure 1 The baseline intervention logic



With the revised intervention logic under the 1st interim report, presented in the Figure 2 below, the consortium aims to present how the regulatory environment could be improved in order to facilitate more efficient implementation of noise solution in such a way as to deliver a 20-50% reduction of noise-induced health burden. It depicts the result of the assessment of the relevant policies as viewed at this interim stage. The scheme is not an illustration of the functioning of the END but rather an amalgamation of the relevant EU- and national level policies.

Figure 2 Revised intervention logic



The revised intervention logic, presented above, shows how an improved regulatory environment could facilitate the delivery of the reduction of noise-induced health burden. The updated scheme builds on the identified inefficiencies of the current EU and member state level regulatory environment, which may stem from:

- indicative EU level noise limits;
- discrepancies between member states' regulatory requirements related to maximum noise reception limits;
- absence of a harmonised EU-level requirement for evaluating the efficiency of previous noise solutions/action plans;
- differences between member states in the availability of financial resources for the implementation of noise solution measures;

Additionally, there are differences in the approaches that the Member States put forth, e.g. combined approaches in agglomerations versus transport-specific approaches, for tackling noise pollution, although these may be explained by regional specificities. It has been specified that the revised intervention logic will be further modified along with the study according to the latest findings.

Finally, the explanation of the current regulatory framework, its drivers and implementation were followed by the consortium presentation of preliminary conclusions. The preliminary findings of the research conclude that:

- NAPs are relatively descriptive and comprehensive, providing information on the planned measures, the results from the noise mapping, public consultations, and other data;
- Some NAPs mention a long-term strategy or a cooperation with mobility planning and sustainability considerations;
- Some NAPs provide reduction targets in terms of people exposed to high noise levels, therefore, providing goals to the NAP for the given timeline;
- Data on the evaluation of previous NAPs was provided in an uneven way across NAPs.

Based on these findings, the consortium provided the preliminary recommendations:

- Open discussions on the need for further harmonization and synthetization of NAPs;
- Enhanced monitoring of NAP implementation;
- Enhanced understanding of the relationship between noise pollution and urban planning;
- Development of common guidelines and good practices.

For further information, the Annex 1 contains the full PowerPoint presentation of this session.

2.2.2 Q&A overview

The discussion following the presentation touched upon various topics. First, the discussion opened with a question on the impact that quiet areas could have as a solution for air traffic noise. The consortium answered that the functionality of quiet areas may differ based on socio-economic factors. Secondly, regarding urban planning and noise abatement, the consortium highlighted that this issues as highly increasing in the exchange will be examined in detail at the later stage of the research. The participants agreed that a more integrative approach, including noise abatement measures and urban planning, would be more beneficial.

Attendees recommended that the consortium consult residents and citizens' associations as well as stakeholders involved in drafting the NAPs. The consortium explained that the current analysis was made on based the NAPs documentation and that the responsible authorities were contacted regarding the missing data and in the second phase of the study these consultations would continue.

Furthermore, the issue of low participation in stakeholders' consultation from Member States authorities was raised by participants. The consortium clarified that often Member States representatives are less responsive. Hence, the stakeholder consultation with national representative can be more difficult.

Finally, participants provided some suggestions of elements to be considered under this research, such as

- preventing noise from infrastructure projects,
- the noise policy outside of the NAPs, and
- creative and uncommon measures implemented in the framework of the NAPs.

In addition to the above, it is recommended to consider the local context and non-acoustical factors in assessing the effectiveness of measures and looking at the impact of respite from aircraft noise when flight paths are switched on a daily basis.

Other topics of discussion raised by participants included the way of evaluating the prominence of noise-abatement actions, or the fact that the most common actions might not be the most efficient. Nevertheless, that costs elements could also be taken into consideration.

2.3 Methodology for health benefits

2.3.1 Summary of the presentation

The consortium explained that the objective of the study was to achieve a 20% to 50% reduction in noise health burden by identifying the most cost-effective noise solutions for road, railway and aviation sectors. The methodology includes calculations and test sites. Noise emissions create significant impacts on human health, manifested during the day by annoyance and during the night throughout sleep disturbance. There are two methods for calculating health effects coming from noise exposure in euros (monetisation) used for road and railway traffic noise. The two methods give different health cost results, as it would be presented below.

- Method 1 – based on EC guidelines 2019;
- Method 2 – based on EU project Heimtsa and the calculation method used at the EEA related to the number of people (highly annoyed, highly sleep-disturbed, myocardial infraction) and estimated in Disability-Adjusted Life Years (DALY).

The consortium presented an overview of the different transport modes included in the study, test sites and calculation methodology for the reduction of health burden.

The following results were discussed during the presentation:

- **Road traffic noise:**
    - There is a causal chain of noise that can be explained by the relationship between road noise sources (road network, traffic flow), noise emission (rolling noise, propulsion noise), noise levels (sound propagation, buildings, barriers), exposure (exposure distribution), health effects (number of cases, DALYs, euros);
    - When comparing the baseline scenario with the noise solution scenarios, it is clear that noise measures are necessary to create health benefits in the next ten years (by 2030);
    - According to the submitted noise maps (2017) and exposure distributions, the exposure from road traffic is more concentrated in urban areas (mostly between 55 dB and 60 dB, representing respectively 17.5% and 15%) than around major roads

  - outside agglomerations, which constitutes less than 10% for each dB category in the range between 55-75 dB;
  - The two methods to measure health impacts give significantly different calculations: method 1 (EC guidelines 2019) estimates health burden costs of EUR 60 billion and method 2 (EU project Heimtsa EEA) amounts to EUR 15 billion;
  - The noise solutions and the hypothetical future scenario foresee that 100% use of hybrid vehicles by 2030 would produce a low noise reduction from both urban areas (- 2 dB) and non-urban roads (- 1dB). The monetized health effects using both calculation methods would reduce the health burden costs between 10 to 20%. An important difference was pointed out between estimated health burden costs between method 1 and method 2.
  - The **test sites** selected for road traffic noise are both motorways (A4 and A20 in the Netherlands) and urban roads with average speed of 30-50km/h (Amsterdam, Karlsruhe and Antwerp)
- **Railway traffic noise:**
  - The noise solutions envisaging future scenarios in 2030 with the use of 100% smooth tracks would produce a reduction of noise by 8 dB on both urban and non-urban tracks. According to method 1, it would produce a reduction of 81% of the monetized health effects of noise, while according to method 2, it would represent a reduction of 66%.
  - The two calculation methods monetised in euros are giving different cost results: method 1 (EUR 12 billion) and method 2 (EUR 5 billion);
- **Aviation noise**:
  - There are 60 airports reported under the END (2017) of which 11 are selected for **test sites**.

The consortium concluded that to achieve the reduction objective up to 50% noise health burden, it is necessary to combine different noise solutions. It seems that a single solution would not be sufficient on its own. The traffic noise will continue to increase in the future and previous scenarios have shown that it was not easy to increase large dB reduction per single measure.

For further reference, the Annex 1 contains the complete PowerPoint presentation of the project introduction.

2.3.2 Q&A overview

The questions following the presentation enquired first about **non-acoustic factors for aviation.** The consortium replied that they will not use in the study the calculation for non-acoustic factors as the study focus on the physical noise solutions.

Secondly, questions about the use of **method 1 and method 2 (double calculation methods) and different cost outcomes were raised**, as well as on the use of **dose response**. In overall, the consortium pointed out that the study examines the recapitulation of present knowledge and situations that provide guidance for the right policy direction in the future.

At the end of the session, **the workshop participants were invited to express their opinion to the poll question**: "*What do you think is the most important origin of uncertainty of the methodology?*". Most participants (36%) indicated that the reason for this uncertainty represents "health impact assessment such as: calculating health effects from exposure distributions".

For further reference, the Annex 2 contains the complete Poll result questions and answers.

2.4 Noise solutions, CBA and scenarios

2.4.1 Summary of the presentation

In this session, the consortium provided an overview of **noise abatement solutions** (scope, aspects, types, regional differences, drivers and examples for each transport mode), **cost-benefit-analysis** (approach, examples, cost estimations of noise solutions), **scenarios** for the next ten years (2020-2030), both single and combined scenarios. In addition to the impact of the ongoing Covid-19 situation was mentioned as a potential input to the scenarios to be considered.

- **Noise abatement solutions**:
    - The report considers the use of physical abatement solutions (i.e. at source, in the propagation path, at the receiver, urban and land planning, traffic restrictions) in the next ten years. Moreover, some noise solutions have synergies with other policy areas (e.g. air quality, Green Deal, energy, well-being etc.). Although modal shift (road to rail, air to rail, road to foot or bike) is not in scope as a separate solution, it may be taken into account in terms of autonomous developments or other sustainability measures. Innovative solutions are not included in the study due to uncertain effectiveness and timescale.
    - The report acknowledges asymmetrical traffic volume, the state of infrastructure, exposed population, health burden and the implementation of noise solutions across Member States and EU regions.
    - At the current stage, among the drivers for noise solutions are national legislation (i.e. reception limits), infrastructure investments, increasing public pressure, complaints as well as NAPs.
    - The noise abatement solutions for all transport modes refer to measures at source (e.g. quieter tyres for road or landing and take-off profiles for aircraft), propagation path (quiet road surfaces, tracks and flight dispersion), receiver (noise barriers, sound insulation), urban and land planning, traffic restrictions and curfews.
- **Cost-Benefit-Analysis:**
    - As a general principle, the costs are higher than the benefits initially, but subsequently benefits usually exceed costs. Investments with a benefit-to-cost ratio (BCR) higher than 1, are worthwhile. Furthermore, considering the short timeframe considered in the study (2020-2030), a longer period would allow better cost benefit return.
    - A CBA example of tighter noise limits for road vehicles showed a break even point in 2033, including initial costs of R&D and additional production costs. The CBA calculations would be harder to assess for urban planning. However, a high BCR is ensured by integrating noise requirements in new infrastructural projects.
- **Scenarios:**
    - The consortium explained that the baseline scenario for 2020-2030 assesses components such as vehicle fleet composition, infrastructure, noise exposure, predictions for traffic growth and evaluation of present laws and implementation.
    - Alternative scenarios could focus on single or multiple combined solutions for contributing to health burden reduction.

- A temporary scenario (Covid-19) could be useful to illustrate which level of dB reduction would be possible to achieve with reduced traffic use from all transport modes. All transport sectors have recorded a decrease in traffic that is currently slowly recovering (e.g. 30-50% drop in road and rail sector, almost complete flight suspension for some airline companies between countries). This situation is also a driver for an increased use of individual transport (e.g. cars), a reduced use of public transport and possible shift towards greater soft mobility (e.g. cycling and walking) and re-adapting city design (e.g. increasing pedestrian zones).

For further reference, the Annex 1 contains the complete PowerPoint presentation of the project introduction.

2.4.2 Q&A overview

During the Q&A section on noise solutions, CBA and scenarios, the participants raised issues relevant to **the CBA and its relevance for the period beyond 2030**. The study is primarily focusing on solutions that would give results in the short-term until 2030, but it will also consider and acknowledge other noise solutions that go beyond this period to manifest results and expected noise reduction. As for the **CBA calculations for roads** and its health benefits, the consortium clarified that cost reduction is expected on the longer-term basis beyond immediate short-term health benefits.

Then, the other questions concerned the **Covid-19 scenario** and its impacts on the transport sector. Regarding the Covid-19-related temporary scenario, the consortium explained that it would be necessary to ensure that there are available data measured during the lockdown period which could be compared with the noise situation before, and after that period.

Finally, the use of **different calculation methods** with different scenarios were also discussed as well as **the link between noise solutions and legislative interventions**. Given that relevant **noise solutions and legislation are closely connected**, the consortium mentioned the importance of identifying the best practices along with the effective drivers.

3 Presentation of sectorial findings

The second part of the workshop focused on the findings of sector-specific research on technical noise solutions and scenarios. First, noise solutions and scenarios in aviation were addressed before issues and findings pertaining to railway-related noise reduction were discussed. Finally, the second segment of the workshop concluded with a presentation and discussion on road traffic noise solutions and scenarios. At the end of each of the three presentations, attendees were asked to answer questions in a poll on issues relevant to the respective sector (aviation, railway, road).

3.1 Aviation Noise

3.1.1 Summary of the presentation

In the presentation on aviation noise, the **main sources of noise** were outlined first. While engine (fan, jet, turbine, combustor) and airframe (landing gear, flaps, slats) are commonly the main sources of noise, it is nonetheless difficult to efficiently reduce aircraft noise levels since different noise sources have to be addressed at the same time.

Notably, the **degree of implementation** of the Balanced Approach and the EU Regulation No. 598/2014 varies significantly among airports in Europe. The aim is to harmonise the different degrees of implementation across the EU in the future.

Addressing various approaches to noise reduction in aviation, **relevant selected noise solutions** were presented and discussed. The most relevant of which are highlighted in bold below:

1) noise reduction at the source
2) **operational procedures**
3) **operational restrictions**
4) **land-use planning and management**
5) community engagement

The first four discussed solutions constitute the four pillars of the Balanced Approach to Aircraft Noise Management of the International Civil Aviation Organization (ICAO). Although, the fifth solution is not part of the Balanced Approach of the ICAO, the consortium stated that community engagement has recently become an important part of the discourse on aviation noise**.** It was also explained that community engagement (solution 5) can be a powerful solution, yet it is not mature enough to model at present as part of the Phenomena project. Moreover, it was clarified by the members of the consortium that a solution for noise reduction at the source (solution 1) will not be directly provided as part of the scenario exercise since noise at the source is regulated at the global level by the ICAO.

Based on the technical and legislative information above, the consortium presented **eight common approaches to noise reduction in aviation** that builds the foundation of the scenario development for the Phenomena project. The table below indicates these eight noise solutions in aviation.

Table 2: Eight solutions to noise reduction in aviation

Noise solution	Noise reduction	Implementation level	Implementation time	Synergies	Obstacles	Cost	Comments
1. Landing and take-off improved profiles (flight procedures)	1-3 dB	Medium	Short	In some cases: Fuel consumption	• Safety • In some cases: Fuel consumption	Low	• Flight procedures require a balancing between the source noise level and the distance to the observer/receiver. There are two central procedures, the 'close-in procedure' (reduces noise level near the airport but increases it in the distance) and the 'distant procedure' (creates greater noise level near the airport but reduces it in the distance). Therefore, reducing noise at one location can increase it at another location. • The drivers of this solution are local airport rules (e.g. fines for level exceedance, allocations of slots for quiet flights) and fuel consumption
2. Dispersion or concentration of flights (route optimization)	Airport dependent	Medium	Medium	In some cases: fuel consumption	In some cases: Fuel consumption	Low	• Concentration or dispersion of aircraft movements over residential areas can be changed depending on needs. • Notably, flight route optimization can either decrease fuel consumption (synergy) or increase it.
3. Operational restriction: Curfew	Airport dependent	Medium/High	Low	/	Economic effect on operators	High	• Restriction of certain aircraft types during certain times of the day or prohibition of operation of all aircraft types (usually during the night) • In the last 5-10 years, the operation of aircrafts during "shoulder hours' (late evening and early morning flights) has increased, commonly by low-cost carriers
4. Operational restriction: Prohibition of operation for noisier aircraft	Airport dependent	Medium/High	Low	/	Economic effect on operators	High	• Salient issue: Some aircraft operators choose noisier (i.e. older) aircrafts since they are usually cheaper in terms of the cost of ownership. However, these aircrafts have a

							high operation cost due to high fuel consumption.
5. Operational restriction: Forced phase out of older aircraft	Airport dependent	Low	Low	/	Economic effect on operators	High	• Implementation is focused on regional/airport level: Operational restrictions such as this solution depend on decisions made at the airport level. What solutions work and do not work can vary for every airport.
6. Acquisition of new quieter aircraft	2-3 dB	Low	Medium/High	Energy (fuel)	• Delivery times • Cost	High	• New aircrafts are typically 15-20% more fuel-efficient but also 10% more expensive. • In western countries, aircrafts have a lifetime of about 15-20 years, which is why the speed of implementation of this solution is slow. • Production rates of aircrafts have set limits, even if these limits have increased in recent years. This can be an obstacle to the implementation of this noise measure.
7. Sound insulation of residential and communal buildings	10-25 dB indoors	Medium	Medium	Energy saving	Cost	Medium	• The drivers of this measure are the national legislation and reception limits.
8. Extension of land barrier, land use planning including the acquisition of dwellings	Airport dependent	Low	High	/	• Cost • Long lead times	High	• The drivers of this measure are the national legislation and reception limits. • This measure should be taken into account during the airport designing stage, as land use is difficult to change later. For many existing cases, this measure can only be implemented through the acquisition of dwellings. • Example of a good practice: Calgary International Airport implements measures (Noise Exposure Forecast (NEF) areas, Airport Vicinity Protection Area (AVPA) regulation) to prohibit certain land uses within noise-affected zones to protect local communities from high noise levels around the airport.

Based on these eight solutions, the consortium presented a series of **scenarios for Phenomena**, recommending single and combined noise abatement solutions. The developed **single noise abatement solutions** comprise:

A) Improved take-off procedures	Solution 1
B) Dispersion or concentration of flights	Solution 2
C) Night curfew	Solution 3
D) Prohibition of noisy aircraft at night	Solution 4
E) Phase out of noisiest aircraft	Solution 5
F) Fleet replacement with quiet aircraft	Solution 6
G) Dwelling insulation	Solution 7
H) Buffer Zone	Solution 8

The developed **combined noise abatement solutions** are a composite of:

- **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) = **3D optimization**
- **E** (Phase out of noisiest aircraft at night) + **F** (Fleet replacement with quiet aircraft) = **Quietest fleet**
- **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) + **E** (Phase out of noisiest aircraft) + **F** (Fleet replacement with quiet aircraft) = **Best possible on "aircraft side**

The Annex 1 contains the full PowerPoint presentation of the session for further details and references.

3.1.2 Q&A overview

After the presentation, the consortium provided open questions and a poll for attendees to participate in order to initiate a discussion on the subject. The main points of discussion that were addressed after the presentation were about the level of implementation and the representativeness of the analysed data, the quantification and integration of community engagement in the analytic model, and the issue of land use planning.

First, the members of the consortium were asked whether their calculations consider how many airports have **already implemented measures.** In this context, measures to avoid dispersions, to recommend companies specific Noise Abatement Departure Procedures (NADP 1 or 2), or to impose other restrictions were addressed. The consortium agreed that they are considered, taking into account the time and budget restrictions of the project. In addition, ANOTEC is investigating individual flights and what vehicle is used at each of the selected 11 airports. The selected airports were divided into three groups depending on their size (large, medium, smaller). Moreover, airports that have already implemented the best practices possible, and which cannot increase measures any further are also accounted for in the study.

In this context, the issue of **airport sample selection** was addressed. The selection of these 11 airports aims to provide a broad, geographically well-distributed insight into European airports to make the study as representative as possible when it is extended to the EU level. The time and budget restraints of the project were also taken into consideration when the number of airports to study was determined. It was clarified that small airports with less than 50,000 movements per annum are not considered. Furthermore, the consortium only takes into consideration current numbers of airport movements, avoiding speculations about the volume of movements at airports in the future.

The following points were raised concerning the **significance of community engagement** to reduce aviation noise. Firstly, a part of the discussion revolved around the **quantification of community engagement** to measure noise reduction and health benefits. This quantified data was considered an important step to elevate the issue of noise-related health burdens to the EU level. It was suggested that, based on this data, a bonus-malus system could be developed to reduce noise levels. A bonus-malus system financially rewards aircraft operators if they use low-noise solutions for aviation. Vice versa, the operators will receive a fine if they do not use low-noise solutions. The consortium suggested that one way to quantify community engagement could be to determine the noise reduction equivalent of a community engagement project in dB (for instance 5dB for one project) to see what the overall benefit of a project is. It was also suggested that, once developed, such a method should be included in noise-related regulations. Finally, it was added that community engagement should be considered an important component of noise reduction measures in any case because of its evident benefits, even if it is not possible to quantify and integrate it into the model and relevant legislation. The discussion on this point was concluded with the statement that it may not be impossible to quantify community engagement in general, but it is impossible to do so at present.

The final major point of discussion was the **issue of land use planning**. Noise exposure levels for residential areas near an airport must be planned for from the very beginning when an airport is designed. After the construction of an airport, significant changes are difficult to make. Therefore, it may be difficult and costly to reconstruct airports and their surrounding areas if noise-related measures were not planned from the very beginning. It was highlighted that land use planning is not a solution per se but rather a last resort option to stop noise pollution from becoming worse.

3.2 Railway Noise

3.2.1 Summary of the presentation

In the presentation on railway noise, the **main sources of noise** were outlined first: rolling noise generated by wheel and rail roughness, traction noise (mainly at lower speeds), and aerodynamic noise (mainly at high speeds) were defined as the main sources of noise.

The consortium presented six selected noise abatement solutions, based on which the scenarios for the Phenomena project were developed. These six selected noise abatement solutions are summarised in the table below.

Table 3: Six solutions to noise reduction for railways

Selected solution	Noise abatement measure	Noise reduction in dB	Implementation level	Implementation time	Synergies	Obstacles	Cost	Comment
1. Infrastructure measures[2]	a. Acoustic rail grinding	1-3	Limited	Short	Effect stronger for smooth wheels	Monitoring + maintenance	Low/Medium	
	b. Quieter rail pads	2-4	~50% stiff pads	Short	Effect stronger for low noise wheels	Sleeper loading	Low	
	c. Rail dampers	1-3	Medium/Low	Short	Idem	Durability	Medium	
	d. Rail shielding	1-4	Low	Short	Idem	Durability	Medium	
2. Quieter rolling stock[3]	a. Smoother wheels	1-3	Medium	Medium	Effect stronger for smooth rails	Monitoring + maintenance	Medium	• Measures *c* and *d* are less relevant, particularly for rolling noise • Implementation level: many of the measures are already implemented • Infrastructure costs are higher in some cases
	b. Damped or optimized wheels	2-4	Limited	Medium/Long	Effect stronger for quiet tracks	Thermal or loading requirements	Medium	
	c. Quieter powertrains	1-3	Medium	Long	/	Cost, Cooling	Medium	
	d. Streamlined vehicles	1-5 (high speed)	Medium	Long	Power consumption	?	Medium	
3. Noise barriers, standard or special	a. Normal barriers	5-15	High	Medium	Safety	Cost, View	High	• Drivers are national legislation or EU action plans • Measure *b* is implemented at low level, but it is working very well
	b. Close/low barriers	5-10	Low	Medium	Integration, Escape Platform	Safety	High	

[2] Noise reduction effect larger if combined with track measures.

[3] Noise reduction effect larger if combined with track measures.

								• Obstacle of measure *b*: beside cost and view, the potential of safety risk in case of low barriers as they may obstruct escape from the track.
4. Urban and spatial planning	a. Relocation of dwellings or infrastructure	>10	High	Long	Transport capacity, Quality of life	Cost, Impact	High, but potential returns	• It must be highlighted that, notably, measure *b* is implemented across the EU • Another option regarding measure *c* is closing a façade • Measure *d* is relatively successful in cities • In general, the costs of these measures are high, but very often the potential returns (e.g. property taxes) are high as well, which they can be considered low cost in fact
	b. Tunneling	>10	High	Long	Safety, New space, Air quality	Cost, Impact	High, but potential returns	
	c. Blind façade building along tracks	>10	Medium	Long	New dwelling space, Safety	Safety, Impact	High, but potential returns	
	d. Non-residential building along tracks	>10	High	Long	New space	Existing dwellings	High, but potential returns	
5. Sound insulation of residential and communal buildings	a. Windows and/or whole building	10-40 indoors	High	Low/Medium	Energy saving	Cost	Medium	/
	a. Rerouting of noisy vehicles	2-6	Medium	Short/Medium	Track wear	Capacity shift of exposure	Medium	

6. Rerouting and access restrictions	b. Restrictions on noisy vehicles	3-10	Low	Short/Medium	Vibrations	Capacity	Low	• This solution is in fact implemented to a considerable extent, why it was included by the consortium • Main drivers of this solution are the EU and national legislation, and they focus mostly on freight wagons • This solution is very different from road traffic restrictions • Speed restrictions is not always a popular measure, but capacity to implement is available
	c. Noise differentiated access charging	2-3	Low	Short	Other charges	Administration, Harmonisation	Medium	
	d. Speed restrictions	1-6	Low	Short	Vibrations	Capacity	Medium	

Based on these six solutions, the consortium presented a series of **scenarios for Phenomena**, recommending single and combined noise abatement solutions. The developed **single noise abatement solutions** are:

A) Smooth tracks, grinding	Solution 1
B) All wheel's composite/disc braked or better, and wheel flat control	Solution 2
C) All wheels 4 dB quieter design by 2030	Solution 2
D) Widespread implementation of quieter tracks by 2030	Solution 1
E) 30% of fleet 3dB quieter than 2020 for other sources	Solution 2
F) Length of tracks with noise barriers: factor 3 higher in 2030	Solution 3
G) Access restrictions, rerouting out of urban area	Solution 6
H) Urban planning: tunnelling, blind façade buildings, integration of noise abatement in urban building	Solution 4
I) 10% more dwelling insulation than baseline	Solution 5

The developed **combined noise abatement solutions** comprise the following scenarios:

- **A** + **B** = **Smoother wheels and rails**
- **C** + **D** + **E** = **Vehicles/wheels and tracks of quieter design** (e.g. wheel dampers, rail shielding, etc.)
- **A** + **B** + **C** + **D** + **E** = **Combination of the above**
- **F** + **G** + **H** + **I** = **Increased noise barrier length, traffic management, urban planning solutions including tunnels, enhanced building insulation**
- Other scenarios to be suggested in the remaining course of the project

The single solutions are based on available known measures for noise reduction. The combined scenarios are proposed for measure combinations that will result in a larger noise reduction. Many other combinations are feasible but the several promising ones are given here.

Annex 1 contains the full PowerPoint presentation of the session.

3.2.2 Q&A overview

During the Q&A section on railway noise, various issues were addressed in the discussions, including close/low barriers, rail pads, rail dampers, urban and land use planning, the estimated noise reduction range, the consultation of citizens, the extent of implemented measures in the EU rail network, and the interconnection of noise abatement solutions.

First, the distinction between normal and **close/low noise barriers** was addressed in the context of their cost-effectiveness and efficiency. While close/low barriers are cheaper compared to normal barriers, it was suggested that they are less efficient regarding noise reduction and have been related to safety issues due to their proximity to the track. It was also recommended that close/low barriers should be integrated into new infrastructure rather than placed on existing structures to mitigate associated risks.

Issues regarding other infrastructure measures, specifically **rail pads** and **rail dampers**, were brought up in the discussion. It was clarified that there is ongoing work on optimizing rail pads for noise. Considerations regarding the effectiveness of rail pads should also include other factors such as the soil and infrastructure. It was mentioned that the International Union of Railways (UIC) proposed the testing of rail pads to optimize stiffness, starting in 2021, to assess them in different geographies and with different railway lines. Regarding the effectiveness of rail dampers, it was mentioned that the noise emissions of both rails and wheels must be controlled at the same time as they both contribute to the total level.

Concerning **urban and land use planning**, the workshop attendees discussed that, since urban planning is complex, noise solutions must be grouped and those that are not cost-effective can be excluded. It was also suggested that tunnelling and rebuilding urban space around railway structure should be considered and that green areas should be rebuilt. Finally, it was mentioned that instead of building barriers in urban space source measures such as smoother rails or wheels would be more effective.

The topic of the **noise reduction range proposed by the consortium** was queried, as to whether the noise reductions indicated in the presentation are average noise reductions. The consortium clarified that these numbers reflect a range based on experience. While residents living close to the noise source will be affected by noise to a greater extent than those living further away, the consortium stated that any noise reduction measure at the source will have an equal effect on the surrounding area.

Regarding the **consultation of citizens** in the study, it was mentioned that individual citizens were not consulted, and that the consortium has not come across any other noise solutions recommended by citizens that fit into the scope of the project.

In the course of the Q&A session, it was mentioned that CER (Community of European Railway and Infrastructure Companies) can forward more **information on the EU infrastructure and fleet level** to the consortium, potentially giving indications of the percentages of tracks, soft pads, and other solutions in the EU rail network.

Finally, the EC highlighted that **noise abatement measures must be viewed as an interconnected system**. Measures must be coupled for both wheel and rail, for instance, to achieve significant noise reductions. This applies to road noise as well. Moreover, the question of whether mobility and traffic can be shifted from one mode to another (e.g. road to rail) was raised. It was concluded that the best available measures must be collected and combined in order to obtain substantial results.

3.3 Road Noise

3.3.1 Summary of the presentation

The consortium introduced the seven different types of noise solutions targeting road traffic noise. These include:

- Three solutions at source (quiet tyres, quiet road surface and quiet vehicles);
- Noise barriers; and
- Three urban planning measures (traffic restrictions, longer term urban planning solutions, insulation measures).

Subsequently, the consortium presented findings on each of the noise solutions.

1. **Quiet tyres target the rolling noise**. The induced noise depends on speed, the type of tyre as well as the road surface. The European tyre labels also include a noise dimension. This noise solution can generate a noise reduction of 2 to 4 dB. It has, however, a low level of implementation and takes between 4 to 6 years to be implemented. A benefit of this measure is that it is a low-cost measure. A main obstacle to the implementation of quiet tyres, which tend to have a smaller breadth, are current vehicle manufacturing trends. A part of this trend is the manufacturing of new vehicles that require wider (i.e. noisier) tyres.
2. **Quiet road surface** can enable a reduction of noise by 1 to 5 dB over time. Their implementation varies across Europe, and they require additional maintenance and higher costs.
3. **Quiet vehicles**. Electric vehicles will represent 2% of the fleet by 2030, and hybrid vehicles 25% according to EC forecasts. The expansion of quiet vehicles is driven by the EU vehicles emission limits, national legislation and green procurement of commercial fleets. While this noise solution allows a noise reduction of 2 to 4 dB, the rolling noise remains and limits the possible reduction of noise. The implementation of this measure is rather slow as fleet replacement takes about 12 years. There can be synergies with the tyre noise limits. However, technical constraints can present some obstacles to tyre noise limits.
4. **Noise barriers** typically enable a 10 dB noise reduction on average. This noise solution is widely implemented in the EU. A benefit of this measure are its synergies with road safety (for drivers and residents). However, obstacles include visual aspects (barriers may block the landscape view for residents) and high costs, particularly costs for construction.
5. **Traffic restriction solutions** include access restrictions, access charging, rerouting, speed restrictions, parking restrictions and road sharing. While these measures can reduce noise levels significantly, policymakers and road planners must be more aware of the impact and risks that come with changing the infrastructure and traffic movement (e.g. through rerouting, access restrictions, or road sharing). These measures are widely applied and can be easily implemented. There are multiple synergies possible between air quality, urban planning, and climate. Notably, the cost of traffic restriction solutions is not very high, making them affordable. Obstacles, however, may include reduced access for vehicles to certain urban areas and the long planning duration.
6. Longer term **urban planning** includes road tunnelling, bypass or circular roads, building relocation, office barriers, quiet areas, quiet facades, pedestrian zones. There are uncertainties as to how the effects of quiet areas should be calculated. The road measures induce large reductions and are frequently implemented. Measures on buildings also allow a large reduction but their implementation varies. All the measures require long implementation time, and their costs are very high and create an obstacle to their implementation. Synergies exist notably with urban quality.
7. **Insulation of dwellings,** such as deaf facades, create high reductions of indoor levels between 10 to 40 dB, even though it has no effect on the noise level at the facade. This solution is widely applied and creates synergies with energy saving. However, among the major difficulties encountered by this solution are costs and related to this matter insufficient public funding.

For the purpose of better understanding, the above-mentioned elements are summarized in the table below.

Table 4. Seven solutions for road traffic noise

Selected solution	Noise abatement measure	Noise reduction in dB	Implementation level	Implementation time	Synergies	Obstacles	Cost
1. Noise solutions at the source	Quiet tyres	2-4 dB	low	4-6 years	Energy (fuel)	Other tyre criteria, vehicle weight trend	Limited
	Quiet road surface	1-5 dB	- 10% DE, 22% ES, 88% NL - uncommon in many countries	Short	/	High costs, maintenance	High (both investment and LCC)
	Quiet vehicles	2-4 dB	New vehicles must comply, and fleet age varies in the EU	Fleet replacement: 12 years	Tyre noise limits	Technical constraints	Moderate (R&D)
2. Noise barriers	Noise barriers	10 dB	Wide	Medium	Safety	Costs and view	High for construction
3. Urban planning	Traffic restrictions	Large	Wide	Short	Urban quality, air quality, climate	Costs, reduced access, planning duration	low/medium (reconstructi on, enforcement)
	Roads (tunneling bypass or circular roads); building (relocation, office barriers); quiet areas	Roads - large	High	Long	Urban quality	Costs, planning	High
		Buildings – large	Varies	Long	/	Costs, planning	High
		Quiet areas - /	Varies	Long	Urban quality	Costs, planning	High
	Insulation (façades and windows)	10-40 dB indoor	Wide	Short	Energy	Costs and public funding	High

Based on these findings the consortium defined several scenarios.

Table 5. Road traffic noise scenarios

Noise solution	Current situation	Target (scenario)
A. Quiet road surface	5% of EU roads	15% in 2030
B. Quiet tyres		4 dB reduction
C. Vehicles limits		Enhanced compliance
D. Electrification	25% hybrid and 2% electric	50% hybrid
E. Noise barriers	5% of EU roads	10%
F. Speed restrictions in urban areas		30 km/h for residential streets Motorways reduction plans Planned reduction depending on the road types
J. Reception limit		60 dB L_{den}, 55 dB L_{night}

For three other scenarios, namely:

- G. Access restrictions, rerouting
- H. Urban planning
- I. Dwelling insulation

there are uncertainties on how to model them as they are not source measures. Therefore, they may have different effects in different places in the area. That is:

Following the definition of these different scenarios, the consortium added the possibility of combining them and suggested three combinations:

- Scenarios A, B and C
- Scenarios A, B, C and D
- Scenarios F, G, H and I

  The combined scenarios are proposed for measure combinations that will result in a larger noise reduction than single measures. Many other combinations are feasible but the several promising ones are given here.

The Annex 1 contains the full PowerPoint presentation of the session for further details and references.

3.3.2 Q&A overview

The consortium had prepared poll questions for the participants under this presentation. To the question “which noise solutions are most important for achieving 20-50% reduction of health effects in 2030?”, the majority of participants (49%) answered source solutions (quiet vehicles and quiet road surfaces), while 44% chose urban planning solutions (roads, buildings, quiet areas), and 31% traffic restrictions.

Subsequently, when asked which legislation was the best driver for implementation, EU vehicle limits ranked first (38%), followed by national and local regulations (35%) and the END (32%). Almost a quarter of the respondents (23%) chose the EU tyre limits. Most respondents (42%) considered that type-test regulation should better reflect real-world noise levels, and almost a half (52%) that

CNOSSOS should be made suitable for planning beside noise mapping. Stricter limits on tyres were also suggested.

The discussion with the participants included several topics. First, the question of whether electric cars are heavier and have a higher noise profile on the tyres was raised. The consortium explained that this statement was not certain. Furthermore, the participants pointed out the issue of availability of quiet tyres on the market in the modelling of traffic noise. The consortium explained that a separate investigation on the market distribution of wider tyres was needed. For the time being, the quietest tyres do not constitute a large share of the fleet.

Another part of the Q&A section for road noise revolved around the issue of traffic. In one question, the issue of socio-economic costs associated with traffic restrictions was addressed. The consortium explained that it did not take into account socio-economic factors in the development of scenarios, since this would have required a much broader calculation model. Specifically, the question referred to the socio-economic impact of speed limits. Furthermore, the issue of other traffic limitations such as congestions and their impact on noise levels was addressed. Finally, participants discussed the main driving forces behind traffic noise, such as urbanization and population growth.

Another point of discussion was the high noise reduction potential of insulation measures, which was questioned by participants. The consortium explained that the presented 40dB noise reduction potential of insulation measures was a rough estimate and that it depended on factors such as the state of the dwelling (new or old building) before the insulation. It was concluded that, in general, 10 dB is a good, realistic level of noise reduction. By contrast, a 40 dB reduction through insulation may be possible, but it would also require sound insulation of other components such as doors, ventilation and roofing.

In the discussion round on road noise, participants also commented on the idea of combining solutions. This issue was raised previously in the workshop (see Q&A section on railway noise). The participants suggested drafting a list of affordable measures that the consortium may consider combining. Participants also suggested that an efficient way to achieve noise reduction by connecting measures is combining the electrification of vehicles with speed restrictions (i.e. lower speed limits). Note: this is already proposed.

Additionally, a modal shift from one means of transport to another (from road to rail) for the purpose of noise reduction was also mentioned several times again in the course of the discussion.

Moreover, participants also highlighted the issue of vehicles equipped with AVAS (Acoustic Vehicle Alert System). AVAS are designed to make pedestrians aware of the presence of approaching, quiet electric vehicles by producing sound for safety reasons. The reason for this is that very quiet electric vehicles may pose a risk to the safety of pedestrians. While it is highly important to keep pedestrians safe, the participants of the workshop were aware of the associated noise pollution.

Finally, innovations such as the use of diffractors, which resulted in a reduction of about 1 dB in Rotterdam, was mentioned by a participant in the Q&A section. The aim of diffraction is not to absorb or block sound but rather to 'bend it away. The concept is based on the scientific principle that sound waves can deflect each other when interacting, therefore abating noise.

4 Stocktaking

The third and final part of the workshop was designed to take stock of the presented findings and subsequent discussions. The plenary session feedback included open questions from participants on below-mentioned topics related to the subjects of the presented study. The discussion on selected topics was ongoing in parallel in the workshop chat. The main inputs from stakeholders are summarised below and will be taken into account during the next stage of the study. Finally, the session was concluded with a series of poll questions.

Leisure noise

Regarding the citizen's initiative on the noise inside agglomerations, it was suggested that urban planning is an important aspect. However, it does not solve on its own noise problems. When a street is transformed to a pedestrian zone, the type of noise may shift from vehicle to leisure noise. It was suggested that the study should consider the noise as a comprehensive subject and include the leisure noise as a part of the calculation. But this would be hard to predict due to lack of information, and leisure noise is different to traffic noise.

Covid-19 scenarios

In terms of Covid-19, it was suggested to review reduced traffic data collected by the Bruitparif during the lockdown period in France. This data could be useful for the development of temporary Covid-19 scenario effects. The data from the lockdown period shows symmetrical noise reduction, both from vehicles and leisure noise. The studies on the subject compare the situation before and during the lockdown period.

In addition, a new comparative study will soon be published about the noise reduction levels in Greece for road and aircraft noise based on monitoring stations data for the lockdown period and the 2018-2019 noise data.

Furthermore, useful data was collected by the EUROCITIES on the noise data during the Covid-19 lockdown, which could be used for this research.

Noise solutions

Regarding noise solutions, it was pointed out that the largest potential for physical noise reduction comes from the interventions at the vehicles and in the transmission path. However, the fastest solutions to implement are related to vehicle' operation (e.g. driving style, aircraft take-off and landing) and restrictions. While at the national level among the most significant drivers for implementing noise solutions constitute the reception limits legislation, at the EU level this is the noise source limit legislation (e.g. vehicles, tires, rolling stock etc.). Also, an important factor in the noise impact is the population and traffic density. Finally, it was stated that the greatest obstacle to the implementation of any noise solution is the investment cost.

Population scenario

Given that significant population growth is not expected in the next 10 years (the period for noise solutions covered by this study), the estimates foresee only 1% increase in the traffic flow over the same period in Europe. However, in the longer-term, beyond the next decade, the population and the traffic are expected to grow.

Feedback from stakeholders on noise laws and policy

The consortium will seek further consultation with the representatives of the Member States on the implementation of national and EU legislation on noise policy to identify the key drivers for noise solutions. This stakeholder's consultation aims to demonstrate a possible need for new sectorial legislation. For the time being, less than a quarter of the Member States representatives agreed to share their input with the consortium during the stakeholder consultation. The active participation from the Member States was limited during the workshop. The key messages gathered during the workshop on national level noise policy are listed below:

- The quality assessment of NAPs at the EIONET platform should be improved, as well as the gaps in terms of the END reporting; (Greece)
- There is a lack of guidance in urban planning regarding the environmental noise; (UIC)
- The externalisation of noise costs may be an area where the EU level could play a role, at least to give indications on what is acceptable and reasonable. This might ensure that external costs do not become an element of competition between regions (e.g. for airports or trans-European fast rail) - *(German Acoustical Society - DEGA e.V.)*;
- The relationship between urban planning and urban noise control shows the importance of the analysis of national regulations. For instance, in Germany the framework regulation for urban planning is adopted at the national law (Baugesetzbuch) - (NEG Member);
- In Switzerland, there are available methods that could extrapolate lower noise levels (below 55 dB), where most of the health burden occurs;
- According to a Finnish participant it would be more realistic to explore scenarios with 10%-20% use of electric cars by 2030 rather than the scenario with the use of 100% hybrid vehicles;
- Shift between transport modes should be further explored. Especially, in the period of the Covid-19 situation, at the national level replacing of the national flights with train connections should be sought – (Slovenia);
- It was suggested that were it is impossible to avoid passive noise solution coming from urban densification, the study explore the cost benefit aspects between existing and new buildings - (Romania);
- It was suggested to consult the EUROCONTROL CNS dashboard about the airport's grounding equipment (e.g. it could help identify airports with the GBAS equipment allowing better approaches/landings in terms of noise) - (Romania);
- It was pointed out that the ICAO balanced approach and 598/2014 EU regulation were perceived as a legislation put in place to avoid the adoption of noise-related operating restrictions - (Greece, Romania);
- Regarding the management of different environmental policies, in the case of aircraft operations trade-off is almost inevitable considering environmental noise and CO2 emissions/fuels consumption (noise/air quality) - (Slovenia);
- It was suggested to cover the modal shift under the present study (considering the merging of transport modes should give the higher beneficial outcome) - (Greece);
- The road speed limits apply only to urban roads while at major (national) roads the socio-economic costs for lower speeds are much higher due to longer travel time. However, controlled, and reduced speed limits are important for all road types - (NEG Member);
- The national authorities are responsible for policies that had created traffic noise considering the population growth, socio-economic development and urbanisation. Therefore, the noise abatement measures are mainly treating the consequences and not causes; (Finland)
- Some Member States were favourable to the introduction of the noise reception limits at the END level. According to the discussion, Member States expressed an opinion that they

have difficulties at observing national noise threshold levels that are generally less strict than the WHO thresholds. It was mentioned that some Member States have legislation on noise reception limits relevant to specific situations. However, these different noise benchmarks could represent a driver for the reduction of the noise level in a shorter period of time, while working towards achieving the WHO thresholds in the medium or longer term. - (Greece, Swedish NEG Member, Denmark).

Noise reception limits

Given that noise reception limits are regulatory competence of the Member States, consensus has not yet been reached on the introduction of EU noise limits. However, it was pointed out that at the current stage the harmonisation of practices could be improved by adoption of guidelines for Member States and other soft law means. Member States also have different noise reception limits values. Especially, the difference can be noted between the East and the West European countries.

WHO noise limit values

The workshop participants have expressed difficulty to fulfil the WHO's noise thresholds at the national level. In general, the current Member States' noise thresholds exceed the noise limit values established at the WHO level. The achievement of the WHO's thresholds is an ambitious aim that could be, however, realised in a two-stage approach (short term and mid/long term). First, in a short term perspective, the introduction of the EU situation specific thresholds could be recommended (e.g. for existing or new infrastructure, tyres, vehicles etc.).[4] Secondly and in parallel to the first step, in a mid/long term perspective the EU and its Member States should aim to achieve the WHO's thresholds.

Infrastructure investments

It was emphasised that noise solutions should be considered as a part of future infrastructure projects. Therefore, as such, they should be included in future investment projects as well as across other policy areas (e.g. quality of life, air quality etc.). It is especially important as most often the noise solutions come from physical sources (e.g. vehicles, tires, tracks, roads etc.).

Noise Action Plans implementation

The workshop participants pointed out that the implementation of NAPs measures should be better monitored at the EU level. It was suggested that for identification of efficient noise solution the assessment of measures should go beyond those mentioned in NAPs. Nevertheless, given very weak availability of data, the assessment of the implementation rate of the existing noise solutions remains very difficult under this study. The information on the implementation rate is mostly collected from the interviews.

Communication, citizens and political engagement

Citizens' awareness of the noise issue is an important aspect of formulation of future noise policies. Gathering the feedback from citizen's organisations across Europe could be performed more systematically with the harmonisation of practices by guidance. An increasing public pressure could put a higher priority of this matter on the political agenda at the local level. A more important political engagement could considerably increase the willingness to the more effective implementation of noise solutions. Therefore, the feedback provided in the framework of the open public consultation on the END is very relevant.

Future noise solutions in cities

The cities could pay an increasing attention in the future to the noise aspects, especially, while developing urban planning measures and other environmentally friendly initiatives (e.g. mobility,

[4] Already present in some Member States regulatory framework.

greening, renovation etc.) Special attention should be paid to the future cities' infrastructure undertakings and the development of residential areas.

Poll questions

At the end of the last session, the workshop participants were invited to express their opinions to the series of poll questions on noise solutions, their implementation, the costs of these solutions, and surrounding legislation. For further reference, the Annex 2 contains the complete Poll results questions and answers section.

4.1 Key remarks and concerns

During the closing session some key remarks and concerns were raised:

- Lack of adequate measuring of community consultation and engagement;
- Need for harmonisation of NAPs implementation across the EU member states;
- Need for harmonisation of noise thresholds and noise-related policies that could help decrease noise pollution;
- Need for consistent guidance for development and monitoring of implementation of NAPs;
- Single noise abatement solutions should be combined with each other in an effective way in order to increase their impact;
- Noise pollution should be considered as early as possible at the planning stage (e.g. urban areas, airport, railway, road, infrastructure) given difficulties to make substantial changes after the construction of structures.

The above-mentioned key remarks will be considered by the consortium during the next stage of the Phenomena project implementation.

4.2 Action points/next steps

The Commission and the consortium have agreed on the following points after the workshop:

- The comments on the 1st interim report and the workshop will be integrated in the 2nd interim report;
- Further discussion on the implemented measures having effect after 2030 is to be organized before the submission of the 2nd interim report;
- Stakeholders interviews and NAPs analysis will continue before the submission of the 2nd interim report. Especially, the stakeholder consultation will seek the feedback from the Member states transport authorities (e.g.: Transport Ministries) and local level representatives;
- Noise solutions, cost-Benefit analysis and scenarios will be further developed;
- The 2nd interim report is to be submitted by October 15th;
- The 2nd workshop is to take place on November 10th;
- The 2nd interim meeting is to take place on November 18th.

Annex 1: Workshop presentations

Annex 2: Poll results

During the workshop, a series of polls was conducted with the participants as part of the sessions on the methodology for the health benefits assessment and the aviation, railway, and road noise solutions and scenarios. The plenary feedback session also included polls that allowed participants to voice their opinion in the final discussion of the workshop.

After the presentation on the **methodology for the health benefits assessment**, participants were asked to respond to the question "What do you think is the most important origin of uncertainty of the methodology?" and the majority (36%) selected the answer "Health impact assessment – Example: calculating health effects from exposure distributions". The second most selected answer was "Exposure distributions – Example: exposure represented by façade level; different national methods used for noise mapping", receiving 17% consent from participants.

The session on **aviation noise solutions and scenarios** included three poll questions, which focused on future outlooks for noise solutions as well as noise legislation. Responding to the question "Which (single) noise solutions are most important for achieving 20-50% reduction of health effects in 2030", most participants (26%) viewed "land use planning" as most important solution to reduce noise in the next decade. The solution "operational restrictions" also received significant approval by the participants (22%). In the second question, participants were asked which (single) solution they considered most likely to be implemented in 2025. The most popular answer was "operational procedures" (26%), followed by noise management (15%) and operational restrictions (14%). Notably, "land use planning" (8%) was regarded the least likely solution to be implemented. This shows that there is a discrepancy between what solution is most likely to be implemented (operational procedures) and what is in fact considered most beneficial for health (land use planning).

Finally, participants were asked whether they think that the EU Regulation 598/2014 is sufficient to implement the potential solutions. Most attendees answered with "no" (26%), demonstrating that there is a need for further improvement.

Similar to the poll on aviation noise, the poll on **railway noise solutions and scenarios** also included questions on future outlooks for noise solutions and legislation. Additionally, questions regarding the ease of implementation, effectiveness, and cost-effectiveness of solutions were asked.

Answering the question "Which (single) noise solutions are most important for achieving 20-50% reduction of health effects in 2030", attendees considered "rail roughness control" (37%), "wheel roughness control" (31%), and "quieter vehicle/wheel design" (28%) as the most important in the future. Furthermore, responding to a question on what solutions participants expect to be implemented in their country within the next 10 years, most answered with "noise barriers" (32%), "rail roughness control" (23%), and "wheel roughness control" (17%). This shows that despite the potential of other solutions, noise barriers are likely to remain a popular solution for railway noise abatement in the future.

Moreover, workshop participants regarded "rail roughness control" (38%), "wheel roughness control" (25%), and "noise barriers" (29%) the easiest solutions to implement at present. By contrast, solutions with a wider infrastructural scope such as urban planning and rerouting/traffic restrictions were considered the most difficult to implement. Answer a question on what solutions are most effective, participants responded with "rail roughness control" (25%), "noise barriers" (25%), and "quieter vehicle/wheel design" (19%). Following up on this topic, the next question asked participants which solution they consider most cost-effective. "Rail roughness control" (30%) and "wheel roughness control" (25%) were clearly the most selected answers, demonstrating that these two solutions were considered the easiest to implement as well as the most cost-effective among all presented solutions. Additionally, rail roughness control was also considered the most effective among all solutions, ranking in the top in all of these three questions.

Regarding EU legislation, attendees found that the TSI – Technical Specifications for Interoperability (21%) and the END – Environmental Noise Directive (13%) provide the best means for driving the implementation of solutions. Notably, no participant selected the answer "NDTAC – Noise Differentiated Track Access Charges" (0%). On the national and local level, participants considered "reception limits" (25%) and "emission ceilings" (13%) the best means for driving implementation.

The poll of the session on **road noise solutions and scenarios** contained questions on future outlooks of solutions, noise legislation, and noise-related planning methods.

Following the rationale of the poll on aviation and railway noise, participants were asked the question "Which (single) noise solutions are most important for achieving 20-50% reduction of health effects in 2030". According to the poll, the most important solutions are "source solutions (quiet vehicles and quiet road surfaces" (49%) and "urban planning solutions (roads, buildings, quiet areas)" (44%). The solution "traffic restrictions" (31%) also received considerable approval.

In regard to EU legislation, EU vehicle limits were considered the best driver for implementation (38%), followed by national/local regulations (35%) and the END (32%). Furthermore, participants clearly agreed (42%) that test type regulations should better reflect real world noise levels.

Finally, participants were asked whether, besides noise mapping, CNOSSOS should be made suitable for planning. Approximately half of all participants (52%) agreed that it should (answer "yes").

The final round of polls during the **plenary feedback session** contained a range of different questions about noise solutions, implementation, the cost of solutions, and legislation. The majority of participants agreed on the following statements:

- Physical solutions have the largest potential when combined (e.g. vehicle and track, engine/tyres and road surface) (64% approval)
- Operational solutions/restrictions are fastest to implement, others take much longer (51% approval)
- Strong drivers for solutions are reception limits (national) and source limits (EU) (62% approval)
- Implementation of solutions is highest in countries with high population density and traffic volume, strongest need, and policy drive and funding (42% approval)
- Concerning road vehicles, the link between type test source regulation and real-world noise/prediction models needs improving (50%)
- Cost/investment and time to take full effect are obstacles for implementation (58% approval)

Discussing EU noise legislation, participants believed that new/amended legislation on the noise source (38% approval) has a greater potential to increase the implementation of measures than new/amended legislation on the receiver (27% approval). Finally, most participants (32%) agreed that the harmonization of practices is the best regulatory option. Hard legislation was found to be another good regulatory option (25% approval), while soft legislation was not considered very useful with only 9% approval.

The table below presents the complete list of polls and their results based on the attendees' responses from the workshop. For all questions, the ratio of "No Answer" responses can be explained by the fact that the consortium and the Commission – and sometimes a number of other workshop participants – did not participate in the polls.

Table 6: Complete list of all workshop polls and their results

Methodology for health benefits assessment (TNO)	
1.What do you think is the most important origin of UNCERTAINTY of the methodology?	
A. Noise sources - Example: minor urban streets are often neglected in noise mapping	16/113 (14%)
B. Exposure distributions - Example: exposure represented by façade level; different national methods used for noise mapping	19/113 (17%)
C. Health impact assessment - Example: calculating health effects from exposure distributions	41/113 (36%)
No Answer	37/113 (33%)
Aviation noise – solutions and scenarios (ANOTEC)	
1.Which (single) noise solutions are most important for achieving 20 50% reduction of health effects in 2030?	
A. Operational procedures	12/103 (12%)
B. Operational restrictions	23/103 (22%)
C. Land use planning	27/103 (26%)
D. Noise management	9/103 (9%)
No Answer	32/103 (31%)
2.Which (single) noise solutions are most likely to be implemented until 2025?	
A. Operational procedures	27/103 (26%)
B. Operational restrictions	14/103 (14%)
C. Land use planning	8/103 (8%)
D. Noise management	15/103 (15%)
No Answer	39/103 (38%)
3.Is EU Regulation 598/2014 sufficient to implement the potential solutions?	
A. Yes	6/103 (6%)
B. Yes, with minor adaptation	18/103 (17%)
C. No	27/103 (26%)
No Answer	52/103 (50%)
Railway noise – solutions and scenarios (TNO)	
1.Which noise solutions are MOST IMPORTANT for achieving 20-50% reduction of health effects in 2030?	
A. Wheel roughness control	32/104 (31%)
B. Rail roughness control	38/104 (37%)
C. Quieter vehicle/wheel design	29/104 (28%)

D. Noise barriers	26/104 (25%)
E. Urban planning buildings/infra	25/104 (24%)
F. Dwelling insulation	6/104 (6%)
G. Rerouting and traffic restrictions	12/104 (12%)
No Answer	40/104 (38%)
2.Which solutions are EASIEST to implement?	
A. Wheel roughness control	26/104 (25%)
B. Rail roughness control	39/104 (38%)
C. Quieter vehicle/wheel design	13/104 (13%)
D. Noise barriers	30/104 (29%)
E. Urban planning buildings/infra	4/104 (4%)
F. Dwelling insulation	15/104 (14%)
G. Rerouting and traffic restrictions	3/104 (3%)
No Answer	41/104 (39%)
3.Which solutions are most EFFECTIVE?	
A. Wheel roughness control	18/104 (17%)
B. Rail roughness control	26/104 (25%)
C. Quieter vehicle/wheel design	20/104 (19%)
D. Noise barriers	26/104 (25%)
E. Urban planning buildings/infra	19/104 (18%)
F. Dwelling insulation	12/104 (12%)
G. Rerouting and traffic restrictions	14/104 (13%)
No Answer	44/104 (42%)
4.Which solutions are most COST-EFFECTIVE?	
A. Wheel roughness control	26/104 (25%)
B. Rail roughness control	31/104 (30%)
C. Quieter vehicle/wheel design	15/104 (14%)
D. Noise barriers	13/104 (13%)
E. Urban planning buildings/infra	9/104 (9%)
F. Dwelling insulation	5/104 (5%)
G. Rerouting and traffic restrictions	7/104 (7%)
No Answer	50/104 (48%)
5.Which solutions do you EXPECT TO BE IMPLEMENTED in your country in the next 10 years?	
A. Wheel roughness control	18/104 (17%)

B. Rail roughness control	24/104 (23%)
C. Quieter vehicle/wheel design	12/104 (12%)
D. Noise barriers	33/104 (32%)
E. Urban planning buildings/infra	9/104 (9%)
F. Dwelling insulation	14/104 (13%)
G. Rerouting and traffic restrictions	3/104 (3%)
No Answer	50/104 (48%)
6.Which EU legislation provides the best means for driving implementation?	
A. END - Environmental Noise Directive	14/104 (13%)
B. TSI - Technical Specifications for Interoperability	22/104 (21%)
C. NDTAC - Noise Differentiated Track Access Charges	0/104 (0%)
D. 'Quiet Routes' obligation	5/104 (5%)
E. Retrofitting	10/104 (10%)
No Answer	53/104 (51%)
7.Which national or local regulations provide the best means for driving implementation?	
A. Reception limits	26/104 (25%)
B. Emission ceilings	14/104 (13%)
C. Other	7/104 (7%)
No Answer	57/104 (55%)
Road noise – solutions and scenarios (TNO)	
1.Which noise solutions are most important for achieving 20-50% reduction of health effects in 2030?	
A. Source solutions (quiet vehicles and quiet road surfaces)	47/95 (49%)
B. Noise barriers	17/95 (18%)
C. Traffic restrictions	29/95 (31%)
D. Urban planning solutions (roads, buildings, quiet areas)	42/95 (44%)
E. Dwelling insulation	11/95 (12%)
No Answer	28/95 (29%)
2.Which EU legislation is the best driver for implementation?	
A. END	30/95 (32%)
B. EU tyre limits	22/95 (23%)
C. EU vehicle limits	36/95 (38%)
D. National / local regulations	33/95 (35%)
No Answer	30/95 (32%)
3.Should type test regulation better reflect real world noise levels?	

A. Yes	40/95 (42%)
B. No	5/95 (5%)
C. Do not know	20/95 (21%)
No Answer	30/95 (32%)
4.Should CNOSSOS be made suitable for planning, beside noise mapping?	
A. Yes	49/95 (52%)
B. No	11/95 (12%)
No Answer	35/95 (37%)
Plenary feedback session (entire consortium)	
1.Physical solutions have the largest potential when combined, e.g. vehicle and track, engine/tyres and road surface	
A. Yes	55/86 (64%)
B. No	5/86 (6%)
C. No opinion	2/86 (2%)
No Answer	24/86 (28%)
2.Operational solutions / restrictions are fastest to implement, others take much longer	
A. Yes	44/86 (51%)
B. No	6/86 (7%)
C. No opinion	9/86 (10%)
No Answer	27/86 (31%)
3.Strong drivers for solutions are reception limits (national) and source limits (EU)	
A. Yes	53/86 (62%)
B. No	4/86 (5%)
C. No opinion	4/86 (5%)
No Answer	25/86 (29%)
4.Implementation of solutions is highest in countries with high population density and traffic volume, strongest need, policy drive and funding	
A. Yes	36/86 (42%)
B. No	5/86 (6%)
C. No opinion	18/86 (21%)
No Answer	27/86 (31%)
5.Road vehicles: Link between type test source regulation and real-world noise / prediction models needs improving	
A. Yes	43/86 (50%)
B. No	1/86 (1%)

C. No opinion	13/86 (15%)
No Answer	29/86 (34%)
6.Cost/investment and time to take full effect are obstacles for implementation	
A. Yes	50/86 (58%)
B. No	3/86 (3%)
C. No opinion	6/86 (7%)
No Answer	27/86 (31%)
7.How can EU (noise) legislation increase the implementation of measures?	
A. New/amended legislation source	29/77 (38%)
B. New/amended legislation receiver	21/77 (27%)
No Answer	27/77 (35%)
8.Which regulatory options?	
A. Hard legislation	19/77 (25%)
B. Soft legislation	7/77 (9%)
C. Harmonisation of practices	25/77 (32%)
No Answer	26/77 (34%)

Annex 4: Workshop Background report

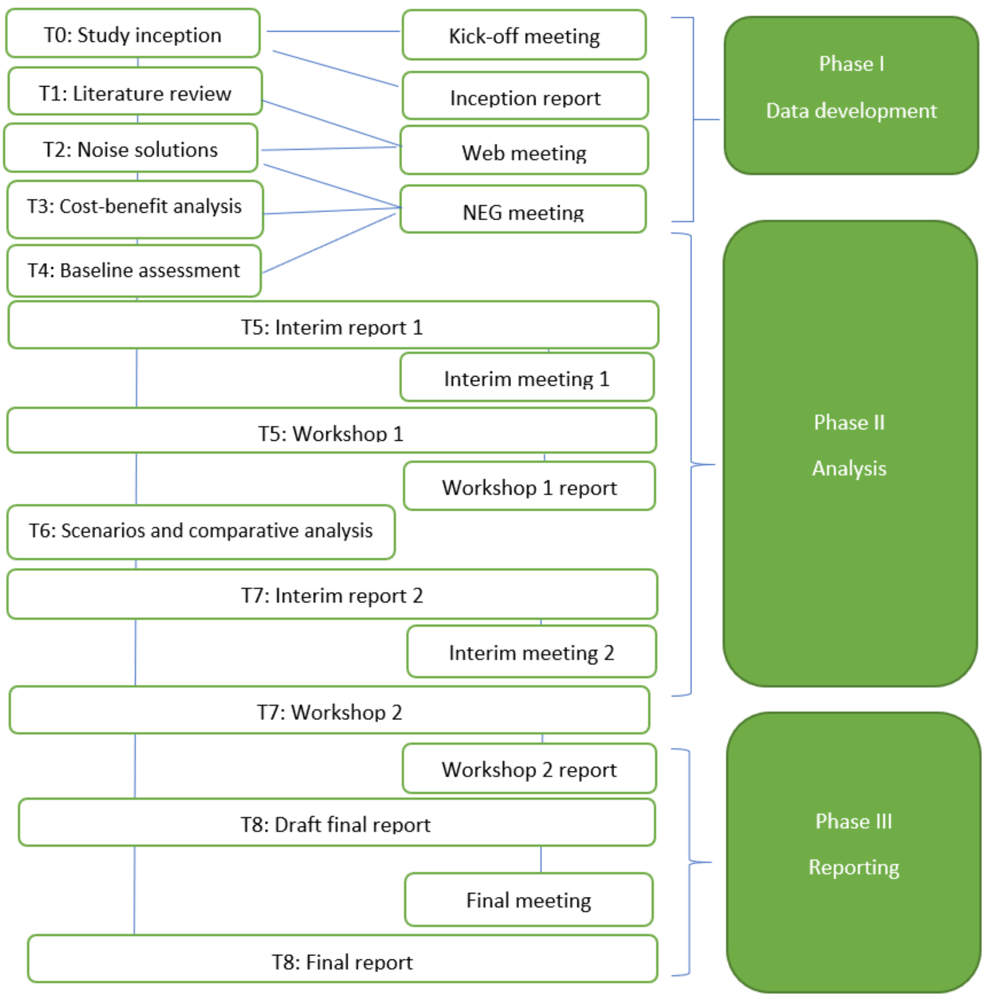
1 State of play

1.1 Objectives

The objective of the study is to support the European Commission in defining the potential of measures capable of delivering significant reductions (20%-50%) of the health burden due to environmental noise from roads, railways and aircraft, and to assess how relevant noise related legislation could enhance the implementation of measures, while considering the constraints and specificities of each transport mode. The project collects and analyses data from the geographic areas with the following limitations:

- roads and railways inside agglomerations of more than 100,000 inhabitants;
- major roads of more than 3 million vehicles a year;
- around major railway lines of more than 30,000 trains a year; and
- around major airports of more than 50,000 movements a year.

1.1.1 Tasks



1.2 Output

The first interim report of the project was submitted on the 29th of May, presenting the early results of the stakeholder consultation, the literature and legislative review including the general review of 100 and the in-depth review of further 50 noise action plans.

The report also contains the first results of the legislative drivers as identified from the first set of noise action plan assessment. The methodology used to derive health benefits and CBA for legislative as well as noise solution scenarios is described, and an overview of noise abatement solutions is given for each transport mode. Also, the baseline for single noise solutions, their potential scenarios for 2030 are suggested, together with some combined scenarios.

2 Results

The results of the first interim report of the Phenomena project are summarised below.

2.1 Noise legislation, drivers, and implementation

2.1.1 Literature and NAP review.

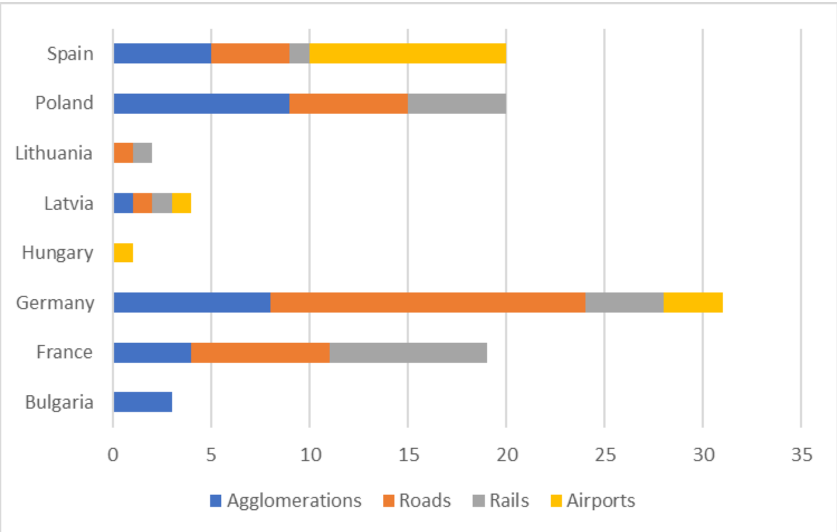
A comprehensive desk-based and legislative research was carried out to assess the current policy and technical environment related to noise solutions. More specifically, the aim of the desk-based research is to provide information on the current level of progress, ambitions, and challenges regarding the implementation of noise abatement measures in member states. It is composed of the following main elements:

- Overview of relevant member state and 'END and noise source legislation (including action plans and legislation on noise at source);
- Assessment of the level of implementation (compliance and benefits) of relevant member states and EU level policies; and
- Identification and analysis of noise solutions.

Selected NAPs for general review

100 noise action plan (NAPs) summaries[5] were analysed from eight member states, namely: Bulgaria, France, Germany, Hungary, Latvia, Lithuania, Poland and Spain covering agglomerations, roads, railways and airports. The aim of this general analysis was to identify whether there were any interventions resulting from the noise action plans and if so, what type of interventions these were. An overview of the action plan analysis per type of transport mode and country is shown in the following graph.

Figure 3 Selected NAPs for general review by country and noise source



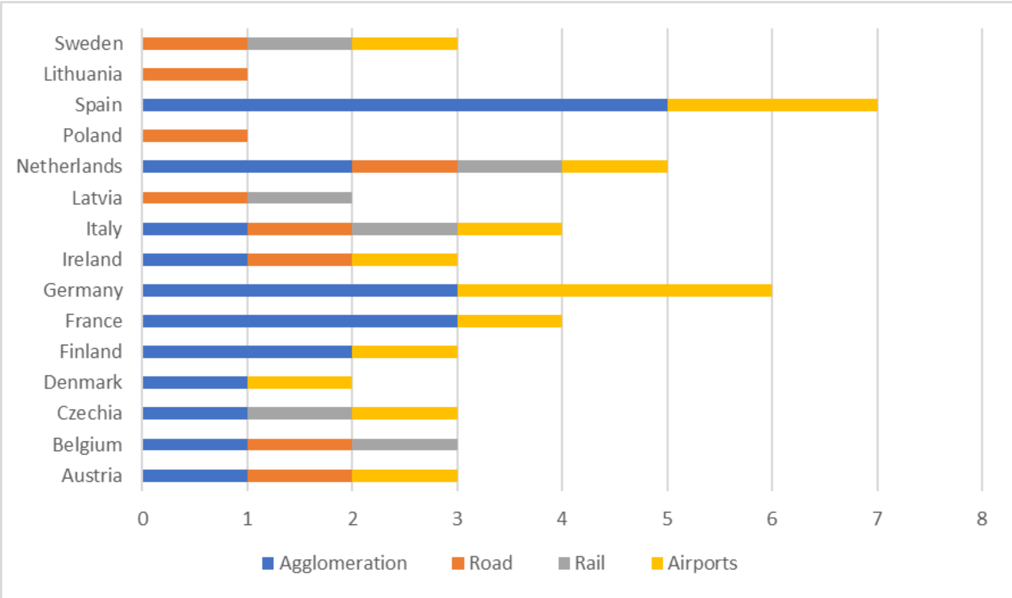
[5] Delivered in Reportnet, which is Eionet's infrastructure for supporting and improving data and information flows. https://www.eionet.europa.eu/reportnet

An additional 100 noise action plans will be analysed in the second half of the study, integrating the feedback from the Commission and the stakeholder groups, and adapted to the availability of data reported by member countries.

Selected NAPs for in-depth review

Further to the general analysis, we have also completed in-depth analysis of 50 noise action plans from Spain, Poland, Lithuania, Latvia, Germany, France, the Netherlands, Belgium, Italy, Ireland, Denmark, Czechia, Sweden, Finland, and Austria. An additional 50 noise action plans will be analysed in the second half of the study following the first round of feedback from the Commission and the stakeholder groups.

Figure 4 Selected NAPs for in-depth review by country and noise source



2.1.2 Legislative drivers

The analysis examined the causal links that exist between EU and national legislation, as well as the number and types of noise solutions that have been implemented. Hence, the study sought to define:

- how legislation drives the implementation of noise solutions,
- how successful these measures are in terms of reaching their objectives (reducing noise, reducing the number of people who are exposed to higher noise pollution etc.)

This assessment is built on the findings of the literature review, stakeholder interviews and the analysis of the noise action plans.

Results

The in-depth assessment of specific action plans indicated that the implementation of the END had a significant impact on EU-wide legislative framework and provided relevant drivers for:

- the implementation of regional and national level initiatives;
- providing transparency on the implementation and efficiency of previous measures;
- allowing for feedback from the public and interested stakeholders;
- creating a platform for comparative analysis specifically as it refers to:
  - identification of best practices;

- cross-border initiatives.

Due to the complexities of the sources, distribution and impact of various noise levels, the study has shown that it is imperative that legislative measures remain flexible enough to accommodate regional specificities of climate and weather as well as urban development trends, innovation and cost effectiveness of measures. The literature points out that within the relatively wide concept of urban development trends, specific attention must be paid to socio-economic issues such as housing and poverty to avoid a disproportional impact of noise pollution on low-income households or marginalised communities. Examples have shown that transport infrastructure operators alone have a relatively limited toolkit to counterbalance larger socio-economic trends. These may include the acquisition of dwellings or banning/limiting the number of housing developments in the vicinity of high noise areas. A less frequently used action was communication and dissemination of information particularly one that focuses on the health impacts of noise pollution not only on the level of noise. To facilitate wider outreach and communication with citizens highlighting health implications of noise exposure, a number of stakeholders must cooperate including the transport operators/managers, local and national authorities as well as NGOs and public health representatives. In addition to education and dissemination campaigns collaboration/consultation between these stakeholders could support urban planning and smart city initiatives targeting sustainable environments.

Additionally, no indication was found (in the selection of NAPs reviewed) that infrastructure relocation would be among the considered options for reduction of noise at source. Limiting traffic at certain times or on specific section of roads, rail or airways is used among the solutions however complete relocation of the noise source infrastructure (airport, railway, road) was not recommended in the reviewed NAPs. This is largely due to the associated financial costs of such a move. Instead attention was paid to reduce noise at the receiver via new insulation, urban planning, introducing quiet areas etc. Nevertheless, it has been noted that in the reviewed period the railway tunnelling, bypass roads and relocated airports were built in Europe. These noise source of infrastructures will be the subject of an in-depth analysis in the second reporting period. The combination of these measures combined with the introduction of low noise emission vehicles and aircraft may reduce noise induced health burden, although the extent of this has not been identified by the action plans.

As mentioned above, flexibility of implementation is important to allow for the development of specific noise solutions adapted to the needs of the given region; however also it can lead to differences in implementation. These differences may be a result of different strategies related to the development of certain area, however, some stakeholder interviews identified challenges related to the financing of noise solutions due to a requirement on co-financing of these investments. Bridging the financing gap is a national and/or regional decision which is often determined by long-term strategic priorities. One possible way to bridge the financing gap and highlight the importance of noise solution measures is to underline the linkage between public health and noise exposure specific to the region or urban area in question. It will result in combining of other benefits to the actions undertaken besides the noise.

2.1.3 Intervention logic

The methodological approach for the intervention logic presented below follows general principle of the European Commission used when preparing new initiatives, proposals and when managing and evaluating legislation. This approach is defined in the European Commission's Better Regulation Guidelines.[6] The study aims to identify to what extent the existing legislative drivers serve for the implementation of noise abatement solutions. In doing so, both the cases where all legislation is

[6] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

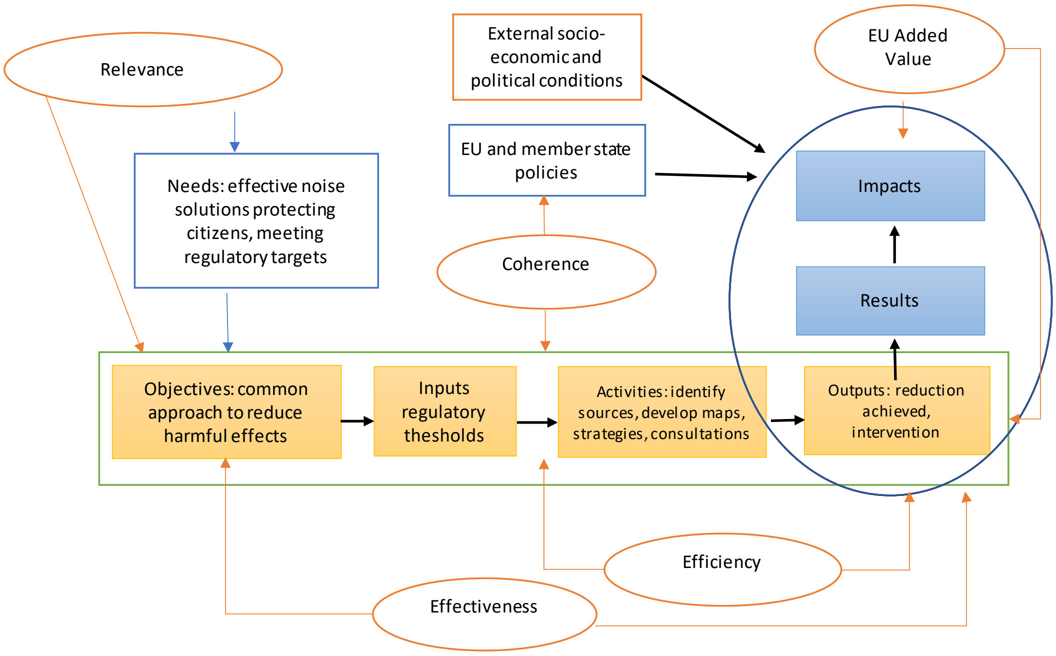
fully implemented and enforced as well as, the cases where the legislation is failing to be respected are considered. To this aim, the study team at the preliminary stage of the project, designed a baseline Intervention Logic to provide a context and narrative highlighting the objectives of the relevant policies and their outputs/impacts. The objective of the intervention logic is to illustrate how the intervention was expected to work (chain of events that should lead to the intended change). An intervention should be understood as a legislative context behind the solution to a problem, which under the present study is noise pollution. The present intervention logic should be perceived as a tool that visualises the different steps, action and actors involved in the intervention, as well as their interdependencies. It demonstrates the cause and effect of these relationships and how both actors and actions were expected to interact to deliver the planned changes over a given lap of time to achieve the objective of the EU intervention behind.

A view of the current intervention logic is presented in Figure 3 below. Baseline reflects the situation at the time when the intervention was designed. The elements of the figure represent the following

- Arrows: the causal assumption/relationships between the boxes;
- Needs: needs that triggered the EU intervention, the problem that the EU intervention aimed to solve;
- Objectives: 'a desired situation' that was supposed to be achieved; changes that were expected to be achieved;
- Inputs: inputs that are supposed to be used to achieve the defined objectives (e.g. understood as human resources, equipment, legislation to be adopted);
- Activities: events that were planned to happen (e.g. what obligations were set or what provisions were expected to be put in place);
- Outputs, results and impacts: consideration of changes over times that were supposed to happen and are presented in the expected order of activities;
- External factors: are factors that could influence the performance of the initial EU intervention, alternate it, or generate the same type of effects;
- Other EU policies: other actions/intervention undertaken at the same time at the EU level that can have a positive and negative effect on the impacts and result of the intervention.

In addition, physical inputs are frequently translated into monetary values, leading to a broader consideration of what has been needed to achieve objectives and possibly to considerations of costs and benefits. For example, in the present case, the costs and benefits related to the noise solutions chosen. Cost analyses can include life cycle cost analyses, where relevant, and benefit analyses where health benefits are monetised, costs for hospitalisations are considered, and increase in real estate value.

Figure 5 Current intervention logic of the current legislative environment



For the purpose of comparison, a revised version of the above figure can be found on the subsequent page in Figure 4. Input into the development of the revised intervention logic was delivered from the literature review, analysis of the NAPs as well as the interviews. The revised intervention logic aims to present how the regulatory environment could be improved in order to facilitate more efficient implementation of noise solution in such a way as to deliver a 20-50% reduction of noise-induced health burden. It depicts the result of the assessment of the relevant policies as viewed at this interim stage. The scheme is not an illustration of the functioning of the END but rather an amalgamation of the relevant EU- and national level policies.

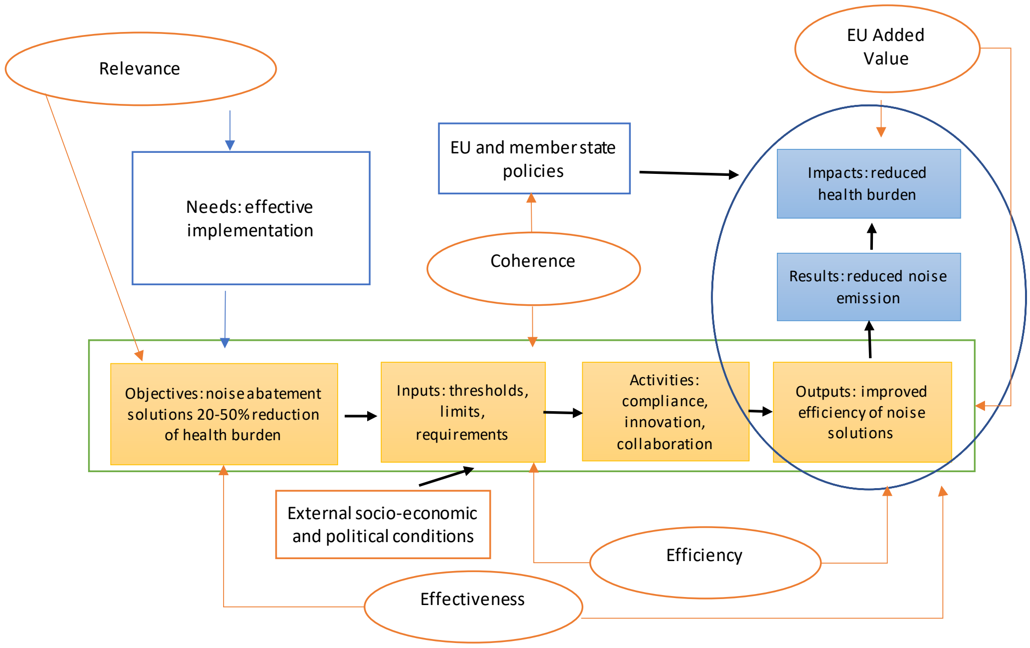
As shown in the figure above, relevant policies identify the need for introducing effective noise solutions to protect citizens from unhealthy levels of noise exposure. Their overarching objective is to reduce harmful effects by using a number of measures. Inputs to the measures are the regulatory drivers and thresholds such as noise limits. A wide range of activities are implemented to comply with the regulatory inputs and meet the objectives including physical interventions, restrictions, limitations at source, interventions at the receiver, education and communication. Outputs are defined as the interventions completed such as flight restrictions, retrofitting of wagons or quieter pavements. Results under this baseline scenario are the noise reductions achieved and the improved public health outcomes realised up until 2019. Corresponding impacts could, in theory, include wider public health improvements, increased number of sustainable transport-related innovative solutions, increased public awareness of noise induced health impacts and wide-scale sustainable urban development concepts. During the assessment however, we found relatively limited evidence of such impacts partly because socio-economic trends (including urbanisation and transport innovation) can change faster than regulatory mechanisms and noise solution impacts. Consequently, the delineation of the impacts of noise solution measures from technical innovations and other complex sustainable policy instruments can be difficult especially when considering changes in external socio-economic conditions including housing crises or population increase.

The revised intervention logic, presented below, shows how an improved regulatory environment could facilitate the delivery of the reduction of noise-induced health burden. The updated scheme builds on the identified inefficiencies of the current EU and member state level regulatory environment, which may stem from:

- indicative EU level noise limits;
- discrepancies between member states' regulatory requirements related to maximum noise reception limits;
- absence of a harmonised EU-level requirement for evaluating the efficiency of previous noise solutions/action plans;
- differences between member states in the availability of financial resources for the implementation of noise solution measures;

Additionally, there are differences in the approaches that member states put forth, e.g. combined approaches in agglomerations versus transport specific approaches, for tackling noise pollution, although these may be explained by regional specificities.

Figure 6 Revised intervention logic



The revised intervention logic works with a more defined objective for reducing the health burden, which is met by using common noise thresholds that take into consideration socio-economic characteristics (e.g. share of low-income households). Corresponding noise solutions reflect the inputs and focus on compliance with thresholds, innovation and collaboration. The output and results of this intervention scheme are defined by the efficiency of noise solutions and their overall impacts revert back to the objective of reducing health burden.

2.1.4 Preliminary conclusions

During the assessment of noise action plans and the corresponding interviews, a number of good practices and solutions had been identified. These are shown in the table below. Additional findings and conclusions are described in a qualitative manner after the table.

Table 8 List of solutions and good practices

Sector	Solution	Examples	Notes
Road	Quiet pavement	Netherlands National Roads	Through the NAP, it is apparent that the Netherlands does an effort to communicate the benefits of quiet pavement, pointing at different types of quiet asphalt and the noise reduction potential in dB.

	Research on cost-effectiveness of solutions	Austria National Roads	Austria is conducting an infrastructure research project to optimise noise barriers by developing a method to find the best solution for noise barrier planning regarding costs and effectiveness. In this project, the wall geometry based on the wall costs, the exceeding of limit value, and secondary conditions are optimised. The mathematical formalism is based on the established Austrian Regulations and standards for road and railway noise abatement projects. The functioning is demonstrated with concrete examples.
	Noise barriers	Torino-Alessandria-Piacenza (Italy)	The Road section A21 Torino-Alessandria Piacenza is connecting 3 Italian regions as the part of highway Torino –Brescia. The road crosses 53 municipalities. The neighbouring area is protected by, considered as the most efficient noise reduction measure, the installation of noise barriers.
	Early stages of planning	Sweden National Roads	Prevention of noise using four-step planning principles: (1) influence transport needs and the choice of transport (2) better use of existing roads (3) limited use in some circumstances (4) new investment and developments.
Rail	Noise barriers & embankments	Latvia Major Railways	Regarding the planning of the measures and outlining them in the NAP, Latvia has integrated detailed information on the exact extent of measures to be implemented (in metres) and their costs as well as the expected decrease in percentage of residents affected by the noise, thereby ensuring transparency.
	Ensuring that noise mitigation measures are expanded through predictive assessment	Netherlands National Rail	The Netherlands clearly maps out by how many km rail track constructions, rail silencers/dampers, and noise barriers will be expanded and the increase of this in percentage. Furthermore, it states the ratio of quiet rolling stock by 2020 in percentage. According to the assessment, the Netherlands expects to have a ratio of 80% quiet rolling stock and 20% noisy rolling stock by 2020. The general noise reduction levels (in dB) of these measures is also considered and included in the NAP.
	Path interventions (maintenance and optimization)	Prague	Line reconstruction and optimization of identified noise 'hotspots' (e.g. Prague - Podbaba and Úvaly; Prague - Beroun line, i.e. including Černošice). The maintenance of the railway line, its modernisation, and the acceleration of the fundamental modernisation of the rolling stock are often the most effective anti-noise measures.
	Website database and the public consultation on noise	Sacconago – Malpensa (Italy)	FERROVIENORD maintains an online database that records feedback from citizens on present and past noise mitigation measures. Hence, the evaluation of past noise interventions and the planning of new interventions are also considered from the "real-life" feedback throughout the period in between two NAPs reporting.
	Railway noise reduction manuals	Sweden National Railway	Noise reduction measures include all stages of community planning, infrastructure planning, safeguards and noise at source measures. The approaches and the proposed measures together must lead to a 'target image' summarized as "A society with a good sound environment without disturbing vibrations".
Aviation	Good cooperation between airport	Dublin Airport	Dublin Airport NAP is integrated into the City and County Development Plans. The Noise Action Plan was

	stakeholders and local level for NAP planning		prepared jointly by four local authorities: Dublin City Council, Fingal County Council, South Dublin County Council, and Dún Laoghaire-Rathdown County Council. The Dublin Airport Stakeholders closely cooperate with Fingal County Council, as the airport is located in this county in Dublin Agglomeration.
	The use of technology	Helsinki Vantaa Airport	The WebTrak is a public Internet application provided by Finavia that allows authorities, residents and other interested parties to give feedback and monitor aircraft routes and noise levels using a system based on radar data.
	Cost-effectiveness	Milano Malpensa Airport	The NAP mentions the cost of noise solution and the number of impacted population.
	Financial support scheme to noise insulation of buildings	Paris-Charles de Gaulle, Adolfo Suarez Madrid-Barajas, Frankfurt Airport	These schemes include the compensation/financial support for noise insulation in buildings in high-noise zones. For noise from Frankfurt Airport, access to supportive loans for noise affected residents to purchase housing outside of noise zones within the federal country of Hessen has been granted.
	Framework/institution for dialogue with local communities	Paris-Charles de Gaulle, Adolfo Suarez Madrid-Barajas	Paris Charles de Gaulle Airport has several structures, including committees and a house of the environment for the local communities to access information. For Madrid-Barajas, information is available online for local communities, and the airport has a technical working group on noise and environmental monitoring committees, as well as a mixt committee for the establishment of the noise measures and the action plan.
	Urban-architectural measures	Prague Ruzyně Airport	The main principles of the measure can be applied within the framework of spatial planning: (1) noise protection zone (2) monitoring changes in airport operations (3) urban planning with noise cancelling measures.
	Projects to strengthen collaboration with residents and stakeholders	Schwechat, Vienna Airport	For the public consultation stage of the NAP, the forum "Verein Dialogforum Flughafen Wien-Schwechat", which mediates public participation and opinion, was established. Furthermore, a noise protection office (Lärmschutzbüro) was also established for citizens to obtain information and consultation. Finally, the webpage www.laerminfo.at offered citizens and residents the opportunity to not only submit their opinions but also access information on environmental noise (website is still updated in 2020).
		Tegel, Berlin Airport	As part of the NAP for the agglomeration of Berlin, the public consultation for Tegel Airport included various interest groups and associations, a public forum ("Forum Lärmminerungsplanung"), and a public internet platform under the motto "Berlin wird leiser – aktiv gegen Verkehrslärm" (Berlin is becoming quieter – active against traffic noise).
	Long-term noise measures	Stockholm Arlanda Airport	The long-term measure goals and the most cost-efficient noise solutions are the 'measures at source' (e.g. aircraft, operation procedures etc.)
	Research projects to investigate impact of noise on health	Frankfurt Airport	In the context of the NAP for Frankfurt Airport, the noise effect and perception study NORAH ("Noise-Related Annoyance, Cognitions, and Health") was conducted.
Agglomeration	Urban transport	Copenhagen	Copenhagen has an ambition to become the best cycling city. The third of urban traffic and transport

			should be by bicycle. The bicycle projects consist of extending bicycle paths and networks across the city.
	Planning process	Dublin	The planning system is preventing noise situations thanks to the introduction of certain restrictions. The Irish experience offers 'best practices' manuals such as 'multi-function' uses of a street: "Urban Design Manual and the Design Manual for Urban Road and Streets 2013" etc.
	Electrification of train tracks	Grenoble	The section of the Sillon Alpin train that crosses the city of Grenoble was modernised and became electric.
	Support scheme for the insulation (acoustic and thermic) of buildings	Grenoble, Paris	In Grenoble, the MurMur scheme supports sound and thermic insulation. In Paris, several initiatives for insulation since the 2000s are mentioned in the NAP.
	Promoting car sharing in the agglomeration	Grenoble, Paris	Grenoble and Paris have both had their services for car-sharing: CitéLib in Grenoble and AutoLib in Paris.
	Low urban noise barriers for trams	Grenoble	Innovative approach of developing lower noise barriers for the urban areas, integrating them in the urban setting as benches, for instance.
	Green neighbourhoods	Paris	The NAP lists 36 green neighbourhoods benefitting from low traffic and low-speed limits.
	Vehicle procurement criteria	Helsinki	Noise pollution is one of the criteria in the city's public procurement for vehicles. The city is increasing the share of hybrid and electric buses.
	Education and communication	Milano	Activities in schools and with pupils for the International Noise Awareness Day (in 5 years around 1000 pupils from Milan participated in the initiative).
	Noise abatement intervention priorities	Oulu	The priority for noise abatement interventions have the people exposed to noise levels above 65 dB during the day or above 60 dB at night.
	Transport-organizational measures	Prague	Restricting the access of heavy vehicles in urban roads with shifting their routes towards major roads/highway, as well as, introducing fees/tolls for their access on urban roads.
	School programmes	Barcelona, Bilbao	Both cities mention the" Agenda 21" school programme on sustainability in their list of measures.
	Closing traffic lanes on weekends and public holidays	Paris	This scheme is part of the Paris Breathe programme, therefore, tackling air pollution, but also is beneficial for noise pollution-related challenges.
	Acoustic oasis and quiet itineraries in neighbourhoods	Vitoria-Gasteiz	The city has a green belt of green of surrounding areas. The NAP also highlights a focus on the implementation of acoustic oasis in the neighbourhoods.
	Acoustic road surfaces	Paris	The acoustic road surfaces have been applied to selected sections of the ring.
	Collaboration with national and regional stakeholders to develop and promote NAPs	Vienna	The implementing municipal authority MA22 involved the company running most of Vienna's public transit network ('Wiener Linien'), the 23 chairmen of Vienna's 23 districts, residents and members of the public, transport companies, NGOs, and the Chamber of Labour Vienna (Arbeiterkammer Wien) in 2012 and 2013, organising consultations, workshops, and planning and coordination talks.
		Berlin	A public forum ('Forum Lärmminerungsplanung') was implemented, in which the individual stages of the NAP process were presented and discussed. Various interest groups participated (ADAC – General German Automobile Club, ADFC - German Cyclist's Association,

			Fuhrgewerbeinnung – Association for road haulage, Handwerkskammer – Chamber of crafts, IHK – chamber of commerce and industry, real estate industry, health insurances, fractions of the house of parliament, various environmental associations) A public internet platform under the motto "Berlin wird leiser – aktiv gegen Verkehrslärm" (Berlin is becoming quieter – active against traffic noise) was opened early on in process in 2013. This public platform was prepared, promoted and facilitated by press activity, post cards, posters, a press conference, a public speech, social media engagement and public events.

Based on the overall analysis of the different NAPs and stakeholder consultations, the following conclusions and recommendations can be drawn:

- NAPs are relatively descriptive and comprehensive, providing information on the planned measures, the results from the noise mapping, public consultations, and other data. Most of them have both a strategic and operational focus.
- Some NAPs also mention a long-term strategy or a cooperation with mobility planning and sustainability considerations. For instance, noise considerations must be taken into account in urban planning or are paired with sustainability and climate actions. The latter would be for example insulation of dwellings both for noise and energy.
- Some NAPs provide reduction targets in terms of people exposed to high noise levels, therefore, providing goals to the NAP for the given timeline. However, it is mostly lacking across the NAPs analysed, as well as evaluation data for the current NAPs. Data on the evaluation of previous NAPs was provided in an uneven way across NAPs.
- Innovative measures are observed in some NAPs, but the majority follow a trend of common solutions.
- Countries that have developed comprehensive NAPs include the Netherlands, Austria, Spain, France.

Furthermore, stakeholder interviews demonstrated that adoption and implementation of noise abatement measures is a complicated issue. The complexity of noise management relates to the fact that the topic lies at the crossroads of different policy areas (environment, health, transport, urban planning, road safety, construction and product life cycle etc.) and its efficient management requires broad coordination of policies at the national, local, regional as well as at the EU level. Stakeholders perceive an opportunity in reaching the END targets by combining noise action plans with air quality plans, road safety measures as well as, broadly speaking, urban planning in the agglomerations. It seems that when measures are taken in other sectorial areas (e.g. air quality, urban planning -green city, traffic safety etc.) their adoption could also mutually benefit noise abatement measures. Especially, given increasing urbanisation, urban planning has a growing effect on the volume of traffic, vehicle distribution, traffic conditions and consequently on the noise pollution. A better understanding of the relationship between noise pollution and urban planning would leverage the prevention of noise measures. Hence, for the above-mentioned reasons intra- and inter-agency cooperation, especially at the city level, should be further considered. This cooperation could also resolve some of the budgetary challenges that the implementation of noise measures is currently facing. Some of the stakeholders mentioned that urban areas do not have a sufficient and dedicated budget to adopt relevant noise abatement measures. In their view, linking noise measures with other city-related projects could help in perceiving additional funding to implement relevant actions. However, further cooperation between different sectoral areas also requires awareness-raising among the representatives of the relevant department at the national, regional and local level. The latter may lead to a non-committal approach.

Harmonisation and synthetisation of NAPs

The research, NAPs analysis, and stakeholder consultations show that there is no common approach to the creation of NAPs between Member States. While some NAPs are very detailed and comprehensive, others lack important data. The section on the limitations of the research above outlined commonalities among the NAPs, however, it can be concluded overall that the countries approach the developments of NAPs differently, focusing on different priorities. Therefore, it is important to highlight that the creation of NAPs should be more harmonised and synthesised to provide better guidance to Member States.

Monitoring of NAP implementation

The stakeholder interviews offered the insight that there is lacking control over the implementation of NAPs. It was criticised that a lack of mandatory rules and obligations to implement the NAPs would hamper the achievement of noise reduction and mitigation goals. Assessing the implementation rate of previous NAPs could not be carried out as the information was lacking in the NAPs.

Common guidelines and good practices

Furthermore, insight gained from the research shows that there is a lack of shared knowledge of best practices. For agglomerations, the share of good practices happens through European organisations (Eurocities, etc). Stakeholders, also, indicated a lack of common guidelines to NAP drafting. This lack of guidelines could also be highlighted regarding the evaluation of previous measures. Thus, the process of developing and implementing NAPs could be improved by ensuring a common understanding of best practices among Member States.

Next steps – further analysis of NAPs and stakeholder consultation

In the following steps, we will analyse further 50 NAPs in-depth, reaching then 100 NAPs in-depth analyses in total. At the same time, we will continue conducting stakeholder interviews to expand and complement our research findings. This will allow us to continue the work on the intervention logic, develop and propose adequate legislative scenarios which will be combine with relevant scenario for physical noise abatement solutions.

2.2 Methodology for health benefits assessment

2.2.1 General approach

A methodology has been set up for assessing health benefits of noise abatement solutions and scenarios at EU level. The focus is on road, railway, and aircraft noise in the period 2020-2030. The methodology includes a cost-benefit analysis. Test-site calculations are used to validate elements of the methodology.

The starting point is a causal-chain approach for health-impact assessment of environmental noise (as formulated in the EU project HEIMTSA[7]). The causal chain starts from the noise sources and ends with the negative health effects of EU inhabitants exposed to the noise:

noise sources – noise emission – noise levels – noise exposure – health effects.

The causal chain is illustrated in Figure 5 for road traffic noise. In this case the noise sources are the vehicles on the roads. The noise exposure is represented by a statistical distribution of numbers of people exposed to different noise level intervals. The health effects are expressed in three ways:

i) numbers of people affected by three noise-related health endpoints:
   a. annoyance
   b. sleep disturbance
   c. myocardial infarction
ii) healthy life years lost (DALYs),
iii) monetized health effects in Euros.

Health benefits of noise abatement solutions are derived as the differences between health effects calculated for two scenarios in the period 2020-2030:

- a baseline scenario
- an alternative scenario with one or more noise abatement solutions.

This is illustrated in Figure 6. The baseline scenario takes into account autonomous developments of traffic, cities, and population in the period 2020-2030. The alternative scenario also considers the effect of noise solutions. Examples of noise solutions are quiet vehicles (such as electric vehicles), speed limitation, and quiet road surfaces.

[7] D. van den Hout et al, HEIMTSA Deliverable D 7.1.9, 2011
E.M. Salomons et al, Internoise 2010

Figure 5. Illustration of the causal chain for road traffic noise.

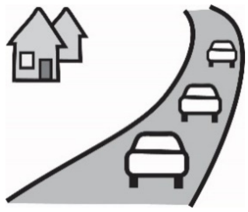
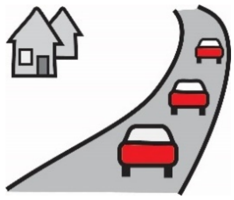
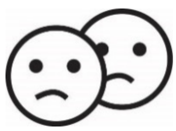
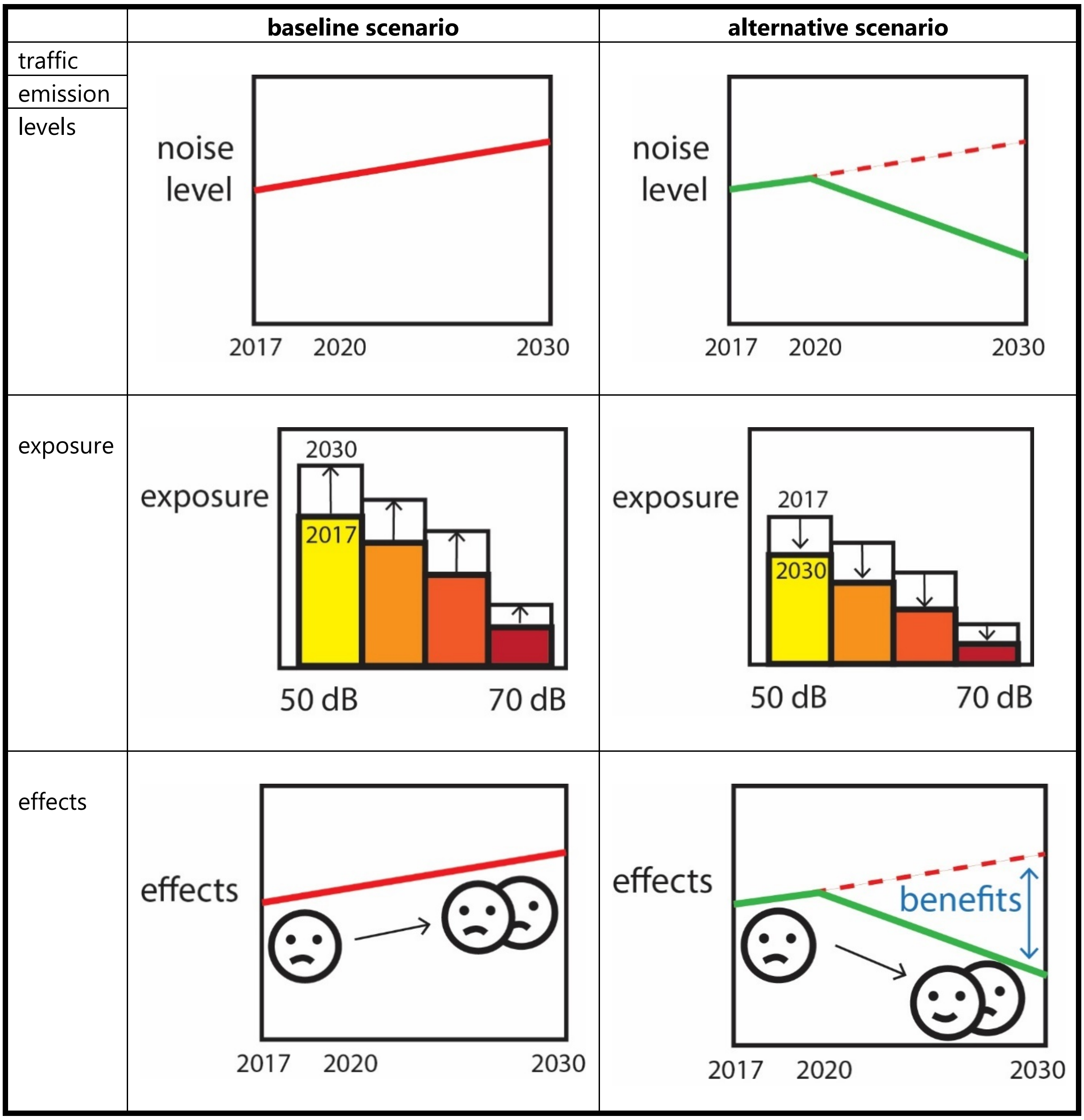
traffic		- road network - traffic volumes - driving speeds - vehicle types
emission		sound emission of vehicles - propulsion noise (engine) - rolling noise (tyres and road)
levels		sound propagation (noise map calculation) - buildings - noise barriers
exposure		numbers of people exposed to noise levels
effects		annoyance, sleep disturbance, myocardial infarction healthy life years lost monetized health effects in Euros

Figure 6. Illustration of methodology for calculating health effects for a baseline scenario and an alternative scenario. The difference between the two is equal to the health benefits.



2.2.2 Noise exposure distributions

The methodology used here deviates from the ideal causal-chain approach in the representation of noise exposure. Rather than using the 'true' noise exposure of people moving along their daily trajectories in their houses and outside (which is virtually impossible to assess), noise levels at the façades of the dwellings are used as approximations:

façade level = approximation for 'true' noise exposure

This approximation is commonly used in impact assessment studies of environmental noise.

Noise is a very local phenomenon and requires detailed data on the noise sources and the infrastructure. Consequently, calculations of traffic noise maps are very computationally intensive. A single calculation model for the noise levels (façade levels) in the complete EU does not exist. Fortunately use can be made of noise maps and noise exposure distributions of EU member states, collected by the EEA in the framework of END noise mapping.

END exposure distribution = approximation for 'true' exposure distribution

The END exposure distributions represent the year 2017. Two types of distributions are distinguished:

- distributions for exposure in urban agglomerations,
- distributions for exposure from major roads, railways, airports outside the agglomerations.

From the END distributions, EU average distributions were derived, which are used in this study as a starting point for extrapolation to the period 2020-2030.

The extrapolation is performed in two steps:

1) average noise level *changes* are calculated for the period 2017-2030
2) these changes are applied to the 2017 exposure distributions.

For the baseline scenario, the noise level changes are calculated for autonomous developments, including

- o autonomous traffic growth,
- o change of vehicle fleet, electrification.

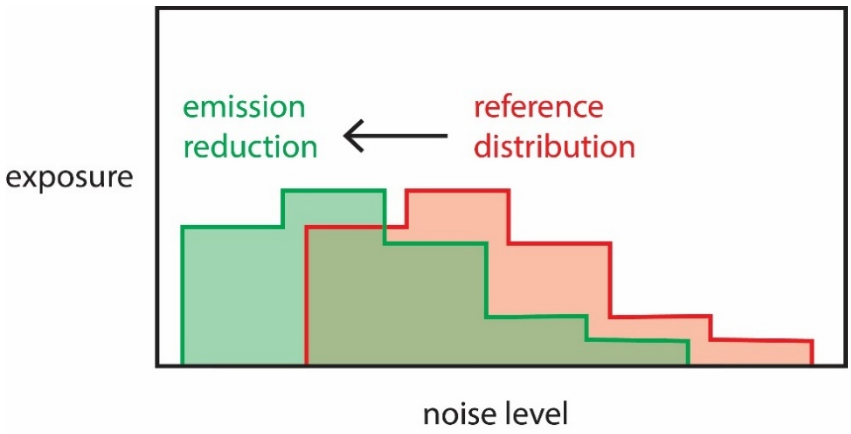
For the alternative scenario, additional noise level reductions may be achieved by four types of noise solutions:

- Noise solutions at source (for example, quiet vehicles)
- Noise solutions in the propagation path. (for example, noise barriers)
- Noise solutions at receiver (for example, quiet façade)
- Noise solutions aimed at the infrastructure and spatial urban planning.

In addition to noise solutions, reception limits are also considered as a possible element of a scenario. A reception limit may be considered a *driver* for noise solutions.

The case of a noise emission solution is useful for explaining the methodology. If all vehicles become 5 dB quieter, for example, then all noise levels on the noise map decrease by 5 dB. The level change of 5 dB is applied to the 2017 exposure distribution, which results in a changed exposure distribution for the years after which the solution has been implemented. This is illustrated in Figure 7.

Figure 7. Illustration of the effect of an emission reduction on the 2017 reference exposure distribution.



In section 2.2.5, the above approach is described further for the case of road traffic noise. A model is described for calculating the noise level changes associated with autonomous developments and noise solutions in the period 2020-2030. The model takes into account various road types, their inhabited lengths at EU level and fleet developments. A similar model has been developed for railway noise.

The approach for aircraft noise is slightly different. For aircraft noise, the evolution of the noise exposure distribution in 2020-2030 is calculated for 11 test airports. The distributions are scaled up to EU level, i.e. to the 60 airports in the EU that had to report noise mapping results in the framework of the END 2017 round. The calculations for the test airports are performed with the aircraft noise model SONDEO developed by Anotec.

2.2.3 Health effects

As described in the foregoing, health benefits of noise solutions are derived as differences between health effects calculated for a baseline scenario and an alternative scenario.

In this study, two different methods are used for the calculation of health effects from the noise exposure distributions:

- Method 1, described in EU Guidelines for External costs of transportation 2019,
- Method 2, developed in the framework of EU project Heimtsa[8].

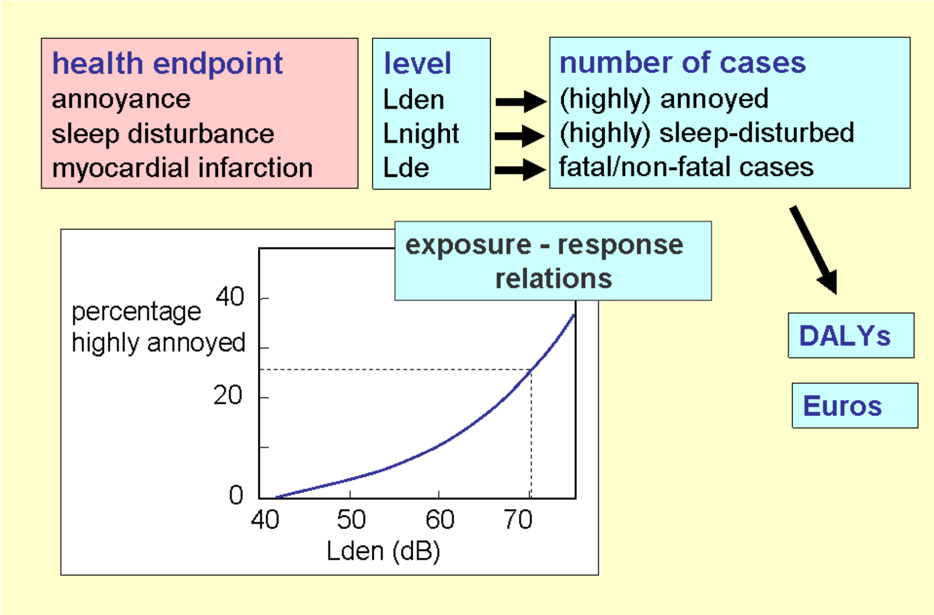
For both methods, the EU exposure distributions are used as input.

Method 1 yields the total costs of health effects caused by noise, for the three transport modes. Method 2 also yields the total costs, but in addition numbers of affected people are calculated, as well as numbers of healthy life years lost (DALYs). By using both methods, a broader picture of the health burden is provided than with a single method. It turns out that the costs estimated with method 1 are considerably higher than the costs estimated with method 2. This difference reflects the fact that noise impact assessments are subject to a large uncertainty.

[8] D. van den Hout et al, HEIMTSA Deliverable D 7.1.9, 2011.
E.M. Salomons et al, Internoise 2010.

Figure 8 presents a simple graphical illustration of method 2. Exposure-response relations for the three health endpoints are important elements of method 2. The figure shows exposure-response relation for high annoyance as an example.

Figure 8. Illustration of method 2 for calculating health effects of noise. Source: Heimtsa report.



2.2.4 Cost-benefit analysis and appraisal period

Costs and benefits are estimated on an annual basis over the whole appraisal period 2020-2030. The highest costs tend to be at the time of implementation and decrease over time, whereas the benefits grow gradually, especially if evolution of the vehicle fleet determines average noise levels.

In the calculation of annual costs and benefits, a correction is made for future growth based on the interest rate, and for the value decrease over time based on a discount rate. The discount rate is applied to determine the present value of future amounts, effectively lowering these with increasing years. A discount rate r_d of 4% and an interest rate r_g of 1% are applied, as suggested in the EU guidelines (EC 2015).

For the appraisal period 2020-2030, the benefits and costs are accumulated over the whole period, resulting in total benefits (B) and total costs (C). From these, the benefit-to-cost ratio BCR is calculated.

For BCR > 1 the benefits exceed the costs, meaning the investment is worthwhile.

Some noise abatement solutions take effect over a longer period than 10 years, for example in the case where vehicle fleet replacement is a factor. Then a longer appraisal period may be required to reach a positive BCR ratio.

Also calculated is the Net Present Value (NPV), which is the difference between accumulated benefits and accumulated costs. The NPV is normally negative before reaching a 'break even' point after several years, after which the benefits exceed the costs.

The costs of noise abatement solutions are based on data from literature and web resources, and where these are lacking, best estimates, to be updated if available. These costs include initial implementation costs (investment) such as purchase, construction and installation, and life cycle costs (LCC), mainly for maintenance and removal or replacement. The implementation costs are incurred initially whereas the LCC are applicable over the whole life of the solution concerned.

2.2.5 Road traffic noise: model and first results

In this section, the above calculation methodology is worked out in some more detail for the case of road traffic noise. First the model is described for calculating the noise level changes described before. Next two illustrative examples are presented.

Road traffic noise calculation model

A detailed calculation model was set up for road traffic noise. With this model the noise level changes due to a noise solution are calculated. These level changes are applied to the 2017 EU exposure distribution, and yield exposure distributions for the period 2017-2030.

The model takes into account the following elements.

- Four types of urban roads: residential, main, arterial, motorway.
- Two types of nonurban roads: main roads and motorways.
- Noise barriers along the roads.
- Four types of quiet road surface.
- Various parameters describing the vehicle fleet, including the percentage hybrid and electric vehicles, and the tyre label.
- Annual overall traffic growth.

Lengths of inhabited roads in the EU were estimated for the six road types. These were combined with average numbers of inhabitants per km, to derive weighted-average urban and nonurban noise levels at short distance from the roads. These yield the required level changes.

The harmonized EU model Cnossos is used for the calculation of emission spectra of road vehicles. The Cnossos model distinguishes two types of noise emission:

- propulsion noise
- rolling noise.

This distinction is important for a calculation of the effects of noise solutions. Some noise solutions, such as electrification, have a larger effect on propulsion noise than on rolling noise. Other noise solutions, such as quiet road surfaces, have a larger effect on rolling noise.

For the baseline scenario, the autonomous developments in 2020-2030 were estimated based on an EC reference scenario for the period until 2030. These include:

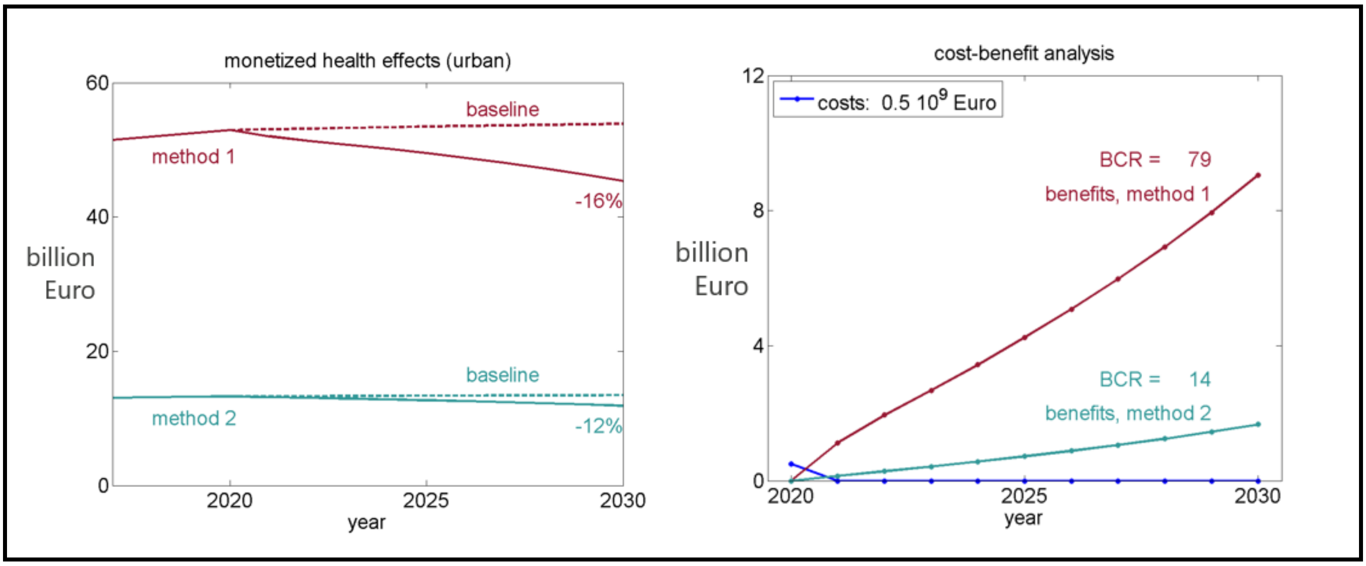
- 1% annual traffic growth,
- 0.1% annual growth of the EU27 population,
- 25% hybrid and 2% electric vehicles in 2030.

Two illustrative examples

To give an impression of the results that are obtained with the calculation method, two examples are presented here for simple, extreme scenarios of urban road traffic noise. In the following sections more realistic scenarios with noise solutions will be described.

The first example is for a scenario with 100% hybrid road vehicles (cars, vans, buses) in 2030. For the baseline scenario this percentage is 25% in 2030. The left graph in figure 9 shows the health effects in billion Euros, calculated with methods 1 and 2. For the baseline scenario (dashed lines), the health costs gradually increase due to annual traffic growth. For the alternative scenario (solid lines), the costs decrease after 2020. The absolute costs calculated with the two methods differs by a factor of about 4. There is better agreement for the *relative decrease* due to the noise solution: 16% with method 1 and 12% with method 2. Note that these decreases are smaller than the objective of the project: 20 to 50% reduction. The right graph shows the evolution of the health benefits, and the associated BCR. Here a hypothetical cost of 0.5 billion Euro in 2020 has been assumed.

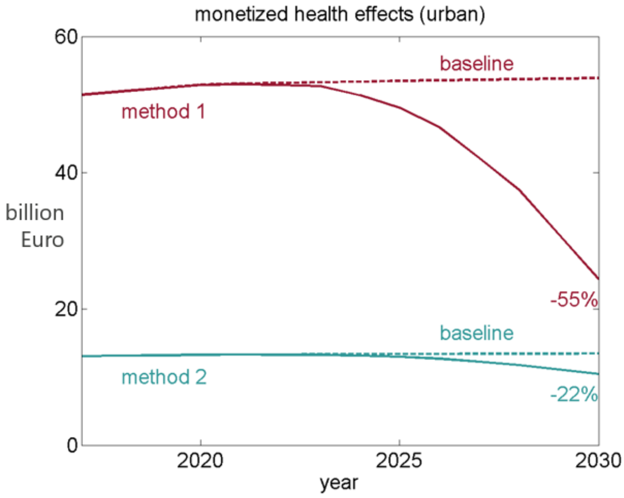
Figure 9. Results for a scenario with 100% hybrid vehicles in 2030. Shown are the monetized health effects (left) and the costs and benefits (right).

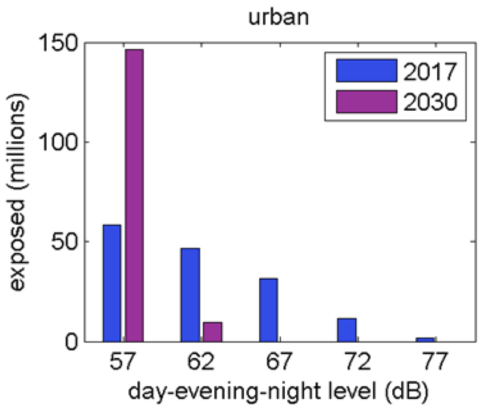


The second example is for a scenario with a reception limit of 60 dB Lden. It is assumed that the EU member states will gradually comply with this limit in the period 2020-2030. The right graph in figure 10 shows the effect on the exposure distribution. The left graph shows again the health effects in billion Euros, calculated with methods 1 and 2. In this case the reduction of the health costs is much larger: 55% with method 1 and 22% with method 2.

It should be noted that a reception limit is not a true noise solution. Rather, it should be considered as a trigger for various noise solutions. The result found here can be interpreted as the *potential* effect of a combination of noise solutions.

Figure 10. Results for a reception limit of 60 dB Lden. The graphs show the monetized health effects (left) and the exposure distributions in 2017 and 2030 (right).





2.2.6 Test sites

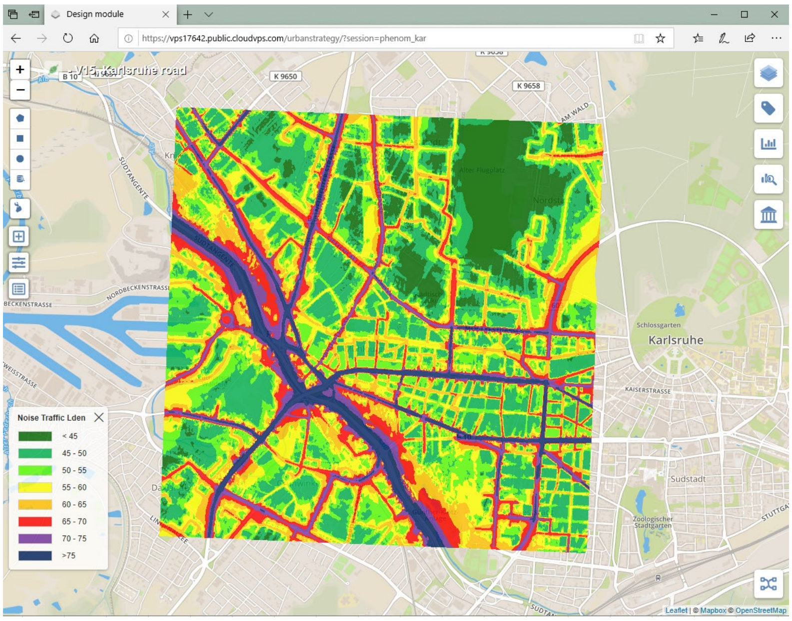
Test site calculations are performed in this project for validation of elements of the calculation methodology. Examples of the elements are:

- The mean effect of noise barriers along roads and railroads,
- The shape of exposure distributions,
- The relative contributions of motorways and other roads in urban areas.

Figure 11 shows an example of a test site calculation, for a 4 x 4 km area in Karlsruhe (DE). Similar calculations were performed for other cities. From these calculations it follows that motorways in cities often have a limited contribution to the overall exposure distribution. The contribution from the other roads (with speeds up to 50 km/h) is considerably larger. This has implications for noise solutions aimed at urban planning and rerouting traffic.

It should be noted that test site calculations are not required at all possible locations in the EU. The representativeness of the results of the calculation methodology is ensured by the central role of EU exposure distributions, with contributions from all EU member states.

Figure 11. Noise map calculated for a test site in Karlsruhe (DE). The test site is a 4 x 4 km area, with a motorway and other urban roads. The colours represent Lden levels from 45 to 75 dB.



2.3 Potential of available noise solutions

In the context of this study and the terms of reference, a number of noise abatement measures are selected for each transport mode to assess their overall potential impact in terms of health benefits. Measures which are not yet available or require further research are not included as in general, they would not have significant impact before 2030. This is because approval can take several years, after which several more years are required before implementation over the whole fleet or infrastructure takes place.

The noise abatement solutions described are primarily physical ones, although in most cases there is a legislative link, and implementation triggers or drivers which are also mentioned.

Each measure is described in terms of its

- Principle
- Illustration
- Potential noise reduction
- Availability
- Implementation level
- Implementation time and life cycle
- Costs and benefits at EU level
- Triggers and obstacles for implementation at national or EU level
- Causal links to legislation
- Key references.

Solutions for road, rail and aviation are applicable to noise both inside and outside agglomerations, which are therefore not treated separately in terms of noise solutions.

Application and implementation levels of noise abatement solutions differ substantially between member states and regions, which in turn depends on policy priority, traffic, fleet and infrastructure characteristics, and available funding.

Solutions related to land use, urban planning and traffic control are wider in scope than technical solutions at source or receiver, as there are many factors well beyond the issue of the classical noise exposure in terms of Lden/Lnight levels, such as safety, mobility, air quality, and social-economic issues. Although these factors are beyond the scope of this study, there are often synergies between them leading to higher benefits than when only noise exposure is considered.

Modal shift

Modal shift from road to other more sustainable means of transport also has potential as a noise abatement solution, either driven by policy or incentives.

Examples of modal shift, both at local or international level, are:
- introduction of light rail or electric buses and restriction of private vehicles
- expansion of rail passenger traffic shifting from road and air transport to rail
- shifting of road freight to rail or waterways
- discouraging of car use in urban centres and encouraging cycling and walking.

Modal shift includes both transport and tourism, passenger and freight.

It is not included here as a separate solution, although it is in fact indirectly covered within individual solutions and scenarios such as electrification, urban planning and access restrictions.

Modal shift goes beyond individual road noise solutions in a much broader context and scope. In the report 'Modal shift in European transport: a way forward' (2018) [9], it is set out that the change at EU level is very slow in this respect, due to multiple obstacles including current infrastructure, fleets, private car ownership, transport costs and time, rate of digitization and others.

At EU level, targets have been set in the 2011 White Paper on transport, including a shift to rail, driven by environmental factors. However, the report states:

'Despite an increase in freight volumes, the modal share of road, rail and inland waterway freight transport remained substantially unchanged between 1996 and 2016, both for passenger and freight transport, with road transport showing a slight increase. Looking at future projections, ***road transport is expected to keep its predominant position both for the passenger and freight sectors****. However, its modal share is expected to decrease by a few percentage points, mainly to the benefit of rail transport.*

The following noise abatement solutions for road traffic noise were selected:

1) Tyre noise reduction via the tyre noise label
2) Reduction of rolling noise by road surface, such as porous asphalt and/or smooth asphalt
3) Whole vehicle noise reduction, by quieter powertrains (e.g. electric) and tyres
4) Noise barriers, standard or special, including absorbent or tilted barriers and lane barriers
5) Re-routing or limiting road traffic, for example by a congestion charge or access restrictions for areas with high noise exposure and noisy vehicles, including low emission zones (LEZ)

[9] Pastori E, Brambilla M, Maffii S, Vergnani R, Gualandi E, Skinner I, 2018, Research for TRAN Committee – Modal shift in European transport: a way forward, European Parliament, Policy Department for Structural and Cohesion Policies, Brussels

6) Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, parks, courtyards, and urban planning at national or local level
7) Sound insulation of residential and communal buildings, including government incentives for homeowners.

For railway noise, the selected solutions include :

1) Infrastructure measures, such as acoustic rail grinding, quieter rail pads, rail dampers or rail shielding
2) Quieter rolling stock, including smooth, damped or optimized wheels and quieter powertrains
3) Noise barriers, standard or special, including absorbent and low barriers near the track
4) Urban and spatial planning, increasing sound attenuation between source and receiver by buildings, parks, courtyards, and urban planning at national or local level
5) Sound insulation of residential and communal buildings, including government incentives for homeowners

For aircraft noise, the selected solutions include :

1) Landing and take-off improved profiles (flight procedures)
2) Dispersion or concentration of flights (route optimization)
3) Operating restrictions - curfew (Airport regulation)
4) Operating restrictions - prohibition of operation for noisier aircraft (airport regulation)
5) Forced phase out of older aircraft (airport regulation)
6) Acquisition of new quieter aircraft (EU or national level incentives for airlines)
7) Sound insulation of residential and communal buildings, including government incentives for home owners
8) Extension of land barrier, land use planning including acquisition of dwellings.

Analysis has shown that in many cases, single solutions are insufficient to achieve wide scale reduction of health burden, and combinations are required, for example quiet road surfaces with quieter tyres, smooth wheels and smooth rails and others.

Each of these solutions will be assessed with a CBA and potential health benefits individually, and in best combination scenarios.

2.4 Scenarios

Two types of scenarios are set out below:

- scenarios with single noise solutions, including their influence parameters,
- scenarios with combined noise solutions.

The CBA analysis will be presented in the second Interim report, once the most effective combined scenarios have been identified.

2.4.1 Road traffic noise

For road traffic noise, the following elements and parameters are used for the specification of scenarios with noise solutions.

- Engine noise and electrification
    - percentage compliance with six different vehicle emission limits, per vehicle type
- Tyre noise
    - tyre label per vehicle type
- Quiet road surfaces
    - fractions of road lengths with quiet surface
- Noise barriers
    - fractions of road lengths with noise barriers
- Vehicle speed
    - speeds per road type and per vehicle type
- Urban planning, access restrictions and insulation
    - vehicle access restrictions, car-free zones
    - quiet façade of dwellings
    - dwelling insulation.

The first two solutions under urban planning are modelled by direct modification of the EU exposure distributions for urban agglomerations. The other solutions are modelled with the road traffic noise emission model.

In addition to the above physical noise solutions, scenarios with reception limits will also be considered. Reception limits should be considered as triggers for physical solutions, and the effects of reception limits represent the *potential* effects of scenarios with noise solutions.

Scenarios with a single noise solution

In table 2 scenarios A-J with a single solution are specified.

Table 9 Scenarios with a single noise solution for road traffic noise.

Scenario	Description
A	Length of roads with quiet surface: factor 3 higher Length fractions of 'roads with a quiet surface' for road types 5-8 are changed from 5% (baseline) to 15% in 2030.
B	Tyre label 3-5 dB reduced Tyre labels for three vehicle types are changed from 70/72/75 (baseline) to 66/69/70 in 2030.
C	Faster compliance with new vehicle limits The percentages for the six limits are changed as follows: - 20/30/20/3/25/2% (baseline) to 10/10/40/13/25/2% in 2030 (cars, vans, buses) - 30/40/25/5/0/0% (baseline) to 10/10/65/15/0/0% in 2030 (lorries and, heavy trucks)
D	Enhanced electrification, 55% in 2030 The compliance percentages for the six limits are changed as follows: - 20/30/20/3/25/2% (baseline) to 20/30/20/3/50/5% in 2030 (cars, vans, buses)
E	Length of roads with noise barriers: factor 2 increase The length fractions of 'roads with a barrier' for road types 5-8 are changed from 5% (baseline) to 10% in 2030.
F	Traffic speed restrictions in urban area The vehicle speeds are changed as follows. - road types 1-4: from 30-50 (baseline) to 30 km//h in 2030 - road type 5 (main road): from 70-80 (baseline) to 50 km/h in 2030 - road type 6 (motorway: from 85-115 (baseline) to 80 km/h in 2030.
G	Traffic access restrictions, traffic rerouting, tunnelling Car-free and car-restricted zones are doubled by 2030. This will be modelled by direct modification of the EU exposure distributions for urban agglomerations.
H	Urban planning: quiet façade of dwelling The effect of a quiet façade is a reduction of about 2 dB at the non-quiet façade. This will be modelled by direct modification of the EU exposure distributions.
I	Enhanced dwelling insulation The percentage of dwellings with insulation is changed from 0% (baseline) to 10% in 2030, for road types 5-8.
J	Reception limits A scenario with reception limits L_{den} = 60 dB and L_{night} = 55 dB will be considered.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.
ABC) Combination of A, B and C (quiet road surface, tyre label, vehicle limits).
ABCD) As ABC, but also 55% of fleet electric or hybrid.
FGHI) Combination of F-I (traffic speed, traffic restrictions, quiet façade, dwelling insulation).

Other scenarios are to be suggested.

2.4.2 Railway noise

For railway noise, the following elements and parameters are used for the specification of scenarios with noise solutions.

- Combined wheel-rail roughness
  - Percentages of railway type distribution over five roughness classes R1-R5.
- Track type
  - Percentages of railway type distribution over seven track type classes T1-T7.
- Vehicle type
  - Percentages of railway type distribution over six vehicle type classes V1-V6.
- Noise barriers: low and high barriers
  - fractions of road lengths with low and high noise barriers
- Traffic management
  - Alternative routes, mainly for freight
- Urban planning
  - Dwelling insulation.

In addition to the above physical noise solutions, scenarios with reception limits will also be considered (see previous section).

Scenarios with a single noise solution

In table 3 scenarios A-J with a single solution are specified.

Table 10 Scenarios with a single noise solution for railway noise.

Scenario	Description
A	Smooth tracks, grinding The percentages for R1-R5 are changed to 10/25/20/20/25% in 2030.
B	All wheels composite/disc braked or better, and wheel flat control. The percentages for R1-R5 are changed to 0/20/30/30/20% in 2030.
C	All wheels 4 dB quieter design by 2030: 80% damped and optimised wheels for passenger trains and 50% improved freight wagons with better bogies and suspension. The percentages for V1-V6 are changed to 5/4/3/3/5/80% in 2030.
D	Widespread implementation of quieter tracks at sensitive locations including railpads, rail dampers and/or rail shielding. The percentages for T1-T7 are changed to 0/0/43/0/0/43/14)% in 2030.

E	30% of fleet 3 dB quieter than 2020 for stationary/acceleration noise and Vmax for aerodynamic noise of high-speed trains. Note: low significance in this model.
F	Length of railways with noise barriers: factor 2 higher The length fractions of railways with barriers are changed from 1.5% to 3% for high barriers and from 0 to 1% for low barriers, in 2030.
G	Traffic management: move freight trains outside urban area The length distribution of railway types 1-4 are changed from 0.25/0.25/0.25/0.25 to 0.15/0.15/0.35/0.35 in 2030.
H	Urban planning; reduced noise exposure due to various urban planning solutions (tunnelling, closed facade buildings along lines, integration of noise abatement in urban building). This will be modelled by direct modification of the EU exposure distributions for urban agglomerations.
I	Enhanced dwelling insulation The percentage of dwellings with insulation is changed from 0% (baseline) to 10% in 2030.
J	Reception limits A scenario with reception limits L_{den} = 60 dB and L_{night} = 55 dB will be considered.

Scenarios with combined noise solutions

The following scenarios with combined noise solutions will be considered.

AB : smooth wheels and smooth rails

CDE : Wheels and tracks of quieter design

ABCDE : combination of the above

FGHI : Increased noise barrier length, traffic management, urban planning solutions including tunnels, enhanced building insulation and reception limits,

Other scenarios are to be suggested.

Questions for the workshop

During the workshop, feedback is sought on the following questions

For each transport mode:

- Which legislation provides the best means for driving implementation?
  END
  EU Source legislation
  National legislation
  Local regulations

  Other
- How the harmonisation of urban and noise planning could be further enhanced at the EU level?
- Would it be possible to create a more integrative approach between noise planning, urban planning and air pollution policies to enhance the common effort towards increasing citizens health?
- How could urban planning further endeavour to ensure the reduction in noise exposure?
- What are the key failures in effective implementation of the noise action plans?
- What could be done to ensure a better implementation of the NAPs?
- Do the local authorities have sufficient competencies and resources to implement effectively relevant noise abatement measures in their territories?
- What are key drivers for implementation of technical noise solutions?
- Are there any important (available) technical solutions missing?
- Is there up-to-date information on costs of solutions available?
- Which solutions are most effective?
- Which solutions are the most cost-effective?
- Which ones are easiest to implement?
- Which ones do you expect to be implemented in your country in the next 10 years?

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Annex 9: Second workshop proceedings report

2nd Workshop Proceedings

Report

Assessment of **P**otential **He**alth Benefits of **No**ise Abate**men**t Me**a**sures in the EU

Phenomena project

Contract number

07.0203/2019/ETU/815591/ENV.A.3

10 November 2020

Valdani Vicari & Associati
ECONOMICS & POLICY

TNO innovation for life

anotec engineering

tecnalia Inspiring Business

UAB Universitat Autònoma de Barcelona

Foreword

This report contains the proceedings of the second Interim Workshop of the Phenomena Project. The workshop was designed to introduce the intermediary findings of the study to a wider group of stakeholders at month 11 of the project implementation.

The second Phenomena project workshop was held on the 10th of June 2020 via teleconference with 96 participants. The workshop was co-organised by the European Commission (DG ENVI) Services and the Phenomena project consortium (VVA, TNO, Anotec, Tecnalia, Universitat Autonoma de Barcelona).

The Phenomena project aims to support the European Commission in defining the potential of measures capable of delivering significant reductions (20-50%) of the health burden due to environmental noise. It includes major roads, railways and airports. It will assess which and how legislation at local, national, EU and/or international level could be enhanced to strengthen the implementation of mitigation measures, whilst considering the constraints and specificities of each transport mode. In this light, the Phenomena project seeks to understand what kind of legislative measures could bring added value to the desired outcome, and how likely it is to be undertaken.

Contents

1 Introduction

1.1 General context and objective of the workshop

Phenomena is a 15 month-long research project which started in December 2019. The project aims at supporting the European Commission in defining the potential of measures capable of delivering significant reductions (20%-50%) of the health burden due to environmental noise. The outcome of the project will provide recommendations for enhanced legislation to achieve the targets for the reduction of health burden. Legislative options to be considered may include mandatory action plans, noise limits at dwellings, vehicle noise limits, the link between END and vehicle legislation.

A first workshop took place on the 18th of June following the submission of the first interim report at the end of May 2020. The second interim report was delivered mid-October 2020, and the second workshop was held on the 10th of November 2020, to further discuss the preliminary findings of the study. The workshop was co-organised by the European Commission (DG ENVI) services together with the Phenomena project consortium (VVA, TNO, Anotec, Tecnalia, Universitat Autonoma de Barcelona) and held via videoconference.

The objectives of the workshop are multiple. First, it aims at further sharing and disseminating the preliminary results of the study with the European Commission and the different stakeholders involved in the question of environmental noise (e.g. experts of the Noise Expert Group) or in the studied sectors. Secondly, it also provides a platform for discussion on pending research questions. Finally, allows stakeholders to share their comments and inputs with the consortium and the European Commission. Attendees received before the workshop background documents to familiarise themselves with the content of the second interim report. This background document can be consulted in Annex 4 of this report.

The workshop provided the following elements:

- Consultation and validation of the preliminary results with a wider group of stakeholders by the consortium;
- Insightful feedback and suggestions from the participants to be considered by the consortium in the next stages of the project (e.g. discussions and poll results);
- Discussion on specific issues with stakeholders (analysis, policy solutions, scenarios and sector specifications);

The workshop resulted in lively discussions, which were supported by a number of provided questions and on-line polls aiming to gather feedback from the participants. Suggestions that were made during the workshop will be considered in the final stage of the project. This includes potential noise solutions or innovations or good practices, and inputs on scenarios.

1.2 Workshop components

Ms Claudia Fusco (Head of Unit of Environmental Knowledge, Eco-Innovation and SMEs) from DG Environment gave an introductory speech to open the 2nd PHENOMENA Workshop. Noise related issues are cross-cutting policy matters, which are part of different EU strategies and initiatives such as the Green Deal, Circular Economy, 8th Environmental Program, Smart Mobility Strategy, and Zero pollution initiative.

The one-day online workshop was divided into two main sessions (morning and afternoon). During the morning session, the consortium presented the project and its findings in terms of noise action plans, good practices and challenges. Subsequently, the consortium introduced potential policy solutions.

In the afternoon session, the consortium developed on the scenarios for the three different sectors: road, rail and aviation noise. Finally, a closing plenary session for feedback from the participants was organised.

During the sessions, questions and sometimes polls were shared with the participants. Sessions were followed by discussions and questions from the stakeholders. The workshop agenda is presented in the box below.

Box 1 Workshop Agenda

Morning session

10:00 – 10:15	Opening and Introduction (VVA, TNO) (Aim, structure and preliminary conclusions)
10:15 – 10:50	Noise action plans, good practices, challenges (VVA)
10:50 – 11:00	Q&A
Break (15 min)	
11:15 – 12:00	Policy solutions (VVA, TNO)
12:00 – 12:30	Q&A

Afternoon session

13:15 – 13:30	Road scenario results: Erik Salomons, TNO
13:30 – 13:40	Q&A
13:40 – 13:55	Rail scenario results: Michael Dittrich, TNO
13:55 – 14:05	Q&A
14:05 – 14:20	Aviation scenario results: Nico van Oosten, Anotec
14:20 – 14:30	Q&A
15:00 – 15:10	Conclusions and closing plenary session

1.3 Participants

The workshop was attended by 96 stakeholders, including:

- Members of the noise expert group (NEG)
- Scientific experts
- Policy makers from Member States
- NGOs, European and international industry associations, local citizens' associations.

- European Commission representatives
- The consortium members.

This wide range of stakeholders ensures varied and insightful feedback on the preliminary findings of the study. The complete list of attendees is available in Annex 3.

Experts who were not able to attend the workshop, will be invited to take part in interviews.

2 General overview of the key findings

The first part of the workshop was designed to present the Phenomena project, its main findings in terms of NAPs analysis, and to provide insights on potential policy solutions. Specifically, participants were asked to provide feedback on the findings and proposed policy solutions. This part of the workshop aimed to provide a policy baseline for the second part of the workshop during which sectorial and technical findings were presented and discussed by the participants.

2.1 Project Introduction

2.1.1 Summary of the presentation

The consortium explained that the workshop aimed at sharing the progress of the PHENOMENA study with the European Commission and interested stakeholders. It provided a platform for workshop participants to express their views and suggestions towards the finalisation of the study (January 2021). The study will last 15 months, and the consortium is led by VVA in partnership with TNO, Anotec, Tecnalia and UAB. The study objectives are twofold:

I. Defining the potential of measures capable of delivering a significant reduction (20-50%) of health burden due to environmental noise from roads, railways and aircrafts;

II. Assessing how relevant noise related EU legislation could enhance the implementation of measures, while considering the constraints and specificities of each transport mode.

The study is considering the END parameters for each transport mode inside and outside of agglomerations for road and railway transport, as well as for major airports.

The study has implemented different research methods: data collection and analysis, stakeholders' interviews, legislative, policy and literature review, cost-benefits analysis, scenario development, comparative assessment, and stakeholders consultations though two workshops.

Figure 1 Project Structure & Deliverables

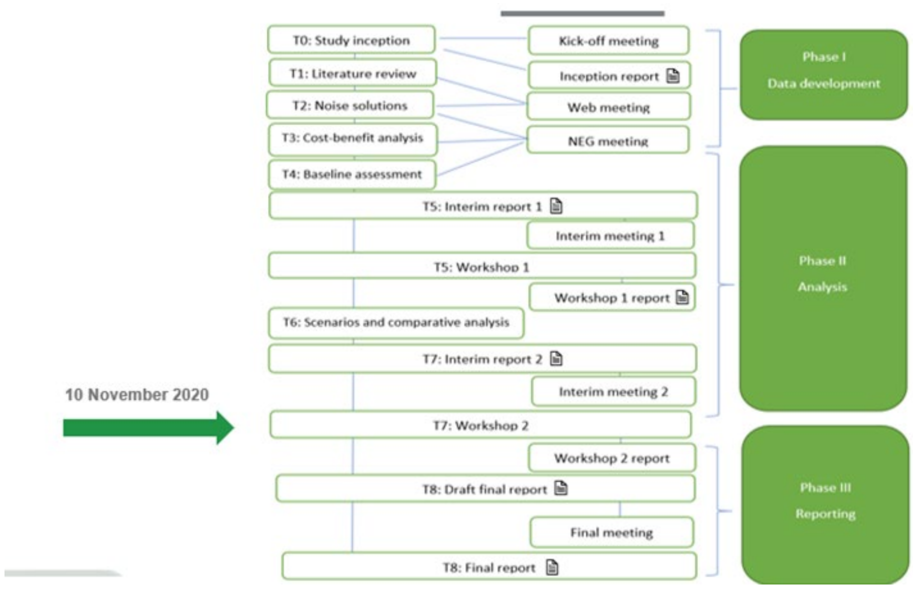
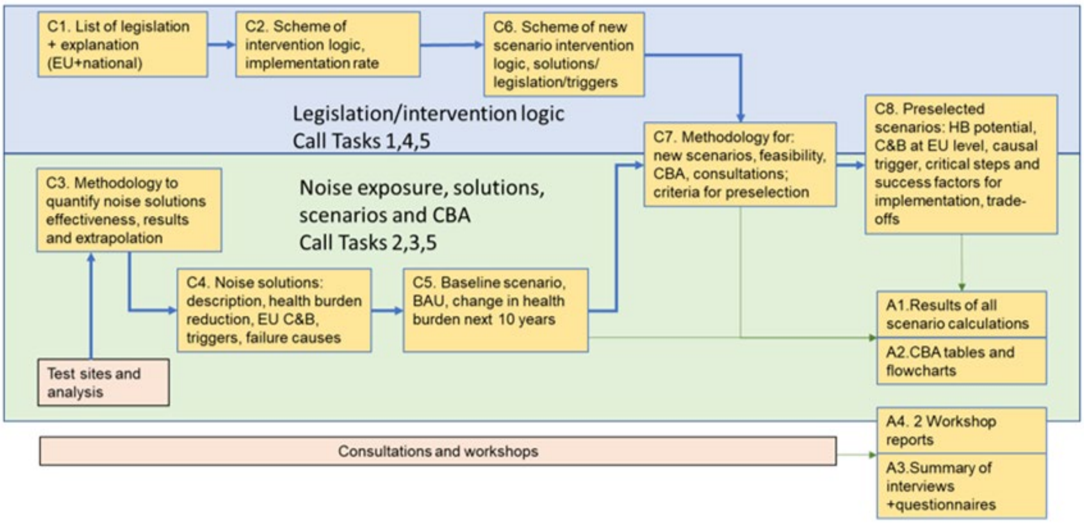


Figure 2 Report elements and links



As for the first part of the study, the aim of the analysis was to **identify recurring noise solutions from Noise Action Plans (NAPs) and their potential costs and benefits**, as well as assessing regulatory drivers (international, EU, national, local) underpinning noise reduction. The NAP review was conducted by VVA and UAB in two parts (March-May and June-September): overarching (200 NAPs) and in-depth analysis (100 NAPs). Moreover, in order to complement the understanding on recurrent noise solutions and regulatory drivers, relevant stakeholders were contacted to share their knowledge and experience through interviews (EU, national, local public administration, industry and membership organisations, NGOs, researchers, academia and other experts).

As for the second part of the study, conducted by TNO, Anotec and Tecnalia**, a cost-benefits analysis (CBA) was performed for single and combined scenarios for all transport modes** (road, rail and aviation). The solutions allowing a 20% health burden reduction from noise scenarios was found for the rail and aviation sectors, but it has proven more difficult for the road sector. The results depend on a defined baseline scenario including traffic growth and fleet evolution predictions relevant in the next 10 to 15 years. Scenarios take into consideration combined urban and non-urban situations.

The complete PowerPoint presentation is available in Annex 1.

2.2 Noise action plans, good practices, and challenges

2.2.1 Summary of the presentation

This session sought to introduce the main findings of the **noise action plans (NAPs) analysis**. This analysis was carried out in two streams:

- In the first six months of the project, an analysis of 150 NAPs was completed: 100 NAPs with an overarching review, and 50 NAPs with an in-depth analysis.
- The second part saw the completion of another 150 NAPs, with again 100 in an overarching review and 50 in an in-depth analysis.

The objective of the in-depth analysis was to see the noise solution measures in a context, such as driving factors, what makes the Member States opt for a solution or others, how stakeholder engagement is fostered, and access to financing presented. This part of the analysis was supported by **stakeholder interviews.** The consortium attempted to ensure a balance between the countries in geographical terms, and a balance between the various transport modes and agglomerations. The same considerations applied to the overarching analysis.

The consortium then presented the **results of the NAPs analysis per sector**. For each type of transport, the consortium provided tables with the various noise solutions that are the most frequently applied. The tables show the implemented and planned measures in the different transport modes.

Road traffic noise:

- In terms of implemented measures, road surface developments, noise barriers, soundproofing, new roads, insulation of buildings are solutions frequently implemented for roads outside agglomerations. Inside agglomerations, there is a much longer list of noise solutions containing the same measures, but also land-use planning, increased awareness raising, and sustainable mobility.
- The consortium provided a comparative figure between the measures planned outside and inside agglomerations. As for the implemented measures, path interventions were the most frequently implemented type of solution. Education and communication measures were more observed in agglomerations.
- The consortium observed that most often **infrastructure intervention was used in combination with path interventions**. Road maintenance and continuous noise monitoring are examples of solutions to ensure the effectiveness of the noise abatement measures. Education, communication and mobility planning seem to be less frequently used.
- The data provided was sometimes **uneven**, particularly on costs. The consortium provided an example of costs information in Spain.
- **Road surface measures and noise barriers** are frequently mentioned. The choice of measures can also depend on geographic specificities, or population density.

Rail traffic noise:

- The analysis considered rail specific NAPs and rail measures within agglomeration NAPs.
- The information on implemented measures seems limited compared to the planned measures. Among the implemented measures, **source intervention, and paths interventions** (noise barriers) measures are mostly observed. The most relevant category seems to be **intervention at source** solutions, which are implemented outside agglomerations, for location considerations. Inside agglomerations, the list is shorter, with less focus on source intervention but **an increasing importance of path interventions** (noise barriers).
- As for the planned measures, the Member States seem more ambitious, with a number of various future measures. There is **an increasing importance of land-use planning** and use of noise barriers. Inside agglomerations, source intervention, infrastructure intervention, soundproof windows are widely planned. There is a greater variety of planned solutions, and wider combination of measures, observed by the consortium.
- The in-depth analysis showed the **important element of financing**. The consortium highlighted that a combination of EU and national financing and cross-border collaboration should be further explored.
- Examples of solutions observed include lane irrigation to limit noise disturbance (Basque country, Spain), home relocations (Sweden), and noise partnerships for financing (Denmark).
- Some NAPs provided different noise limits regarding passengers and freight wagons, or regarding specific areas.

- Finally, the consortium explained that **finding the right combination of measures** is very important in rail noise management.

Aviation noise:

- The analysis comprises the NAPs for major airports and the NAPs for agglomerations which included an airport.
- The consortium identified a **strong predominance of source interventions** in the implemented noise solutions, such as certification limits, as well as a lot of education and communication solutions. Regarding the measures in agglomerations, the list is shorter, with some similarities such as air operations measures, curfew, and regulation of routes. Quiet areas and noise monitoring are also important in an agglomeration context.
- The consortium stressed that the **range of measures was more important in the NAPs for airports.** Regarding the planned measures, most of the already existing measures are aimed to be continued in the future. There is a **clear continuation** between previous NAPs and current ones.
- Regarding the planned measures, for the airports outside agglomerations, there is an **increasing importance of path intervention** such as building insulation. For the airports inside agglomerations, an increasing importance of land-use planning, noise barriers, soundproof windows, dissemination of noise information was observed.
- A **trend of implementing a wide combination of measures** was observed, as in rail. The consortium noted a large continuation of implemented measures improvements as well, resulting from technical implementation and innovation. Airport NAPs often contain long-term measures, but a few information on costs.
- The consortium highlighted that the END NAP threshold for airports had changed over the years, and that some airports only drafted their first NAPs in the third round (for example Sofia).

Agglomerations:

- The aim of analysing agglomeration NAPs was to identify how urban areas integrate noise reduction measures and address more than one transport mode. It shows how reduction of noise emission levels can be **incorporated into wider policy planning instruments**, and how to ensure investments are better optimised.
- The consortium observed a shorter list of measures in the overarching analysis, which were not targeting a specific source. However, the list of planned measures was significantly longer. This shows connectivity and the importance of the combination of measures within agglomerations.
- The consortium added that it was important to note that **some areas remain outside the scope of activities** and could be considered, such as working from home, or vehicle sharing.
- The in-depth analysis included the review of NAPs from 17 countries. Some recurring elements comprise quiet areas, land-use planning and dissemination of information, which are very relevant elements in agglomerations. The consortium highlighted the wide range of measures included and that combination of noise solutions was very important. For instance, Helsinki planned over 23 noise measures.
- **Continuation of measures between implemented and planned solutions is also very important.** The consortium indicated that support schemes should be further developed, as a lack of financing was identified as a key barrier. When comparing the 2013 and 2019

NAPs of Pecs, the continuation of measures can be noticed, as well as the fact that many more measures were further developed in the 2019 round.

- The consortium then stressed that **public buy-in was very important**.

The consortium identified **issues in NAPs** which resulted of limitations of research, as for instance:

- A lack of availability of in-depth information,
- A limited quantity of content,
- A lack of harmonisation across NAPs and of data provided on costs, costs-effectiveness, monitoring and evaluation process criteria,
- Few elements highlighting good practices,
- Uneven information on public consultation,
- Difficult comparability of data.

The consortium then presented a few examples of **good practices,** while adding that the lack of exchange on such practices was an issue. The consortium suggested to share these good practices, to inform what are the practices which would be worth looking into.

Furthermore, the consortium explained the **intervention logic**. It consists in a policy-making tool which helps policy makers define a framework of a new or a reviewed policy. It facilitates the identification of the policy's relevance. It helps assessing how the environmental noise issue should be decided at the EU level or at the national level. Environmental policy is a horizontal issue in which the European Commission has a very strong mandate, as the same requirements should apply to all Member States. The consortium introduced the baseline and updated intervention logics:

- **Baseline intervention logic:** the process focuses on identifying needs, effective noise solutions, and a common approach on harmful effects. The activities required to do so include noise maps, strategies, and public consultation. The expected outputs are achievement of noise reduction. The expected results are compliance of Member States to the thresholds and improved health conditions. However, this should include socio-economic factors that highlight the fact that environmental policies do not evolve in a separate bubble but are indeed impacted by socio economic conditions.
- **Updated intervention logic:** this intervention logic is based on the same needs, objectives, inputs, outputs and outcomes as the baseline logic, with additional elements. For instance, the needs also include protecting citizens and meeting the defined targets. The objectives now contain the use of innovation and integrating NAPs in broader policy objectives. The Inputs comprise financial support schemes needed to complete the noise solution measures (for instance, Horizon Europe). The actions remain the same as in the baseline. Transparency of noise sources, ability to see trends, enforcement system and an improved legislative system are now considered within the outputs. The outcomes include the reduction of noise sources, the improvement of living conditions and the reduction of compliance costs through the financing of research. Finally, reduced noise emissions, improved health outcomes, increased number of quiet areas, increased research uptake and increased public awareness on health impacts are listed in the expected impacts.

In terms of **legislative drivers,** the consortium pointed out that rules of Member States should also be considered. They added that the END had been a very important tool to kickstart the harmonisation of noise policy across the EU. Most Member States have very different approaches compared to others. Indeed, noise policy can often be integrated in sectorial legislation or environmental legislation. **Differences in regulatory environment can be observed**. The consortium stressed that it was important to have **flexibility maintained** in future legislation when looking at policy measures to better **serve and accommodate** regional differences (regional climate, urban development trends, innovation and cost effectiveness). However, such flexibility could also lead to differences in the implementation.

The consortium introduced the following **preliminary conclusions**:

- NAPs are relatively descriptive and comprehensive. They provide information on the planned measures, the results from the noise mapping, public consultations, and other data.
- While there is a lot of information on the planned measures, only a few NAPs provide reduction targets in terms of people exposed to high noise levels, and therefore, providing goals to the NAP for the given timeline. These targets are more visible in airport NAPs, but they are not consistently available.
- The data on the evaluation of previous NAPs was provided in an uneven way across NAPs.
- Innovative measures are observed in some NAPs, but the majority follow a trend of common solutions.

The consortium provided the **following recommendations**:

- Open discussions on the need for further harmonization and synthetization of NAPs and methodologies including evaluation of previous results (noting subsidiarity)
- Enhanced monitoring of NAP implementation (lack of mandatory rules and obligations)
- Better understanding the relationship between noise pollution and urban planning - potential in reaching the END targets by combining noise action plans with air quality plans, road safety measures as well as, broadly speaking, urban planning in the agglomerations
- Encourage the development of common guidelines and good practices. This recommendation was particularly highlighted, on harmonization of NAPs and exchange of methodologies and noise solutions.

The complete PowerPoint presentation is available in Annex 1.

2.2.2 Q&A overview

During the discussion part of the session, various stakeholders commented on the presented results. It was highlighted that the results comprise a **wide range of noise abatement solutions**, and that the NAPs allow the Member States to **create innovative solutions**, **which could be shared alongside good practices.** Listing these good practices shows the **added value of the NAPs**, and that exchange around these practices should be further explored. Nevertheless, it was pointed out that the value of NAPs could be further enhanced if more information on costs was provided. The expected result of exchanging good practices could promote the **implementation of innovative solutions by NAP authorities**, where they have proved to be successful elsewhere. This will increase **confidence in such solutions**. The exchange of such practices should be promoted at the national level, but mostly at the local one. It was therefore suggested to develop a handbook of good practices which could be **disseminated through existing networks of cities** (e.g. Eurocities, Polis, ARC).

Furthermore, it was pointed out that regarding the END, national specificities could lead to **discrepancies in terms of directive's implementation**, as well as in the efficiency of adopted NAPs. Stakeholders highlighted that this issue could be addressed by adoption of the directly enforceable legislation at the EU level. However, this solution is difficult to be implemented given the shared competencies of the EU Member States in the area. The consortium explained in details possible enhanced requirements and proposed policy solutions in the second presentation. These could be understood as ways to leverage the enforceability of the current legislative frameworks. In this regard, it was emphasised that buy-in from the Member States is necessary.

Regarding **structural funding,** a question was raised as to whether areas that can benefit from them could be redefined to consider environmental issues. The consortium explained that operational programmes include already environmental priorities and infrastructural development. It was added that it would be interesting to revisit the operational programmes and see how they could be more aligned with infrastructure development. An obligation to dedicate a share of these funds for environmental priorities could be considered.

Several questions were raised targeting the issue of **comparability between the NAPs**. The consortium explained that while some NAPs are developed around a 5-year strategy, others do not provide information on this. Although some NAPs include broader horizon, they lack substantial information on the effectiveness of previous measures or solutions. For instance, the number of impacted people increased, however the analysis providing the reasoning behind was not provided.

Stakeholders also asked if the NAPs summaries could be shared in English by the Member States. The European Commission mentioned that it could be reflected upon, while stressing that the Member States were free to use their own language in the NAP reporting.

In the online discussion, further comments were made. For instance, the issue of assessing the efficiency of the NAPs in terms of the individual measures was mentioned on several occasions. the use of new noise indicators in that regard, for instance **event-based indicators,** was broadly supported by stakeholders, as it would help in the reduction of real-world noise levels. Stakeholders also highlighted the importance of qualifying the positive impact of measures in terms of health benefits. Stakeholders pointed out difficulties for countries in drafting the NAPs with very specific details about the measures.

The importance of stakeholder engagement in aviation NAPs and noise management was also stressed. However, participants added that the increase of traffic has had a negative impact on the effects noise abatement measures.

2.3 Policy solutions

2.3.1 Summary of the presentation

The presentation on noise policy solutions aimed to give an overview of the **key outcomes of the study** so far. The central question to be answered as part of this presentation and for the purpose of the study is, **"Why have we not seen a reduction of noise pollution over the last decades and what can be done to tackle this issue?"**

The complete PowerPoint presentation of this session is available in Annex 1.

<u>The EU noise policy in a broader context & EU noise policy vs. real world noise</u>

In the course of the study, the consortium aimed to identify policy options and reduce noise pollution as well as noise-related health burdens. Additional objectives of the study were 1) the integration of the latest scientific knowledge and research into EU noise policies, 2) the integration of new measures reducing noise at the source, and 3) the identification of new concepts for urban design and spatial planning to reduce noise pollution. In order to achieve these goals, transport-specific policies (rail, road, aviation) and horizontal noise-related initiatives were investigated by the consortium. The members of the consortium clarified that the timeline they took into consideration for the policy measures covers the next 10 to 15 years.

The key inputs of the study were taken from the noise maps, noise action plans (NAPs), and noise reception limits of EU Member States in order to **map EU noise policy in a broader context** at the international, EU, national, and local level. National and local-level legislation is underpinned by international and EU-level legislation. Conversely, international and EU legislation is described by the consortium as a passive measure to mitigate the effects of environmental noise. Based on the environmental integration principle (article 11 of the Treaty on the Function of the European Union – TFEU),[1] the consortium additionally highlighted that noise issues should be integrated more into other relevant policy areas and EU initiatives. Such relevant policy areas include climate targets (e.g. Green Deal, 7th Environmental Action Programme), mobility and modal shifts (between modes of transport), energy saving (building insulation), vehicle and traffic safety regulations, market surveillance, infrastructure charging, and procurement (transport fleets, infrastructure, urban planning, construction).

END improvement options

The consortium presented a series of policy suggestions to reduce noise pollution. The first suggestions covered the END in general. The suggested **END improvements** include: 1) improved implementation of noise action plans, 2) creating a link between monitoring and real-world noise levels, 3) using a vehicle and tyre certification process to obtain source data and monitor the market, 4) considering the CNOSSOS-EU also for planning, 5) accumulating better source data for electric/hybrid vehicles, PTWs (motorcycles) and dynamic urban conditions, and 6) developing an improved definition of façade exposure positions.

Options for road, railway, and aircraft noise

Road, railway and aircraft noise policy options were presented consecutively. **After the presentation of each transport mode, a poll with the workshop participants was conducted**, asking for feedback on the suggested policy options. The poll mainly asked to what degree the participants agree with the presented options. Annex 2 presents the results of the poll in detail.

Regarding ***road noise solutions***, the consortium presented improvements on EU legislation for road vehicle noise limits, tyre noise limits, and road infrastructure. The main points for **road vehicle noise limit legislation** is that there is room for targeted tightening of limits for louder vehicles in order to affect Lden levels and Lmax levels as well as for powered two-wheelers (PWT). Furthermore, it was suggested that the whole speed and rpm range must be covered to achieve reductions in real world noise exposure. Therefore, the gap between real-world noise, type tests and noise mapping must be addressed. Additionally, in synergy with the Green Deal, propulsion noise should be reduced even if electrification does not occur as fast as foreseen.

Regarding **tyre noise limits**, the consortium highlighted that there seems to be room for further noise reduction based on tyre label statistics. If this reduction is feasible, it would have an EU-wide benefit within several years. Moreover, the consortium also recommended providing more (financial) incentives in addition to tightening noise limits. Finally, better information on the tyre fleet and its full reduction potential should be provided to improve tyre-related policies.

In terms of **road infrastructure policy suggestions**, the consortium pointed out that the monitoring and mapping of road surface quality in noise-sensitive locations should be linked to maintenance, both for less maintained roads in urban areas and for busy main roads and motorways with quiet surfaces near dwellings. In addition, the following suggestions were introduced: 1) the harmonisation

[1] Article 11 in the Treaty on the Function of the European Union (TFEU) states that 'Environmental protection requirements must be integrated into the definition and implementation of the Union policies and activities, in particular with a view to promoting sustainable development.'

of road surface noise indicators and potential labels, 2) guidelines on degradation and maintenance and 3) a review of the implementation potential in different member states.

In terms of ***railway-related EU legislation and TSI noise*****, vehicle limits, track roughness management and vehicle/track design** were discussed. The presented policy suggestions include: 1) there is room to tighten limits to levels of modern EMUs and other rolling stock, 2) there is a scope for better management of wheel and rail roughness by mapping rail surface quality and wheel noise monitoring, 3) rail surface milling seems to have additional benefits, 4) there should be more consideration of noise as requirement for new tracks and track replacement in terms of track design, quieter rail pads and add-on devices and 5) the combination of quiet wheel and track design has a significant noise reduction potential. Finally, it was highlighted that what can be done within the TSI noise and legislation and enforcement at the national level should be taken into consideration.

Regarding ***aircraft noise***, the following suggestions were made: 1) based on the NAPs, operational and traffic management initiatives are key instruments for meeting noise thresholds in and around airports, 2) at the EU level, a fleet replacement with quieter aircraft could be implemented through incentives or non-additional/non-operation rules, 3) noise operations at night could be avoided through reception limits (based on Lmax, not on margin to certification limits), 4) at the airport level, 3D-optimised flight procedures should be considered as solutions, 5) at the airport level, stakeholder engagement/dialogue with the public should be fostered, 6) land use planning should be improved to avoid encroachment, 7) the extension of the END/BAR to smaller airports (<50,000 movements/year) should be considered, cine many of those airports experience significant growth; this presents an opportunity to avoid noise issues rather than correct them in the short-medium term.

National legislation and noise reduction in real life

First, national legislation options were presented, followed by the interaction between legislation and real-world noise and finally conclusions on noise reduction in real life.

The presented **national legislation for road, railways and airports** are summarised in the table below.

Table 1: National legislation options for road, railways and airports

	Road	Railways	Airports
Noise reception limits	Evaluate, harmonise and tighten LDEN/Lnight limits Lmax guidelines	Evaluate, harmonise and tighten LDEN/Lnight limits Lmax guidelines	Evaluate, harmonise and tighten LDEN/Lnight limits Lmax guidelines
Implementation of EU legislation	Assess/enforce	Assess/enforce	Assess/enforce
Infrastructure quality in relation to noise	Traffic and infrastructure monitoring	Traffic and infrastructure monitoring	Traffic and flight path monitoring
Urban planning	Include noise at early stage Road and building layout, bypass and tunneling, procurement	Include noise at early stage, choice of rolling stock and infra Track and building layout, procurement	Include noise at early stage: locations, land use and layout, procurement
Traffic and access restrictions	Include noise and use synergies: 30 km/h, LE Zones, restrict noisier vehicles	Restrict noisier vehicles	Flight paths, night operations/curfews

Based on these findings the consortium concluded that **real-world noise in terms of legislation, Lmax, and noise perception are influenced by a series of factors**, which include:

- Local action plans
- Reception limits
- Surveys
- Public consultations and information on noise
- Monitoring of noise levels
- Enforcement of legislation concerning traffic and noise
- Implementation/availability of low emission zones
- Green procurement
- Environmental and mobility policy
- Urban planning and infrastructure

Finally, the consortium introduced **main findings regarding noise reduction in real life**. These findings included:

- Questions about the potential of the END to produce real-world noise reduction based on calculated noise reduction and health benefits (i.e. Do calculated effect and real-world effect overlap? Does the END reduce real-word noise?).
- Including considerations about the real-life impact of noise disturbance, e.g. driving behaviour, real fleet conditions, road conditions, other noise sources such as motorbikes, claxons, etc.
- The divergence between hidden health benefits and Lden due to the lack of a proper dose-effect relationship for peak noise.
- The reduction of different transport noise may be achieved by monitoring other indicators than Lden: e.g. monitoring the frequency and intensity of noise peak events, e.g. Lmax and night operations, excessive noise from motorcycles and tuned vehicles
- Introducing an integrative approach for air pollution and noise to achieve real-life noise reduction.

2.3.2 Q&A overview

The main question discussed during the Q&A session was structured around understanding **what the problem regarding noise pollution is and if the solutions are known, as what can be done to reduce noise pollution?'** This question revolved around factors such as the status quo of noise solutions, policy options, funding, etc. In response, one participant pointed out that no increase in noise levels in the last decades is already a positive result. This result already shows that the noise solutions are working. Following this comment, the participants addressed whether the END is useful and can achieve a reduction in noise pollutions. It was highlighted that nowadays there is a trend focusing more on the noise source for noise reduction, which is considered a significant step forward since the introduction of the END. Another comment added that an assessment of noise at the source may be worthwhile but that a real-life impact of noise should be given more focus.

Regarding the **role of the industry in this context**, participants commented, on the one hand, that the industry has already made an effort to reduce noise (in this case tyre noise specifically) and that no further improvements can be made. Furthermore, tyres are subject to various regulations, which is why noise cannot be the only factor taken into account. On the other hand, respondents argued for more rigorous regulation of industry and products in order to achieve greater reductions in decibel (as many as 10dB).

The discussion point was further continued with the **need for legislative alignment.** Phenomena does not only investigate EU legislation but also local or national legislation, which will be considered as policy options if they result in effective noise reduction. One participant added that END and noise limit legislations are not aligned which is why noise reduction does not deliver substantial positive results. International, national and local legislation should rely on guidance from the END. **A clear source noise limit should be provided by the EU in noise source regulations, and this limit should be cascaded down to the various Member State authorities and industry**. To summarise, at the source level, the legislation is currently not aligned locally, nationally, at the EU level or internationally.

On the subject of **aviation**, the participants of the workshop highlighted that there is no solution that fits all airports. One suggestion by a participant was that there should be regulations for airports at EU level which would be then applicable to all airports, with room for exceptions for some airports.

Responding to another question about how **increasing traffic and noise solutions** can be managed simultaneously, the consortium replied that the issue of traffic growth is a problem and has generally cancelled out noise reduction measures. Traffic management is very important, and no further steps are taken currently, noise pollution will become worse.

The follow-up topic covered **urban planning**. The participants stated that urban planning should harmonise with noise solutions, otherwise the risk of noise solutions not being effective is high. Furthermore, urban planning and procurement should be taken integrated into a policy framework, however since it is a long-term measure the implementation will be slow and step-by-step. Consequently, the urban planning scenario is relatively complicated due to these long-term costs and benefits.

On the subject of the **monitoring of noise** on **roads**, the consortium stated that the biggest problem are zones with high levels of noise exposure which is not reflected in the noise mapping. Therefore, more statistical results are needed for such monitoring. It was added that more monitoring of noise levels should be carried out in **cities**.

A question on **road surface labelling** was met with a positive response from the consortium who stated that it is an option worth exploring. It was further noted by the consortium that quiet road surfaces have an immediate positive impact on noise levels, and the wider the implementation, the wider is the impact.

Towards the end of the discussion the topic of **legislation and implementation at different levels (EU, international, national, local)** was addressed. The European Commission asked the participants at what level urban planning should be addressed. If urban planning is addressed at global level and it is effective, should the EU implement it? Or is local-level legislation required if urban conditions are different in different places? Overall, this addresses the issue of balance between the different forces and legislations at different levels. One participant strongly recommended the cooperation between different levels. Once this cooperation has become effective and efficient, more focus can be put on defining common targets and efforts for the next 5-10 years to reduce noise levels. The discussion was closed with the summary that the EU could assume the role of a coordinator between the different actions (i.e. targets and policies). Further developing on this point, a participant asked **whether the EU should set a noise threshold that is not a WHO value**. Responding to this, the European Commission stated that the goal regarding a noise limit lies between the current reality and the WHO recommendation.

Finally, the consortium summarised that **the discussion largely revolved around two competing arguments – one for stricter regulation and environmental controlling (noise in this case) and one for the maintenance of economic competitiveness**. The second argument largely addressed the willingness of companies to spend more money on noise reduction measures. It was added that further **support could be given to product improvement** (e.g. quiet tyres, quiet vehicles, etc.). In this context, incentives to motivate companies should be revised.

3 Presentation of sectorial findings

The second part of the workshop focused on the findings of sector-specific research on technical noise solutions and scenarios. Firstly, noise solutions and scenarios in road traffic noise were addressed before issues and findings pertaining to railway-related noise reduction were discussed. Finally, the second segment of the workshop concluded with a presentation and discussion on aviation noise solutions and scenarios. At the end of each of the three presentations, attendees were encouraged to share feedback relevant to the respective sector (road, railway, aviation).

3.1 Road scenario results

3.1.1 Summary of the presentation

Method

This session focused on presenting the results obtained and the scenarios designed regarding road traffic. The consortium provided a summary of the methodology used, which is split into two parts:

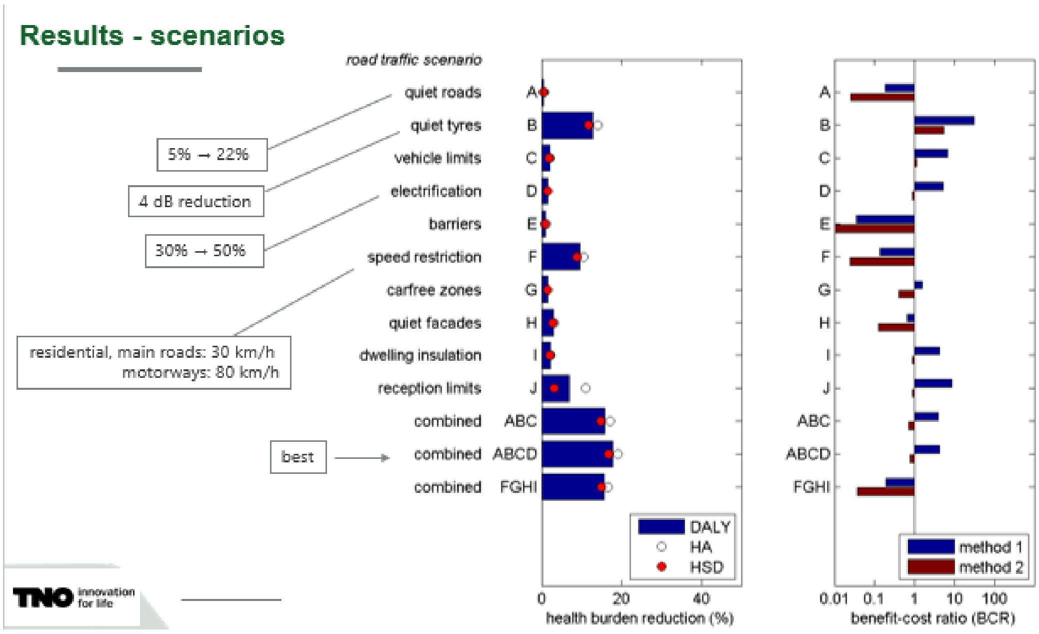
- **Health burden**: it is calculated based on road traffic noise, along a causal chain. The consortium starts with an average baseline noise distribution for the whole EU and calculates the change in it due to the selected scenarios. The health burden is then expressed in annoyance or high annoyance, sleep disturbance or high sleep disturbance, cardio-vascular diseases, in DALYs (Disability Adjusted Life Years) and in monetized results. The latter are provided for two calculation methods, with method 1 providing usually a larger monetized health burden. Using two different methods helps reflect potential uncertainties in the causal chain.
- **Scenarios**: the consortium starts from a baseline scenario where an increasing health burden is foreseen, to be compared with scenarios defined for the noise solutions. This provides inputs for the cost-benefits analysis.

Results for road noise and conclusions

The results of the **baseline scenario** present the health burden of road traffic noise in 2030, if a 1% traffic growth per year is considered, as well as demographic change and electrification of vehicles. The results show 28% of persons highly annoyed, and 13.4% highly sleep disturbed. In DALYs, this provides 935 thousand for sleep disturbance, and 559 for annoyance.

The consortium highlighted that **road traffic was the sector where it was not easy to achieve the target of 20% reduction of the health burden**.

Figure 3. Scenarios for road traffic noise



Regarding the scenarios, the following considerations conclusions could be drawn:

- For the **baseline scenario**, it was assumed that 5% of roads had a quiet road surface, while the projected scenario considers 22% of roads. Therefore, the reduction of noise exposure and subsequent health burden at EU level is relatively low. The BCR is below 1 due to the costs, but this scenario may still be revised.
- The quiet tyres considered are 4 dB quieter than those in the baseline scenario resulting in a significant reduction in health burden and positive BCR due to its widespread and fast impact.
- It is considered that the **electrification of vehicles would increase** from 30 to 50% compared to the baseline scenario, resulting in a modest reduction in health burden and a positive BCR, being limited by tyre noise.
- Regarding speed restriction, this would mean reducing to 30 km/h for urban areas, and to 80 km/h for motorways. It has a substantial reduction in health burden but low BCR due to extra travel time.
- **The best scenario is the combination of ABCD**: quiet roads, quiet tyres, vehicle limits, and electrification of vehicle, having both a moderate reduction in health burden and a BCR well above 1.
- **The best single solution scenario are the quiet tyres.** According to method one, it would correspond to EUR 55 billion per year, while method 2 provides a much lower cost. However, method one provides higher benefits in terms of health burden after four years, while method 2 has smaller benefits. The costs of this scenario are not so high as quiet tyres are estimated to be 1% more expensive than others.
- **Within the ABCD combination, scenario B dominates in terms of results.** The three other solutions it comprises provide some additional decrease. However, 75% of the results is due to the inputs of quiet tyres.

The health burden and costs and benefits over time are presented in the figures below for scenario B (quiet tyres) and for the combined scenario ABCD.

Figure 4. Benefit-costs ratio scenario B

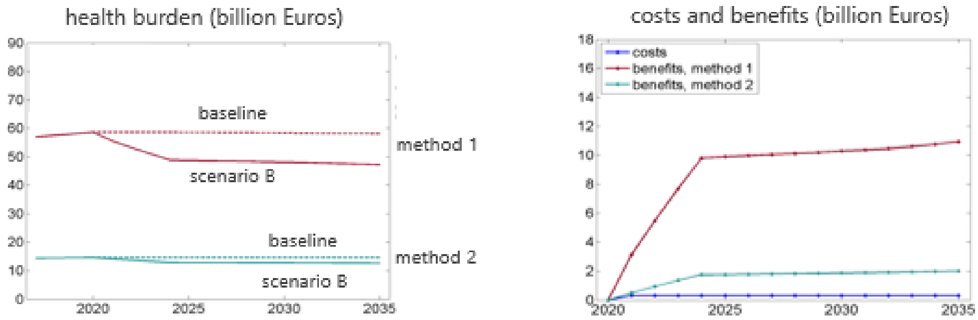
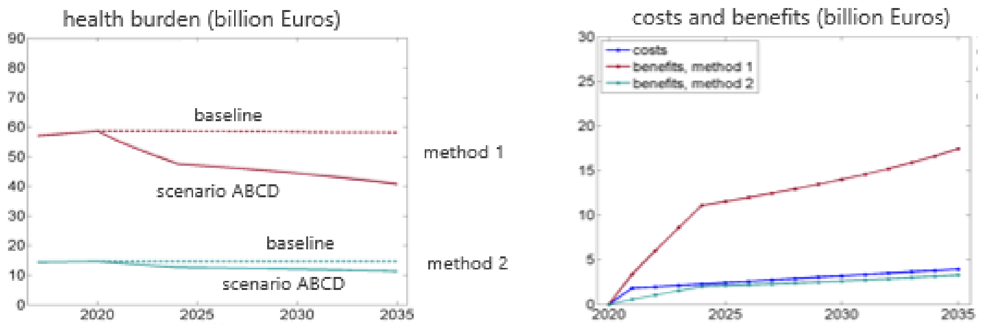


Figure 5. Benefit-costs ratio scenario ABCD



The complete PowerPoint presentation is available in Annex 1.

3.1.2 Q&A overview

During the discussion part of the session, the different scenarios presented were commented upon by the stakeholders. There was first a comment on the **quiet road scenario**. Stakeholders highlighted that for this noise solution, **road maintenance is a key element**, as well as **considerations on the type of quiet road**. Indeed, some quiet roads have longer life expectancy based on the materials used, which has an impact on costs and benefits. The **variation of maintenance**, according to stakeholders, shows up to 16 dB(A) of difference across the EU. The consortium explained that in this scenario, elastic road surfaces were not considered, but only currently implemented types of road surfaces. They added that **quieter surfaces could perhaps show better results**. The European Commission highlighted that this could be refined in a future report.

Another discussion point dealt with the **split between quiet tyres and quiet roads in the given scenarios.** Participants argued that they were **not to be split as they come from the same source**, as tyre noise results in the interaction between the tyres and the road. They added that Cnossos did not reflect the reality, in that regard. The consortium replied that indeed the Cnossos model was used, regarding rolling noise and propulsion noise, and known correction factors for road surface types. The European Commission highlighted that this topic should be clarified and suggested that the consortium should exchange with the stakeholder on this point.

The difference between roads inside and outside urban areas was also pointed out, with suggestions to split the scenarios. The consortium explained that the data presented was a sum of the data for inside and outside agglomerations. The result of -4 dB was also discussed, and the consortium explained that the estimation was related to the tyre label and the road type. There is a model taking into account the effect of road and the effect of tyre levels. The results for quiet roads can seem low because the starting point in the baseline is a very low level of quiet roads in inhabited areas in the EU. Stakeholders stressed that the **lack of quiet roads in the EU should be highlighted in the report to explain the provided low impact of this solution**.

The question of speed was also discussed, with stakeholders pointing out a low benefit-cost ratio and asking why it was not part of the combined scenario (ABCD). The consortium explained that the **combined scenario ABCD was focusing on the vehicle side of noise abatement measures, while speed was integrated in the infrastructure scenario (FGHI)**. The European Commission added that the combinations had to be possible and implemented throughout the EU, as well as providing a good cost-benefit ratio, to be considered.

In the online discussion, further comments were made, on how urban planning could contribute to the improvement of the living environment quality and should be considered in a wider approach than noise abatement. The noise measures targeting infrastructure appeared to not bring the expected positive benefits, and some stakeholders suggested explaining this further.

3.2 Rail scenario results

3.2.1 Summary of the presentation

Method

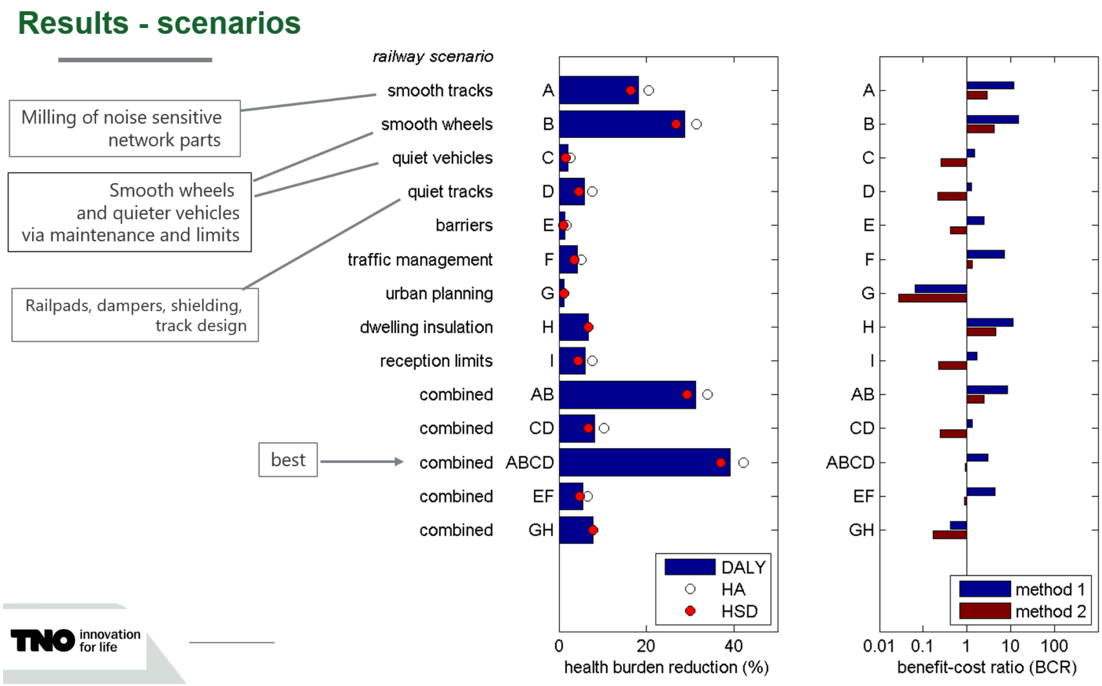
The method for the rail scenarios follows the same approach as the method for the road scenarios (see 3.1.1 Summary of the presentation). While the road scenario methodology includes propulsion noise and rolling noise, the railway methodology additionally includes aerodynamic noise since this is another significant type of noise for railways. For railways, rolling noise is the most important type of noise overall, propulsion noise is the most important at low speeds and aerodynamic noise is the most important at high speeds.

Results for railway noise and conclusions

The results of the baseline scenario present the health burden of rail traffic noise in 2030, if a 1% traffic growth per year as well as demographic change are considered. In urban areas, the results show 8% of persons highly annoyed, and 3.6% highly sleep disturbed. In DALYs in urban areas, this provides 249 thousand for sleep disturbance and 159 for annoyance. Regarding the monetisation, method 1 results in a larger monetised health burden (EUR 8.8 billion), while method 2 results in a monetised health burden of EUR 3.6 billion.

The figure below presents the CBA analysis of the different types of scenarios.

Figure 6: Railway scenario results



The CBA analysis shows that the overall **best results can be achieve through the ABCD solution** which combines smooth tracks (A), smooth wheels (B), quiet vehicles (C) and quiet tracks (D), as can be seen in Figure 6: Railway scenario results. The consortium added that there are good possibilities to achieve the anticipated results for railways.

Smooth tracks (A) on their own are considered by the consortium a fairly good measure which leads to a reduction of health burden. **Smooth wheels (B)** as a separate scenario also achieve a quite large positive effect. **Quiet vehicles (C)** provide only low improvement because there are already a reasonable number quiet vehicles in fleets, and track noise also contributes; however, improvement in the ratio of quiet vehicles in fleets is certainly possible. **Regarding quiet tracks (D)**, rail dampers, shielding and other measures can be introduced when tracks are replaced; a part of railway networks have a scope for such improvement.

Other solutions such as **barriers (E)** results in a lower noise abatement effect since barriers can only be built in certain places where there is enough space. The study team also found that **traffic management (F)** provides some potential positive effect, while **urban planning (G)** clearly has a positive effect but a very low BCR since it is a long-term and expensive measure to implement (not all European cities can be redesigned within 10 years). Furthermore, while dwelling insulation is fairly easy option to implement, it does not solve the noise problem per se. **Reception limits (I)** can help reduce the health burden, although the BCR results are mixed.

To conclude, the study results show that the combined **scenario ABCD offers the largest possible benefits and effectiveness.**

3.2.2 Q&A overview

The Q&A of the session of rail scenario results revolved around the following four topics: **the selection of the scenarios, noise barriers, rail grinding, and the application of the scenarios for agglomerations**.

The first comment addressed the reasoning behind the selection of the best scenarios. It was commented that while the scenarios AB (smooth tracks and smooth wheels) seem effective, F (traffic management) and H (dwelling insultation) also show positive results. Responding to the question, the consortium explained that the noise reduction mechanisms are very different for the various scenarios. Dwelling insulation may not be considered an entirely effective solutions since it only applies to the indoors. Therefore, the scenario ABCD is considered the best scenario in terms of reduction potential and applicability.

Another question revolved around the usage of noise barriers for railways. The workshop participant expressed doubt about the utility of barriers for noise reduction, commenting that barriers for rail should be considered differently than for road because barriers can be placed all along rail tracks and, moreover, very close to the train tracks. The participant further highlighted that the protective effect of barriers may be limited (only a few decibels reduction) and that a larger noise reduction is needed to reduce the health burden. In this context, the participant added that the market should be stimulated more to explore new solutions. Responding to the issue, the consortium explained that barriers have some limitations for railways in terms of effectiveness.

Another participant asked whether the consortium took into account that some railway networks already include grinding for noise benefits and not just for maintenance reasons. The Consortium clarified that this was taken into account but not generally implemented for noise benefits. If rail grinding is carried out, it is mainly done for maintenance reasons.

Finally, one participant asked about the applicability of the results for agglomerations and whether city authorities can use the study results for urban planning. The consortium clarified that the study results are general, EU-wide conclusions. Therefore, the monitoring of specific tracks is important. Furthermore, inside as well as outside agglomerations, authorities should also take into account the length of tracks alongside which residents are living. The discussion ended with the conclusion that the participant (Eurocities) would follow up with the TNO members on the specificities of this issue at a later point.

3.3 Aviation scenario results

3.3.1 Summary of the presentation

Method

This session focused on presenting the results obtained and the scenarios designed regarding aircraft noise. The consortium provided a summary of the methodology used, which is split into two parts:

- **Method**: is based on a causal chain between noise emission, exposure distributions (50-70dB) and health burden (annoyance, sleep disturbance, cardiovascular diseases in DALYs and in monetized results). The monetised results are presented with method 1 (higher health burden) and method 2 (lower health burden) relevant for the same scenario.
- **Scenarios:** (1) baseline scenario, without noise-abatement interventions, that forecast an increased noise burden in 2030 for highly annoyed (1.6 million people and 33 thousand

DALYs) and highly sleep-disturbed people (0.6 million people and 40 thousand DALYs). The data from the baseline scenario relevant to aircraft noise show that there are significantly less sleep-disturbed people than annoyed people. Likewise, the monetised results for the baseline scenario for method 1 is EUR 1.1 billion and for method 2 is EUR 0.8 billion. Similar costs show that high monetisation costs do not depend on the method pursued.

- (2) two scenarios with noise solutions contributing to the noise reduction between 2020-2035 from the cost-benefit perspective. Particular short-term circumstances on air transport arising from the Covid-19 pandemic were not taken into account for the scenarios, because the effects are not impacting air transport on a mid-long-term basis considering the rating of noise solutions.

Results for aviation noise and conclusions

In addition, considering the effects of the Covid-19 pandemic on the baseline scenario, the IATA recorded a 55% reduction of movements in 2020. It is expected that in 2023, air traffic will recover and achieve the numbers of movements from the pre-Covid-19 period (2019). The normal baseline scenario, as predicted before the current aviation crisis, is expected to resume from 2023. In the pre-Covid-19 baseline scenario, according to the EASA Environmental report on aviation, annual air traffic growth was predicted at 1.8%, while noise reduction from natural fleet renewal was predicted at 0.1%.

Regarding the proposed aircraft scenarios, the study proposed a variety of single solution scenarios and three combined scenarios. **However, those scenarios are applied based on small number of airports that have similar flight profiles and are not applicable for all airports**. Compared to road and rail traffic, aircraft noise cannot be distinguished between urban and non-urban areas.

Single scenarios are: (A) improved flight profiles (2 dB reduction from take-off and CDA approach), (B) P-RNAV (track concentration), (C) (D) night curfew by 2025 and by 2030 and night curfew non-Ch4 2025 and night curfew non-Ch4 2030 (E) phase-out non Ch4 by 2025 and by 2030 (F) accelerated fleet renewal (force airlines to switch to quieter aircraft) (I) stakeholder engagement (5 dB reduction and contributes to the noise sensitivity awareness), (J) reception limits.

The three combined scenarios are: (1) 3D optimisation (AB): improved flight profiles, P-RNAV (track concentration); (2) quietest fleet (EF): phase out non-Chapter 4 aircraft (related to the change towards the quieter aircraft) for 2025 and 2030 and accelerated fleet renewal; (3) best possible from aircraft side (ABEF): improved flight profiles, P-RNAV (track concentration), phase out non-Chapter 4 aircrafts by 2025 and by 2030 and accelerated fleet renewal.

The cost benefit and DALY calculations were selected for one single solution scenario (A – improved flight profiles) and one combined scenario (ABEF – best possible from the aircraft side).

Figure 7 Scenarios for air traffic noise

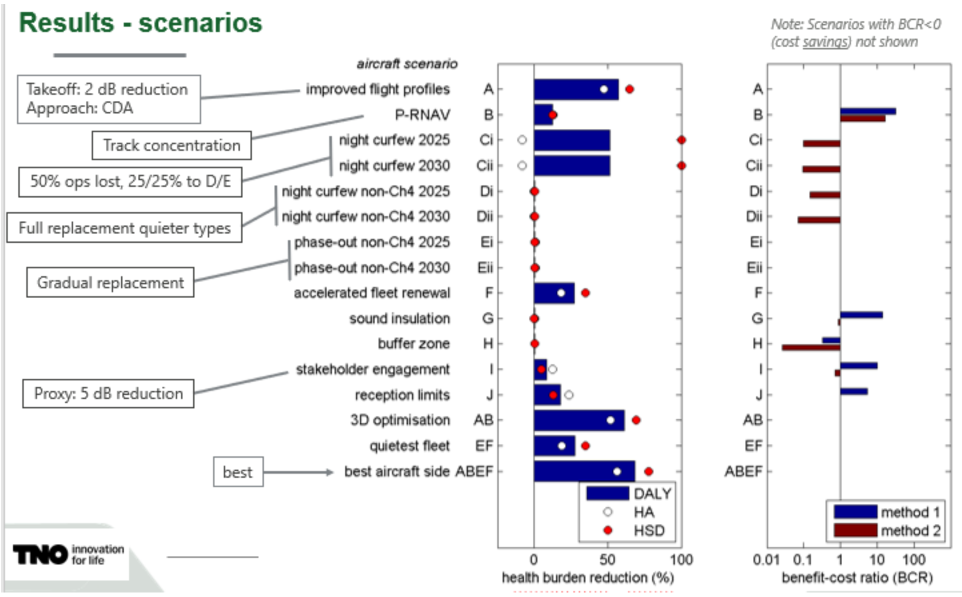


Figure 8 Benefit-costs ratio scenario A – improved flight profiles

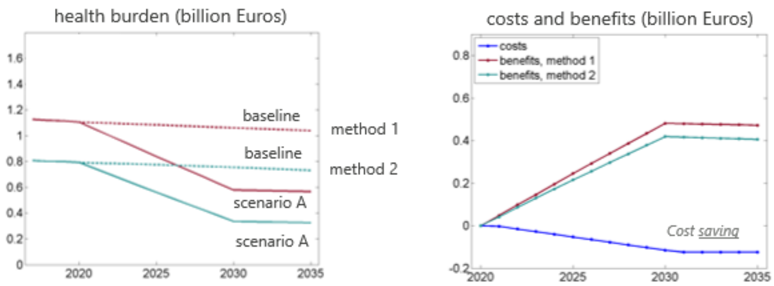
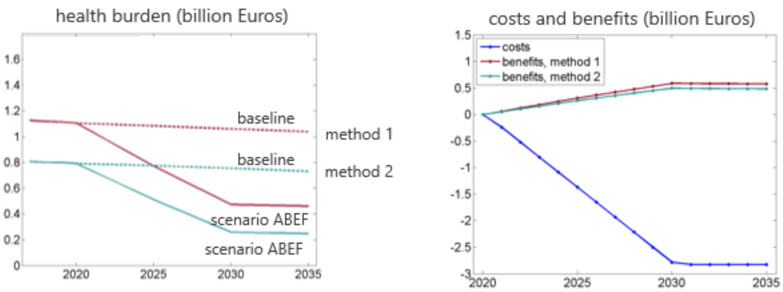


Figure 9 Benefit-costs ratio scenario ABEF - best possible from aircraft side



The comparison between the selected single and combined scenarios shows that **the combined scenario gives a greater health burden decrease.** The result of selected single scenario result, A – improved flight profiles, gives **modest cost-benefit savings and no significant difference between method 1 and method 2.** On the other hand, the combined scenario ABEF (i.e. improved flight profiles, P-RNAV (track concentration), phase out non-Ch4 by 2025 and by 2030 and accelerated fleet renewal) – best possible from aircraft side predicts much higher cost-benefits and health burden release. Therefore, according to the study context, the most appropriate solution for aircraft noise is the mix of single solutions in combined scenario.

The complete PowerPoint presentation is available in Annex 1.

3.3.2 Q&A overview

During the discussion part, participants commented on the presentation, different noise solutions and scenarios using spoken interventions or by writing in online discussion. The discussion was opened on the subject of the noise solution proposing the **concentration of aircraft movements from one track (P-RNAV).** It was pointed out that Heathrow airport has a different approach where tracks should be frequently changed to avoid high annoyance of one group of residents living by airports and to allow different resident groups a 'break' from the noise.

From the Finnish perspective, it was important to **acknowledge geographical differences between airports and that ''one-size-fits-all" approach for the reduction of aircraft noise is not possible**. The reasons put forward in that regard are: (1) different local geography and climate; (2) time zone difference, which makes it impossible to implement a night flight ban as universal measure; (3) buildings insulation is better in the northern than in the southern countries, because of thermal insulation requirements; (4) urban and land use planning is a national competence.

From the UECNA perspective, **the residents near airports are facing noise problems, which could further increase when considering predictions that air traffic will increase in the following years**. Around 30% of residents living near airports are exposed to aircraft noise. The Balanced Approach should be better implemented in all airports with the aircraft noise burden for the local residential areas, including also night curfew and flight bans in case that other solutions are not decreasing the noise burden on residents. Furthermore, the question on the noise sensitivity of residents and innovative insulations measures (i.e. roof and ventilation insulation) should be considered as noise solutions if curfew measures cannot be implemented. Noise is also reducing housing and land prices near airports.

There was a comment that is equally applicable to aircraft, road and railway noise that housing **insulation measures** should be considered only in the areas where noise represents a health burden on the population and not in uninhabited areas. Besides insulation, better buildings quality materials could also prevent noise creation, which is an argument relevant for all transport noise sources. Furthermore, housing insulation is a good noise solution when it is necessary to significantly reduce noise for residential areas near airports (up to 20dB).

On the workshop chat, the participants commented on presented noise solutions and scenarios. It was pointed out that the reference to the chapter 14 would be, in overall, more efficient for the aircraft noise certification standards than chapter 4 that is focused on the phasing out of old aircraft. Participants also raised a question on how it could be possible to achieve a 5dB noise reduction with stakeholders' engagement. Participants commented that annoyance could be reduced from stakeholders' engagement, but not the noise as such. Participants also agreed that it is impossible to implement night curfew because of cargo hubs and different geographic connections from different time zones. They further added that different noise scenarios and solutions would not be successful if they are not supported by the ICAO. As for noise solutions, the ICAO is actively supporting measures for accelerated fleet renewal and new noise certification (i.e. ch.14 to be adopted instead of ch.4). As for the NAPs, stakeholders suggested that the European Commission could further improve the monitoring and efficiency of noise measures. This is important as every airport is different. Thus, a better control of implemented measures from NAPs would be a possible solution that acknowledges different local specificities. Participants also commented that the WHO Europe noise guidelines for aircraft noise are very low and unrealistic, and they are expected to be re-estimated based on more balanced evidence.

4 Stocktaking

The final session of the workshop was designed to draw conclusions on the presented findings receive final comments from stakeholders. These are mentioned below and will be taken into account during the last stage of the study.

4.1 Key remarks and concerns

The project will last for another three months. The consortium will integrate the comments and key issues discussed with stakeholders during the workshop. The elements highlighted include compliance of Member States, evaluation of measures implemented, monitoring of the effectiveness of the measures, the enforcement of policies, and harmonization of approaches. The consortium pointed out that many NAPs have to choose between environmental objectives and economic growth. In regard to this, the innovation could bring and added value and provide more balanced solutions.

Furthermore, the consortium pointed out that the impact of Covid-19 had to be taken into account. The current lack of understanding of more innovative measures in the NAPs could be addressed by obvious solutions seen in the current pandemic, such as the impact of working from home on road traffic, for instance. The consortium will therefore refine policy recommendations.

In the discussions, stakeholders indicated that a hierarchization of critical situations could be carried out, as a very high number of people were still exposed to very high levels of noise. It was suggested that these infrastructures and groups of people should be considered as the starting points for the NAPs development/review. Stakeholders face the challenge when it comes to ensure transmission of the relevant information to authorities to foster implementation of NAPs. Participants also stressed the importance of developing strong findings which would have a substantial impact on noise reduction.

4.2 Action points/next steps

The following action points were discussed:

- The consortium will continue organising interviews until the drafting of the final report.
- The European Commission invited stakeholders to reach out to the consortium for interviews.
- A handbook on NAPs guidelines and good practices is to be considered.

Annex 1: Workshop presentations

The presentations are available in an additional file.

Annex 2: Poll results

During the workshop, a series of three polls was conducted with the participants as part of the workshop morning session on policy solutions. The polls asked for feedback on the presented suggestions on policy solutions in the road, railway, and aviation sector. The table below indicates all questions and responses collected during the polls. While only three response options were prepared by the consortium (Yes, No, Partly Agree), participants who chose none of these three options were counted in the 'No Answer' segment, as indicated in the table below.

Overall, of those participants responding to the poll, most participants agreed with the policy suggestions of the consortium in all three poll questions. The second-most selected answer was partial agreement, and the least-selected answer was clear disagreement with the policy suggestions. Therefore, it appears that the consortium is on a good path regarding the development of policy options. The full range of suggested policy options is presented below the table which indicates the poll results.

Table 2: Poll results

Policy Solutions (VVA & TNO)	
1. Do you agree with these road-related policy suggestions?	
A. Yes	131/93 (33%)
B. No	4/93 (4%)
C. Partly agree	18/93 (19%)
No Answer	40/93 (43%)
2. Do you agree with these railway-related policy suggestions?	
A. Yes	30/94 (32%)
B. No	1/94 (1%)
C. Partly agree	10/94 (11%)
No Answer	53/94 (56%)
3. Do you agree with these aircraft-related policy suggestions?	
A. Yes	30/96 (31%)
B. No	1/96 (1%)
C. Partly agree	19/96 (20%)
No Answer	46/96 (48%)

1. **Policy Suggestions for Road**

Road vehicle limits (EU legislation)

- There is more room for **targeted limit tightening for the louder vehicles**, not only to affect Lden but also Lmax levels including powered two-wheelers (PTW)
- Vehicle noise limits restrict both tyre and propulsion noise of NEW vehicles

- Propulsion noise is most relevant for 1/3 of urban road lengths with low speeds, also gradients, junctions and for larger and louder vehicles
- The **whole speed and rpm range must be covered** to achieve reductions in real world noise exposure (gap between real noise, type test and mapping)
- Electric vehicles reduce propulsion noise not tyre noise
- In synergy with the Green Deal, **propulsion noise should be reduced** even if electrification is not as fast as foreseen
- Simplify and facilitate in-use compliance/enforcement

Tyre noise limits (EU legislation)

- Tyre noise is significant and can take effect very quickly throughout the EU compared to quiet road surfaces and vehicles
- Tyre limits also include aftermarket (replacement) tyres
- Tyre life is about 4 years so easy to replace for whole fleet
- There seems to be **room for further reduction** based on the label statistics
- Besides tighter limits also **incentives** required (financial)
- Noise vs safety: take vehicle OEM tyres as a starting point, these are all safe!
- Better models and test procedures for tyre noise required
- Better **info on tyre fleet required**, and full reduction potential

Road infrastructure (EU legislation)

- **Monitoring and mapping of road surface quality in noise sensitive locations** to be linked to maintenance: both for less maintained roads in urban situations and for busy main roads and motorways with quiet surfaces near dwellings
- Widescale upgrading to quiet roads is expensive at EU level, but can be cost-effective at local level
- Some urban roads with high roughness can easily be made quieter
- **Harmonisation** of road surface noise indicators and potential label
- **Guidelines** on degradation and maintenance
- **Review** of potential in different member states

2. **<u>Policy Suggestions for Railway</u>**

Railway vehicle limits, roughness management and vehicle/track design (EU legislation – TSI noise)

- **Room to tighten limits** to levels of modern EMUs and other rolling stock
- Scope for **better management of wheel and rail roughness, by mapping rail surface quality and wheel noise monitoring**
- Low rail roughness is precondition to ensure rolling noise reduction
- **Rail surface milling seems to have additional benefits** in extending life of rails, besides noise reduction reducing need for barriers

- More consideration of **noise as requirement for new tracks and track replacement**: track design, quieter rail pads or add-on devices
- **Combination of quiet wheel and track design** has significant potential
- What can be done within the **TSI and at national level**?

3. **Policy Suggestions for Aviation**

Aircraft noise

- Based on the NAPs, **operational and traffic management initiatives** are one of the key instruments for meeting noise thresholds in and around airports
- No room for tightening vehicle limits, since this is regulated at global level (ICAO)
- At EU level a **fleet replacement with quieter aircraft** may be implemented (through incentives or non-addition/non-operation rules)
- **Avoiding noisy operations at night** (based on Lmax, not on margin to certification limits) – reception limits
- At Airport level **3D-optimised flight procedures** should be considered
- At Airport level **stakeholder engagement/dialogue** with public should be fostered
- **Land use planning** should be improved to avoid encroachment
- Consider **extension of END/BAR to smaller airports** (<50.000 mov), since many of those experience significant growth. Opportunity to avoid noise issues (rather than correct them) in short-medium term

Annex 4: Workshop Background report

1 Executive Summary

1.1 Objectives

The objective of the study is to support the European Commission in defining the potential of measures capable of delivering significant reductions (20%-50%) of the health burden due to environmental noise from roads, railways and aircraft, and to assess how relevant noise related legislation could enhance the implementation of measures, while considering the constraints and specificities of each transport mode. The project collects and analyses data from the geographic areas with the following limitations:

- roads and railways inside agglomerations of more than 100,000 inhabitants;
- major roads of more than 3 million vehicles a year;
- around major railway lines of more than 30,000 trains a year; and
- around major airports of more than 50,000 movements a year.

1.2 Results so far

1.2.1 NAP analysis

During the project, the research team has carried out the (a) overarching analysis of 200 and the (b) in-depth review of 100 noise action plans. The aim of this analysis was to (a) map the relevant noise solution measures that have been planned and implemented as well as to (b) identify the key regulatory drivers facilitating the implementation of the noise solutions, underlying challenges, associated costs and benefits. The NAP analysis was supplemented with stakeholder interviews, and based on cumulative findings the following conclusions can be drawn:

- NAPs are relatively descriptive and comprehensive, providing information on the planned measures, the results from the noise mapping, public consultations, and other data. Most of them have both a strategic and operational focus.
- There is no overarching common approach to the creation of NAPs between Member States. While some NAPs are very detailed and comprehensive, others lack important data.
- Innovative measures are observed in some NAPs, but the majority follow a trend of common solutions.
- Some NAPs also mention a long-term strategy or a cooperation with mobility planning and sustainability considerations.
- Some NAPs provide reduction targets in terms of people exposed to high noise levels, therefore, providing goals to the NAP for the given timeline. However, this information is missing in most NAPs analysed together with data on evaluation of previous results.
- Stakeholder interviews identified lack of control over the implementation of NAPs including mandatory rules and obligations to implement the NAPs.

- Furthermore, insight gained from the research shows that there is a lack of shared knowledge of best practices.

Due to the complexities of the sources, distribution and impact of various noise levels, the analysis has shown that it is imperative that legislative measures remain flexible enough to accommodate regional specificities of climate and weather as well as urban development trends, innovation and cost effectiveness of measures

1.2.2 Noise solutions and scenarios

A CBA has been performed for the single solution scenarios and several combined scenarios for road and rail, and two single scenarios for aircraft. The reductions in health burden and the benefit to cost ratio BCR are shown for road, rail and aircraft in figures 1, 2 and 3 respectively. These give first indications of the potential in terms of EU-wide health benefits, and can serve as a basis for policy considerations. Health burden reductions above 20% are currently only found for rail and aircraft, and not yet for road. This may be possible by adjusting the inputs of the road scenarios. The benefits are expected to be higher if other impacts than noise are also taken into account, or if the baseline is adjusted, for example on growth and electrification.

The results in terms of reduced health burden and BCR strongly depend on the definition of the baseline and the appraisal period up to 2030/2035, which includes traffic growth and fleet evolution forecasts. They are in terms of EU-wide application and including urban and non-urban situations combined.

Figure 10 Results of calculations for road traffic noise scenarios

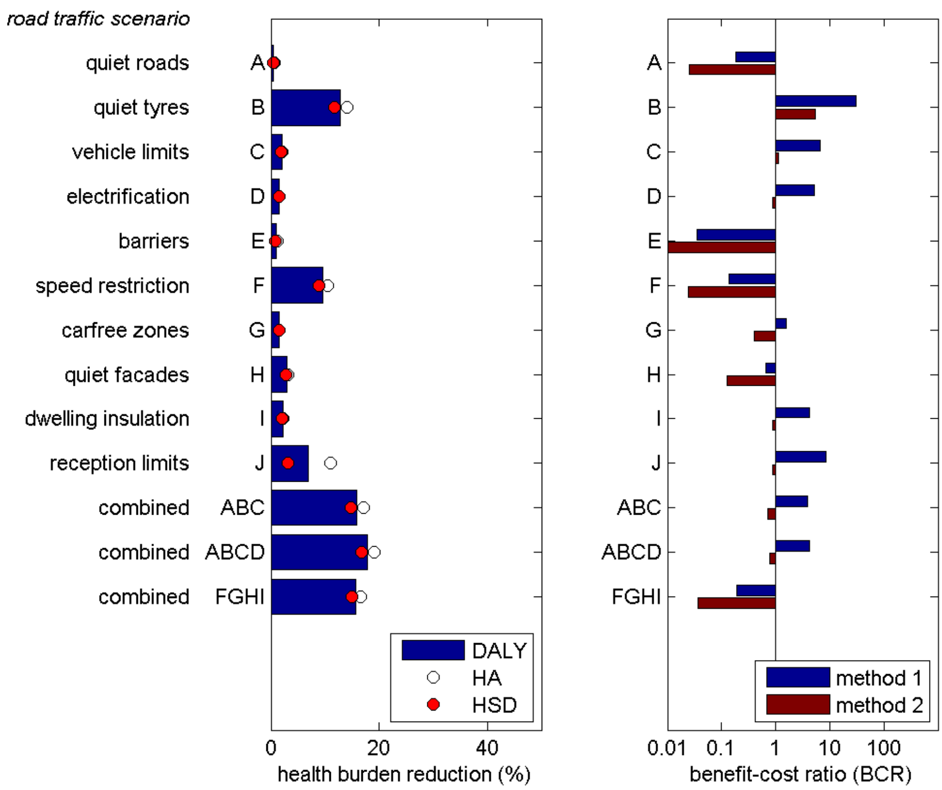


Figure 11 Results of calculations for railway noise scenarios

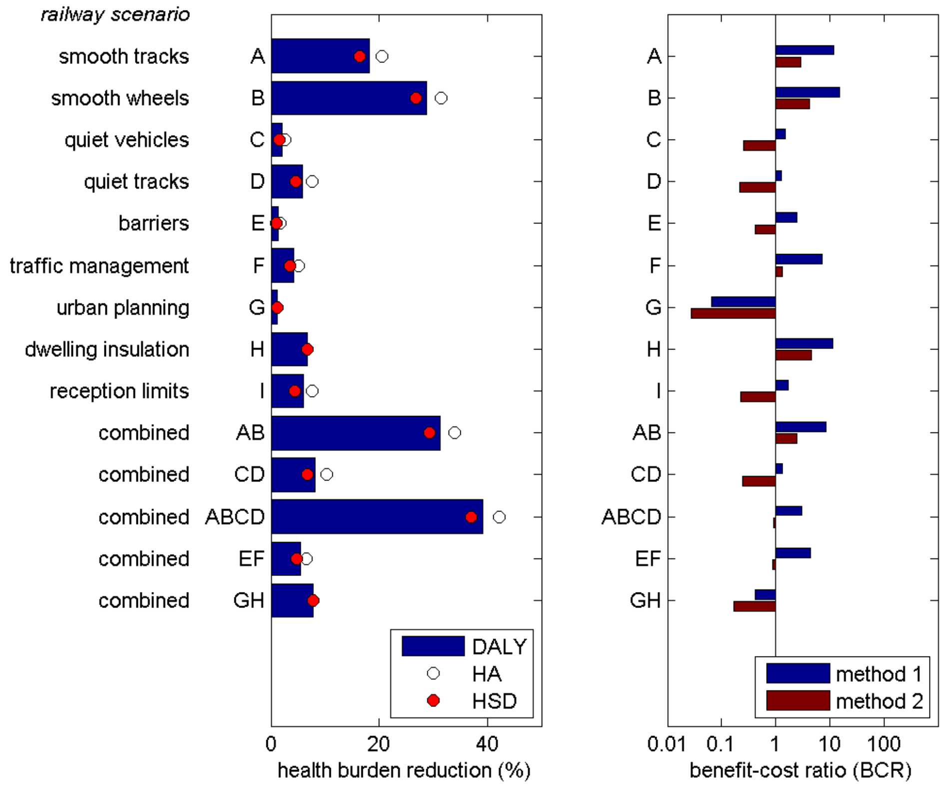
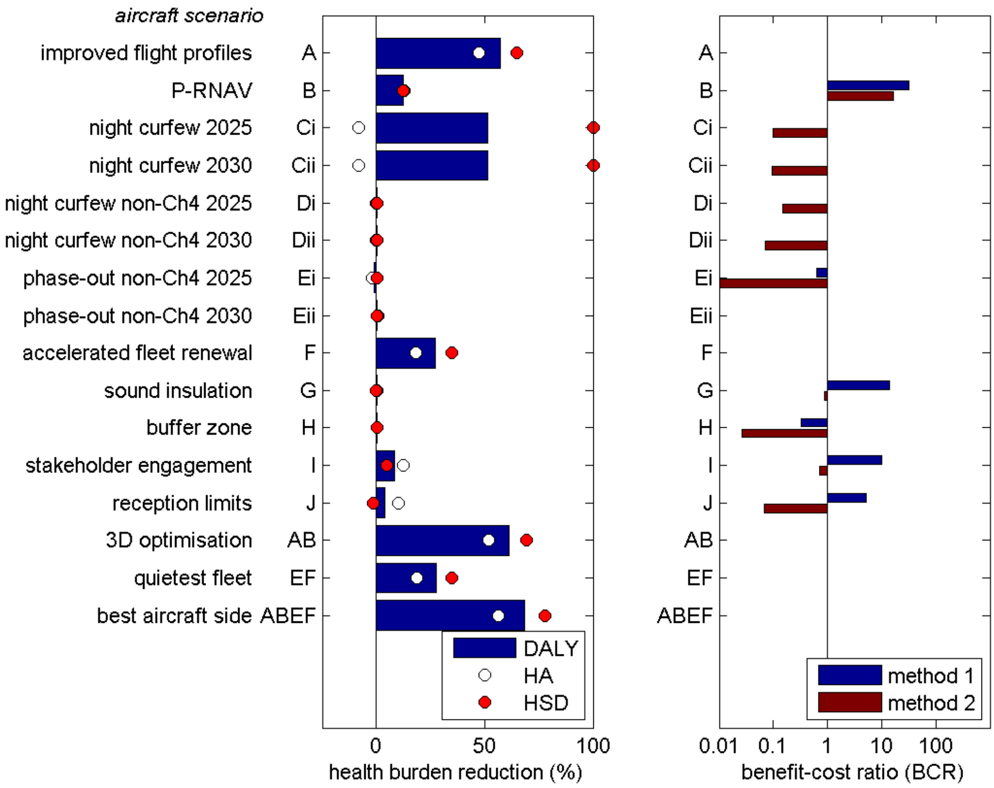


Figure 12 Results of calculations for aircraft noise scenarios



1.3 Questions for the workshop

During the workshop, your feedback is sought on the following questions

For each transport mode:

- What measures would be most useful for improving cross-border co-operations for noise solutions?
- The Structural Funds mechanism gives an opportunity for each member state to define the areas most in need of EU financial support. Considerable segment of this support goes for infrastructural and transport development. Would collaborative/knowledge sharing platforms be beneficial so that stakeholders from other member states can have a view of the planned noise solutions particularly the technological or operational improvements?
- At what level is knowledge sharing most beneficial: local – regional or national?
- Would the introduction of new indicators be helpful for reduction of real-world noise levels?
- What are the most suitable policy options enhancing the reduction of noise disturbance for rail, road, and airports?

2 Results

The results of the first and second interim report of the Phenomena project are summarised below.

2.1 Noise legislation, drivers, and implementation

2.1.1 Literature and NAP review

A comprehensive desk-based and legislative research was carried out to assess the current policy and technical environment related to noise solutions. More specifically, the aim of the desk-based research is to provide information on the current level of progress, ambitions, and challenges regarding the implementation of noise abatement measures in member states. It is composed of the following main elements:

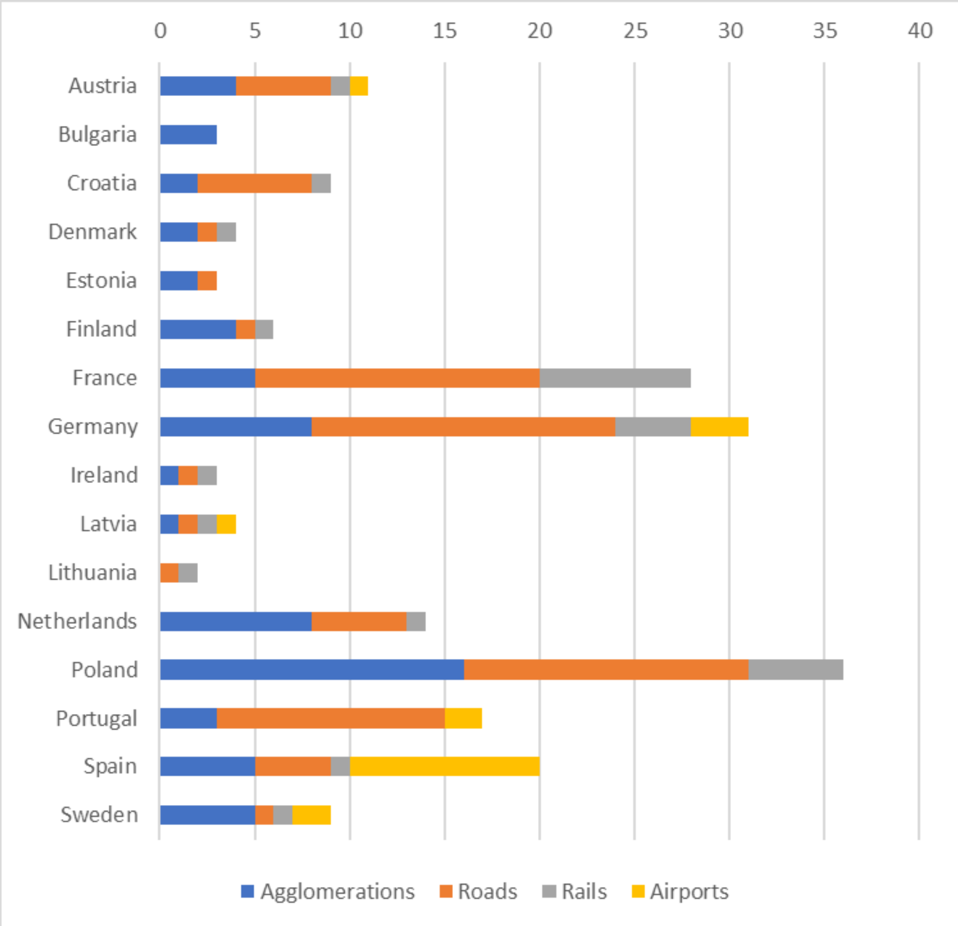
- Overview of relevant EU and national level legislation (including action plans and legislation on noise at source);
- Assessment of the level of implementation (compliance and benefits) of relevant member states and EU level policies; and
- Identification and analysis of noise solutions.

Selected NAPs for general review

200 noise action plan (NAPs) summaries[2] were analysed from 16 member states, namely: Austria, Bulgaria, Croatia, Denmark, Estonia, Finland, France, Germany, Ireland, Latvia, Lithuania, Netherlands, Poland, Portugal, Spain and Sweden. These noise action plan summaries cover agglomerations, roads, railways and airports. The aim of this general analysis was to identify whether there were any interventions resulting from the noise action plans and if so, what type of interventions these were. An overview of the action plan analysis per type of transport mode and country is shown in the following graph.

[2] Delivered in Reportnet, which is Eionet's infrastructure for supporting and improving data and information flows. https://www.eionet.europa.eu/reportnet

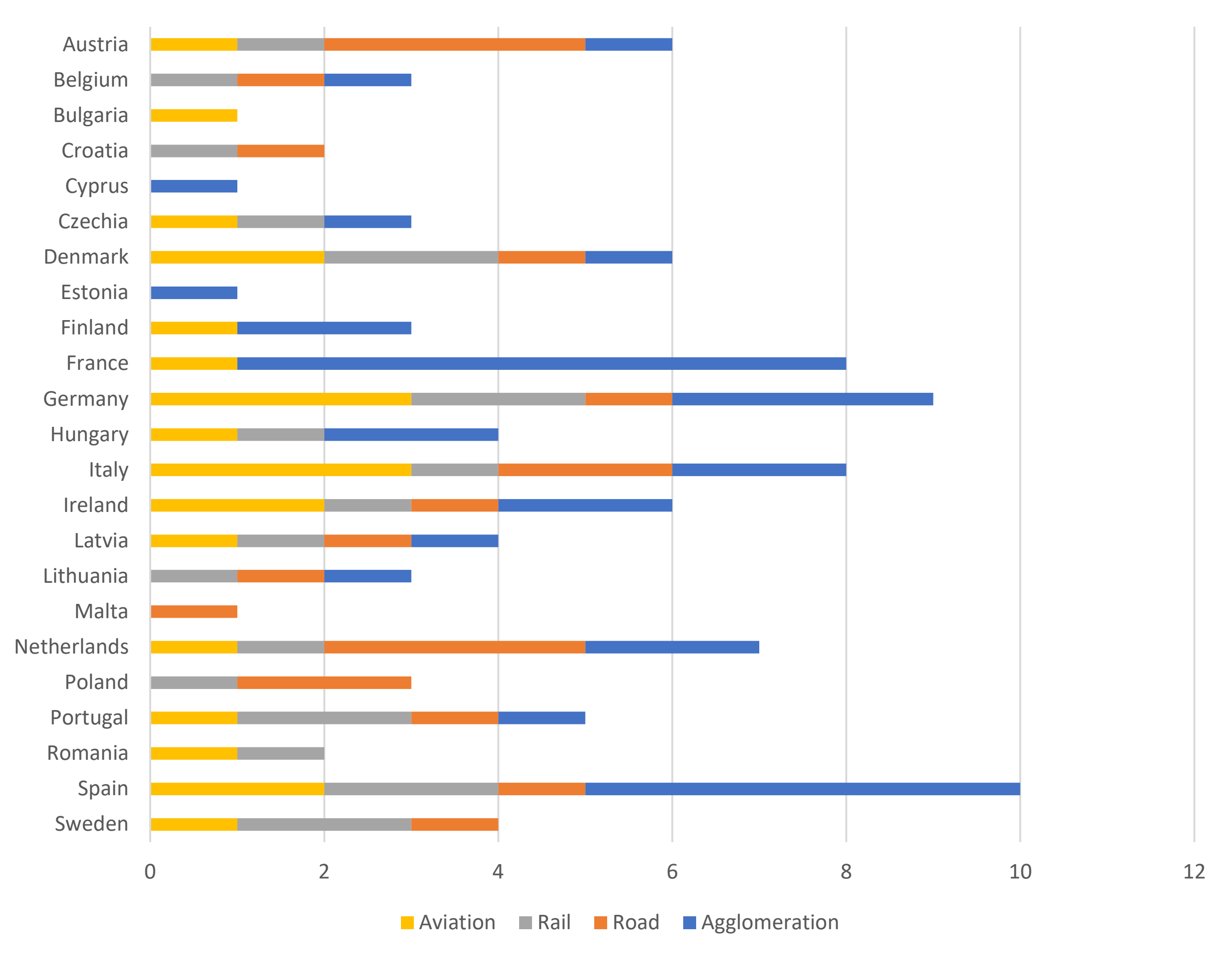
Figure 13 Selected NAPs for general review by country and noise source



Selected NAPs for in-depth review

Further to the general analysis, we have also completed an in-depth analysis of a total of 100 noise action plans from Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Hungary, Italy, Ireland, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Spain and Sweden. Since the first workshop on 18th June 2020, the in-depth analysis has focused particularly on noise action plans from Austria, Bulgaria, Croatia, Cyprus, Denmark, Estonia, France, Germany, Hungary, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Spain and Sweden.

Figure 14 Selected NAPs for in-depth review by country and noise source



2.1.2 Legislative drivers

The analysis examined the causal links that exist between EU and national legislation, as well as the number and types of noise solutions that have been implemented. Hence, the study sought to define:

- how legislation drives the implementation of noise solutions,
- how successful these measures are in terms of reaching their objectives (reducing noise, reducing the number of people who are exposed to higher noise pollution etc.)

This assessment is built on the findings of the literature review, stakeholder interviews and the analysis of the noise action plans.

Results

The in-depth assessment of specific action plans indicated that the implementation of the END had a significant impact on EU-wide legislative framework and provided relevant drivers for:

- the implementation of regional and national level initiatives;
- providing transparency on the implementation and efficiency of previous measures;
- allowing for feedback from the public and interested stakeholders;
- creating a platform for comparative analysis specifically as it refers to:

- identification of best practices;
- cross-border initiatives.

Due to the complexities of the sources, distribution and impact of various noise levels, the study has shown that it is imperative that legislative measures remain flexible enough to accommodate regional specificities of climate and weather as well as urban development trends, innovation and cost effectiveness of measures. The literature points out that within the relatively wide concept of urban development trends, specific attention must be paid to socio-economic issues such as housing and poverty to avoid a disproportional impact of noise pollution on low-income households or marginalised communities. Examples have shown that transport infrastructure operators alone have a relatively limited toolkit to counterbalance larger socio-economic trends. These may include the acquisition of dwellings or banning/limiting the number of housing developments in the vicinity of high noise areas. A less frequently used action was communication and dissemination of information particularly one that focuses on the health impacts of noise pollution not only on the level of noise. To facilitate wider outreach and communication with citizens highlighting health implications of noise exposure, a number of stakeholders must cooperate including the transport operators/managers, local and national authorities as well as NGOs and public health representatives. In addition to education and dissemination campaigns collaboration/consultation between these stakeholders could support urban planning and smart city initiatives targeting sustainable environments.

Additionally, no indication was found (in the selection of NAPs reviewed) that infrastructure relocation would be among the considered options for reduction of noise at source. Limiting traffic at certain times or on specific section of roads, rail or airways is used among the solutions however complete relocation of the noise source infrastructure (airport, railway, road) was not recommended in the reviewed NAPs. This is largely due to the associated financial costs of such a move. Instead attention was paid to reduce noise at the receiver via new insulation, urban planning, introducing quiet areas etc.

As mentioned above, flexibility of implementation is important to allow for the development of specific noise solutions adapted to the needs of the given region; however also it can lead to differences in implementation. These differences may be a result of different strategies related to the development of certain area, however, some stakeholder interviews identified challenges related to the financing of noise solutions due to a requirement on co-financing of these investments. Bridging the financing gap is a national and/or regional decision which is often determined by long-term strategic priorities. One possible way to bridge the financing gap and highlight the importance of noise solution measures is to underline the linkage between public health and noise exposure specific to the region or urban area in question. It will result in combining of other benefits to the actions undertaken besides the noise.

2.1.3 Intervention logic

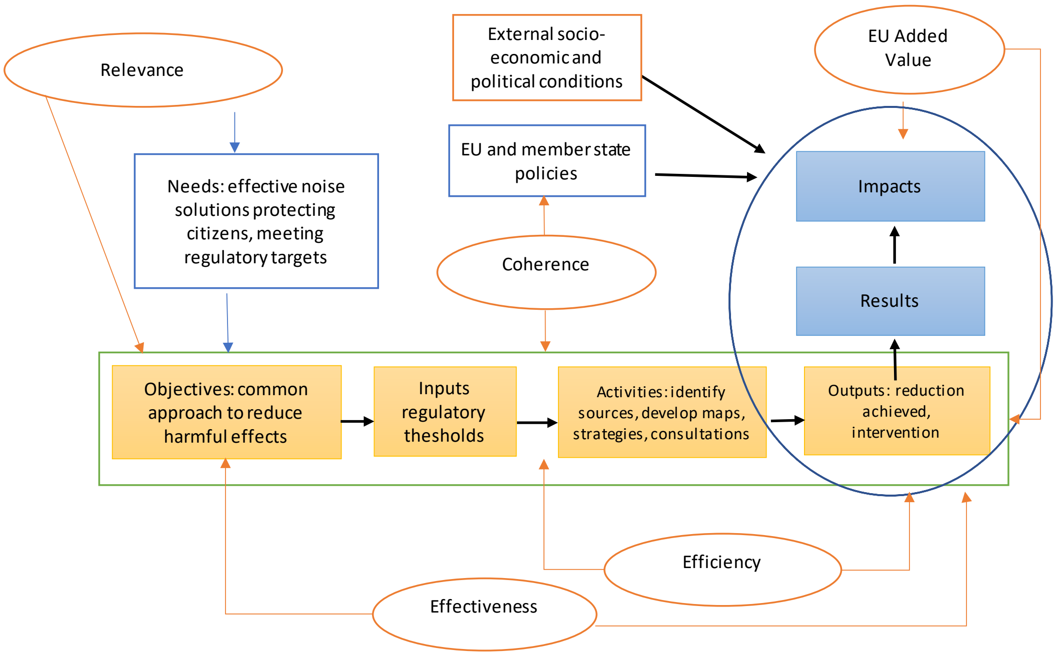
The methodological approach for the intervention logic presented below follows the general principle that the European Commission uses when preparing new initiatives, proposals and when managing and evaluating legislation. This approach is defined in the European Commission's Better Regulation Guidelines.[3] The study aims to identify to what extent the existing legislative drivers serve the implementation of noise abatement solutions. In doing so, both the cases in which all legislation is fully implemented and enforced as well as the cases in which the legislation is failing to be respected are considered. To this aim, at the preliminary stage of the project, the study team designed a baseline Intervention Logic to provide a context and narrative highlighting the objectives

[3] https://ec.europa.eu/info/law/law-making-process/planning-and-proposing-law/better-regulation-why-and-how/better-regulation-guidelines-and-toolbox_en

of the relevant policies and their outputs/impacts. The objective of the intervention logic is to illustrate how the intervention was expected to work (chain of events that should lead to the intended change). An intervention should be understood as a legislative context behind the solution to a problem, which is noise pollution under the present study. The current intervention logic visualises the different steps, action and actors involved in the intervention, as well as their interdependencies. It demonstrates the cause and effect of these relationships and how both actors and actions were expected to interact to deliver the planned changes over a given lap of time to achieve the objective of the EU intervention behind. A view of the current intervention logic is presented in the figure below. The baseline reflects the situation at the time when the intervention was designed. The elements of the figure represent the following

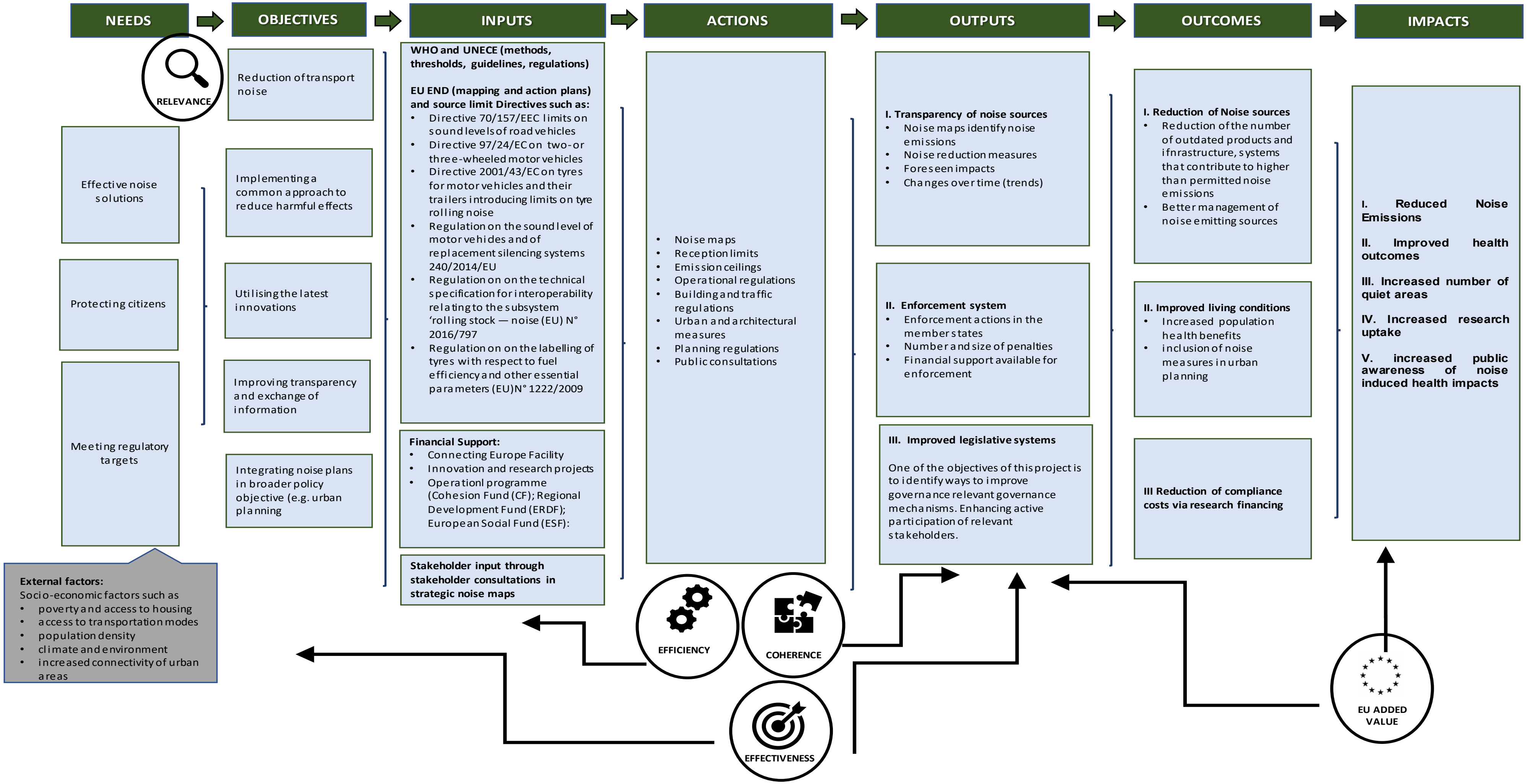
- Arrows: the causal assumption/relationships between the boxes;
- Needs: needs that triggered the EU intervention;
- Objectives: 'a desired situation' that was supposed to be achieved;
- Inputs: inputs that are supposed to be used to achieve the defined objectives;
- Activities: events that were planned to happen;
- Outputs, results and impacts: consideration of changes over times that were supposed to happen and are presented in the expected order of activities;
- External factors: factors that could influence the performance of the initial EU intervention;
- Other EU policies: other actions/intervention undertaken at the same time at the EU level.

Figure 15 Current intervention logic of the current legislative environment



For the purpose of comparison, a revised version of the above figure can be found on the subsequent page. Input into the development of the revised intervention logic was delivered from the literature review, analysis of the NAPs as well as the interviews. The revised intervention logic aims to present how the regulatory environment could be improved in order to facilitate more efficient implementation of noise solution in such a way as to deliver a 20-50% reduction of noise-induced health burden. It depicts the result of the assessment of the relevant policies as viewed at this interim stage. The scheme is not an illustration of the functioning of the END but rather an amalgamation of the relevant EU- and national level policies.

Figure 16 Revised intervention logic



The revised intervention logic works with a more defined objective for reducing the health burden, which is met by using common noise thresholds that take into consideration socio-economic characteristics. Corresponding noise solutions reflect the inputs and focus on compliance with thresholds, innovation and collaboration. The output and results of this intervention scheme are defined by the efficiency of noise solutions and their overall impacts revert back to the objective of reducing health burdens.

2.1.4 Preliminary conclusions

Based on the overall analysis of the different NAPs and stakeholder consultations, the following conclusions and recommendations can be drawn:

- NAPs are relatively descriptive and comprehensive, providing information on the planned measures, the results from the noise mapping, public consultations, and other data. Most of them have both a strategic and operational focus.
- Some NAPs also mention a long-term strategy or a cooperation with mobility planning and sustainability considerations. For instance, noise considerations must be taken into account in urban planning or are paired with sustainability and climate actions. The latter would be for example insulation of dwellings both for noise and energy.
- Some NAPs provide reduction targets in terms of people exposed to high noise levels, therefore, providing goals to the NAP for the given timeline. However, it is mostly lacking across the NAPs analysed, as well as evaluation data for the current NAPs. Data on the evaluation of previous NAPs was provided in an uneven way across NAPs.
- Innovative measures are observed in some NAPs, but the majority follow a trend of common solutions.
- Countries that have developed comprehensive NAPs include the Netherlands, Austria, Spain, France.

Furthermore, stakeholder interviews demonstrated that the complexity of noise management relates to the fact that the topic lies at the crossroads of different policy areas (environment, health, transport, urban planning, road safety, construction and product life cycle etc.) and its efficient management requires a broad coordination of policies at the national, local, regional as well as at the EU level. Stakeholders perceive a potential in reaching the END targets by combining noise action plans with air quality plans, road safety measures as well as, broadly speaking, urban planning in the agglomerations. It seems that when measures are taken in other sectorial areas (e.g. air quality, urban planning -green city, traffic safety etc.) their adoption could also mutually benefit noise abatement measures. Considering growing urbanisation, urban planning in particular has an increasing effect on the volume of traffic, vehicle distribution, traffic condition and consequently on noise pollution. A better understanding of the relationship between noise pollution and urban planning would leverage the prevention of noise measures.

Improving the methodology of noise monitoring was also mentioned by stakeholders with a suggestion to use indicators beyond Lden which focus on noise events, their frequency and intensity. Using sensors capable of identifying the responsible noise source was also put forward. Hence, for the above-mentioned reasons intra- and inter-agency cooperation, particularly at the city level, should be further considered. This cooperation could also resolve some of the budgetary challenges that the implementation of noise measures is currently facing. Some of the stakeholders mentioned that urban areas do not have a sufficient and dedicated budget to adopt relevant noise abatement measures. In their view, linking noise measures with other city-related projects could help in perceiving additional funding to implement relevant actions. However, further cooperation between different sectoral areas also requires awareness-raising among the representatives of the relevant department at the national, regional and local level.

Harmonisation and synthetisation of NAPs

The research, NAPs analysis, and stakeholder consultations show that there is no common approach to the creation of NAPs between Member States. While some NAPs are very detailed and comprehensive, others lack important data. The section on the limitations of the research above outlined commonalities among the NAPs, however, it can be concluded overall that the countries approach the developments of NAPs differently, focusing on different priorities. Therefore, it is important to highlight that the creation of NAPs should be more harmonised and synthesised to provide better guidance to Member States.

Monitoring of NAP implementation

The stakeholder interviews offered the insight that there is a lack of control over the implementation of NAPs. This included a lack of mandatory rules and obligations to implement the planned noise solutions. Assessing the implementation rate of previous NAPs could not be carried out as this information was missing in the NAPs reviewed.

Common guidelines and good practices

Furthermore, insight gained from the research shows that there is a lack of shared knowledge of best practices. For agglomerations, the share of good practices happens through European organisations (Eurocities, etc). Stakeholders, also, indicated a lack of common guidelines to NAP drafting. This lack of guidelines could also be highlighted regarding the evaluation of previous measures. Thus, the process of developing and implementing NAPs could be improved by ensuring a common understanding of best practices among Member States.

2.2 The potential of EU policies to deliver better results on the implementation of noise solutions

2.2.1 Overview

At the EU level, noise policy is composed of both EU and national elements. For instance, END introduced an integrative management of environmental noise in the EU, which established several actions to be applied across the EU member states, such as monitoring of environmental noise via strategic noise mapping, managing environmental noise issues by drawing up national action plans, enhancing public information and consultation of strategic noise-related documents, and developing of a long-term EU strategy towards noise.

However, END cannot be perceived as a complete, stand-alone regulatory framework on environmental noise. It needs to be complemented with EU transport regulations (vehicles, tyres, TSI, 'balanced approach' etc.) for road, rail and aviation sectors and national laws on noise limit values. To this aim, at the EU level, there is a strong corpus of sectorial legislation regulating vehicles noise limits, tyres' limits, rolling stock noise and noise-related operating restrictions at airports. Especially, Regulation (EU) No 598/2014 provides rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced approach. In addition, these EU-wide measures are also supplemented by associated relevant legislation at the national level such as noise reception limits.

Nevertheless, it should be pointed out that according to the environmental integration principle included in Art. 11 of the Treaty on the Functioning of the EU, 'environmental protection requirements must be integrated into the definition and implementation of the Union policies and activities, in particular with a view to promoting sustainable development.' Therefore, there are other key policy instruments at the EU level that could further take into consideration the environmental protection encompassing the noise solutions. These are numerous and include both directives (e.g. Public Procurement Directive, Outdoor Equipment Directive, Air Quality Framework Directive etc.) as well broader policy initiatives that should guide the EU activities in a long-term planning (e.g. Green Deal, 7th Environmental Action Programme etc.). Thus, the noise policy in the EU interacts in a broader context with climate targets (e.g. electrification and energy transition), energy savings (building insulation), vehicles and traffic safety, mobility and modal shift, market surveillance, infrastructure charging, procurement (fleets, infrastructure, urban planning and construction). Hence, noise solutions should be seen as a part of environmental protection and, therefore, be further integrated into a wide range of EU and national policy areas. This would add a more holistic dimension to the implementation of the noise solutions, which likely would be reflected in their more effective implementation across the EU.

2.2.2 Road surface improvements

Examining the relevant policy instruments that relate to road works, we find that the management of road surfaces is the prerogative of national governments, which includes road development investments and the incorporation of innovative solutions. Although a prerogative of national governments, competences on road surface improvements are often delegated to regional and local authorities. Consequently, the effective implementation of these measures goes hand in hand with the available sources of financing at the disposal of relevant actors. Relevant European-level policy instruments refer primarily to safety related issues of road infrastructure such as the **Road Surface Quality Directive** 2008/96/EC[4] which focuses on the establishment of road safety impact assessments and road audits.

As the analysis of planned noise solutions had shown, member states do rely on road surface improvements as a primary noise solution measure resulting perhaps from the fact that noise reduction can easily be integrated into regular road maintenance works. Consequently, in this area the emphasis of future policy development should rely on **exchange of good practices, cross-border collaborations, EU-wide joint innovation projects and availability of financial sources at the EU (funding), national and local level**.

Furthermore, monitoring and mapping of road surface quality is very important, especially in noise sensitive locations. The results of the monitoring can be reflected in the maintenance needs for less maintained roads in urban situations and for busy main roads and motorways with quiet surfaces near dwellings

2.2.3 Vehicle and tyre noise limits

Vehicle specific noise emissions are governed by the Regulation on the **sound level of motor vehicles**, 540/2014/EU, which sets limits for all passenger and freight vehicles (M and N categories). These limits are for specific conditions and do not guarantee low noise levels for the whole range of driving conditions.

Stakeholder feedback received during bilateral interviews and the project workshop, confirmed the benefits of the Directive's provisions stemming from requirements for strategic noise mapping and noise limiting thresholds. Nonetheless some areas of improvement have also been identified and these relate primarily to further **clarifying the content of the noise action plans** including information on the effectiveness of previously implemented solutions.

[4] Directive 2008/96/EC of the European Parliament and of the Council of 19 November 2008 on road infrastructure safety management https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32008L0096

The research has demonstrated that there is room for targeted limit tightening to affect not only Lden but also Lmax limits. Furthermore, in synergy with the Green deal propulsion noise should be reduced and in doing so, it could go beyond the simple electrification of vehicles fleet.

Tyre noise is significant, and its reduction can be very effective across the EU, taking into account that the tyre lifespan is about 4 years. Given that the replacement of tyres for whole fleet seems to be easily achievable, there seems to be room for further noise reduction by tightening tyre noise limits based on label statistics. Noise emission limits for new tyres are set by UN Regulation N°117, referred to by EU Regulation 2019/2144. Tyre labelling including the noise level is regulated in 1222/2009/EU. As part of this Regulation manufacturers are obliged to consider introducing certificates of conformity and prevent sales of tyres that do not meet the minimum standards put forth by the legislation. In its Annex I, the Regulation 1222/2009 identifies **rolling noise emission limits** for newly manufactured tires and one potential way to facilitate vehicle noise emission could be the **review of these limits**. In fact, keeping in line with the fast pace of vehicle innovations, tyre rolling noise emission limits could be reviewed regularly **every 3 years** to allow for adjustments.

2.2.4 Railway infrastructure interventions

Within rail infrastructure interventions, rail surface improvements and wheel maintenance for low roughness are key considerations. Railway lines are often part of strategic national infrastructure and their maintenance is overseen by member state authorities. Relevant legislative elements pertaining to noise emissions of railways includes Directive 2012/34[5] on the Single European Railway Area and its implementing Regulation 2015/429[6]. A review of this implementing Regulation could help identify whether further changes to the current noise charging scheme would be required in order to deliver better results in member states. Furthermore, an **analysis into the relevant financing schemes** including the Connecting Europe Facility, Structural and Cohesion Funds could help identify the **efficacy** of the current support mechanisms.

An additional element for consideration is the **acceptance of low noise barriers close to railway tracks, overcoming safety issues**. This may be more cost-effective than normal barriers in some situations, without visual obstruction. There is a large variety of sound insulation barriers including steel, aluminium or mineral fibre. Their roll-out and development is a member state or operator competence. Selection of the routes, where these barriers may be developed, is largely dependent on the traffic and the state of the rolling stock. The cost of developing these sound insulating barriers may be weighed against the costs rail operators would be levied under the noise charging scheme as contained in Regulation 2015/429. It is not evident whether further European legislation specifically focusing on noise barriers would be necessary provided that current efforts for reducing rolling stock noise are effective.

2.2.5 Rail: rolling stock

On the member state level, as identified by the 2018 impact assessment[7] of the TSI, the share of silent wagons and braking systems varies considerably between member states, and consequently, the mitigation actions of the countries are also in stark contrast. According to the report Germany and Switzerland planned to **restrict operation of noisy wagons** from 2020. While these measures

[5] Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32012L0034

[6] Commission Implementing Regulation (EU) 2015/429 of 13 March 2015 setting out the modalities to be followed for the application of the charging for the cost of noise effects https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R0429

[7] European Union Agency for Railways, 2018 Revision of the Noise TSI - Application of NOI TSI requirements to existing freight wagons https://www.era.europa.eu/sites/default/files/library/docs/recommendation/006rec1072_full_impact_assessment_en.pdf

can provide a timely response to noise pollution, exchange of information among member states can be useful to **avoid obstacles against free movement of goods**. Further **coordinated roll-out** of such operating restrictions could be organized through a European platform of competent authorities. Further support to innovative approaches for silent brake technology could be delivered through EU research financing such as Horizon Europe or the Connecting Europe Facility.

Various legal instruments to reduce the number of cast-iron block-braked wagons are already in place. But the quality of the wheel surface also depends on wear and tear and maintenance. Additional provisions to minimise wheel flats would yield additional benefits, either by specifying on-board monitoring systems or maintenance procedures. This could be part of the TSI or separate guidelines. Current modern rolling stock, in particular EMUs, often has quieter (well damped or smaller) wheels resulting in noise levels well below TSI limits. Even on rougher tracks, such vehicles produce less noise than the previous generations. This trend could be reflected in future TSI noise limits. Therefore, there is a room to tighten limits on noise levels of modern EMUs and other rolling stock.

For freight wagons, further progress beyond the retrofit principle is feasible. Freight wagons are more susceptible to reduced maintenance and will of course produce higher noise levels on tracks with rough rails. Design improvements on wheels, bogies, suspension and superstructure should allow further reduction in future both on new wagons and potentially also existing ones. The high axle density, different bogies and wagon structure offers room for improvement, which also could be encouraged through the TSI or other instruments. Hence, there is a scope for better management of wheel and rail roughness, which can be achieved by mapping the quality of rail surfaces and monitoring wheel noise.

In addition, more consideration should be given to various aspects of noise disturbance as a pre-requirement when new tracks are developed and track replacement is performed (e.g. pads or added-on devices).

2.2.6 Air traffic management

The **current regulatory requirements** coupled with the airport outreach and communication initiatives seem to provide the necessary coverage to ensure compliance. Nevertheless, further stakeholder engagement between the airports and the public should be sought.

Considerations could be given to incorporate noise emission constraints into the **EU Slot Regulation**. In its current form the Regulation does contain reference (Article 3) to environmental factors relating to airport capacity analysis which shall take into consideration environmental constraints. It may be useful to assess whether further references could be made to noise emission limits during specific times (morning or evening).

According to the stakeholders interviewed, the reduction of noise sources stemming from international legislation is the best long-term solution for eliminating environmental noise. However, in the short term, the most efficient measures are the change of flight routes, night flight bans and the implementation of the ‘’polluter pays’’ principle for early morning/late evening flights. For instance, the introduction of Lmax reception limits at night could be considered a solution to avoid noisy flight operation. In addition, land use planning should be seen as another important tool, which use could be further improved to avoid urban encroachment around the airports. For instance, the impact of green belts around the airports have been constantly ignored. Thus, the noise consideration should be taken into account at the very early stage of planning of airports location, development of urban planning around the airports, and land use management of their surroundings.

Also, the research has demonstrated that the current set of legislation (END and BAR) setting out the obligation of noise reduction at airports is not sufficient. The scope of both legislative frameworks should be, ideally, broadened to smaller airports (<50.000 mov), since many of those experience significant growth.

On the member state level environmental taxation is also a frequently cited instrument to facilitate compliance of airlines and aircraft operators. **Taxation** is a member state competence and even though discussions on the introduction of a possible EU-level **green tax** have been on-going there is no indication that this would become reality by 2030. Despite the lack of EU-wide approach, member states can work together to share good practices and coordinate approaches to improve harmonisation and avoid fragmentation of the internal market.

2.2.7 Aircraft Innovation

Although there is no room at the EU level of tightening vehicles limited as it falls under ICAO competence at the global level, one of the most promising angles for reducing aviation noise is innovation. Research and innovation into low-noise aircrafts have delivered significant benefits. Current research focuses not only on the reduction of jet engine noise but also on **friction and turbulence noise** (airframe or aerodynamic noise).

As the industry continues to develop, despite its current setbacks as a result of the COVID-19 epidemic, further incentives could be provided via international research platforms under the umbrella of ICAO or Horizon Europe. Moreover, the renewal or replacement of the EU fleet with quitter aircrafts could be encouraged via incentives or non-addition/non-operation rules. Non-addition rules prohibit additional movements or operations in general, or from a specific type of aircraft. Non-operation rules ban the operation of aircrafts based on environmental considerations.

In addition, the feedback received from interviews has shown that the issues of noise and air traffic pollution should be addressed conjointly while looking for environmental solutions. There should not be a 'trade-off' between the choices of allowing either more CO2 emissions or more noise. It is crucial that R&D on 'source polluters' (aircraft manufacturers) finds optimal solutions for a comprehensive environmental footprint.

Finally, the reduction of different transport noise could be further achieved by monitoring other indicators than Lden. Suggestions included monitoring the frequency and intensity of noise events, particularly relevant for aviation and rail.

2.3 Road traffic noise: scenarios

For the road traffic noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Reduced vehicle noise emission and electrification
    - Modelled by changing the percentages of compliance with six different vehicle emission limits, per vehicle type.
- Reduced tyre noise
    - Modelled by reducing the tyre label per vehicle type
- More quiet road surfaces
    - Modelled by increasing the percentages of road lengths with quiet surface.
- More noise barriers
    - Modelled by increasing the percentages of road lengths with noise barriers.
- Vehicle speed reduction

    - Modelled by reducing the speeds per road type and per vehicle type.
- Vehicle access restrictions, car-free zones, rerouting
    - Modelled by changing the noise exposure distributions.
- Quiet facades
    - Modelled by changing the noise exposure distributions.
- Dwelling insulation
    - Modelled by changing the noise exposure distributions.

Vehicle access restrictions, car-free zones, and rerouting may be part of an *urban planning* scenario of a city. Such a scenario may also include more expensive solutions such as tunnelling or the construction of office buildings that shield dwellings from traffic noise.

In addition to the above physical noise solutions, scenarios with reception limits are also considered. Reception limits should be considered as triggers for physical solutions, and the effects of reception limits represent the *potential* effects of scenarios with noise solutions.

Scenarios with a single noise solution

Scenario A is an increase of quiet road surface. The end situation in 2035 is: 22.5% of roads of types 5-8[8] have a quiet road surface. For intermediate years, linear interpolation is applied. This means that for year 2030 the percentage is 15%, which is three times higher than the baseline percentage of 5%. The costs are 3 Euro per m^2 for implementation and 0.4 Euro per m^2 for annual maintenance; the area was calculated from the road lengths assuming an average road width of 20 m.

Scenario B is a reduction of the tyre noise levels, according to the tyre label, by 3-5 dB. Since the lifetime of tyres is about four years, the end situation with quieter tyres is reached in 2024, again with linear interpolation for the intermediate years. After 2024, the situation remains constant with quiet tyres. The costs are 300 million Euro per year.

Scenario C represents a faster compliance with new vehicle emission limits. For example, the percentage of vehicles complying with the newest vehicle limits of 2024/2026 is chosen three to four times higher than in the baseline scenario. For this scenario the percentages of hybrid and electric vehicles are kept at the baseline values. The costs are 190 million Euro per year.

Scenario D is enhanced electrification, with a higher percentage of hybrid and electric vehicles in 2035. The percentages of the other four vehicle groups are decreased, as the sum remains 100%. For the costs, the same 190 million Euro per year is used as for quieter vehicles.

Scenario E is an increase of noise barriers along roads of types 5-8. In 2035 12.5% of these roads have noise barriers, which is a factor of 2.5 higher than the baseline value of 5%. For the costs, an average barrier height of 5 m is used, which yields 2.5 million Euros per km of barrier.

Scenario F is a reduction of vehicle speeds in all urban areas. For intermediate years, linear interpolation is applied, as an approximation for the gradual introduction of speed reductions. The costs are calculated from the average value of 9 Euro per person per hour, for the 'value of time'.

Scenario G is the introduction of new car-free zones in urban areas, by means of vehicle access restrictions and traffic rerouting. It is assumed that the new car-free zones in 2035 cover 2.5% of the total urban area of END cities (i.e. cities reporting END noise maps). For the costs, 1 million Euros per km^2 is used for implementation and 0.2 million Euro per km^2 for maintenance.

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[8] Road type 5 = urban arterial road, type 6 = urban motorway, type 7 = non-urban motorway, type 8 = non-urban main road.

Note. Scenario G can also be interpreted as an urban planning / reconstruction scenario, where a 2.5% reduced noise exposure is achieved by urban planning solutions such as tunnelling and screening of dwellings by new office buildings. The costs of such urban planning solutions, however, are much higher than the costs of the traffic measures in scenario G (by a factor of 10 to 100), This should be taken into account when considering the results of the cost-benefit analysis.

Scenario H is the creation of quiet facades for 30% of the dwellings in urban area, which are assumed to have no quiet façade in 2020. A quiet façade is defined as a façade where the L_{den} level is low, for example 10 dB lower than the level at the most-exposed façade, or simply lower than 48 dB (this definition is used in Dutch cities such as Amsterdam). The effect of a quiet façade is modelled as a reduction of 2 dB of the L_{den} and L_{night} levels at the most-exposed façade[9]. The creation of quiet facades requires traffic measures such as rerouting. It is assumed to the 30% of dwellings with a quiet façade is achieved by traffic measures equivalent to measures required for car-free zones covering 15% of the total urban area.

Scenario I is an increase of dwellings with façade insulation. It is assumed that the percentage of dwellings with façade insulation, along roads of types 5-8, is increased by 10% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings can be neglected, so these dwellings are eliminated from the exposure distributions. The costs are 1000 Euro per dwelling.

Scenario J is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated above, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from 'no limits' to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario an annual cost of 1 billion Euro was assumed. This value was derived by looking at the costs for scenario A (quiet road surface) and scenario G (car-free zones), assuming that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- ABC, combination of A, B, and C,
- ABCD, combination of A, B, C, and D,
- FGHI, combination of F, G, H, and I.

Scenario ABC is a combination of scenario A (quiet roads), scenario B (quiet tyres), and scenario C (vehicle limits). It is expected that this combination will have a larger effect than the single solutions separately. The three single solutions are independent of each other in the model, so the combination is straightforward. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

In combined scenario ABCD, electrification (scenario D) is also included. For the combination of scenario C (vehicle limits) and scenario D (electrification), the fleet percentages for the six limits in 2035 are changed as follows.

[9] QSIDE project, www.qside.se.

- cars: from 15/15/30/10/9/21% (baseline) to 0/0/18/32/19/31%.
- vans: from 15/15/35/14/9/12% (baseline) to 0/0/22/37/19/22%.
- buses: from 15/15/25/7.5/10.5/27% (baseline) to 0/0/12/30.5/20.5/37%.
- lorries: from 15/20/30/9.5/24/1.5% (baseline) to 0/0/22.5/32/34/11.5%.
- heavy trucks: from 15/20/30/9.5/24/1.5 (baseline) to 0/0/22.5/30/34/11.5%.

For the costs, the same value is assumed as for scenario ABC, as the costs for scenario C may be partly used for electrification instead of compliance with vehicle limits.

Scenario FGHI is a combination of scenario F (speed restriction), scenario G (car-free zones), scenario H (quiet façade), and scenario I (dwelling insulation). This combination is also expected to have a larger effect than the single solutions separately. The four single solutions are independent of each other in the model, so the combination is straightforward. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios. Calculation results for the combined scenarios are also presented in the next section.

2.4 Road traffic noise: results

Scenarios with a single noise solution

Scenario B (quiet tyres) yields the largest reduction of the health burden. This scenario also has a high benefit-cost ratio, as the costs of quieter tyres are limited. The health reduction for scenario A (quiet roads) is smaller, as the percentage of roads with a quiet surface is assumed to remain limited. The effects of quieter vehicles in scenarios C and D are relatively small, mainly due to the definition of the baseline scenario with 14-25% hybrid and electric vehicles in 2030. For the same reason, the effect of electrification (scenario D) is small. It affects only the powertrain noise, while rolling noise dominates, except at low speed. The effect of barriers (scenario E) is small, as the percentage of roads with a barrier is assumed to remain limited. The benefit-cost ratio for scenario E is very small, because the costs of noise barriers are high. The effect of speed restriction in urban area (scenario F) is large, where it should be noted that the speed restriction is applied to all urban areas, which is rather ambitious. The effect of vehicle access restrictions and car-free zones (scenario G) is small, as it is assumed that this can be achieved in a limited percentage (2.5%) of the urban areas in the EU. The effects of quiet facades (scenario H) and dwelling insulation (scenario I) are small.

The results of scenario J (reception limits) show the effect of decreasing all levels above the limit to the limit. The fact that the health burden reduction is not very large implies that a large part of the health burden is caused by noise levels below the limits (60 dB L_{den} and 55 dB L_{night}).

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the single-solution scenarios. The reductions for the combined scenarios are in the range 15-22%. The difference between the reductions for scenarios ABC and ABCD is small.

The benefit-cost ratio for scenarios ABC and ABCD is considerably smaller than the benefit-cost ratio for scenario B. This suggests that there is room for optimization of combined scenarios such as ABC and ABCD. The benefit-cost ratio for scenario FGHI is small.

Figure 17 Results of calculations for road traffic noise scenarios

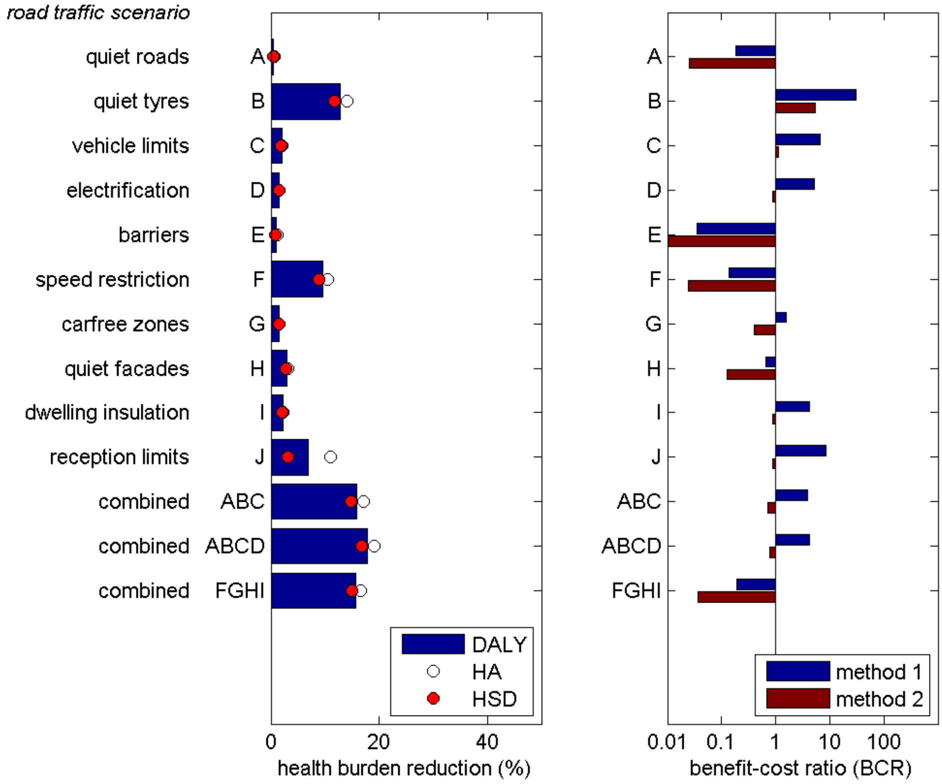


Table 4 Annual EU health burden of road traffic noise in 2030, for the baseline scenario.

	Annual value in 2030
Highly annoyed persons	31.2 million
Highly sleep-disturbed persons	14.6 million
DALYs	1669 thousand
Monetized health burden (method 1 / 2)	58.4 / 14.6 billion Euro

Table 5 Percentage reduction of annual EU health burden of road traffic noise in 2030, relative to the baseline scenario, for single solution scenarios and combined scenarios.

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A quiet roads	0.6	0.4	0.5	1.0 / 0.5
B quiet tyres	14.0	11.8	12.8	17.6 / 12.8
C vehicle limits	2.0	1.9	2.0	2.7 / 1.9
D electrification	1.5	1.5	1.5	2.1 / 1.5
E barriers	1.1	0.8	0.9	1.6 / 0.9
F speed restriction	10.5	8.9	9.6	13.3 / 9.6
G car-free zones	1.5	1.5	1.5	1.5 / 1.5
H quiet facades	3.1	2.8	3.0	3.8 / 2.9
I dwelling insulation	2.3	2.1	2.2	2.6 / 2.2
J reception limits	11.1	3.2	6.9	19.3 / 7.7
ABC combined	17.2	14.8	15.9	21.5 / 15.8

ABCD combined	19.2	16.7	17.9	24.0 / 17.8
FGHI combined	16.6	14.9	15.7	20.0 / 15.7

Table 6 Results of cost-benefit analysis of single solution scenarios and combined scenarios of road traffic noise, for 2020 2035.

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) billion Euro	Break-even year (method 1 / 2)
A quiet roads	0.18 / 0.03	-22.5 / -26.9	- / - *
B quiet tyres	30.3 / 5.5	105.3 / 16.0	2021 / 2021
C vehicle limits	6.7 / 1.2	13.1 / 0.3	2021 / 2034
D electrification	5.2 / 0.9	9.6 / -0.3	2022 / -
E barriers	0.03 / 0.01	-240 / -247	- / -
F speed restriction	0.14 / 0.02	-445 / -504	- / -
G car-free zones	1.6 / 0.4	2.8 / -3.0	2026 / -
H quiet facades	0.7 / 0.13	-9.8 / -26	- / -
I dwelling insulation	4.3 / 0.9	10.9 / -0.4	2023 / -
J reception limits	8.6 / 0.9	91.0 / -1.5	2027 / -
ABC combined	3.9 / 0.7	95.6 / -9.9	2021 / -
ABCD combined	4.3 / 0.7	108.8 / -7.3	2021 / -
FGHI combined	0.2 / 0.04	-448 / -534	- / -

* (not reached in 2020-2035)

2.5 Railway noise: scenarios

For the railway noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Reduced combined wheel-rail roughness
  - Modelled by changing the distribution over the five roughness classes R1-R5.
- Quieter tracks
  - Modelled by changing the distribution over the seven track type classes T1-T7.
- Quieter vehicles
  - Modelled by changing the distribution over the six vehicle type classes V1-V6.
- More noise barriers (low and high barriers)
  - Modelled by increasing the percentages of railway lengths with low and high noise barriers.
- Improved traffic management: alternative routes, mainly for freight.
  - Modelled by changing the numbers of trains on railway lines.
- Noise reduction by urban planning and reconstruction (e.g. tunnelling)
  - Modelled by changing the exposure distributions in urban areas
- Noise reduction by dwelling insulation
  - Modelled by changing the noise exposure distributions.

In addition to the above physical noise solutions, scenarios with reception limits are also considered (in the same way as for road traffic noise).

Scenarios with a single noise solution

Scenario A is an increase of smooth tracks, by means of rail grinding or milling. The end situation in 2035 is specified by the percentages of five roughness classes R1-R5 which deviate from the initial values in 2017-2020 (which remain constant in the baseline scenario). For intermediate years, linear interpolation is applied. The costs are 3000 Euro per km.

Scenario B is an increase of smooth wheels. In 2035 all wheels are composite/disc braked or better, and wheel flat control is applied. The percentages for R1-R5 move towards smoother wheels in 2035. The costs are 250 million Euro per year.

Scenario C is an increase of quiet vehicles. The percentages for vehicle types V1-V6 move towards quieter vehicles in 2035 . The costs are 250 million Euro per year.

Scenario D is an increase of quiet tracks, by means of a) railpads and b) rail dampers and/or rail shielding. The percentages for track types T1-T7 move towards quieter tracks in 2035. For the costs, it is assumed that the quiet tracks are achieved for 50% by railpads (3000 Euro per km) and the other 50% by rail dampers and/or shielding (0.6 million Euro per km).

Scenario E is an increase of noise barriers along railways. In 2035, 3% of the (inhabited) railways have high noise barriers (1.75% in the baseline scenario), and 1% have low noise barriers (0% in the baseline scenario). For the costs, a height of 2.5 m is assumed for high barriers and 1 m for low barriers. This yields 1.25 million Euros per km of high barrier and 0.5 million Euros per km of low barrier.

Scenario F is traffic management that moves freight trains from urban area to nonurban area. The traffic flow values of freight lines 1-4 are adapted accordingly for 2035. For the costs, a fixed 100 million Euro per year is assumed.

Scenario G is urban planning and reconstruction, resulting in 2.5% reduced noise exposure in urban area in 2035. Solutions may include tunnelling, screening by buildings along lines, and integration of noise abatement in buildings. For the implementation costs, 10 million Euro per km^2 is used.

Scenario H is an increase of dwellings with façade insulation. It is assumed that the percentage of dwellings with façade insulation is increased by 10% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings is so much reduced that these dwellings can be eliminated from the exposure distributions. The costs are 1000 Euro per dwelling.

Scenario I is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated previously, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from 'no limits' to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario an annual cost of 1 billion Euro was assumed. This value was derived by looking at the costs for scenario D (quiet tracks), assuming that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- AB, combination of A and B,
- CD, combination of C and D,
- ABCD, combination of A, B, C, and D,

- EF, combination of E and F,
- GH, combination of G and H.

Scenario AB is a combination of scenario A (smooth tracks) and scenario B (smooth wheels). This is a well known recipe for lower noise emission from railways. The low noise emission from trains with disc- or composite block-braked wheels still depends on sufficiently low rail roughness. By controlling this in noise sensitive areas, and also managing the occurrence of wheel flats, lower noise levels can be achieved. The two single solutions are *not* independent of each other in the model, as both affect the combined wheel-rail roughness. The percentages for roughness classes R1-R5 in 2035 are changed as follows:

- from 20/20/20/20/20% (baseline) to 0/5/55/30/10%.

The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario CD is a combination of scenario C (quiet vehicles) and scenario D (quiet tracks). This scenario focuses on the effect of wheel and track design on noise, disregarding the wheel and rail roughness. Examples are: trains with wheel mounted disc brakes or smaller wheels running on tracks with optimised railpads or rail dampers. The two single solutions are independent of each other in the model, so the effect on the noise emission is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario ABCD is a combination of the four scenarios A, B, C, and D. This combination provides the best potential noise reduction at source. For the emission, the model parameters from scenarios AB, C, and D are combined. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario EF is a combination of scenario E (barriers) and scenario F (traffic management). These scenarios are relatively short term and local. The two single solutions are independent of each other in the model, so the effect on the noise emission is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

Scenario GH is a combination of scenario G (urban planning) and scenario H (dwelling insulation). These scenarios are related to urban infrastructure and buildings. The two single solutions are independent of each other in the model, so the effect on the noise levels is a straightforward combination of the two single-solution scenarios. The cost of the combined scenario is equal to the sum of the costs of the single-solution scenarios.

2.6 Railway noise: results

Scenarios with a single noise solution

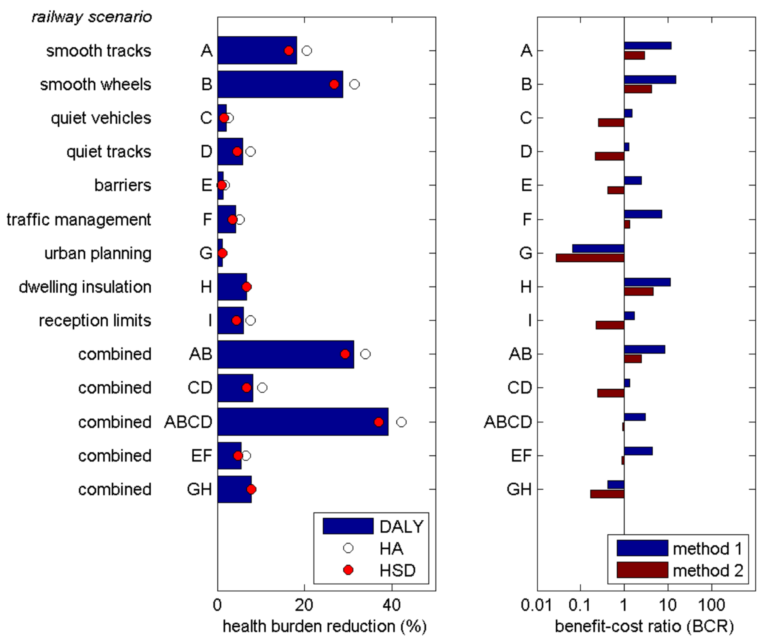
On the average, the calculated health burden reductions are a bit higher for railway noise than for road traffic noise. The largest reduction occurs for scenario B (smooth wheels). The effects for scenario A (smooth tracks) are similar, although a bit smaller. The effects for scenario C (quiet vehicles) and scenario D (quiet tracks) are considerably smaller. The effects of noise barriers (scenario E) are small, as they affect only a limited percentage of the railway lengths. Traffic management (scenario F) has a moderate effect. The effect of urban planning in scenario G is small as it affects only a small percentage of the urban area in the EU. The effect of dwelling insulation (scenario H) is moderate.

In the same way as for road traffic noise, the results for scenario I (reception limits) are interesting. The fact that the health burden reduction is not very large implies that a large part of the health burden is caused by noise levels below the limits (60 dB Lden and 55 dB Lnight).

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the single-solution scenarios. The reductions in health burden for the combined scenarios cover the wide range of 5-52%. The largest reductions occur for combined scenario ABCD, with smooth tracks and wheels, quiet vehicles, and quiet tracks. The reductions for scenarios C and D are approximately independent of each other, which means that the reductions for combined scenario CD is equal to the sum of the reductions for scenarios C and D. This is not the case for scenarios A and B, as both affect the combined wheel-rail roughness. The reductions are larger for scenario AB (smooth tracks and wheels) than for scenario

Figure 18 Results of calculations for railway noise scenarios



*CD (quiet vehicles and tracks)

Table 7 Annual EU health burden of railway noise in 2030, for the baseline scenario.

	Annual value in 2030
Highly annoyed persons	11.0 million
Highly sleep-disturbed persons	4.9 million
DALYs	570 thousand
Monetized health burden (method 1/2)	12.4 / 5.0 billion Euro

Table 8 Percentage reduction of annual EU health burden of railway noise in 2030, relative to the baseline scenario, for single solution scenarios.

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A - smooth tracks	20.5	16.4	18.1	26.9 / 16.7
B – smooth wheels	31.4	26.8	28.7	39.3 / 27.1
C – quiet vehicles	2.7	1.6	2.0	4.1 / 1.7
D – quiet tracks	7.6	4.6	5.8	11.7 / 4.9
E - barriers	1.7	1.0	1.3	2.7 / 1.1
F – traffic management	5.1	3.5	4.2	7.9 / 3.5
G – urban planning	1.2	1.2	1.2	1.2 / 1.2
H – dwelling insulation	6.7	6.7	6.7	6.7 / 6.7
I – reception limits	7.6	4.3	6.0	17.5 / 5.7
AB – combined	33.9	29.2	31.2	42.2 / 29.5
CD - combined	10.3	6.7	8.2	15.4 / 7.0
ABCD - combined	42.2	37.1	39.2	51.5 / 37.3
EF – combined	6.6	4.7	5.5	9.7 / 4.7
GH – combined	7.8	7.8	7.8	7.8 / 7.8

Table 9 Results of cost-benefit analysis of single solution scenarios of railway noise, for 2020 2035.

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A - smooth tracks	11.7 / 2.9	27.9 / 5.0	2021 / 2026
B – smooth wheels	15.2 / 4.2	42.4 / 9.7	2121 / 2025
C – quiet vehicles	1.5 / 0.26	1.6 / -2.2	2030 / -
D – quiet tracks	1.3 / 0.22	2.9 / -7.9	2032 / -
E - barriers	2.5 / 0.41	1.8 / -0.7	2026 / -
F – traffic management	7.1 / 1.3	7.3 / 0.4	2022 /2032
G – urban planning	0.07 / 0.03	-18.6 / -19.4	- / -
H – dwelling insulation	11.3 / 4.6	6.7 / 2.3	2021 / 2023
I – reception limits	1.7 / 0.23	8.8 / -9.2	2032 / -
AB – combined	8.7 / 2.5	42.9 / 8.2	2021 / 2028
CD - combined	1.3 / 0.24	4.0 / -9.9	2031 / -
ABCD - combined	3.1 / 0.90	38.5 / -1.8	2025 / -
EF – combined	4.5 / 0.89	8.3 / -0.3	2023 / -
GH – combined	0.42 / 0.17	-12.0 / -17.1	- / -

2.7 Aircraft noise: description of scenarios

For the aircraft noise scenarios, the following noise abatement solutions are considered, each with its own calculation parameters in the noise model.

- Take-off improved profiles (flight procedures)
  - Modelled by changing the flight profiles in Departure
- Dispersion or concentration of flights (route optimization)
  - Modelled by reducing the horizontal dispersion in the flight tracks
- Operating restrictions - curfew
  - Modelled by shifting flights from one period to another and/or reducing the total amount of flights
- Operating restrictions - prohibition of operation for noisier aircraft at night
  - Modelled by changing the fleet composition
- Forced phase out of older aircraft
  - Modelled by changing the fleet composition
- Acquisition of new quieter aircraft (EU or national level incentives for airlines)
  - Modelled by changing the source noise levels
- Sound insulation of residential and communal buildings
  - Modelled by changing the noise exposure distributions.
- Buffer zone
  - Modelled by changing the noise exposure distributions.
- Stakeholder engagement
  - Modelled by changing the noise exposure distributions.

In addition to the above physical noise solutions, scenarios with reception limits are also considered (in the same way as for road and rail traffic noise).

Scenarios with a single noise solution

Scenario A is considering the implementation of improved take-off procedures. For departure operations, the noise levels will be reduced by 2 dB, which is the noise reduction that may be expected from optimised procedures with respect to standard profiles. It is assumed that in 2030 all take-off operations will have been replaced. For the intermediate years linear interpolation will be applied. Although for specific situations a tailormade flight profile might be required, when considering more generically applicable procedures, a main driver for airlines to implement them is fuel saving. With an estimated fuel cost saving of 50€ per operation and considering a current implementation of these operations of 30%, around 150 million euros may be saved a year by introducing optimised flight profiles. If cost like additional training etc are included, a total cost reduction of around 125 million per year may be expected.

Scenario B considers the implementation of Precision-Area Navigation (P-RNAV). This will result in more accurately flown flights, thus minimising horizontal dispersion of especially departures. This scenario will be modelled by imposing that all departures will remain on the backbone of the Standard Instrument Departures (SIDs). It is assumed that in 2030 all operations will have been replaced. For the intermediate years linear interpolation will be applied. This solution is considered budget neutral.

Scenario C is the introduction of an operating restriction, namely a night curfew. This will be simulated by shifting 25% of the night flights to the evening, 25% to the day and by cancelling the remaining 50%. The effect of an implementation in i) 2025 and ii)2030 will be assessed. The cost of this solution is estimated to be TBD €.

Scenario D is the introduction of the prohibition of operation for noisier aircraft during a certain period as another operating restriction. This is simulated by replacing all non-chapter 4 aircraft by a chapter 4 equivalent. Considering the relevance of the shoulder hours for sleep disturbance, the period considered will be from 22h to 08h. The effect of an implementation in i) 2025 and ii)2030 will be assessed. The cost of this solution is estimated to be TBD €.

Scenario E is considering the forced phase out of older aircraft. In this scenario all non-chapter 4 compliant aircraft will be replaced by chapter 4 compliant equivalents. The effect of an implementation in i) 2025 and ii)2030 will be assessed. The cost of this solution is estimated to be TBD €.

Scenario F is acquisition of new quieter aircraft. In the baseline scenario a natural renewal of the aircraft fleet is already assumed. This has been simulated by assuming a 0.1 dB noise reduction per year (ICAO/CAEP), effectively resulting in a complete fleet renewal in 20 years. For this scenario an accelerated fleet renewal will be simulated by applying an additional 0.1 dB noise reduction per year, effectively meaning that the fleet will have been completely renewed by 2030. After that, the natural fleet renewal will take over again. The additional cost of new generation aircraft will be offset by a lower fuel consumption. Depending on the methodology used, the estimated cost savings will range from 1 to 5 billion euros per year.

Scenario G is sound insulation of residential and communal buildings. It is assumed that the percentage of dwellings with façade/roof insulation is increased by 10% in 2035. As an approximation it is further assumed that the noise exposure for insulated dwellings is so much reduced that these dwellings can be eliminated from the exposure distributions. The costs are 2000 Euro per dwelling.

Scenario H is the creation of a buffer zone. It is assumed that in 2035 no population is living in areas with L_{den}>70 and L_{night}>65dB. The costs are TBD € per person.

Scenario I is on stakeholder engagement. It is assumed that in 2035 the sensitivity of the population towards aircraft noise has been reduced by an equivalent of 5 dB. The costs are TBD € per person.

Scenario J is the introduction of reception limits, with 60 dB L_{den} and 55 dB L_{night}. As indicated previously, this is not a scenario with a specific noise abatement solution, but rather a scenario that shows what can be achieved with one or more solutions that result in complying with the reception limits. Linear interpolation from 'no limits' to the limits in 2035 is applied as an approximation for the gradual compliance with the limits. For this scenario an annual cost of TBD Euro was assumed. This value was derived by looking at the costs for scenario TBD, assuming that local authorities would select such solutions for complying with reception limits.

Scenarios with combined noise solutions

The following scenarios with combined solutions are considered.

- **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) = **3D optimization**

- • **E** (Phase out of noisiest aircraft at night) + **F** (Fleet replacement with quiet aircraft) = **Quietest fleet**
- • **A** (Improved take-off procedures) + **B** (Dispersion or concentration of flights) + **E** (Phase out of noisiest aircraft) + **F** (Fleet replacement with quiet aircraft) = **Best possible on "aircraft side"**

The cost of the combined scenarios is equal to the sum of the costs of the single-solution scenarios.

2.8 Aircraft noise: results

Calculation results for single-solution scenarios A-J and combined scenarios are presented in Table 2 - Table and Figure . The results for the single-solution scenarios A-J are first discussed, followed by the results for the combined scenarios.

Scenarios with a single noise solution

In Table 2 results for the baseline scenario are given; the annual EU health burden in 2030 is expressed in four quantities:

- number of highly annoyed persons,
- number of highly sleep-disturbed persons,
- number of DALYs (Disability Adjusted Life Years),
- monetized health burden in billion Euros.

In Table the reduction of the annual EU health burden in 2030 is given for the single-solution scenarios. In **Error! Reference source not found.** the results of the cost-benefit analysis for 2020-2035 are set out for the single-solution scenarios. Values given in Table and Table are also presented in the bar diagrams in Figure .

For scenario A – improved flight procedures, there is a large reduction in exposure of the period 2020-2030, which results in a large reduction of the health burden. The health burden in DALYs is reduced by 57%. It should be noted that the costs for scenario A are negative, due to fuel savings.

Amongst all the single solution scenarios, the largest reduction occurs for scenario A. The second largest reduction occurs for scenario F – accelerated fleet renewal, with a reduction in DALYs of 27%.

Scenarios Ci and Cii – night curfew in 2025 / 2030 are of special interest. For these scenarios, night flights are partly eliminated and partly shifted to the day and evening periods. Consequently, the reduction in sleep disturbance (HSD) is 100%, while the reduction in annoyance is negative. In this situation, monetization methods 1 and 2 give opposing results. Method 1 is based on the Lden level only, so the monetized health burden reduction is negative. Method 2 on the other hand takes into account both Lden for annoyance and Lnight for sleep disturbance. In this case the the monetized health burden reduction is positive. Method 2 is more reliable than method 1 in this case.

Combined scenarios

As expected, the health burden reductions for the combined scenarios are larger than for the single-solution scenarios. The reductions in health burden for the combined scenarios in Table cover the wide range of 18-69%. The largest reductions occur for combined scenario ABEF, which is the best possible scenario 'from the aircraft side'.

Figure 9. Results of calculations for aircraft noise scenarios.

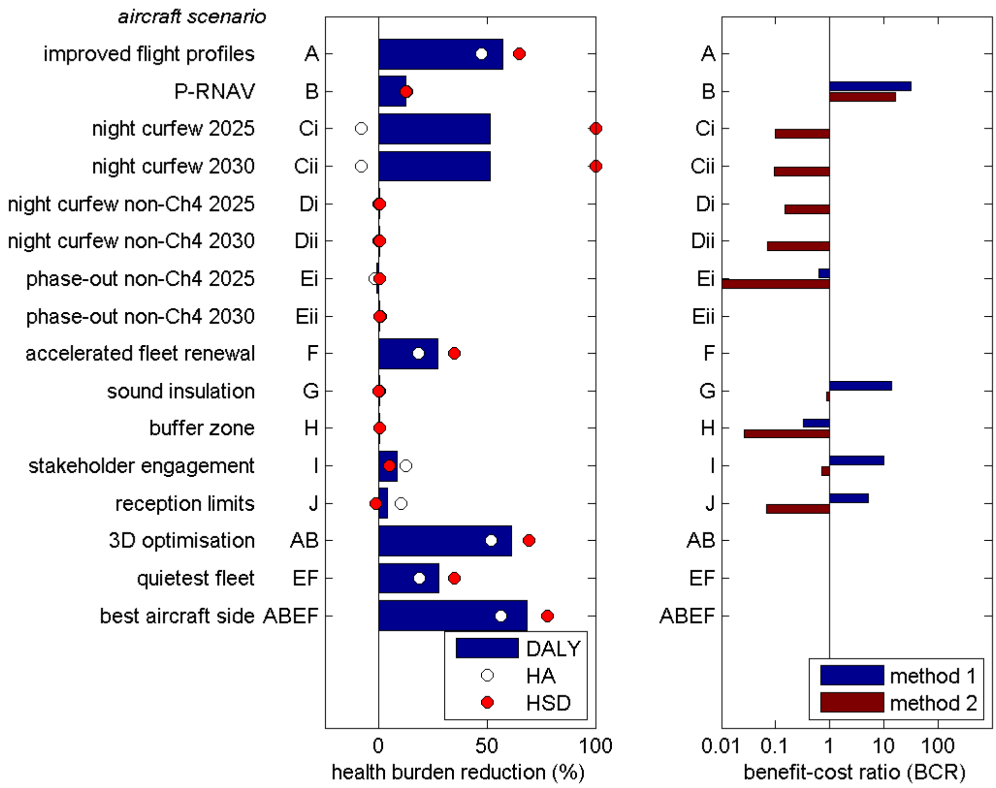


Table 2. Annual EU health burden of aircraft noise in 2030, for the baseline scenario.

	Annual value in 2030
Highly annoyed persons	1.6 million
Highly sleep-disturbed persons	0.6 million
DALYs	73 thousand
Monetized health burden (method 1/2)	1.1 / 0.8 billion Euro

Table 8. Percentage reduction of annual EU health burden of aircraft noise in 2030, for single-solution scenarios.

Scenario	Highly annoyed persons (%)	Highly sleep-disturbed persons (%)	DALYs (%)	Monetized health burden (method 1 / 2) (%)
A – improved flight profiles	47.4	65.0	57.1	45.4 / 55.5
B – P-RNAV	12.7	12.5	12.6	15.9 / 12.0
Ci – night curfew 2025	-8.1	100	51.5	-13.7 / 33.6
Cii – night curfew 2030	-8.1	100	51.5	-13.7 / 33.6
Di – nigh curfew non-Ch 2025	0.0	0.3	0.2	0.0 / 0.1
Dii – nigh curfew non-Ch 2030	0.0	0.3	0.2	0.0 / 0.1

Ei – phase-out non-Ch 2025	-2.0	0.3	-0.8	-10.2 / -0.3
Eii – phase-out non-Ch 2030	0.6	0.3	0.4	0.7 / 0.5
F – accelerated fleet renewal	18.3	34.8	27.4	18.3 / 24.5
G – sound insulation	0.2	0.0	0.1	0.8 / 0.1
H – buffer zone	0.5	0.2	0.3	1.7 / 0.2
I – sound insulation	12.5	4.6	8.2	51.5 / 5.1
J – reception limits	10.2	-1.4	3.8	54.7 / 0.6

Table 9. Results of cost-benefit analysis of single-solution scenarios of aircraft noise, for 2020-2035.

Scenario	Benefit-cost ratio BCR (method 1 / 2)	Net present value NPV (method 1 / 2) (billion Euro)	Break-even year (method 1 / 2)
A – improved flight profiles	-4.22 / -3.67	4.7 / 4.2	2021 / 2021
B – P-RNAV	31.61 / 16.77	1.3 / 0.7	2021 / 2021
Ci – night curfew 2025	-0.06 / 0.10	-22.6 / -19.3	- / -
Cii – night curfew 2030	-0.05 / 0.10	-11.4 -9.8	- / -
Di – nigh curfew non-Ch 2025	-0.11 / 0.07	-0.0 / -0.0	- / -
Dii – nigh curfew non-Ch 2030	-0.11 / 0.15	-0.0 / -0.0	- / -
Ei – phase-out non-Ch 2025	0.63 / 0.00	0.3 / 0.9	2021 / 2022
Eii – phase-out non-Ch 2030	-0.09 / -0.08	0.8 / 0.8	2021 / 2022
F – accelerated fleet renewal	-0.08 / -0.08	22.1 / 22.0	2021 / 2021
G – sound insulation	13.78 / 0.88	0.1 / -0.0	2024 / -
H – buffer zone	0.33 / 0.03	-0.3 / -0.5	- / -
I – sound insulation	10.11 / 0.71	4.4 / -0.1	2021 / -
J – reception limits	5.18 / 0.07	4.2 / -0.9	2022 / -

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