ETC-HE Report 2022/5

Projected health impacts from transportation noise – Exploring two scenarios for 2030

Authors:
Núria Blanes (UAB), Jaume Fons-Esteve (UAB), Matthias Hintzsche (UBA), Maria José Ramos (UAB), Martin Röösli (Swiss TPH), Miquel Sáinz de la Maza (UAB), Raquel Ubach (UAB), Danielle Vienneau (Swiss TPH), Eulàlia Peris (EEA)

European Environment Agency
European Topic Centre
Human health and the environment

Cover design: EEA
Cover image © Antonio Atanasio Rincón, Sustainably Yours /EEA
Layout: EEA/ETC HE

Publication Date: June 2022

EEA activity no. 3.2 Environmental impacts on health and well-being: SO1: Supporting policy implementation and sustainability transitions, SO2: Providing timely input to solutions for sustainability challenges, SO4: Making full use of the potential of data.

ETC-HE coordinator: NILU - Stiftelsen Norsk institutt for luftforskning (NILU - Norwegian Institute for Air Research)

ETC-HE consortium partners: Federal Environment Agency/Umweltbundesamt (UBA), Aether Limited,
Czech Hydrometeorological Institute (CHMI), Institut National de l'Environnement Industriel et des Risques (INERIS),
Swiss Tropical and Public Health Institute (Swiss TPH), Universitat Autònoma de Barcelona (UAB),
Vlaamse Instelling voor Technologisch Onderzoek (VITO), 4sfera Innova S.L.U., klarFAKTe.U

ISBN 978-82-93970-03-3

How to cite this report:
Blanes, N., Fons-Esteve, J., Hintzsche, M., Ramos, M.J., Röösli, M., Sáinz de la Maza, M., Ubach, R., Vienneau, D., Peris, E. (2022). Projected health impacts from transportation noise – Exploring two scenarios for 2030 (Eionet Report – ETC/HE 2022/5).

European Topic Centre on
Human health and the environment (ETC-HE)

Contents

Acknowledgements

A technical review completed by Wood E&IS GmbH, "Developing noise outlooks for the period 2017-2030" under the Implementing Framework Service Contract EEA/HSR/20/003, was used as input to the report presented. We want to thank the authors of this report: Maria Paola Calasso, Dimitrios Kostovasilis, Andrew Monk-Steel, Jo Webb and Ian Keyte.

Summary

The EU Action Plan 'Towards Zero Pollution for Air, Water and Soil' commits to reduce by 2030 the share of people chronically disturbed by noise from transport by 30 % compared to 2017.

This report provides outlooks to 2030 on the population exposed to road, rail and aircraft noise and health impacts. The outlooks comprise two scenarios, one conservative (i.e. the minimum implementation of existing and forthcoming regulations) and one optimistic scenario, which includes a more extensive set of measures.

Based on the overall results of this assessment, the zero-pollution action plan objective on noise is unlikely to be achieved by 2030. One of the main stoppers is the difficulty in reducing the large number of people exposed to road traffic noise. However, a combination of measures such as switching to electric vehicles in cities, reducing speed limits in cities, implementing the noise emission regulations for vehicles, and extending low noise asphalts and noise barriers, could bring a reduction between 3-15 % of people affected by noise.

Looking at individual noise sources, the assessment shows that the number of people chronically disturbed by aircraft noise could be reduced by 30 % with progressive uptake of quieter aircraft and improved landing and taking off procedures. In terms of railway noise, it is likely that the number of people affected by railway noise will increase due to increased railway activity, speed, and high-speed lines, which offsets the benefits of silent brake regulations and improved maintenance of the tracks.

1 Introduction

After 18 years of the implementation of the Environmental Noise Directive (END) (EU, 2002), trends between 2012 and 2017 suggest that the number of people exposed to levels of noise considered harmful to human health has not significantly been reduced (EEA, 2020a). Achieving a reduction of the negative impacts of noise pollution is essential within the context of the Zero Pollution Action Plan (EC, 2021). Specifically, the commitment is to reduce by 2030 the share of people chronically disturbed by noise from transport by 30 % compared to 2017. To achieve this commitment, the EC has agreed on a number several actions:

- Monitoring progress towards achieving a 30 % reduction on people chronically disturbed in 2030 based on EEA assessments.
- Improving the EU noise-related regulatory framework on tyres, road vehicles, railways, aircrafts, also at international level.
- Reviewing progress in 2022, based on noise pollution trends resulting from Member State noise, and consider whether there is a need to set noise reduction targets at the EU level in the Environmental Noise Directive.
- Improving integration of noise action plans into sustainable urban mobility plans and benefiting from an extension of clean public transport and active mobility.

To support the Zero pollution Action Plan (EC, 2021), this report focuses on outlooks based on trends and future scenarios for the period from 2017 (reference year) to 2030. These scenarios are not predictions. Instead, the scenarios seek readers to compare different possible outlooks of the future and the levers and actions that produce them to stimulate insights into the future of noise in Europe.

Previous outlooks were developed in 2019 by ETC/ATNI (Blanes et al., 2019) using the inputs described below:

- the projected growth of population, based on the land use based integrated sustainability assessment datasets (Lavalle and Jacobs Crisioni, 2014);
- the road and rail traffic growth forecast for passenger and freight transport, based on the EU reference scenario 2016 (Capros et al., 2016);
- the aviation traffic forecast and technology improvement scenario from the European aviation environmental report 2016 (EASA et al., 2016);
- the policy on rail freight silent fleet development under the technical specifications for interoperability relating to the subsystem 'rolling stock — noise' (EUAR, 2014);
- the non-binding target of 50 % electrification of the fleet in urban areas (EC, 2011), using an estimated reduction of 0.4 dB.

The outlooks were published as part of the *Environmental noise in Europe - 2020 report* (EEA, 2020a).

There is a need to update and improve the noise outlooks assessments by including a more extensive and reliable set of input variables. To create outlooks for 2030 the latest data on transport forecasts, impacts of covid situation, population forecasts, policies that influence noise, new technologies and future mobility trends need to be used. To model outlooks to 2030, plausible scenarios need to be identified and defined. The scenarios are to be used to guide noise policy implementation.

2 Objective

This report aims to define and model transport noise scenarios in Europe for 2022 and 2030 and assess the feasibility to achieve the objectives of the Zero Pollution Action Plan (EC, 2021) for noise under two scenarios for 2030: a conservative scenario and another scenario considering the best implementation practices.

3 Methodology

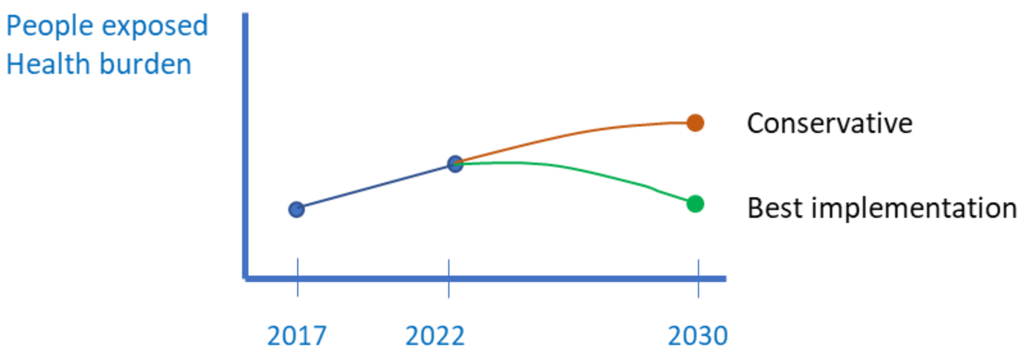
3.1 Overview

Two scenarios are developed for three noise sources: road, rail and air traffic noise inside and outside agglomerations.

The scenarios are defined for the period 2017 -2030 as follows (Figure 3.1):

- **Year 2017**: it is the baseline year. The Environmental Noise Directive (END) requires that Member States (MS) report data on the population exposed to different noise sources every five years. The latest available information is from 2017 - the subsequent reporting is due by the end of 2022. Therefore, 2017 is the baseline.
- **Year 2022**: is included as an intermediate step linked to the current situation for which data is not yet available. Values for this year are common to all scenarios.
- **Year 2030 Conservative estimate**: A minimum implementation of existing and forthcoming regulations are considered. The scenario also considers minimum values for different noise abatement measures like low noise asphalt. The feasibility of the target of the Zero Pollution Action Plan will be evaluated under the conditions of minimum implementation.
- **Year 2030 Best implementation estimate**: A reasonable maximum values for different measures that would lead to significant noise reduction as justified in each noise source and scenario are considered. This is the scenario with the best plausible values for different factors. The feasibility of the target of the Zero Pollution Action Plan will be evaluated under the conditions of optimal implementation.

Figure 3.1 Overview of scenarios calculated in all noise sources. (This figure is obtained specifically per each noise source.)

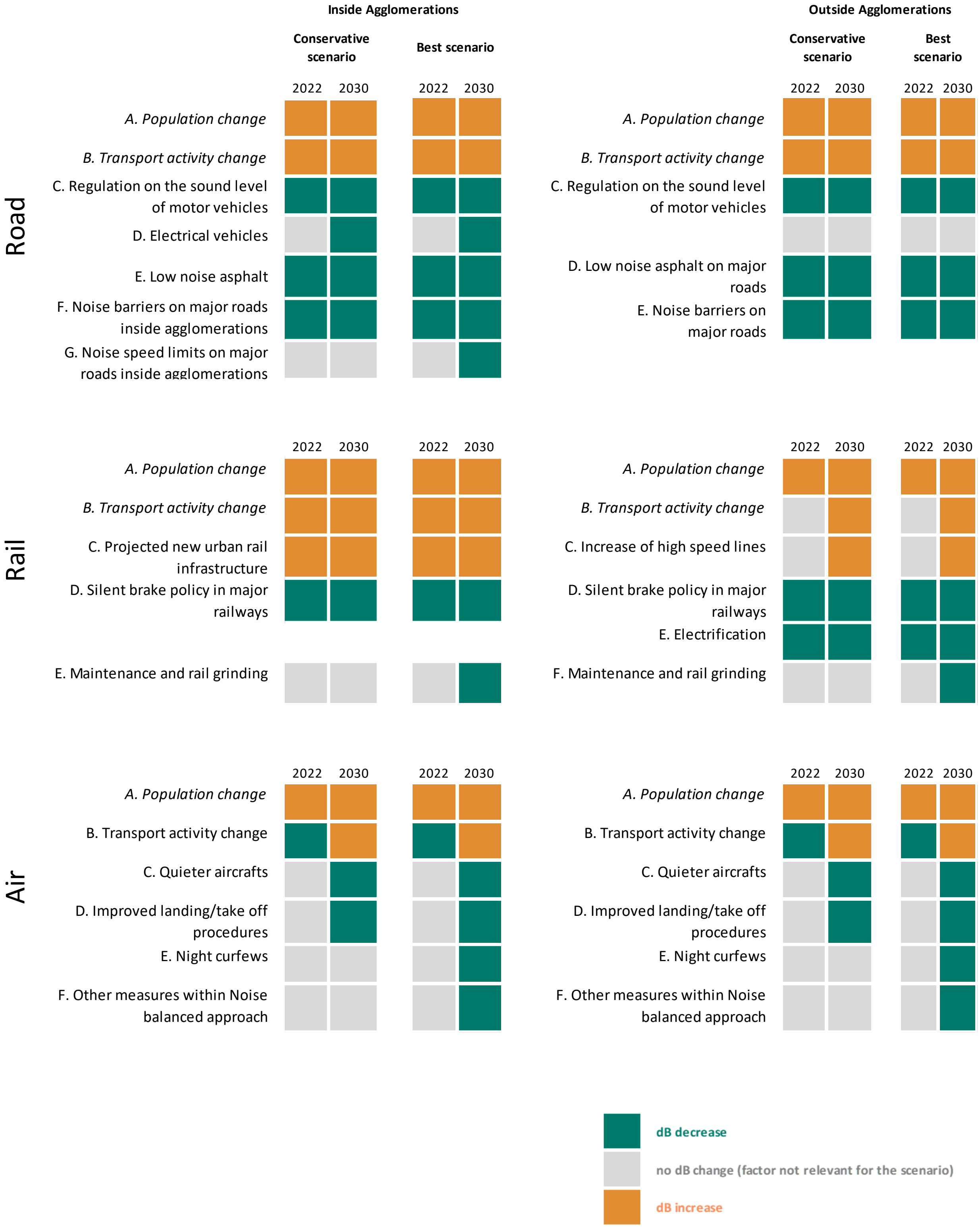


The selection of the factors included in the scenarios is based on the best available data. The input variables were chosen based on different sets of information identified under Implementing Framework Service Contract EEA/HSR/20/003, action plans under the END, the expert judgment of the ETC/HE authors and EEA, and other sources of information considered relevant including the PHENOMENA project (EC et al., 2021a). Only existing and available noise abatement solutions are considered in the scenarios. Even if innovative solutions may be under development, it generally takes several years to come onto the market, obtain approval for general application, and be sufficiently widely implemented to impact noise exposure at the EU level.

Figure 3.2 provides an overview of the factors included per noise source and scenario. The colour indicates if the considered factor reduces noise levels, is not relevant for a specific scenario, or increases noise levels. The colour does not show the magnitude of change which is further described in the devoted section per each noise source. Moreover, the final result combining all the factors is evaluated in chapters 4 and 5.

It should be noted that there are two elements in common to all scenarios, which are the demographic change and the transport activity change, which are country dependent (except transport activity change for air traffic noise which is common for all airports). The values presented in Figure 3.2 for these two parameters reflect the European average.

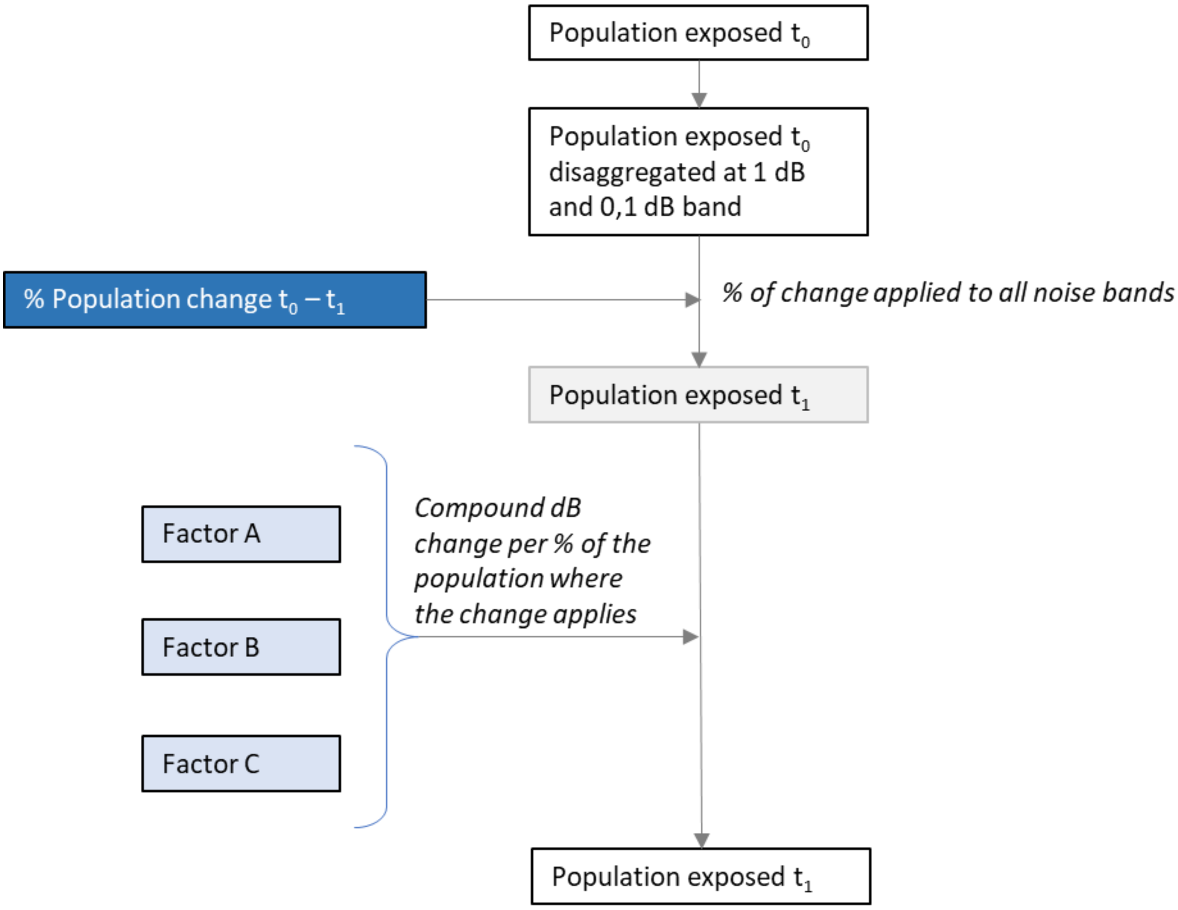
Figure 3.2. Overview of the road, rail and air noise scenarios, inside and outside agglomerations. The figure indicates how the different factors influenced the scenarios calculations: factors increasing the noise levels (orange), factors not relevant for a specific scenario (grey) or factors decreasing the noise levels (green). In italics: country-specific factors; the colour refers to the European average.



3.2 General workflow to calculate scenarios

All the scenarios follow the same workflow, as described in Figure 3.3, and are based on the change in the population exposure due to the demographic factor, transport projections, and noise abatement measures in a specific period.

Figure 3.3 General workflow of scenarios for a specific noise source. Demographic changes (in dark blue), transport projections and related noise factors (in light blue) contribute to the population change exposed to a specific noise source between t_0 and t_1. Boxes in grey refer to intermediate calculations.



Below is a summary of the main steps involved in the calculation of the different scenarios:

1. Select the baseline.
   The baseline is the population exposed to noise in 2017 as provided by Member States under the Environmental Noise Directive requirements (see details in section 3.3). Because of some countries' incomplete reporting of noise exposure data, gap filling was performed to complete any missing information and ensure a full assessment of environmental noise in Europe. Detailed information on the gap-filling methodology can be found in (Fons-Esteve et al., 2021b). Detailed completeness of the data by country can be seen in the EEA noise fact sheets (EEA, 2021a).

2. Estimation of people exposed below END threshold
   Population exposed below END threshold have been estimated to be able to compare the outcomes of the scenarios according to the WHO noise guidelines (WHO Europe, 2018).

Table 3.1. Applied methods to estimate noise levels below END threshold by nosei source.

Noise source	Exposure estimation at lower noise levels method	Assumptions
Road noise exposure inside agglomerations	Option 1: Use the values provided by the country Option 2: Use the methodology estimations calculated at country level outlined in Houthuijs et al. (2018)	Distribution over all noise bands has a normal distribution
Rail noise exposure inside agglomerations	Option 1: Use the values provided by the country Option 2: Use the percentages calculated at European level in Alberts et al. (2016)	Distribution over all noise bands has an exponential distribution. Proportionate distribution assumed as the same behaviour as for major roads outside agglomerations.
Air noise exposure inside agglomerations	Option 1: Use the values provided by the country Option 2: Use the methodology estimations calculated at country level outlined in Houthuijs et al. (2018)	Distribution over all noise bands has an exponential distribution (same criteria as per major roads exposure outside agglomerations)
Major roads exposure outside agglomerations	Option 1: Use the values provided by the country Option 2: Use the percentages calculated at European level in Alberts et al. (2016)	Distribution over all noise bands has an exponential distribution
Major rail exposure outside agglomerations	Option 1: Use the values provided by the country Option 2: Use the percentages calculated at European level in Alberts et al. (2016)	Distribution over all noise bands has an exponential distribution Proportionate distribution assumed as the same behaviour as for major roads outside agglomeration
Major air exposure outside agglomerations	Option 1: Use the values provided by the country Option 2: Use the methodology estimations calculated at country level outlined in Houthuijs et al. (2018)	Distribution over all noise bands has an exponential distribution (same criteria as per major roads exposure outside agglomerations)

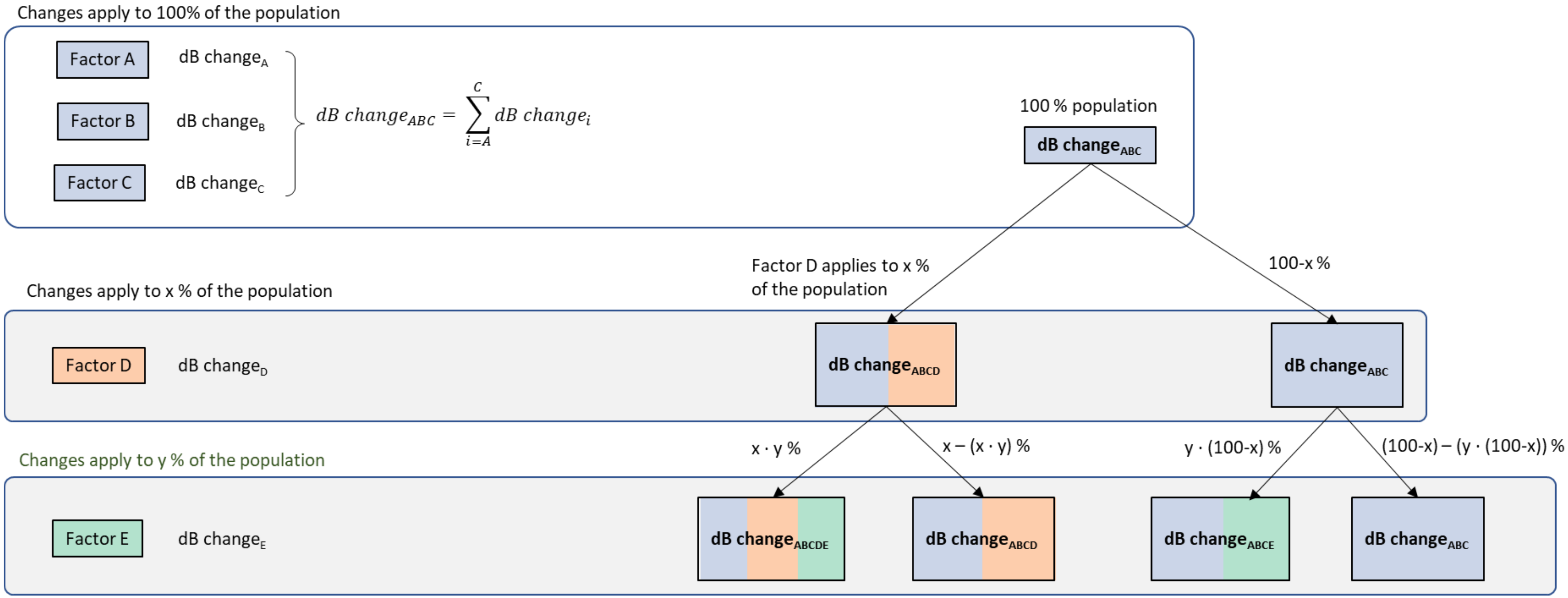
3. Disaggregate the population at a 1 dB noise band (one decimal precision)
The population exposed to different noise sources and indicators is reported per 5 dB noise intervals following the END requirements. The various factors that modify noise exposure result in a change of dB units or lower. Therefore, the 5 dB intervals must be disaggregated at the decimal level (one decimal precision) to integrate these changes. The methodology is described in Blanes et al. (2019)-chapter 5.2.

4. Apply the demographic changes.
Demographic changes are considered in all the scenarios based on the LUISA model (Lavalle and Jacobs Crisioni, 2014)-see section 3.3 for details. We assume homogenous population change both inside agglomerations and outside agglomerations. Therefore, the ratio of population change is applied to the population exposed to all noise bands at t_0.

5. Calculate the dB change from the different factors
Each factor (light blue boxes in Figure 3.3) needs to be translated into a dB change in order to estimate the final distribution of the population exposed at t_1. Details are provided per noise source in next sections. Unless it is specifically mentioned, the resulting dB change for a specific factor is applied to all noise bands.

6. Integrate all dB changes
   Some factors apply to the entire population, and some other factors only apply to a limited share of the population. For instance, the noise reduction of the regulation on sound level of motor vehicles is applied to all the population whilst the noise reduction of sound barriers is only applied to those people exposed to major roads. Figure 3.4 provides an overview of the approach to integrate the dB change of all factors under a specific noise source and scenario. It is considered that all the factors interact, therefore, all the combinations resulting from different percentages are identified. Existing groups from a previous step are further divided according to the percentage of the factor under consideration. In the last step the final groups with different percentages are obtained, each with a specific result of dB change. The subindexes on the figure reflect the factors included in each aggregated dB change.

Figure 3.4 Process to aggregate the dB change of different factors for a specific noise source and scenario. The figure provides an example with five factors (A to E). Three factors apply to the entire population (A, B, C), and two other factors only apply to a fraction of the total population exposed (D, x%; and E, y%).



3.3 Common factors to all scenarios

Table 3.2 provides an overview of the common factors used to calculate the projections of the scenarios.

Scenarios focus on EU27 since this is the minimum area with complete data coverage and includes the countries where EU noise regulations and the Zero Pollution Action Plan apply.

Table 3.2. Overview of the common factors used to calculate noise scenarios.

Data	Description	Reporting units	Reference Year(s)	Source
Noise exposure	People exposed road traffic, rail traffic and air traffic. Used as a baseline for all scenarios.	Inside agglomerations Outside agglomerations	2017	Data provided by MS according to the END and gap filled for missing values (EEA, 2021b).
Population projections	Population projection for EU27 based on the assumptions of the EU Reference Scenario	100 x 100 m grid	2020, 2025, 2030	LUISA (JRC, 2022)
Passenger and freight transport activity	Road traffic growth forecast (in Gpkm), and the freight traffic growth (in Gtkm) based on the EU Reference Scenario (EC et al., 2021b) and PRIMES model (E3 Modelling, 2018).	Country	2005 to 2050 by 5 years time step	EU Reference Scenario 2020: Main results on energy, transport and GHG emissions (Excel) (EC et al., 2021b)

3.3.1 Noise exposure

The baseline for the scenarios is the latest delivery reported by MS under the Environmental Noise Directive (END), 2017 (reference year). The data is reported in 5dB bands as follows:

- L_{den}: 55-59, 60-64, 65-69, 70-74, ≥75,
- L_{night}: 50-54, 55-59, 60-64, 65-69, ≥70.

Data included considers data delivered by Member States up to 1st January 2021, and missing data was estimated according to (Fons-Esteve et al., 2021b). Three noise sources have been considered: road, rail and air traffic noise, both inside and outside agglomerations.

3.3.2 Population projections

Population changes are based on the LUISA model (Lavalle and Jacobs Crisioni, 2014). The LUISA Territorial Modelling Platform is based on the concept of 'land function' for cross-sector integration and for the representation of complex system dynamics. Beyond a traditional land use model, LUISA adopts a new approach towards activity-based modelling based upon the endogenous dynamic allocation of population, services and activities. LUISA is primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. LUISA is configured to project a baseline (or reference) scenario, assuming official socio-economic trends (from ECFIN and EUROSTAT), business as usual processes, and the effect of established European policies with direct and/or indirect territorial impacts.

Data covers EU27, and it is provided as a 100 x 100 m grid for three years: 2020, 2025 and 2030.

3.3.3 Passenger and freight transport activity

The macroeconomic and demographic assumptions used in the EU Reference Scenario 2020 (EC et al., 2021b) are the basis for the projected transport activity in the PRIMES model (E3 Modelling, 2018). The output is the transport activity as the number of passengers and tones of goods (Gpkm and Gtkm respectively), which are translated into dB change in order to calculate scenarios on END population exposure in 2022 and 2030.

3.4 Specificities for road traffic noise scenarios

Road traffic noise is dependent on traffic flow and composition and on 'at source' factors, which include vehicle speed, type of vehicle, the friction between the tyres and the road surface generating rolling noise and the design of the propulsion system causing propulsion noise. The noise received at the receptor is influenced by the distance between the road and the receptor, the intervening noise barrier, and the insulation of the receptor. The insulation is not considered in this report, as it is only pertinent for indoor noise levels. Measures to reduce road traffic noise may intervene on the above factors, which then need to be modelled to evaluate such measures.

3.4.1 Road traffic noise inside agglomerations scenarios

Table 3.3 provides an overview of the scenarios for road traffic noise inside agglomerations, with references and specifications for the different factors that are taken into consideration for calculating the scenarios.

Figure 3.5 provides an overview of the workflow to calculate road traffic noise exposure scenarios inside agglomerations. This workflow is common for the three scenarios (2022, and two scenarios for 2030).

Calculation details in relation to each factor included in the scenarios, including explanations, references, assumptions and examples on how to perform the calculations, have been included in Annex 1.

Based on the sources mentioned in section 3.1 , the following factors have been excluded since they have been considered not significantly contributing to road traffic noise under the different scenarios:

- **Tyre noise**: Noise reduction due to tyre noise is somehow considered when integrating other measures such as the regulation of the sound level of motor vehicles or speed regulation. No further reductions are specifically introduced in the scenarios for tyre noise – beyond the assumption that all tyres will meet the 2016 limits, and the effect is related to road surface type. Emissions from noise tyres are regulated by Regulation 117 (UNECE, 2011) and applicable from 2016. Given that car tyres are considered to have an average life of 4 years, it is assumed that by 2022 all tyres in use will meet the requirements set in the Regulation. Therefore, tyre noise does not require adjustments except that the noise performance of the tyre depends on the road surface type, which is included in the model. It should be noted that lowering the noise limit values for tyres would have been an effective instrument to reduce noise at the source.
- **Urban planning**: A general strategy cannot be specified for solutions aimed at infrastructure and urban spatial planning (such as traffic rerouting). The change in exposure distributions can only be derived from test-site calculations or ad hoc arguments, and therefore no quantitative noise change has been provided for this.
- **Road extension**: Although agglomerations are expected to grow, the corresponding increase in road length is considered negligible. Expansion of transport networks (all types inside and outside

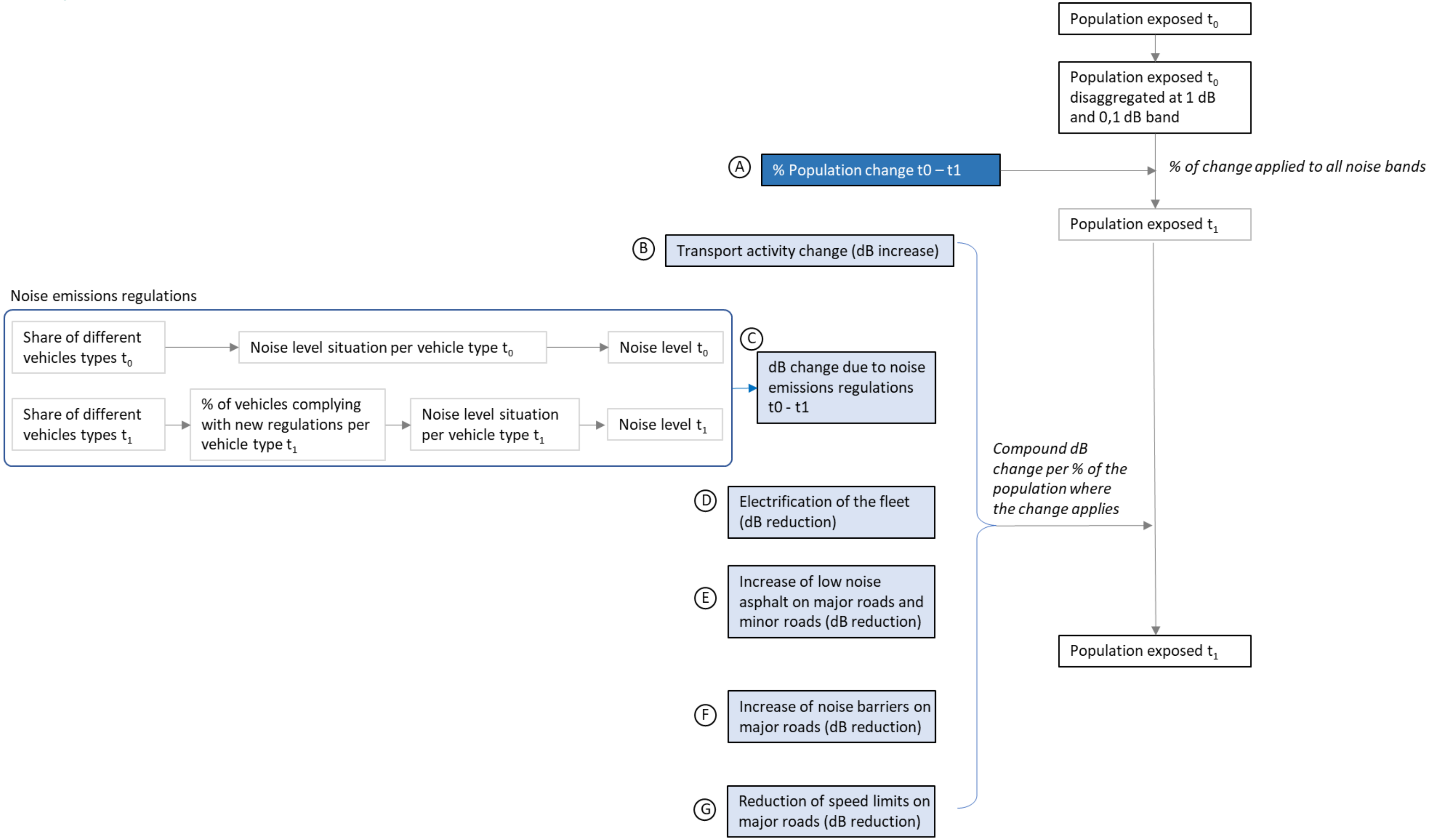
agglomerations) accounted for 0,3 % for 2012-2018 (CORINE Land Cover; EEA, 2019). Although CORINE Land Cover does not fully reflect changes in road length, this value provides a reference for the magnitude of change.

Table 3.3 Overview of the factors related to road traffic noise scenarios inside agglomerations. Cells in red indicate those factors contributing to increased noise pollution. Green indicate that the considered factor results in a dB decrease (noise pollution reduction) in the specific scenario. Cells in grey are related to factors that are not relevant for the particular year and scenario.

Factor	Reference	Scenario 2022	Conservative scenario 2030	Best implementation scenario 2030
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Extrapolation from LUISA projections for 2020 and 2025 (backwards extrapolation for 2017-2020)	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Transport activity change	Road traffic growth forecast (in Gpkm), and the freight traffic growth (in Gtkm) based on the EU Reference Scenario (EC et al., 2021b) and PRIMES model (E3 Modelling, 2018).	Road traffic growth forecast is provided at a country level and for each year of the scenarios. Values for 2030 are the same in both scenarios. It is assumed 3 dB increase per doubling traffic volume.		
C. Regulation on the sound level of motor vehicles	Share of vehicles from ACEA 2022 (ACEA, 2022). Percentage of vehicles complying with new regulations (EC et al., 2021a) and emission values (Linear regression from EC et al., 2021a).	The decrease in emissions is based on the vehicle fleet, the change in the percentage of vehicles complying with regulation on sound level of motor vehicles of 2015, 2016, 2020/2022 and 2024/2026.	The decrease in emissions is based on the vehicle fleet, change on the percentage of vehicles complying with regulation on sound level of motor vehicles of 2015, 2016, 2020/2022 and 2024/2026.	-2 dB (linear reduction of 2 dB over a period of 15 years from 2015 to 2030)
D. Electrical vehicles	It is assumed 0.5 dB reduction for 100 % electric vehicles (Goubert, 2015).	Noise reduction from the electrification of the fleet between 2017 and 2022 is assumed to be negligible.	25 % of vehicles are electric -0,12 dB	50 % of vehicles are electric -0,24 dB
E. Low noise asphalt	It is assumed 2 dB reduction on major roads and 1 dB reduction on other roads. Phenomena project (EC et al., 2021a) and END Noise Action Plans (Blanes et al., 2020; Fons-Esteve et al., 2021a)	2 % increase of low noise asphalt from 2017 -2 dB on 2 % of major roads inside agglomerations -1 dB on 2 % of non-major roads	5 % increase of low noise asphalt from 2017 -2 dB on 5 % of major roads inside agglomerations -1 dB on 5 % of non-major roads	10 % increase of low noise asphalt from 2017 -2 dB on 10 % of major roads inside agglomerations -1 dB on 10 % of non-major roads

Factor	Reference	Scenario 2022	Conservative scenario 2030	Best implementation scenario 2030
F. Noise barriers on major roads inside agglomerations	It is estimated a 10 dB reduction because of implementing new noise barriers (EC et al., 2021a). Percentage of increase of major roads are own estimates based on data from countries and END Noise Action Plans.	0,5 % increase in noise barriers on major roads -10 dB on 0,5 % of major roads	1,3 % increase in noise barriers on major roads -10 dB on 1,3 % of major roads	3 % increase in noise barriers on major roads -10 dB on 3 % of major roads
G. Noise speed limits on major roads inside agglomerations	Noise speed limits result in a 3 dB reduction on major roads (Rossi et al., 2020)	Not relevant for the 2022 scenario. Speed limit reduction not considered since there is not any specific regulation at European level.	Speed limit reduction not considered	30 % of major roads -3 dB on 30 % of major roads inside agglomerations

Figure 3.5 General workflow of scenarios for road traffic noise inside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), technological changes resulting from policy measures (C and D), other noise abatement measures (E and F) and reduction of noise speed limit (G) contribute to the population change exposed to road traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.3, which provides the reference values used for the different scenarios. Further details can be found in Annex 1.



3.4.2 Road traffic noise outside agglomerations scenarios

Table 3.4 provides an overview of the scenarios for road traffic noise outside agglomerations, with references and specifications for the different factors that are taken into consideration for calculating the scenarios.

Figure 3.6 provides an overview of the workflow to calculate road traffic noise scenarios outside agglomerations. This workflow is common for the three scenarios (2022 and two scenarios for 2030).

Calculation details in relation to each factor included in the scenarios, including explanations, references, assumptions and examples on how to perform the calculations, have been included in Annex 2.

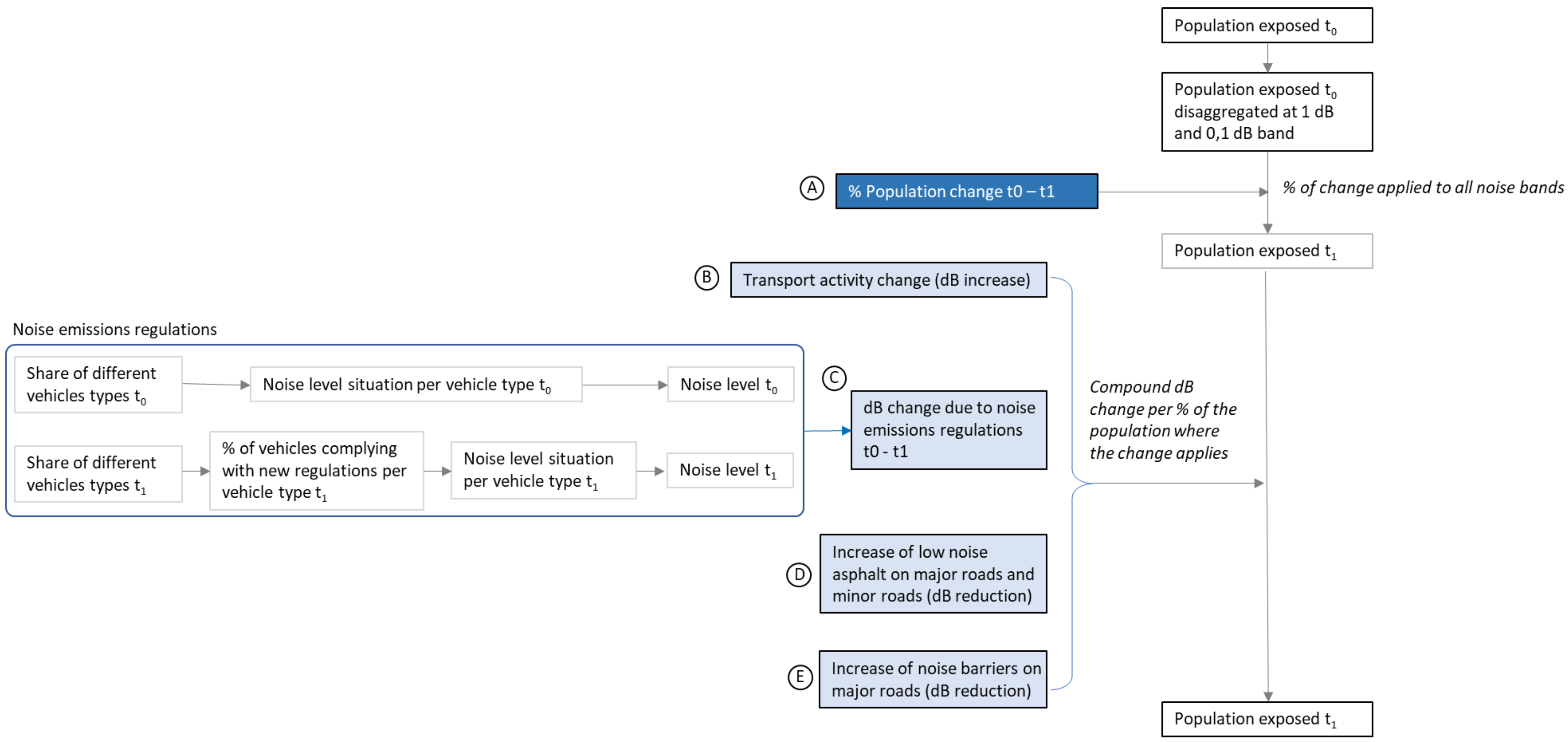
Based on the sources mentioned in section 3.1, the following factors have been excluded since they have been considered not significantly contributing to road traffic noise under the different scenarios:

- **Tyre noise**: Noise reduction due to tyre noise is somehow considered when integrating other measures such as the regulation of the sound level of motor vehicles or speed regulation. No further reductions are specifically introduced in the scenarios for tyre noise – beyond the assumption that all tyres will meet the 2016 limits, and the effect is related to road surface type. Emissions from noise tyres are regulated by Regulation 117 (UNECE, 2011) and applicable from 2016. Given that car tyres are considered to have an average life of 4 years, it is assumed that by 2022 all tyres in use will meet the requirements set in the Regulation. Therefore, tyre noise does not require adjustments except that the noise performance of the tyre depends on the road surface type, which is included in the model.
- **Road extension**: Expansion of transport networks accounted for 0,3 % for 2012-2018 (CORINE Land Cover; EEA, 2019). Although CORINE Land Cover does not fully reflect changes in road length, this value provides a reference for the magnitude of change. Therefore, road extension has not been included in the scenarios.
- **Speed limit outside agglomerations**: This is an effective measure; however, there is no specific regulation at the European level, and practices vary from country to country. Therefore, unlike inside agglomerations, where there is a broad convergence to apply this measure, the speed limit is not considered outside agglomerations.

Table 3.4 Overview of the factors related to road traffic noise scenarios outside agglomerations. Cells in red indicate those factors that contribute to an increase in noise pollution. Green indicate that the considered factor results in a dB decrease (noise pollution reduction) in the specific scenario. Cells in grey are related to factors that are not relevant for the particular year and scenario.

Factor	Reference	Scenario 2022	Scenario 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Extrapolation from LUISA projections for 2020 and 2025 (backwards extrapolation for 2017-2020)	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Transport activity change	Road traffic growth forecast (in Gpkm), and the freight traffic growth (in Gtkm) based on the EU Reference Scenario (EC et al., 2021b) and PRIMES model (E3 Modelling, 2018).	Road traffic growth forecast is provided at a country level and for each year of the scenarios. Values for 2030 are the same in both scenarios. It is assumed 3 dB increase per doubling traffic volume.		
C. Noise emissions regulations	Share of vehicles from ACEA 2022 (ACEA, 2022). Percentage of vehicles complying with new regulations (EC et al., 2021a) and emission values (Linear regression from EC et al., 2021a).	The decrease in emissions is based on the vehicle fleet, change on the percentage of vehicles complying with new regulations (2020) and related emission values	The decrease of emissions is based on the vehicle fleet, change on the percentage of vehicles complying with new regulations (2024) and related emission values	-2 dB
D. Low noise asphalt on major roads	It is assumed 2 dB reduction on major roads and 1 dB reduction on other roads. Phenomena project (EC et al., 2021a) and END Noise Action Plans (Blanes et al., 2020; Fons-Esteve et al., 2021a)	2 % increase of low noise asphalt from 2017 -2 dB	5 % increase of low noise asphalt from 2017 -2 dB	10 % increase of low noise asphalt from 2017 -2 dB
E. Noise barriers on major roads	Own estimates based on data from countries	0,5 % increase in noise barriers on major roads -10 dB reduction	1,3 % increase in noise barriers on major roads -10 dB reduction	3 % increase in noise barriers on major roads -10 dB reduction

Figure 3.6 General workflow of scenarios for road traffic noise outside agglomerations. Demographic changes (A) (in dark blue), factors related to traffic flow (B), technological changes resulting from policy measures (C), and other noise abatement measures (D and E) contribute to the population change exposed to road traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.4, which provides the reference values used for the different scenarios. Further details can be found in Annex 2.



3.5 Rail traffic noise scenarios

3.5.1 Rail traffic noise inside agglomerations scenarios

Table 3.5 provides an overview of the scenarios for rail traffic noise inside agglomerations, with references and specifications for the different factors that are taken into consideration for calculating the scenarios.

Figure 3.7 provides an overview of the workflow to calculate rail traffic noise scenarios inside agglomerations. This workflow is common for the three scenarios (2022 and two scenarios for 2030) and it is developed in a stepwise process where the several factors that interact with noise exposure are progressively integrated.

Calculation details in relation to each factor included in the scenarios, including explanations, references, assumptions and examples on how to perform the calculations, have been included in Annex 3.

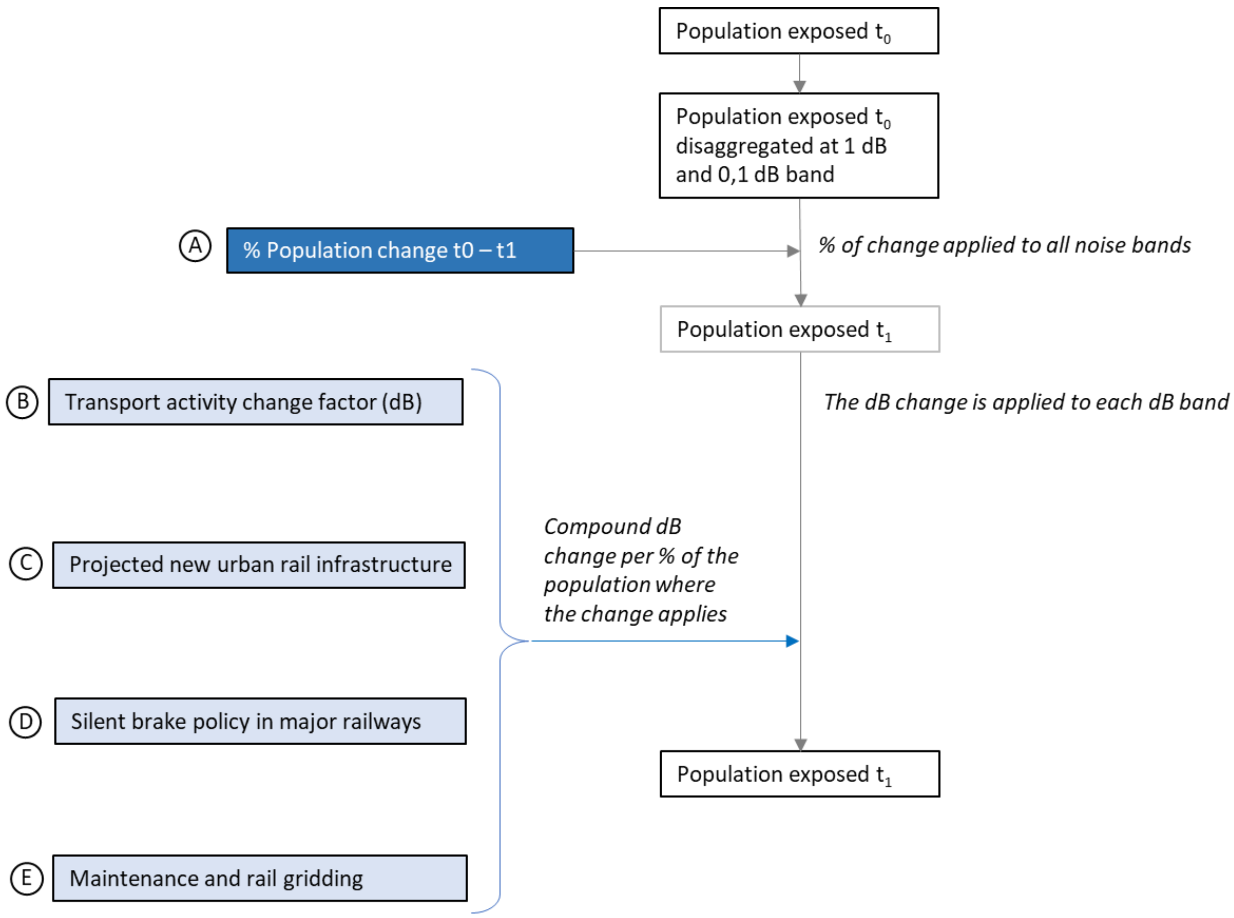
Since the railway network in Europe is mainly electrified (EC, 2017), and rail runs almost exclusively on electricity in urban areas as of 2017, the electrification factor has not been included in scenarios for rail inside agglomerations.

Moreover, it should be considered that noise barriers were not included in the scenarios calculated for rail traffic noise since we opted to prioritise those measures subject to European regulations. Also, the Phenomena study (EC et al., 2021a) concluded that the effects of noise barriers are small, as they affect only a limited percentage of the railway lengths. It has also been considered that noise barriers for railway are already widely applied, and therefore, there is less room for an increase. Moreover, the dB increase of new lines considers the whole infrastructure that includes noise barriers in urbanised areas.

Table 3.5 Overview of the factors related to rail traffic noise scenarios inside agglomerations. Cells in red indicate those factors contributing to increased noise pollution. Green indicate that the considered factor results in a dB decrease (noise pollution reduction) in the specific scenario. Cells in grey are related to factors that are not relevant for the particular year and scenario.

Factor	Reference	Scenario 2022	Scenario 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Extrapolation from LUISA projections for 2020 and 2025	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Transport activity change	Projections based on International Union of Railways (IEA and IUR, 2017)	Increase by 12 % of rail activity +0,5 dB	Increase by 87 % of rail activity +2,7 dB	Increase by 33 % of rail activity +1,2 dB
C. Projected new urban rail infrastructure	(UITP, 2019)	+0,3 dB	+1,5 dB	+0,5 dB
D. Silent brake policy in major railways	(EUAR, 2018)	-0,3 dB	-0,7 dB	-0,7 dB
E. Maintenance and rail grinding	Phenomena project (EC et al., 2021a)	Not considered in this scenario	Not considered in this scenario	-2 dB

Figure 3.7 General workflow of scenarios for rail traffic noise inside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), new urban rail infrastructure (C) and other noise abatement measures (D and E) contribute to the population change exposed to rail traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.5 which provides the reference values used for the different scenarios. Further details can be found in Annex 3.



3.5.2 Rail traffic noise outside agglomerations scenarios

Table 3.6 provides an overview of the scenarios for rail traffic noise outside agglomerations, with references and specifications for the different factors that are taken into consideration for calculating the scenarios.

Figure 3.8 provides an overview of the workflow to calculate rail traffic noise scenarios outside agglomerations. This workflow is common for the three scenarios (2022, and two scenarios for 2030) and it is developed in a stepwise process where the several factors that interact with noise exposure are progressively integrated.

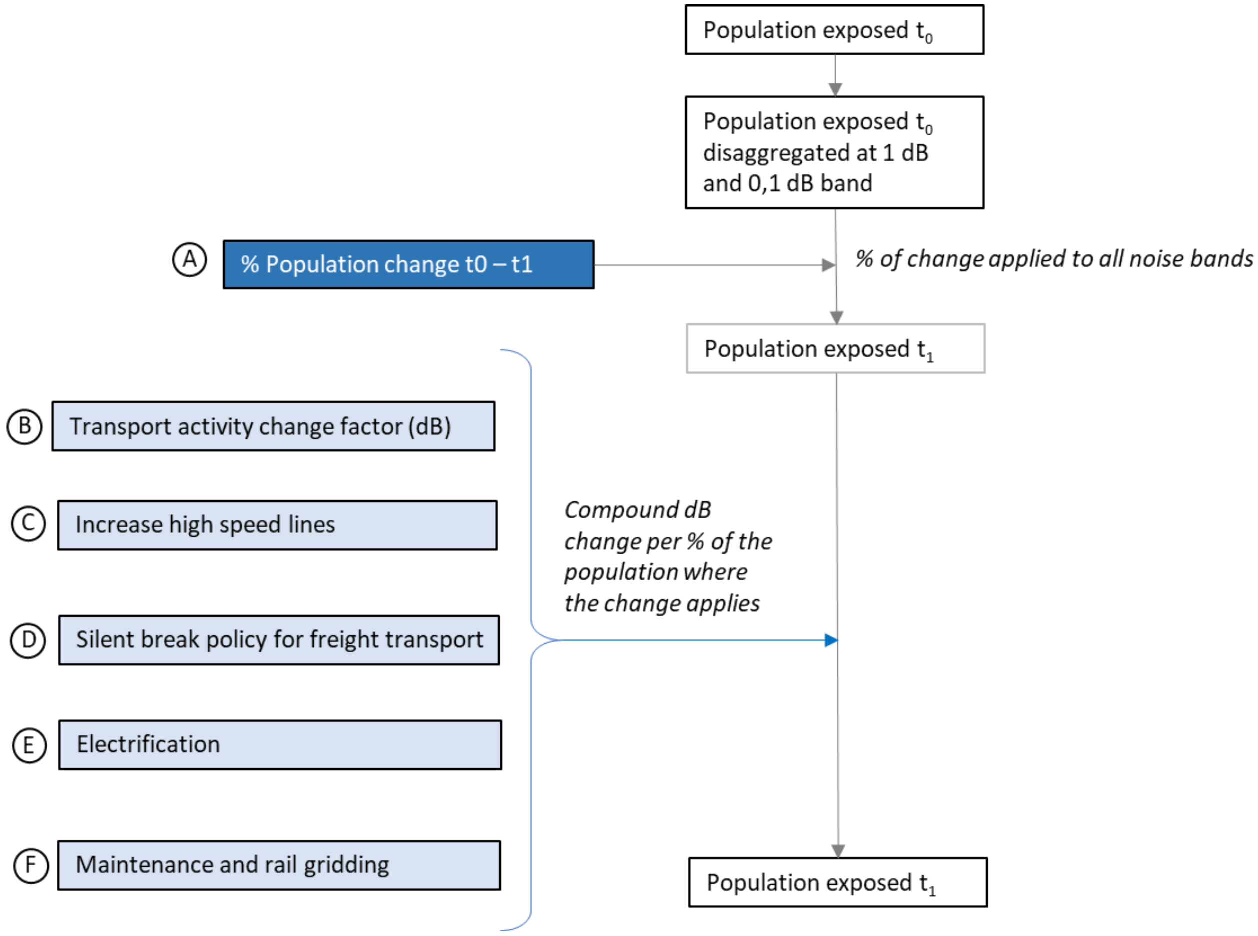
Calculation details in relation to each factor included in the scenarios, including explanations, references, assumptions and examples on how to perform the calculations have been included in Annex 4.

Moreover, it should be considered that noise barriers were not included in the scenarios calculated for rail traffic noise since we opted to prioritise those measures subject to European regulations. Also, the Phenomena study (EC et al., 2021a) concluded that the effects of noise barriers are small, as they affect only a limited percentage of the railway lengths. It has also been considered that noise barriers for railway are already widely applied, and therefore, there is less room for an increase.

Table 3.6 Overview of the factors related to rail traffic noise scenarios outside agglomerations. Cells in red indicate those factors contributing to increased noise pollution. Green indicate that the considered factor results in a dB decrease (noise pollution reduction) in the specific scenario. Cells in grey are related to factors that are not relevant for the particular year and scenario.

Factor	Reference	Scenario 2022	Scenario 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Extrapolation from LUISA projections for 2020 and 2025	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Transport activity change	Rail passenger traffic growth forecast (in Gpkm), and the freight traffic growth (in Gtkm) based on the EU Reference Scenario (EC et al., 2021b) and PRIMES model (E3 Modelling, 2018)	Rail traffic growth forecast is provided at a country level and for each year of the scenarios. Values for 2030 are the same in both scenarios. It is assumed 3 dB increase per doubling traffic volume.		
C. Increase of high speed lines	Based on UIC (2021)	Not considered in this scenario	+1,5 dB	+0,8 dB
D. Silent brake policy for freight transport	(EUAR, 2018)	-0,3 dB	-0,7 dB	-0,7 dB
E. Electrification	Estimations based on EC (2017)	-0,1 dB	-0,3 dB	-0,3 dB
F. Maintenance and rail grinding	Phenomena project (EC et al., 2021a)	Not considered in this scenario	Not considered in this scenario	-0,5 dB

Figure 3.8 General workflow of scenarios for rail traffic noise outside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), new high-speed lines (C) and other noise abatement measures (D, E and F) contribute to the population change exposed to rail traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.6, which provides the reference values used for the different scenarios. Further details can be found in Annex 4.



3.6 Aircraft noise scenarios (inside and outside agglomerations)

The factors included in the scenarios for air traffic noise are the same inside and outside agglomerations. Therefore, the scenarios are not described separately.

A major constraint to calculate scenarios for airports is that each airport has its specificities (location of the airport, population living next to the airport, the proportion of the people affected living within or outside an urban area, fleet mix, flight procedures, night movements, degree of implementation of noise control measures under the Balanced Approach, etc.), which significantly influence the outcomes of the scenarios.

Some of the changes selected for a given scenario will have a positive effect on one airport, whereas the same measure at another airport may not have an effect at all. Even at a single airport, a noise solution with a benefit at one location may negatively affect another location (e.g. shift of flight tracks). The effects at specific locations and the overall effect for the whole airport will depend on the local situation and the actual scenario considered. However, the scenarios proposed in this report are intended to be aggregated at a EU27; therefore, local differences may compensate by providing reasonable European projections.

Noise reductions for new aircraft are driven by ICAO (2017) and adopted in the EU through Regulation (EU) No 2018/1139 (European Parliament and Council, 2018) and the EASA Certification Noise Levels (EASA, 2018). The most recent reduction in permitted noise standards for subsonic jet and propeller-driven aeroplanes was adopted in 2014, and it is applicable to new aeroplane types submitted for certification on or after 31 December 2017 and on or after 31 December 2020 for aircraft less than 55 tonnes in mass.

Mitigation of aircraft noise associated with airports' operation is regulated by the Balanced Approach Regulation (European Parliament and Council, 2014). The Balanced Approach Regulation, which the ICAO Assembly adopted in 2001, encompasses four main fields of action:

- noise reduction at the source;
- operational procedures;
- operational restrictions; and
- land-use planning and management.

The different elements included in the Balanced Approach are relevant and could reduce noise pollution equivalent to 2dB by 2030 (EC et al., 2021a).

Table 3.7 provides an overview of the scenarios for aircraft noise (inside and outside agglomerations), with references and specifications for the different factors that are taken into consideration for calculating the scenarios.

The following factors were not considered in the calculations of the aircraft noise scenarios:

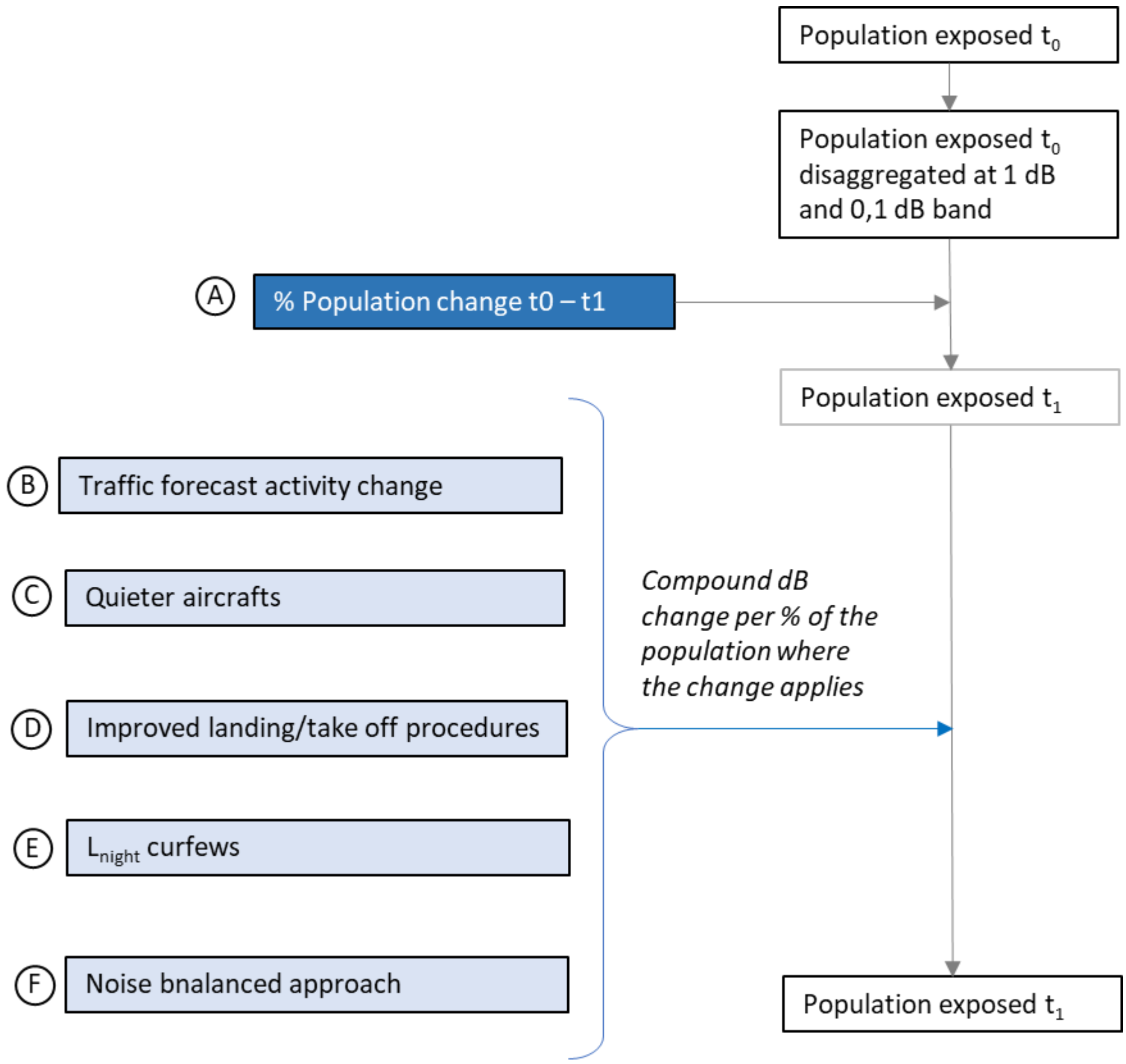
- Sound insulation of residential and communal buildings, including government incentives for homeowners. Sound insulation is a valuable mitigation tool as it is a straightforward measure that can be retrofitted in a short timescale. It is unlikely that a regulation is brought forward, and even if it were, it is unlikely that the benefit would be seen within the project timescales or at the EU scale; and
- Extension of land barrier, land use planning including acquisition of dwellings. These mitigation measures are available to regions and airports. However, in the timeframe for this study, they could not be reasonably imposed at EU level. In contrast, land use planning is effective but is subject to long-time scale regional planning. Nonetheless, they are all valuable and effective tools in reducing health impacts of noise and are worthy of consideration, particularly on a national level and with respect to minimising and mitigating impacts of airport expansion.

Calculation details in relation to each factor included in the scenarios, including explanations, references, assumptions and examples on how to perform the calculations, have been included in Annex 5.

Table 3.7 Overview of the factors related to aircraft noise scenarios inside and outside agglomerations. Cells in red indicate those factors contributing to increased noise pollution. Green indicate that the considered factor results in a dB decrease (noise pollution reduction) in the specific scenario. Cells in grey are related to factors that are not relevant for the particular year and scenario.

Factor	Reference	Scenario 2022	Scenario 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Extrapolation from LUISA projections for 2020 and 2025	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Traffic forecast activity change	"COVID-19 impact on the European air traffic network" (Eurocontrol, 2021). European Aviation Environmental Report (EASA et al., 2019)	10 % reduction from 2019 due to COVID-19 -0,4 dB	Traffic recovery to 2019 levels reached in 2024. Then, from 2024, air traffic growth by 2 % a year. No differences between the two scenarios. +0.09 dB a year from 2024	
C. Quieter aircraft	Low uptake of new technologies 2017 – 2022, and then 0,1 dB reduction per annum (ICAO, 2019)	Assumed to be no significant change in 2022	-0.1 dB per annum	-0.1 dB per annum
D. Improved landing/take-off procedures	(EC et al., 2021a)	Not considered in this scenario	-2 dB	-2 dB
E. Night curfews	(EC et al., 2021a)	Not considered in this scenario	Not considered in this scenario	- 2 dB
F. Noise balanced approach	(EC et al., 2021a)	Not considered in this scenario	Not considered in this scenario	Other -2 dB

Figure 3.9 General workflow of scenarios for air traffic noise (inside and outside agglomerations). Demographic changes (A) (in dark blue), factors related to traffic flow (B), and other noise abatement measures (C to F) contribute to the population change exposed to air traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.7 which provides the reference values used for the different scenarios. Further details can be found in Annex 5.



3.7 Health risk assessment calculations

Noise exposure has negative impacts on human health through various mechanisms. High levels of noise cause chronic sleep disturbances with well-established consequences for cardio-metabolic and mental health. Noise is also a stressor that can lead to the activation of the autonomous nervous system and the hypothalamus-pituitary-adrenal (HPA) axis. This results in changes of blood pressure, heart rate variability, glucose metabolism and lipid metabolism that then contribute to an increased risk of cardiovascular disease, metabolic syndrome (diabetes) and mental health. In the WHO Environmental Noise Guidelines for the European Region (WHO Europe, 2018), noise research published until 2015 has been evaluated to derive guidelines. Specifically, in relation to road, rail, aircraft and wind turbine noise, systematic reviews and meta-analyses have been conducted for the following critical outcomes: incidence of ischemic heart disease (IHD), incidence of hypertension, percentage of highly annoyed (%HA), percentage of highly sleep disturbed (%HSD) and reading and oral comprehension. Further, permanent hearing impairment from leisure noise such as personal audio players was evaluated. In addition to these *critical* outcomes the following *important* outcomes were also evaluated in the WHO report: adverse birth outcomes (birth weight, pre-term delivery, small for gestational age), quality of life, well-being and mental health (emotional and conduct disorders in childhood, self-reported quality of life and various measures of depression, anxiety and psychological distress) as well as metabolic outcomes (diabetes, overweight). In general, research on these *important* outcomes was scarce and less conclusive.

Proposed noise guidelines were set for the levels where the accepted risk was exceeded for the critical outcomes only. Accepted risk increase was set to 5 % relative excess risk for IHD incidence, 10 % relative excess risk for incidence of hypertension, 10 % increase in the proportion %HA people, 3 % increase in the proportion %HSD people and one-month delay in terms of reading age (cognition). Subsequently, from all derived critical thresholds, the lowest level was chosen for the guidelines (Table 3.8).

Table 3.8 Noise guidelines according to WHO and END

Source	WHO		END	
	L_{night}	L_{den}	L_{night}	L_{den}
Road	45 dB	53 dB	50 dB	55 dB
Rail	44 dB	54 dB	50 dB	55 dB
Air	40 dB	45 dB	50 dB	55 dB

In a health risk assessment, the exposure distribution of the target population is combined with exposure response functions, which may be derived from a different context, to obtain the number of people affected by the exposure. In the frame of this report the number of highly annoyed and highly sleep disturbed is calculated for the EU as a whole and for each EU country, stratified by inside and outside agglomeration. This calculation is done for each scenario 2017, 2022, and 2030. For the calculation of %HA the exposure distribution of L_{den} is used, and for the calculation of %HSD the exposure distribution of Ln_{ight} is used. Two calculations were done based on different noise thresholds. 1. for %HA and %HSD effects ≥55 dB (L_{den}) and ≥50 dB (L_{night}) are calculated in line with the END noise reporting standards of the EU. 2. source specific thresholds equal to the WHO noise guidelines (Table 3.7) have been applied. Health risk above the corresponding thresholds was calculated by disaggregating the exposure distribution for road, rail and aircraft noise in 1-dB steps, separated by inside and outside agglomeration region.

For the calculation, the exposure-response functions for %HA and %HSD from the WHO noise guidelines are used as done in the EEA Report Environmental Noise in Europe – 2020 (EEA, 2020b). These exposure-response functions were separately derived for road, rail and aircraft noise (Table 3.9 and Figure 3.10) and provide the percentage of highly annoyed (Guski et al., 2017) and highly sleep disturbed people (Basner and McGuire, 2018) at given noise levels. Finally, the %HA or %HSD in each 1-dB exposure category is multiplied with the corresponding proportion of adults by country in the respective exposure category, and summed, to obtain the number of highly annoyed and highly sleep disturbed people in each country, separated by inside and outside agglomeration.

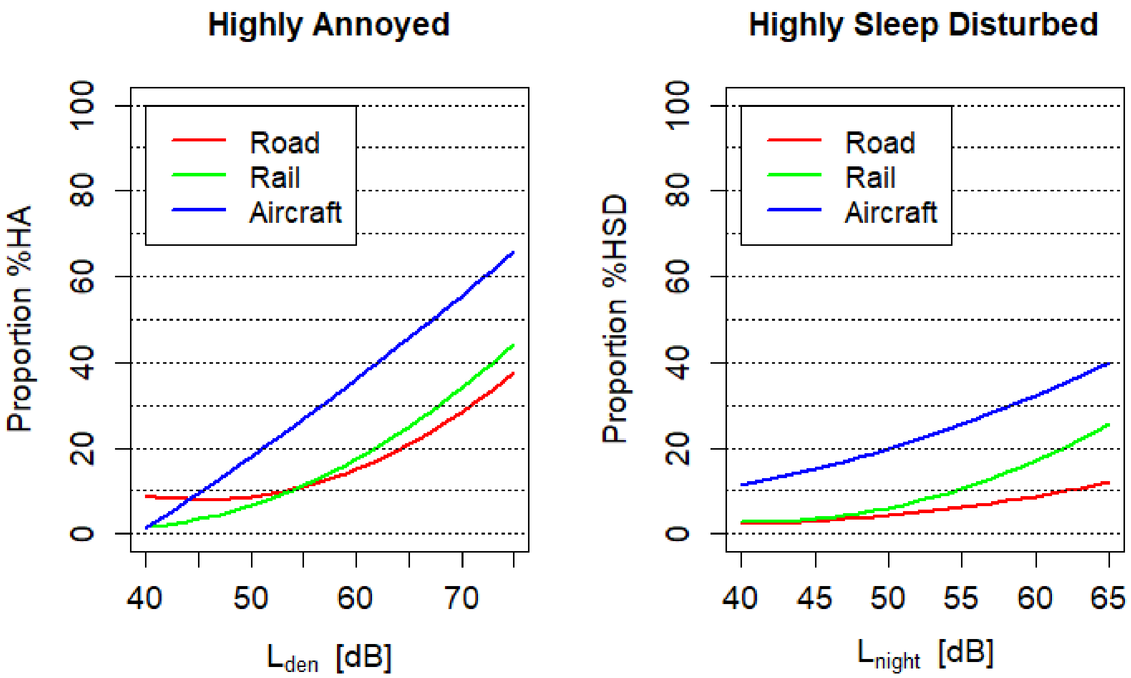
Of note, the exposure-response curves from WHO refer to steady state conditions. They thus do not take into account that the annoyance and potentially also the sleep response of the community to an increase (decrease) in the exposure is typically higher (lower) than what is expected from the change in noise levels alone as estimated by steady-state curves (Brown and Van Kamp, 2017). This *change response* may depend on contextual and so-called non-acoustical factors such as concomitant communication activities, which needs to be considered when interpreting the temporal changes of the projections.

Table 3.9 Exposure-response function for %HA and %HSD from the WHO noise guidelines

Outcome	Source	Formula
Highly annoyed *	Road	Estimated %HA = 78.9270 − 3.1162·*Lden* + 0.0342·*Lden*^{2}
	Rail	Estimated %HA = 38.1596 − 2.05538·*Lden* + 0.0285·*Lden*^{2}
	Aircraft	Estimated %HA = -50.9693 + 1.0168·*Lden* + 0.0072·*Lden*^{2}
Highly sleep disturbed *	Road	Estimated %HSD = 19.4312 − 0.9336 ·*Lnight* + 0.0126·*Lnight*^{2}
	Rail	Estimated %HSD= 67.5406 − 3.1852·*Lnight* + 0.0391·*Lnight*^{2}
	Aircraft	Estimated %HSD=16.7885 − 0.9293·*Lnight* + 0.0198·*Lnight*^{2}

*Original reference for %HA are published in Guski et al., 2017, and for %HSD in Basner and McGuire, 2018.

Figure 3.10 Exposure-response functions of %HA and %HSD according to the WHO noise guidelines.



4 Population exposed to different scenarios

4.1 Overview

Figure 4.1 to Figure 4.4 show that, based on the scenarios analysed in this assessment, overall, the zero-pollution action plan (ZP) objective on noise is unlikely to be achieved by 2030. It should be noted that the Zero Pollution Action Plan call for a 30 % reduction of people chronically disturbed, which is evaluated in chapter 5 on the health impact. Therefore, in this section the 30 % is only set as a potential threshold for comparison between noise sources.

As shown, one of the main stoppers is the large number of people exposed to road traffic noise. A high implementation of a combination of measures such as switching to electric vehicles, reducing speed limits, implementing the noise emission regulations for vehicles, and further extending low noise asphalts and noise barriers could achieve an 18 million decrease to below END thresholds inside agglomerations. The number of measures that can be applied outside agglomerations is more limited and therefore the decrease of the number of people affected by noise from roads outside agglomerations will be more difficult to be reduced. As shown in the conservative scenario, it can even increase by 1,1 million if no additional measures are implemented.

In terms of railway noise, the results show that the number of people exposed to rail traffic can only decrease by about 1 million in the best implementation scenario and only inside agglomerations. The increase in transport activity for rail is much larger than the forecasted for road and aircraft traffic which leads to increased noise levels in the areas affected. Therefore, from the scenarios analysed it seems unlikely that a significant decrease of people exposed to railway noise will be achieved by 2030.

Although the ZP objectives are unlikely to be reached globally, a 30 % reduction of people exposed to aircraft noise could be reached with progressive uptake of quieter aircrafts and improved landing and taking off procedures. The best implementation scenario shows that even a higher percentage of reduction of people exposed to aircraft noise could be achieved. However, even if the objective is met, there will still be a very high number of people exposed to aircraft noise levels above the WHO recommendations.

Figure 4.1. Outlooks for 2022 and 2030 for the day-evening-night period and two scenarios. Colours differentiate between people exposed to END thresholds (≥ 55 dB L_{den}) and additional people exposed to the lower noise limits set by the WHO guidelines. Coverage: EU27.

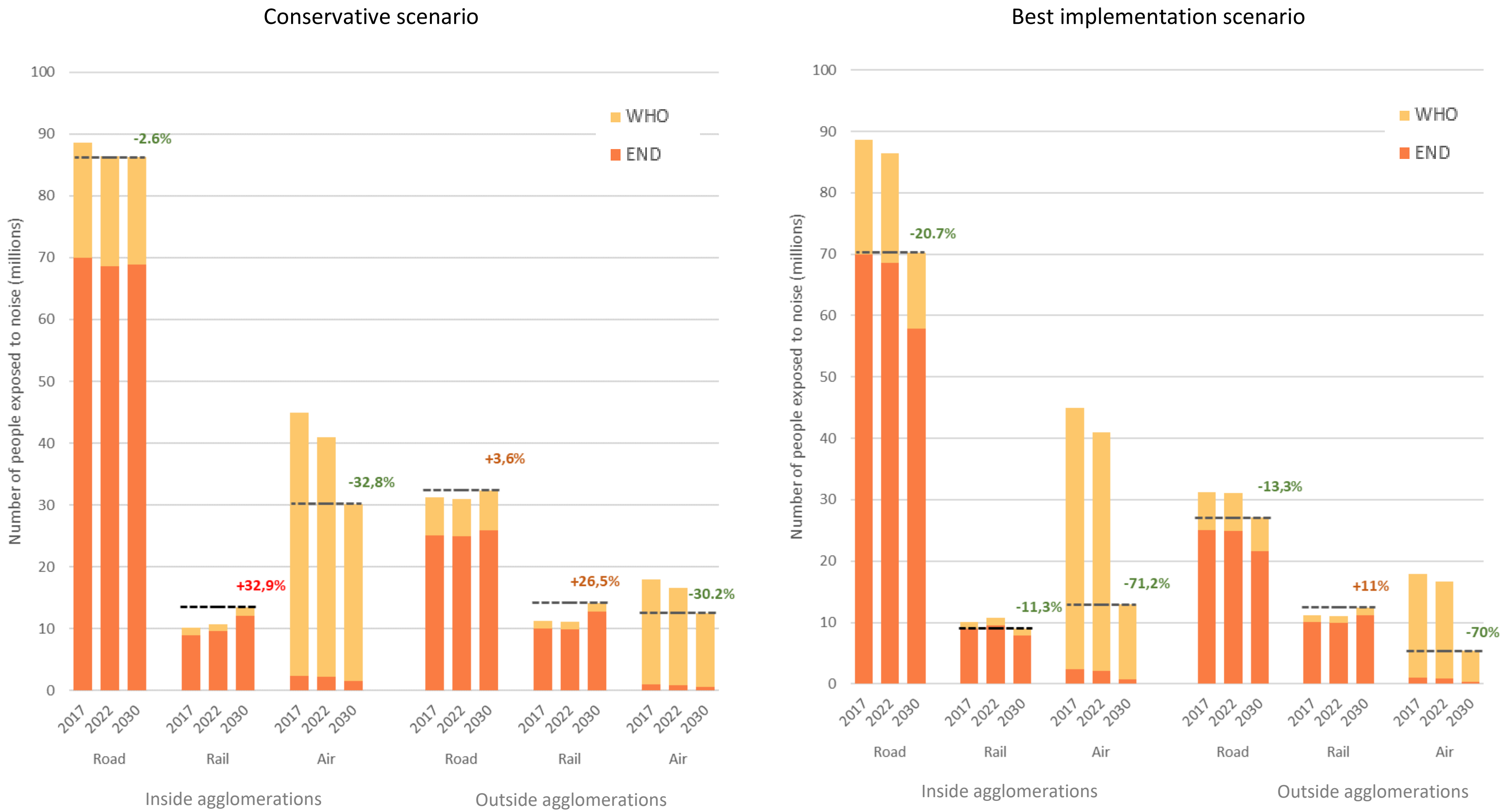


Figure 4.2. Outlooks for 2022 and 2030 for the night period and two scenarios. Colours differentiate between people exposed to END thresholds (≥ 50 dB L_{night}) and additional people exposed to the lower noise limits set by the WHO guidelines. Coverage: EU27.

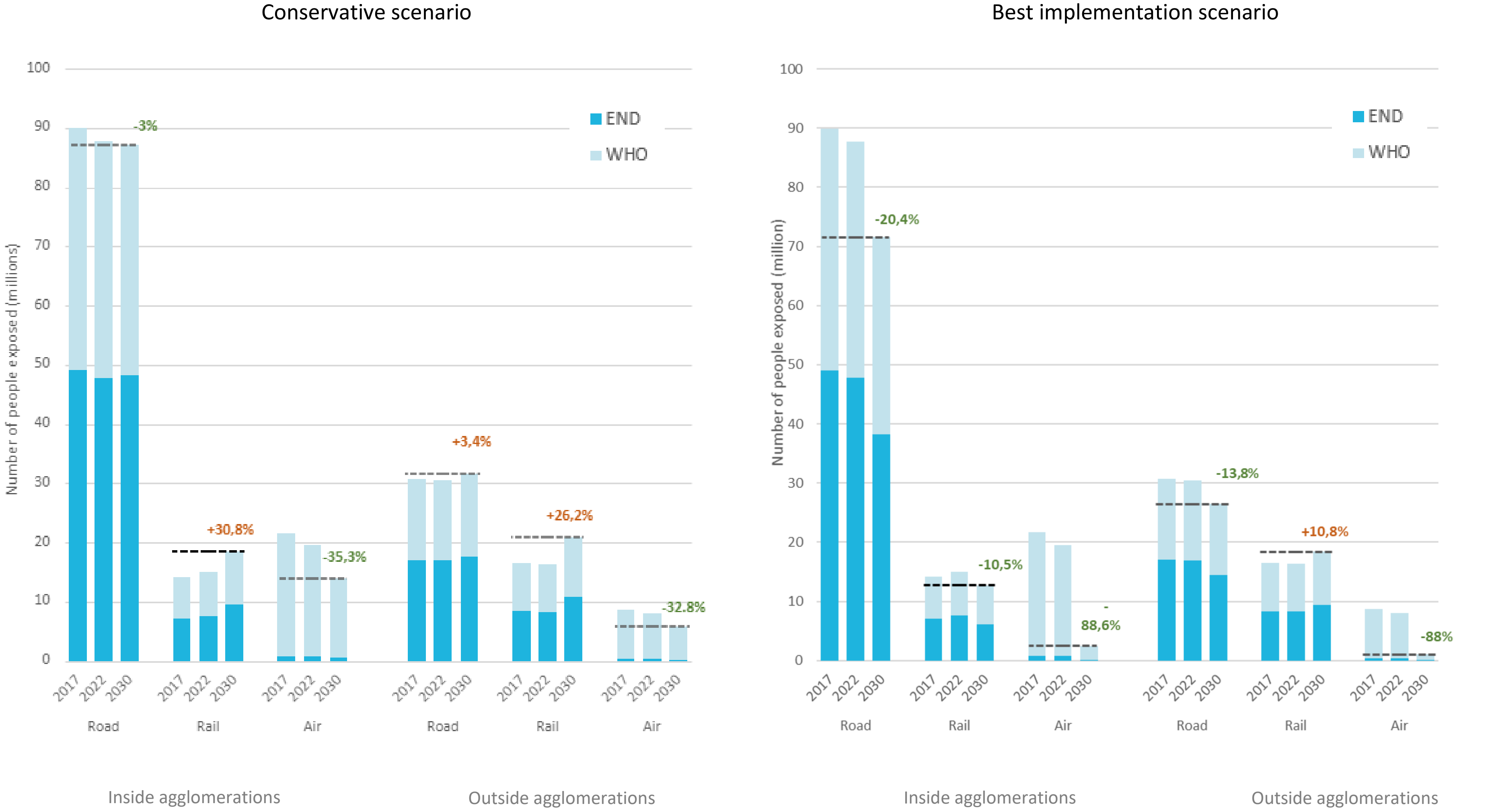


Figure 4.3. Outlooks for 2022 and 2030 in areas covered by the END for the day-evening-night period (left) and night period (right) and for two scenarios (dotted line -conservative, versus solid line -best implementation). Colours differentiate noise sources. A dotted line for each noise source refers to the conservative scenario, and a continuous line shows the best implementation scenario. Each noise source refers to aggregated data for both inside and outside agglomerations. Coverage: EU27.

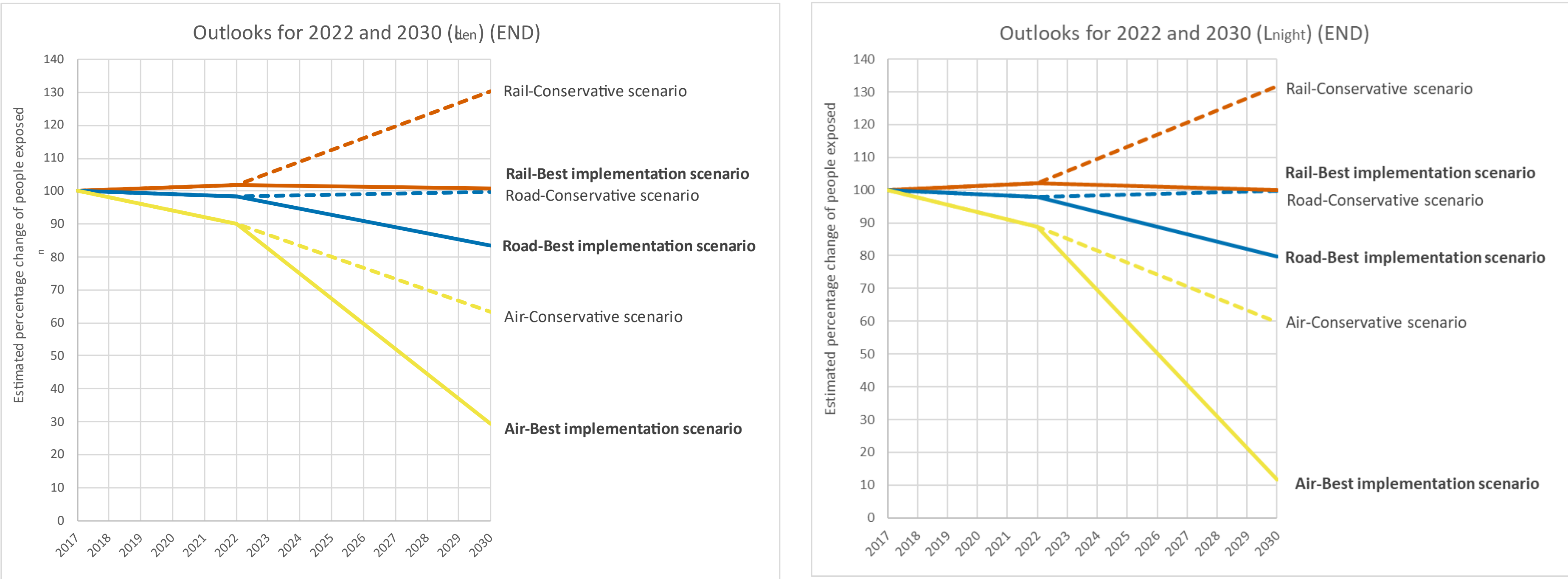
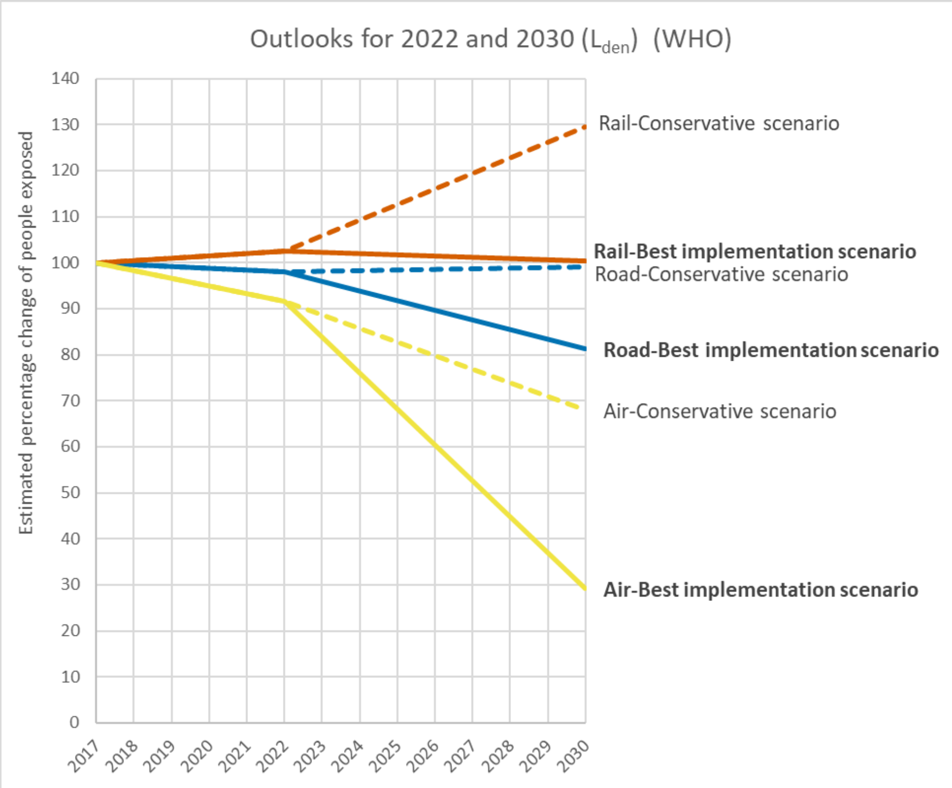


Figure 4.4. Outlooks for 2022 and 2030 according to WHO noise guidelines for the day-evening-night period (left) and night period (right) and for two scenarios (dotted line -conservative, versus solid line -best implementation). Colours differentiate noise sources. A dotted line for each noise source refers to the conservative scenario, and a continuous line shows the best implementation scenario. Each noise source refers to aggregated data for both inside and outside agglomerations. Coverage: EU27.



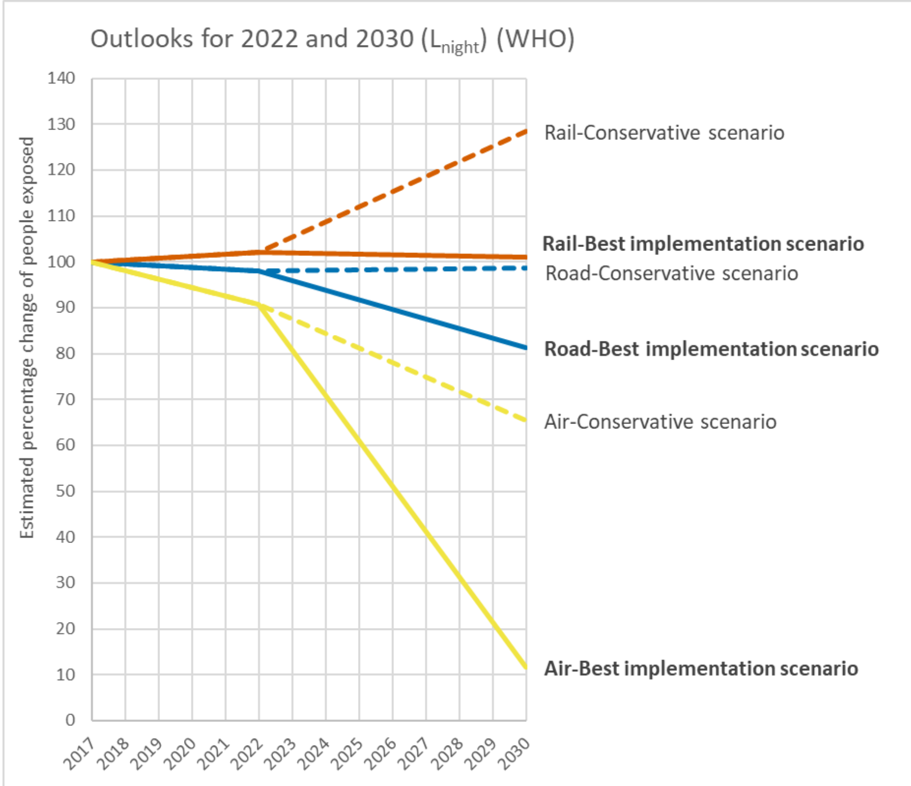
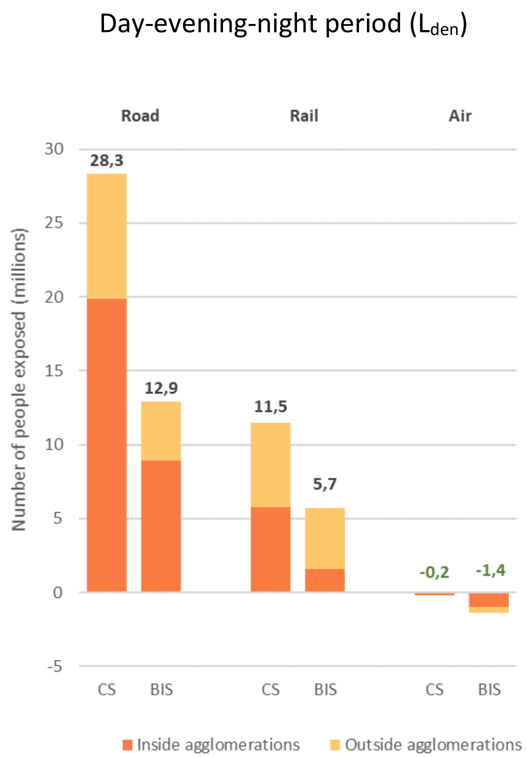
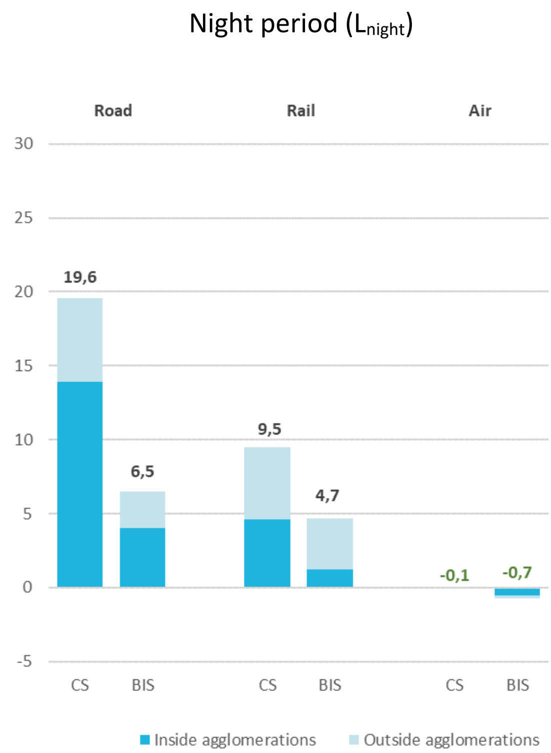


Figure 4.5. Number of people exposed to noise exceeding a theoretical 30 % reduction target by 2030 in the day-evening-night period (left) and night period (right), per noise source and scenario (based on END thresholds). Dark orange and dark blue indicate inside the agglomeration. Light orange and light blue refer to outside agglomeration. Scenarios: CS, conservative scenario; BIS, best implementation scenario. Negative values indicate that the 30 % reduction target has been achieved, and even more people than the target will benefit from the noise pollution reduction.





The values presented in the previous figures are further differentiated into inside agglomerations and outside agglomerations. This differentiation is relevant since noise management has its specificities in each case.

Figure 4.6 shows that noise pollution for the day-evening-night period (L_{den}) will only be significantly reduced for air transport. The same pattern applies to night noise levels (L_{night}) (Figure 4.7). These figures refer to the END thresholds. Moreover, the noise reduction in all air transport cases is below the 30 % target of the Zero Pollution Action Plan.

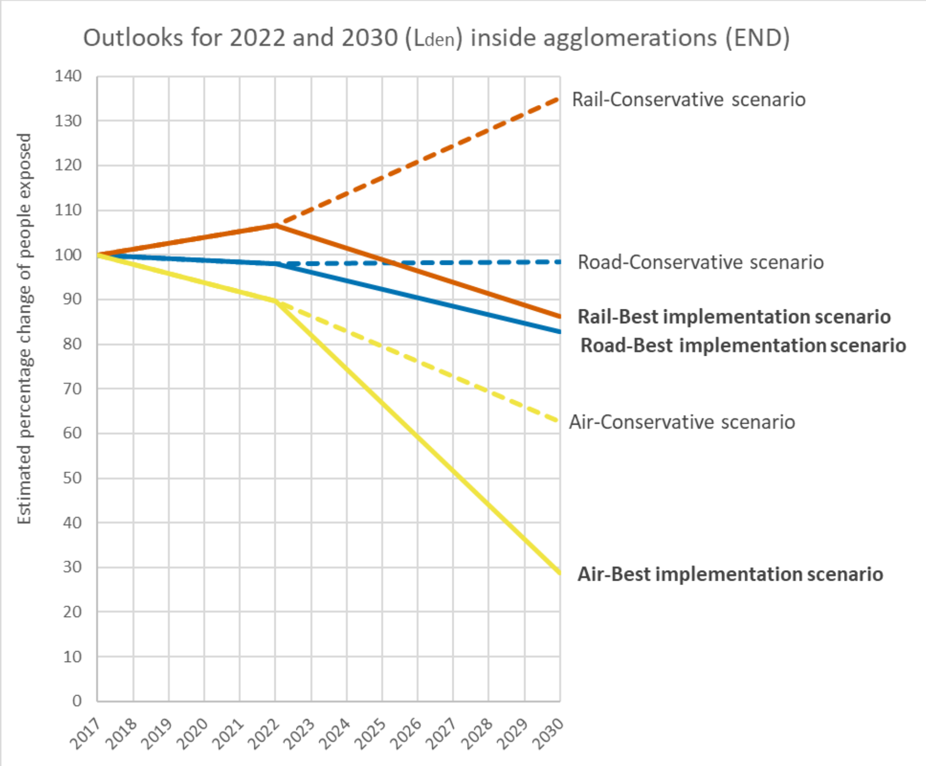
The projected trend for air traffic noise reflects the impact of the COVID-19 restrictions on air traffic in 2022 (estimated reduction of air activity by 10 % compared to 2019). Moreover, improved landing and take-off procedures significantly reduce noise pollution in the conservative scenario -additional factors contribute to a higher decrease in the best implementation scenario. The percentage of change between 2017 and 2030 is the same inside and outside agglomerations.

Under the conservative scenario, rail transport is the source with the highest projected increase, both inside (35 % increase) and outside agglomerations (27 % increase). A similar pattern is observed for the night period. These figures reflect that the noise abatement measures do not offset the impact of increased rail activity and, to a lesser extent, the overall population growth between 2017 and 2030. The best implementation scenario for rail noise outside agglomerations also does not achieve the noise pollution reduction target for 2030, showing an increase of 11 % compared to 2017. On the opposite, rail noise inside agglomerations reduces 14 % of the number of people exposed above the END threshold (≥

55dB L_{den}) in the best implementation scenario. It needs to be highlighted that several factors contribute to the lower performance of railway noise management outside agglomerations: a higher transport activity growth outside agglomerations, new infrastructure (an increase of high-speed lines outside agglomerations) and a lower noise reduction by maintenance and rail grinding outside agglomerations. Details are provided in section 4.3.

The conservative scenario of road traffic noise shows that the number of people exposed remains relatively stable in the period analysed, with a slight decrease inside agglomerations (-1,8 %), while increasing outside agglomerations (3,6 %). The factors considered in the best implementation scenario reduce road traffic noise pollution by 17,3 % inside agglomerations and 13,4 % outside agglomerations (Figure 4.6). These reductions are slightly higher during the night period: 21,9 % inside agglomerations and 15,5 outside agglomerations (Figure 4.7).

Figure 4.6 Outlooks for 2022 and 2030 (L_{den}) inside (left) and outside (right) agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.



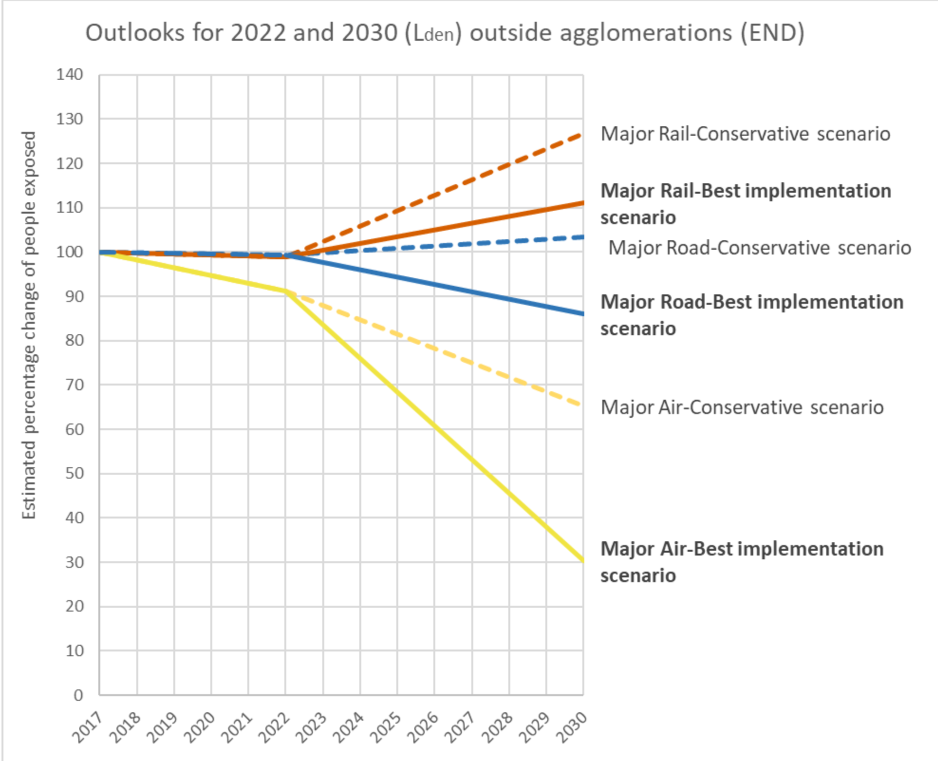
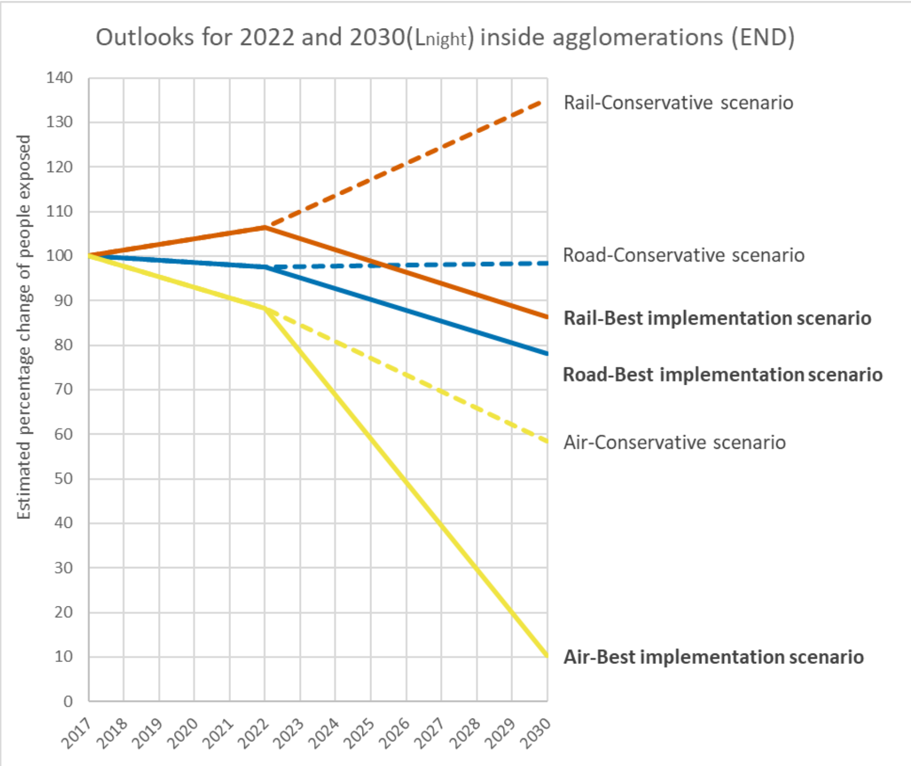


Figure 4.7 Outlooks for 2022 and 2030 (L_{night}) inside (left) and outside (right) agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.



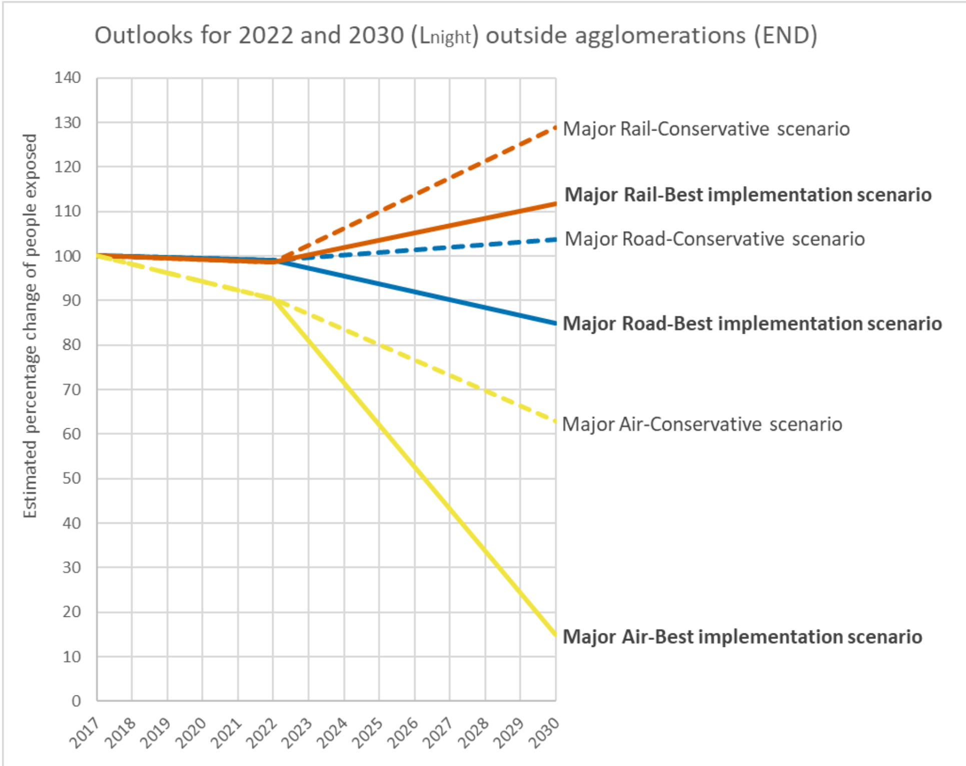


Table 4.1 Change in the population exposed between 2017 and 2030 for two scenarios. Results are presented for two thresholds: END and WHO noise guidelines. For each noise source, the dB threshold is shown (grey line).

		END thresholds			WHO noise guidelines		
		2017 People exposed	**2017 – 2030 People exposed change**		**2017 People exposed**	**2017 – 2030 People exposed change**	
			Conservative scenario	*Best implementation scenario*		*Conservative scenario*	*Best implementation scenario*
Day-evening-night-period	**Road**	END ≥ 55dB			WHO ≥ 53 dB		
	inside	70,0	-1,0	-12,1	88,6	-2,3	-18,4
	outside	25,1	0,9	-3,5	31,2	1,1	-4,2
	Rail	END ≥ 55dB			WHO ≥ 54 dB		
	inside	9,0	3,1	-1,1	10,1	3,3	-1,1
	outside	10,0	2,7	1,1	11,2	3,0	1,2
	Air	END ≥ 55dB			WHO ≥ 45 dB		
	inside	2,4	-0,9	-1,7	44,9	-14,7	-32,0
	outside	1,0	-0,3	-0,7	17,9	-17,9	-17,9
Night period	**Road**	END ≥ 50dB			WHO ≥ 45 dB		
	Inside	49,0	-0,8	-10,8	89,9	-2,7	-18,4
	outside	17,0	5,7	2,5	30,7	1,0	-4,2
	Rail	END ≥ 50dB			WHO ≥ 44 dB		
	inside	7,1	2,5	-1,0	14,2	4,4	-1,5
	outside	8,4	2,4	1,0	16,6	4,3	1,8
	Air	END ≥ 50dB			WHO ≥ 40 dB		
	inside	0,8	-0,3	-0,7	21,6	-7,6	-19,2
	outside	0,4	-0,1	-0,3	8,7	-2,8	-7,6

4.2 Road noise

Projected scenarios lead to a different pattern in road traffic noise inside agglomerations compared with outside agglomerations (Figure 4.8). Inside agglomerations, both scenarios result in a reduction in the number of people exposed by 2030. Although, the reduction for the conservative scenario is meagre (1,5 % for the day-evening-night-period and 1,6 % for the night period). Outside agglomerations, noise pollution is only reduced in the best implementation scenario. Even in the best scenario, the noise reduction is below a potential 30 % reduction target for 2030. Consequently, the number of people exceeding the 30 % target in 2030 in the best scenario is about 13 million people during the day-evening-night period and 6,5 million people during the night period (Table 4.2). These figures take into account the noise threshold set by the END. Considering the more stringent dB threshold recommended by the WHO, the number of people exposed above the 30 % target is half a million more in the day-evening-night period, and 13,6 million exceed the 30 % target for the night period, doubling the figures based on the END (best implementation scenario).

To better understand the difficulties of reducing noise pollution, Table 4.3 provides an overview of the factors included in each scenario and the related dB change. The more limited number of abatement measures outside agglomerations (major roads) may explain its lower performance than inside agglomerations. In the latter case, two specific measures are only applicable in the urban context: speed limit and noise reduction by increased share of electric vehicles in the fleet. It should be noted that speed limit is an effective measure also outside agglomerations. However, it was not considered outside agglomerations, as explained in section 3.4 (Specific factors for road traffic noise). There is no European regulation, and noise limits vary from country to country.

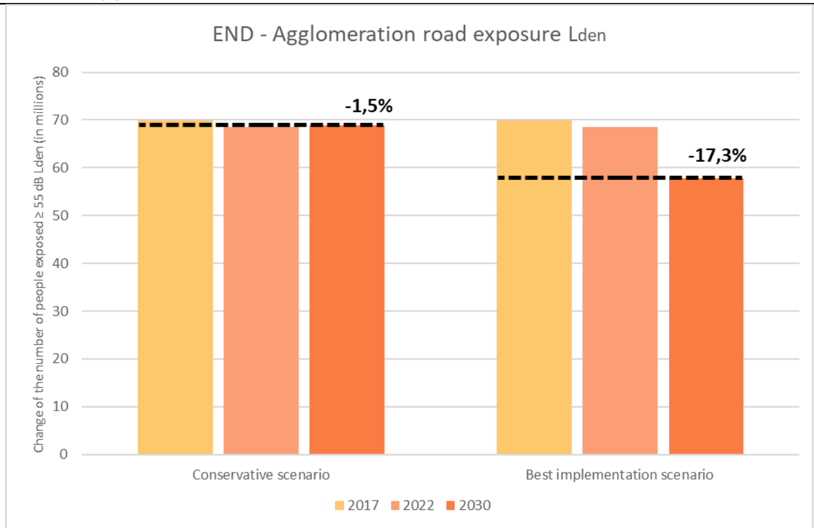
Population growth, which is common in all scenarios and noise sources, and transport activity changes are the two factors that contribute, at the European level, to an increase in the population exposed in 2022 and 2030, compared to the situation in 2017 (baseline), counterbalancing the effect of noise abatement measures. Among these measures, the regulation of the sound level of motor vehicles is the one with the highest positive impact. It should be noted that improved noise asphalt, noise barriers, and noise speed limits only apply to a limited area in the city.

Figure 4.8 Outlooks for 2022 and 2030 for road noise inside (left) and outside agglomerations (right). The bars indicate the number of people exposed in 2017-2022-2030 for the conservative and best implementation scenarios. The percentage change from 2017 to 2030 is indicated in each graph.

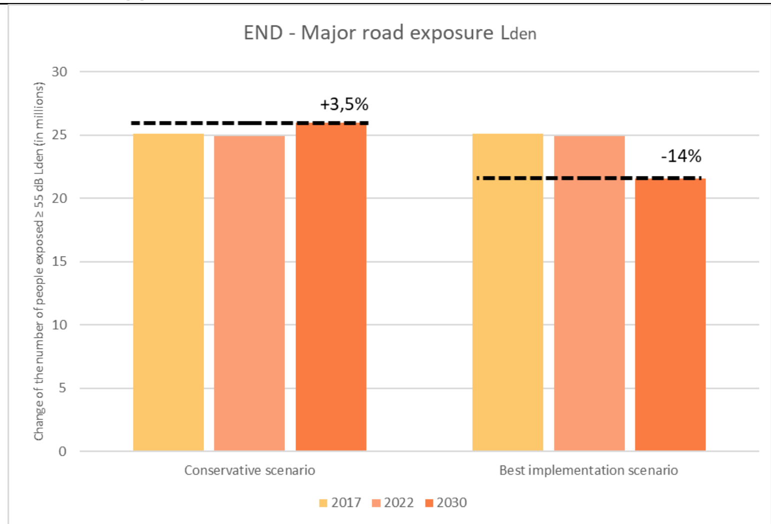
	Inside agglomerations	Outside agglomerations

L_{den}

Inside agglomerations:

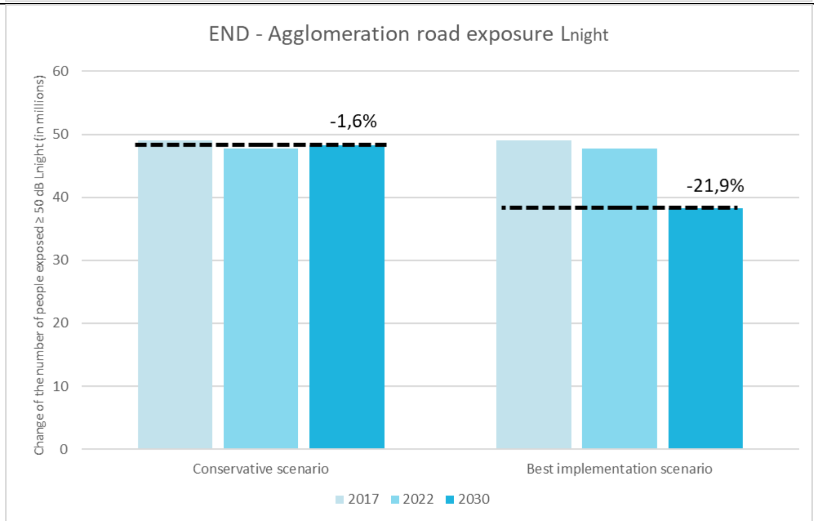


Outside agglomerations:



L_{night}

Inside agglomerations:



Outside agglomerations:

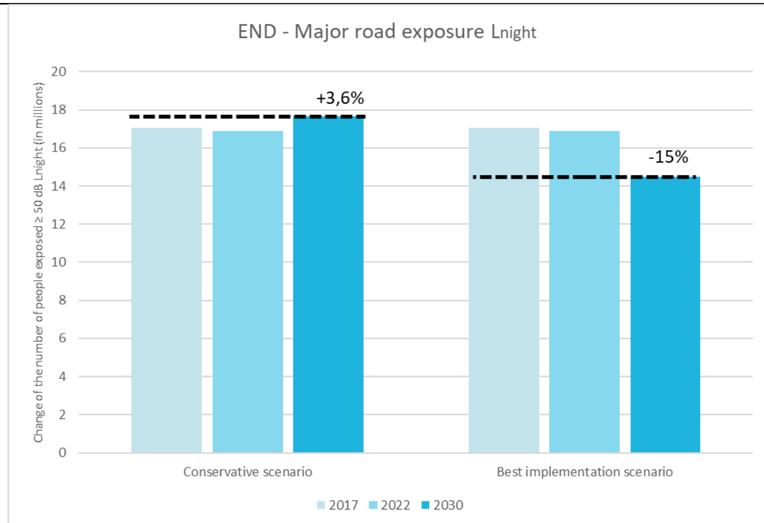


Table 4.2 Projected people exposed in 2030 (two scenarios: CS, conservative scenario; BIS, best implementation scenario) above a potential 30 % reduction target of noise exposure to road traffic noise (inside and outside agglomerations). Data is provided for the END and WHO noise guidelines' thresholds. Data in millions. Coverage: EU27.

Period	Noise sources	END thresholds				WHO noise guidelines thresholds			
		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold	
				CS	*BIS*			*CS*	*BIS*
Day-evening-night	**Road**	END ≥ 55dB				WHO ≥ 53 dB			
	inside agglomerations	70,0	49,0	19,9	8,9	88,6	62,0	24,2	8,2
	outside agglomerations	28,0	19,6	8,4	4,0	31,2	21,9	10,5	5,2
Night period	**Road**	END ≥ 50dB				WHO ≥ 45 dB			
	inside agglomerations	49,0	34,3	13,9	4,0	89,9	62,9	24,2	8,6
	outside agglomerations	15,1	10,6	5,7	2,5	30,7	21,5	10,2	5,0

Table 4.3 Factors specific to the road noise traffic scenarios and population-weighted equivalent dB change. The transport activity change is country-specific, and the values refer to the median of all countries. The colour highlights the combination of factor and scenario, resulting in a dB reduction (green), no change (not relevant for a specific scenario, 0 dB change in grey) or a dB increase (yellow to orange). For the intermediate year 2022, transport activity change results in a dB reduction in four countries, no change in two countries and a dB increase in 21 countries, reflected by the two colours in the corresponding cell. Scenarios: CS, conservative scenario; BIS, best implementation scenario.

		dB change per factor and scenario					
		Inside agglomerations			Outside agglomerations		
Factor		*22*	*30CS*	*30BIS*	*22*	*30CS*	*30BIS*
Transport activity change		0,1	1	1	0,1	1	1
Regulation on the sound level of motor vehicles		-0,1	-0,6	-2	-0,1	-0,6	-2
Electrical vehicles		0	-0,1	-0,2			
Low noise asphalt	dB reduction on major roads	-0,03	-0,08	-0,16	-0,03	-0,08	-0,16
	dB reduction on non-major roads	-0,02	-0,04	-0,09			
Noise barriers on major roads inside	dB reduction	-0,02	-0,05	-0,12	-0,02	-0,05	-0,12
Noise speed limits on major roads in	dB reduction	0	0	-0,7			

4.3 Rail noise

Projected scenarios lead to a different pattern in rail traffic noise inside agglomerations compared with outside agglomerations (Figure 4.9). However, in both cases, there is a considerable difference between the conservative and best scenario. Inside agglomerations, the best scenario reduces the number of people exposed by 2030 (12,8 % reduction in the day-evening-night period and 13,7 % reduction in the night period). Considering that these figures are below a potential 30 % target, 1,6 million people exceed the target for the day-evening-night period and 1,2 million in the night period inside agglomerations (
Table 4.4) in the best implementation scenario. These figures take into account the noise threshold set by the END. However, considering the more stringent dB threshold recommended by the WHO, nearly 2 million people are exposed above the threshold in the day-evening-night period and an increase of 1,6 million people (more than double) compared with the END threshold for the night period.

Outside agglomerations, both scenarios substantially project an increase of the number of people exposed by 2030 (Figure 4.9). Consequently, the number of people exceeding the 30 % target in 2030 in the best scenario is more than 4 million people during the day-evening-night period and 3,5 million people during the night period (
Table 4.4). These figures take into account the noise threshold set by the END. Considering the more stringent dB threshold recommended by the WHO, the number of people exposed above the 30 % target is half a million more in the day-evening-night period for the best implementation scenario and 6,8 million people surpassed the 30 % target for the night period, doubling the figures based on the END.

In addition to population growth at the EU level, two factors explained the difficulty in reducing the number of people exposed to rail traffic noise: a projected increased transport activity and projected new rail infrastructure (urban rail and high-speed lines -Table 4.5), which may result in traffic speed. These factors offset the mitigation measures considered in both scenarios. The increase in transport activity for rail is much larger than forecasted for road and aircraft traffic, leading to increased noise levels in the areas affected. Only in the best implementation scenario, which considers improved maintenance and rail grinding, can the number of people affected be slightly reduced inside agglomerations.

Figure 4.9 Outlooks for 2022 and 2030 for rail noise inside (left) and outside agglomerations (right). The bars indicate the number of people exposed in 2017-2022-2030 for the conservative and best implementation scenarios. The percentage change from 2017 to 2030 is displayed in each graph.

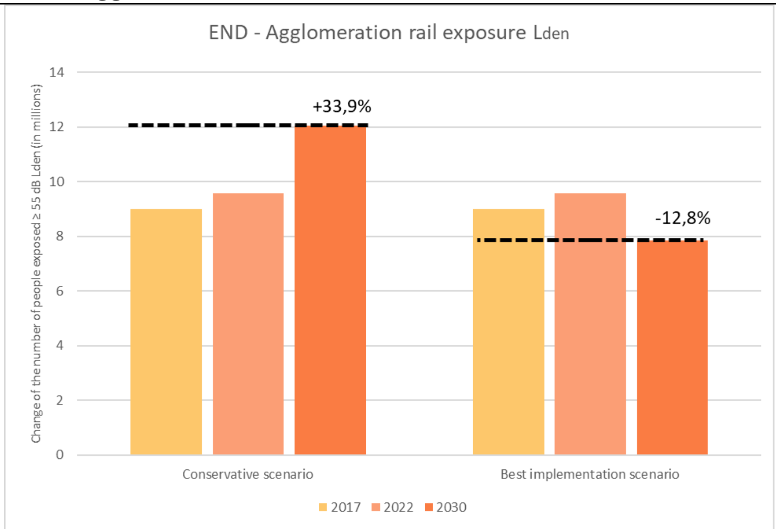
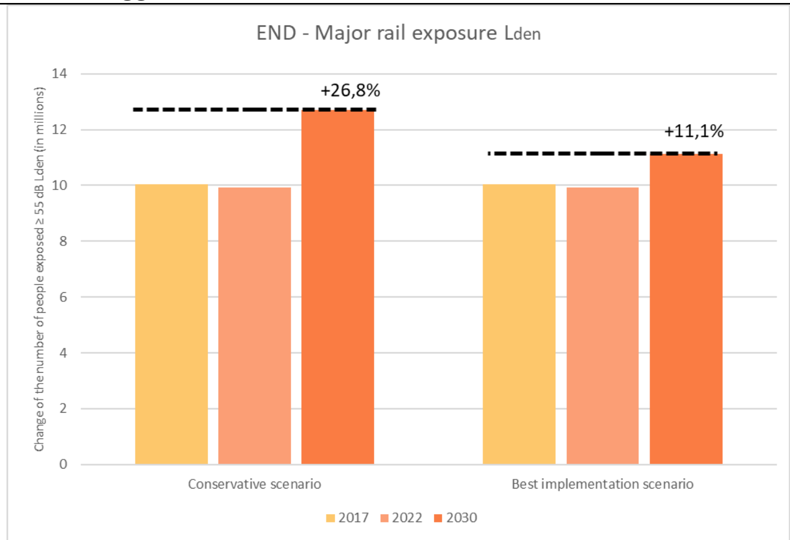
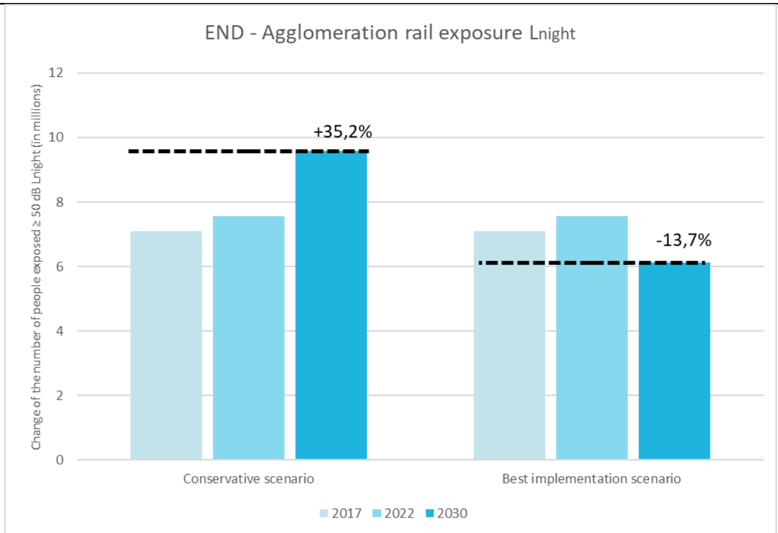
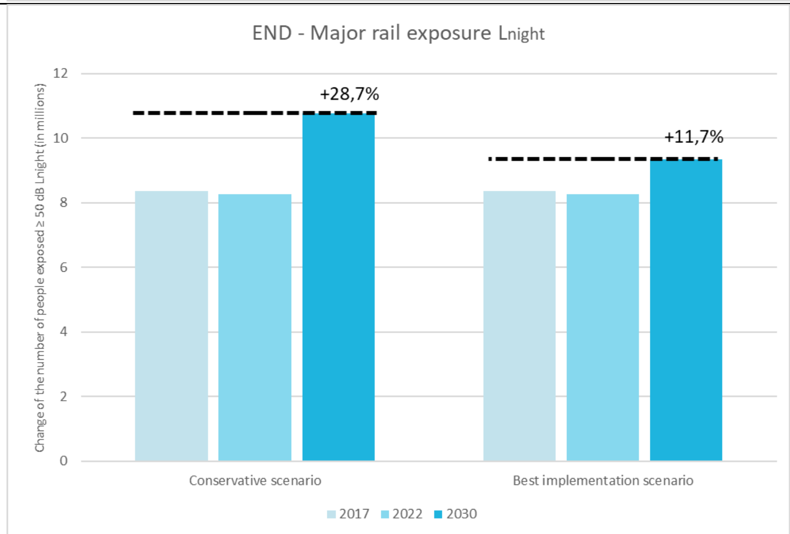
<table>
<tr><th></th><th>Inside agglomerations</th><th>Outside agglomerations</th></tr>
<tr><td>L_{den}</td><td>
</td><td>
</td></tr>
<tr><td>L_{night}</td><td>
</td><td>
</td></tr>
</table>

Table 4.4 Projected people exposed in 2030 (two scenarios: CS, conservative scenario; BIS, best implementation scenario) above a potential 30 % reduction of noise exposure to rail traffic noise (inside and outside agglomerations). Data is provided for the END and WHO noise guidelines' thresholds. Data in millions. Coverage: EU27.

Period	Noise sources	END thresholds				WHO noise guidelines			
		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold	
				CS	*BIS*			*CS*	*BIS*
Day-evening-night	**Rail**	END ≥ 55dB				WHO ≥ 54 dB			
	inside agglomerations	9,0	6,3	5,8	1,6	10,1	7,1	6,4	1,9
	outside agglomerations	10,0	7,0	5,7	4,1	11,2	7,8	6,3	4,6
Night period	**Rail**	END ≥ 50dB				WHO ≥ 44 dB			
	inside agglomerations	7,1	5,0	4,6	1,2	14,2	9,9	8,6	2,8
	outside agglomerations	8,4	5,9	4,9	3,5	16,6	11,6	9,3	6,8

Table 4.5 Factors specific to the rail traffic scenarios and population weighted equivalent dB change. The transport activity change outside agglomerations is country-specific, and the values refer to the median of all countries. The colour highlights the combination of factor and scenario resulting in a dB reduction (green), or a dB increase (yellow to orange). For the intermediate year 2022, transport activity change results in a dB reduction in seven countries and a dB increase in 20 countries, reflected by the two colours in the corresponding cell. Scenarios: CS, conservative scenario; BIS, best implementation scenario.

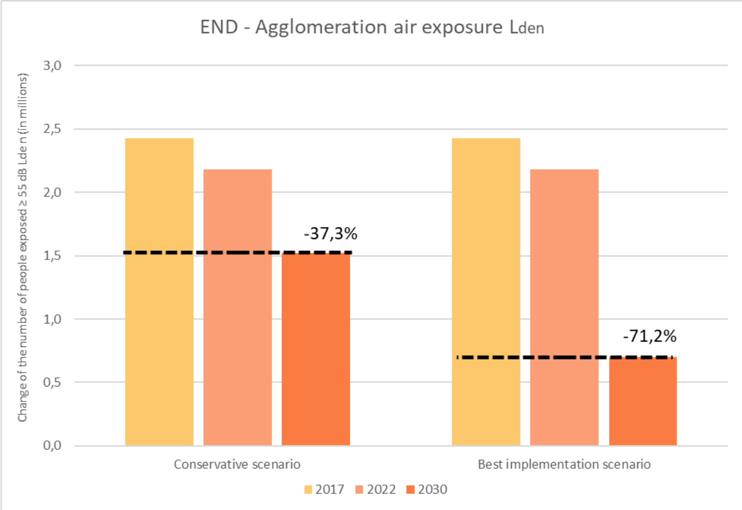
	Inside agglomerations			Outside agglomerations		
Factor	*22*	*30CS*	*30BIS*	*22*	*30CS*	*30BIS*
Transport activity change	0,5	2,7	1,2	0	1,5	1,5
Projected new urban rail infrastructure	0,3	0,5	0,5			
Increase of high speed lines				0	1,5	0,8
Silent brake policy in major railways	-0,3	-0,7	-0,7	-0,3	-0,7	-0,7
Electrification				-0,1	-0,3	-0,3
Maintenance and rail grinding	0	0	-2	0	0	-0,5

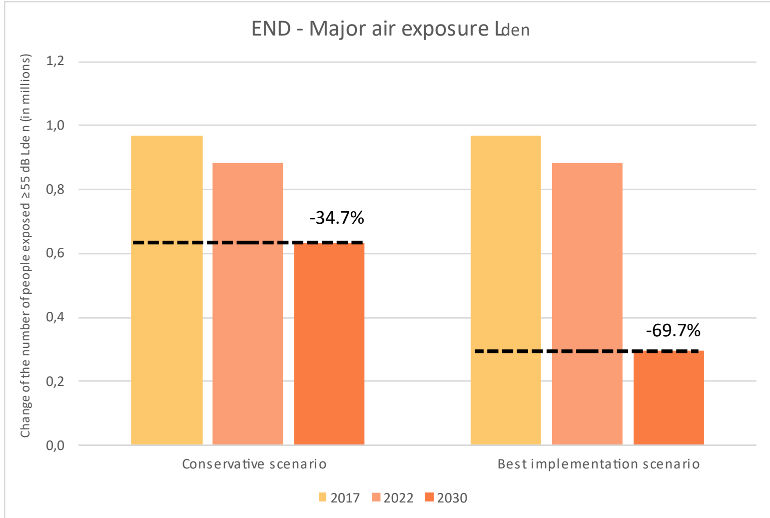
4.4 Aircraft noise

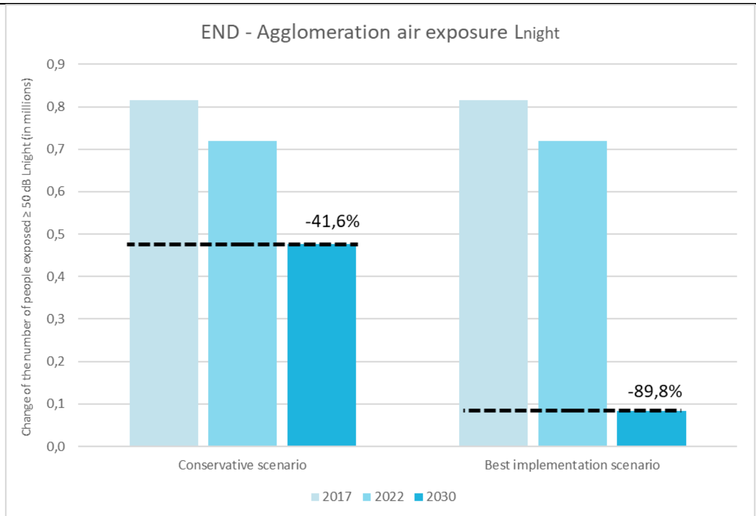
The best implementation scenario estimates a reduction of people exposed to air traffic noise ranging from 89,8 % inside agglomerations during the night period and 69,4 % outside agglomerations for the day-evening-night (Figure 4.10). These percentages are above the 30 % reduction target for 2030. Table 4.6 provides an overview of the number of people estimated to be below this target and comparing values if END thresholds are taken into account, or WHO thresholds are considered.

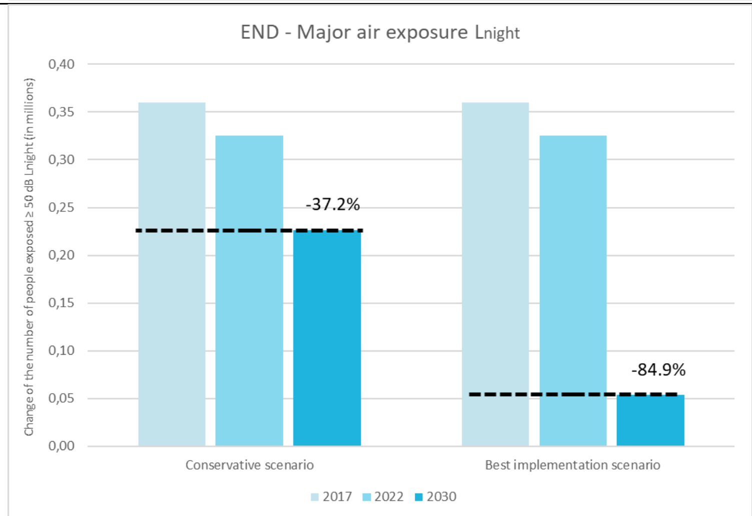
In the best implementation scenario, about 1,4 million people are below this threshold during the day-evening-night period and 0,7 million people during the night period. These figures take into account the noise reporting thresholds set by the END. As the WHO recommendations for aircraft noise are based on much lower levels than for road or rail, the estimates of population affected by noise remains high after implementation of the measures specified in the scenarios.

Figure 4.10 Outlooks for 2022 and 2030 for air traffic noise inside (left) and outside agglomerations (right). The bars indicate the number of people exposed in 2017-2022-2030 for the conservative and best implementation scenarios. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

<table>
<tr><th></th><th>Inside agglomerations</th><th>Outside agglomerations</th></tr>
<tr><td>Lden</td><td>


</td><td>


</td></tr>
<tr><td>Lnight</td><td>


</td><td>


</td></tr>
</table>

Table 4.6 Projected people exposed in 2030 (two scenarios: CS, conservative scenario; BIS, best implementation scenario) above the potential 30 % reduction target of noise exposure to air traffic noise (inside and outside agglomerations). Data is provided for the END and WHO noise guidelines' thresholds. Data in millions. Coverage: EU27.

Period	Noise sources	END thresholds				WHO noise guidelines			
		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold		2017 People exposed	2030 People exposed (30 % reduction)	2030 People exceeding 30 % threshold	
				CS	*BIS*			*CS*	*BIS*
Day-evening-night	**Air**	END ≥ 55dB				WHO ≥ 45 dB			
	inside agglomerations	2,4	1,7	-0,2	-1,0	44,9	31,4	-1,3	-18,5
	outside agglomerations	1,0	0,7	0,0	-0,4	17,9	12,6	0,0	-7,2
Night period	**Air**	END ≥ 50dB				WHO ≥ 40 dB			
	inside agglomerations	0,8	0,6	-0,1	-0,5	21,6	15,1	-1,1	-12,7
	outside agglomerations	0,4	0,3	0,0	-0,2	8,7	6,1	-0,2	-5,0

Table 4.7 Factors specific to the air traffic scenarios and population weighted equivalent dB change. The colour highlights the combination of factor and scenario resulting in a dB reduction (green), or a dB increase (yellow to orange. Scenarios: CS, conservative scenario; BIS, best implementation scenario.

L_{den}

	dB change per factor and scenario		
Factor	***22***	***30CS***	***30BIS***
Traffic forecast activity change	-0,4	0,5	0,5
Quieter aircrafts	0	-0,1	-0,1
Improved landing/take off	0	-2,0	-2,0
Lnight curfew	0	0	-0,5
Noise balanced approach	0	0	-2,0

L_{night}

	dB change per factor and scenario		
Factor	***22***	***30CS***	***30BIS***
Traffic forecast activity change	-0,4	0,5	0,5
Quieter aircrafts	0	-0,1	-0,1
Improved landing/take off	0	-2,0	-2,0
Lnight curfew	0	0	-2,0
Noise balanced approach	0	0	-2,0

5 Health impact assessment at different scenarios

5.1 Overview

This section provides an overview of the people highly annoyed and highly sleep disturbed for a **conservative scenario** and a **best implementation scenario** projected for 2022 and 2030. As described in section 3.7, calculations were done based on the END thresholds and for source-specific WHO recommendations (Table 3.7).

Figure 5.1 shows that in 2017 road traffic causes 14.0 million **highly annoyed people** in the EU 27 countries. Railway noise results in 3.0 million highly annoyed people and aircraft noise in 0.9 million highly annoyed people. Using the WHO guidelines instead of the END thresholds for the health risk calculation yields for road, railway and aircraft noise 16.1 million, 3.2 million and 7.3 million highly annoyed people, respectively (see Annex 7).

The projections of highly annoyed people for 2022 and 2030 depict a similar pattern for the three traffic sources as seen for the number of exposed people (L_{den}, chapter 0). A relatively little change is observed in the conservative scenario regarding absolute numbers of highly annoyed people. For road traffic noise, the numbers remain fairly constant; for railway noise, there is an increase, and for aircraft noise, a decrease. According to the best implementation scenario (Figure 5.1), one would expect in 2030 for road, rail and aircraft noise 11.3, 3.0 and 0.3 million highly annoyed people, respectively. In 2030, for all sources together, the number of highly annoyed people would be 18.6 million in the conservative scenario and 14.5 million in the best implementation scenario, compared to 17.9 million in 2017. According to the WHO based calculation, the projected number of highly annoyed people are 25.0 million and 18.0 million for the conservative and best implementation scenario, respectively.

Figure 5.2 shows the relative changes of highly annoyed people in 2030 compared to 2017 for the conservative and the best implementation scenario (END thresholds). For road traffic noise, virtually no changes in the number of highly annoyed people is expected for the conservative scenario (-0.1 %), whereas a decrease of 19.6 % is expected for the best implementation scenario. For railway noise, the number of highly annoyed people is projected to increase by 36.4 % in the conservative scenario and remains virtually unchanged in the best implementation scenario (+0.2 %). For aircraft noise, a 36.9 % decrease in highly annoyed people is expected for the conservative scenario and a 70.9 % decrease for the best implementation scenario.

Only aircraft noise may thus fulfil the Zero Pollution Action target by 2030 for a 30 % reduction in the share of people chronically disturbed by traffic noise compared to 2017. For road traffic, which is the noise source with the highest number of highly annoyed people, the best implementation scenario results show that substantial efforts are needed to reduce the percentage of people exposed. Business as usual, or minimum efforts, are not enough, in line with the data reported by MS for the period 2012-2017 where numbers broadly remained stable. It is unlikely that rail traffic noise will fulfil the target of the Zero Pollution Action by 2030 since the proportion of highly annoyed people remains similar to 2017 (best implementation scenario) or even increases up to 37 % in the conservative scenario. These results reflect that increased rail transport activity, rail network and population growth offset noise abatement measures considered in both scenarios.

Transport projections for 2030 separated between inside and outside agglomerations are shown in Figure 5.3 and discussed for road traffic noise in chapter 5.2, for railway noise in chapter 5.3 and for aircraft noise in chapter 5.4. Projections based on WHO guidelines show similar relative changes in the number of highly annoyed people in 2030 compared to the calculations based on END thresholds for both scenarios (see

Annex 7). However, since numbers of highly annoyed people are higher for the calculations based on WHO noise guidelines the changes in absolute numbers are higher compared to the END threshold calculations.

The results obtained detailed at dB band level per each health indicator can be seen in Annex 8.

Figure 5.1 Outlooks for 2022 and 2030 for the number of highly annoyed people in two scenarios (END thresholds). Data for each noise source aggregates both inside and outside agglomerations.

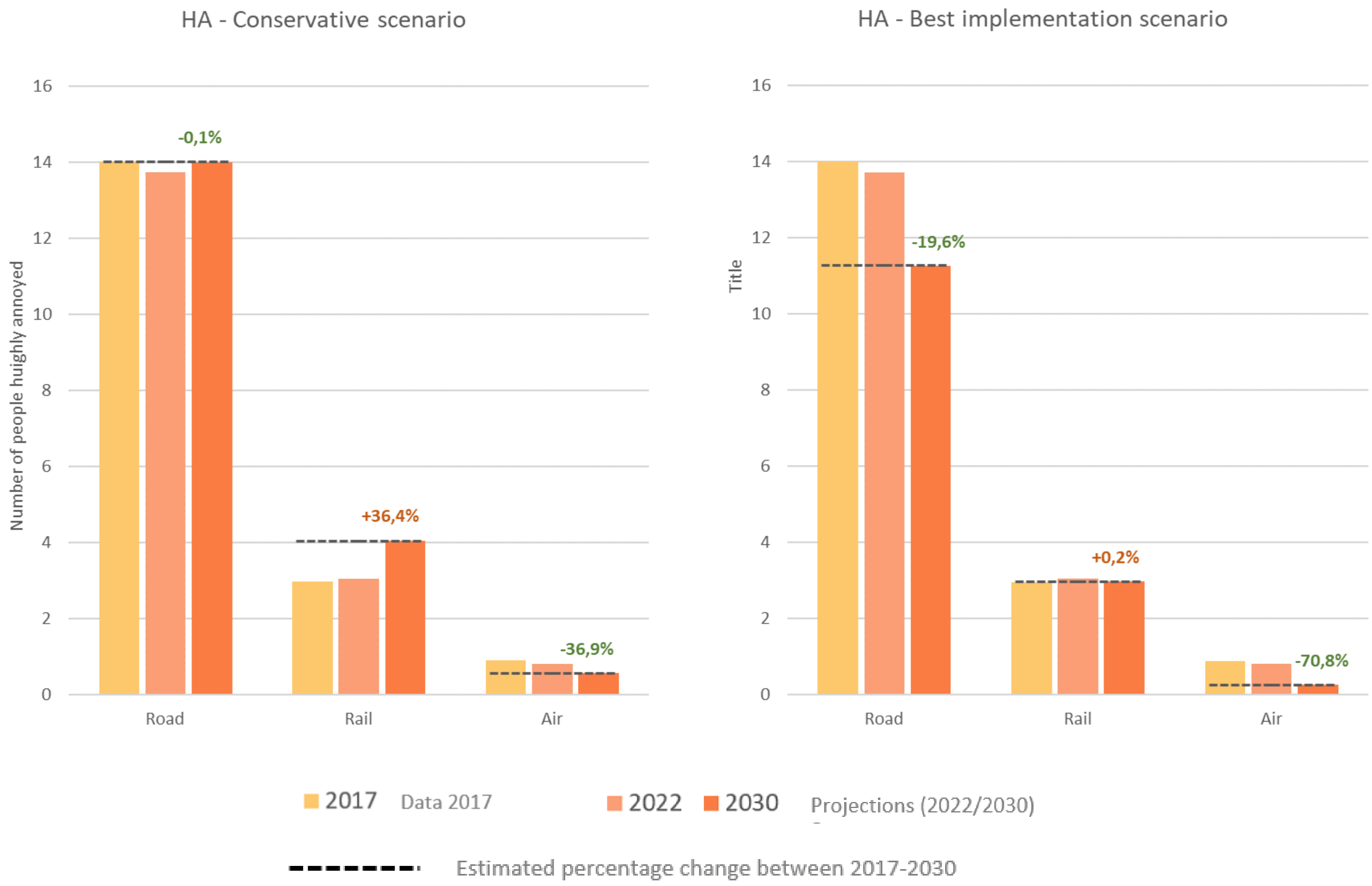


Figure 5.2 Outlooks for 2022 and 2030 for the change in highly annoyed people based on the END thresholds. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

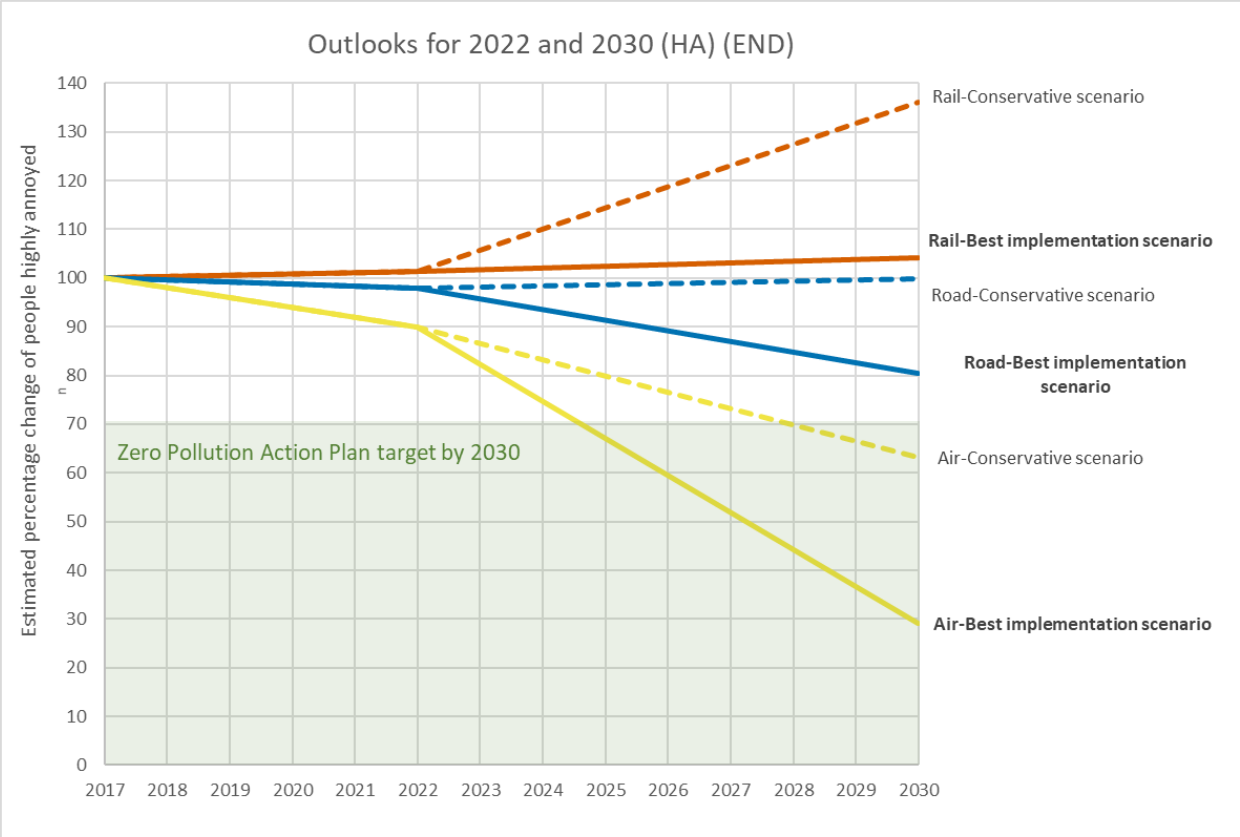


Figure 5.3 Outlooks for 2022 and 2030 for the change in highly annoyed people based on the END thresholds stratified by inside (left) and outside (right) agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

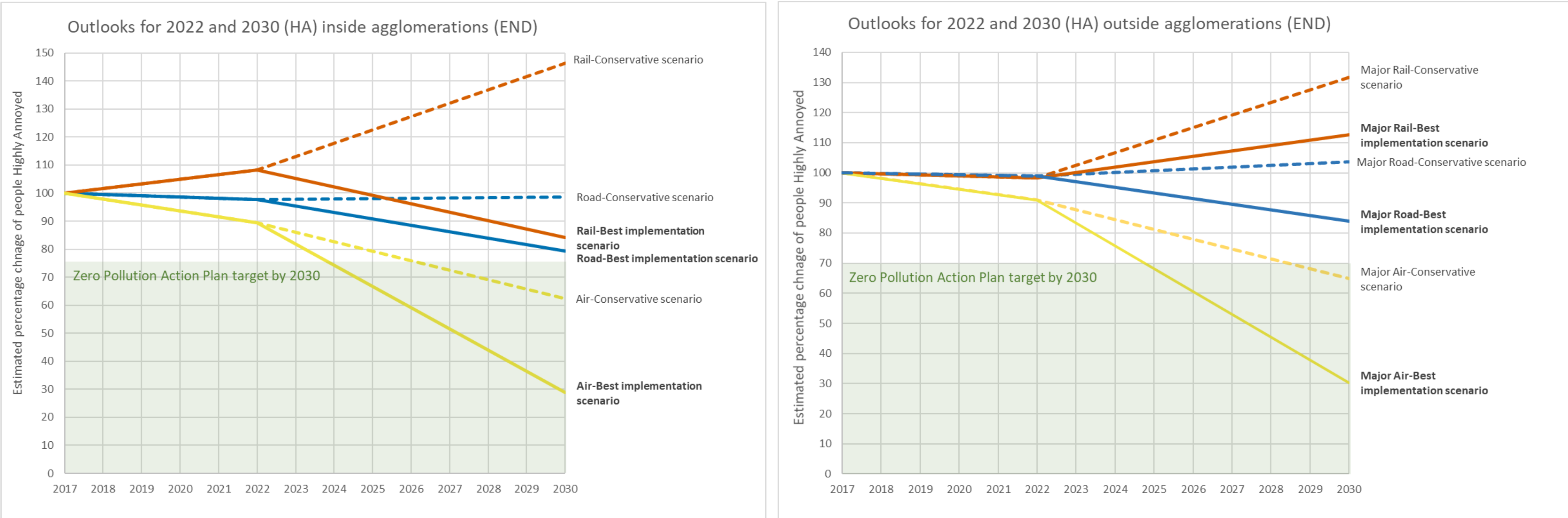


Figure 5.4 shows that in 2017 road traffic caused 3.6 million **highly sleep disturbed people** in the EU 27 countries. Railway noise results in 1.5 million highly annoyed people and aircraft noise in 0.2 million highly annoyed people. Using the WHO recommendations instead of the END thresholds for the health risk calculation yields for road, railway and aircraft noise 5.1 million, 2.0 million and 3.3 million highly annoyed people, respectively (see Annex 7).

The projections of highly sleep disturbed people for 2030 depict a similar pattern for the three traffic sources as seen for the number of noise exposed people during the night (L_{night}, chapter 0). As for highly annoyed people, relatively little change happens in the conservative scenario regarding absolute numbers of highly sleep disturbed people. According to the best implementation scenario (Figure 5.4), one would expect in 2030 for road, rail and aircraft noise 2.8, 1.5 and 0.03 million highly sleep disturbed people, respectively. In 2030, for all sources together, the number of highly sleep disturbed people would be 5.9 million in the conservative scenario and 4.3 million in the best implementation scenario compared to 5.3 million in 2017. According to the WHO based calculation, the projected number of highly sleep disturbed people are 9.9 million and 6.4 million for the conservative and best implementation scenario, respectively.

Figure 5.5 shows the relative changes of highly sleep disturbed people in 2030 compared to 2017 for the conservative and the best implementation scenario (END thresholds). For road traffic noise virtually no changes in the number of highly sleep disturbed people is expected for the conservative scenario (+0.2 %), whereas a decrease of 22.9 % is expected for the best implementation scenario. For railway noise, the number of highly annoyed people is projected to increase by 40.0 % in the conservative scenario and remains virtually unchanged in the best implementation scenario (+0.7 %). For aircraft noise a 39.2 % decrease of highly annoyed people is expected for the conservative scenario and a 88.2 % decrease for the best implementation scenario.

Only aircraft noise may thus fulfil the target of the Zero Pollution Action of a 30 % reduction in the proportion of people chronically disturbed by transportation noise. For road traffic, which is the noise source with the highest number of highly sleep disturbed people, the best implementation scenario results show that substantial efforts are needed to reduce the percentage of people exposed. Business as usual, or minimum efforts, are not enough, in line with the data reported by MS for the period 2012-2017 where numbers broadly remained stable. It is unlikely that rail traffic noise will fulfil the target of the Zero Pollution Action by 2030 since the proportion of highly sleep disturbed people remains similar to 2017 (best implementation scenario) or even increases up to 40 % in the conservative scenario. These results reflect that increased rail transport activity, rail network and population growth offset noise abatement measures considered in both scenarios.

Transport projections for 2030 separated between inside and outside agglomerations for the relative changes of highly sleep disturbed people are shown in Figure 5.6 and discussed for road traffic noise in chapter 5.2, for railway noise in chapter 5.3 and for aircraft noise in chapter 5.4. Projections based on WHO recommendations show similar relative changes in the number of highly sleep disturbed people in 2030 compared to the calculations based on END thresholds for both scenarios (see Annex 7). However, since numbers of highly sleep disturbed people are higher for the calculations based on WHO noise guidelines, the change in absolute numbers is higher compared to the END threshold calculations.

Figure 5.4 Outlooks for 2022 and 2030 for the number of highly sleep disturbed in two scenarios (END thresholds). Data for each noise source aggregates both inside and outside agglomerations

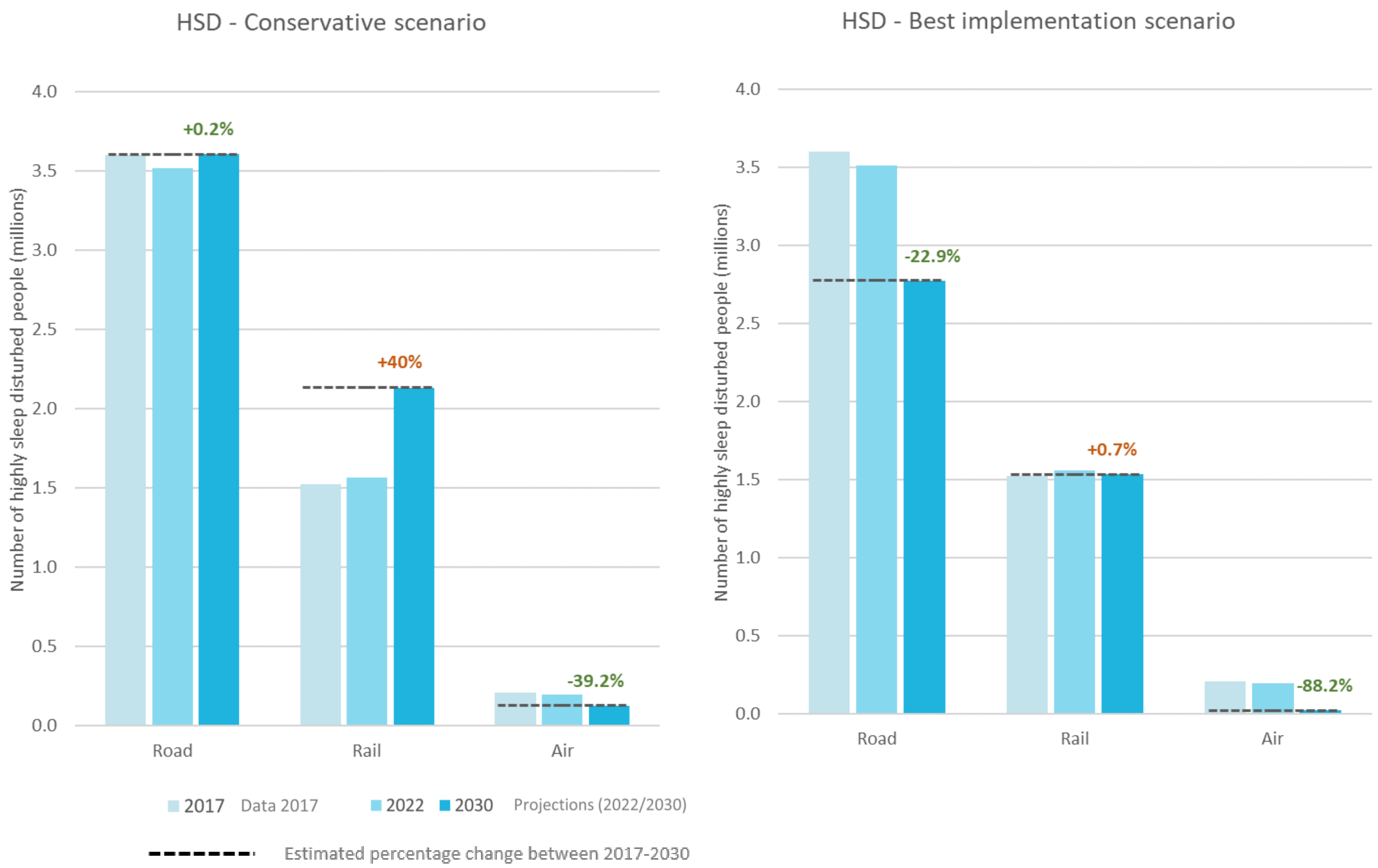


Figure 5.5 Outlooks for 2022 and 2030 for the change in highly sleep disturbed people based on the END thresholds. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

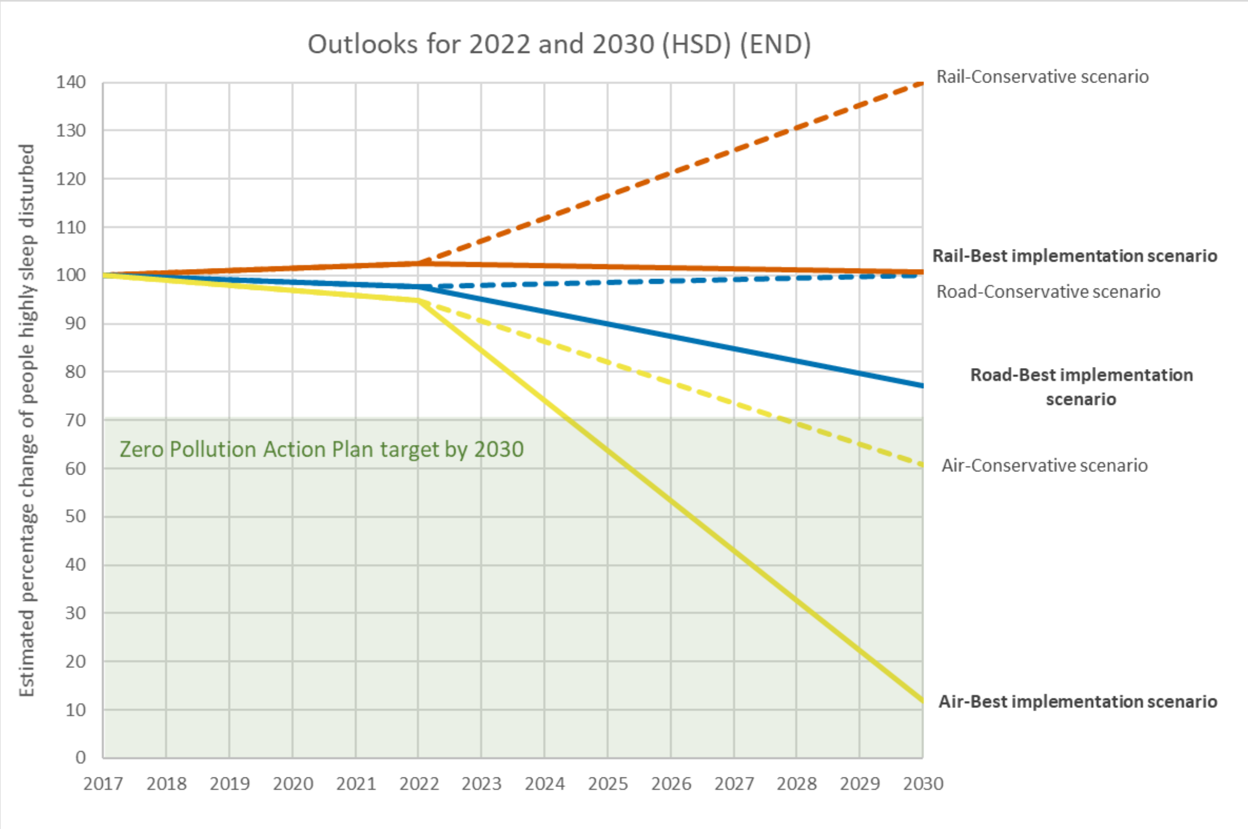
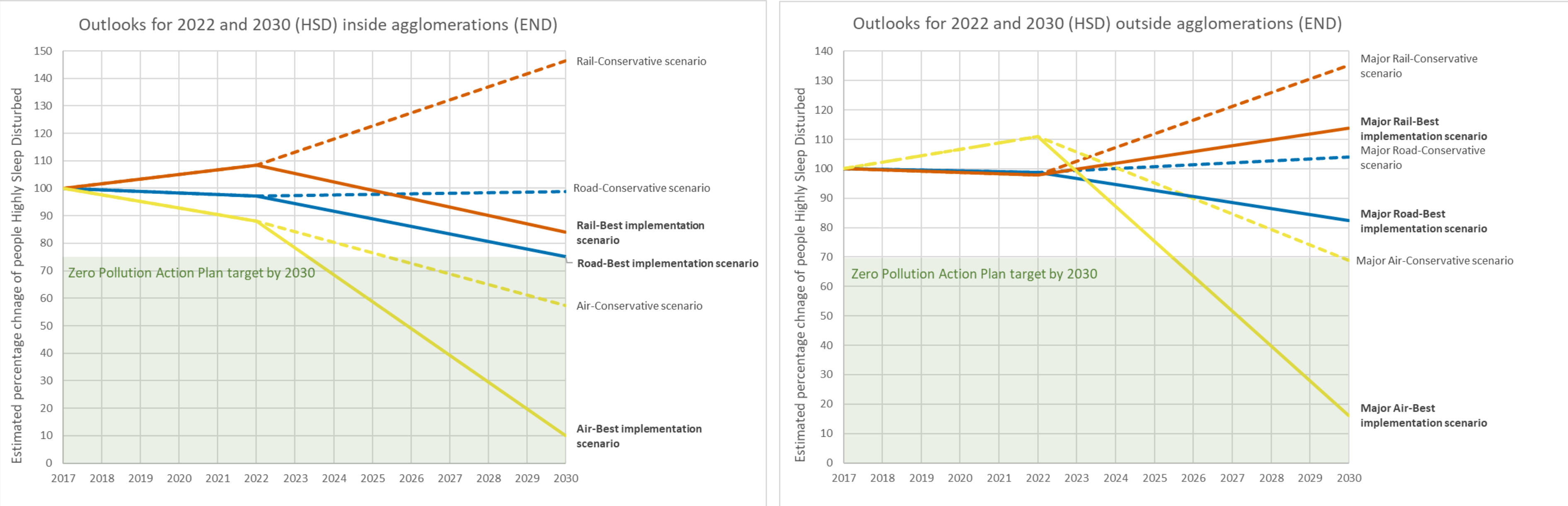


Figure 5.6 Outlooks for 2022 and 2030 for the change in highly sleep disturbed people based on the END thresholds stratified by inside and outside agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

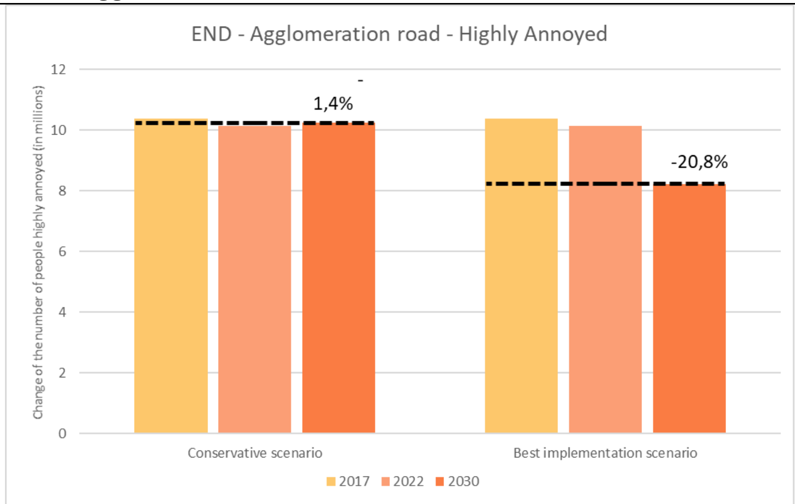
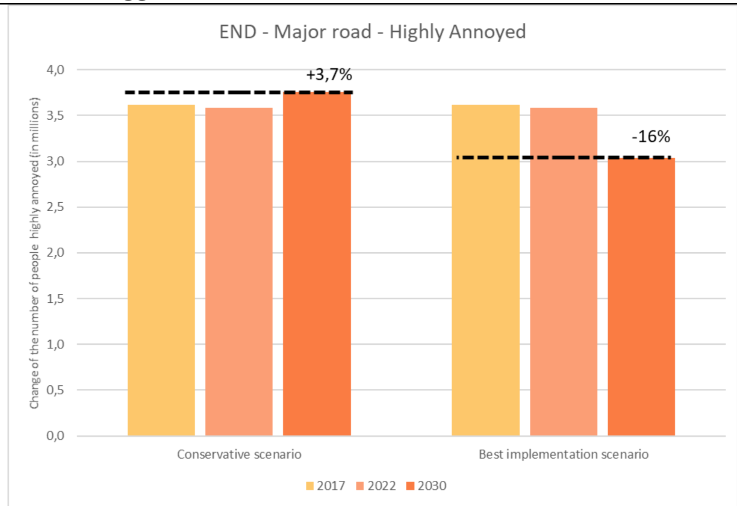
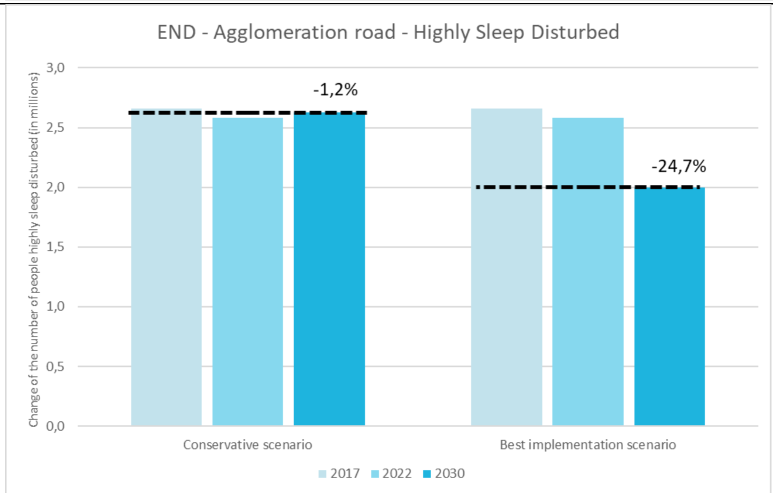
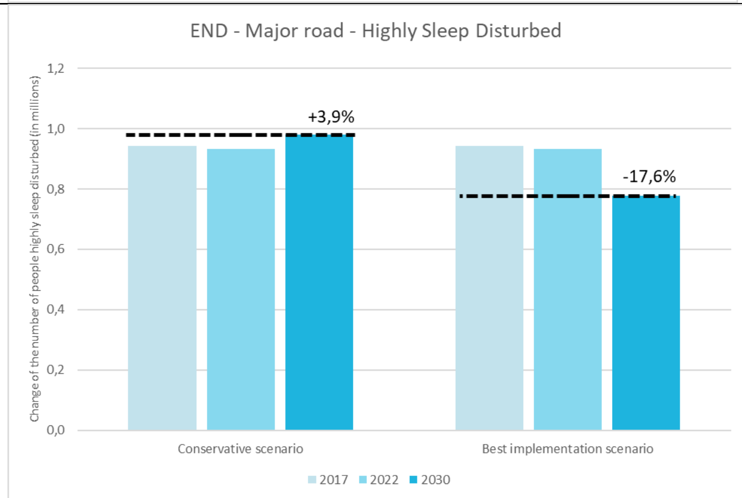


5.2 Road noise

Projections for 2030 separated by agglomeration (Figure 5.7) show for road noise slightly more percentage reduction in the proportion of highly annoyed people inside the agglomeration versus outside the agglomeration for the best implementation scenario. For the conservative scenario, increase in highly annoyed people is slightly higher outside the agglomeration. For high sleep disturbance, the same pattern was observed as for high annoyance. For the conservative scenario, the number of highly sleep disturbed is slightly decreasing inside the agglomeration and slightly decreasing outside the agglomeration. For the best implementation scenario, the decrease of highly sleep-disturbed people is higher (24.7 %) inside agglomeration than outside agglomeration (17.6 %). Similar relative changes, although with higher absolute numbers, are observed for projections based on WHO guidelines (Annex 7). Factors explaining the different pattern between inside and outside the agglomeration are listed in Table 4.3, in the context of the number of people exposed. It should be noted that improved noise asphalt, noise barriers, and noise speed limits only apply to a limited area in the city.

Even in the best scenario, the reduction of highly annoyed and highly sleep disturbed is below the 30 % reduction target for 2030. Consequently, for inside and outside agglomerations combined road traffic noise projections, the number of highly annoyed people exceeding the 30 % target in 2030 is about 4.2 million in the conservative scenario and about 1.5 million for the best implementation scenario. The corresponding numbers for the highly sleep disturbed people is 1.1 and 0.3 million, respectively. These figures take into account the noise threshold set by the END ($L_{den} \geq 55$ dB and $L_{night} \geq 50$ dB). Considering the more stringent dB threshold recommended by the WHO for road traffic noise ($L_{den} \geq 53$ dB and $L_{night} \geq 45$ dB), the number of highly annoyed people above the 30 % target is 4.7 and 1.5 million for the conservative and the best implementation scenario. For high sleep disturbance 1.5 and 0.4 million people, respectively.

Figure 5.7. Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for road noise based on the END thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

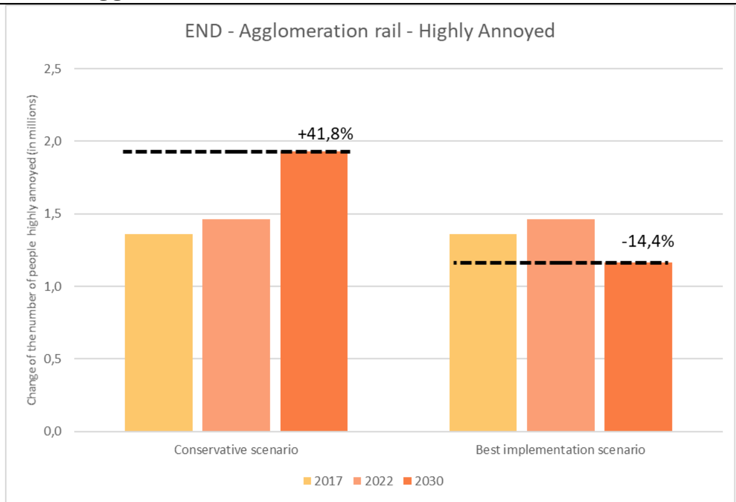
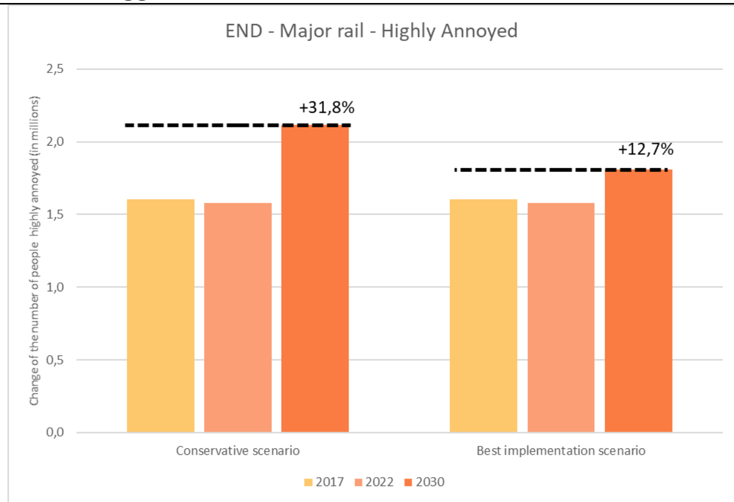
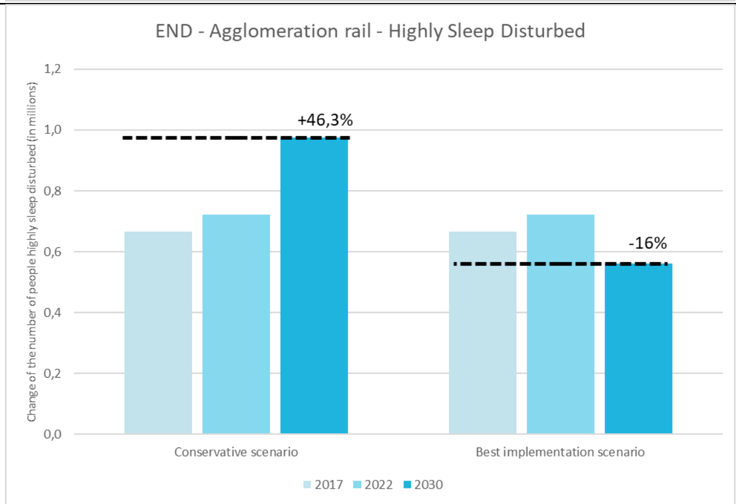
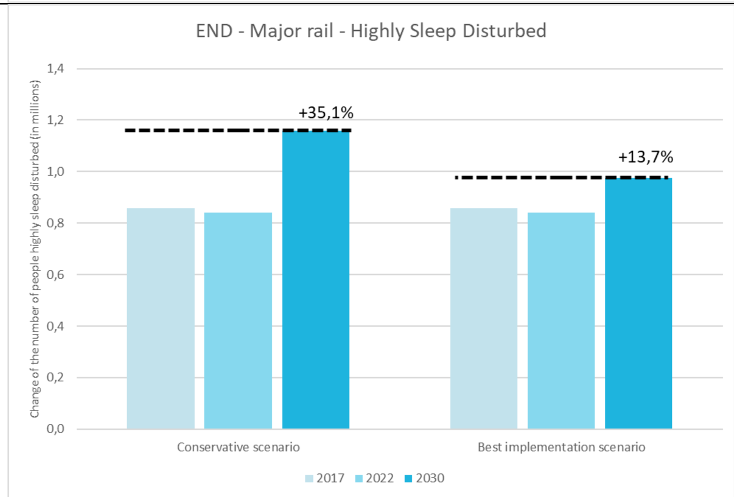
<table>
<tr><td></td><td>Inside agglomerations</td><td>Outside agglomerations</td></tr>
<tr><td>HA</td><td>
</td><td>
</td></tr>
<tr><td>HSD</td><td>
</td><td>
</td></tr>
</table>

5.3 Rail noise

Projections for 2030 separated by agglomeration (Figure 5.8) show for railway noise, inside the agglomeration a decrease of highly annoyed people in the best implementation scenario whereas outside the agglomerations even in the best implementation scenario the number of highly annoyed people will increase. For the conservative scenario the increase of highly annoyed people will be higher inside the agglomeration than outside. For high sleep disturbance, the same pattern is observed, a decrease in the best implementation scenario inside the agglomeration and an increase in the best implementation scenario. For the conservative scenario, the increase of highly sleep disturbed people will be higher inside the agglomeration than outside. Similar relative changes, although with higher absolute numbers, are observed for projections based on WHO guidelines (Annex 7). Factors explaining the different pattern between inside and outside the agglomeration are listed in Table 4.5 in the context of the number of people exposed.

Even in the best scenario, the reduction of highly annoyed and highly sleep disturbed is below the 30 % reduction target for 2030. Consequently, for inside and outside agglomerations combined the number of highly annoyed people exceeding the 30 % target in 2030 is about 2.0 million in the conservative scenario and about 0.9 million for the best implementation scenario. The corresponding numbers for the highly sleep disturbed people is 1.1 and 0.5 million, respectively. These figures take into account the noise threshold set by the END (Lden≥55 dB and Lnight≥50 dB). Considering the slightly more stringent dB threshold recommended by the WHO for road traffic noise (Lden≥54 dB and Lnight≥45 dB), the number of highly annoyed people above the 30 % target is 2.1 and 1.0 million for the conservative and the best implementation scenario. For high sleep disturbance 1.3 and 0.6 million people, respectively.

Figure 5.8. Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for railway noise based on the END thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

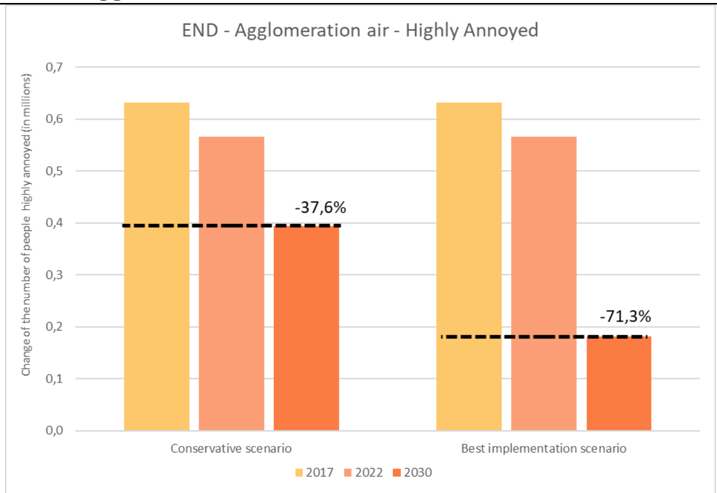
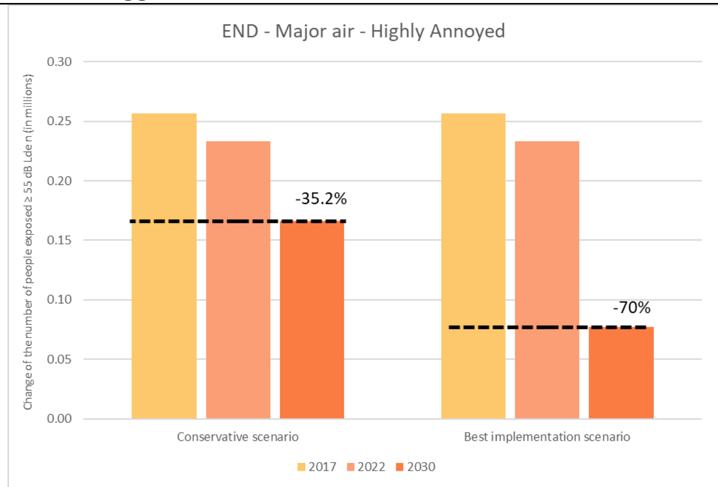
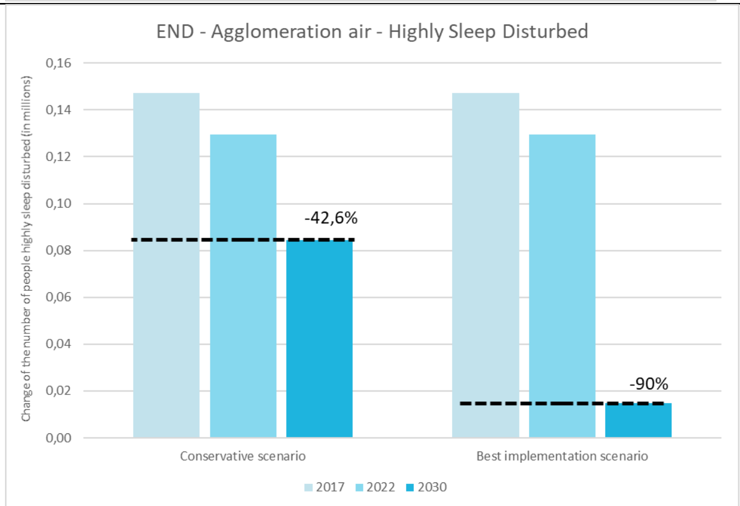
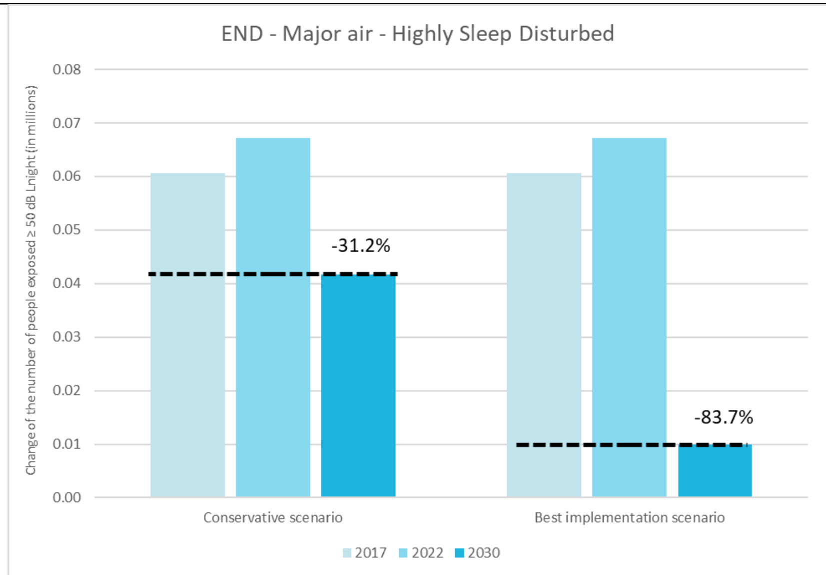
<table>
<tr><th></th><th>Inside agglomerations</th><th>Outside agglomerations</th></tr>
<tr><td>HA</td><td>
</td><td>
</td></tr>
<tr><td>HSD</td><td>
</td><td>
</td></tr>
</table>

5.4 Aircraft noise

Projections for 2030 separated by agglomeration (Figure 5.9) show that the reduction of highly annoyed and highly sleep disturbed people from aircraft noise is more pronounced inside the agglomeration than outside the agglomeration. For both scenarios, the Zero Pollution Action Plan target of a 30 % reduction is expected to be reached. Also, for the calculations based on the WHO guidelines, the Zero Pollution Action Plan targets are achieved inside and outside agglomerations for both scenarios (Annex 7). However, it should be highlighted that a high number of people will be exposed above the WHO recommendations, even achieving the 30 % reduction.

Factors explaining the pattern applied (and the differences between L_{den} and L_{night} indicators) are listed in Table 4.7 regarding the number of people exposed.

Figure 5.9. Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for road noise based on the END thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

	Inside agglomerations	Outside agglomerations
HA		
HSD		

Conclusions

Based on the scenarios analysed in this assessment, the zero-pollution action plan objective on noise is unlikely to be achieved by 2030. One of the main stoppers is the difficulty in reducing the large number of people exposed to road traffic noise. However, a combination of measures such as switching to electric vehicles in cities, reducing speed limits in cities, implementing the noise emission regulations for motor vehicles, and further extending low noise asphalts and noise barriers, a reduction between 3-15 % of chronically disturbed people could be achieved.

There are no prospects of achieving a 30 % decrease in chronically disturbed people due to transport noise by 2030 even with the implementation of a substantial number of noise measures. The best implementation scenario shows that only a reduction of 19 % of chronically disturbed people could be achieved.

Achieving the ZP objective for road and railway traffic noise is not possible with the existing technology and legislation. To globally decrease the number of people exposed to harmful levels of noise, major shifts in the use of motorized transport is needed.

In order to achieve the objective of the ZP action plan, measures need to target the population not only in high noise hot spots but should target the population in the lower bands by focusing on better urban and transport planning as well as changes aimed at reducing the use of motorized transport.

Although a reduction of people exposed to noise can be achieved, results show that there will still be a high number of people above the recommended WHO limits in both scenarios in particular for road and aircraft noise.

Although the ZP objectives are unlikely to be reached globally, a 30 % reduction of chronically disturbed by aircraft noise could be reached with progressive uptake of quieter aircrafts and improved landing and taking off procedures. However, there will still be a high number of people exposed to aircraft noise levels above the WHO recommendations.

List of abbreviations

Abbreviation	Name	Reference
CLC	CORINE Land Cover	https://land.copernicus.eu/pan-european/corine-land-cover
EC	European Commission	https://ec.europa.eu/info/index_en
ECFIN	DG Economic and Financial Affairs	https://ec.europa.eu/info/departments/economic-and-financial-affairs_en
EEA	European Environment Agency	www.eea.europa.eu
END	Environmental Noise Directive	https://ec.europa.eu/environment/noise/directive_en.htm
EUROSTAT	Statistical office of the European Union.	https://ec.europa.eu/eurostat
LUISA	Territorial Modelling Platform	https://joint-research-centre.ec.europa.eu/luisa_en
UNECE	The United Nations Economic Commission for Europe	https://unece.org/
ZP / ZPAP	Zero Pollution Action Plan	https://ec.europa.eu/environment/strategy/zero-pollution-action-plan_en

References

ACEA, 2022, *Vehicles in use Europe 2022*, European Automobile Manufacturers' Association (https://www.acea.auto/publication/report-vehicles-in-use-europe-2022/) accessed 25 April 2022.

Alberts, W., et al., 2016, 'Road traffic noise exposure in Europe in 2012 based on END data.', conference paper presented at: Proceedings of the 45th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2016), Hamburg, Germany, 2016.

Basner, M. and McGuire, S., 2018, 'WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep', *International Journal of Environmental Research and Public Health* 15(3), p. 519 (DOI: 10.3390/ijerph15030519).

Blanes, N., et al., 2019, *Noise exposure scenarios in 2020 and 2030 outlooks for EU 28*, ETC/ATNI Report 3/2019.

Blanes, N., et al., 2020, *Noise Action Plans. Managing exposure to noise in Europe.*, ETC/ATNI Report 8/2019 (https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-8-2019-noise-action-plans-managing-exposure-to-noise-in-europe) accessed 25 April 2022.

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.', 14(8).

Capros, P., et al., 2016, *EU Reference Scenario 2016. Energy, transport and GHG emissions. Trends to 2050*, Publications Office of the European Union.

E3 Modelling, 2018, 'The core PRIMES model' (https://e3modelling.com/modelling-tools/primes/) accessed 25 April 2022.

EASA, et al., 2016, *European Aviation Environmental Report 2016*, EASA, EEA, EUROCONTROL (https://www.easa.europa.eu/eaer/system/files/usr_uploaded/219473_EASA_EAER_2019_WEB_HI-RES_190311.pdf) accessed 25 April 2022.

EC, 2011, *WHITE PAPER Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system*, COM/2011/0144 final.

EC, 2017, *Electrification of the Transport System*, European Commission - Directorate-General for Research and Innovation (https://ec.europa.eu/newsroom/horizon2020/document.cfm?doc_id=46368) accessed 25 April 2022.

EC, et al., 2021a, *Assessment of potential health benefits of noise abatement measures in the EU : Phenomena project*, Publications Office (https://data.europa.eu/doi/10.2779/24566).

EC, 2021, *COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Pathway to a Healthy Planet for All EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'*, COM/2021/400 final.

EC, et al., 2021b, *EU reference scenario 2020 : energy, transport and GHG emissions : trends to 2050*, Publications Office (https://data.europa.eu/doi/10.2833/35750) accessed 25 April 2022.

EEA, 2019, 'Land cover and change statistics 2000-2018' (https://www.eea.europa.eu/data-and-maps/dashboards/land-cover-and-change-statistics) accessed 25 April 2022.

EEA, 2020a, *Environmental noise in Europe — 2020*, EEA Report No 22/2019, European Environment Agency.

EEA, 2020b, 'Health risks caused by environmental noise in Europe — European Environment Agency' (https://www.eea.europa.eu/publications/health-risks-caused-by-environmental) accessed 11 May 2022.

EEA, 2021a, 'Noise country fact sheets 2021' (https://www.eea.europa.eu/themes/human/noise/noise-fact-sheets) accessed 25 April 2022.

EEA, 2021b, 'Reported data on noise exposure covered by Directive 2002/49/EC' (https://www.eea.europa.eu/data-and-maps/data/data-on-noise-exposure-8) accessed 25 April 2022.

EU, 2002, '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', *(OJ L 189, 18.7.2002, p. 12-25)*, 2002.

EUAR, 2014, *Recommendation No 006REC1072-1 of the European Union Agency for Railways on the amendment of Commission Regulation (EU) No 1299/2014*, European Union Agency for Railways.

EUAR, 2018, *Revision of the Noise TSI - Application of NOI TSI requirements to existing freight wagons*, European Union Agency for Railways (https://www.era.europa.eu/sites/default/files/library/docs/recommendation/006rec1072_full_impact_assessment_en.pdf) accessed 25 April 2022.

Fons-Esteve, J., et al., 2021a, *Noise Action Plans. Impact of END on managing exposure to noise in Europe. Update of Noise Action Plans 2019.*, ETC/ATNI Report 07/2020 (https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etc-atni-report-07-2020-noise-action-plans-impact-of-end-on-managing-exposure-to-noise-in-europe-update-of-noise-action-plans-2019) accessed 25 April 2022.

Fons-Esteve, J., et al., 2021b, *Noise indicators under the Environmental Noise Directive 2021. Methodology for estimating missing data*, ETC/ATNI Report 06/2021.

Goubert, L., 2015, *Developing Innovative Solutions for TrAffic Noise Control in Europe. Retrieved from* (https://www.cedr.eu/download/other_public_files/research_programme/call_2012/road_noise/distance/DISTANCE-BRRC-D71-V01-11012016-Policy-brief.pd) accessed 25 April 2022.

Guski, R., et al., 2017, 'WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance', *International Journal of Environmental Research and Public Health* 14(12), p. 1539 (DOI: 10.3390/ijerph14121539).

Houthuijs, D., et al., 2018, *Method to estimate the road traffic noise exposure distribution in Europe*, ETC/ACM Technical Paper 2017/10 (https://www.eionet.europa.eu/etcs/etc-atni/products/etc-atni-reports/etcacm_tp_2017_10_traffic_noise_exposure_distribution_europe) accessed 25 April 2022.

ICAO, 2017, *ICAO. (2017). Annex 16 to the Convention on International Civil Aviation, Vol I, Chapter 14.*

IEA and IUR, 2017, *Railway Handbook. Energy consumption and CO2 emissions.*, International Energy Agency; International Union of Railways (https://iea.blob.core.windows.net/assets/c015f563-ddba-485c-b788-3110d2b1d30e/handbook_iea-uic_2017_web3.pdf) accessed 25 April 2022.

JRC, 2022, 'LUISA Population 2020, 2025, 203'.

Lavalle, C. and Jacobs Crisioni, C., 2014, *OUTPUT - Population distribution (LUISA Platform REF2014)*, European Commission, Joint Research Centre (JRC) (http://data.europa.eu/89h/jrc-luisa-population-ref-2014) accessed 16 April 2022.

Rossi, I. A., et al., 2020, 'Estimating the health benefits associated with a speed limit reduction to thirty kilometres per hour: A health impact assessment of noise and road traffic crashes for the Swiss city of Lausanne', *Environment International* 145, p. 106126 (DOI: 10.1016/j.envint.2020.106126).

UIC, 2021, *Atlas High-Speed rail.*, International Union of Railways (https://uic.org/IMG/pdf/uic-atlas-high-speed-2021.pdf) accessed 25 April 2022.

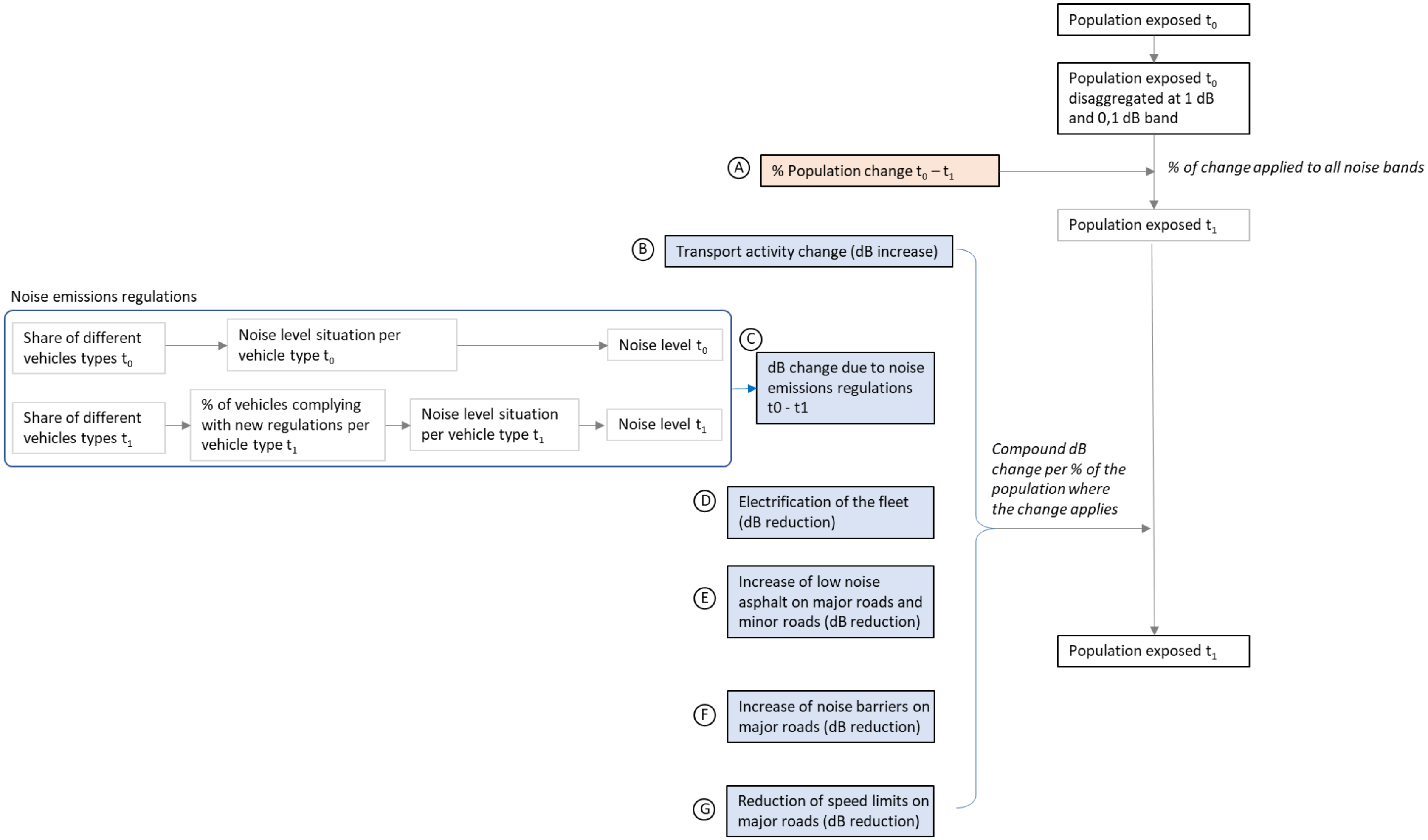
UITP, 2019, *Light Rail and Tram: the European Outlook.* (https://cms.uitp.org/wp/wp-content/uploads/2020/09/Statistics-Brief-LRT-Europe2.pdf) accessed 25 April 2022.

UNECE, 2011, *Regulation No 117 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and to adhesion on wet surfaces and/or to rolling resistance*, OJ L 307, 23.11.2011, p. 3–63 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A42011X1123%2803%29) accessed 25 April 2022.

WHO Europe, 2018, *Environmental noise guidelines for the European region*, World Health Organization Regional Office for Europe, Copenhagen (http://www.euro.who.int/en/health-topics/environment-and-health/noise/publications/2018/environmental-noise-guidelines-for-the-european-region-2018) accessed 25 April 2022.

Annex 1 Calculation details for road traffic noise scenarios inside urban areas

General workflow of scenarios for roads inside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), technological changes resulting from policy measures (C and D), other noise abatement measures (E and F) and reduction of noise speed limit (G) contribute to the population change exposed to road traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.3, which provides the reference values used for the different scenarios and further details in this annex.



A. Population change

As explained in the previous section on data, population projections are based on LUISA, which provides projections for 2020, 2025 and 2030.

Assumptions:

- There are no differences between the two 2030 scenarios;
- The possible impact of COVID is not integrated;
- Population change from 2017 to 2020 is extrapolated from the population growth for the period 2020-2025 since this is the closest reference data from LUISA.

Approach

1. Disaggregation of the population exposed to noise at t_0 (2017) at 1 dB (one decimal precision). As explained in the previous section on data, the population exposed to different noise sources is provided per 5 dB noise intervals.
   The various factors that modify noise exposure change dB units (at one decimal precision). Therefore, the 5 dB intervals must be disaggregated at the decimal level (one decimal precision) to integrate these changes. The methodology is described in Blanes et al. (2019) -chapter 5.2.
2. Calculate the population change rate for the different periods based on LUISA.
   a. Overlay the population grid (100 x 100 m) from LUISA with the delineation of the agglomerations reported by MS under the END.
   b. From the previous step calculate the population for each agglomeration for the years provided by LUISA: 2020, 2025, 2030.
   c. Calculate the population per country and subtract the population in agglomerations (step b) to obtain the population outside agglomerations per country.
   d. Calculate the cumulative average growth rate (CARG) per agglomeration, per country and per the two periods: 2020- 2025, and 2025-2030. The essential values are: the population P_{to} (or starting value), the population at P_{t1} (or ending value), and the T (or period of time to measure growth).

$$CAGR_{t_0-t_1} = \left(\frac{Pop_{t_1}}{Pop_{t_0}}^{1/T}\right) - 1$$

   e. Once the complete list of CAGR have been calculated, the resulting rates are used to project future values of the population exposed to noise using the following formula per each studied period. As mentioned before, the same projections are used for all scenarios.

$$P_{exposed2022} = P_{exposed\ 2017} \cdot (1 + CAGR)^5$$

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR)^8$$

B. Traffic change

The Primes model provides the transport activity data based on the EU Reference Scenario 2020 as the number of passengers and tones of goods (Gpkm and Gtkm, respectively). This data is also available at country level, which allows to reflect interregional differences. While the traffic parameter used by the END is traffic volume, the transport activity data obtained from the EU Reference scenario refers to number of passengers and tones of goods (Gpkm and Gtkm, respectively). Therefore, a linear relationship has been assumed between the increase of passengers and the increase in the traffic volume (i.e. constant occupancy of vehicles over the period analysed). Similarly, a linear relationship has been assumed between the increase of tons of goods and the increase in freight traffic volume.

Data is available at a country level, and for the current scenarios, the years 2015, 2020, 2025 and 2030 have been selected.

Assumptions:

- The same percentage of change of traffic is applied to both inside and outside agglomerations;
- The same percentage of traffic change is applied to all scenarios;
- Uniform reduction of dB to all noise bands.

Approach:

1. Select the following groups of vehicles from the Reference Scenario 2020 (outcome of the Primes model available at *Main results on energy, transport and GHG emissions*[1])
   - Passenger transport
     - Buses and coaches
     - Passenger cars
     - Powered two-wheelers
   - Freight transport
     - Heavy goods and light commercial vehicles
2. Calculate the % of change for each group, per country, for the following periods
   - 2015-2020, used in the 2017-2022 projections
   - 2020-2025, used in the 2017-2022 and 2022-2030 projections
   - 2025-2030, used in the 2022-2030 projections
3. Calculate the dB change for each of the two groups of vehicles. It is assumed to be 3 dB per doubling the traffic volume (Kephalopoulos, Paviotti, & Anfosso-Lédée, 2012). Therefore, the following formula is applied to calculate the change in dB for the period 2017 – 2022 and 2022-2030:

$$dB = 10 \cdot \log\left(1 + \frac{\%\ increase\ of\ traffic}{100}\right)$$

4. Calculate the share of the passenger transport and freight transport from ACEA Vehicle in Use Report (ACEA, 2022). The following equivalence is assumed:

Type of transport	EU Reference scenario (change of traffic)	ACEA (share of type of vehicle)
Passenger transport	Buses and coaches Passenger cars Powered two-wheelers	Buses Passenger cars
Freight transport	Heavy goods and light commercial vehicles	Light commercial vehicles Medium and heavy commercial vehicles

5. Calculate the final dB change per country due to changes in traffic by considering the outcome of step 3 (dB change per type of vehicle) and step 4 (% of each type of vehicle):

$$dB\ traffic\ change = 10 \cdot log\left[\frac{passenger\ share \cdot 10^{(dB\ passenger/10)} + freight\ share \cdot 10^{(dB\ freight/10)}}{100}\right]$$

[1] https://energy.ec.europa.eu/document/download/1485062e-2d65-47cb-887a-a755edc2ec36_en?filename=ref2020_energy-transport-ghg.xlsx

Passenger share = Share of passenger transport as % of total road transport (step 4)
Freight share = Share of freight transport as % of total road transport (step 4)
dB passenger = dB increase for a given period due to the rise in passenger traffic (step 3)
dB freight = dB increase for a given period due to the rise in freight traffic (step 3)

6. The dB change is applied to the people exposed per dB band in the initial year of the period under consideration. The table below exemplifies an hypothetical increase of 0,1 dB due to the traffic increase

Noise level at 0,1dB	Population exposed 2017	New noise level
50,1	100,000	50,1+0,1 = 50,2
50,2	102,000	50,2+0,1 = 50,3
50,3	87,000	50,3+0,1 = 53,4
…	…	…

C. Regulation of the sound level of motor vehicles

EU sound level limits for vehicles changed in 2016 and 2020/2022 and will change further in 2024/2026. We apply this regulation to all cars at any speed. As new model vehicles come into service, the percentage of the fleet that complies with the newer limits will increase. Percentage compliance with vehicle emission limits will increase year on year, with a commensurate reduction in noise. That compliance is predicted by using linear interpolation from the data shown in the following table. For the best scenario we consider a full implementation of the nosie regulations.

Table A. Percentage compliance with vehicle emission limits for 2017-2020 extrapolated to 2022, and emission limits coming into force 2017-2026 in 2030 (Conservative Scenario 2030. 2015* refers to the period up to and including 2015. Source: linear interpolation from Table 5.16 (Phenomena project; VVA et al., 2021)

Vehicle	Scenario 2022				Conservative Scenario 2030				Best Scenario 2030
	2015*	2016	2020/22	2024/26	2015*	2016	2020/22	2024/26	
Car (C1)	89	2	4	1	43	10	20	7	100 % compliance with the 2024/26 regulations
Van (C2)	89	2	5	2	43	10	23	9	
Bus (C3)	89	2	3	1	43	10	17	5	
Heavy truck (C3)	89	3	4	1	43	13	20	7	

Next table presents the foreseen EU noise limits for vehicles categorised as Regulation 540/2014 and adapted to the broader categories of the Dutch calculation method. For the Best Scenario 2030 we estimate a linear reduction of 2 dB over a period of 15 years from 2015 (situation before the regulation) to 2030 (optimistic estimated full implementation), i.e. about 0.13 dB per year.

Table B. EU vehicle noise limits for 2016-2026, with conversion to equivalent limit values for each vehicle category of the Dutch calculation method. This table only applies to 2022, and Conservative scenario 2030.

	EU limits					Equivalent limit values				
Vehicle class EU Regulation	2015 Current	2016 New vehicle types	New vehicle types from 2020 and new regulation from 2022	New vehicle types from 2024 and new regulation from 2026	Vehicle category for NL calculation method	2014/15	2016	2020	2024	Scenario 3 2030+quiet vehicles
M1 (PMR≤120kW/t)	72	72	70	68	LV (Light)	72.3	72.1	70.2	68.3	65.3
M1 (120<PMR≤160kW/t)	73	73	71	69						
M2 (m ≤ 2,5t)	74-75	72	70	69						
M2 (2,5t<m≤3,5t)	75	74	72	71						
N1 (m ≤ 2,5t)	73	72	71	69						
N1 (2,5t < m ≤ 3,5t)	74	74	73	71						
M2 (3,5t<m≤5t, Pn≤135kW)	76	75	73	72	MV (Medium)	76.9	77.6	75.8	74.7	71.7
M2 (3,5t<m≤5t, Pn>135kW)	76-78	75	74	72						
M3 (Pn≤150kW)	77-78	76	74	73						
M3 (150<Pn≤250kW)	79	78	77	76						
M3 (Pn>250kW)	79-81	80	78	77						
N2 (Pn≤135kW)	75-77	77	75	74						
N2 (Pn>135kW)	78-80	78	76	75						
N3 (Pn≤150kW)	78-79	79	77	76	HV (Heavy)	80.7	82.2	80.7	78.7	75.7
N3 (150<Pn≤250kW)	81-83	81	79	77						
N3 (Pn>250kW)	81-83	82	81	79						

Source: Table 2 in Dittrich, M., & Sliggers, J. (2015). A Policy Indicator for Road Traffic Noise Emission. Retrieved from https://unece.org/DAM/trans/doc/2015/wp29grb/GRB-62-14e.pdf

The baseline conditions of the road vehicle fleet, including the proportions of electric vehicles, can be obtained with reference to the ACEA Vehicle in Use Report (ACEA, 2022), which presents vehicle numbers annually from 2011 up to 2020 and in detail for 2020 subdivided into vehicle categories and Member States.

Approach:

1. Calculate the percentage of the type of vehicle (baselinbe and increase).
   The baseline conditions of the road vehicle fleet, including the proportions of electric vehicles, can be obtained with reference to the ACEA Vehicle in Use Report (ACEA, 2022), which presents vehicle numbers annually from 2011 up to 2020 and in detail for 2020 subdivided into vehicle categories and Member States. The annual increase is derived from the % of change 2019-2020 and applied uniformely to estimate the percentage of vehicles in 2022 and 2023 (no differences between scenarios). The following vehicle types are considered.
   - Cars
   - Vans
   - Buses
   - Trucks
2. For each type of vehicle (previous step), determine the percentage of vehicles complying with the new noise regulations (Table A).
3. Determine the noise level situation in t_0 and t_1 as follows:

$$Level\ situation\ t_i = 10 \cdot log \left[\frac{\sum_{n=1}^{4} \sum_{y=1}^{4} \%\ vehicle\ type_{ny} \cdot \%\ compliance_{ny} \cdot 10^{(dB\ limit_{ny}/10)}}{100} \right]$$

Where

- *n* accounts for the type of vehicle (step 1)
- *y* accounts for the years where new sound level limits enter into force (i.e. 2014/15, 2016, 2022, 2024/2025 -Table A)

- *% vehicle type$_{ny}$* represent the % of vehicles of type *n* for the year *y* (a year where new sound level limits enter into force);
- *% compliance$_{ny}$* is the percentage of vechicle type *n* complaiant with the noise limit set in year *y*.
- *dB limit$_{ny}$* is the equivalent limit value per vehicle type $_{n}$ and year $_{y}$ obtained from Table B.

4. Calculate the difference between t_0 and t_1 to obtain the dB reduction for the given period.
5. Apply the dB reduction to all noise bands as explained in step 2 of *B.Traffic*.

Annex 6 provides an example of this calculations for Austria.

D. Electrification

The scenarios consider the benefit of low propulsion noise in electric vehicles to be partly offset by the noise from the Acoustic Vehicle Alerting System (AVAS, Regulation 540/2014). This applies to all new vehicles in such categories coming into the fleet and running up to 20km/h. AVAS must not be louder than a conventional car. The proportion of vehicles in the fleet with AVAS will increase between 2022 and 2030. Based on the findings of the DISTANCE project (Goubert, 2015), the practical benefits of electric vehicles are calculated to be 0.6 to 0.8 dB on principal and minor roads, and 0.3 to 0.4 dB on motorway and trunk roads. From other studies carried out in Germany, for a typical distribution on minor urban roads, the reduction is about 0.5 decibel. Therefore we will assume a reduction of 0,5 dB for roads roads inside agglomeration that are not labeled as major roads when 100 % of the fleet is electric. No reduction is assumed in major roads inside agglomerations.

Assumptions:

- Uniform reduction of dB in all noise bands
- No dB reduction on major roads inside agglomeration
- No effect of electrification in 2022; assumprion of 25 % electric fleet in 2030 conservative scenario (with total reduction of 0,12 dB) and assumption of 50 % electric freet in the optimistic scenario (with a reduction of 0,24 dB).

Approach:

1. Apply the noise reduction values provided in Table 3.3 to the corresponding scenario and per each noise band.

E. Low noise asphalt on other roads

Since quiet asphalt is more effective at higher speeds when the dominating noise source is the road/tyre interaction, a differential dB reduction has been considered: 2 dB reduction on major roads and 1 dB reduction on other roads. The value selected allows for some in-service degradation of noise performance, probably leading to a slight overestimation of noise reduction from propulsion sources.

Assumptions:

- Uniform reduction of dB in all noise bands;
- Percentages of quiet asphalt for each scenario?
- The percentage of major roads per agglomeration is derived from the ratio between people exposed to major roads and total people exposed to road traffic noise from the data reported by MS. The ratio is considered a proxy for the percentage of major roads. When data not available the EU average will apply.

The length of major roads could be estimated from the data provided by MS under the END. However, this data is not complete, and the total length would need to be estimated from other sources, which is out of the scope of the current scenarios. This could be a further improvement of the methodology proposed.

Approach:

1. Calculate the percentage of major roads and other roads.
   The percentage of major roads per agglomeration is derived from the ratio between people exposed to major roads and total people exposed to road traffic noise, from the data reported by MS. When data not available the EU average will apply.
2. Apply the noise reduction values provided in Table 3.3 to the corresponding scenario and per each noise band, considering the % of major roads and other roads.

F. Noise barriers on major roads

ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) estimated that 5 % of the total EU road length benefits benefits from a noise barrier. A source of the estimation is not cited, and it is considered unlikely that data would be available at EU scale to inform it. Further research has not provided data to support or refute such assumptions. It is therefore likely that they have been made based on examples and extrapolations, which could have been optimistic if based on a national or regional example from a country where integration of noise control in infrastructure is well developed. Based on estimations from Germany and proxy information from the Noise Action Plans, more conservative values have been adopted as presented in Table 3.3.

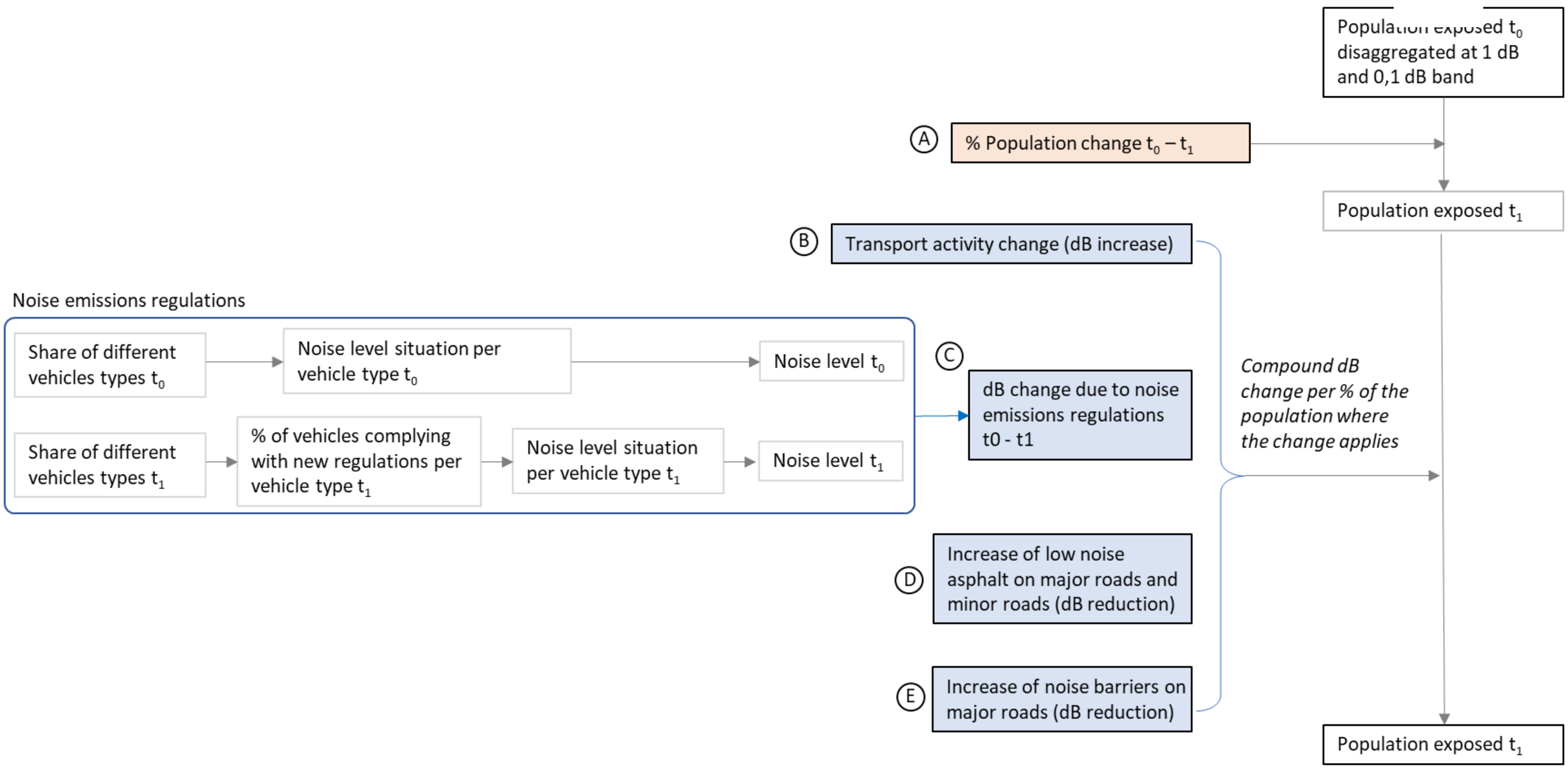
Assumptions: We assimilate the proportion of people exposed to major roads as percentage of major roads.

Approach:

1. Calculate the % of major roads (see E)
2. Apply the noise reduction values provided in Table 3.3 to the corresponding scenario and per each noise band, and type of road

Annex 2 Calculation details for road traffic noise scenarios inside urban areas

General workflow of scenarios for roads outside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), technological changes resulting from policy measures (C), and other noise abatement measures (D and E) explain the population change exposed to road traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.4, which provides the reference values used for the different scenarios and further details in this annex.



A. Population change

As explained in the previous section on data, population projections are based on LUISA, which provides projections for 2020, 2025 and 2030.

Assumptions:

- There are no differences between the two 2030 scenarios;
- The possible impact of COVID is not integrated;
- Population change from 2017 to 2020 is extrapolated from the population growth for the period 2020-2025 since this is the closest reference data from LUISA.

Approach: The same approach as for road noise inside agglomerations is applied.

B. Traffic change

The PRIMES model provides the transport activity data based on the EU Reference Scenario 2020 as the number of passengers and tones of goods (Gpkm and Gtkm, respectively). Therefore, a linear relationship has been assumed between the increase of passengers and the increase in the traffic volume (i.e. constant occupancy of vehicles over the period analysed).

Data is available at a country level, and for the purpose of the current scenarios, the years 2015, 2020, 2025 and 2030 have been selected.

Assumptions:

- The same percentage of traffic change is applied to all scenarios;
- Uniform reduction of dB to all noise bands.

Approach: The same approach as for road noise inside agglomerations is applied.

C. Regulation of the sound level of motor vehicles

EU sound level limits for vehicles changed in 2016 and 2020/2022 and will change further in 2024/2026. We apply this regulation to all cars at any speed. As new model vehicles come into service, the percentage of the fleet that complies with the newer limits will increase. Percentage compliance with vehicle emission limits will therefore increase year on year, with a commensurate reduction in noise.

The baseline conditions of the road vehicle fleet, can be obtained with reference to the ACEA Vehicle in Use Report (ACEA, 2022), which presents vehicle numbers annually from 2011 up to 2020 and in detail for 2020 subdivided into vehicle categories and Member States.

Approach: The same approach as for road noise inside agglomerations is applied.

E. Low noise asphalt on major roads

For quiet road surfaces on major roads (all roads outside agglomerations), a 1 dB reduction is assumed (Wood, 2022). The value selected allows for some in-service degradation of noise performance. This may lead to a slight overestimation of noise reduction from propulsion sources.

Approach:

1. Apply the noise reduction values provided in Table 3.4 to the corresponding scenario and per each noise band.

F. Noise barriers on major roads

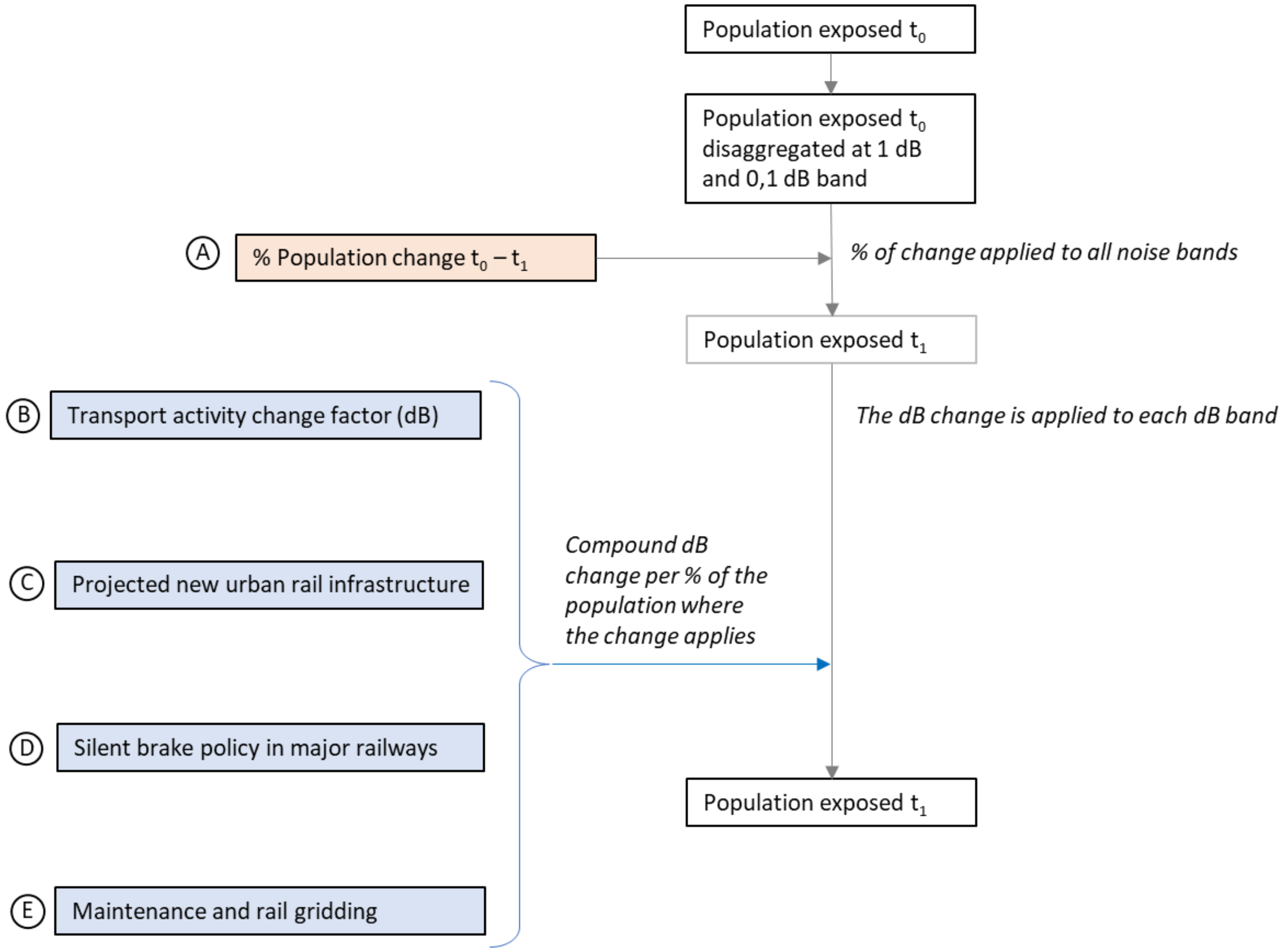
ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) estimated that 5 % of the total EU road length benefits benefits from a noise barrier. A source of the estimation is not cited, and it is considered unlikely that data would be available at EU scale to inform it. Further research has not provided data to support or refute such assumptions. It is therefore likely that they have been made based on examples and extrapolations, which could have been optimistic if based on a national or regional example from a country where integration of noise control in infrastructure is well developed. Based on estimations from Germany and proxy information from the Noise Action Plans, more conservative values have been adopted as presented in

Approach:

1. Apply the noise reduction values provided in Table 3.4 to the corresponding scenario and per each noise band.

Annex 3 Calculation details for rail traffic noise scenarios inside urban areas

General workflow of scenarios for rails inside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), new urban rail infrastructure (C) and other noise abatement measures (D and E) explain the population change exposed to rail traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.5, which provides the reference values used for the different scenarios and further details in this annex.



A. Population change

As explained in the previous section on data, population projections are based on LUISA, which provides projections for 2020, 2025 and 2030.

Assumptions:

- There are no differences between the two 2030 scenarios;
- The possible impact of COVID is not integrated;
- Population change from 2017 to 2020 is extrapolated from the population growth for the period 2020-2025 since this is the closest reference data from LUISA. Alternatively, there is LUISA data for the period 2010 -2020 based on EU Reference Scenario 2016. However, in the latter case, the reference period to calculate the population growth rate is considered too broad.

Approach:

1. <u>Disaggregation of the population exposed to noise at t_0 (2017) at 1 dB (one decimal precision)</u>.

As explained in the previous section on data, the population exposed to different noise sources is provided per 5 dB noise intervals.

The various factors that modify noise exposure change dB units (at one decimal precision). Therefore, the 5 dB intervals must be disaggregated at the decimal level (one decimal precision) to integrate these changes. The methodology is described in Blanes et al. (2019) -chapter 5.2.

2. Calculate the population change rate for the different periods based on LUISA.
    a. Overlay the population grid (100 x 100 m) from LUISA with the delineation of the agglomerations reported by MS under the END.
    b. From the previous step calculate the population for each agglomeration for the years provided by LUISA: 2020, 2025, 2030.
    c. Calculate the population per country and subtract the population in agglomerations (step b) to obtain the population outside agglomerations per country.
    d. Calculate the cumulative average growth rate (CARG) per agglomeration, per country and per the two periods: 2020- 2025, and 2025-2030. The essential values are: the population P_{to} (or starting value), the population at P_{t1} (or ending value), and the T (or period of time to measure growth).

$$CAGR_{t_0-t_1} = \left(\frac{Pop_{t_1}{}^{\frac{1}{T}}}{Pop_{t_0}}\right) - 1$$

    e. Once the complete list of CAGR have been calculated, the resulting rates are used to project future values of the population exposed to noise using the following formula per each studied period. As mentioned before, the same projections are used for all scenarios.

$$P_{exposed2022} = P_{exposed\ 2017} \cdot (1 + CAGR)^5$$

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR)^8$$

B. Rail traffic growth

The PRIMES model provides the transport activity data based on the EU Reference Scenario 2020 as the number of passengers and tones of goods (Gpkm and Gtkm, respectively) as described in the previous section on road traffic noise. However, this model does not allow to differentiate urban railways. Therefore two projections for urban rail transport developed by the International Energy Agency and International Union of Railways (2017) have been adopted:

- Baseline scenario, where urban transport activity in Europe will grow by 30 %, from 95 billion passenger-km in 2017 to 126 billion passenger-km in 2030.
- Higher growth urban rail scenario. Urban transport activity in Europe will grow from 95 billion passenger-km in 2017 to 305 billion passenger-km in 2050 (220 % increase). By way of a linear interpolation, an increase in urban rail activity of 87 % in 2030 is estimated.

The correspondence with these two projections with our scenarios and corresponding values are presented in the following table.

Table C. Rail traffic growht as % of passenger kilometers and in in dB, derived from International Energy Agency and International Unikon fo Railways (2017).

	2022	Best scenario 2030	Conservative scenario 2030
Corresponding scenario in IEAI & IUI (2017)	Baseline scenario	High growth scenario	Baseline scenario
% rail traffic growth	12 %	87 %	33 %
dB increase	0.5	2.7	1.2

Assumptions:

- The same urban rail traffic growth applied to all agglomerations;
- Corresponding noise increase applied to all noise bands.

Approach:

1. The dB increase provided in Table 3.5 is applied to all dB bands calculated in the previous step (A. population change).

C. Projected new urban rail infrastructure

New urban rail infrastructure is derived from the forecast provided by UITP (2019) for the period 2014 - 2021, leading to an increase of 580 km of new light railt transit. The same trend for this period is projected to 2022 and 2030 resulting in the figures presented in the following table.

Table D. Projected new urban rail infrastructure (UITP, 2019)

	2017	2022	2030 (both scenarios)
Kilometers (Gpkm)	9 188	9 767	10 212
Gpkm % change	--	6 %	11 %
dB change	--	0.3	0.5

Assumptions:

- All scenarios are based on the same growth per year.

Approach:

1. The dB increase provided in Table 3.5 is applied to all dB bands.

D. Silent brake policy in major railways

The silent brake policy (European Commission, 2014) sets out noise limits for new rail vehicles, in addition to renewed or upgraded wagons. It also imposes Member States to designate quieter routes.

Values provided in Table 3.5 are derived from the railway noise reduction total for the EU from the silent brake policy by European Railway Agency (2022).

Assumptions:

- Same level of implementation in the 2030 scenarios

Approach:

1. Calculate the percentage of major rails inside agglomerations.
   The percentage of major rail per agglomeration is derived from the ratio between people exposed to major rails and total people exposed to rail traffic noise. The length of major rails could be estimated from the data provided by MS under the END.

2. Apply the noise reduction values provided in Table 3.5 to the corresponding scenario and per each noise band, corrected by the percentage of major rails.

E. Maintenance and rail grinding

Roughness at the wheel-rail interface is the key source of noise generation from railways. The combined roughness of both the wheel and the rail are directly linked to rolling noise emissions from railways. Therefore, a well-maintained wheel and rail are required to maintain low noise levels at source.

Improvements in methods for railhead management (i.e. implementing maintenance activities that promote reduction in roughness levels) are accounted for in the 2030 scenarios, excluding any track renewal activities. This will account for improvements in both final surface finish, but also development of preventive strategies, where the rails are maintained at regular intervals before the onset of significant noise issues. It is expected that the influence would be higher within agglomerations and urban areas, where mitigation is more difficult to achieve.

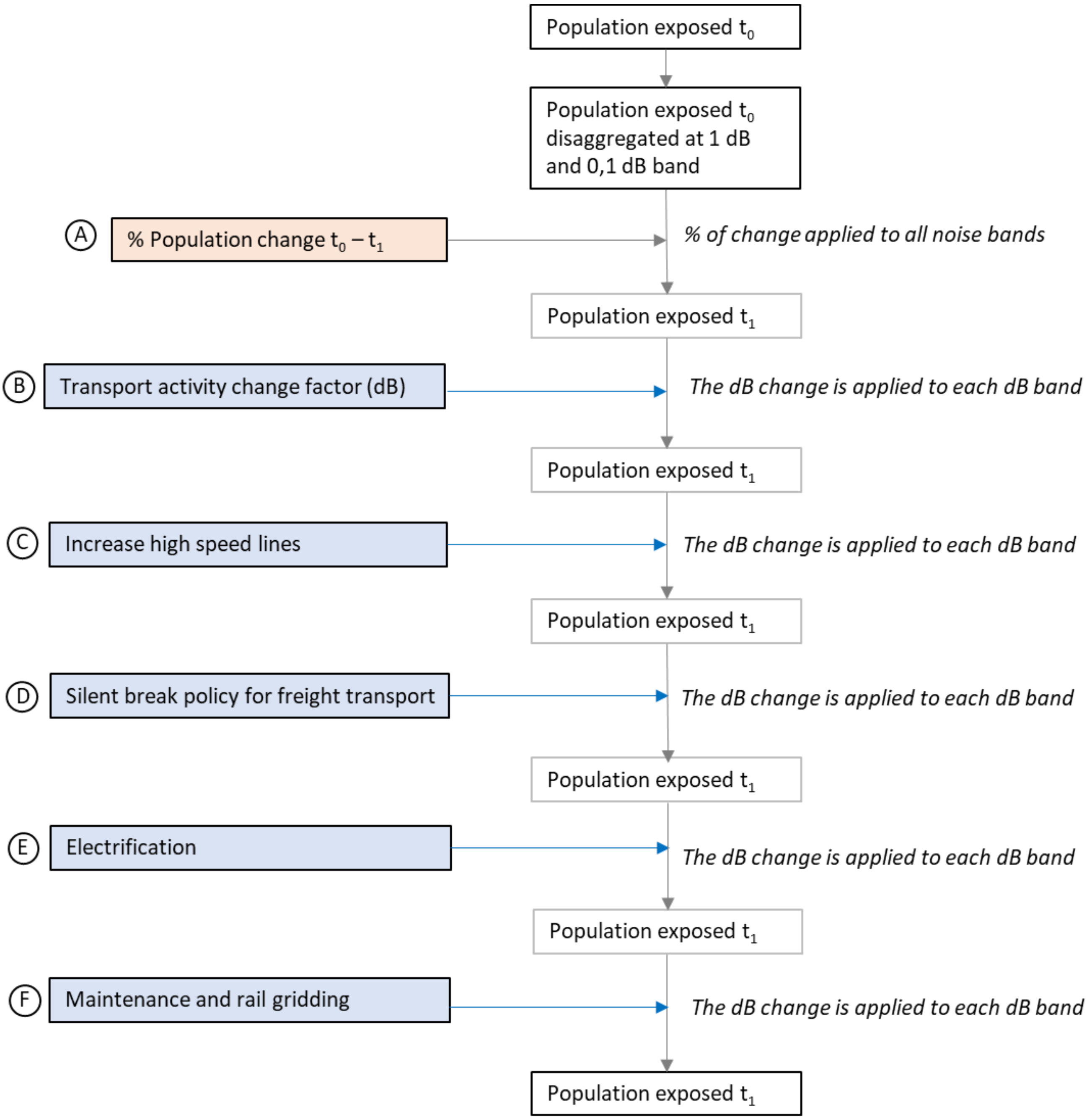
Rail grinding can achieve results of up to 3dB reduction for high-speed traffic and up to 5 dB reductions for conventional traffic (International Union of Railways, 2021c). ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) estimated a 3dB reduction in emissions from the improvement of the rail roughness. Here, it is assumed rolling noise reduction level of 2dB for inside agglomerations for the best scenario.

Approach:

1. The dB decrease provided in Table 3.5 is applied to all dB bands.

Annex 4 Calculation details for rail traffic noise scenarios outside urban areas

General workflow of scenarios for rails outside agglomerations. Demographic changes (A) (in orange), factors related to traffic flow (B), new high speed lines (C) and other noise abatement measures (D, E and F) explain the population change exposed to rail traffic noise between t0 and t1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.6, which provides the reference values used for the different scenarios and further details in this annex.



A. Population change

As explained in the previous section on data, population projections are based on LUISA, which provides projections for 2020, 2025 and 2030.

Assumptions:

- There are no differences between the two 2030 scenarios;
- The possible impact of COVID is not integrated;
- Population change from 2017 to 2020 is extrapolated from the population growth for the period 2020-2025 since this is the closest reference data from LUISA. Alternatively, there is LUISA data for the period 2010 -2020 based on EU Reference Scenario 2016. However, in the latter case, the reference period to calculate the population growth rate is considered too broad.

Approach:

1. Disaggregation of the population exposed to noise at t_0 (2017) at 1 dB (one decimal precision).
   As explained in the previous section on data, the population exposed to different noise sources is provided per 5 dB noise intervals.
   The various factors that modify noise exposure change dB units (at one decimal precision). Therefore, the 5 dB intervals must be disaggregated at the decimal level (one decimal precision) to integrate these changes. The methodology is described in Blanes et al. (2019) -chapter 5.2.

2. Calculate the population change rate for the different periods based on LUISA.
   a. Overlay the population grid (100 x 100 m) from LUISA with the delineation of the agglomerations reported by MS under the END.
   b. From the previous step calculate the population for each agglomeration for the years provided by LUISA: 2020, 2025, 2030.
   c. Calculate the population per country and subtract the population in agglomerations (step b) to obtain the population outside agglomerations per country.
   d. Calculate the cumulative average growth rate (CARG) per agglomeration, per country and per the two periods: 2020- 2025, and 2025-2030. The essential values are: the population P_{to} (or starting value), the population at P_{t1} (or ending value), and the T (or period of time to measure growth).

$$CAGR_{t_0-t_1} = \left(\frac{Pop_{t_1}{}^{\frac{1}{T}}}{Pop_{t_0}} \right) - 1$$

   e. Once the complete list of CAGR have been calculated, the resulting rates are used to project future values of the population exposed to noise using the following formula per each studied period. As mentioned before, the same projections are used for all scenarios.

$$P_{exposed2022} = P_{exposed\ 2017} \cdot (1 + CAGR)^5$$

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR)^8$$

B. Rail traffic growth

The PRIMES model provides the transport activity data based on the EU Reference Scenario 2020 as the number of passengers and tones of goods (Gpkm and Gtkm, respectively) as described in the previous section on road traffic noise.

Data is available at a country level, and for the purpose of the current scenarios, the years 2015, 2020, 2025 and 2030 have been selected.

Assumptions:

- The same percentage of traffic change is applied to all scenarios;
- Uniform reduction of dB to all noise bands.

Approach:

1. It is assumed a 3 dB per doubling the traffic volume (ref). Therefore, the following formula is applied to calculate the change in dB for the period 2017 – 2022.

$$dB = 10 * \log\left(1 + \frac{\%\, increase\ of\ traffic}{100}\right)$$

2. The dB change is applied to the people exposed per dB band.

C. Increase of high speed lines

Conventional rail activity growth is expected to be around 8 % between 2017 and 2030, based on the passenger kilometres (International Energy Agency, 2019). In developed economies, the main reason for the low growth of conventional rail is the focus on the development of high-speed (HS) rail, which is expected to be at 25 % in Europe in terms of the passenger kilometres (wood, 2022).

In terms of infrastructure, it is assumed that no significant growth on the non-high-speed railway network will be occurring in the next few years, as any new lines expected to be constructed are assumed to be at speeds of 200 km/h and above. However, it is assumed that due to technology improvements, the existing conventional rail network will see a +20 km/h increase in the average speed. The current average speed for Europe's conventional passenger network is assumed at 170 km/h. While this is high, it provides a more conservative estimate on the future noise increase.

The projected growth of the construction of high-speed (v>200 km/h) lines across Europe, based on under construction and planned high-speed railway tracks, using an estimated average increase of 45 % from 2020 (International Union of Railways, 2021a), accounting for 13 % of the major railways outside agglomerations, leads to an estimated increase of noise source levels of up to 1.5 dB (wood, 2022)

Approach:

1. The dB increase provided in Table 3.6 is applied to all dB bands.

D. Silent brake policy in major railways

The silent brake policy (European Commission, 2014) sets out noise limits for new rail vehicles, in addition to renewed or upgraded wagons. It also imposes Member States to designate quieter routes.

Values provided in Table 3.6 are derived from the railway noise reduction total for the EU from the silent brake policy by European Railway Agency (2022).

Assumptions:

- Same level of implementation in the 2030 scenarios

Approach:

1. Apply the noise reduction values provided in Table 3.6 Table 3.3to the corresponding scenario and per each noise band.

5.4.1.1 E. Electrification

The railway network in Europe is mostly electrified (European Commission - Directorate-General for Research and Innovation, 2017). In urban areas, rail runs almost exclusively on electricity as of 2017. Outside urban areas, 60 % of the European rail network was already electrified, with 80 % of the traffic running on those lines. While further electrification is possible, a balanced approach will need to be taken with respect to electrifying existing rail infrastructure to achieve the Green Deal goals of 2030. On the basis of the scenarios proposed by Wood (2022), an assumed rate of electrification of the European rail network outside urban areas is considered at 2.5 % per year, from 2022 to 2030. For the year 2022, a level of 65 % electrification of the entire network is assumed, accounting for slow development of construction schemes due to Covid19.

The decibel change related to this activity is taken as 1dB, which is the difference in pass-by noise level between DMU and EMU vehicles, as defined by the Noise TSI. Values of up to 3 dB have been reported for speed lines up to 110 km/h (International Union of Railways, 2021), however, at higher speeds rolling noise is more prominent that traction noise, and therefore, a more conservative value is proposed.

Table E. Projections of noise reductin due to electrification of the railway network outside urban areas for 2022 and 2030.

	2017	2022	2030
% of electrified network	60%	65%	85%
Relative dB reduction	-	0.1	0.3

Source: own elaboration of (European Commission - Directorate-General for Research and Innovation, 2017) including assumed forecasts

Assumptions:

- Same level of implementation in the 2030 scenarios

Approach:

1. Apply the noise reduction values provided in Table 3.6 to the corresponding scenario and per each noise band.

F. Maintenance and rail grinding

Roughness at the wheel-rail interface is the key source of noise generation from railways. The combined roughness of both the wheel and the rail are directly linked to rolling noise emissions from railways. Therefore, a well-maintained wheel and rail are required to maintain low noise levels at source.

Improvements in methods for railhead management (i.e. implementing maintenance activities that promote reduction in roughness levels) are accounted for in the 2030 scenarios, excluding any track renewal activities. This will account for improvements in both final surface finish, but also development of preventive strategies, where the rails are maintained at regular intervals before the onset of significant noise issues. It is expected that the influence would be higher within agglomerations and urban areas, where mitigation is more difficult to achieve.

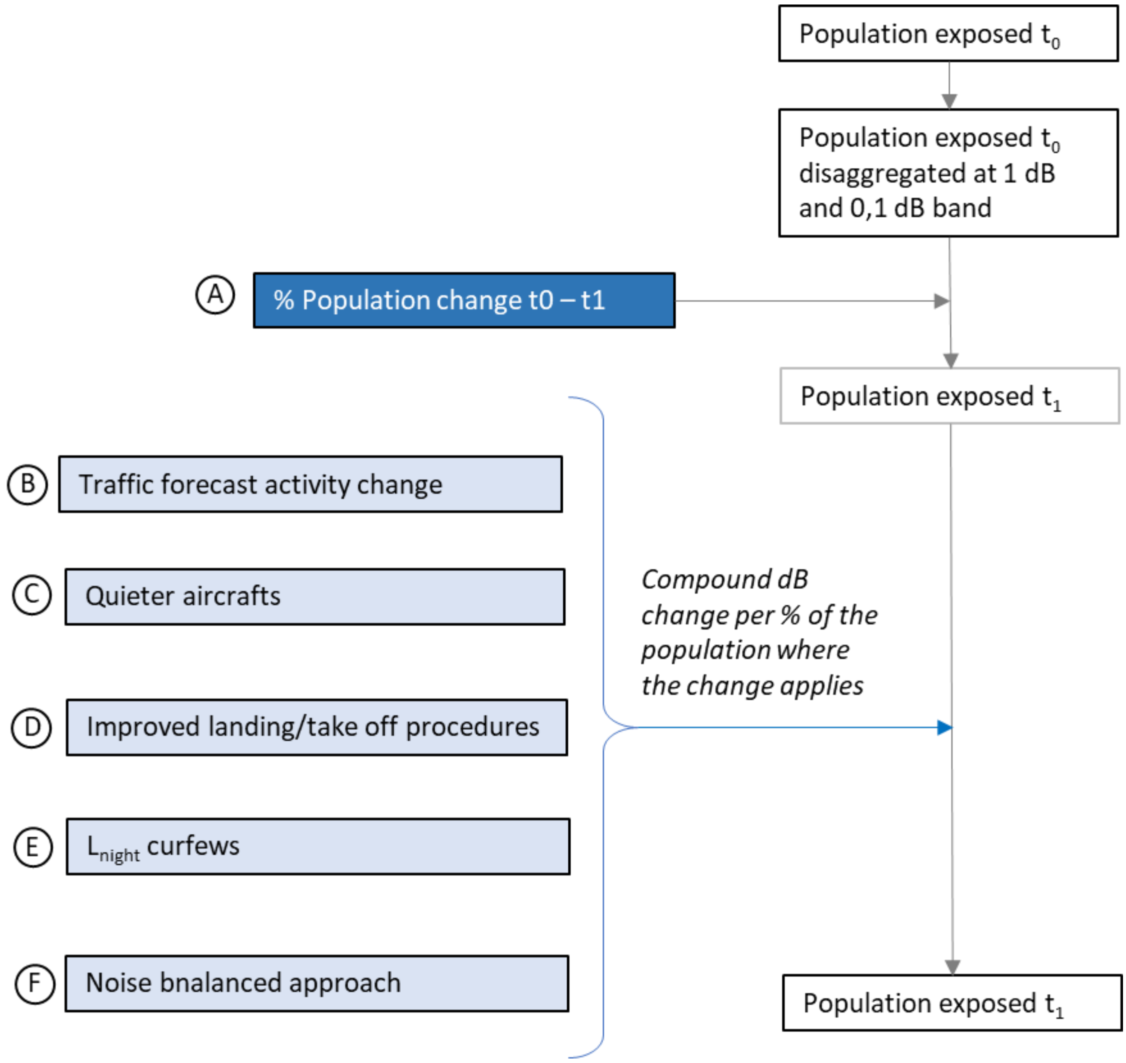
Rail grinding can achieve results of up to 3dB reduction for high-speed traffic and up to 5 dB reductions for conventional traffic (International Union of Railways, 2021c). ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) estimated a 3 dB reduction in emissions from the improvement of the rail roughness. Here, it is assumed rolling noise reduction level of 0,5 dB for outside agglomerations for the best scenario.

Approach:

1. The dB decrease provided in Table 3.6 is applied to all dB bands.

Annex 5 Calculation details for aircraft noise scenarios (inside and outside urban areas)

General workflow of scenarios for air traffic noise (inside and outside agglomerations). Demographic changes (A) (in dark blue), factors related to traffic flow (B), and other noise abatement measures (C to F) contribute to the population change exposed to air traffic noise between t_0 and t_1. Boxes in grey refer to intermediate calculations. Letters link to summary Table 3.7, which provides the reference values used for the different scenarios and further details in this annex.



A. Population change

As explained in the previous section on data, population projections are based on LUISA, which provides projections for 2020, 2025 and 2030.

Assumptions:

- There are no differences between the two 2030 scenarios;
- The possible impact of COVID is not integrated;
- Population change from 2017 to 2020 is extrapolated from the population growth for the period 2020-2025 since this is the closest reference data from LUISA. Alternatively, there is LUISA data for the period 2010 -2020 based on EU Reference Scenario 2016. However, in the latter case, the reference period to calculate the population growth rate is considered too broad.

Approach: The same approach as for road noise inside agglomerations is applied.

B. Traffic forecast activity change

The report *COVID-19 impact on the European air traffic network* (Eurocontrol, 2021) provides projections on the number of flights for the period 2021- 2027 which account for the impact of the COVID. Addtionally, the *European Aviation Environmental Report 2019* (EASA et al., 2019) provides three scenarios for the period 2017 -2040, developed before the COVID. Considering the values provided in both refereces the followng approach has been adopted Table 3.7:

- 2022. Traffic decrease from 2019 by 10 % (Eurocontrol, 2021). In this case we assume no change or low changes for the period 2017 – 2019.
- 2030. The projected increase from EASA etl al. (2019) is considered for both scenarios since they provide a longer time frame. There is a 2 % of annual growth from 2024.

Calculation: The dB change applies to the entire population and all noise bands.

C. Quieter aircraft

Uptake of new technology is assumed to be low between 2017 and 2022 because of the slow introduction of new quieter aircraft coming into service (European Environment Agency; European Union Aviation Safety Agency; Eurocontrol, 2019), (ICAO, 2019). The use of the lower rate for the extrapolation between 2017 and 2020 is also supported by considering the effects on the fleet of the reduction in air travel due to Covid19, and to a lesser extent, to the grounding of the Boeing 737 Max until November 2020. This assumption affects the extrapolation of 2017 END noise data to 2022. It is assumed that there will be a noise level reduction for new aircraft delivered after 2015 of 0,1 dB per annum, reflecting the low technology uptake.

Calculation: The dB change applies to the entire population and all noise bands.

D. Improved landing/take off procedures

It is assumed a reduction in noise resulting from improved flight procedures, in particular as part of take-off procedures (e.g. noise abatement thrust cutback). Noise reduction of 2dB for take-off is assumed across all airports (ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA, 2021). However, these improvements only apply to 2030 scenarios.

Calculation: The dB change applies to the entire population and all noise bands.

E. L_{night} curfews

Operating restriction in the form of preventing the use of noisier aircraft during certain times across all airports could be simulated by replacing all non-Chapter 4 aircraft (ICAO, 2017) by a Chapter 4 equivalent between 22.00 and 08.00 hours (VVA et al., 2021). The reduction is estimated by 2 dB L_{enight} .

Calculation: The dB change applies to the entire population and all noise bands.

F. Noise balanced approach

Noise Action Plan under the Balanced Approach includes proactive stakeholder engagement resulting in reduced sensitivity equivalent to 2dB by 2030 (VVA et al., 2021).

Calculation: The dB change applies to the entire population and all noise bands.

Annex 6 Example of calculation of noise emissions regulations

This Annex provides an example for Austria of the claculations of dB due to noise emissions regulations (step C of road traffic noise inside and outside agglomerations).

1. **Calculate share of different vehicle types (with ACEA report)**

https://www.acea.auto/files/ACEA-report-vehicles-in-use-europe-2022.pdf

PASSENGER CARS [1] acea

	2016	2017	2018	2019	2020	%change 20/19
Austria	4,821,557	4,898,578	4,978,852	5,039,548	5,091,827	1.0
Belgium	5,669,766	5,735,280	5,782,684	5,813,771	5,827,195	0.2
Croatia	1,528,119	1,567,883	1,665,391	1,728,911	1,733,727	0.3
Cyprus	508,284	526,617	550,695	572,501	578,158	1.0

Table extracted from Austria /ACEA Report year 2020. Make percentages per vehicle type.

Total Motor vehicles	**5,633,525**	**100 %**
Bus	**10,064**	**0,18 %**
Medium-Heavy (i.e. truck)	**73,381**	**1,30 %**
Light commercial (i.e.vans)	**458,253**	**8,13 %**
Cars	**5,091,827**	**90,38 %**

Determine the percentage of vehicles complying to different regulations within the percentage share of the country (using tables below)

Table 4.1 Percentage compliance with vehicle emission limits 2017 – 2020 extrapolated to the year 2022

	Limits from year			
Vehicle	Up to and including 2015	2016	2020/22	2024/26
Car / C1	89	2	4	1
Van / C2	89	2	5	2
Bus / C3	89	2	3	1
Heavy truck / C3	89	3	4	1

Source: Linear interpolation from Table 5.16 in (ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA, 2021).

Cars (LV)	**Percentage complying emission regulations**	**Percentage within country (90,38*percentage)/100**
-0.2dB	**2 %**	**1.81 %**
-2.1 dB	**4 %**	**3,62 %**
-4 dB	**1 %**	**0,90 %**

Vans (LV)	Percentage complying emission regulations	Percentage within country (8,13*percentage)/100
-0.2dB	**2 %**	**0.16 %**
-2.1 dB	**5 %**	**0,41 %**
-4 dB	**2 %**	**0,16 %**

Bus (MV)	Percentage complying emission regulations	Percentage within country (0,18*percentage)/100
-0.7dB	**2 %**	**0,0036 %**
-1.1 dB	**3 %**	**0,0054 %**
-2.2 dB	**1 %**	**0,00162 %**

Truck (HV)	Percentage complying emission regulations	Percentage within country (1,30*percentage)/100
-1.5dB	**3 %**	**0,039 %**
-1.5 dB	**4 %**	**0,052 %**
-3.5 dB	**1 %**	**0,013 %**

Determine the noise level situation in 2017 (regulation 2014/2015) and in 2022 (other regulations) using the following table and the percentages calculated :

	EU limits					Equivalent limit values				
Vehicle class EU Regulation	2015 Current	2016 New vehicle types	New vehicle types from 2020 and new regulation from 2022	New vehicle types from 2024 and new regulation from 2026	Vehicle category for NL calculation method	2014/15	2016	2020	2024	Scenario 3 2030+quiet vehicles
M1 (PMR≤120kW/t)	72	72	70	68	LV (Light)	72.3	72.1	70.2	68.3	65.3
M1 (120<PMR≤160kW/t)	73	73	71	69						
M2 (m ≤ 2,5t)	74-75	72	70	69						
M2 (2,5t<m≤3,5t)	75	74	72	71						
N1 (m ≤ 2,5t)	73	72	71	69						
N1 (2,5t < m ≤ 3,5t)	74	74	73	71						
M2 (3,5t<m≤5t, Pn≤135kW)	76	75	73	72	MV (Medium)	76.9	77.6	75.8	74.7	71.7
M2 (3,5t<m≤5t, Pn>135kW)	76-78	75	74	72						
M3 (Pn≤150kW)	77-78	76	74	73						
M3 (150<Pn≤250kW)	79	78	77	76						
M3 (Pn>250kW)	79-81	80	78	77						
N2 (Pn≤135kW)	75-77	77	75	74						
N2 (Pn>135kW)	78-80	78	76	75						
N3 (Pn≤150kW)	78-79	79	77	76	HV (Heavy)	80.7	82.2	80.7	78.7	75.7
N3 (150<Pn≤250kW)	81-83	81	79	77						
N3 (Pn>250kW)	81-83	82	81	79						

The following formula is applied to 2017 and 2022

$$Level\ situation\ t_i\ = 10 * \log\left(\sum_{1}^{n} \%\ share\ cars\ type_n\ complying * \ 10^{(dB\ emission\ car\frac{type_n}{10}}\right.$$

Four types of vehicles are considered: cars, vans, bus and tracks.

Level Situation 2017 = 10 log ((percent share cars reg 2017 * 10 ^ (72.3dB/10) + percent share vans reg 2017 * 10 ^ (72.3dB/10) + percent share bus reg 2017 * 10 ^ (76.9dB/10) + percent share truck reg 2017 * 10 ^ (82.2dB/10)) /100)

Level Situation 2017 = 10 log ((90.38 * 10 ^ (72.3dB/10) + 8.13 * 10 ^ (72.3dB/10) + 0.18 * 10 ^ (76.9dB/10) + 1.3 * 10 ^ (82.2dB/10)) /100) = **72.78 dB**

Level Situation 2022 = 10 log ((percent share cars reg 2017 * 10 ^ (72.3dB/10) + percent share cars reg 2016 * 10 ^ (72.1dB/10) + percent share cars reg 2020 * 10 ^ (70.2dB/10) + percent share cars reg 2024 * 10 ^ (68.3dB/10) + percent share vans reg 2017 * 10 ^ (72.3dB/10) + percent share vans reg 2016 * 10 ^ (72.1dB/10) + percent share vans reg 2020 * 10 ^ (70.2dB/10) + percent share vans reg 2024 * 10 ^ (68.3dB/10) + percent share bus reg 2017 * 10 ^ (76.9dB/10) + percent share bus reg 2016 * 10 ^ (77.6dB/10) + percent share bus reg 2020 * 10 ^ (75.8dB/10) + percent share bus reg 2024 * 10 ^ (74.7dB/10) + percent share truck reg 2017 * 10 ^ (82.2dB/10) + percent share truck reg 2016 * 10 ^ (80.7dB/10) + percent share truck reg 2020 * 10 ^ (80.7dB/10) + percent share truck reg 2024 * 10 ^ (78.7dB/10)) /100)

Level Situation 2022 = 10 log ((84.05 * 10 ^ (72.3dB/10) + 1.81 * 10 ^ (72.1dB/10) + 3.62 * 10 ^ (70.2dB/10) + 0.9 * 10 ^ (68.3dB/10) + 7.4 * 10 ^ (72.3dB/10) + 0.16 * 10 ^ (72.1dB/10) + 0.41 * 10 ^ (70.2dB/10) + 0.16 * 10 ^ (68.3dB/10) + 0.169 * 10 ^ (76.9dB/10) + 0.0036 * 10 ^ (77.6dB/10) + 0.0054 * 10 ^ (75.8dB/10) + 0.00162 * 10 ^ (74.7dB/10) + 1.196 * 10 ^ (82.2dB/10) + 0.039 * 10 ^ (80.7dB/10) + 0.052 * 10 ^ (80.7dB/10) + 0.013 * 10 ^ (78.7dB/10)) /100) = **72.68 dB**

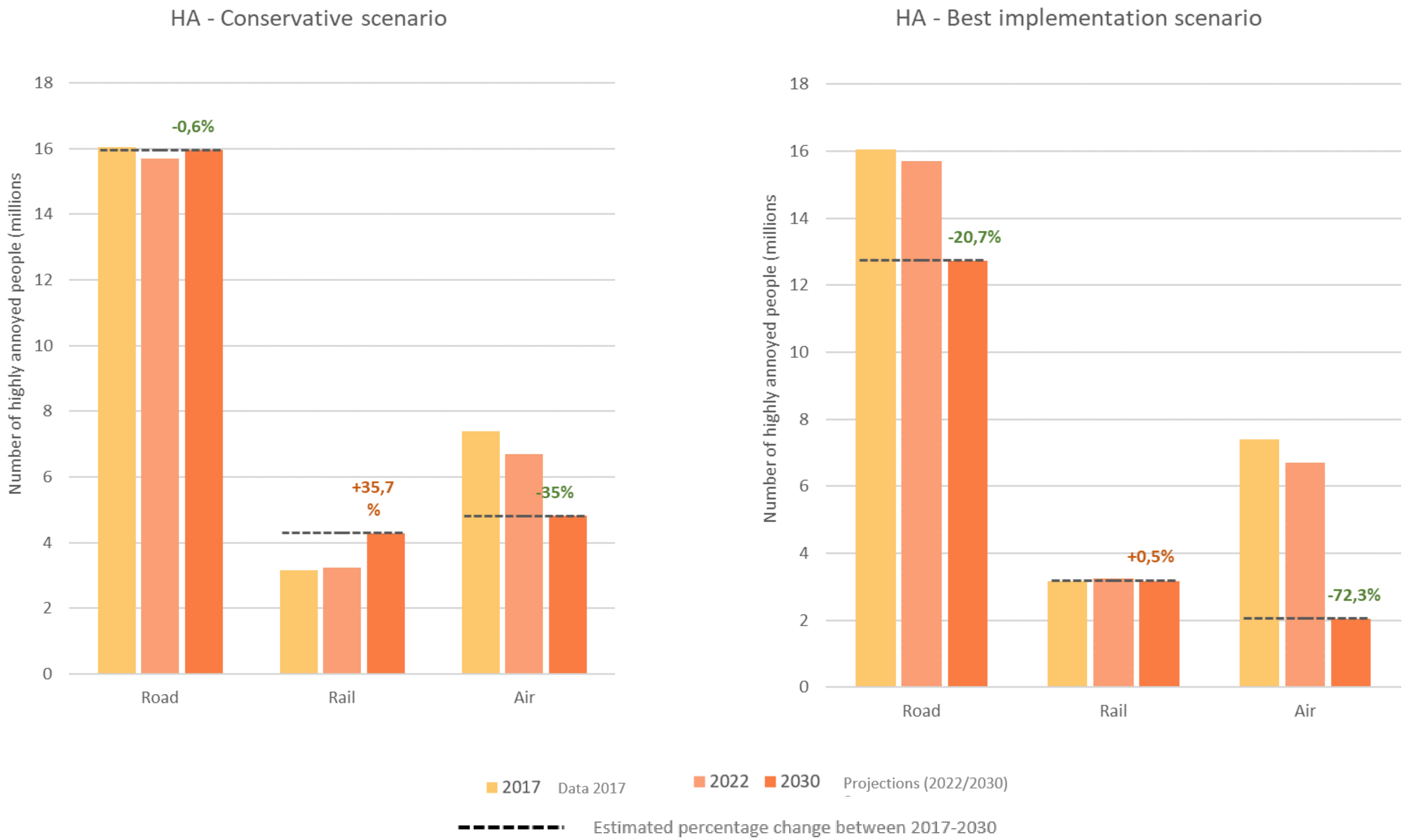
dB reduction in each band = Level Situation 2022— Level Situation 2017
72.78 – 72.68 = **0,1 dB**

Apply dB reduction in population exposed

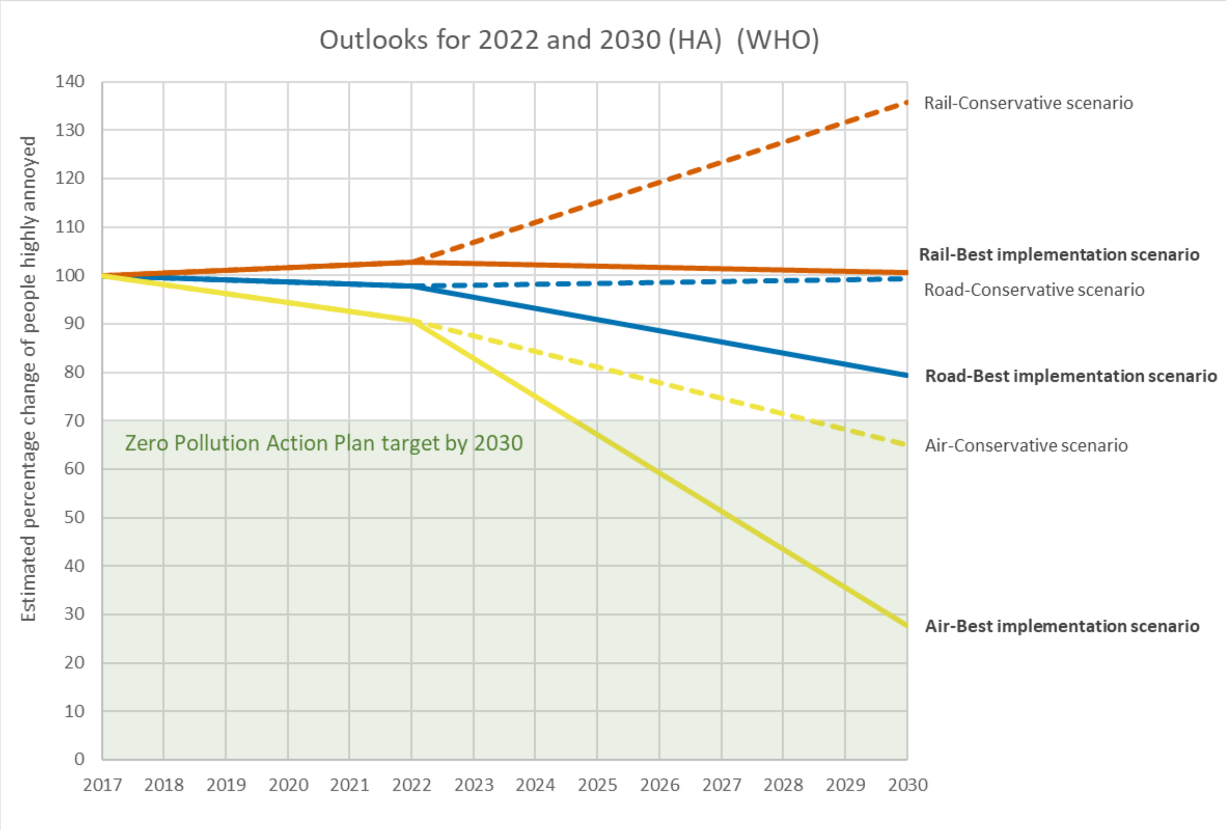
Noise level at 0,1dB	Population exposed 2017	New noise level
50,1	**100,000**	**50,1-0,1 =50.0**
50,2	**102,000**	**50,2-0,1 = 50,1**
50,3	**87,000**	**50,3-0,1 = 53,2**
…	**…**	**…**

Annex 7 Health risk assessment based on WHO recommendations

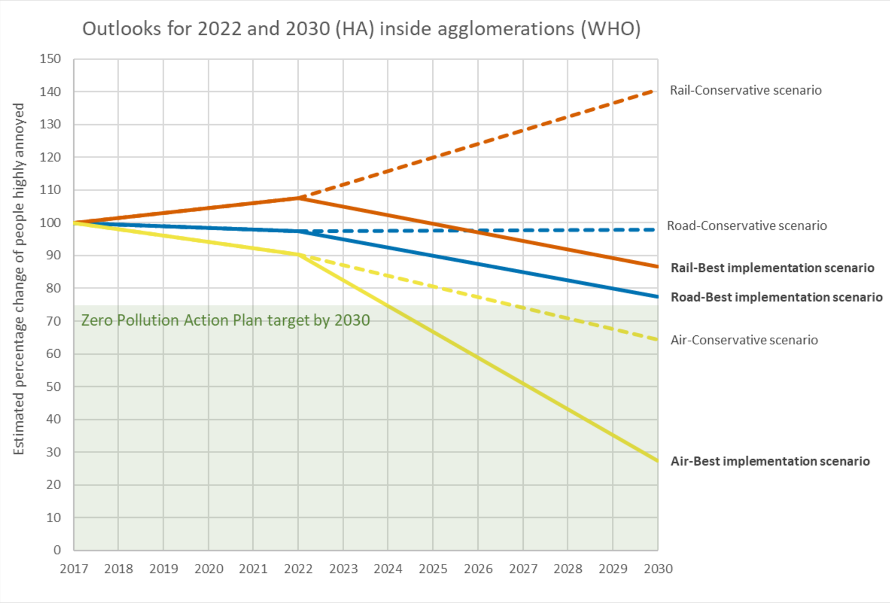
Outlooks for 2022 and 2030 for the number of highly annoyed people combined for inside and outside agglomerations based on the WHO thresholds.

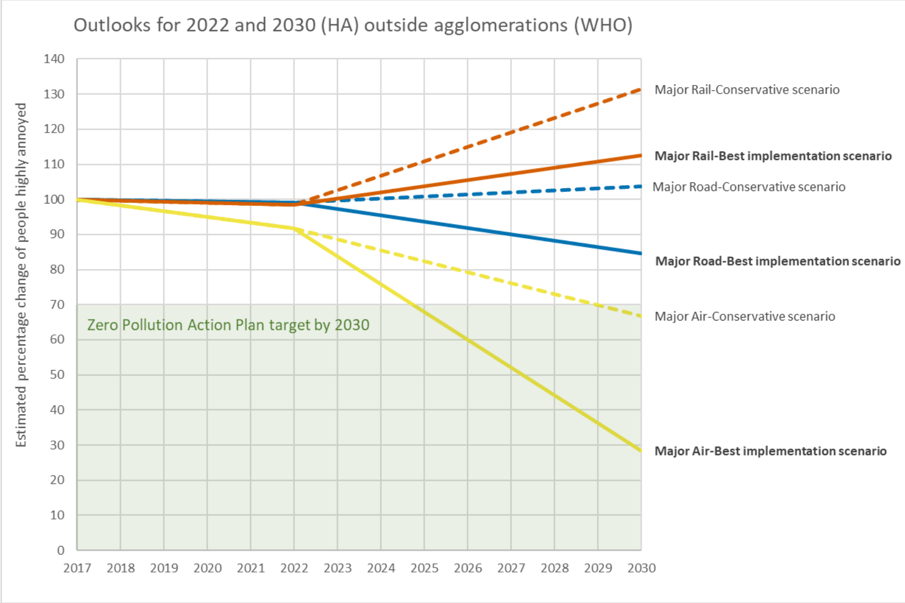


Outlooks for 2022 and 2030 for the change in highly annoyed people based on the WHO thresholds. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

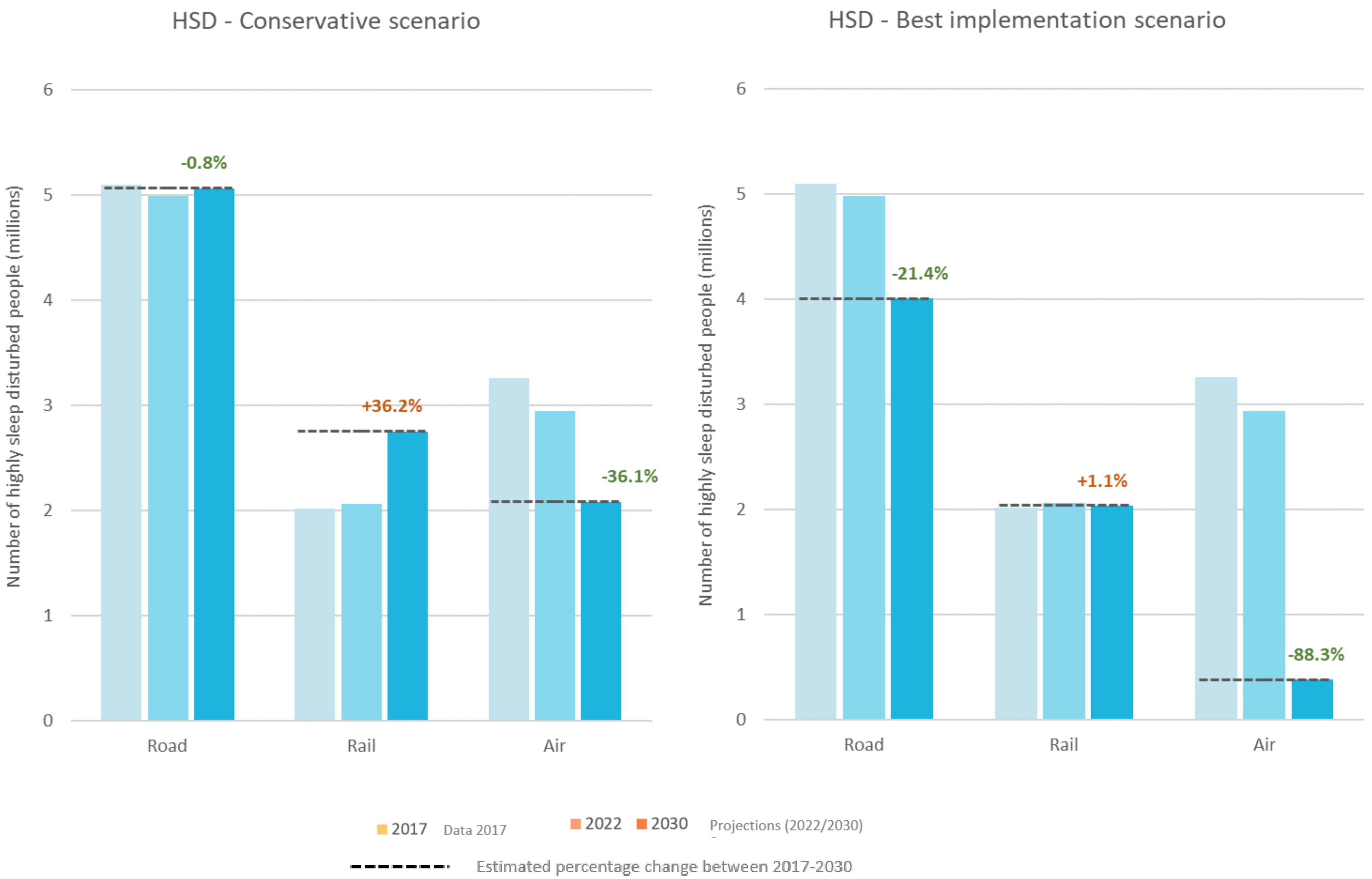


Outlooks for 2022 and 2030 for the change in highly annoyed people based on the WHO thresholds stratified by inside (left) and outside (right) agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

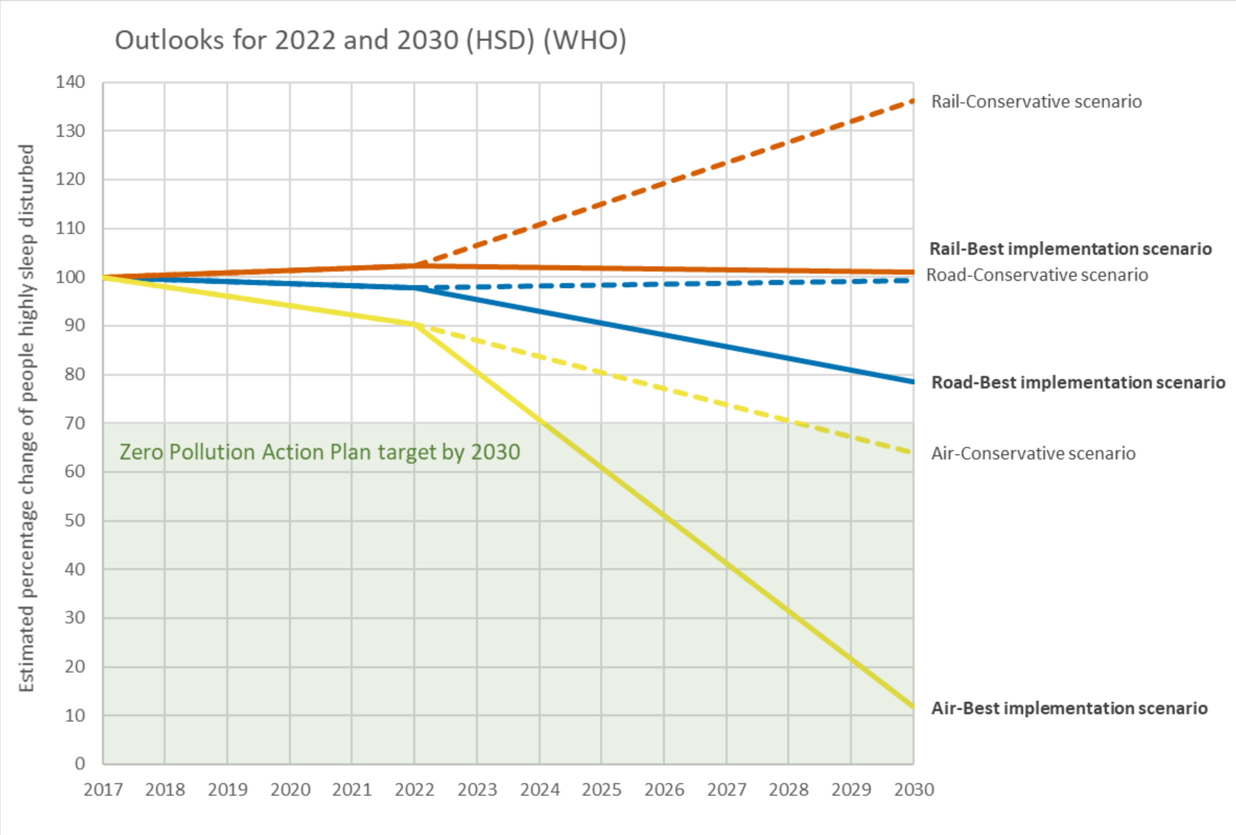




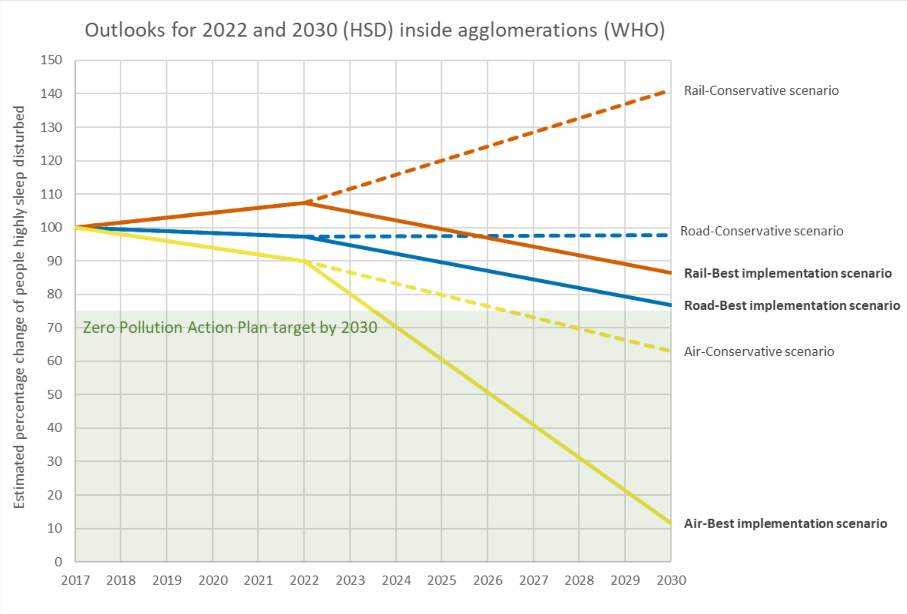
Outlooks for 2022 and 2030 for the number of highly sleep disturbed people combined for inside and outside agglomerations based on the WHO thresholds.

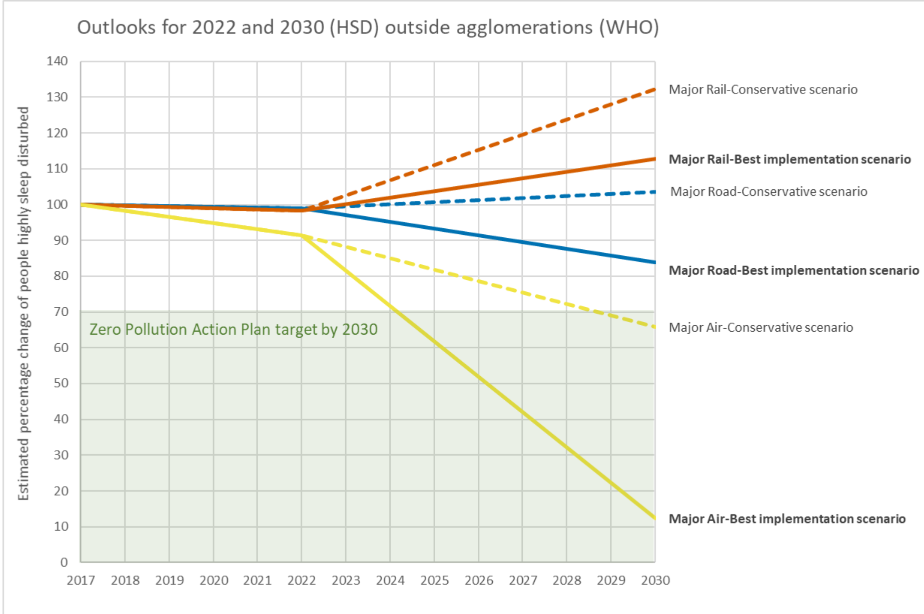


Outlooks for 2022 and 2030 for the change in highly sleep disturbed people based on the WHO thresholds. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

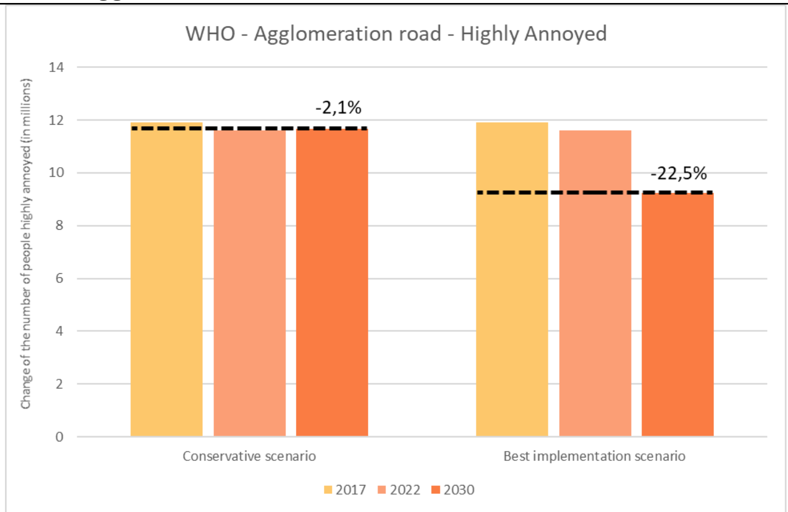
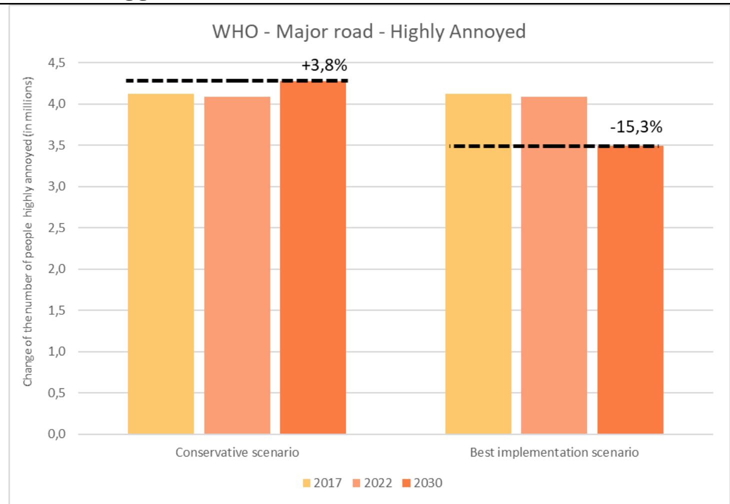
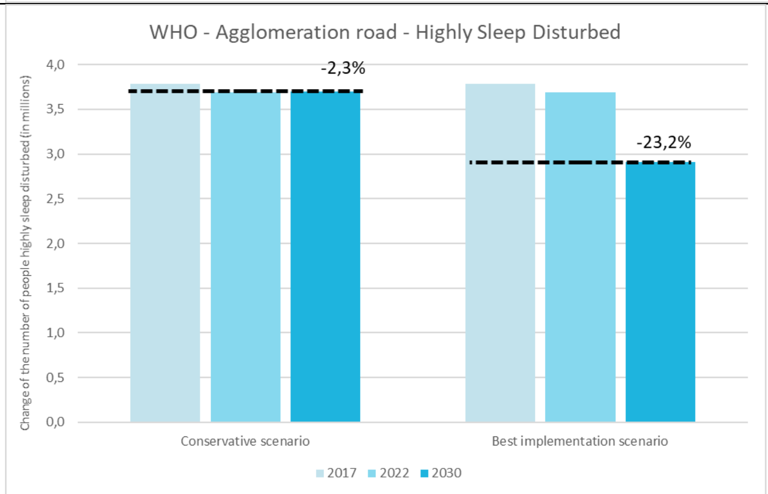
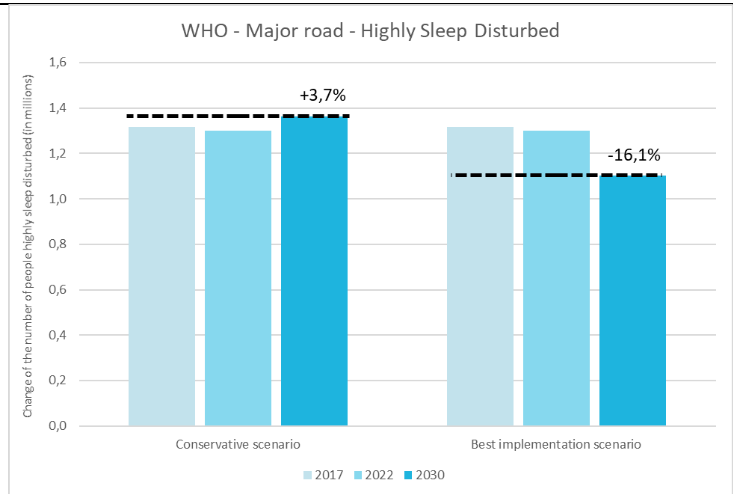


Outlooks for 2022 and 2030 for the change in highly sleep disturbed people based on the WHO thresholds stratified by inside (left) and outside (right) agglomerations. Colours differentiate noise sources. For each noise source, a dotted line refers to the conservative scenario, and a continuous line shows the best implementation scenario.

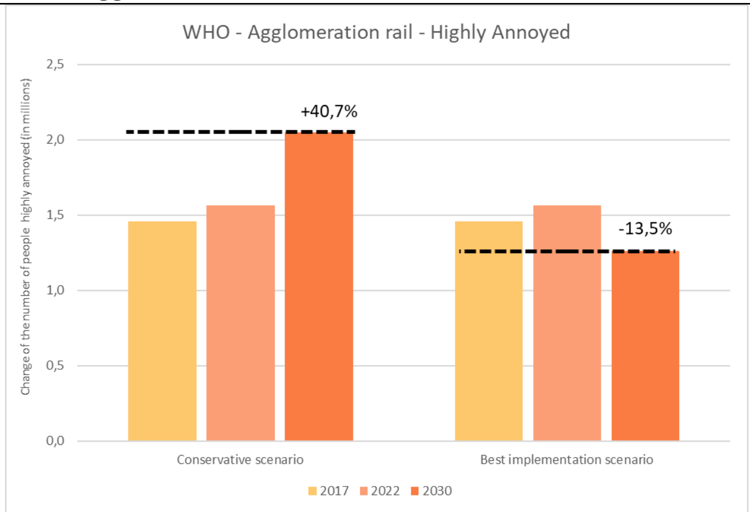
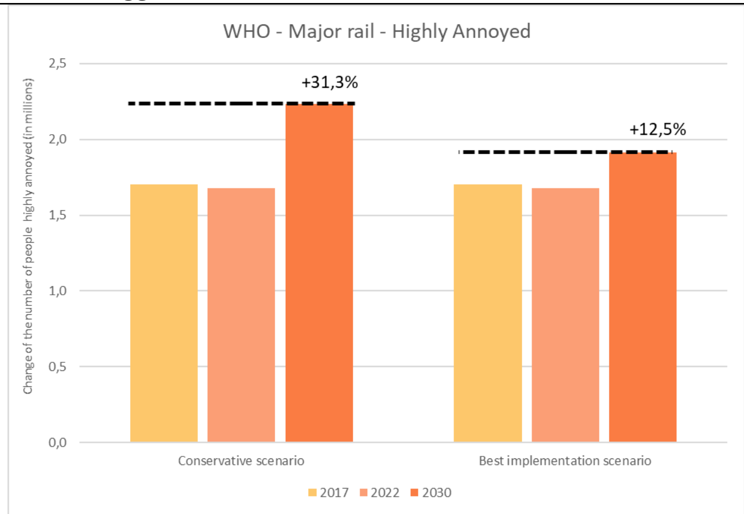
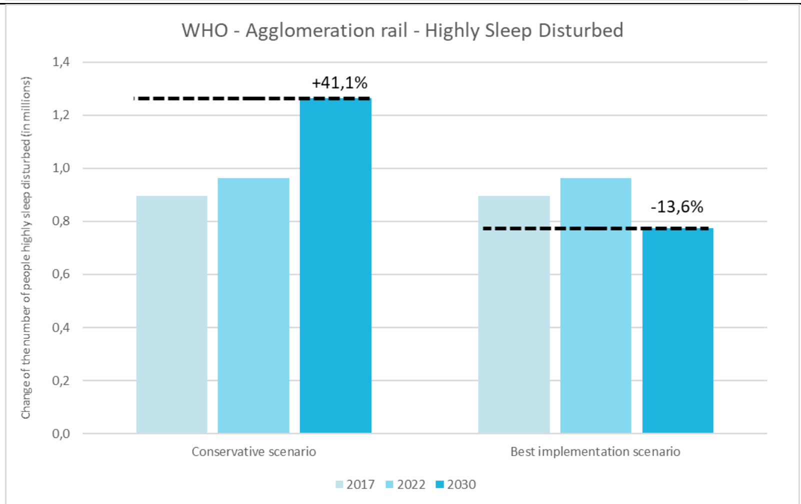
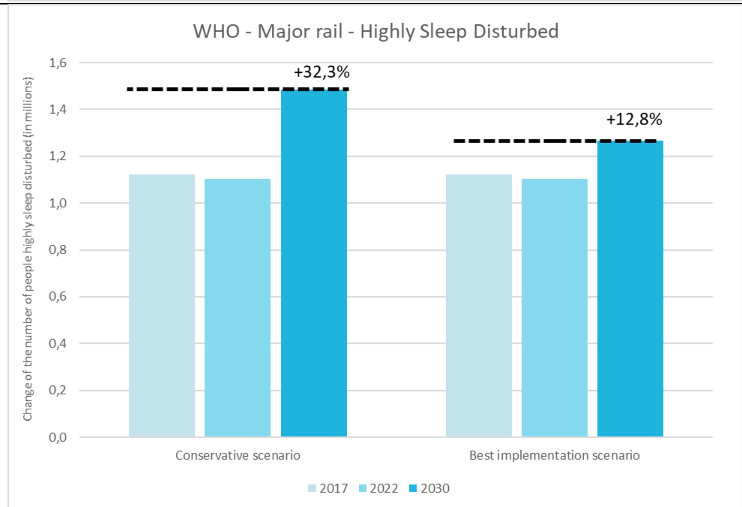




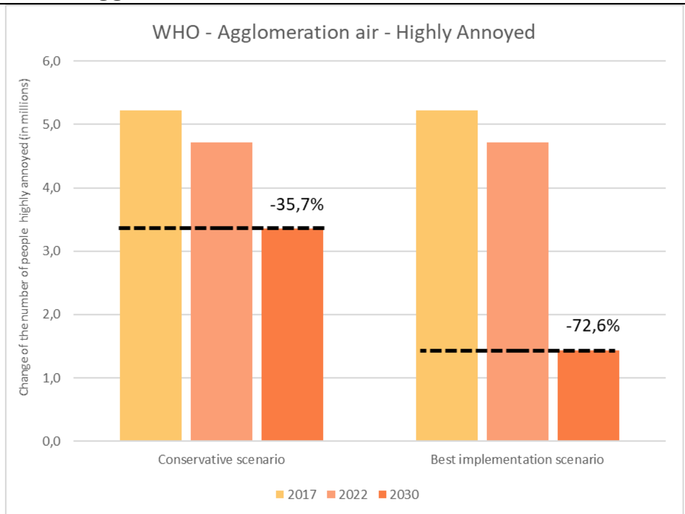
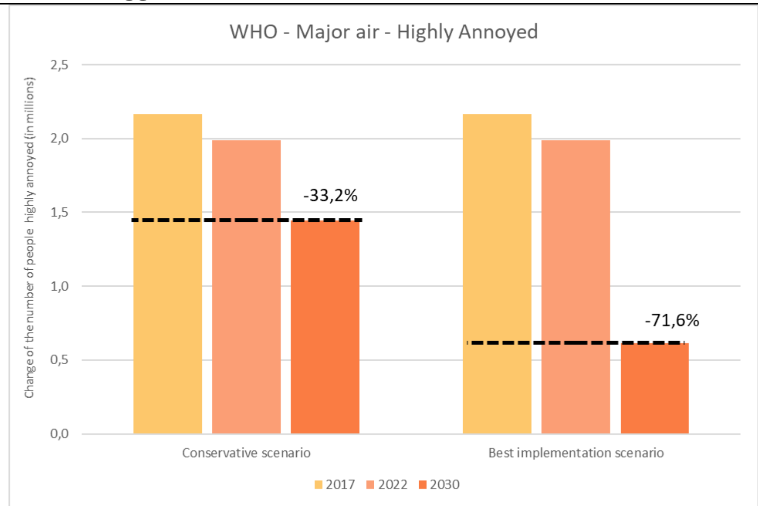
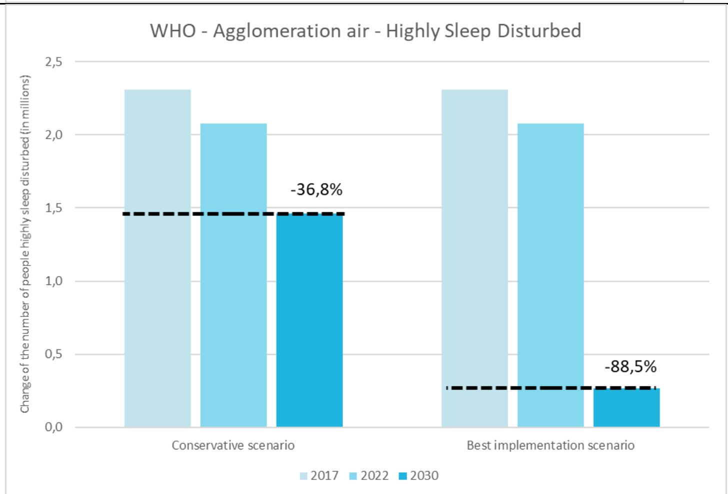
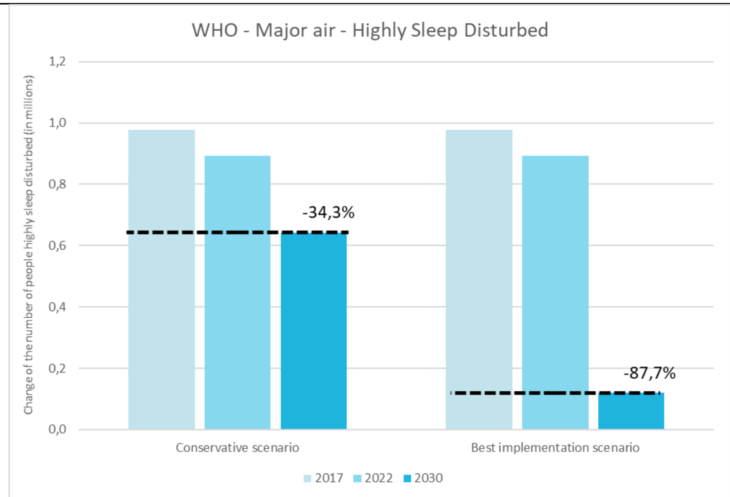
Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for road noise based on the WHO thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

<table>
<tr><td></td><td>Inside agglomerations</td><td>Outside agglomerations</td></tr>
<tr><td>HA</td><td>
</td><td>
</td></tr>
<tr><td>HSD</td><td>
</td><td>
</td></tr>
</table>

Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for rail noise based on the WHO thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

<table>
<tr><th></th><th>Inside agglomerations</th><th>Outside agglomerations</th></tr>
<tr><td>HA</td><td>
</td><td>
</td></tr>
<tr><td>HSD</td><td>
</td><td>
</td></tr>
</table>

Outlooks for 2022 and 2030 for the number of highly annoyed and highly sleep disturbed people stratified by inside and outside agglomerations for air noise based on the WHO thresholds. The orange bars indicate the number of highly annoyed people and the blue bars the number of highly disturbed people. The percentage change from 2017 to 2030 is indicated in each graph by the dotted line.

<table>
<tr><th></th><th>Inside agglomerations</th><th>Outside agglomerations</th></tr>
<tr><td>HA</td><td>
</td><td>
</td></tr>
<tr><td>HSD</td><td>
</td><td>
</td></tr>
</table>

Annex 8 Health risk assessment at 5 dB band

Noise source	Number of people highly sleep disturbed per 5 dB band From WHO recommendation to END thresholds	50-54 dB	55-59 dB	60-64 dB	65-69 dB	>70 dB
Conservative scenario						
Road	1 457 033	1 258 098	1 223 809	811 668	259 538	52 296
Rail	616 389	621 518	618 050	427 614	267 187	198 919
Air	1 956 125	105 756	17 391	2 618	407	47
Best implementation scenario						
Road	1 233 209	1 087 655	977 010	541 823	147 351	23 176
Rail	505 123	515 968	424 206	295 549	180 494	118 907
Air	358 352	20 973	3 110	435	71	0

Noise source	Number of people highly annoyed per 5 dB band From WHO recommendations to END threshold	55-59 dB	60-64 dB	65-69 dB	70-74 dB	>75 dB
Conservative scenario						
Road	1 948 201	3 698 138	3 923 143	3 769 821	2 089 712	520 437
Rail	241 997	1 293 250	1 180 031	782 477	462 533	324 694
Air	4 213 214	395 144	132 964	28 044	4 111	224
Best implementation scenario						
Road	1 461 311	3 286 160	3 510 900	2 928 610	1 307 010	239 116
Rail	204 423	1 086 891	835 477	548 002	304 216	196 936
Air	1 772 181	192 879	55 860	8 888	773	32

European Topic Centre on
Human health and the environment
https://www.eionet.europa.eu/etcs/etc-he

The European Topic Centre on Human health and the environment (ETC-HE) is a consortium of European institutes under contract of the European Environment Agency.

European Environment Agency
European Topic Centre
Human health and the environment