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Methodology for calculating projected health impacts from transportation noise – Exploring two scenarios for 2030

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Summary

The Zero Pollution Action Plan (EC, 2021) aims to reduce the share of people chronically disturbed by transport noise by 30% by 2030 compared to 2017. This report presents updated scenarios for environmental noise in Europe based on previous outlooks to assess the feasibility of reaching the Zero Pollution target in 2030. It incorporates the latest reported data from 2022 to evaluate comprehensively potential future noise exposure levels across the European Union (EU27), Iceland, Norway, and Switzerland. Two scenarios are developed for road, rail, and air traffic noise inside and outside urban areas: a Conservative Estimate, which assumes minimum implementation of existing and forthcoming regulations, and a Best Implementation Estimate, which considers optimal implementation of noise reduction measures.

These scenarios consider various factors affecting noise levels, including demographic changes, transport activity projections, technological advancements in vehicles and infrastructure, and implementation of noise abatement measures. The methodology incorporates data from the 2017 baseline (estimated by backdating data from 2022 to overcome comparability issues between 2017 and 2022 because of the adoption of CNOSSOS in 2022), 2022 reported data, and projections for 2030. The analysis considers noise exposure levels above and below the Environmental Noise Directive (END) thresholds, aligning with WHO noise guidelines.

The report employs a comprehensive approach to calculate future noise exposure scenarios. This includes estimating the exposed population for the 2017 baseline and 2022 reported data, disaggregating population exposure data to 1 dB noise bands for precise calculations, applying demographic changes based on the LUISA model, calculating dB changes resulting from various factors specific to each noise source, and integrating all dB changes to determine the final distribution of exposed population in 2030.

The scenarios consider a range of factors for each noise source. These include vehicle fleet composition, electric vehicle adoption, low-noise road surfaces, speed limits, and traffic management for road traffic. Rail traffic scenarios include track and vehicle technology improvements, electrification, and noise barriers. Air traffic scenarios consider aircraft fleet renewal, operational improvements, and land-use planning.

Based on the estimations of people exposed in 2030 in the two scenarios, the report describes the methodology to estimate the share of highly annoyed people and highly sleep-disturbed people by employing exposure-response functions from WHO.

1 Introduction

The Zero Pollution Action Plan (EC, 2021) commits 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.
- Review 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), a report was produced by ETC/ATNI (Blanes et al., 2019) providing outlooks for 2030 and published as part of the *Environmental noise in Europe - 2020 report* (EEA, 2020a). An updated outlook was produced by ETC/HE (Blanes et al., 2022) including state of the art knowledge to improve the methodology with a more extensive and reliable set of input variables. All these outlooks were based on data reported in 2017, projections for 2022 -not reported yet at that time, and two scenarios for 2030. The current report adopts the methodology described by Blanes et al. (2022) by integrating the latest reported data (2022). Therefore the scenarios for 2030 are based on projections based on 2022 reported data.

The methodology focuses on outlooks based on trends and future scenarios for the period 2022 to 2030. These scenarios are not predictions. Instead, they 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. Moreover, the final results analyse the complete period, from the baseline 2017 to 2030.

2 Methodology

2.1 Overview

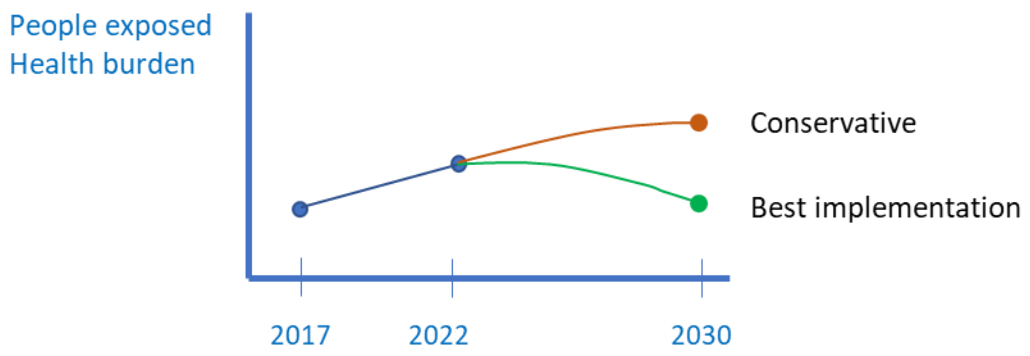
Two scenarios are developed for three noise sources: road, rail and air traffic noise inside and outside agglomerations.

The scenarios are defined for the period 2022 -2030, with the period 2017-2022 based on reported data (**Error! Reference source not found.**):

- **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. However, from 2019 on, countries can no longer use their national calculation methods and have to change their calculation method to CNOSSOS-EU. This results in non-comparable data between strategic noise maps reported in 2017 and the following reporting years. To solve this issue, a 2017 baseline was created based on backdating 2022 reported data (Blanes et al., 2023). This baseline is the data used in this report.
- **Year 2022:** This is the latest reported data and the first delivery following the CNOSSOS-EU method (common for all countries).

- **Year 2030 Conservative estimate**: The scenario considers a minimum implementation of existing and forthcoming regulations. It also considers minimum values for different noise abatement measures, like low-noise asphalt. Under the conditions of minimum implementation, the feasibility of the Zero Pollution Action Plan target will be evaluated.
- **Year 2030 Best implementation estimate**: 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 2.1: This is an overview of scenarios calculated for all noise sources. (This figure is obtained specifically for each noise source.) Data for 2017 is based on estimated data and 2022 reported data

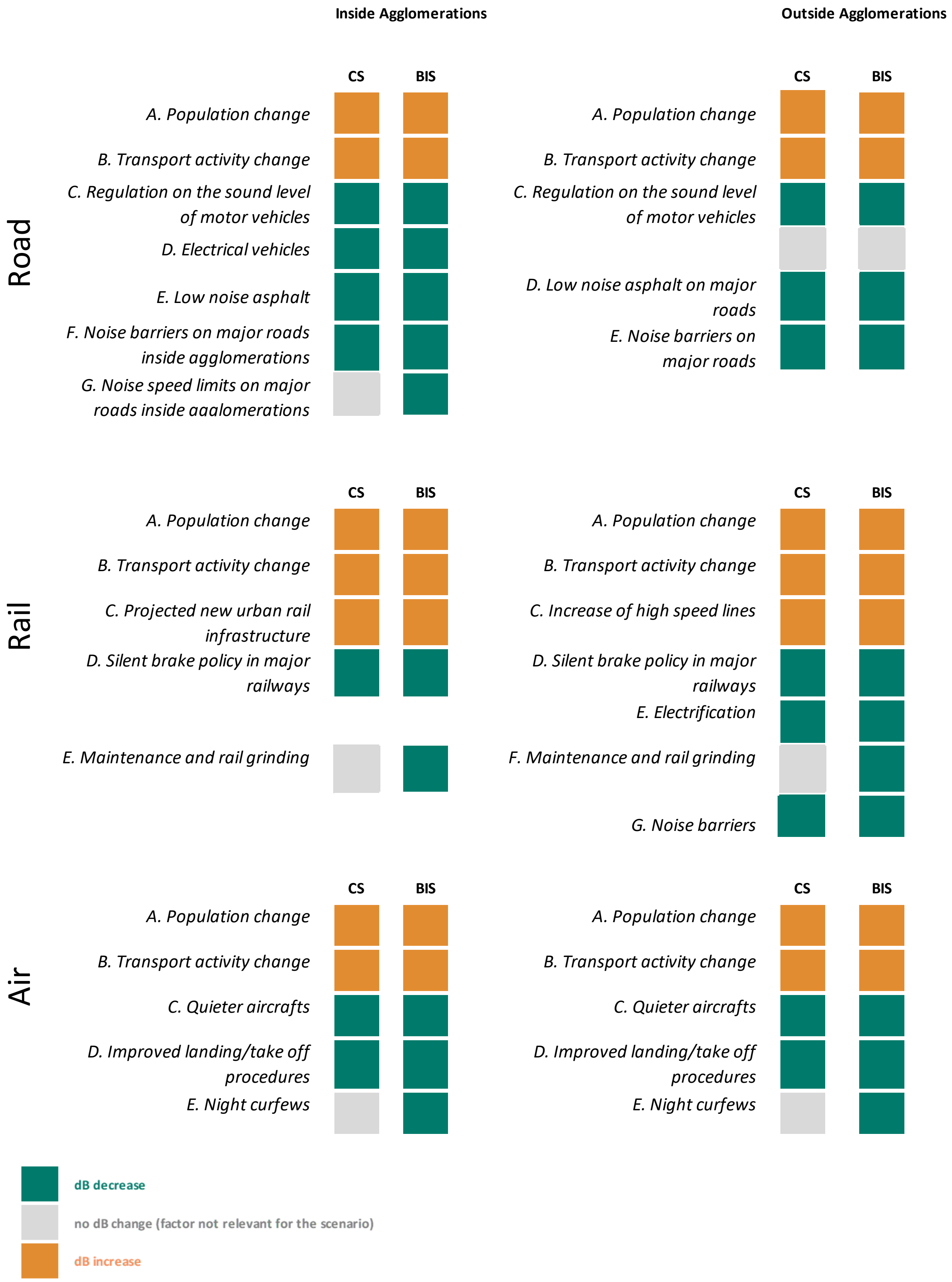


The selection of the factors included in the scenarios is based on the best available data. The input variables were chosen based on different sets of information identified under Implementing Framework Service Contract EEA/HSR/20/003, action plans under the END, the expert judgment of the ETC/HE authors 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, they generally take 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 2.2 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 2.2 for these two parameters reflect the European average.

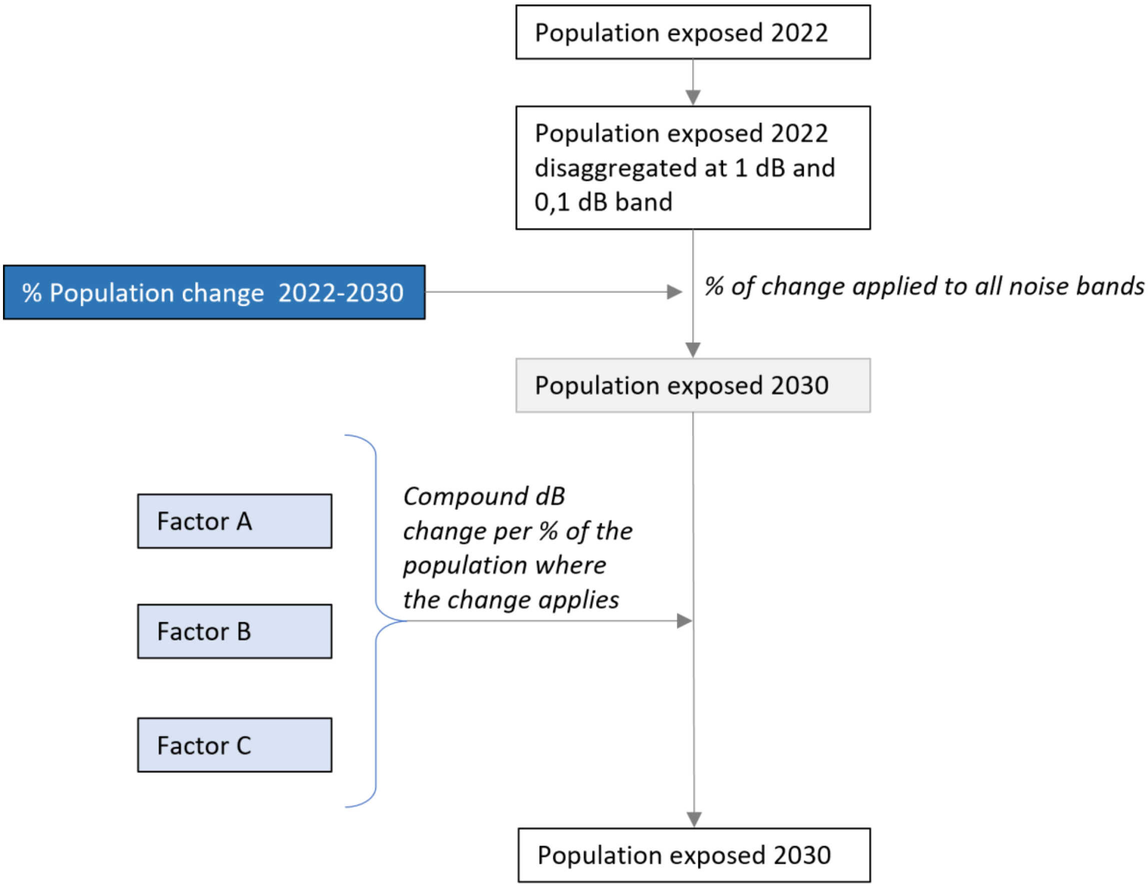
Figure 2.2: Overview of the road, rail and air noise scenarios, inside and outside agglomerations. The figure indicates how the different factors influenced the scenarios calculations: factors increasing the noise levels (orange), factors not relevant for a specific scenario (grey) or factors decreasing the noise levels (green)



2.2 General workflow to calculate scenarios

All the scenarios follow the same workflow, as described in Figure 2.3, and are based on the change in population exposure due to demographic factors, transport projections, and noise abatement measures in a specific period.

Figure 2.3 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_{2022} and t_{2030}. Boxes in grey refer to intermediate calculations



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

1. Estimate exposed people for 2017 baseline using the methodology described by Blanes et al. (2023) to align 2017 reported data, based on national methods with 2022 reported data, based on the common method CNOSSOS-EU.
2. Select year 2022 as the starting year for the calculation of the scenarios. This is the latest available reported data.
   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 Blanes et al. (2023).

3. 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 2.1 Applied methods to estimate noise levels below END threshold by noise 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)

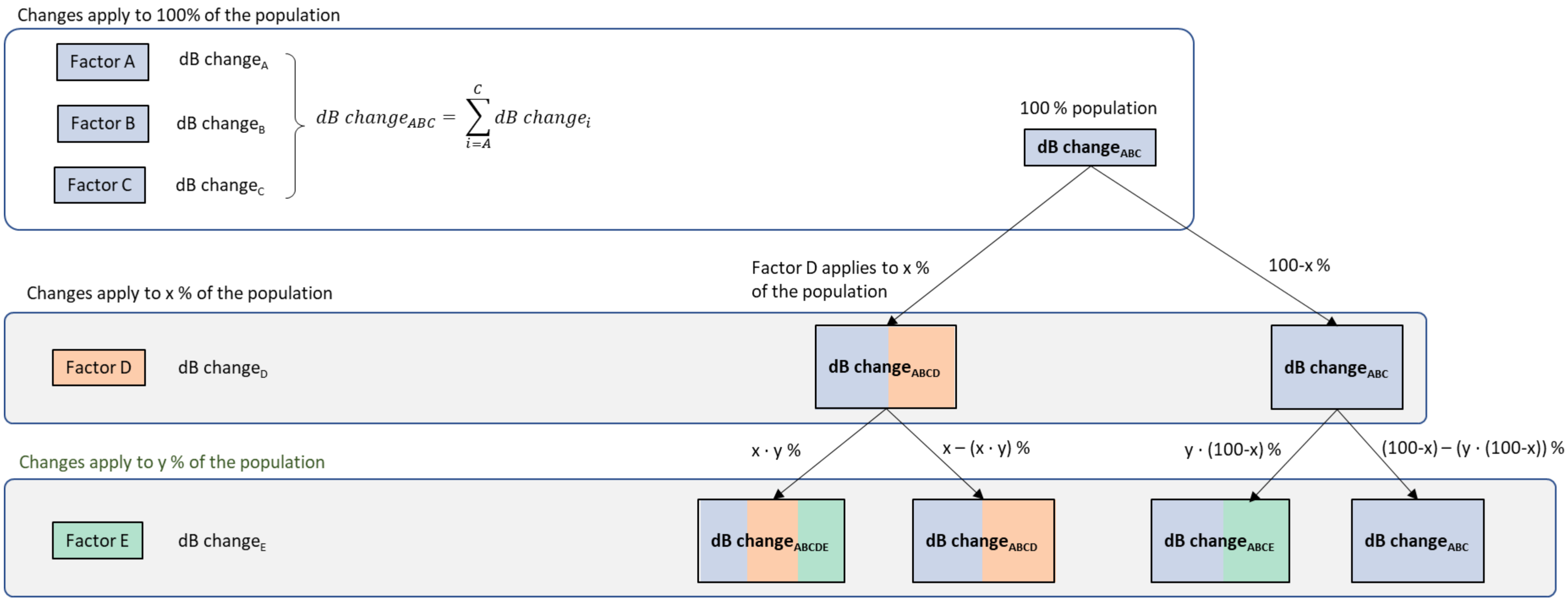
4. Disaggregate the population at a 1 dB noise band (one decimal precision)
The population exposed to different noise sources and indicators is reported per 5 dB noise intervals following the END requirements. The various factors that modify noise exposure result in a change of dB units or lower. Therefore, 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. (2023)-chapter 5.2.

5. Apply the demographic changes.
Demographic changes are considered in all the scenarios based on the LUISA model (Lavalle and Jacobs Crisioni, 2014)-see section 2.3 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 in 2022.

6. Calculate the dB change from the different factors
   Each factor (light blue boxes in Figure 2.3) needs to be translated into a dB change in order to estimate the final distribution of the population exposed in 2023. 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.

7. 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 2.4 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 in the figure reflect the factors included in each aggregated dB change.

Figure 2.4 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%)



2.3 Common factors to all scenarios

Table 2.2 provides an overview of the common factors used to calculate the projections of the scenarios.

As mentioned before. 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. However, Iceland, Norway and Switzerland are also included because they are part of and adhere to most of the EU environmental policies. Since some of the factors used in the scenarios are only provided by EU27, data from a closer/more similar EU27 country has been used for anon EU27 country: factors from Denmark have been applied to Iceland, factors from Sweden have been applied to Norway, and factors from Austria have been applied to Switzerland-

Table 2.2 Overview of the common factors used to calculate noise scenarios

Data	Description	Reporting units	Reference Year(s)	Source
Noise exposure	People exposed to road traffic, rail traffic and air traffic noise. Used as a baseline for all scenarios.	Inside agglomerations Outside agglomerations	(2017) 2022	For 2017, backdating from 2022 to align with CNOSSOS-EU method (Blanes et al., 2023) For 2022, data provided by MS according to the END and gap filled for missing values (Blanes et al., 2023)
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	2020 to 2050 by 5 years time step	EU Reference Scenario 2020: Main results on energy, transport and GHG emissions (Excel) (EC et al., 2021b)

2.3.1 Noise exposure

The baseline for the scenarios, where to apply population change, traffic change and implementation of noise abatement measures is the latest delivery reported by MS under the Environmental Noise Directive (END), 2022. 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 20 April 2024, and missing data was estimated according to Blanes et al. (2023). Three noise sources have been considered: road, rail and air traffic noise, both inside and outside agglomerations.

2.3.2 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. For countries where EU27 is not available, projections at NUTS3 from Eurostat have been used.

2.3.3 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 to calculate scenarios on END population exposure in 2022 and 2030.

2.4 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.

2.4.1 Road traffic noise inside agglomerations scenarios

Table 2.3 provides an overview of the scenarios for road traffic noise inside agglomerations, with references and specifications for the different factors considered in calculating the scenarios.

Figure 2.5 This provides an overview of the workflow for calculating road traffic noise exposure scenarios inside agglomerations. This workflow is common for the two scenarios (conservative 203 and best implementation 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 2.1, the following factors have been excluded since they have been considered not significantly contributing to road traffic noise under the different scenarios:

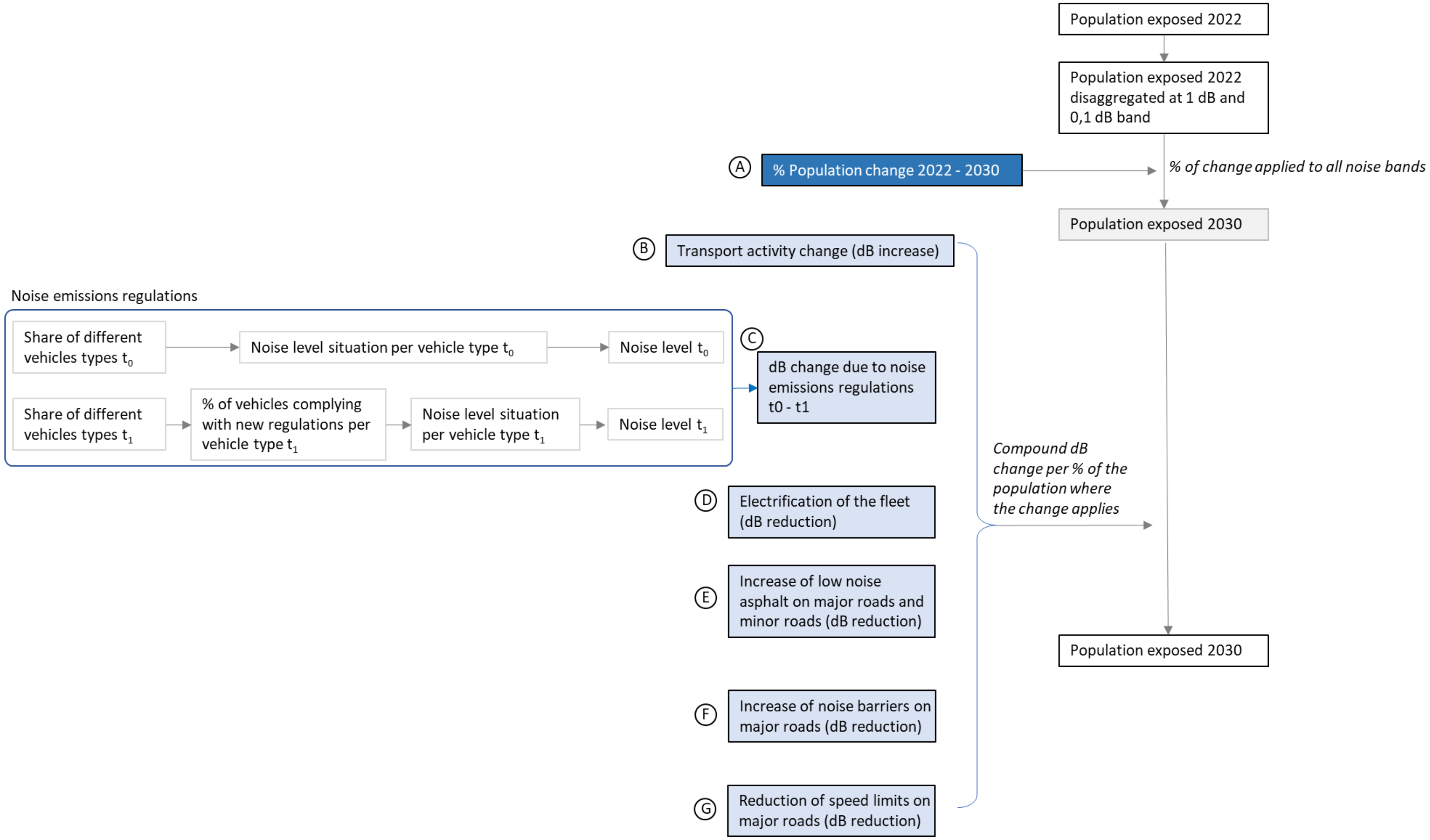
- **Tyre noise**: Noise reduction due to tyre noise is somehow considered when integrating other measures such as the regulation of the sound level of motor vehicles or speed regulation. No further reductions are specifically introduced in the scenarios for tyre noise – beyond the assumption that all 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 2.3 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	Conservative scenario 2030	Best implementation scenario 2030
A. Population change	LUISA model provides population projections for 2020, 2025, and 2030 EU27. Eurostat annual projections at NUTS3 for Iceland, Norway and Switzerland.	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios). Eurostat projections at NUTS3 (2022-2030) were used for Iceland, Norway and Switzerland.	
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, change on the percentage of vehicles complying with regulation on sound level of motor vehicles of 2024/2026.	-1,1 dB (linear reduction of 2 dB over a period of 15 years from 2015 to 2030 applied to the period 2022-2030)
D. Electrical vehicles	It is assumed 0.5 dB reduction for 100% electric vehicles (Goubert, 2015) only on non major roads inside agglomerations.	25% of vehicles are electric -0,12 dB on non major roads	50% of vehicles are electric -0,24 dB on non major roads
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)	3% increase of low noise asphalt from 2022 -2 dB on 3% of major roads inside agglomerations -1 dB on 3% of non-major roads	8% increase of low noise asphalt from 2022 -2 dB on 8% of major roads inside agglomerations -1 dB on 8% of non-major roads
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.	0,8 % increase in noise barriers on major roads from 2022 -10 dB on 0,8% of major roads	2,5% increase in noise barriers on major roads from 2022 -10 dB on 2,5% of major roads

Factor	Reference	Conservative scenario 2030	Best implementation scenario 2030
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)	Speed limit reduction not considered	30% of major roads -3 dB on 30% of major roads inside agglomerations

Figure 2.5 General workflow of scenarios for road traffic noise inside agglomerations. Demographic changes (A) (in dark blue), 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Error! Reference source not found.**, which provides the reference values used for the d ifferent scenarios. Further details can be found in Annex 1**



2.4.2 Road traffic noise outside agglomerations scenarios

Table 2.4 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 2.6 provides an overview of the workflow to calculate road traffic noise scenarios outside agglomerations. This workflow is common for both scenarios.

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.

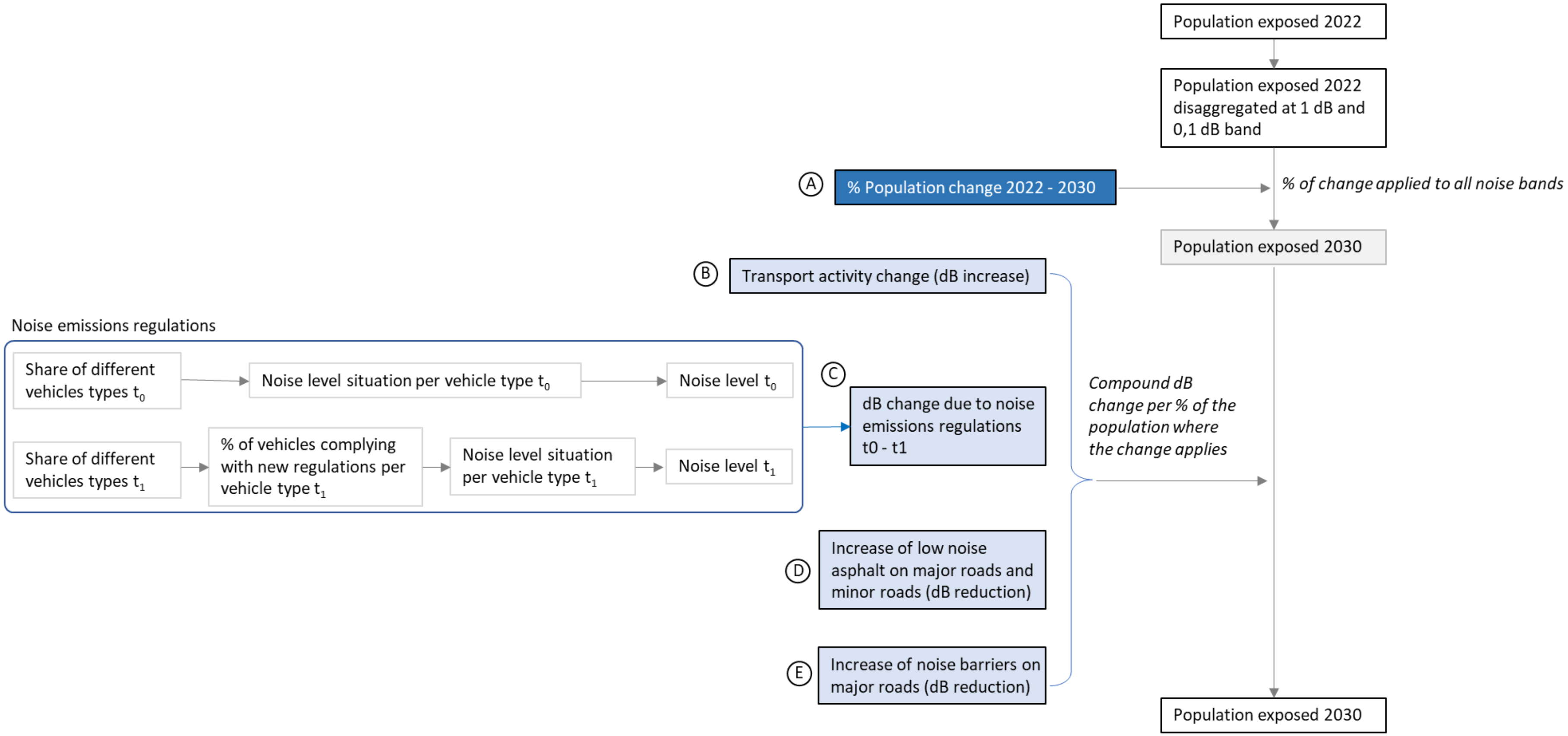
Based on the sources mentioned in section 2.1, the following factors have been excluded since they have been considered not significantly contributing to road traffic noise under the different scenarios:

- **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 2.4 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 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	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 of emissions is based on the vehicle fleet, change on the percentage of vehicles complying with new regulations (2024) and related emission values	-1,1 dB (linear reduction of 2 dB over a period of 15 years from 2015 to 2030 applied to the period 2022-2030)
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)	3% increase of low noise asphalt from 2022 -2 dB	8% increase of low noise asphalt from 2022 -2 dB
E. Noise barriers on major roads	Own estimates based on data from countries	0,8 % increase in noise barriers on major roads from 2022 -10 dB reduction	2,5% increase in noise barriers on major roads from 2022 -10 dB reduction

Figure 2.6 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Error! Reference source not found.**, which provides the reference values used for the different s cenarios. Further details can be found in Annex 2**



2.4.3 Summary of dB change per factor and scenario

Table 2.5. provides a summary of the factors presented in the previous sections for inside and outside agglomerations. Values for each factor and scenario indicate the equivalent dB change.

Table 2.5 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). Scenarios: CS, conservative scenario; BIS, best implementation scenario

		dB change per factor and scenario			
		Inside agglomerations		Outside agglomerations	
Factor		*30CS*	*30BIS*	*30CS*	*30BIS*
Transport activity change		0,75	0,75	0,75	0,75
Regulation on the sound level of motor vehicles		-0,5	-1,1	-0,5	-1,1
Electric vehicles		-0,1	-0,2		
Low noise asphalt	dB reduction on major roads	-0,05	-0,13	-0,05	-0,13
	dB reduction on non-major roads	-0,03	-0,07		
Noise barriers on major roads		-0,03	-0,1	-0,03	-0,1
Noise speed limits on major roads inside agglomerations		0	-0,7		

2.5 Rail traffic noise scenarios

2.5.1 Rail traffic noise inside agglomerations scenarios

Table 2.6 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 2.7 provides an overview of the workflow to calculate rail traffic noise scenarios inside agglomerations. This workflow is common for both scenarios.

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.

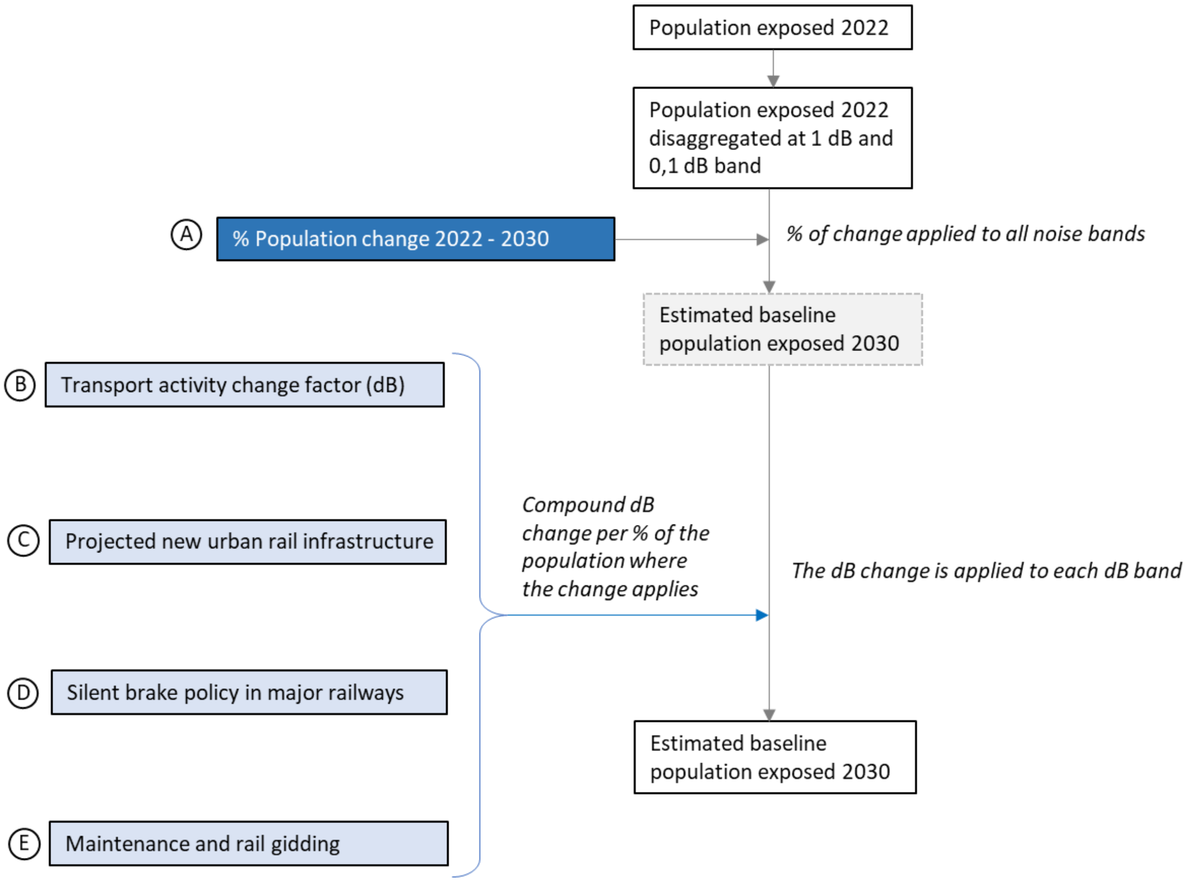
Since the railway network in Europe is mainly electrified (EC, 2017), and rail runs almost exclusively on electricity in urban areas as of 2017, the electrification factor has not been included in scenarios for rail inside agglomerations.

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 2.6 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 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	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 54% of rail activity from 2022 +1,9 dB	Increase by 20% of rail activity from 2022 +0,8 dB
C. Projected new urban rail infrastructure	(UITP, 2019)	+0,2 dB	+0,2 dB
D. Silent brake policy in major railways	(EUAR, 2018)	-0,7 dB	-0,7 dB
E. Maintenance and rail grinding	Phenomena project (EC et al., 2021a)	Not considered in this scenario	-2 dB

Figure 2.7 General workflow of scenarios for rail traffic noise inside agglomerations. Demographic changes (A) (in dark blue), 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Table 2.5 which provides the reference values used for the different scenarios. Further details can be found in Annex 3



2.5.2 Rail traffic noise outside agglomerations scenarios

Table 2.7 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.

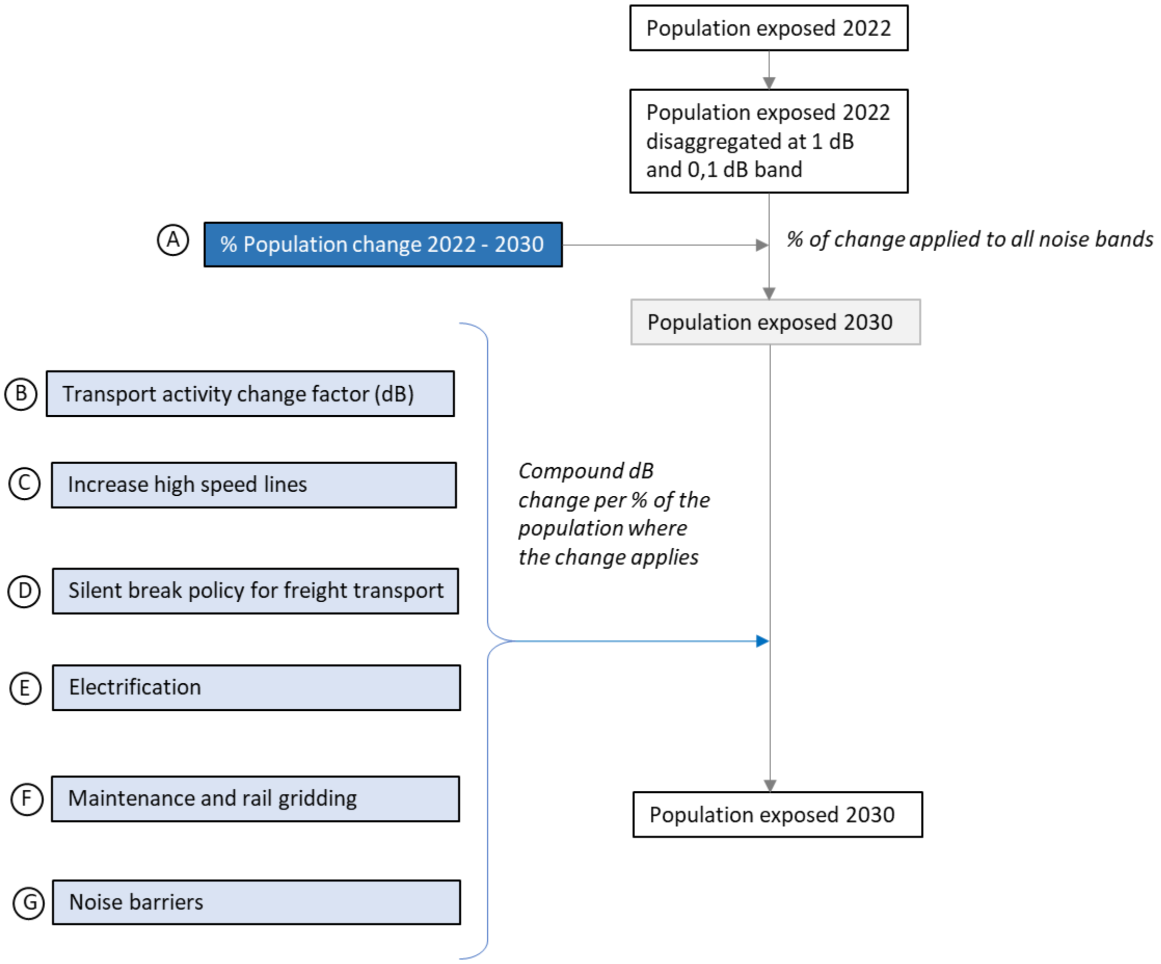
Figure 2.8 provides an overview of the workflow to calculate rail traffic noise scenarios outside agglomerations. This workflow is common for both scenarios.

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.

Table 2.7 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 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	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 and non-high speed liens	Based on UIC (2021)	+1 dB	+1 dB
D. Silent brake policy for freight transport	(EUAR, 2018)	-0,3 dB	-0,3 dB
E. Electrification	Estimations based on EC (2017)	-0,3 dB	-0,3 dB
F. Maintenance and rail grinding	Phenomena project (EC et al., 2021a)	Not considered in this scenario	-0,5 dB
G. Railway Noise barriers	Based on German data and expert knowledge (M. Hintzsche, personal communication)	0,15% annual increase in noise barriers (2022-2030) -10 dB	0,30% annual increase in noise barriers (2022-2030) -10 dB

Figure 2.8 General workflow of scenarios for rail traffic noise outside agglomerations. Demographic changes (A) (in dark blue), factors related to traffic flow (B), new high-speed lines (C) and other noise abatement measures (D to G) contribute to the population change exposed to rail traffic noise between 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Table 2.7, which provides the reference values used for the different scenarios. Further details can be found in Annex 4



2.5.3 *Summary of dB change per factor and scenario*

Table 2.8 provides a summary of the factors presented in the previous sections for inside and outside agglomerations. Values for each factor and scenario indicate the equivalent dB change.

Table 2.8 Factors specific to the rail 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). Scenarios: CS, conservative scenario; BIS, best implementation scenario

	dB change per factor and scenario			
	Inside agglomerations		Outside agglomerations	
Factor	*30CS*	*30BIS*	*30CS*	*30BIS*
Transport activity change	1,9	0,8	1,5	1,5
Projected new urban rail infrastructure	0,2	0,2		
Increase of high speed and non high speed lines			1	1
Silent brake policy on major rail infrastructure	-0,7	-0,7	-0,3	-0,3
Electrification			-0,3	-0,3
Maintenance and rail grinding		-2		-0,5
Railway noise barriers			-0,05	-0,09

2.6 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.

Table 2.9 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 2.9 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 2030 (conservative)	Scenario 2030 (best scenario)
A. Population change	LUISA model provides population projections for 2020, 2025, 2030.	Calculated from LUISA 2020, 2025 and 2030 (the same forecasts for both scenarios)	
B. Traffic forecast activity change	Eurocontrol Forecast 2024-2030 (Eurocontrol, 2024).	Air traffic growth by 3,6% a year (2022-2030). No differences between the two scenarios. +0,14 dB a year from 2022	
C. Quieter aircraft	From 2022 on, 0,1 dB reduction per annum (ICAO, 2019)	-0.1 dB per annum (from 2022)	-0.1 dB per annum (from 2022)
D. Improved landing/ take-off procedures	(EC et al., 2021a)	-2 dB	-2 dB
E. Night curfews	(EC et al., 2021a)	Not considered in this scenario	-0,5 L_{den} - 2 dB L_{night}

Figure 2.9 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 Error! Reference source not found. **which provides the reference v alues used for the different scenarios. Further details can be found in Annex 5**

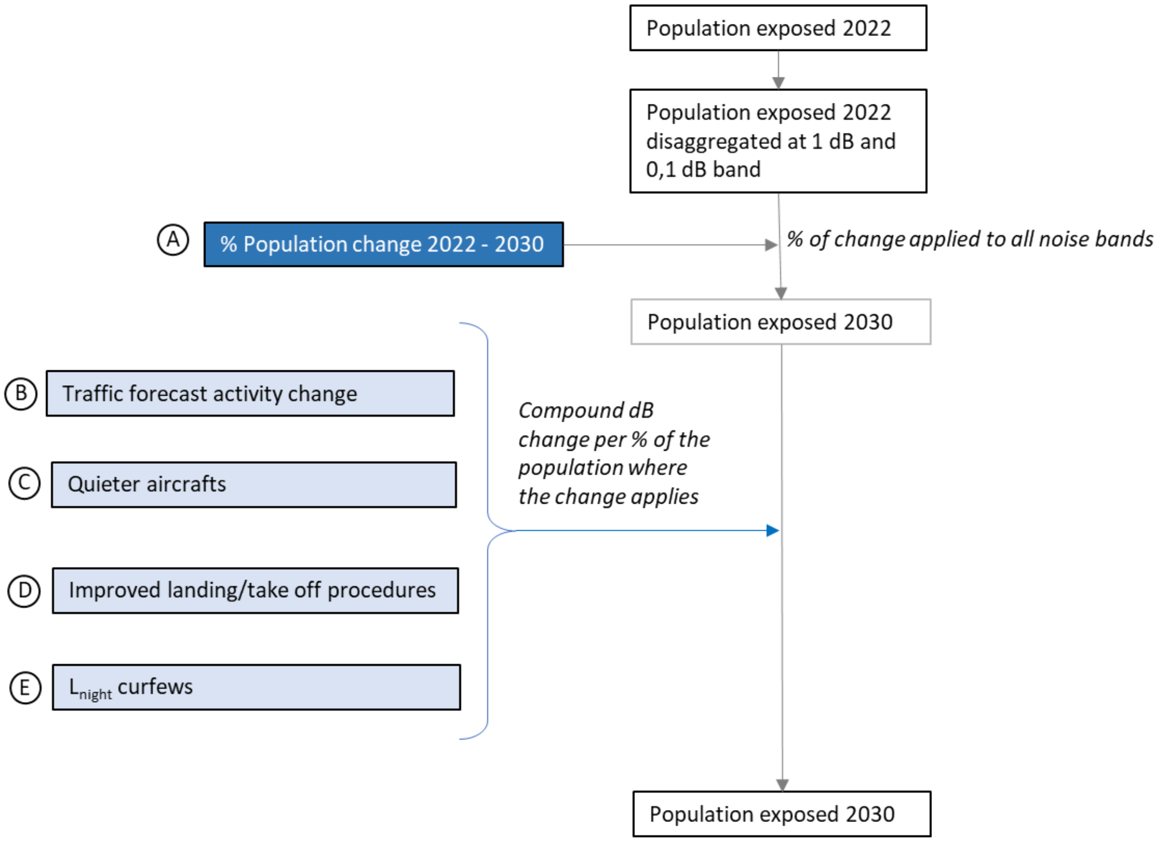


Table 2.10 summarises the factors and equivalent dB change for the two scenarios. In the case of aircraft noise, the factors and dB change are the same for inside and outside agglomerations. However, there are different values for the night curfews between L_{den} and L_{night}.

Table 2.10 Factors specific to aircraft noise traffic scenarios and population-weighted equivalent dB change. 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 (orange). Scenarios: CS, conservative scenario; BIS, best implementation scenario. The scenarios are the same for aircraft noise inside agglomeratoins and outside agglomerations

	dB change factor per scenario			
	L_{den}		L_{night}	
Factor	*30CS*	*30BIS*	*30CS*	*30BIS*
Traffic forecast activity change	1,1	1,1	1,1	1,1
Quieter aircraft	-0,8	-0,8	-0,8	-0,8
Improved landing/take-off procedures	-2	-2	-2	-2
Night curfews		-0,5		-2

2.7 Health risk assessment calculations for projections

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 2.11).

Table 2.11 Recommendations from WHO Environmental Noise Guidelines and noise levels set up in the 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 L_{night} is used.

For the calculation of the scenarios, 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 2.12 and Figure 2.10) and they 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.

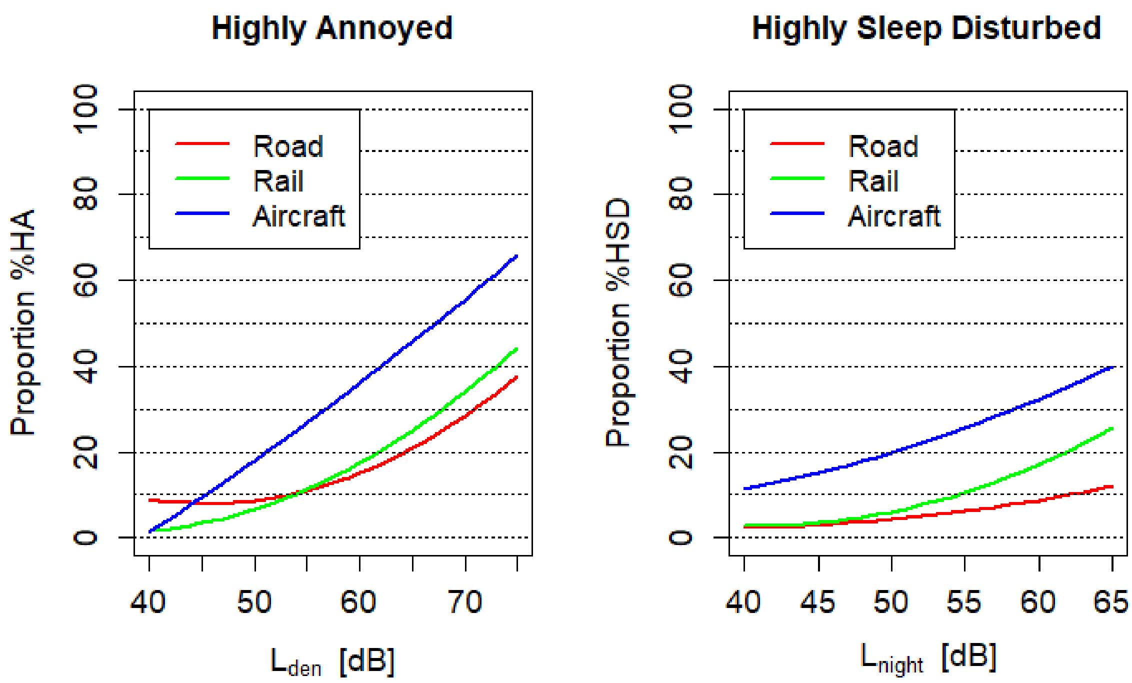
Of note, the exposure-response curves from WHO refer to steady state conditions. They thus do not take into account that the annoyance and potentially also the sleep response of the community to an increase (decrease) in the exposure is typically higher (lower) than what is expected from the change in 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 2.12 Exposure-response function for %HA and %HSD from the WHO noise guidelines used to calculate projections to 2030

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

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

Figure 2.10 Exposure-response functions of %HA and %HSD according to the WHO noise guidelines



As these exposure-response relationships start below the END thresholds, meaning that there are people highly annoyed and highly sleep disturbed due to noise below 55 dB L_{den} and 50 dB L_{night}, two calculations can be done based on different noise thresholds:

- Number of people HA and HSD equal and above 55 dB (L_{den}) and 50 dB (L_{night}) based on the END noise reporting standards of the EU.
- Number of people HA and HSD above the WHO noise recommendations (Table 3.7).

The health risk above the corresponding thresholds is calculated by disaggregating the exposure distribution for road, rail and aircraft noise in 1-dB steps, separated by inside and outside agglomeration region.

3 Conclusions

One of the headline targets of the zero pollution action plan of the EC is to reduce the number of people chronically disturbed by transport noise by 30% by 2030 compared with 2017. The EEA is monitoring and assessing the progression to this target periodically by means of data reported under the Environmental Noise Directive and an outlook to 2030.

This report outlines a methodology for estimating a 2030 outlook based on two scenarios, one conservative and one optimistic. The methodology considers the presentation of the results in terms of Highly Annoyed and Highly Sleep Disturbed due to noise from road, rail and aircraft. This methodology is an update of a study by the European Topic Centre on Human Health and the Environment entitled: *Projected health impacts from transportation noise — Exploring two scenarios for 2030* .

The projections proposed in this methodology are informed by existing noise regulations, the implementation of measures outlined in action plans reported under the Environmental Noise Directive (END), recent research on noise management, and forecasts related to population and transportation. The selected measures concentrate on those that are currently actionable and can be enforced by countries or competent authorities. As such, the projections do not take into account new or enhanced policies.

It is important to note that this methodology rely on various hypotheses, assumptions, and approximations, each carrying its own uncertainties. The projections derived from this methodology presuppose uniform application of these measures across all countries. The potential for reduction varies between countries based on the extent to which actions and measures have already been implemented.

4 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

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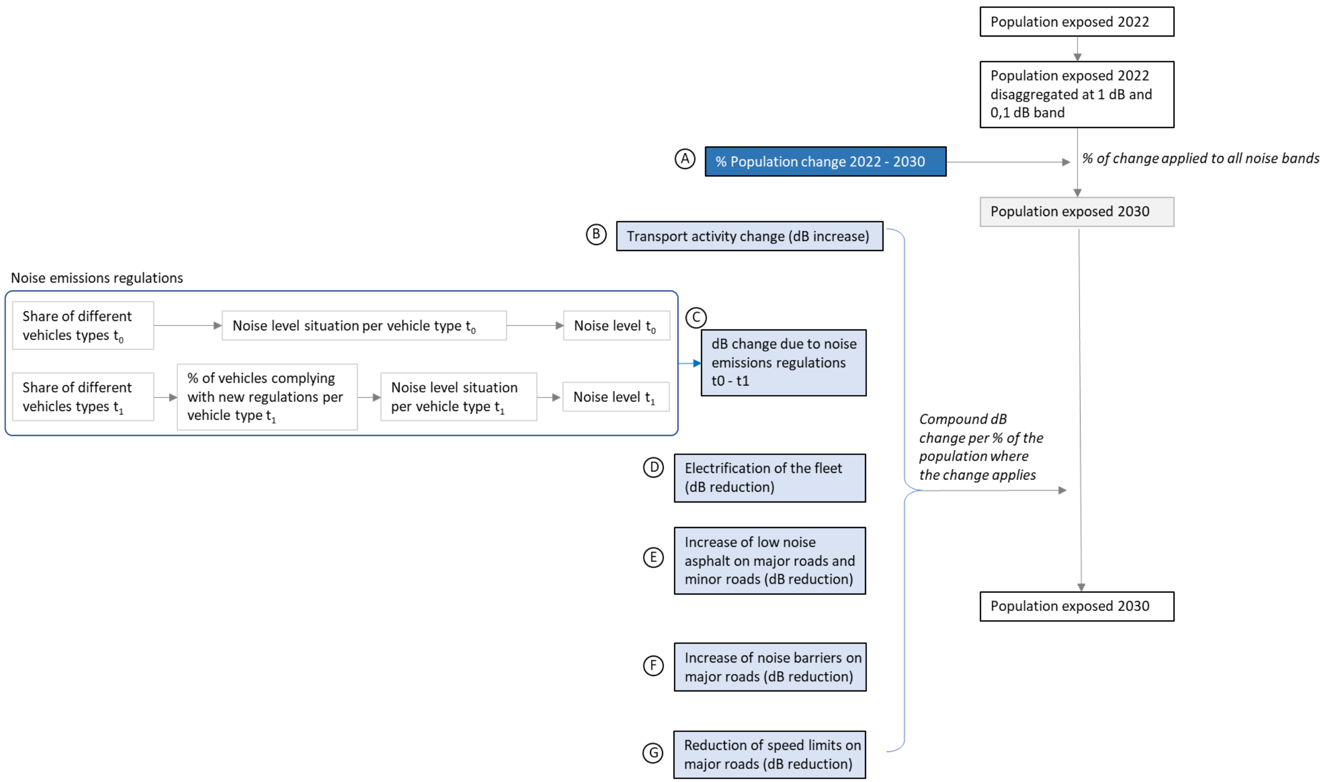
UNECE, 2011, *Regulation No 117 of the Economic Commission for Europe of the United Nations (UN/ECE) — Uniform provisions concerning the approval of tyres with regard to rolling sound emissions and to adhesion on wet surfaces and/or to rolling resistance*, OJ L 307, 23.11.2011, p. 3–63 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A42011X1123%2803%29) accessed 25 July 2024.

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 July 2024.

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

General workflow of scenarios for road traffic noise inside agglomerations. Demographic changes (A) (in dark blue), 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Error! Reference source not found.**, which provides the reference values used for the different scenarios and further details in this a nnex**



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.

Approach

1. Disaggregation of the population exposed to noise at t_1 (2022) 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. (2023)-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. As mentioned before, the same projections are used for all scenarios.

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR_{20-25})^3 \cdot (1 + CAGR_{25-30})^5$$

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 the country level, and the years 2020, 2025, and 2030 have been selected for the current scenarios.

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
    - 2020-2025
    - 2025-2030
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 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, 2024). 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 noise 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	2022 (baseline)				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 (baseline 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, 2024), which presents vehicle numbers annually from 2011 up to 2022 subdivided into vehicle categories and Member States. 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_{2022} and t_{2030} 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 vehicle type *n* compliant 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_{2022} and t_{2030} 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 these 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 inside agglomeration that are not labelled 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
- 25% electric fleet in the 2030 conservative scenario (with a total reduction of 0,12 dB) and assumption of 50% electric fleet in the optimistic scenario (with a reduction of 0,24 dB).

Approach:

1. Apply the noise reduction values provided in Table 2.3 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 2.3 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 2.3.

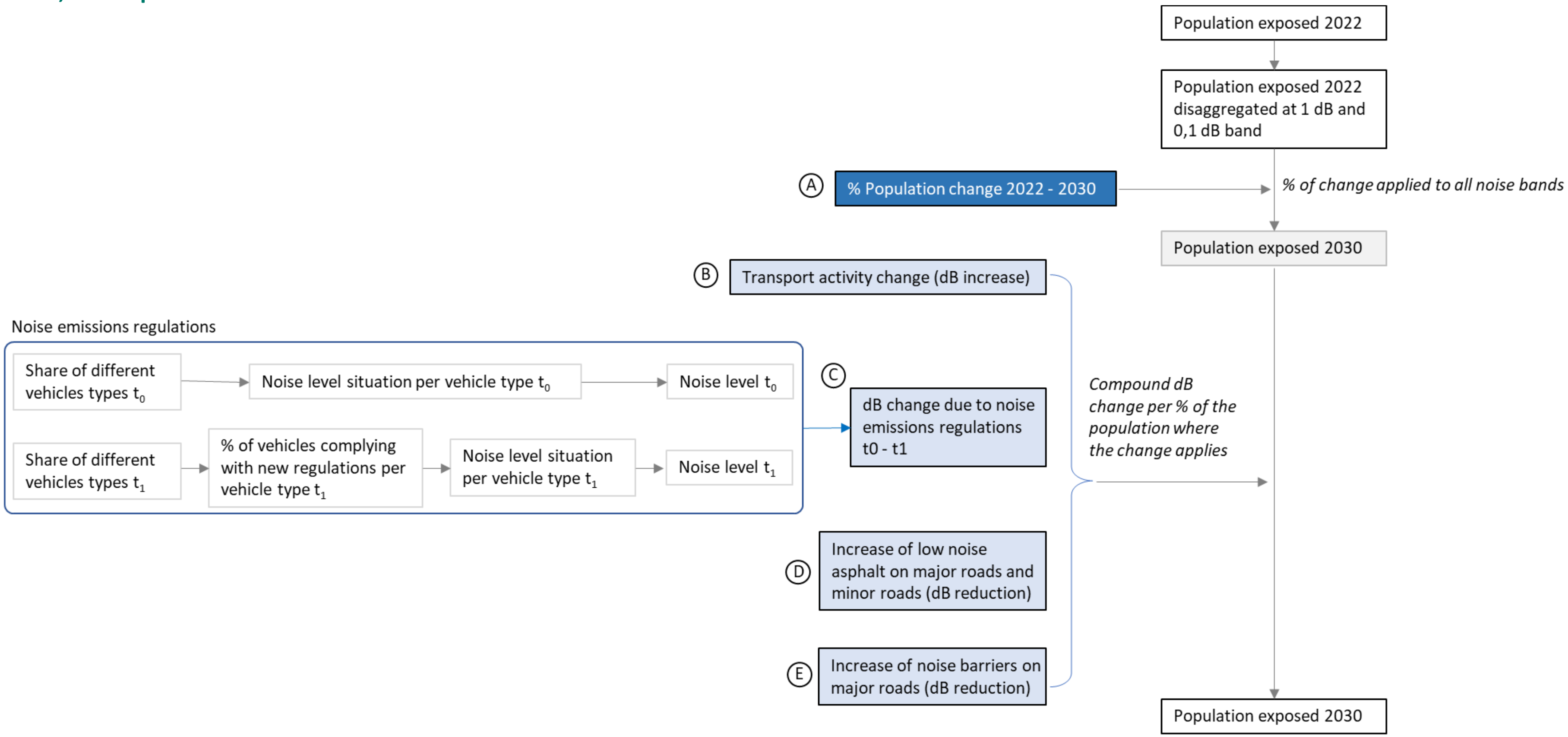
Assumptions: We assimilate the proportion of people exposed to major roads as percentage of major roads.

Approach:

1. Calculate the % of major roads (see E)
2. Apply the noise reduction values provided in Table 2.3 to the corresponding scenario and per each noise band, and type of road

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

General workflow of scenarios for roads 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Error! Reference source not found.**, 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;

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 the country level, and the years 2020, 2025, and 2030 have been selected for the current scenarios.

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, 2024), 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.

D. Low noise asphalt on major roads

A 2 dB reduction is assumed for quiet road surfaces on major roads (all roads outside agglomerations) (Wood, 2022). The value selected allows for some in-service degradation of noise performance, which may lead to a slight overestimation of noise reduction from propulsion sources.

Approach:

1. Apply the noise reduction values provided in Table 2.4 to the corresponding scenario and per each noise band.

F. Noise barriers on major roads

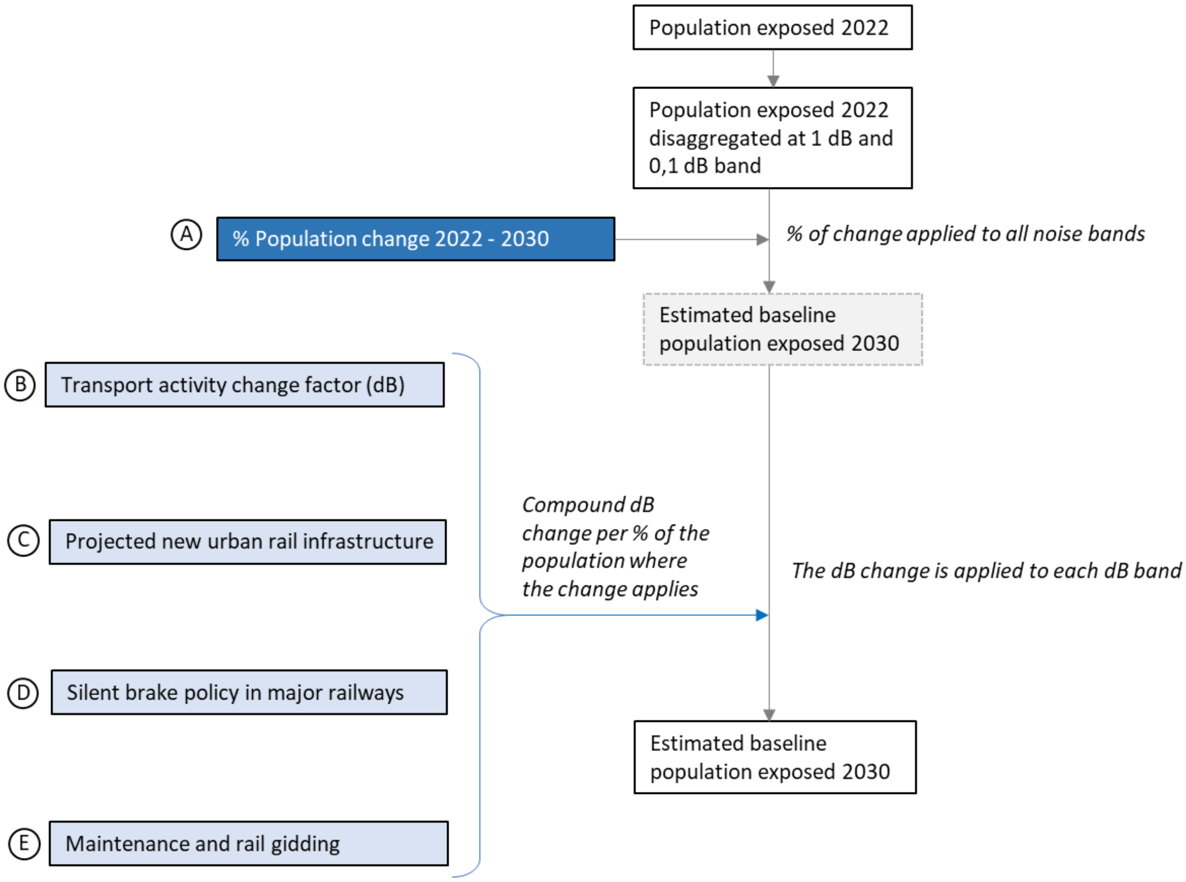
ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) estimated that 5% of the total EU road length benefits benefits from a noise barrier. A source of the estimation is not cited, and it is considered unlikely that data would 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 2.4 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 dark blue), 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 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Error! Reference source not found.**, which provides the reference values used for the d ifferent 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;

Approach:

1. Disaggregation of the population exposed to noise at t_0 (2022) 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. (2023) - 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).

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

   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.

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR_{20-25})^3 \cdot (1 + CAGR_{25-30})^5$$

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 20%, from 105 billion passenger-km in 2020 to 126 billion passenger-km in 2030.
- Higher growth urban rail scenario. Urban transport activity in Europe will grow from 105 billion passenger-km in 2022 to 305 billion passenger-km in 2050 (191% increase). By way of a linear interpolation, an increase in urban rail activity of 57% in 2030 is estimated.

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

Table C. Rail traffic growth as % of passenger kilometers and in in dB, derived from International Energy Agency and International Union for Railways (2017)

	Conservative scenario 2030	Best scenario 2030
Corresponding scenario in IEAI & IUI (2017)	High growth scenario	Baseline scenario
% rail traffic growth	57%	20%
dB increase	1,9	0,8

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 2.6 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 rail transit. The same trend for this period is projected to 2022 and 2030 resulting in a 0,2 dB equivalent increase for both scenarios.

Assumptions:

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

Approach:

1. The dB increase provided in Table 2.6 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 2.6 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. 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 2.6 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.

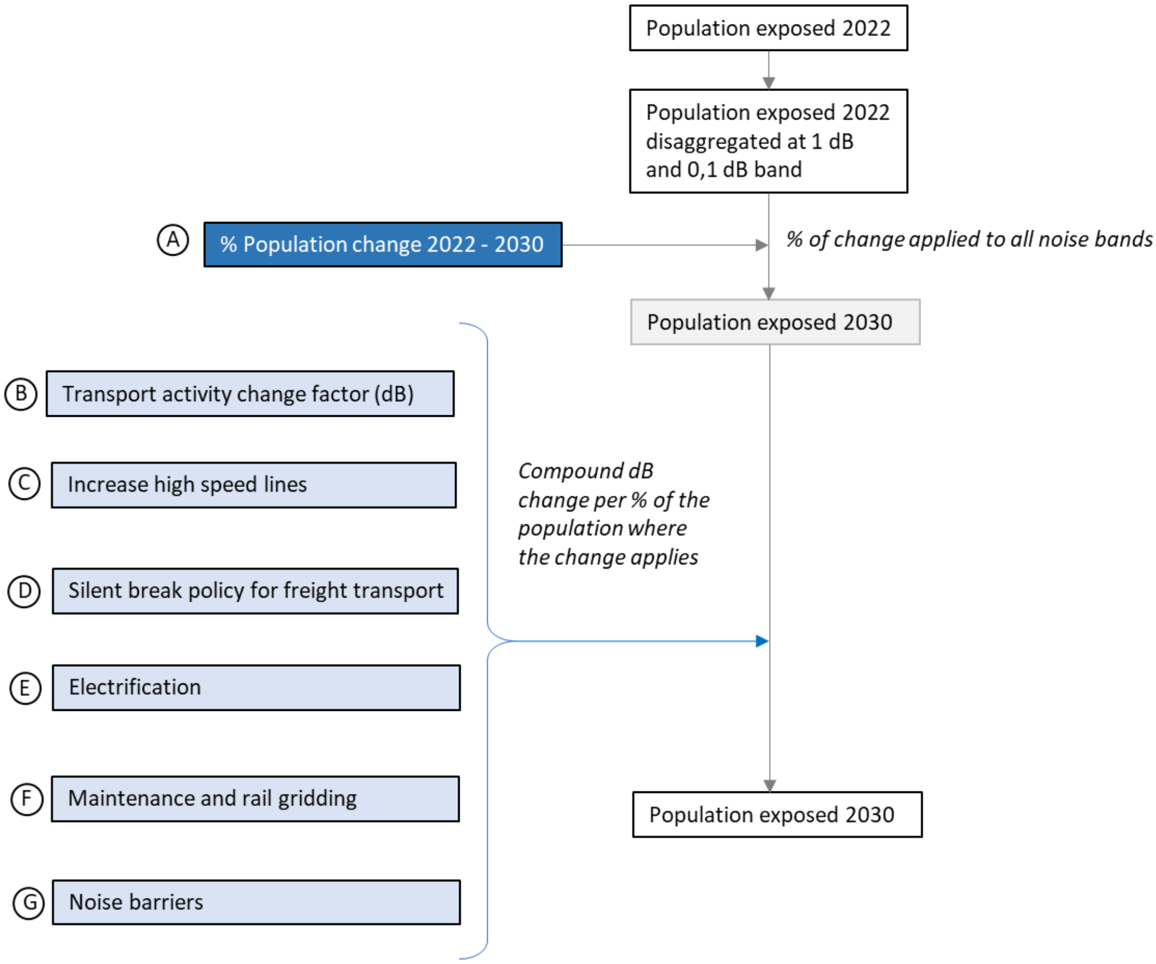
Rail grinding can achieve results of up to 3dB reduction for high-speed traffic and up to 5 dB reductions for conventional traffic (International Union of Railways, 2021c). ANOTEC, Directorate-General for Environment (European Commission), Tecnalia, TNO, Universitat Autònoma de Barcelona, VVA (2021) 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 2.6 is applied to all dB bands.

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

General workflow of scenarios for rail traffic noise outside agglomerations. Demographic changes (A) (in dark blue), factors related to traffic flow (B), new high-speed lines (C) and other noise abatement measures (D to G) contribute to the population change exposed to rail traffic noise between 2022 (latest reported data) and 2030. Boxes in grey refer to intermediate calculations. Letters link to summary Table 2.7, 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;

Approach:

1. Disaggregation of the population exposed to noise at t_0 (2022) 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. (2023) - 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).

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

   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. As mentioned before, the same projections are used for all scenarios.

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR_{20-25})^3 \cdot (1 + CAGR_{25-30})^5$$

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 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 dB (Wood, 2022).

Approach:

1. The dB increase provided in Table 2.7 is applied to all dB bands.

D. Silent brake policy in major railways

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

Values provided in Table 2.7 are derived from the total railway noise reduction for the EU from the silent brake policy by the European Railway Agency (2022).

Assumptions:

- Same level of implementation in the 2030 scenarios

Approach:

1. Apply the noise reduction values provided in Table 2.7 to the corresponding scenario and per each noise band.

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. 60% of the European rail network outside urban areas 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. Based on 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 than traction noise, and therefore, a more conservative value is proposed.

Table E. Projections of noise reduction 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 2.7 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 2.7 is applied to all dB bands.

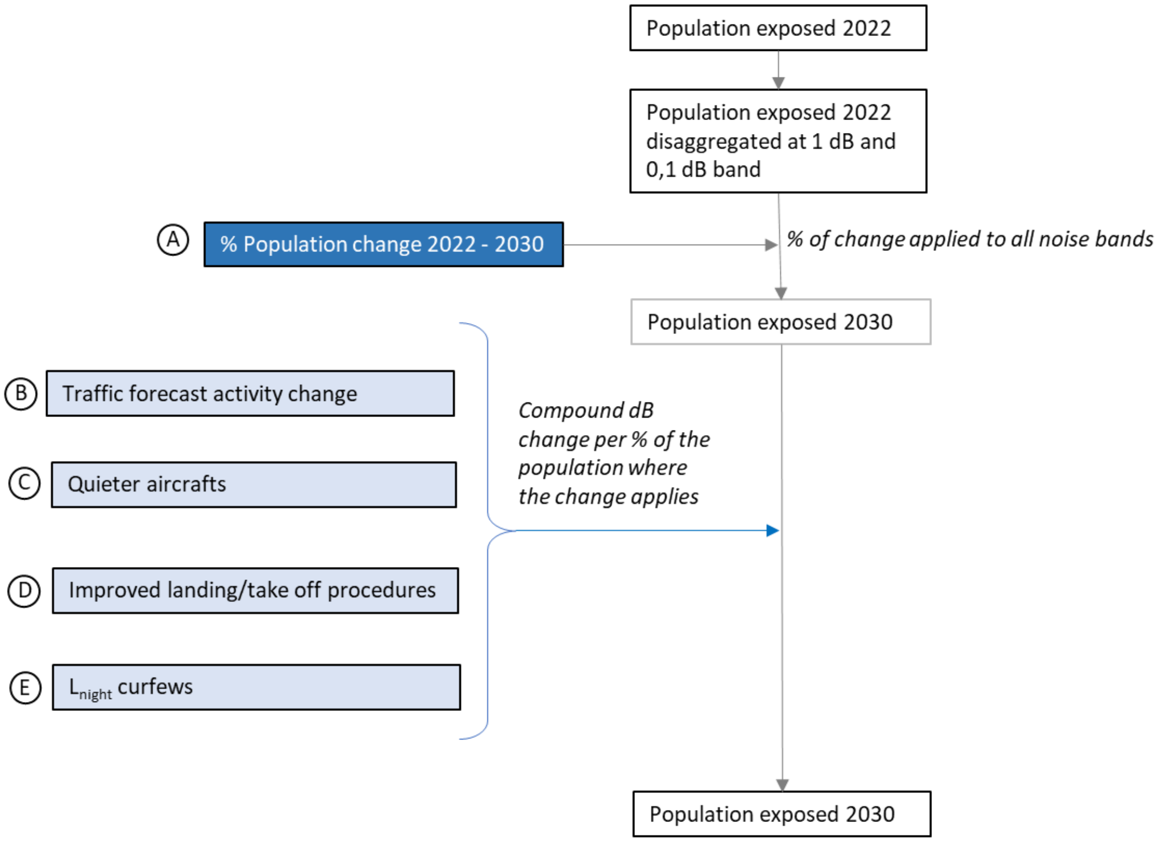
F. Noise barriers on major rails

The previous assessment of scenarios did not include noise barriers on major rails because of the need for more evidence to estimate potential implementation in the upcoming years (Blanes et al., 2022).

UIC (2016) mentions a planned increase of 1,7% in noise barriers for 2016-2026 in seven European rail networks (without further specification on the networks). Data from Germany complemented this information with a 0,15% increase in new noise barriers yearly (estimation from last 5 years; M. Hintzsche, personal communication, July 9, 2024). Then, the figure of 0,15% was considered the basis for the conservative scenario (CS). For the best implementation scenario (BIS), a value of 0,30% was considered, doubling the value of the CS based on expert judgment.

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 2.9, 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;

Approach:

1. Disaggregation of the population exposed to noise at t_0 (2022) 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. (2023) - 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).

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

   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.

$$P_{exposed2030} = P_{exposed\ 2022} \cdot (1 + CAGR_{20-25})^3 \cdot (1 + CAGR_{25-30})^5$$

B. Traffic forecast activity change

Eurocontrol (2024) provides actual data on the number of flights for the period 2019-2023 and projections of three scenarios (high, base, and low scenarios) for the period 2024- 2030. In our report, we have adopted the base scenario from Eurocontrol for both the conservative and best implementation. The outcome is a 3,6% annual traffic growth (2022-2030), with an equivalent increase of 0.14 dB per year from 2022.

C. Quieter aircraft

Uptake of new technology is assumed to be low because of the slow introduction of new quieter aircraft coming into service (European Environment Agency; European Union Aviation Safety Agency; Eurocontrol, 2019), (ICAO, 2019). It is assumed that there will be a noise level reduction for new aircraft delivered 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).

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.

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