European Network of the Heads of Environment Protection Agencies (EPA Network)

Interest Group on Noise Abatement

Report

Interest Group on Noise Abatement - Final Report 2017-2022

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Prepared for EPA Network Interest Group in Noise Abatement (IGNA)

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Members of the IGNA that endorse this report are the Environmental Protection Agencies of the following countries:
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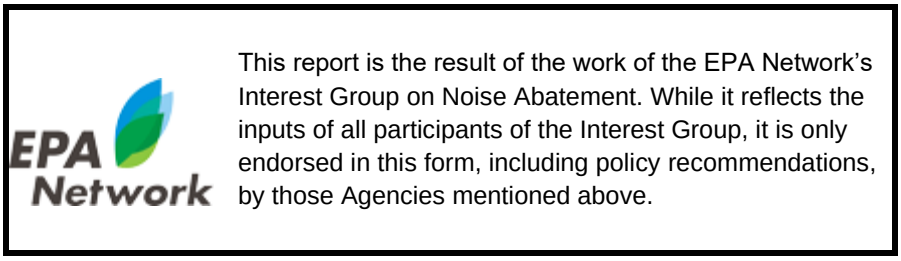

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Summary

The EPA Network Interest Group on Noise Abatement (IGNA) has been working to exchange information, experience and opinions on environmental noise topics since it's founding in 2010. Currently, IGNA unites 15 European environment agencies. The first five-year mandate in 2011 – 2016 focused on road, rail and air traffic noise as these were, and still are, the most important sources of noise-related health impacts everywhere in the European region. This first period was closed with the previous Final report published in 2016 [39]. The current Final report marks the end of the 2017-2022 mandate. The report serves three purposes. First, it summarises the work and all the information that IGNA has produced in the last five years. Second, it gives an overview of the current 2022 situation with regards to environmental noise. And third, it provides conclusions and recommendations as to what should be the focus of the European noise community, and the IGNA group itself, in the years to come.

In the past period from 2017 to 2022, the IGNA group has widened its focus. Three topics have been the main work items, focused on the environmental noise problem on a more general level:

- decision and cost/benefit methods for noise abatement: Many decisions on noise abatement, from high-level EU and national policy development down to inner city infrastructure projects, require a balance between the costs to reduce or prevent noise on one hand and the positive or negative impact on public health and well-being on the other. A 2018 IGNA report, based on an information survey around European countries, presents and compares decision methods available and used throughout Europe to make such decisions. Most methods are based on some level of cost/benefit analysis or cost effectiveness consideration. The information collected and published can help authorities that want to make profound decisions or implement such methods in legislation to learn from other countries and available research material.
- critical noise values: In the light of the new WHO Environmental Noise Guidelines published in 2018, this 2019 IGNA study gathers and reports information about noise limit and target values for different noise sources used in European countries and compares these to the WHO recommended levels. The study also regards the scope to which such limits apply and what consequences are attached to exceeding these levels. Among the conclusions is the fact that there is a high level of noise regulations around Europe, but that immission limit values defined in these regulations are most often considerably higher than what the WHO recommends. The study describes the 'situation zero' in Europe. It will be interesting to see, in several years time, how legislation has changed possibly, also as a result of the Guidelines.
- quiet areas, soundscaping and urban sound planning: Solutions to the environmental noise problem, especially on a local scale, are not always or only about reducing the decibel levels. Not all sound is noise, and this IGNA study shifts the attention to improving the acoustic quality by focusing on areas where it is good. This may be quiet areas, where noise levels are generally low, but also other attractive soundscapes, filled with positive and characteristic sounds that complement visual and socio-cultural aspects of the location. The report is an anthology of interesting examples how such an approach can be put into practice, helping urban planners to shape and design areas with a good acoustic quality in mind, and to value and protect areas that are already of high acoustic quality.

The IGNA reports and workshops from the last period have brought together lots of relevant information, as much as possible in a complete and objective way. This information is now available to help policy makers and experts, and to raise awareness and understanding among citizens. Still, looking at the current state of the acoustic environment, the situation has not yet improved or even grown worse, judging from the total number of exposed European citizens. The Commission has put forward the ambitious goal to reduce by 2030 the number of people chronically disturbed by noise with 30%. This requires that the efforts to reduce noise, mainly from transportation, should be increased.

This report formulates some recommendations for the upcoming years, in summary:

- For road traffic noise, noise regulations for vehicles and tyres should be further improved to reduce noise at the source. This should also include further uptake of enforcement to get the most annoying, possibly illegal, vehicles off the roads. Furthermore, low noise tyres and pavements should be further promoted to reduce road noise at higher speeds, and also at inner city roads given the expected increase of electric vehicles.
- For railway noise, good progress is being made to reduce the number of noisy freight wagons with cast iron brake blocks, but this should be monitored and promoted further. Meanwhile, other categories of rail noise, such as parked trains in urban areas and high-speed railway, should also be addressed.
- For aircraft noise, the implementation of the Balanced Approach around European airports should be well evaluated and actions to improve regulations or the implementation thereof by the airports should be stimulated. Also, new trends towards unmanned aerial vehicles ('drones') and supersonic flight require adequate regulations and policy to avoid future problems when such vehicles become more common.
- Urban planners and real estate developers must be aware of the environmental noise issue when planning new residential areas, to avoid more people living close to aircraft noise exposed areas. This is particularly important given the current pressure on new housing in many European countries. As stated, urban areas should also have spaces with quietness or other high quality soundscapes, where people can restore and escape from more noisy areas.

The IGNA members remain in dear memory of our colleague Rosalba Silvaggio of ISPRA Italy, who unexpectedly fell away in 2021. We are grateful for her active and essential contributions to the IGNA workshops and reports, and we will remember her warm and positive personality.

Contents

1 Introduction

1.1 Interest Group on Noise Abatement

The EPA Network is an informal grouping bringing together the directors of environment protection agencies across Europe. The network exchanges views and experiences on issues of common interest to organisations involved in the practical day-to-day implementation of environmental policy. In the September 2010 EPA-Network meeting in Krakow the Interest Group on Traffic Noise Abatement (IGNA) was created and in 2017 its mandate was renewed for 2017-2022 at the EPA plenary meeting in Rome, thereby enlarging the scope of IGNA activities to all noise issues, rather than only traffic noise. The key activities of IGNA will focus on recommendations for short and long term objectives, mainly to the following issues:

- Harmonization of noise-monitoring: harmonization and standardization of methods for monitoring and evaluation of noise exposure and remedial measures;
- Noise abatement measures at source and quiet areas: Information and exchange of successful measures to limit noise at sources and to protect quiet areas; exchange knowledge on action plans with stringent regulatory and incentive measures at sources such as for vehicles and machines;
- Critical levels: harmonized critical levels (limit values) that trigger specific remedial measures;
- Economical instruments: cost-benefit aspects and application of financial instruments in order to compensate external costs and to set incentives for measures at sources.

1.2 Overview of IGNA activities 2017-2022 and before

In the first IGNA mandate 2011-2016, the group focused on noise from road, rail and air transport, as these are the most important sources of environmental noise. In yearly workshops with noise experts from the national EPAs and the EEA, important information on current and future developments was acquired, exchanged and discussed. The IGNA developed a series of reports describing the current situation as well as the State-of-the-Art in legislation and noise abatement measures, for road noise [36], railway noise [38] and aircraft noise [37]. In addition to these reports, letters were sent to the European Commission, the European Parliament and the European Railway Agency, to convey the importance of tackling these noise sources and to recommend specific policy actions to be taken, such as the adoption of stricter road and rail vehicle regulations and noise limits. Results of the 2011-2016 period were summarized in a final report [39], which applied a higher level framework approach of Drivers-Pressure-State-Impact-Response (DPSIR) as defined by the EEA[1] to the problem of transportation noise.

Having covered transportation noise, the second IGNA mandate in 2017-2022 devoted attention to other important aspects of noise policy and abatement, which are less source specific and more focused on the problem of environmental noise as a whole. This work has again led to three reports that have been discussed in the IGNA workshops and published:

- cost/benefit and decision making methods for noise abatement: This 2018 report [32] presents and compares decision methods available and used throughout Europe to make decisions on noise abatement measures, as well as cost/benefit analysis methods that can be part of the decision making;
- critical noise values: In the light of the new WHO Environmental Noise Guidelines published in 2018 [41], this 2019 IGNA study [29] gathered and reported information about noise limit and target values for different noise sources used in European countries and compared these to the WHO recommended levels. The study also regarded the scope to which such limits apply and what consequences are attached to exceeding these levels;

[1] https://www.eea.europa.eu/help/glossary/eea-glossary/dpsir

- quiet areas, soundscaping and urban sound planning: Solutions to the environmental noise problem, especially on a local scale, are not always or only about reducing the decibel levels. Also, not all sound is noise. This 2022 report [31] focuses on improving the acoustic quality of the neighbourhood, or protecting current areas with good quality from unwanted noise in the future.

To present this work to the noise community, as well as to promote the EPA Network and the noise interest group itself, the IGNA organised its own conference session at the ICA / EuroRegio 2019 conference in Aachen[2]. In seven presentations, IGNA members provided the public with information about the impact of (traffic) noise, recommendations for abatement, regulations and limits, quiet areas, public communication and future trends.

In this final report, Chapter 2 presents an overview of the current situation with regards to environmental noise and related policy in Europe, including significant developments in the last five years. Chapters 3 - 5 summarise the last three reports mentioned above, to create an overview of the IGNA activities in the 2017-2022 mandate. This final report ends in conclusions as to what has been achieved and what IGNA recommends as next steps for a potential new mandate.

All reports and letters from IGNA as well as the other interest groups of the EPA Network can be found on their website: https://epanet.eea.europa.eu/reports-letters/reports.

[2] see https://pub.dega-akustik.de/ICA2019/data/index.html, session 08 H

2 Situation overview

2.1 Summary of previous Final Report (2011-2016)

The first mandate period of IGNA focused on road, rail and air traffic noise. In the previous Final Report concluding this period in 2016 [39] the problem of transportation noise is described from a higher level 'helicopter view', following the DSPIR framework. Figure 1 below indicates what drivers, pressure, state and impact apply in the case of transport noise. It also indicates that responses may act at each element. The report explains that responses actually act mainly on the links between the elements (the red arrows).

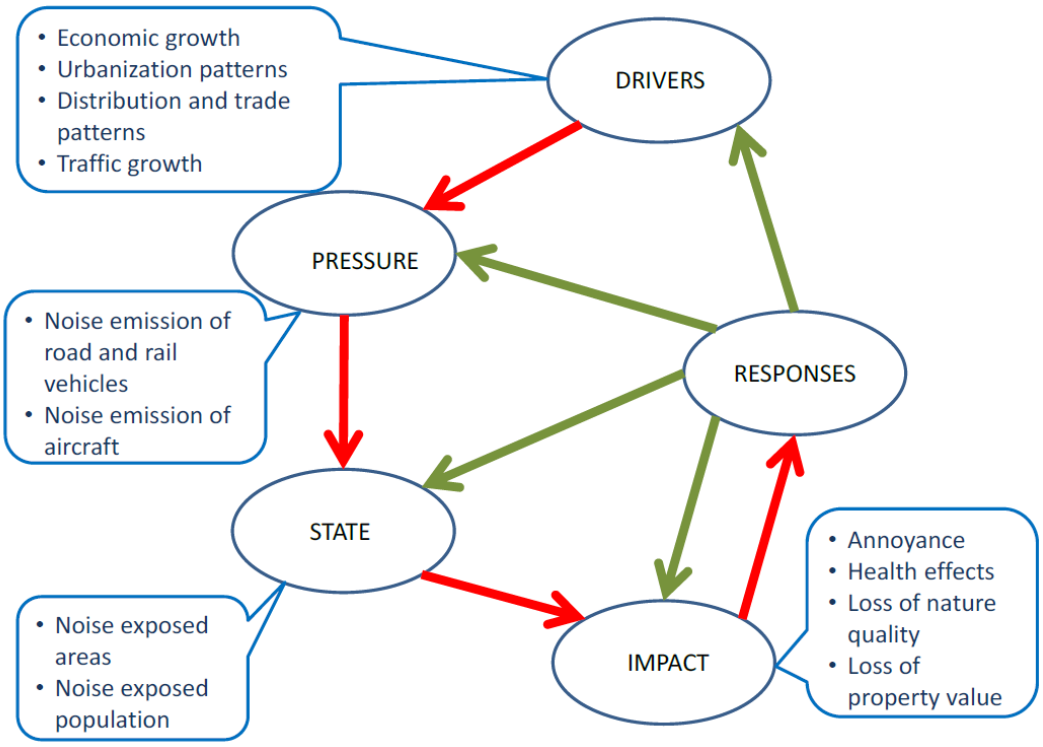

figure 1 *DPSIR framework to define and analyse the interactions and causal relationships between society and environment, in this case environmental noise (from [39])*

The report concludes that:

- drivers for road and rail transport are not so much the growth of transport as a whole, but rather the urbanisation and the concentration of urban settlements around major infrastructure axes. Aviation, however, has been growing as a whole, at least until 2016;
- pressure arising from these drivers is increased emission of noise from road, rail and aircraft vehicles, tyres and rails. The pressure differs per transport mode: under generic assumptions, it is shown that rail traffic emits the lowest amount of noise per person-kilometer, or per ton-km for freight traffic (assuming disc brakes or composite brake blocks);
- the state is that, in 2012 according to the 2nd round of END noise maps, 140 million EU-28 inhabitants are exposed to traffic noise levels over 55 dB L_{den}, with 45 million over 65 dB L_{den}. It is shown that about 2/3 of these people live in the larger agglomerations, and explained that this is probably an underestimation as smaller urban areas and smaller infrastructure are taken into account. It is also shown that road traffic noise is by far the largest source of noise exposure (89%), followed by rail and then aircraft noise;

- the consequential impact is that, according to 2015 RIVM calculations, 21 million people in EU-27 experience severe annoyance and 14 million people experience severe sleep disturbance as a result of road, rail or aircraft noise. This leads to 18.000 years of life lost due to premature mortality, and 1.5 million healthy life years lost if disability is taken into account. In economic terms, external costs in the order of 45 billion Euro (2004) are associated with this impact, resulting from loss of real estate and land value, productivity loss, health costs and other factors.

Responses to reduce or compensate for the impact are found at different levels.

- drivers: A reduction of the total amount of traffic is relatively ineffective: a severe reduction of 25% of the total traffic flow would only lead to a 1.2 dB lower L_{den}. More effect could be expected from a modal shift e.g. from aircraft to rail: even if the effect on the total L_{den} is limited, the effect on annoyance and sleep disturbance will be greater due to the higher sensitivity of people towards aircraft noise.
- drivers → pressure relation: reduction measures at the source are generally effective and cost-efficient. These include low noise tyres/pavements, rails/wheels or engines, or reduction of traffic speeds and aggressive driving behaviour.
- pressure → state relation: this includes measures to keep emitted noise away from the people. It can be measures in the propagation path, such as noise barriers, tunnelling or relocation of infrastructure or housing. It also includes noise insulation of facades and windows.
- state → impact relation: for people that are exposed to noise, the annoyance, sleep disturbance and other health impact may be reduced by soundscape improvements, e.g. masking noise with positive sounds, or by providing rest and relief at another time or location, e.g. nearby quiet areas or 'respite' periods for aircraft noise. Finally, the attitude of people towards the noise can be improved by means of communication, education and participation processes.

The report recommends, as was done in the earlier reports for the separate transport modes, that more pressure is put on improving type approval regulations for road/rail vehicles and aircraft. This should not focus only on lower approval limits and phasing out noisy airplanes, but also on improving the representativity of test methods, e.g. for real driving conditions of high performance cars. General, non-source specific recommendations are to lower the thresholds for the END noise mapping to 45 dB L_{den} and 40 dB L_{night}, in order to include the significant health burden that exists at lower levels. Finally, it is recommended to make cost/benefit decisions more transparent and fairer, and to improve decision making by harmonisation and knowledge exchange between countries.

2.2 Developments in environmental noise 2017-2022

During the 2017-2022 IGNA mandate, there have been some major developments in Europe regarding environmental noise in general, or transport noise more specifically.

2.2.1 General developments

- European Green Deal: The European Green Deal [6] is the Commission's roadmap for a sustainable EU economy, aiming to turn climate and environmental challenges into opportunities across all policy areas and making the transition just and inclusive for all. The Green Deal was approved by the other EU institutions in 2020. Europe strives to be climate-neutral by 2050, which requires action from all economic sectors including transport. The Green Deal aims to reduce transport greenhouse gas emissions by 90% in 2050 while also making private and public transport cleaner and healthier. An impact on traffic noise may result from this through further electrification of road vehicles or an increased modal shift from aviation to rail, for example.
- Zero Pollution Action Plan: The Green Deal itself does not mention environmental noise explicitly. However, the Commission in May 2021 adopted the *EU Action Plan: "Towards a Zero Pollution for Air, Water and Soil"* [9], also known as the *Zero Pollution Action Plan* (ZPAP). The

ZPAP aims that by 2050 air, water and soil pollution is reduced to levels no longer considered harmful to health and natural ecosystems. Six interim targets are set for 2030, which includes a specific target for transport noise: Under EU law, Green Deal ambitions and in synergy with other initiatives, by 2030 the EU should reduce *[…] 2. by 30% the share of people chronically disturbed by transport noise. It is stated that the Commission will focus on better tackling noise at source, notably by securing proper implementation on the ground and, where appropriate, improving the EU noise-related regulatory framework on tyres, road vehicles, railways, aircrafts, also at international level. […].* It will review progress in 2022 and consider whether there is a need to set noise reduction targets at EU level in the Environmental Noise Directive.

- WHO Environmental Noise Guidelines: The World Health Organization (WHO) published their new Environmental Noise Guidelines for the European Region (ENG) in October 2018 [41]. In the ENG, WHO recommends reducing noise levels below certain limits, with specific L_{den} and L_{night} levels given for each noise source. IGNA was present at the launch of the ENG in Basel and discussed the potential consequences in their subsequent workshop. Generally, the new evidence shows that annoyance and health impact from rail and aircraft noise are bigger, at the same noise level, than what was assumed before. Railway noise, for instance, is now equally annoying as road noise. The 2019 IGNA report, see Chapter 4 below, describes the WHO guidelines in more details and compares the recommended levels to current limit and target noise values around Europe. In most countries and for most sources, recommended levels are considerably below limit values currently used in regulations. The publication of the ENG has caused increased awareness and pressure on authorities to address the noise issue. Politicians and citizen's groups around Europe are using the WHO guidelines to stress the need for increased action. It may have triggered countries to start updating regulations; the WHO and EEA are currently working on a survey to investigate the status of ENG implementation around WHO European member states.
- Environmental Noise Directive updates: The END [1] is the Commission's main overarching policy document relating to environmental noise since 2002. Among other regulations, it requires Member States to produce strategic noise maps and subsequent noise action plans (NAPs) every five years. While interim calculation methods have been allowed and used for the first three rounds of noise mapping (2007, 2012, 2017), Directive 2015/996 [3] specifies a common noise assessment method in END Annex II, to be used by all Member States from 2018. This method, also known as 'CNOSSOS-EU' has been amended in 2021 [8] and in 2022 Member States will be using this method for the fourth round (R4) of noise mapping, of which results should be published in each Member State later this year. Also, Annex III of the END that specifies the exposure-response functions (ERFs) for calculating the health burden in the noise action plans has been updated through Directive 2020/267 [7]. The new Annex III now contains the ERFs from the WHO ENG. For road noise, this includes new ERFs for annoyance and sleep disturbance, but also a new ERF for ischaemic heart disease (IHD), which will be mandatory to include in the upcoming R4 action plans.
- EEA reports on environmental noise and the state of the environment: The European Environment Agency (EEA) collects and analyses the noise map data reported under the END. Based on these analyses they regularly report on the state of environmental noise in Europe and the observed trends, most recently in their Environmental Noise in Europe 2020 report [18]. They conclude that noise remains a major environmental problem in Europe, with at least 20% of the EU population living in areas where traffic noise levels are harmful to health. Road noise is by far the most prevalent noise source with 113 million people exposed to L_{den} > 55 dB, and rail and aircraft noise coming in second and third at 22 million and 4 million respectively. The report further predicts, based on growth scenarios for population and traffic, that it is unlikely that the situation will improve before 2030 and tends to become worse. This is also reflected in the EEA's State of the Environment (SOER 2020) report [16] which now addresses also noise. Table I shows that, contrary to what happens for air pollution, the noise problem is not decreasing or increasing, and is not on schedule to meet 2020 policy targets.

table I *Past trends, outlooks and prospects of meeting policy objectives; selection of air pollutant and noise risks, from [17]*

Theme	Past trends and outlook		Prospects of meeting policy objectives/targets		
	Past trends (10-15 years)	Outlook to 2030	2020	2030	2050
Safeguarding from environmental risks to health and well-being					
Concentrations of air pollutants			☒	☑	
Air pollution impacts on human health and well-being				☑	
Population exposure to environmental noise and impacts on human health			☒		
Preservation of quiet areas			☒		

Indicative assessment of past trends (10-15 years) and outlook to 2030	Indicative assessment of prospects of meeting selected policy objectives/targets		
Improving trends/developments dominate	Year	☑	Largely on track
Trends/developments show a mixed picture	Year	☐	Partially on track
Deteriorating trends/developments dominate	Year	☒	Largely not on track

- New END data repository: The END reporting is defined in the Directive 2002/49/EC and the reporting requirements are further defined in the Commission Implementing Decision (EU) 2021/1967 of 11 November 2021 on Setting up a mandatory data repository and a mandatory digital information exchange mechanism according to Directive 2002/49/EC1 [9]. The current reporting obligations of the Environmental Noise Directive have been adapted to also fulfil the new INSPIRE directive which is based on the harmonisation and sharing of spatial data and infrastructures based on the 2019/1010 EU regulation which amends different articles of the END. Firstly, the regulation obliges countries to produce noise maps and action plans according to the INSPIRE Directive and secondly, it obliges the EC and the EEA to develop a mandatory digital information exchange mechanism that countries have to use to report and share the END data. Therefore, the use of the Reportnet 3 platform and the use of data that is INSPIRE-compliant are mandatory from 1 January 2022 for the reporting of data under the END.
- Horizon2020 and other research projects: The Commission continuously supports and funds research projects and collaborations through various programmes. From 2014 to 2020, the Horizon2020 was the main funding programme for research and innovation, which has been succeeded by Horizon Europe 2021-2027. In parallel, the Commissions LIFE programme has funded projects aimed at climate and environment. Both programmes have funded several projects focusing on noise in general and road traffic noise in particular. One other important recent project from the Commission is the Phenomena study [11][12], which assessed the potential health benefit that could be gained in Europe by abatement of noise from road, rail and air traffic. The study aimed at a reduction of 20 to 50% of the total health burden by 2030, supporting the target set in the ZPAP. It concludes that a reduction around 20%, or more for specific sources, is possible but requires a combination of different noise reduction measures: vehicles, aircraft, tyres, tracks and pavements, operations and speed reductions, building insulation, quiet facades and other urban planning measures. The study also shows that the benefit-cost ratio is generally good, and remarks that many measures will have positive effects on other environmental aspects as well.

2.2.2 Transport noise

Road transport:

- EU vehicle and tyre noise regulations:
  - The type approval methods for cars and trucks (M and N categories) regulated by EU directive 540/2014 and UNECE Regulation 51.03 have been updated with smaller amendments since 2014. This includes the introduction of Additional Sound Emission Provisions (ASEP) to cover a wider range of operating conditions, to avoid vehicles being

tuned to emit low noise only under specific test conditions ('cycle beating'). Further improvements towards Real Driving (RD-ASEP) are in development and a draft version has been published by the UNECE GRBP Informal Working Group on ASEP [35]. Another GRBP Informal Working Group focuses on reducing measurement uncertainty, which includes reduction of variation between noise test tracks according to the ISO10844 standard. This standard has also been updated in 2021 to reduce site-to-site variation.

  - The Commission has published two reports on feasibility and effectiveness of lowering vehicle noise limits. For categories M and N [14] it is concluded that on top of the already agreed 3rd phase of reductions (2024-2026) a limited extra reduction of ca. 1 dB is possible. The report underlines the importance of improving the test methods for wider driving conditions (i.e. ASEP methods). For L-category vehicles (motorcycles, mopeds, tricycles, etc.) [13] a limit reduction of 2 – 3 dB is considered feasible and cost-effective within ca. 5 years. It is noted, however, that the problem of noise for these vehicles is also caused by tampering and tuning of vehicles by the user, replacement of exhaust systems by (mostly illegal) aftermarket products, and by aggressive driving behaviour.
  - In 2018, the EU introduced Regulation 2018/858 on market surveillance of vehicles, trailers and their components. The introduction of market surveillance means that all EU Member States are required to test a certain fraction of in-use vehicles, to ensure that these still fulfil type approval regulations including safety, air emissions (i.e. EURO class specs) and noise (i.e. 540/2014 limits). If a particular brand and model does not comply, there will be consequences for the manufacturer. For noise, the marker surveillance regulation covers M- and N-category vehicles (cars and trucks) as well as their trailers, and also their tyres in class C1, C2 and C3 according to UNECE Regulation 117. The 2018/858 is in force from September 2020.
  - There have been no significant changes to tyre noise in type approval regulations (R117 and/or EU 661/2009) since 2012, but effects of 2012 modifications should have led to reduction of noise by now as pre-2012 tyres will all have been replaced.
  - Improvements to the ISO10844 specification for tyre and vehicle noise test tracks [24] will also affect tyre noise.
  - The tyre label has been updated in May 2021 by EU regulation 2020/740, but for noise this mainly concerns the visual appearance, not a real change to the labelling values.
- CEDR activities: The Conference of European Directors or Roads (CEDR) is the network organisation of EU National Road Authorities (NRAs). CEDR has had a task group on noise from 2005 to 2017, delivering several State-of-the-Art reports and recommendations. Supporting these recommendations, CEDR has had a 2018 call leading to three research projects on road noise that have been recently finished. These projects and reports cover noise measures, such as low noise pavements, tyres and noise barriers, but also cost/benefit methods and psychoacoustic effects ('non-acoustic factors'). Information about the call and the results is available on the CEDR website[3].

Rail transport:

- TSI Noise: The Technical Specifications for Interoperability (TSI) for rail vehicles around Europe have a specification also for noise. Through EU Regulation 2019/774 [5] the Quieter Routes approach has been introduced, which aims to trigger further retrofitting of cast iron brake blocks by composite brake blocks, leading to severe reduction of noise emissions for rail freight wagons. From December 2024, wagons with cast iron brake blocks will be banned on Quieter Routes, which are the parts of the railway network with more than twelve trains during the night-time, as a daily average. Exceptions for special cases are possible, such as specific track gauges or if problems are found with sufficient braking under Nordic winter conditions. The European Railway Agency (ERA) has an up-to-date list of Quieter Routes on their website[4].

[3] https://www.cedr.eu/peb-research-programme-2018-noise-and-nuisance

[4] https://www.era.europa.eu/activities/technical-specifications-interoperability_en#meeting4

Further ‘spill over’ of quiet freight wagons on non-quieter routes is expected, leading to a lasting noise reduction for 90% of the people living close to the railway track[5].

- UIC State-of-the-Art report: The International Union of Railways (UIC) regularly provides updated information regarding developments in noise and vibration issues on European railways. A new State of the Art report [23] was published and launched in February 2021, which is an update to their previous 2016 report. It addresses several major developments regarding railway noise in the period 2016-2021, several of which overlap with this IGNA Final Report, e.g. the WHO guidelines, the Green Deal, the END developments and EEA reports, and specific railway developments such as the TSI Noise. It also highlights the activities undertaken by the railway sector itself to improve the railway noise situation, which is particularly important in the light of the European Green Deal that promotes an increase in railway traffic as the greenest mode of passenger and rail transport.
- several developments to stimulate the further retrofitting of cast iron brake blocks by composite brake blocks, leading to severe reduction of noise emissions for rail freight wagons. These developments include European funding through the third round of the Connecting Europe Facility (CEF), as well as national noise abatement programmes, national regulations (CH and DE) and implementation of noise differentiated track access charges.

Air transport:

- The EU Aviation Safety Agency (EASA) together with the EEA and EUROCONTROL published their third European Aviation Environmental Report (EAER) in 2022 [20][6], after their first and second [19] reports in 2016 and 2019. The 2022 report concludes in summary that the impact of aviation noise on European citizens has been increasing: the number of people exposed to 55 dB L_{den} or more has increased by 30% from 2005 to 2019 before dropping by 2/3 during the 2020-2021 pandemic. It is forecasted to grow back, but stay below the 2019 level and potentially decrease significantly until 2050 depending on the development of traffic and technology (see figure 2). The noise emission of the average single flight has actually decreased mainly due to the introduction of new, modern and more silent aircraft. This counteracting development towards less noisy airplanes is expected to continue.

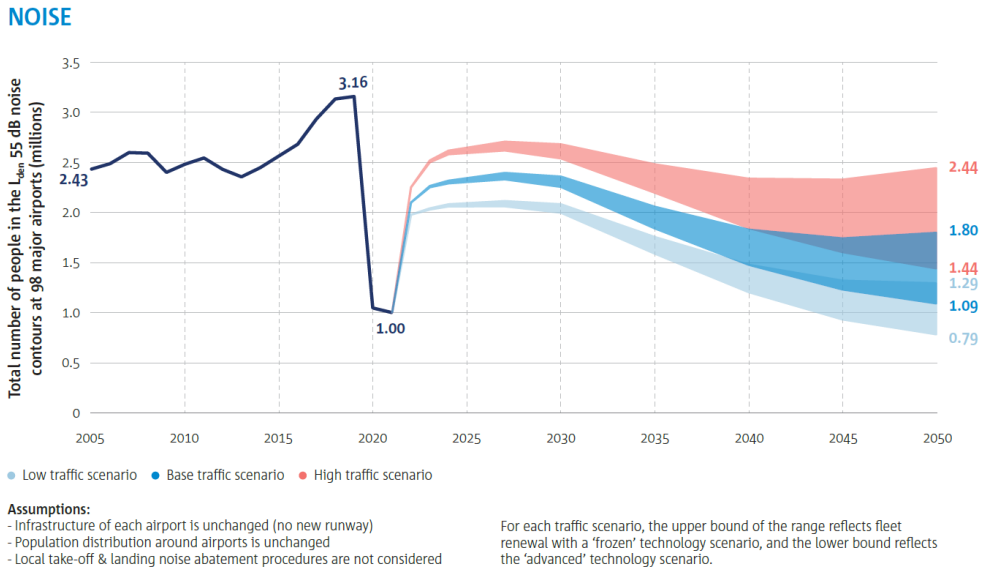

figure 2 *Development of aircraft noise exposure at European airports 2005-2021 and prognosis towards 2050 following various scenarios (from [20])*

[5] as expressed by the DG MOVE representative in the 9th IGNA workshop, Berlin 2017

[6] The EAER is also available in the form of a website: https://www.easa.europa.eu/eaer/

- As of January 2018, newly built airplanes must comply with stricter ‘Chapter 14’ noise limits as set by the International Civil Aviation Organization (ICAO), see figure 3. For example, the NEO and MAX models of the Airbus 320 and Boeing 737 are considerably more silent than their predecessors. Combined with the fact that these models are also larger, the noise emission per passenger-km or ton-km is further decreased. New noise-reducing technologies include aerodynamic optimisation of landing gear, for example, and ‘vortex generators’[7] to reduce tonal noise of approaching airplanes. The lower limits only apply to new aircraft, however. It may take many years before older, noisier aircraft are taken out of service, although this is hopefully enhanced by the fact that newer airplanes also use less fuel.

Aircraft categories as defined by ICAO/CAEP independent experts (IE)

	Description	MTOW (tonnes)
RJ	Regional Jet	30 - 50
SMR2	Short/Medium Range 2-engine	58 - 98
CROR	Counter-Rotating Open Rotor	58 - 91
LR2	Long Range 2-engine	170 - 290
LR4	Long Range 4-engine	330 - 550

Airbus A380 plotted for information as outside weight range for LR4 (575 tonnes)

figure 3 *Improvement in aircraft noise performance over time, from [19]*

- There are specific concerns around the noise from unmanned aerial vehicles (UAV), or ‘drones’, for which regulation is still under development. Heavier drones are considered aircraft and must comply with normal aircraft noise regulations. Lighter drones, however, such as those used for urban logistics, do not fall under these regulations. As they are much closer to people, they may lead to considerable annoyance even if they are quieter than traditional aircraft. There are also concerns with regards to supersonic flight, for which new commercial applications could be in service in a couple of years [19]. The ‘sonic boom’ that may arise from supersonic flight could be so loud that it’s contours drown out those for regular aviation completely. The Commission has stated a clear position, however, that supersonic flight must not be noisier than subsonic flight. They expect that new supersonic aircraft will comply with ICAO Chapter 3 limits.
- Flight path accuracy is improved with additional navigation guiding elements around airports, leading to Required Navigation Performance (RNP) [22]. This enables more accurate flight

[7] https://cleantechhub.lufthansagroup.com/en/focus-areas/aircraft-related-hardware/vortex-generator.html

paths to avoid deviations or short-cuts over more densely populated areas. Also, when using low-thrust continuous descending approaches, operators are increasing their glide angle so the plane is at a larger vertical distance for a longer portion of the approach path. This may, however, come with additional noise closer to the airport due to heavier braking required.

- By EU Regulation 2015/996 (i.e. “CNOSSOS-EU”), a calculation method based on ICAO Doc29 Revision 4 is now the mandatory noise mapping method for all EU Member States, making noise maps for different airports more comparable. The national implementations of the method may differ, however, mainly in their input data. For instance, the level of detail in vertical flight path definitions are an important factor. Where Schiphol airport uses a database of around 10.000 different flight paths, German airport calculations are based on a simpler worst-case scenario, i.e. long sections of low heights in the approach path.
- The Commission has recently commissioned an evaluation of the Balanced Approach (BAR) as set in EU Regulation 598/2014 [2], which is currently underway. The study should provide information on how the BAR and the END regulations have been implemented for some 60 European airports. This could then lead to further improvement of these regulations, or their implementation in national legislation.
- Following the publication of the WHO Environmental Noise Guidelines in 2018, there has been some debate surrounding the WHO evidence and systematic reviews of aircraft noise annoyance, which has taken place in scientific publications and comments. The debate was recently summarised by M+P in an Annex to a report for the Dutch Ministry [25] (in English). In the report itself, interviews with several western European airports and governments have been summarised, with the conclusion that none of these airports currently plan to implement the WHO recommended levels. Among other things, the WHO is criticised by other experts for their selection of studies involved in their final exposure-response function (ERF) and for the lack of a cost/benefit analysis to substantiate the feasibility of their recommendations. To some extent, the critique was answered by the WHO research team, while other fair critique remains.
- Research on aircraft noise and reduction continues, including further reduction of noise at the source (e.g. more silent and efficient aircraft). A particular recent example of another type of research project is the ANIMA project[8] which focuses on annoyance and perception of aviation noise and on noise management strategies, rather than on low-noise engineering. ANIMA includes research and case studies of stakeholder involvement and communication. Among other things, the project has provided a Noise Platform website containing helpful information to better understand aviation noise, the implementation of interventions and the experience from case studies around different airports. Also, the project consortium published an interesting and instructive open access book on aviation noise impact management [27].

[8] https://anima-project.eu/

3 Decision and cost/benefit methods

3.1 Report summary

Environmental noise has a serious impact on public health. Annoyance, sleep disturbance and related health impacts lead to a lower state of wellbeing, to economic loss and to health costs. Abatement measures exist to decrease noise levels and protect the people from these negative impacts, but such measures need to be paid for, usually by local or national government administrations. The question whether these costs are justified by the positive effect on the environment and the people in it, arises in various situations. For serious noise related health hazards, cost considerations may not be relevant. But often, administrations need to decide whether the costs for a noise abatement measure are justified by the benefits.

The 2018 IGNA report on decision and cost/benefit methods [33] presents the different approaches to the balancing and to identify the approach that is best fit-for-the-job. Based on literature review as well as a questionnaire among the EEA's EIONET network, we identified five different types of methods, see table II. These methods mainly differ in the way the benefits of noise measures are quantified, which may be:

- the total noise reduction obtained, in dB * number of people affected;
- the number of healthy life years gained, e.g. in DALY[9];
- benefits translated into an economic monetary value, using Willingness-To-Pay (WTP) or similar methods, and/or by attaching a monetary value to every healthy life year gained;
- one or more arbitrary numeric scales, combining different criteria with weighting factors. This may include criteria that are difficult to quantify otherwise, such as aesthetic aspects or socio-cultural preferences.

table II *Overview of decision methods*

method	decision criteria	remarks
cost-minimization	cheapest measure that fulfils the target	the output is fixed, to the required noise reduction; costs are then the only variable parameter
cost-effectiveness (CEA)	optimal ratio between noise reduction and costs	for noise, the output parameter is usually the noise reduction (in *dB *persons*)
cost-utility (CUA)	optimal ratio between public health (utility) parameter and costs	the health impact contains various endpoints; the impact is expressed in DALY/QALY units
cost-benefit (CBA)	optimal ratio between multiple, monetized criteria,summed to a single value, and costs	every benefit is translated to monetary units, e.g.using WTP
multi-design criteria analysis (MDCA)	highest score as a weighted sum over multiple criteria, each on a different arbitrary scale	costs and benefits are scored, then combined on a numeric scale using weighting factors

The IGNA study investigated what methods are used in different European countries by means of an online questionnaire. The report describes several examples of cost/benefit, cost-effectiveness

[9] Disability Adjusted Life Years, see [40]

and other methods that are defined in national regulations, or have been used in case studies. The questionnaire also included questions on how costs are calculated and, most importantly, what factors are taken into account when calculating costs for noise abatement measures (see figure 4). The study also investigated, from the survey and from literature, if countries do apply monetisation of annoyance and health benefits. Different methods to obtain monetary values (WTP values) are explained, such as stated vs. revealed preferences.

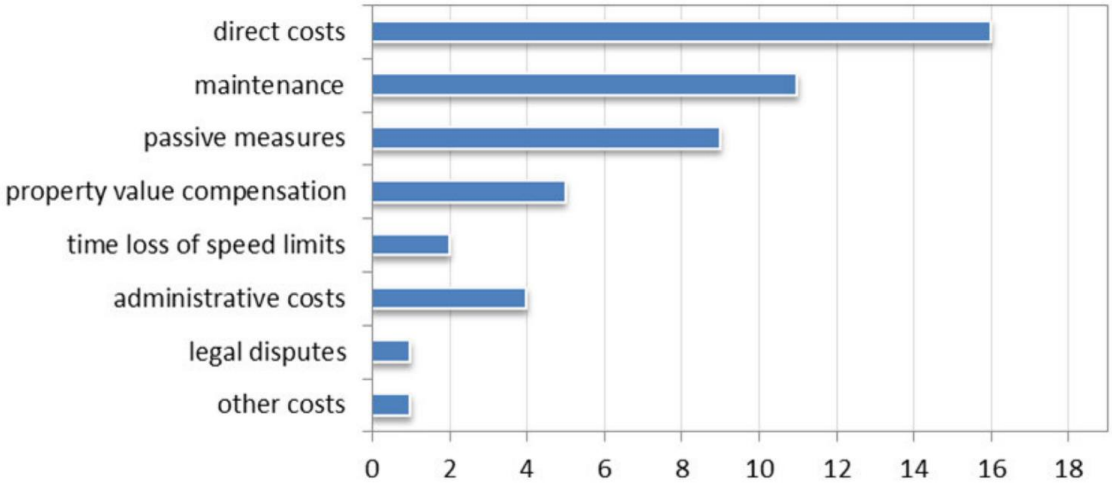

figure 4 *EIONET survey results: cost categories included in the cost considerations; the number indicates the number of respondents that included the cost category*

In summary, the following is concluded from the report:

- Fair and transparent decisions on noise abatement measures require an objective decision method that is applied consistently in different situations and projects.
- Some European countries have well established decision-making methods, that are defined in regulations or guidance documents. Such methods may serve as good examples for other countries seeking for good practices to apply in their own noise abatement decisions.
- The most commonly used methods are cost-benefit analysis (CBA), cost-effectiveness analysis (CEA) and cost-utility analysis (CUA). For large-scale projects or (inter)national policy decisions, CBA is recommended as it is the most complete and the only method to enable an absolute comparison of costs vs. benefits. Monetisation of benefits is however required and can be quite inaccurate. CUA can also be used to substantiate health-based policy decisions, and to compare noise to other health aspects. CEA is more about fair and transparent distribution of budget over different projects and situations, rather than to determine how much budget should be spent in total. It is well-suited for legal implementation, and several countries have done so.
- From comparing different methods in use, it is clear that there are big differences in cost values and what costs are taken into account. It is also clear that monetary values used to quantify the benefits differ widely, up to a factor of 10 between different EU countries, even those with comparable levels of welfare.

It is recommended to noise policy and decision makers to be clear and specific about the method, the assumptions and the outcome. Also, they should be clear and realistic about the uncertainties, especially with CBA and CUA methods. Any decision should be accompanied by a report specifying WTP or similar cost factors, dose-response functions and other important values that determine the results. It should also be made clear what is included on the costs side, and with what price levels. It is recommended to member states and decision makers that seek for guidance to make decisions on noise abatement measures to look into existing good examples of cost-effectiveness and cost-benefit systems from other EU countries. The IGNA report may actually help with that.

3.2 Publicity and feedback

A summary with best practices derived from the IGNA report on decision and cost/benefit methods was presented with a paper [32] and presentation at ICBEN 2017 in Zurich. Also, a 2016 paper [34] and presentation at Inter-Noise 2016 in Hamburg focused more specifically on the aspect of monetarisation of noise annoyance and health impacts. Preliminary results of the EIONET survey were presented at the 2016 EIONET noise workshop in Copenhagen. Some of the graphs in the IGNA report are used in a book on Environmental Noise Control [20].

Feedback on the report includes the comment that the recommended decision methods are based on economic valuation of the impact, by balancing the costs against the benefits or choosing the most cost-effective or simply lowest cost solution. Experts mention that the assumption that optimising costs vs. benefits leads to the fairest solution is only true in a neoliberal perspective. Another perspective could be an egalitarian one, where fairness means that there should be no social injustice and everyone should have an equal right to live without traffic noise. Then the 'polluter pays' principle would be important: the question should not be what exposed people would be willing to pay to avoid noise, but what the traffic user would be willing to pay to avoid inflicting damage on others.
With regards to the cost utility approach it is mentioned that this does not require monetisation, as a direct comparison of the effect in DALYs is sufficient. Also, experts claim that monetisation of one DALY depends on the underlying disease and its possible cure or prevention costs, and that a generic economic value of a DALY does not exist.
All in all, this is good and useful feedback that could be used to improve a future update of the IGNA report.

3.3 Recent developments

The report was published in February 2018 and is based on research performed in 2016 and 2017. In the five years since then, there have been a few developments related to decision making and cost/benefits that the reader should be aware of:

- The WHO has published their new Environmental Noise Guidelines in 2018 [41]. These include new exposure-response functions (ERFs), that have also been prescribed by the Commission in the new END Annex III [7]. Any cost-utility analysis should be based on these new ERFs, and cost-benefit or cost-effectiveness regulations based on these ERFs should be updated.
- The Commission DG MOVE has published an update to their Handbook on external costs of transport [15]. It is an update to the earlier 2008 and 2014 publications that are references in the IGNA report. These reports describe methods and results for all external costs related to transport, including safety, climate change, air pollution, noise and other aspects. The study provides total costs, average costs (€ per km) as well as marginal costs (the extra costs associated with every extra vehicle-km) for different countries and transport modes. The new Handbook provides new WTP values and health costs as a function of the noise level. What is new is that these values are now increasing incrementally: the costs value, in € per person per year for every extra dB, now increases with higher noise levels, where in earlier reports it was constant. An additional dB at high levels costs more than an additional dB at low levels. The updated Handbook used ERFs based on the systematic reviews used for the WHO Guidelines, but the definitive ERFs were not yet available. The 5 dB 'rail bonus', however, was no longer considered for the external costs.
- The most recent significant effort to quantify costs and benefits for noise abatement was the Phenomena study published by the Commission in 2021 [11]. This project studied the feasibility of a 20% to 50% reduction of the health impacts by traffic noise by 2030, including a consideration of costs and benefits. Although this is a difficult and complex task, the study is considered the current State-of-the-Art and is used to substantiate the noise ambitions in the Zero Pollution Action Plan.

4 Critical noise levels

4.1 Report motivation and background

The WHO published their new Environmental Noise Guidelines (ENG) [41] in October 2018, as a result of several years of research. A WHO research team systematically reviewed existing evidence into what negative impacts result from exposure to environmental noise. This was done for five different noise sources: road and rail traffic, aircraft, wind turbines and leisure activities (e.g. music, sports, bars/restaurants, etc.). Systematic evidence reviews were performed and published for different specific health endpoints: annoyance, sleep disturbance, cardiovascular diseases, mental illness, etc. In each review, the different noise sources were studied separately. The WHO also reviewed evidence of the effect of interventions: What noise measures are proven to be effective for what sources?

A main result of the WHO's systematic reviews are new exposure-response functions (ERFs), that indicate the occurrence or prevalence of a particular health endpoint as a function of the noise level (L_{den} or L_{night}). A separate WHO team, the guideline development group, set thresholds for individual health aspects, e.g. maximum 10% highly annoyed or maximum 3% highly sleep disturbed people. These thresholds in combination with the new ERFs then led to maximum noise levels, see table III, above which the WHO recommends taking appropriate interventions to reduce the noise. The levels mentioned here are long-term average noise immission levels, defined as outdoor levels close to the dwelling façades.

table III *Intervention levels for environmental noise, per noise source, recommended by WHO [41]*

noise source	average noise	night-time noise
road traffic	53 dB L_{den}	45 dB L_{night}
rail traffic	54 dB L_{den}	44 dB L_{night}
aircraft	45 dB L_{den}	40 dB L_{night}
wind turbines	45 dB L_{den}	-

These noise levels are recommendations by the WHO. Individual EU Member Sates or other European countries could implement these recommendations, for instance by setting limit or target values for the various noise sources, but there is no obligation to do so. Also, there are no noise immission limits or targets set by the EU, e.g. in the Environmental Noise Directive. Many countries will, however, take notice of the new WHO guidelines and consider adapting their noise policy regulations. The IGNA then wanted to know what critical noise levels (limits or targets) were defined in current national regulations, in the 'zero situation' before any updates following the ENG. Such an overview could serve as a basis for a future review of how the WHO guidelines have impacted noise legislation in Europe.

4.2 Report summary

The writing process for the IGNA report on critical noise values in the European Region [29] started after the 2018 IGNA workshop in Basel. The main research questions were:

- How does the current situation with regards to noise limit values in Europe relate to the WHO recommendations? This means: what types of limit values exist for which noise sources, what indicators and values are used?

- How are limit values implemented: What is their scope, in what situations do they apply and what are the consequences of exceedance?

A 'limit value' could be defined as a maximum noise level that is never to be exceeded. In practice, however, it may also be regarded as the starting point above which any action is taken, or in other words: the level below which nothing happens. And also, some countries have both limit and target values, see figure 5. Here, the target level is the level above which noise abatement actions or measures are considered and the limit level is the maximum level that should never, or only in exceptional cases, be exceeded. For the analysis summarised below, only limit values were taken into account.

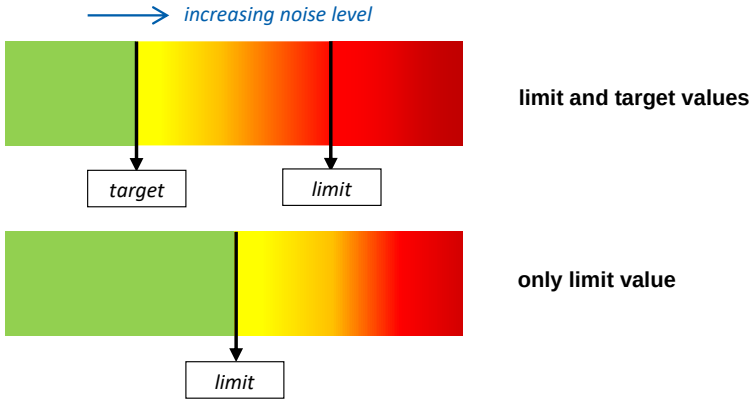

figure 5 *Definition of limit vs. target values*

The main research method was by means of a survey supported with fact sheets. For each country represented in the EEA's EIONET network, a fact sheet was prepared that answered seven different questions. Each fact sheet was pre-filled as much as possible with information found in literature. The fact sheet was then sent to one or more contact persons in each country to verify existing information (if any) and supply the missing information. Out of 35 fact sheets sent, 29 were returned with information, representing 27 countries[10].

A separate three-page executive summary of the report is available, see [29]. Some main conclusions from the report are the following:

- European countries have a high level of noise legislation: 90% of the respondents indicate that noise limit values are defined in their legislation; the remaining countries do not have any limits, or only guidance values.
- Limit values may not apply to all sources; roughly 75% of the countries has separate limits for road, rail, aircraft and industrial noise, and ca. 50% has limits specifically for wind turbines. Some countries also have different limits for different zones, e.g. reception limits may be stricter for housing areas or hospitals/schools than for commercial or industrial areas.
- All countries have their limit values defined as long-term equivalent noise levels, mostly in terms of L_{day} and L_{night}. It is actually a minority who uses L_{den} (and L_{night}), which are the quantities used in the WHO recommendations. A few examples exist where other indicators are used additionally, such as the number of events with an L_{max} above a certain level.
- One notable change in the new WHO findings was the fact that the ERFs for road and rail noise are similar, whereas previously rail noise was considered to be less annoying (at the same L_{den}) than road noise. 25% of the respondents indicate that their rail noise limits are (mostly) 5 dB higher than for road noise. Aircraft noise, on the other hand, has always been proven to be more annoying than road noise, yet this is not reflected in stricter aircraft noise limits in any country.

[10] For Belgium, separate fact sheets were supplied for Flanders, Wallonia and Brussels

- The actual dB values used in the different countries vary widely, with a difference of 20 dB or more between the countries with the highest and lowest value (see figure 6). For the vast majority of countries responding, their current noise limits are higher than the WHO recommended levels (indicated with dashed vertical lines).
- In a few countries, limits apply only to new situations (new housing or new infrastructure). Most countries have limits also for existing situations (e.g. reconstruction), although the values used for existing situations are sometimes higher, typically +5 dB.

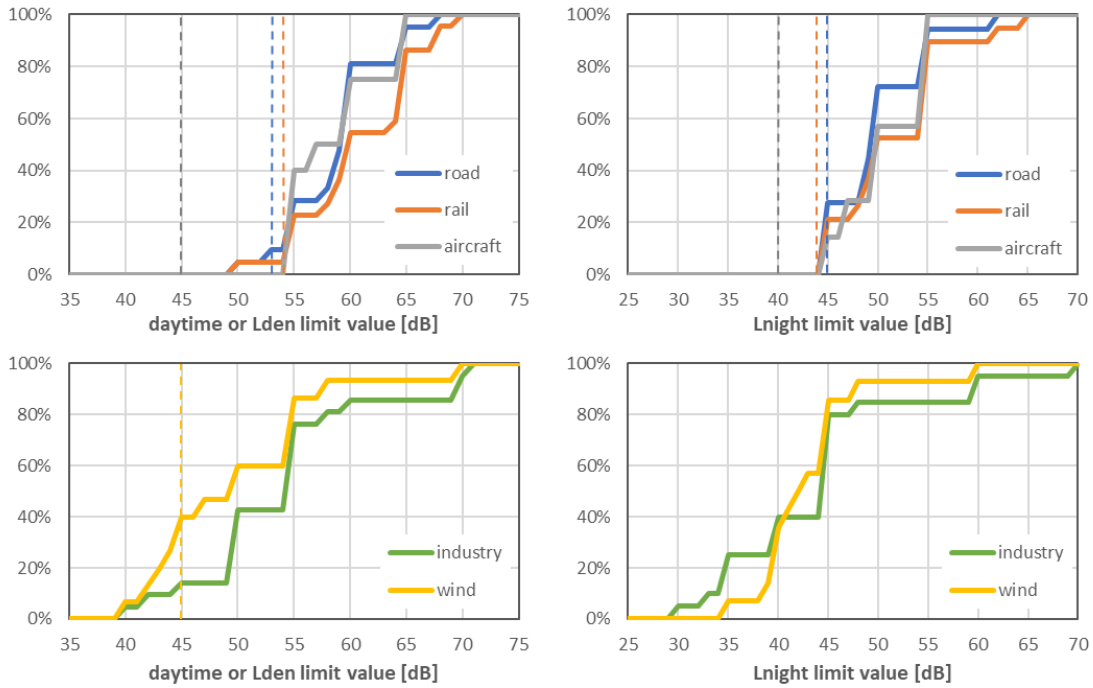

figure 6 *Cumulative distributions of limit values (L_{day}, L_{den} or other daytime indicator) per noise source, expressed as a percentage of all countries that have limits for that particular source. Vertical dashed lines indicate the WHO recommended L_{den} levels*

The survey also asked about the consequences when the noise limit is exceeded. Usually, active noise measures are required, such as noise barriers, low-noise pavements or rail dampers. For aircraft and industry noise, active noise measures are less common and exceedance often leads to a stop of the noise-producing activities. Passive noise measures, such as façade and/or window insulation, are also common, also as a fallback option in case active noise measures are not possible or not cost-effective. Financial sanctions are less common for road/rail noise, but apply in 50% or more countries for aircraft and industrial noise. This also includes financial compensation of exposed residents, which could come in place of building insulation.

The most important recommendations in the report, aiming at countries that are considering implementing or updating their noise limits, are:

- to be clear about the objective of the limit value: is it a target value above which actions should be considered, or a maximum value that is not be exceeded?
- to consider not only the limit value itself but also its implementation, as it's effect is largely determined by the consequences attached to exceeding it. Authorities should also regard enforcement methods and triggers, as well as the legal consequences of exceedance;
- to be clear and to publicly document the rationale behind the noise limit values. Preferably, limits are based on exposure-response functions, along with transparent cost-benefit and other possible considerations.

4.3 Publicity and feedback

The IGNA report and survey results on EU limit and target values have been presented at the ICA2019 conference in Aachen, in the IGNA noise policy session. A conference paper was also submitted [28]. The results were presented at the yearly Dutch noise conference GTL in 2019. An article was published in 2020 in the Dutch noise magazine *Geluid* [30]. Results of the study were also featured in the EEA Environmental Noise in Europe 2020 report [18]

5 Quiet areas, Soundscaping and Urban sound planning

5.1 Report summary

All IGNA reports until 2019 focused on abatement of noise: how to protect citizens from harmful impacts caused by traffic and other sources of unwanted, annoying and stressful sounds. In 2020-2021 the IGNA has worked on a report that addressed the issue from a slightly shifted perspective, namely on how to improve the acoustic quality of the environment. The difference in this new perspective is that is focuses on positive acoustic environments, how to protect or improve these and how to identify and communicate their value. This is different from 'noise abatement' as the latter focuses on bringing down the levels of unwanted sounds as far as possible.

The report covers three items:

- quiet areas: As mentioned specifically in the Environmental Noise Directive, quiet areas are areas where the acoustic quality is good and should be preserved. Although no further formal definition is given, this usually translates into areas with low L_{den} levels, or at least relatively low compared to their surroundings. Quiet areas in terms of the END are shown on the strategic noise maps and mentioned in the action plans. More specific national legislation exists, and examples are given in the report.
- soundscaping: The definition of the soundscape, according to ISO12319-1, is the *acoustic environment as perceived or experienced and/or understood by a person or people, in context*. The soundscape approach to improving the acoustic environment typically focuses on what people *do want to* hear, in a particular place and time: not all sound is noise. It focuses on the presence of positive sound, such as sound of nature, human sounds, or particular 'soundmarks' that give character to a place, similar to a certain landscape or a particular smell. Although rather academic initially, there is an increasing number of good examples of how the soundscape can actually be improved, several of which are described in the report. Also, standardisation and quantification of soundscapes, in other terms and quantities than dB levels, are in development. This includes new descriptors such as Pleasantness or Eventfulness.
- urban sound planning: Whereas the task of 'urban planning' focuses on designing and improving the urban environment, by changing its physical form or its social and economic function, the task of 'urban sound planning' focuses specifically on how sound and noise are taken into account in that process. The term *Urban Sound Planning* was formulated during the EU research project SONORUS. Here it is described as a holistic approach that aims not to make the area quieter but to define policies to value, introduce and preserve the characteristics of a good sonic environment. In a broader sense, however, it is about how and when sound and noise is dealt with when designing and improving an urban area.

These three topics are closely related and overlapping. For instance: quiet areas are not supposed to be totally silent. In terms of their soundscape, they are usually characterised by sound of nature (birds, running water, rustling trees, walking on gravel), although other sounds (e.g. human sounds like people talking, children playing) could also be an important quality certainly in an urban environment. Both the success of soundscaping and quiet areas require good and early urban sound planning.

The subject of this IGNA report, which will be published in the second half of 2022, is less tangible and specific than the earlier reports. Also, the topics included are slightly less mature and have received less attention from policy makers than the earlier noise abatement topics. There is much less legislation on these topics, on EU as well as Member State and regional levels. The IGNA report, therefore, is mainly an anthology of the way in which quiet areas, soundscaping and urban sound planning are dealt with, on national and local scale. It contains examples of legislation, guidance documents, case studies and other interesting literature, and it means to serve as

inspiration for policy makers, urban planners and noise experts. The report also touches upon related subjects and synergies with other topics, such as citizen science, air quality, urban green, biodiversity and climate change.

From the various case studies and examples, some conclusions and recommendations are given:

- Acoustic quality is more than the absence of noise. Unwanted sources of noise are brought down because there are others sounds we do want to hear. Even in quiet areas, people will want to hear sounds. However, there are typical sound sources such as traffic and industry that are generally disliked and harmful, and which should be constrained.
- Quiet areas are appreciated by the public and have a positive effect on people's well-being. However, they are under pressure due to scarcity of space, and there are little regulations ensuring that quiet areas designated today will still be quiet tomorrow.
- Unified qualifications for quiet areas do not exist. Apart from acoustic criteria, quiet areas should have green qualities and be easily accessible at no cost. Identification of quiet areas can be achieved through GIS-based methods. Public participation by local residents is advantageous, especially when trying to identify smaller urban oases.
- The soundscape approach is being translated into guidelines and ISO standards. Evidence of legislation regarding this approach exists, but scarcely. Even without legislation, a lot of effort is done across Europe to create and preserve pleasant soundscapes and quiet areas. Quantification of soundscapes, using descriptors like Pleasantness and Eventfulness, is under development.
- By including sound in their planning process, urban planners and authorities can significantly improve the living environment. Their focus should not be solely to bring down noise levels, but to optimize the acoustic environment as a whole. Urban sound planners should be aware of other tools to reduce annoyance and health impacts, besides reducing the level at the most exposed facade. In highly exposed areas, the availability of a quiet side to a dwelling and the presence of nearby green nearby are valuable tools.
- The emerging field of Citizen Science, aiming to involve and empower the citizens by taking them aboard research and policy development projects, is particularly promising for environmental acoustics. After all, the impact of sound on public health and well-being is subject to the attitude of the people exposed to it, perhaps more so than for other environmental polluters.

In summary, these conclusions and recommendations lead to key messages in the report that are repeated below.

Key messages

Quiet Areas

- have a positive effect on people's wellbeing
- should create a contrast to the noisy environment
- benefit from being green, clean and accessible
- are regularly defined, but more efforts should be taken to preserve them
- require more evidence of their value to withstand housing demand and economic development

Soundscaping

- helps to quantify the acoustic environment as experienced by its users
- provides planners with tools to design and improve the quality of the acoustic environment as a whole

Urban Sound Planning

- should be about acoustic quality, not just about dB's
- should consider nearby quiet areas
- should strive to create a quiet side to noise-exposed dwellings
- should consider green in the surroundings to reduce noise annoyance

And synergy: strengthen the business case for improving acoustic quality by partnering up with other environmental topics: **1 + 1 = 3**!

5.2 Follow-up

The IGNA report on Quiet areas, soundscaping and urban sound planning was written in 2020 and 2021. A final draft version was discussed in the last IGNA workshop in Malta, October 2021. After the workshop, the report was finalised and circulated among the EPA Network members for endorsement. It is expected that the report will be endorsed before the EPA Network plenary meeting in Q3 2022, after which it will be made public and available through the EPA Network website.

6 Conclusions and recommendations

6.1 Conclusions

From 2017, the IGNA has widened its perspective on the environmental noise problem. While transport noise, and each particular transport mode in it, has its own technical and legal challenges and solutions, there are general aspects of environmental noise that are common to all transport noise, and also other noise sources like industry, wind turbines and leisure activities. Also, the group has slightly stepped away from a more technical engineering perspective, looking into more qualitative subjects such as socio-economics, costs and benefits, annoyance and health impacts, and people's general attitude towards their acoustic environment. Rather than discussing dB-values and graphs with noise spectrograms, the reports from the last few years contain more text and photos.

This has been an important step for the group, and it should be an important realisation for other experts in the acoustic community as well. Although 'sound' is a very physical phenomenon, and the waves of pressure in air can be studied in an extreme level of detail, the end goal is to improve public health and well-being. How people perceive noise and how they value it differs from source to source, from place to place, from time to time and from person to person. Psychological, social and cultural aspects are much more difficult to quantify and regulate. Solving the problem of environmental noise, therefore, will always require discussion and exchange between experts from different fields, and interaction between policy makers and citizens to balance opinions and decide how much effort and money should be spent to improve the situation. The IGNA reports and workshops from the last period have brought together lots of relevant information, as much as possible in a complete and objective way. This information is now available to help policy makers and experts, and to raise awareness and understanding among citizens.

In the meantime, however, the situation has not improved. The total number of Europeans exposed to harmful levels of noise has not decreased and is expected to increase further, according to the EEA's prognoses from the END noise mapping [18]. Good progress has been made in some aspects: rail freight wagons and modern airplanes are considerably more silent than their predecessors, which are gradually being phased out. However, air traffic volumes have grown rapidly at least up until the Covid pandemic, and rail traffic is also expecting to grow further precisely because it is the most environmental-friendly transport mode in every other aspect but noise. For road traffic, which is still by far the largest source of noise exposure, some noise reduction is expected near low-speed roads from further electrification, but with increasing vehicle weights and tyre widths, the general vehicle fleet is not yet becoming more silent. And finally, there is a large demand for more housing in many European cities and regions, which puts more pressure on making land available for residents. This means more houses in high noise-exposed areas on one side, and less space available for green and quiet areas on the other.

6.2 Recommendations

With these conclusions in mind, IGNA has several recommendations, which are aimed here at policy makers, the industry and the noise community in general. Making these recommendations more specific and bringing these closer to the attention of decision makers would be a focus for IGNA in a potential new mandate from the EPA Network in the next five years.

Generally, efforts to reduce exposure to environmental noise must be increased, with a focus on the prevention of noise directly at the sources. This is also endorsed by the European Commission, who have set in their Zero Pollution Action Plan (ZPAP) a goal for the EU *to reduce by 2030 the*

share of people chronically disturbed by transport noise by 30% [9]. That means first of all, that the current *increase* of transport noise impacts must turn into a *decrease*, and second that it should be such a significant decrease that the whole European population is relieved from transport noise by one third, in less than ten years time. This is an ambitious goal and, as the results from the Phenomena study have shown, this will require significant noise measures at all segments: source reduction, operations, propagation and receiver measures and urban planning. Bearing in mind, that the cost/benefit ratio of noise abatement measures is generally favourable, it will mainly require political will and action to achieve the considerable improvement goals set by the European Commission.

As road noise is still the largest source of negative health effects due to noise exposure everywhere in Europe, it should be a main focus in the coming years. The Commission sets the ZPAP goal correctly as a reduction of noise *disturbance*, not 'noise exposure'. That implicates that the goal could be reached by reducing the actual noise levels as well as by changing people's perception of noise annoyance. For example: motorcycles and other high noise emitters cause considerable annoyance, even though their effect on the yearly average noise levels is small. A reduction for this particular category will not be reflected in the noise maps, as the L_{den} will be reduced only slightly. But the effect on the perceived annoyance will be significantly larger, leading to a decrease in the dose-response curves (i.e. less disturbance at the same noise level). Besides these noisy vehicles, with the increase of electric vehicles in the next decade the importance of low-noise tyres and pavements is even greater than before. It is recommended that:

- noise experts and policy makers stay on top of the EU and UNECE noise regulations for vehicles and tyres, put further pressure on improving the measurement methods and establish lower emission limits;
- both EU and local authorities make more effort of enforcing measures against noisy vehicles, motorcycles and noisy exhaust systems in order to take the most harmful vehicles off the road. This could be done by increasing roadside inspections or further introduction of noise limits for Low Emission Zones. Local initiatives and actions should be supported by appropriate and adequate EU legislation;
- low noise tyres and pavements should be further promoted, as increased demand for such products will also drive tyre manufacturers and road contractors to innovate and make these available. Tyre and possible road labelling could be enhanced, and citizens, fleet owners and road infrastructure managers could be stimulated to buy low-noise tyres or low noise pavements.

For rail noise, the uptake of composite brake blocks to replace cast iron brakes on freight wagons has been significant and should increase further in the next years. This is important, as rail traffic volumes are expected to increase further. As the rail sector itself concludes [23], a next step to further bring down the noise will be more difficult, or at least less cost-effective. They foresee a future focus in noise reduction to be on the track. Also, the noise from parked trains in urban areas must be mentioned as a topic of importance, as well as noise reduction for high-speed passenger trains. It is recommended that:

- the implementation of the new TSI noise and the Quieter Routes approach is further monitored and supported, as the EPA Network also recommended in its 2018 letters to the European Railway Agency and DG MOVE;
- other noise issues with regards to railway noise are identified and addressed. Further measures at the source must be examined, such as disc brakes, rail pads or sleepers. Especially given the expected growing demand, further noise reduction of railways is still required.

Aircraft noise has an impact on a relatively small number of people exposed to noise in Europe and as such it will not be the transport mode that can contribute most to the 30% ZPAP reduction goal. Nevertheless, it is a very prominent issue on a local scale near the airports. Also, aircraft noise has more impact on people than other noise sources at the same dB level, due to the event-based

nature of noise events and due to non-acoustic factors such as people's attitude towards flying in general. Aircraft noise also received much media attention, and how authorities handle the issue may very well impact how the public values their government's efforts to the issue of environmental noise in general. It is recommended that:

- the Commission's evaluation regarding the implementation of the Balanced Approach Regulation and the Environmental Noise Directive around EU airports, once finished, is closely considered and any actions resulting from it should be stimulated and followed;
- remaining discussions towards the WHO evidence with respect to aircraft noise annoyance are settled, with additional research efforts if needed;
- knowledge and good practices to manage noise exposure and annoyance around airports, such as from the ANIMA project, are disseminated and exchanged, among airports as well as among local and regional planning authorities responsible for house planning in these areas;
- the need for additional or updated EU or national regulations with regards to unmanned aerial vehicles (UAV) and supersonic flight is well identified and communicated with the Commission if necessary.

Lastly, there are a number of recommendations with regards to various other aspects of environmental noise:

- urban planning: Given the increased pressure for new housing, urban planners should take into account environmental noise in an early stage. If successful reduction of emissions leads to new housing being built even closer to the infrastructure, the noise exposure will not decrease. It is important to retain or expand buffer zones between infrastructure, airports or noisy industrial activities and residential areas.
- quiet areas and positive soundscapes: The importance of retaining certain areas with good, attractive and restorative soundscapes, preferably close to or inside cities, should be highlighted especially with local authorities and urban planners. The noise community should further highlight the value of such areas in terms of public health and economics.
- vibrations and low frequency noise: These subjects are closely related to environmental noise but generally receive much less attention. Especially for rail traffic, wind turbines and industry these are important sources of annoyance and health impacts that should not be neglected. As remediation measures are more difficult (e.g. noise barriers are much less effective), it is even more important to regard these aspects early, already in the planning and design phase.

In summary, the IGNA welcomes the ambitions of the European Commission set forward in the Zero Pollution Action Plan, as more ambition is needed indeed to decrease the harmful impact of environmental noise on European citizens. This will require action from policy makers, transport authorities and industries, noise researchers and experts, on all levels. As there are many other challenges in the world today, it will be a challenge to raise the issue of noise on the agenda. All IGNA members are keen to keep contributing to this task by continuing to exchange knowledge and opinions, sharing good practices and hopeful results.

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