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Towards A Comprehensive Noise Strategy

STUDY

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POLICY DEPARTMENT A: ECONOMIC AND SCIENTIFIC POLICY

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STUDY

Abstract

The study reviews the latest evidence on the health effects of environmental noise. It also provides an overview of the current EU regulatory framework on noise (Environmental Noise Directive and legislation on noise sources), assessing its effectiveness and identifying ways for future improvement. Recommendations are put forward for the development of a more comprehensive noise strategy.

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LIST OF ABBREVIATIONS

ACARE	Advisory Council for Aeronautics Research in Europe
AVAS	Acoustic Vehicle Alerting System
CBA	Cost Benefit Analysis
CEA	Cost Effectiveness Analysis
CICA	Convention on International Civil Aviation
CIRCA	Communication and Information Resource Centre Administrator
CNOSSOS	Common Noise Assessment Methods in Europe
DALY	Disability adjusted life year
dB	Decibel
DEFRA	Department for Environment, Food and Rural Affairs
DG	Directorate General
EC	European Commission
EEA	European Environment Agency
EIONET	European Environment Information and Observation NETwork
EMAS	European Eco-Management and Audit Scheme
END	Environmental Noise Directive (EU 2002/49)
ENDRM	Environmental Noise Directive Reporting Mechanism
ENNAH	European Network on Noise And Health
ENVI	Committee on Environment, Public Health and Food Safety of the European Parliament
EPA	Environment Protection Agency
EPNL	Effective Perceived Noise Level
EPoN	EEA Expert Panel on Noise
ERA	European Railway Agency
ETRS	European Terrestrial Reference System
EU	European Union
FEHRL	Forum of European National Highway Research Laboratories
FP	(Research) Framework Programme
GIS	Geographic Information System

GHG	Greenhouse gas
HYENA	Hypertension and Exposure to Noise near Airports
ICAO	International Civil Aviation Organisation
JRC	Joint Research Centre
L_A	A-weighted sound level indicator
L_{den}	Day-evening-night equivalent sound level
L_{night}	Night equivalent sound level
NAPST	National Action Plan Support Tool
NOISE	Noise Observation and Information Service for Europe
PINCHE	Policy Interpretation Network on Children's Health and Environment
RANCH	Road Traffic and Aircraft Noise and Children's Cognition and Health
ROD	Reporting Obligation Database
SEL	Sound Exposure Level
T&E	Transport and Environment
TSI	Technical Specification for Interoperability
UBA	Umweltbundesamt (Federal Environment Agency in Germany)
UNECE	United Nations Economic Commission for Europe
WG AEN	Working Group on Assessment of Exposure to Noise
WHO	World Health Organization

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EXECUTIVE SUMMARY

This report has been prepared at the request of the Committee on Environment, Public Health and Food Safety (ENVI) of the European Parliament. It aims to contribute to a better understanding of the health effects of environmental noise, to suggest improvements to the current EU regulatory framework, to analyse the feasibility and added value of further EU action and to provide recommendations for a comprehensive noise strategy.

Health impacts

Traffic-related noise is by far the most significant and widespread source of noise exposure, causing the most annoyance, sleep disturbance and public health concern. The assessment of the first round of noise maps submitted by Member States indicates that a large proportion of the European population living in big agglomerations is affected by environmental noise above the level considered as safe by the World Health Organization (WHO). In particular, road traffic noise is the most significant contributor, with more than half of the EU population regularly exposed to 55 decibels or more in urban areas. These data are worrying as a growing body of evidence shows that exposure to environmental noise is associated with a wide range of health effects. In particular, noise levels above certain thresholds may cause annoyance, sleep disturbance, cognitive impairment, cardiovascular disorders, ringing in the ears and even premature death. Health impacts might be particularly dangerous for children and other vulnerable groups.

On the basis of the burden of disease methodology, the WHO estimates that at least one million healthy life years are lost every year from traffic-related noise in western European countries, including 61,000 years lost for ischaemic heart disease, 45,000 for cognitive impairment of children, 903,000 for sleep disturbance, 22,000 for tinnitus and 654,000 for annoyance.

Current EU regulatory framework

Directive 2002/49/EC relating to assessment and management of environmental noise (the Environmental Noise Directive, hereinafter END) regulates exposure to noise. Under the END, Member States have to develop strategic noise maps and action plans with measures to address noise and its effects for major roads, railways, airports and large agglomerations. However, the END does not set any limit values or specific measures to be included in the action plans. In addition, there is no legal requirement to implement the plans.

A number of legislative acts regulate noise at the source, namely on road, aircraft and railway noise, as well as noise emitted by equipment for use outdoors, recreational craft and household appliances. Legislation on sources is complementary to the END as regulation of noise at the source obviously affects the result of exposure at the receiver end. However, at the moment, the two sets of legislation do not complement each other as effectively as they should in order to have a comprehensive approach to noise at EU level.

Effectiveness of the END

The END has introduced an ambitious data collection and reporting process. Despite some delays, Member States have now completed the first round of strategic noise maps and action plans. So far, the main challenges to implementation have been delays, non-enforcement of noise limit values, poor quality of strategic noise maps and action plans, inconsistent approaches in mapping and in the designation of quiet areas, as well as confusion amongst responsible bodies regarding the END requirements.

In terms of effectiveness, the END has led to little progress in reaching the objective of reducing the proportion of the EU's population suffering from noise pollution. However, some best practices from national and local level show that the END has increased awareness of the noise problem and inspired ideas and solutions to tackle the issue.

Improving EU legislation on sources of noise

The current EU legislation on sources of noise does not reflect the latest evidence on the health effects of noise. Hence, there is a need to introduce more stringent control policies. A number of legal texts are currently being revised, namely with the proposed Regulations on the sound level of motor vehicles and on noise-related operating restrictions at Union airports, as well as with the expected update of the Technical Specifications for Interoperability (TSI) standards for rail noise.

With regard to road traffic noise, the most effective control strategies involve noise control at source. This can only be achieved by stricter and more ambitious targets for reduction in permissible noise levels from motor vehicles. In particular, the test method for motor vehicles must reflect real-world driving conditions. If the new test method is instituted without a corresponding reduction in permissible noise levels, it will effectively allow manufacturers to produce louder vehicles. For aircraft noise, it may not be technically feasible (at the moment) to achieve significant noise reductions at source and alternative strategies for noise control must be adopted as part of a balanced mitigation approach around airports. Freight trains are the main source of railway noise, which is heavily affecting the EU population. Although railway noise has been overall reduced over the last few decades, there is wide scope and potential for enhanced noise reduction with the current revision of the TSI, which should take into account new developments in design and testing techniques. Finally, further research is needed to establish new noise limits for different outdoor machinery types, as well as to assess the impacts of recreational craft on parklands and conservation areas.

Feasibility and added value of further EU action on environmental noise

A review of the evidence shows that the most cost-effective noise control and regulation measures are those targeted at the noise source. However, an effective policy-mix between mitigation of noise at the source (e.g. through legislation on noise sources) and noise abatement strategies at the receiver (e.g. through mitigation measures such as noise barriers, noise insulation, low-noise road surfaces) is desirable.

In its 2011 implementation report, the Commission identified a number of areas for improvement of the END, namely on finalising the harmonised framework for mapping methods, developing EU implementation guidance, improving synergies between air quality and noise management, and facilitating reporting issues. On EU implementation guidance, good progress has been made, in particular on quiet areas and on the development of the common methodology for noise assessment (CNOSSOS-EU). Although further guidance on the development of the national action plans is also desirable, EU action to develop mandatory harmonised measures would encroach significantly on the principles of proportionality and subsidiarity and would therefore not be recommended. Regarding synergies between air quality and noise management, so far the comparison of data remains superficial, although further work in this area may serve to facilitate future interaction between the two policies. Finally, reporting has been successfully streamlined with the introduction of the electronic END Reporting Mechanism managed by the European Environment Agency.

The Commission's implementation report also identified issues for further consideration, i.e. the establishment of EU wide limit, target or trigger values, the possible revision of noise indicators, the enforcement of the provisions in the national action plans, as well as further harmonisation of definitions, information and measures. The setting of mandatory noise limit values at EU level would touch upon subsidiarity issues and be difficult to implement, whereas the introduction of health-based trigger values or recommended target values would be more feasible, politically acceptable and effective, especially if linked with stronger legislation to reduce noise at source. Enforcement of the provisions in the national action plans would eventually be possible only if noise targets are introduced. Regarding indicators, further research is needed to assess their appropriateness under the END.

1. IMPACT OF ENVIRONMENTAL NOISE ON HEALTH

KEY FINDINGS

- Traffic-related noise is by far the most widespread source of noise exposure, causing the most annoyance, sleep disturbance and public health concerns. It is estimated that more than half of the European population living in large agglomerations is exposed to daily road noise levels beyond what is considered as safe by the World Health Organization (WHO).
- The assessment of the first round of noise maps submitted by Member States suggests that around 56 million people across the EU are exposed to noise above 55 dB during daytime from road traffic within agglomerations, and 33 million are exposed to noise from major roads outside agglomerations.
- Environmental noise is associated with a wide range of health effects. A growing body of evidence is showing that noise levels above certain thresholds may cause annoyance, sleep disturbance, cognitive impairment, cardiovascular disorders, ringing in the ears (tinnitus), mental health problems and even premature death. Health impacts might be particularly dangerous for children and other vulnerable groups.
- The recent methodology developed by the WHO to assess the burden of disease due to environmental noise represents the state of the art in risk assessment and quantification of the health effects of noise exposure.
- The WHO estimates that at least one million healthy life years are lost every year from traffic-related noise in western European countries, including 61,000 years lost for ischaemic heart disease, 45,000 for cognitive impairment of children, 903,000 for sleep disturbance, 22,000 for tinnitus and 654,000 for annoyance. The WHO report also concludes that one in three individuals in Europe is annoyed during the daytime and one in five has disturbed sleep at night because of traffic noise.

Noise pollution is a major environmental and public health burden, ranked second only to air pollution according to the World Health Organization (WHO)[1], and is increasingly concerning and affecting people. A Eurobarometer survey published in 2010 showed that 44% of Europeans believe that noise affects human health to a "large extent"[2]. In addition, country reviews demonstrate that the number of complaints from citizens regarding exposure to noise is increasing in many European countries[3].

Noise pollution also generates substantial economic costs, including a devaluation in house prices, productivity losses from health-related impacts and distributional impacts[4]. The social costs of rail and road noise across the EU was recently estimated at 40 billion EUR a year including health care costs[5], i.e. about 0.4% of the total EU GDP.

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1 World Health Organization (WHO), Burden of disease from environmental noise. Quantification of healthy life years lost in Europe, 2011. Available at: http://www.euro.who.int/en/what-we-publish/abstracts/burden-of-disease-from-environmental-noise.-quantification-of-healthy-life-years-lost-in-europe.

2 Special Eurobarometer 347 on Electromagnetic Fields, June 2010 : http://ec.europa.eu/public_opinion/archives/ebs/ebs_347_en.pdf.

3 World Health Organization (WHO), Guidelines for Community Noise, 1999. Available at: http://www.eea.europa.eu/publications/good-practice-guide-on-noise.

4 Report from the Commission to the European Parliament and the Council on the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC. COM(2011) 321 final.

5 CE Delft, Traffic Noise Reduction in Europe, 2007. Available at: http://www.transportenvironment.org/sites/default/files//docs/Publications/2008/2008-02_traffic_noise_ce_delft_report.pdf.

The Commission's 2011 White Paper on Transport estimates that, unless further action is taken, the noise-related external costs of transport would continue to increase[6].

This chapter provides an overview of the main sources of noise to which the population is exposed, reviews the evidence regarding the effects of noise on human health and identifies current methodologies for assessing the health risks of environmental noise.

1.1. Different sources of noise

Noise can be characterised as "unwanted sound" or "sound that is loud, unpleasant or unexpected"[7] and that can eventually cause disturbance, impairment or damage to health[8]. The WHO specifies that community noise (also called environmental noise, residential noise or domestic noise) is noise emitted from all sources except noise at the industrial workplace.

People are therefore exposed to different sources of environmental noise, including:

- Transport (road traffic, rail traffic, air traffic);
- Construction and industry;
- Community sources (neighbours, radio, TV, bars, restaurants);
- Social and leisure sources (portable music players, fireworks, etc.);
- Indoor noise sources (ventilation systems, office machines, home appliances and neighbours) [9].

As such, noise is associated with many human activities, but it is road, rail and air traffic noise that brings about the highest impact.

1.1.1. Transport-related sources of noise

Noise from transport is by far the most widespread source of noise exposure, causing the most annoyance, sleep disturbance and public health concerns[10]. **Road traffic noise** is the most significant contributor to environmental noise, with the CE Delft report estimating that approximately 210 million EU citizens are regularly exposed to 55 decibels (dB) or more of road noise[11]. The European Environment Agency's 2008 TERM report further estimated that 55% of people living in urban areas with more than 250,000 inhabitants in the EU-27 endure daily road noise levels above the lower EU benchmark (55 dB L_{den}) for excess exposure[12]. The major contributors to road traffic noise are passenger cars and lorries, with minor contributions from buses and motorcycles[13]. Road traffic noise is determined by engine noise and rolling noise and increases with the vehicle speed and depending on the road surface[14].

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6 White Paper Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system, COM(2011) 144 final. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:EN:PDF.

7 Future Noise Policy - European Commission Green Paper (COM(96) 540) : http://ec.europa.eu/environment/noise/pdf/com_96_540.pdf.

8 European Environment Agency (EEA) Technical Report No 11/2010, Good practice guide on noise exposure and potential health effects, 2010. Available at: http://www.eea.europa.eu/publications/good-practice-guide-on-noise

9 WHO (1999).

10 CALM II Network, Research for a quieter Europe in 2020. An updated strategy paper of the CALM II Network. European Commission, Research Directorate General, 2007.

11 CE Delft (2007).

12 European Environment Agency (EEA) Report No 3/2009, Transport at the Crossroads (TERM 2008), 2009. Available at: http://www.eea.europa.eu/publications/transport-at-a-crossroads.

13 Transport and Environment, Can you hear us? Why it is finally time for the EU to tackle the problem of noise from road and rail traffic, T&E 08/1, 2008, Brussels. Available at: http://www.transportenvironment.org/publications/can-you-hear-us-why-it-finally-time-eu-tackle-problem-traffic-noise.

14 Workshop Proceedings "Sound Level of Motor Vehicles", European Parliament, Brussels 11 April 2012 : http://www.europarl.europa.eu/document/activities/cont/201205/20120524ATT45762/20120524ATT45762EN.pdf.

Railway noise is the second most dominant source of environmental noise in Europe, with approximately 9 million people exposed to levels beyond 50 dB at night[15]. Railway noise depends on engine noise, rolling noise and aerodynamic noise. A recent study carried out on behalf of the European Parliament Transport and Tourism Committee[16] identifies rolling noise as the main noise source affecting all kinds of train. In 2003, European experts ranked rail freight noise as the key contributor to railway noise problems, especially during the night, followed by high speed railways and inner-urban railways[17]. In several European countries, the discussion about railway noise has become crucial as railway transport plays a more and more important role in greening transportation as mentioned in the Commission 2011 White Paper on Transport[18]. The White Paper indicates that the environmental impact of railway operations needs to be minimised in order to maintain rail's position as a green transport mode.

In Europe, **aircraft noise** affects a much smaller proportion of the population compared to road and traffic noise. However, aircraft noise is regarded as being more annoying than both road traffic and railway noise[19]. Aircraft noise is mainly produced by the aircraft or its components during various phases of a flight, particularly as a result of airframe noise and jet engine noise. Thanks to technological developments, individual aircraft have become 75% less noisy over the last 30 years. However, the growing volume of air traffic means that many EU citizens are still exposed to high levels of noise, particularly during the night. The results from noise surveys[20] show that in the majority of Member States about 15% of the population is affected by aircraft noise, particularly in the immediate vicinity of airports. However, in order to ensure the sustainability of aviation, measures addressing noise impacts should target not only particular airports but also the aviation system as a whole. This is further explained in Chapter 4.

1.1.2. Noise indicators and thresholds

To set the context, it is important to introduce at this point the concepts of "indicators" that are used to measure noise and "thresholds" above which noise exposure may become a problem.

Directive 2002/49/EC on the assessment and management of environmental noise (commonly known as the Environmental Noise Directive and abbreviated as END)[21] establishes two main indicators to measure noise exposure: L_{den}[22] to assess annoyance and L_{night} to assess sleep disturbance[23]. As further explained in Chapter 2 of this study, Member States have to use these common indicators to develop strategic noise maps.

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[15] Report from the Commission to the European Parliament and the Council on the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC, 1st June 2011.

[16] European Parliament study, Reducing Railway Noise Pollution, March 2012. Available at: http://www.europarl.europa.eu/committees/de/studiesdownload.html?languageDocument=EN&file=72911.

[17] EEA (2009).

[18] COM(2011) 144 final.

[19] ISO 1996-1 (2003) Acoustics – Description, Measurement and Assessment of Environmental Noise – Part 1: Basic Quantities and Assessment Procedure.

[20] Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the regions, Air Transport and the Environment, Towards meeting the Challenges of Sustainable Development, COM (1999) 640 final. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:1999:0640:FIN:EN:PDF.

[21] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise - Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise, OJ L 189, 18.7.2002, p. 12–25. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0049:EN:HTML.

[22] L_{den} is the annual long-term average noise level over 24 hours, combining the L_{day}, $L_{evening}$ and L_{night} levels.

[23] The indicators L_{den} and L_{night} should be calculated (or measured) 4 m above the ground on the most exposed façade of a dwelling, and should represent incident sound only (see Annex I of the Directive for more details on the calculation of L_{den} and L_{night}).

In the Directive, Member States are required to report the noise exposure of the population for L_{den} above 55 dB and L_{night} above 50 dB. According to the WHO Guidelines for Community Noise, the threshold of 55 dB during daytime should not be exceeded to prevent the majority of people from being seriously annoyed[24]. According to the WHO Night Noise Guidelines for Europe, 40 dB should be the target for the night noise guideline to protect the public, including the most vulnerable groups such as children, the chronically ill and the elderly[25]. These thresholds are essential to interpreting the population exposure to environmental noise, as further explained in the following section.

1.1.3. Population exposure to environmental noise

Noise maps provided for major agglomerations (equal or more than 250,000 inhabitants) under the END's 2007 reporting round have generated estimates of the number of EU citizens within each Member State that are exposed to noise levels above 55 dB L_{den} and 50 dB L_{night}[26]. Although there are acknowledged problems with a lack of consistency in mapping methods (as discussed in Chapter 3), the data collected through the first strategic mapping exercise and made available in the Noise Observation and Information Service for Europe database[27], provide an initial indication of current levels of exposure to environmental noise in the EU.

Table 1: Summary of total number of people exposed to environmental noise based on data submitted by the Member States up to 30 June 2011

Scope	Number of people exposed to noise above L_{den}[28] > 55 dB [million]	Number of people exposed to noise above L_{night} > 50 dB [million]
Within agglomerations		
All roads	56	40.2
All railways	7.8	6.2
All airports	3.4	1.9
Industrial sites	0.8	0.5
Major infrastructures, outside agglomerations		
Major roads	33.4	22.7

[24] WHO (1999).
[25] World Health Organization (WHO), Night Noise Guidelines for Europe, 2009. Available at: http://www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf.
[26] Strategic noise maps pursuant to annex VI were provided in the first round for: agglomerations ≥ 250,000 inhab., major civil airports ≥ 50,000 movts/y , major roads ≥ 6 millions veh/y , major railways ≥ 60,000 trains/y.
[27] Noise Observation and Information Service for Europe database – N.O.I.S.E.: http://noise.eionet.europa.eu/.
[28] L_{den} – day-evening-night noise indicator.

Major railways	5.8	4.8
Major airports	1.3	0,4

Source: Noise Observation and Information Service for Europe.

The assessment of the first round of noise mapping (according to the data submitted by Member States up to June 2011) suggests that around 56 million people across the EU are exposed to noise above 55 dB during daytime from road traffic within agglomeration, and 33 million are exposed to noise from major roads outside agglomerations. Also, 40 million people across the EU are exposed to noise above 50 dB from roads within agglomerations during the night. The data, summarised in Table 1, clearly show that road transport is by far the largest source of noise exposure, and these figures are expected to be revised upwards as more noise maps are received and/or assessed[29]. Also, further increase in noise emissions and therefore exposure is also likely as road traffic volumes are expected to intensify in the future.

1.2. Risk for health related to noise exposure

Environmental noise is associated with a wide range of health effects. A growing body of evidence, including from research projects funded by the EU, is showing that noise levels above certain thresholds may cause annoyance, sleep disturbance, elevated hormone levels, physiological stress reactions, cardiovascular disorders, mental health problems and even premature death. As explained in this section, health impacts might be particularly dangerous for children and lead to cognitive impairment, as well as overall diminished quality of life. In particular, adverse noise effects occur when intended activities such as concentration, communication, relaxation and sleep are disturbed[30]. The health effects of exposure to noise are comprehensively reviewed in the EEA's 2010 publication entitled "Good practice guide on noise"[31]. An extensive review of the evidence on the health impacts of noise exposure was also carried out in the framework of the European Network on Noise and Health (ENNAH) project, funded under the FP7 programme[32].

The WHO considers noise not only as an environmental nuisance but also as a threat to public health. In its 2011 report on the "Burden of disease from environmental noise", the WHO concludes that one in three individuals in Europe is annoyed during the daytime and one in five has disturbed sleep at night because of traffic noise. The trend is that noise exposure is increasing in Europe compared to exposure to other stressors (e.g. second-hand smoke, dioxins and benzene), which are in decline[33].

[29] Report from the European Commission to the European Parliament and the Council On the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC(COM/2011/0321 final). Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0321:FIN:EN:PDF.

[30] Ancona C, Mataloni F, Forastiere F, Perez L and Kuenzli N (2011) "Workshop Report on Workshop 5: Measurements of health outcomes in epidemiological studies on noise (WP5a) and European Health Impact Assessment (WP5b)" *Project number: 226442* ENNAH European Network on Noise and Health. Available at: http://www.ennah.eu/work-package-reports?lang=en.

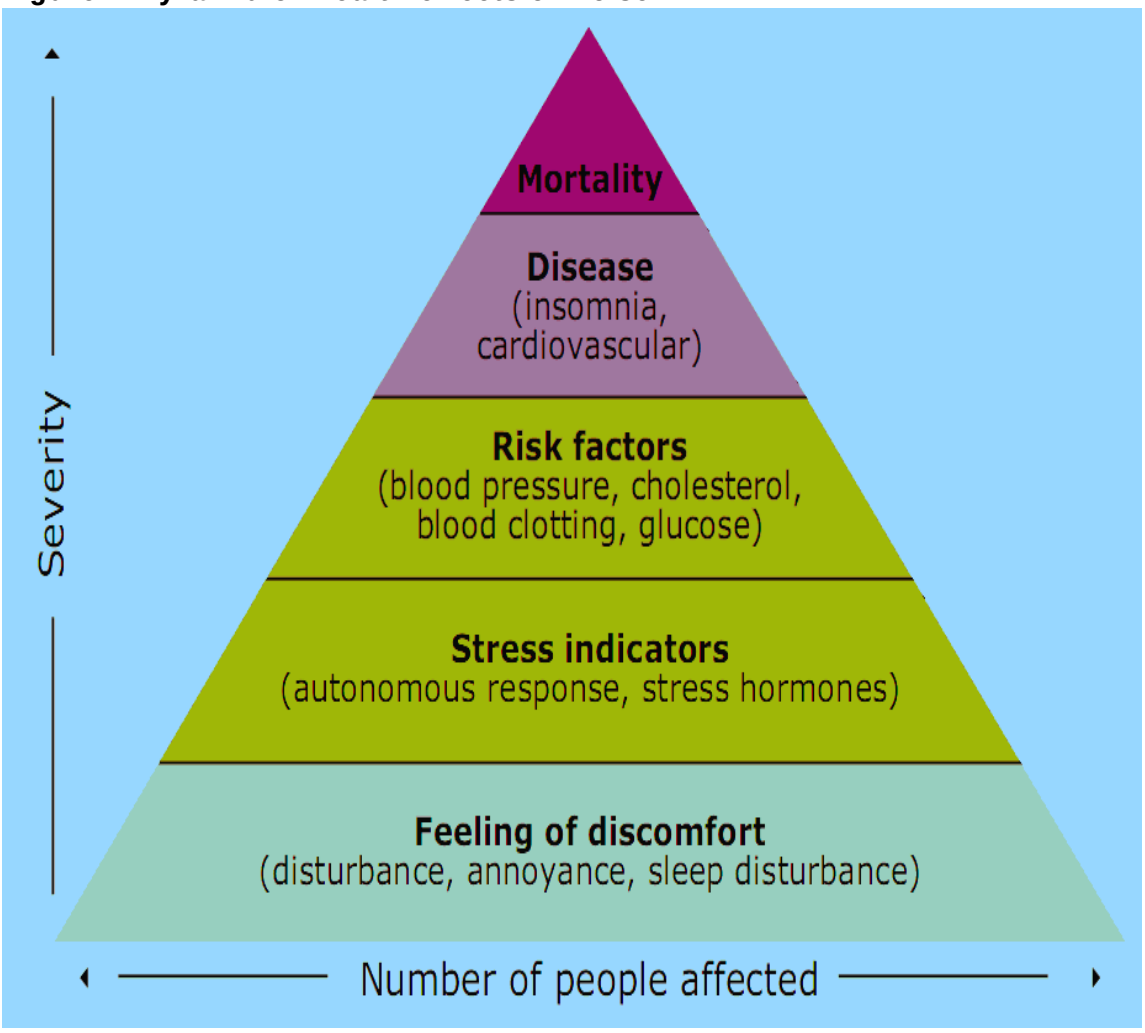
[31] EEA (2010).

[32] See ENNAH project: www.ennah.eu.

[33] WHO (2011).

The WHO Pyramid of Health effects of Noise presented in Figure 1 on the next page illustrates the severity of health effects due to noise together with the number of people affected. A large proportion of people exposed to substantial noise are likely to develop feelings of discomfort. Some of the exposed population may also experience more serious adverse effects such as stress reactions, sleep-stage changes and other biological and biophysical effects. These effects may in turn increase the role of additional risk factors, such as blood pressure. For a relatively small part of the population this may cause other clinical symptoms like insomnia and cardiovascular diseases which, as a consequence, can even increase the mortality rate[34].

Figure 1: Pyramid of Health effects of Noise



Source: Babisch, 2002[35]

As explained above under section 1.1.2, the WHO Guidelines for Community Noise[36] present noise levels for day time above which negative effects on health are to be expected. In addition, the WHO Night Noise Guidelines for Europe[37], which focus on the health effects of nocturnal noise, indicate threshold levels for each effect (as summarised in Table 2 on the next page) and propose a guideline value for night-time levels.

[34] EEA (2010).
[35] Babisch, W., 2002. The noise/stress concept, risk assessment and research needs. Noise Health, 4(16), 1–11.
[36] WHO (1999).
[37] WHO (2009).

When we compare the thresholds to the data presented in Table 1, we can see that considerable numbers of EU citizens are currently exposed to noise levels significantly above the threshold at which effects occur[38].

Table 2: Summary of effects and threshold levels for effects of nocturnal noise where there is *sufficient* evidence available (taken from WHO Night Noise Guidelines for Europe, 2009)

Effect		Indicator	Threshold, dB
Biological effects	Change in cardiovascular activity	[1]	[1]
	EEG awakening	$L_{Amax, inside}$	35
	Motility, onset of motility	$L_{Amax, inside}$	32
	Changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep	$L_{Amax, inside}$	35
Sleep quality	Waking up in the night and/or too early in the morning	$L_{Amax, inside}$	42
	Prolongation of the sleep inception period, difficulty in getting to sleep	[1]	[1]
	Sleep fragmentation, reduced sleeping time	[1]	[1]
	Increased average motility when sleeping	$L_{night, outside}$	42
Well-being	Self-reported sleep disturbance	$L_{night, outside}$	42
	Use of somnifacient drugs and sedatives	$L_{night, outside}$	40
Medical conditions	Environmental insomnia[2]	$L_{night, outside}$	42

Source: WHO (2009). Night Noise Guidelines for Europe

Notes:

1. Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined
2. Environmental insomnia is the result of diagnosis by a medical professional whilst self-reported sleep disturbance is essentially the same, but reported in the context of a social survey

The main health impacts of environmental exposure are discussed below. This section is largely based on a literature review conducted by Milieu for a study on the implementation of the END[39] and on the endpoints identified in the 2011 WHO report on the burden of disease[40], i.e. annoyance, sleep disturbance, cognitive performance and development of children, cardiovascular risk, and tinnitus. In addition, we draw in the conclusions from a number of research projects on noise conducted over recent years. Some considerations on combined effects and vulnerable groups are made in section 1.2.6.

1.2.1. Annoyance

Annoyance is the most widely acknowledged effect of exposure to environmental noise, and is considered to be the most widespread[41]. Since WHO defines health as a state of complete physical, mental and social well-being (and not merely the absence of disease or infirmity), annoyance is considered as an environmental health burden.

[38] Milieu Ltd, Review of the Implementation of Directive 2002/49/EC on Environmental Noise – DG Environment, Service contract No 070307/2008/510980/SER/C3, 2010. Available online at : http://ec.europa.eu/environment/noise/milieu.htm.
[39] Milieu (2010).
[40] WHO (2011).
[41] NOPHER. 2003. Noise pollution health effects reduction. Final Report: 2002-2003.

In a report assessing the effects of traffic noise reduction in Europe[42], it was estimated that around 57 million people (12% of the population) in 25 EU countries (not including Cyprus and Malta) are annoyed by road traffic noise, approximately 24 million (42%) of whom are severely annoyed. Also, rail traffic noise was estimated to cause annoyance in about 5.5 million people (1% of the European population), of whom about 2 million are severely annoyed.
It is estimated that a maximum of 33% of individual noise annoyance is accounted for by acoustic parameters. Non-acoustic factors (such as age, economic dependence on the noise source, fear of the noise source[43] and self-reported noise sensitivity[44,45]) have been found to play a major role as well. On the basis of a large number of studies into noise annoyance arising from community transportation, separate exposure-response relationships were derived for high annoyance by aircraft, road and rail traffic noise[46].

Annoyance studies have typically focussed on annoyance in adults, while studies investigating annoyance in children are rare. The EU-funded RANCH project (Road Traffic and Aircraft Noise and Children's Cognition and Health)[47] is a notable exception and focused on the effects of road traffic and aircraft noise on children's cognition and health, studying children's annoyance due to transportation noise around three major European airports. Results confirm that children are annoyed by long-term exposure to both road traffic and aircraft noise, and that the emotional response of children is consistent with the response of adults[48,49].

1.2.2. Sleep disturbance

Sleep disturbance is a major effect of environmental noise[50]. It may cause primary effects during sleep (e.g. difficulty in falling asleep, frequent awakenings, increased blood pressure and heart rate, changes in respiration and cardiac arrhythmia), as well as secondary effects that can be assessed the day after night-time noise exposure. Plenty of evidence indicates that sleep is a biological necessity and uninterrupted sleep is a prerequisite for good physiological and mental functioning. Disturbed sleep is associated with a number of health problems, and studies of sleep disturbance in children and in shift workers clearly show the adverse effects. Also, evidence indicates that disturbed sleep might have long-term impacts on mental and cardiovascular health[51].

The effects of sleep disturbance are particularly relevant for vulnerable groups. Although children have higher awakening thresholds than adults, they seem to be equally or more reactive than adults to other effects and are therefore considered a risk group.

[42] CE Delft (2007).
[43] Miedema HME, Vos H. (1999). Demographic and attitudinal factors that modify annoyance from transportation noise. J Acoust Soc Am 105: 3336-3344.
[44] Miedema HME, Vos H. (2003). Noise sensitivity and reactions to noise and other environmental conditions. J Acoust Soc Am 113: 1492-1504.
[45] Kamp I van, Job RF, Hatfield J, Haines MM, Stellato RK, Stansfeld SA. (2004). The role of noise sensitivity in the noise-response relation: a comparison of three international airport studies. J Acoust Soc Am 116: 3471-3479.
[46] Miedema HME, Oudshoorn CGM. (2001). Annoyance from transportation noise: relationships with exposure metrics DNL and DENL and their confidence intervals. Env Health Persp 109: 409-416.
[47] RANCH project : Road Traffic & Aircraft Noise & Children's Cognition & Health.
Available at: http://www.wolfson.qmul.ac.uk/RANCH_Project/.
[48] Stansfeld SA, Berglund B, Clark C, Lopez-Barrio I, Fischer P, Ohrstrom E. (2005). Aircraft and road traffic noise and children's cognition and health: a cross-national study. The Lancet 365: 1942-1949.
[49] Kempen EEMM van, Kamp I van, Stellato RK, Lopez-Barrio I, Haines MM, Nilsson MEl. (2009). Children's annoyance reactions to aircraft and road traffic noise. J Acoust Soc Am 125: 895-904.
[50] WHO (2009).
[51] Ibid.

Also, since with age the sleep structure becomes more fragmented, elderly people are more vulnerable to disturbance. Pregnant women, people with disabilities and shift workers are other groups at higher risk from noise exposure during the night[52].

1.2.3. Cognitive performance and development of children

Considering the potential long-term consequences of impaired cognitive development during childhood, much of the research effort into the effects of noise exposure on cognitive performance has focussed on children[53]. Indeed, exposure to (traffic) noise has been shown to be detrimental to task performance and attention in children[54]. Findings of the above-mentioned RANCH study are important as they represent some of the most recent, multinational findings concerning the influence of traffic noise exposure on children's cognitive performance. The project examined exposure-effect relationships between chronic aircraft noise exposure, chronic road traffic noise exposure and combinations of aircraft noise and road traffic noise exposure at school and cognitive and health outcomes in three European countries: the Netherlands, Spain and the United Kingdom. The project concluded that high levels of chronic aircraft noise exposure impair children's reading comprehension and recognition memory and confirmed previous findings that children experience annoyance following exposure to aircraft and road traffic noise[55]. Another EU-funded project, PINCHE (Policy Interpretation Network on Children's Health and Environment), concluded that very few noise episodes affect children's hearing instantaneously and most effects are long-term and cumulative[56]. In adults too, exposure to traffic noise is known to influence cognitive functioning (information processing, comprehension, and learning)[57].

The 1999 WHO Community Guidelines highlight that children chronically exposed to aircraft noise in schools around airports under-perform in proof reading, in persistence on challenging puzzles, in tests of reading acquisition and in motivational capabilities. Also, the WHO indicates that classroom noise levels above 35 dB on average can affect the children's understanding capacity[58].

Policy-makers are aware of the special vulnerability of children to noise. In 2010, during the WHO Ministerial conference on Environment and Health, all EU Environment and Health Ministers signed the "Parma Declaration"[59], including a commitment to reduce children's exposure to noise and to support the WHO in the development of further guidelines.

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[52] Ibid.
[53] Milieu (2010).
[54] Evans GW. 2006. Child development and the physical environment. Annu Rev Psychol 57: 423-451.
[55] Clark. C., Martin, R., van Kempen. E., Alfred. T., Head. J., Davies. H.W., Haines. M.M., Lopez Barrio. I., Matheson. M. and Stansfeld. S.A. (2006). Exposure-effect relations between aircraft and road traffic noise exposure at school and reading comprehension: the RANCH project. *American Journal of Epidemiology*, *163* (1), 27-37.
[56] Bistrup ML, Babisch W, Stansfeld S, Sulkowski W. PINCHE's policy recommendations on noise: how to prevent noise from adversely affecting children. Acta Paediatr Suppl. 2006 Oct;95(453):31-5.
[57] Stansfeld SA, Matheson MP. (2003). Noise pollution: non-auditory effects on health. Br Med Bull 68: 243-257.
[58] WHO (1999).
[59] Parma Declaration on Environment and Health, EUR/55934/5.1, 11 March 2010. Available at : http://www.euro.who.int/__data/assets/pdf_file/0011/78608/E93618.pdf.

1.2.4. Cardiovascular risk

Environmental noise exposure may also lead to increases in cardiovascular risk in combination with other factors[60]. In recent years, a growing body of evidence from epidemiological studies has indicated an association between exposure to road traffic and aircraft noise and hypertension and ischaemic heart disease, including myocardial infarction[61, 62, 63].

According to the WHO Night Noise Guidelines, noise-disturbed sleep must also be considered as a particular pathway for the development of cardiovascular disorders[64].

Several recent findings have contributed to the evidence. Results suggest the existence of an association in adults between road traffic or aircraft noise exposure and hypertension[65,66], although a direct causal link is yet to be fully established. A study carried out as part of the EU-funded project HYENA (Hypertension and Exposure to Noise near Airports) shows that night time noises, such as aircraft roaring overhead or road traffic, can cause a person's blood pressure to raise, even without waking them up[67]. Another study under HYENA concluded that people who have been living for at least five years under a flight path or near an international airport have a greater risk of developing high blood pressure than a population living in quieter areas[68].

A recent study from Denmark on the linkages between exposure to long-term residential road traffic noise and heart attacks shows that the risk of a heart attack increases by 12% for every 10 dB higher exposure to noise[69]. Also, a Swedish study published in 2012 suggests an increased risk of cardiovascular disease among subjects exposed to railway noise equal or above 50 dB[70].

1.2.5. Tinnitus (ringing in the ears)

Tinnitus is defined as the sensation of sound in the absence of an external sound source. In some people, tinnitus can cause sleep disturbance, cognitive effects, anxiety, psychological distress, depression communication problems, frustration, irritability, tension, inability to work, reduced efficiency and restricted participation in social life[71].

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[60] WHO (2011).
[61] Babisch W, Beule B, Schust M, Kersten N, Ising H. (2005). Traffic noise and risk of myocardial infarction. Epidemiology 16: 33-40.
[62] Willich SN, Wegscheider K, Stallman M, Keil T.(2005). Noise burden and the risk of myocardial infarction. Eur Heart J 27: 276-282.
[63] Selander J, Nilsson Mats E, Bluhm G, Rosenlund M, Lindqvist M, Nise G, Pershagen G. (2009). Long-term exposure to road traffic noise and myocardial infarction. Epidemiology 20: 272-279.
[64] WHO (2009).
[65] Kempen EEMM van, Houthuijs DJM. (2008). Omvang van de effecten op gezondheid en welbevinden in de Nederlandse bevolking door geluid van weg-en railverkeer. 630180001/2008. Bilthoven:RIVM.
[66] Babisch W, Kamp I van. (2009). Exposure-response relationship of the association between aircraft noise and risk of hypertension. Noise Health 11: 161-168.
[67] Haralabidis AS, Dimakopoulou K, Vigna-Taglianti F, Giampaolo M, Borgini A, Dudley ML, Pershagen G, Bluhm G, Houthuijs D, Babisch W, Velonakis M, Katsouyanni K, Jarup L; for the HYENA Consortium. Acute effects of night-time noise exposure on blood pressure in populations living near airports. Eur Heart J. 2008 Feb 12.
[68] Jarup L, Babisch W, Houthuijs D, Pershagen G, Katsouyanni K, Cadum E, Dudley M-L, Savigny P, Seiffert I, Swart W, Breugelmans O, Bluhm G, Selander J, Haralabidis A, Dimakopoulou K, Sourtzi P, Velonakis M, VignaTaglianti F, on behalf of the HYENA study team. Hypertension and Exposure to Noise near Airports - the HYENA study. Environ Health Perspect 2008; 116:329-33.
[69] Sørensen M, Andersen ZJ, Nordsborg RB, Jensen SS, Lillelund KG, et al. (2012) Road Traffic Noise and Incident Myocardial Infarction: A Prospective Cohort Study. PLoS ONE 7(6): e39283. doi:10.1371/journal.pone.0039283.
[70] Eriksson C, Nilsson ME, Willers SM, Gidhagen L, Bellander T, Pershagen G. Traffic noise and cardiovascular health in Sweden: The roadside study. Noise Health. 2012 Jul-Aug;14(59):140-7.
[71] WHO (2011).

Excessive exposure to noise is generally what causes tinnitus. Between 50% and 70% of patients with chronic noise trauma[72] and between 12% and 50% of persons with noise-induced hearing loss[73] report having tinnitus. However, tinnitus may also be experienced by persons exposed to excessive noise who do not have measurable hearing loss[74].

1.2.6. Combination effects and vulnerable subgroups

Combination effects of noise from different sources should be considered over 24 hours, as noise may interfere with speech in the day and create sleep disturbance at night, especially in residential areas which are heavily polluted with noise. Hence, the precautionary principle should be applied[75] until combination effects have been fully explored.

In addition, when recommending noise protection or noise regulations, the special vulnerability of certain subgroups of the general population, such as children, the elderly and people with particular diseases, should be taken into account. Researchers and the medical community are increasingly concerned that people with low socio-economic status are at greater risk of health impacts of noise pollution. A recent report by the British Medical Association[76] notes that, as with air pollution, socially disadvantaged people are more likely to live near busy roads, and are at greater risk of the negative effects of noise pollution. The above-mentioned Danish study highlights that participants living at residences with a road noise level of over 60 dB had also a lower education.

1.3. Methodologies for estimations of the burden of disease from environmental noise

Quantitative assessment of the health effects of environmental noise is important to guide EU environmental noise policy towards the prevention of harmful effects and the prioritisation between policy options. Several guidelines exist in this respect as well as several frameworks to carry out risk assessment, i.e. assessment of the risks of adverse effects on human health and the environment from chemicals, physical factors and other environmental stressors[77]. However, the assessments performed so far to evaluate the impact of environmental noise have been based mostly on the annoyance it causes. The 2011 WHO report "Burden of disease from environmental noise – Quantification of healthy life years lost in Europe" provides a reference methodology for the overall assessment of the impacts of environmental noise on the main health endpoints, not only annoyance.

The report, developed in collaboration with the European Commission Joint Research Centre (JRC), aims at providing a summary of the scientific evidence on the health effects of environmental noise, as well as an estimation of the Environmental Burden of Disease (EBD). The publication provides not only a quantification of the impact of noise on public health but also a thorough methodology and guidance for future risk assessment.

[72] Spoendlin H. Inner ear pathology and tinnitus. In : Feldman H, ed. Proocedings of the Third International Tinnitus Seminar. Munster, Harsch Verlag Karlsrehe, 1987 :42-51.
[73] Sindhusake D et al. Factors predicting severity of tinnitus : a population-based assessment. Journal of the American Academy of Audiology, 2004, 15 :269-280.
[74] Jones JR et al. (1998). Self-reported work-related illness in 1995. Results from a household survey. Norwich, The Stationery Office.
[75] EEA (2010).
[76] British Medical Association (BMA), Healthy transport = Healthy lives, July 2012. Available at: http://bma.org.uk/transport.
[77] WHO (2011).

On the basis of the available evidence and data, the working group of experts convened by the WHO European Centre for Environment and Health, Bonn Office and supported by the JRC identified the following health outcomes[78] (*hazard identification*) in order to calculate the EBD:

- Cardiovascular disorders;
- Cognitive impairment of children;
- Sleep disturbance;
- Tinnitus;
- Annoyance.

The EBD methodology consists of calculating the burden of disease on the basis of the exposure-response relationship, exposure distribution, population-attributable fraction, background prevalence of disease and disability weights of the outcome.

As discussed in the first part of this chapter, the population is exposed to different sources of noise, some of which are difficult to assess whereas for others (for example air traffic and road traffic) considerable work has already been done. Exposure can be assessed using the noise exposure mapping required by the END Directive. For example, the WHO report uses exposure data collected in the Noise Observation and Information Services for Europe (N.O.I.S.E.) to estimate ischaemic heart disease burden from road traffic noise in EU Member States.

The exposure-response relationship is obtained from existing epidemiological studies or meta-analysis of published results. The incidence or prevalence of the health outcome in a population (e.g. for cardiovascular diseases) can be obtained by the national health statistics or surveys of the population. The "attributable fraction" is the proportion of disease in the population that is estimated to be caused by the noise. Disability weight factors are then used to reflect the severity of the disease on a scale from 0 (perfect health) to 1 (equivalent to death)[79]. The burden of disease is expressed in terms of disability-adjusted life years (DALYs), which is the sum of potential years of life lost due to ill-health, disability or early death and the equivalent years of "healthy" life lost by virtue of being in states of poor health or disability.

DALYs = YLD + YLL

Years **L**ived with **D**isability + **Y**ears of **L**ife **L**ost

One DALY is equivalent to one year of healthy life lost.

Using this calculation method, the WHO draws the conclusion that every year in the EU urban areas, the DALYs lost by disease attributable to noise exposure in the EU Member States and other western European countries are at least:

- 61,000 years for ischaemic heart disease;
- 45,000 years for cognitive impairment of children;
- 903,000 years for sleep disturbance;
- 22,000 years for tinnitus;
- 654,000 years for annoyance.

[78] Hearing impairment was not included because the epidemiological studies linking this health end-point with exposure to environmental noise were considered too sparse and inconclusive.

[79] For the list of disability weights, see: http://www.who.int/healthinfo/global_burden_disease/GBD2004_DisabilityWeights.pdf

It is therefore estimated that 1~1.6 million healthy life years are lost every year from traffic-related noise in the western European countries including the EU Member States. According to the report, sleep disturbance and annoyance, mostly due to road traffic noise, represent the main burdens of environmental noise.

The main advantage of the EBD methodology is that it introduces a well-established, common approach in comparative risk assessment. The drawback is that these methods require detailed data on noise exposure, the outcome and exposure-response relationship, which are not always easy to gather or extrapolate.

2. OVERVIEW OF THE CURRENT EU LEGISLATIVE FRAMEWORK

KEY FINDINGS

- The main legislation on environmental noise in the EU is Directive 2002/49/EC relating to assessment and management of environmental noise (the Environmental Noise Directive, hereinafter END), which regulates noise at the side of exposure. Under the END, Member States have to develop strategic noise maps and action plans containing measures addressing noise issues and their effects for major roads, railways, airports and big agglomerations. However, the END does not impose any limit values or specific measures to be included in the action plans.
- A number of legal texts exist to regulate noise at the source, namely on road, aircraft and railway noise, as well as noise emitted by equipment for use outdoors, recreational craft and household appliances. Although these legal texts have the main purpose of harmonising the internal market, permissible noise levels are also included.
- Legislation on sources is complementary to the END in that regulation of noise at the source obviously affects the result of exposure at the receiver end. However, in legislative terms, the two sets of legislation do not complement each other as they should for a more comprehensive and effective approach to noise.

The Green Paper on Noise Policy[1], adopted by the European Commission in 1996, represented the first comprehensive step towards the development of an EU-wide noise policy. It examined the environmental impacts of noise and the noise situation in the EU and analysed existing policies to reduce noise exposure, focusing on three main approaches: reducing noise at source, limiting the transmission of noise by placing barriers between the source and people affected and reducing noise at the reception point such as through noise insulation of buildings. Based on the analysis of the noise situation and the implementation of current policies, the Commission proposed a new framework for EU noise policy. It indicated shared responsibility as the key to an effective noise policy and reaffirmed that the management and reduction of noise from different sources should be the main area of Community involvement in the field.

In 2002, the European Union introduced legislation related to noise reception (as opposed to noise sources) for the first time. Directive 2002/49/EC[2] relating to the assessment and management of environmental noise (the Environmental Noise Directive, hereinafter END) is considered as the main EU legal instrument on noise bringing together Member States' efforts in addressing this issue. A number of other legal acts cover the different sources of noise in a rather scattered way, across different policy areas and under the responsibility of different Commission Directorate-Generals. The table in Annex I of this study provides an overview of the current legislative framework on environmental noise in the EU, organised by source of noise pollution.

[1] Green Paper on Future Noise Policy (COM(96) 540).

[2] Directive 2002/49/EC of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise - Declaration by the Commission in the Conciliation Committee on the Directive relating to the assessment and management of environmental noise (OJ L 189, 18.7.2002, p. 12–25).

The following sections provide a summary of the Environmental Noise Directive and of legislation related to the different sources of noise: road traffic, air traffic, railways traffic, airborne noise emitted by household appliances, equipment for use outdoors and recreational craft. An analysis of how the legislation on sources contributes to the aims and objectives of the END is also carried out.

2.1. The Environmental Noise Directive

The overall objective of the END is to identify an EU common approach aimed at avoiding, preventing or reducing the negative and harmful effects due to exposure to environmental noise. In the light of the Directive's provisions, environmental noise is defined as unwanted or harmful outdoor sound created by human activity, such as noise emitted by means of transport, road traffic, rail traffic, air traffic and industrial activity. The Directive indicates a number of actions that need to be progressively implemented by Member States in order to achieve the objectives of the Directive. These actions relate to four main principles:

- **Monitoring of environmental noise** – Member States must develop strategic noise maps, using a common methodology, in order to determine the exposure to environmental noise in priority areas in their territories;
- **Managing environmental noise issues** – on the basis of the developed strategic noise maps, Member States have to adopt action plans containing measures designed to address noise issues, including noise prevention/reduction and preserving environmental noise quality where it is good;
- **Public information and consultation** – strategic noise maps, action plans and relevant information about noise exposure, its effects and measures considered to address environmental noise issues should be made available to the public or developed in consultation with the public;
- **Development of EU long-term strategy** – with a view to reduce noise emitted by the major sources (in particular road and rail vehicles and infrastructure, aircraft, outdoor and industrial equipment and mobile machinery), the EU and Member States should cooperate in order to provide a framework for EU policies addressing environmental noise issues.

2.1.1. Scope of the Directive

The Directive applies to environmental noise to which humans are exposed, particularly in industrial or build-up areas, public parks and in other quiet areas in agglomerations and in open country, near schools, hospitals, etc. However, the Directive does not apply to noise caused by the exposed person, noise created by domestic activities or neighbours, noise at work place or inside means of transportation. Member States are obliged to designate competent national authorities responsible for the implementation of the Directive.

2.1.2. Strategic noise mapping

One of the objectives of the END is to establish a common approach to assess the exposure to environmental noise throughout the European Union. For this purpose, a set of common noise indicators is defined in the Directive, namely the day□evening□night level L_{den} and the night level $L_{night,}$ as already mentioned in Chapter 1. On the basis of these indicators, Article 7(1) of the END requires Member States to produce strategic noise maps for all major roads, railways, airports and agglomerations on a five□year basis, starting from 30 June 2007. Exposure should be measured at the most exposed *façade*. The strategic maps must satisfy minimum requirements as listed in Annex IV to the END and should be reviewed every five years.

Article 6.2 empowers the European Commission to establish common assessment methods for the determination of the noise indicators L_{den} and L_{night}. Until these methods are adopted, Annex II recommends interim assessment methods. At the same time, Annex II allows Member States to adapt existing national assessment methods to the indicators L_{den} and L_{night}, providing they yield equivalent results to those obtained with the interim methods. In order to support Member States in their efforts towards preparation of the noise maps, the Working Group on the assessment of exposure to noise delivered two guidance papers indicating good practices in strategic noise mapping[3]. To this end, a Commission Recommendation concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road traffic noise and railway noise, and related emission data [4] was also issued.

Following the first round of strategic noise mapping (2006-2007), the Commission assessed the comparability of the results generated across the Member States and determined that the assessment methods laid down in the national transposing measures differ significantly from the interim methods[5]. It was not possible to draw on the first round of mapping to present consistent and comparable figures on the number of people being exposed to excessive noise levels within and across the Member States. Difficulties relate to a number of issues, including the means of collecting data, data quality and availability, data reporting and the assessment methods used[6]. Article 6.2 of the Directive foresees the development of a harmonised methodological framework for noise assessment and, in 2009, the Commission decided to develop CNOSSOS□EU (Common Noise aSSessment MethOdS) for noise mapping of road traffic, railway traffic, aircraft and industrial noise. The new set of common assessment methods was elaborated by the Joint Research Centre and published in September 2012[7]. Implementation of the CNOSSOS-EU harmonised methodology will generate comparable figures on road, railway, aircraft and industrial noise. Such a common framework for noise assessment will also contribute to collecting and analysing comparable information on noise levels, thus improving strategic noise mapping and action plans in the future.

Following the development phase (Phase A) of CNOSSOS-EU, the Commission will amend Annex II of the END Directive during with the implementation phase (Phase B) of the project from 2012□2015. The ultimate objective is to have the common noise assessment methodology implemented and operational for the third round of strategic noise mapping in 2017.

[3] Available at : http://ec.europa.eu/environment/pdfinfo.htm.

[4] Commission Recommendation of 6 August 2003 concerning the guidelines on the revised interim computation methods for industrial noise, aircraft noise, road traffic noise and railway noise, and related emission data, C(2003) 2807 (OJ L 212 of 22.08.2003).

[5] DG JRC report on "Assessment of the equivalence of national noise mapping methods against the interimmethods" prepared in the context of the NOISE□I administrative arrangement between DG ENV and DG JRC(contract no 07□0303/2007/477794/MAR/C3).

[6] Report from the Commission to the European Parliament and the Council on the implementation of the Environmental Noise Directive in accordance with Article 11 of the Directive 2002/49/EC, COM(2011) 321 final. Available at: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0321:FIN:EN:PDF.

[7] Stylianos Kephalopoulos, Marco Paviotti, Fabienne Anfosso□Lédée (2012), Common Noise Assessment Methods in Europe (CNOSSOS□EU).European Commission Joint Research Centre - Institute for Health and Consumer Protection. Available at: http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/26390/1/cnossos-eu%20jrc%20reference%20report_final_on%20line%20version_10%20august%202012.pdf.

2.1.3. Action plans, quiet areas and public participation

Based upon noise mapping results, Member States must prepare action plans containing measures addressing noise issues and their effects for major roads, railways, airports and big agglomerations. According to article 8.1(b), the plans should also aim to protect quiet areas against an increase in noise.

The vague definition of quiet areas left ample discretion for interpretation to Member States, which led to confusion and divergence in approach as further discussed in Chapter 3.

The action plans must meet the minimum requirements laid down in Annex V of the END, relating, *inter alia*, to designation of competent authorities, indication of any limit values in place, noise-reduction measures already in place and projects in preparation, actions to be taken in the following five years, long-term strategies and financial information. However, it is important to note that the END does not impose any limit values or specific measures that need to be included in the action plans – those measures are left at the discretion of competent national authorities. The END also requires that the public shall have the opportunity to comment on proposals for action plans and the possibility to participate in the elaboration and reviewing of the action plans (Art.8).

2.1.4. Data collection and reporting

The reporting obligations set out under the END are contained in a number of provisions and have been summarized in Annex II of this study, which is based on a document drafted by DG Environment[8].

Member states are obliged to provide the Commission with information from their strategic noise maps, summaries of the action plan details and noise control programmes at regular intervals, as well as to update the Commission on competent bodies, noise limit values and designated roads, railways, airports and agglomerations. On the basis of this information, every five years the Commission publishes a summary report and sets up a database of strategic noise maps in order to facilitate the compilation of a report on the implementation of the Directive. The first implementation report was published by the Commission on 1 June 2011[9] and its findings are summarised in Chapter 3.

2.2. EU legislation regulating noise sources

The END represents a primary EU legal instrument addressing noise pollution and triggering necessary action both at the EU and Member States level. However, a wide range of other relevant EU instruments contain provisions related to sources of environmental noise. Legislation on sources is complementary to the END in that regulation of noise at the source will obviously affect the result of exposure at the receiver end. However, in legislative terms, the two sets of legislation do not complement each other as effectively as they should in order to have a comprehensive approach to noise at EU level. Ways to improve the interaction between the END and legislation on sources is further discussed in Chapter 5.

Legislation regulating noise sources is summarised below. For the purpose of this study, the legislative acts are grouped and identified by source of environmental noise and relate to the following areas: road traffic, railway traffic, air traffic, airborne noise emitted by household appliances, equipment for use outdoors and recreational craft. The proposed revision of some of these acts is analysed in detail in Chapter 4.

[8] Avaiable at: http://ec.europa.eu/environment/noise/pdf/reporting.pdf
[9] COM(2011) 321 final

2.2.1. Road traffic noise

Noise pollution caused by road traffic is addressed mostly by internal market measures.

The **Motor Vehicle Directive 70/157/EEC**[10] establishes noise limit for motor vehicles. It applies to all types of motor vehicles intended for use on the road, with or without bodywork, having at least four wheels and a maximum design speed exceeding 25 km per hour, with the exception of vehicles which run on rails and of agricultural and forestry tractors and all mobile machinery. The Directive lays down limits for the sound level of moving motor vehicles and detailed measuring requirements (Annex I). The permissible noise limits stipulated in the Directive range from 74 dB(A) to 80 dB(A), depending on the category of vehicle concerned (starting from passenger vehicles comprising of less than 9 seats to vehicles intended for carriage of goods with an engine power of not less than 150 kW). If the vehicle or the exhaust system satisfies requirements of the Directive, Member States cannot refuse to grant EEC or national type approval for the vehicle or exhaust system concerned on grounds relating to the permissible sound level and the exhaust system. Similarly, Member States cannot refuse or prohibit the sale, registration, entry into service or use of any vehicle if the sound level and the exhaust system satisfy the Annex I requirements. Since noise limits for motor vehicles have not been changed since 1996, the European Parliament, the Commission and the Council are currently working on a new Regulation proposal (COM (2011) 856 final)[11] that aims to review and update the requirements for the type-approval system as regards the sound level of motor vehicles and of their exhaust systems. The revision of the Motor Vehicle Directive is further discussed in Chapter 4.

The **Motor Cycle Directive 97/24/EC**[12] contains provisions in respect of certain components and characteristics to be fulfilled by two or three-wheel motor vehicles (vehicles covered by this Directive are subdivided into: mopeds, motorcycles, tricycles and quadricycles). For the purpose of contributing to the protection of the environment and reduction of noise pollution, the Directive indicates permissible sound levels for motor cycles and requirements for exhaust or intake silencer. The permissible sound levels range from 66 dB(A) (for two wheel mopeds) to 80 dB(A) (for tricycles). Detailed requirements for measuring conditions and methods for testing of the vehicle (relating to the type of apparatus used for measuring, test side, positioning of the microphone, etc.) are specified in Chapter 9 of the Directive. In the light of the Directive's provisions, Member States should grant a component type-approval in respect of the sound level if requirements of the Directive are satisfied. Furthermore, Article 6 of the Directive stipulates that Member States can make provision for tax incentives only for motor vehicles conforming to the air-pollution and noise pollution measures.

The **Tyres Directive**[13], as amended, applies to the tyre noise levels. In the light of the Directive's provisions, tyre noise emission refers the noise arising from the contact between tyres in motion and the road surface. **Regulation 661/2009**[14] sets out, *inter alia*, minimum requirements for the external rolling noise of tyres.

[10] Council Directive 70/157/EEC of 6 February 1970 on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicles (OJ L 42, 23.2.1970, p. 16–20).

[11] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the sound level of motor vehicles /* COM/2011/0856 final - 2011/0409 (COD).

[12] OJ L 226, 18.8.1997, p. 1.

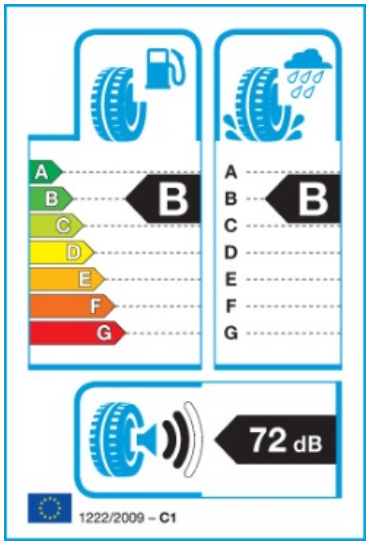
[13] Council Directive 92/23/EEC of 31 March 1992 relating to tyres for motor vehicles and their trailers and to their fitting (OJ L 129, 14.5.1992, p. 95).

[14] Regulation (EC) No 661/2009 of the European Parliament and of the Council of 13 July 2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefore (OJ L 200, 31.7.2009, p. 1–24).

To that end, Annex II Part C (Requirements for rolling noise) indicates noise limit values (in dB(A)), which differ according to the class of tyre in question (C1, C2 and C3)[15]. The noise standards must be determined by Member States in accordance with the procedure specified in the implementing measures adopted in the light of the provisions of Council Decision 1999/468/EC. Annex II part C provides also that for snow tyres, extra load tyres or reinforced tyres, or any combination of these classifications the permissible noise limits should be increased by 1 dB(A). The Regulation states that Directive 92/23/EEC (the Tyres Directive, see above) will be repealed with effect from 1 November 2017, as it is appropriate to provide for a longer period for implementation of rolling noise requirements with regard to new tyres of existing types.

The latest piece of legislation on tyres is **Regulation 1222/2009**[16] aiming at increasing the safety and the economic and environmental efficiency of road transport by promoting fuel-efficient and safe tyres with low noise levels. For this purpose, the Regulation establishes a framework for the provision of harmonised information on tyre parameters, including information on external rolling noise of tyres, through labelling in order to allow end-users to make an informed choice when purchasing tyres. The level of noise is indicated in the tyre labels as illustrated in Figure 2 below.

Figure 2:Tyre label



Source: European Commission DG Energy website

To sum up, legislation on road traffic noise mainly consists of internal market measures which aim to ensure that only motor vehicles, motor cycles and vehicle tyres that do not exceed required noise limits can be approved by competent authorities and put on the EU market. These instruments directly contribute to the objectives of the END as they contain specific measures (such as harmonised noise limits and measurement methods) aiming at the management and reduction of noise pollution caused by road traffic in places located nearby major roads and big agglomerations. The Motor Cycle Directive contains tax incentives which may significantly contribute to the limitation of environmental noise. Finally, Regulation 1222/2009 provides specific measures to ensure that tyre consumers make informed decisions when purchasing tyres. Informed purchasing with regard to the external rolling noise of tyres can contribute to the reduction of environmental noise caused by road traffic as well as to general public awareness on the adverse effects of noise.

[15] For further information regarding classes of tyres see: Article 8 of the Regulation.

[16] Regulation (EC) No 1222/2009 of the European Parliament and of the Council of 25 November 2009 on the labelling of tyres with respect to fuel efficiency and other essential parameters (Text with EEA relevance) (OJ L 342, 22.12.2009, p. 46–58).

2.2.2. Air traffic noise

For decades, international standards (recommended by International Civil Aviation Organization (ICAO), the so-called Chapter 2, 3, and 4 standards for aircraft) have been used as benchmarks for Community legislation on environmental noise. For instance **Directive 89/629/EC**[17] aims at ensuring that civil subsonic jet aeroplanes registered in the territory of one Member State may not be operated in its territory or territory of another Member State unless granted a noise certificate with the standards at least equal to those indicated in Part II, Chapter 3, volume 1 of Annex 16 of the CICA. In 2006, **Directive 2006/93/EC** on the regulation of the operation of aeroplanes covered by the Convention on International Civil Aviation[18] was adopted. This Directive obliges Member States to ensure that all civil subsonic jet aeroplanes operating from airports situated in their territory comply with the standards. Furthermore, **Regulation 216/2008/EC on common rules in the field of civil aviation**[19] provides that certain aeronautical products, parts and appliances must comply with the environmental protection requirements, including noise standards, contained in Amendment 8 of Volume I and in Amendment 5 of Volume II of Annex 16 to the CICA. Finally, on the basis of the agreement reached in the ICAO for the banning of the older and noisier Chapter 2 jet aircraft, a total ban of Chapter 2 aircraft took effect in the EU from April 2002 onwards[20].

However, the international approach is not addressing all dimensions of environmental noise within the EU and the need to introduce a coherent and integrated EU noise pollution policy in the area of air traffic was therefore recognised. Accordingly, the 1992 **White Paper on the future development of the Common Transport Policy**[21] already highlighted that areas surrounding airports should be adequately protected against an increase in noise volume due to the growth in air transport. Subsequently, the **Communication on air transport and environment** (1999)[22] developed and elaborated the approach of the White Paper. In the Communication, the Commission stressed the importance of further work on noise certification standards (within the framework of the ICAO) and the introduction of more stringent noise emission levels in order to provide a framework for future aircraft design. In addition, economic and regulatory incentives were recognized as adequate measures to encourage operators to use environmentally friendly techniques. Finally, measures aiming at assisting airports (such as a common noise measurement index, a methodology for noise calculation or minimum requirements for noise monitoring) and advancing technological improvements were endorsed.

In the light of the above mentioned EU instruments, **Directive 2002/30/EC on Operating restrictions at Community Airports**[23] was adopted in March 2002. The Directive underlines the necessity for the introduction of measures aimed at reducing the noise pollution from aircrafts at airports with particular noise problems.

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[17] Council Directive 89/629/EEC of 4 December 1989 on the limitation of noise emission from civil subsonic jet aeroplanes (OJ L 363, 13.12.1989, p. 27–29).

[18] Directive 2006/93/EC of the European Parliament and of the Council of 12 December 2006 on the regulation of the operation of aeroplanes covered by Part II, Chapter 3 , Volume 1 of Annex 16 to the Convention on International Civil Aviation, second edition (1988) (OJ L 374, 27.12.2006, p. 1–4).

[19] Regulation No 216/2008/EC of the European Parliament and of the Council of 20 February 2008 on common rules in the field of civil aviation and establishing a European Aviation Safety Agency, and repealing Council Directive 91/670/EEC, Regulation (EC) No 1592/2002 and Directive 2004/36/EC (OJ L 79, 19.3.2008, p. 1–49).

[20] Report from the Commission to the Council and the European Parliament, Noise Operation Restrictions at EU Airports (Report on the application of Directive 2002/30/EC), COM (2008) 66 final.

[21] COM(92)494 final.

[22] COM (1999) 640 final.

[23] Directive 2002/30/EC of the European Parliament and of the Council of 26 March 2002 on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports (OJ L 85, 28.3.2002, p. 40–46).

Hence, the main goal of the Directive is to facilitate the introduction by Member States of operating restrictions in a consistent manner at airport level so as to limit the number of people affected by the harmful effects of noise. For this purpose, Member States should adopt a balanced approach in dealing with noise problems at airports located in their territories and introduce adequate measures including land-use planning, noise abatement operational procedures, economic incentives and operating restrictions, in particular on aircrafts that are marginally compliant with Chapter 3 of CICA. When considering their operating restrictions, Member States should take into account information contained in Annex II, which refers, *inter alia*, to noise maps and action plans prepared under the terms of the END. In addition, the Directive on Operating Restrictions at Community Airports refers also to Directive 85/337 on the assessment of effects of certain public and private projects on the environment[24] as an adequate measure for providing a comprehensive assessment of airport projects, also with regard to noise issues. The Directive lays down identical rules for airports across the EU as it applies to all airports which have more than 50,000 movements of civil subsonic jet airplanes per calendar year. However, for five selected city airports[25], the Directive stipulates that more stringent measures can be introduced with regard to the rules of assessment for the operating restrictions.

The EU legislative instruments related to air traffic noise are closely connected with the objectives of the END as the END sets forth requirements related to the management of noise issues for major European airports. In this respect, the most relevant is Directive 2002/30/EC as it fills the "air traffic noise pillar". This Directive refers directly to the END and establishes a specific framework for adoption of certain methods and cost-effective measures aiming at reduction of noise pollution at EU airports. Those measures could be incorporated by Member States in their action plans under the END.

2.2.3. Railway traffic noise

Noise is considered to be one of the most significant environmental impacts of rail traffic. However, contrary to road traffic where the EU noise limits at the source have existed since the 70s, noise standards for trains only came into force at the beginning of XXI century. In general, EU legislation on rail traffic noise gave priority to measures at the source (vehicles and tracks) as they are generally more cost-effective than other noise abatement measures[26], as further explained in Chapter 5. Accordingly, the EU addressed railway noise through two Directives: Directive 96/48/EC on the interoperability of the trans-European high-speed rail system[27] and Directive 2001/16/EC on the interoperability of the trans-European conventional rail system[28].

[24] Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment (OJ L 175, 5.7.1985, p. 40–48).

[25] Annex I to the Directive 2002/30/EC : Berlin-Tempelhof, Stockholm Bromma, London City and Belfast City, Port Lotniczy Lodz-Lublinek.

[26] WG Railway Noise of the European Commission, 'Position Paper on the European strategiesand priorities for railway noise abatement', Version 19403. Available at: http://ec.europa.eu/transport/rail/ws/doc/position-paper.pdf.

[27] Council Directive 96/48/EC of 23 July 1996 on the interoperability of the trans-European high-speed rail system (OJ L 235, 17.9.1996, p. 6–24).

[28] Directive 2001/16/EC of the European Parliament and of the Council of 19 March 2001 on the interoperability of the trans-European conventional rail system (OJ L 110, 20.4.2001, p. 1–27).

Those Directives were amended in 2004 by Directive 2004/50/EC[29] and subsequently repealed in 2008 by **Directive 2008/57/EC**[30], which merged their provisions together into a single instrument with a view to simplification and provides a legislative framework for technical and operational harmonization of the European rail network.

On this basis, Community procedures for the preparation and adoption of Technical Specifications for Interoperability (TSI) were introduced, containing, *inter alia*, measures addressing noise issues. Additionally, the trans-European high-speed train system and the trans-European conventional system were divided into subsystems. TSIs are the specifications by which each rail subsystem or part of it is covered in order to meet the essential requirements set out by Directive 2008/57/EC and to ensure the interoperability of the rail system within the European Union. Within this framework, noise TSI concerning noise limits of high speed trains and conventional trains have been established. The relevant Commission Decisions containing noise TSI are listed in the table below:

Table 3: Commission Decisions on noise TSI

Noise TSI for the trans-European high-speed rail system	Noise TSI for the trans-European conventional rail system
• Commission Decision 2002/735/EC concerning the technical specification for interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system[31]. • Commission Decision 2002/732/EC concerning the technical specification for interoperability relating to the infrastructure subsystem of the trans-European high-speed rail system[32].	• Commission Decision 2011/229/EU concerning the technical specifications of interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system[33].

The Commission Decisions establishing TSIs are summarised below, with a particular focus on the noise TSIs.

[29] DIRECTIVE 2004/50/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 amending Council Directive 96/48/EC on the interoperability of the trans-European high-speed rail system and Directive 2001/16/EC of the European Parliament and of the Council on the interoperability of the trans-European conventional rail system (OJ L 164, 30.4.2004, p. 114–163).

[30] Directive 2008/57/EC of the European Parliament and of the Council of 17 June 2008 on the interoperability of the rail system within the Community (Recast) (OJ L 191, 18.7.2008, p. 1–45).

[31] Commission Decision 2002/735/EC of 30 May 2002 concerning the technical specification for interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Directive 96/48/EC (Text with EEA relevance) (notified under document number C(2002) 1952) (OJ L 245, 12.9.2002, p. 402–506).

[32] Commission Decision 2002/732/EC of 30 May 2002 concerning the technical specification for interoperability relating to the infrastructure subsystem of the trans-European high-speed rail system referred to in Article 6(1) of Council Directive 96/48/EC (Text with EEA relevance) (notified under document number C(2002) 1948) (OJ L 245, 12.9.2002, p. 143) as amended.

[33] Commission Decision 2011/229/EU of 4 April 2011 concerning the technical specifications of interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system (notified under document C(2011) 658) (OJ L 99, 13.4.2011, p. 1–39).

Commission Decision 2002/735/EC introduces technical specification, including noise TSIs, for the rolling stock subsystem of the trans-European high-speed rail system. The TSIs are applicable to trains running at a speed of at least 250 km/h on the lines specifically built for high speed and at a speed of the order of 200 km/h on existing lines which have been or are to be specially upgraded.

The noise TSIs underline that *"the repercussions on the environment of the establishment and operation of the trans-European high-speed rail system must be assessed and taken into account at the design stage of the system in accordance with the Community provisions in force*". The TSIs indicate stationary noise levels for rolling stock ("noise levels in stations or on stabling tracks shall not exceed 65 dB(A) measured continuously or 70 dB(A) intermittently") and noise levels in high-speed service for rolling stock ("the noise level generated by a trainset in service shall not exceed a value of 87 dB(A) at a speed of 250 km/h, 91 dB(A) at a speed of 300 km/h and 92 dB(A) at a speed of 320 km/h"). The noise TSIs establish also detailed provisions related to methods and conditions for noise measurements. Moreover, they provide that in areas particularly sensitive to noise, the level of noise perceived on the passing of a train can be reduced by the installation of sound attenuating measures placed along the track. With regard to interior noise caused by rolling stock of the trans-European high-speed rail system, the TSIs state that the interior noise level of passenger vehicles is not considered to be an interoperability constituent, however the noise level within the driver's cab should not exceed 84 dB(A) for over 30 minutes. Application scope of the TSIs covers only new or substantially updated interoperable rail vehicles.

Commission Decision 2002/732/EC establishes TSIs relating to the infrastructure subsystem of the trans-European high-speed rail system and states the noise level generated by the trans-European high-speed rail system should remain acceptable for its surroundings and be kept within limits suitable to protect neighbouring populations and their activities. Although TSIs relating to the rail infrastructure do not establish any specific noise limits, they refer to the Environmental Impact Assessment Directive 85/337/EEC and foresee that the environmental impact study must show that the noise levels perceived by neighbours along new or upgraded infrastructure do not exceed the noise levels defined by national rules, taking into account the noise emission characteristics of the interoperable trains as defined in the rolling stock TSI (see the Commission Decision above). Alike TSIs for rolling stocks, TSIs for infrastructure subsystems do not apply to renewals or maintenance-related replacements.

Commission Decision 2011/229/EU sets noise TSIs which are applicable to the rolling stock of the trans-European conventional rail system. The rolling stock that is the subject of this TSI comprises self-propelling thermal or electric trains, thermal or electric traction units, passenger carriages, freight wagons and mobile railway infrastructure construction and maintenance equipment likely to travel on all or part of the trans-European conventional rail network. The rolling stock noise TSI include noise limits for stationary noise, starting noise, pass-by noise and interior noise of locomotives, multiple units and driving trailers. The Commission Decision establishes noise standards (in dB(A)) as well as functional and technical specifications and detailed measuring methods for each type of the rolling stock. All the noise TSIs apply to new and existing rolling stock.

Currently the European Railway Agency (ERA), which has a mandate to draft a proposal for the Noise TSI and a report including further proposals for rail noise abatement, is working on the comprehensive revision of the TSIs which will include the TSI for conventional rail vehicles as well as the TSI Rolling Stock for high-speed rail.

The intention is to merge both into a single TSI Noise, with a scope of application which should also be expanded beyond the trans-European rail network[34]. The revision of the TSIs is discussed in Chapter 4.

EU legal measures related to railway traffic establish unified noise limits aimed at the reduction of railway traffic noise pollution as well as at the harmonization of measurement procedures and test conditions. As such, they contribute to the main objectives of the END, especially with regard to the noise reduction for major railways. In particular, measures specified in the above legislation may contribute towards a process of creation of action plans by Member States, since such plans must be developed for major railways located in the Member States territories.

2.2.4. Airborne noise emitted by household appliances

In the past, noise emitted by household appliances was regulated under one EU legal act, namely **Directive 86/594/EEC on airborne noise emitted by household appliances**[35], which defined the procedure to determine the permissible noise levels (Article 6) and laid down the conditions under which publication of information on the noise emitted by household appliances may be required in all Member States. This Directive was repealed in 2005 by **Directive 2005/32/EC establishing a framework for the setting of ecodesign requirements for energy-using products**[36] (currently **Directive 2009/125/EC**[37], hereinafter 'the Ecodesign Directive').
The Ecodesign Directive establishes a framework for the setting of EU ecodesign requirements for energy-using products (EuP), which relate also to a number of household appliances. EuP should be covered by implementing measures adopted by the Commission and laying down ecodesign requirements for defined EuPs and/or for environmental aspects of them. Until now, 13 implementing measures have been adopted by the Commission.[38] Implementing measures covering household appliances are summarized below.

Regulation 206/2012/EU[39] establishes eco-design requirements for the placing on the market of electric air conditioners with a rated capacity of ≤ 12 kW for cooling (or heating) and comfort fans with an electric fan power input ≤ 125W. The Regulation states that sound power level of air conditioners in the use phase constitutes one of their most significant environmental aspects. In that regard, it establishes (in Annex I, section 2) indoor sound power levels for the products in question, which range between 60 dB(A) and 70 dB(A), depending on the rated capacity of the air conditioner/fan concerned. Member States' surveillance authorities should consider air conditioner model as complying with the Regulation's requirements if the maximum sound power level does not exceed more than 2 dB(A) of the declared value. Regulation 26/2012/EU will enter into force in January 2013.

[34] For more details see: Transport & Environment, 'Revision of EU rail noise standards (TSI), Input to the ERA Working Party TSI Noise', November 2011.
[35] Council Directive 86/594/EEC of 1 December 1986 on airborne noise emitted by household appliances, (OJ L 344, 6.12.1986, p. 24–27).
[36] Directive 2005/32/EC of the European Parliament and of the Council of 6 July 2005 establishing a framework for the setting of ecodesign requirements for energy-using products and amending Council Directive 92/42/EEC and Directives 96/57/EC and 2000/55/EC of the European Parliament and of the Council (OJ L 191, 22.7.2005, p. 29–58).
[37] Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products (OJ L 285, 31.10.2009, p. 10–35).
[38] Full list of the implementing measures available at : http://ec.europa.eu/enterprise/policies/sustainable-business/documents/eco-design/legislation/implementing-measures/index_en.htm
[39] Commission Regulation (EU) No 206/2012 of 6 March 2012 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans (OJ L 72, 10.3.2012, p. 7–27).

Regulation 1016/2010/EU[40] sets forth ecodesign requirements for the placing on the market of household dishwashers. With regard to permissible noise emissions of the products in question, the Regulation establishes, in Annex IV, airborne acoustical noise emissions levels ranging between 41 dB(A) and 53 dB(A), depending on type of the dishwasher.

Regulation 643/2009/EC[41] establishes ecodesign requirements for the placing on the market of electric household refrigerating appliances with a storage volume up to 1 500 litres. In Annex VI the Regulation obliges Member States to apply the best available technology on the market for household refrigerating appliances in terms of noise. In that regard, it indicates noise limits ranging between 0 dB(A) and 37 dB(A), depending on the type of the refrigerator.

Regulation 1015/2010[42] provides requirements for the placing on the market of electric household washing machines, including those sold for non-household use and built-in household washing machines. The Regulation establishes airborne acoustical noise emissions limits during washing/spinning for the standard 60 °C cotton programme at full load. Those noise limits range between 48/62 dB(A) and 57/73 dB(A), depending on the capacity of the product concerned. Moreover, for certain types of washing machines the Regulation does not provide any noise limits due to the lack of information regarding the best available technology for the types of washing machines in question.

The above mentioned EU legislation on noise emitted by household appliances does not seem to significantly contribute to achieving the aims of the END as the END does not apply to noise caused by domestic activities.

2.2.5. Noise emitted by outdoors equipment

In the past, the EU legislation on noise emitted by equipment for use outdoors consisted of nine directives covering certain types of construction machinery and lawnmowers. These Directives laid down the requirements for, *inter alia*, permissible noise levels and noise test codes for each type of equipment separately. In its Green Paper on the Future Noise Policy[43] the Commission announced its intention to simplify this legislation and to create a common framework for the reduction of noise emission by equipment for use outdoors. Accordingly, the **framework Directive 2000/14/EC on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors**[44] was adopted in May 2000.

The main objective of the Directive is to harmonise the legislation of the Member States relating to noise emission standards, conformity assessment procedures, marking, technical documentation and collection of data concerning the noise emission of equipment for use outdoors with a view to contributing to the smooth functioning of the internal market, while protecting human health and well-being.

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[40] Commission Regulation (EU) No 1016/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household dishwashers (OJ L 293, 11.11.2010, p. 31–40).

[41] Commission Regulation (EC) No 643/2009 of 22 July 2009 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances (OJ L 191, 23.7.2009, p. 53–68).

[42] Commission Regulation (EU) No 1015/2010 of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines (OJ L 293, 11.11.2010, p. 21–30).

[43] The Green Paper on Future Noise Policy, (COM(96) 540).

[44] Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors (OJ L 162, 3.7.2000, p. 1–78).

The Directive applies to equipment listed in Article 12 (equipment subject to noise limits) and in Article 13 (equipment subject to noise marking only). Article 12 of the Directive, besides listing the equipment subject to noise limits, contains a table indicating permissible sound power levels (in dB/1 pW)[45] for each type of the equipment concerned. Annex III of the Directive establishes specific methods of measurements of airborne noise emitted by equipment for use outdoors that should be utilized by Member States. In the light of the Directive, each type of equipment covered by the Directive must bear (in visible, legible and indelible form) the CE marking of conformity that should be accompanied by the indication of the guaranteed sound power level.

The Directive puts specific obligations on manufacturers of equipment for outdoor use to protect EU citizens from negative effects of noise pollution caused by such equipment. For this purpose, it contains a number of preventive measures to tackle environmental noise from the source (CE marking, conformity assessment). It also indicates noise standards that cannot be exceeded by the equipment in question. As such, the Directive indicates harmonised procedures and instruments that tackle urban noise and contribute to the aims of the END, especially with regard to addressing noise issues in big agglomerations.

2.2.6. Noise from recreational craft

Directive 94/25/EC on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft[46] (the Recreational Craft Directive) lays down requirements for the design and construction of recreational craft to be fulfilled in order to enable the free circulation of these products in the internal market. The Recreational Craft Directive has been amended by **Directive 2003/44/EC**[47], which established harmonized limits for exhaust and noise emissions that recreational crafts must comply with in order to have free access to the EU internal market.

With regard to noise emissions, the Recreational Craft Directive applies to the following types of crafts: recreational crafts with inboard or stern drive engines without integral exhaust, personal watercrafts and outboard engines and stern drive engines with integral exhaust. Annex I section C of the Directive indicates essential requirements for noise emissions for the above crafts. It provides that the crafts in question should be designed, constructed and assembled so as to not exceed the specified noise limits. The permissible noise limits range between 67 and 75 dB(A), depending on the single engine power of the craft concerned. Recently, the Commission proposed new legislation on recreational boats with the aim to clarify the responsibility of economic operators and make the use of recreational crafts more environment-friendly[48], as further discussed in Chapter 4. However, there are no changes planned for the noise emission limits, which, according to the Commission's proposal, should remain as defined by the Directive 2003/44/EC.[49] The Recreational Craft Directive contributes to the overall goal of the END, which is the prevention and reduction of the harmful effects of environmental noise, as it establishes harmonized noise levels and measurement standards aimed at limiting noise pollution.

[45] Noise limits are laid down following a general formula: L = A + B 1g P, where L is the sound emission limit, P is a power-related descriptor, A and B are product-related constants.

[46] Directive 94/25/EC of the European Parliament and of the Council of 16 June 1994 on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft (OJ L 164, 30.6.1994, p. 15–38).

[47] Directive 2003/44/EC of the European Parliament and of the Council of 16 June 2003 amending Directive 94/25/EC on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft (OJ L 214, 26.8.2003, p. 18–35).

[48] 2011/0197 (COD).

[49] Proposal for a Directive of the European Parliament and of the Council on recreational craft and personal watercraft, SEC(2011) 958 final, SEC(2011) 959 final.

3. ASSESSMENT OF THE EFFECTIVENESS OF THE ENVIRONMENTAL NOISE DIRECTIVE

KEY FINDINGS

- The Environmental Noise Directive (END) has introduced an ambitious data gathering and reporting process. Despite some delays, Member States have now completed the first round of strategic noise maps and action plans.
- Implementation has shown some achievements and shortcomings. In particular, the main challenges have been delays, non-enforcement of noise limit values, poor quality of strategic noise maps and action plans, inconsistent approaches in mapping and confusion amongst responsible bodies regarding the END requirements.
- In terms of effectiveness, the END has led to little progress in reaching the objectives of reducing the proportion of the EU's population suffering from noise pollution.
- Best practices from national and local level show that the END has inspired innovative ideas and solutions to tackle the issue of environmental noise.

The Environmental Noise Directive 2002/49/EC (hereinafter END) had to be transposed by 18 July 2004. Despite some delays in communication with the Commission, the overall quality of legal transposition in Member States was satisfactory[1].

This Chapter looks at how the END has been implemented so far, highlighting achievements and shortcomings in the implementation process. An analysis is also carried out on the effectiveness of the Directive in reaching its objective to "*define a common approach intended to avoid, prevent or reduce on a prioritised basis the harmful effects, including annoyance, due to exposure to environmental noise".* Finally, some examples of actions at national and local level are presented to show that the END has sparked creative ideas and solutions to reduce the overall exposure to environmental noise.

3.1. Implementation of the Environmental Noise Directive

3.1.1. Implementation process

The END introduces several reporting obligations and other requirements for Member States. The deadlines for each of the requirements lead to an ambitious periodic implementation and reporting cycle[2] as summarised in Annex II of this study.

The European Commission published a report on the implementation[3] of the END in June 2011. The report took stock of progress in implementation, identifying achievements and challenges as well as ideas for future work to increase the effectiveness of the Directive.

A general overview of the implementation process shows that:

- Regarding the designation of responsible administrative bodies, all Member States have allocated competences for the implementation of END. However, problems remain with the coordination of these different bodies, as further explained below.

[1] Report from the Commission to the European Parliament and the Council on the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC. COM(2011) 321 final. Available at: http://ec.europa.eu/environment/noise/pdf/reporting.pdf.
[2] COM(2011) 321 final.
[3] COM(2011) 321 final.

- The END introduces noise indicators for reporting but does not set any legally binding EU-wide noise limit values or target. As a result, countries have taken different approaches and national limits (when set) are mostly above what has been indicated by the WHO as "safe limits" and/or have not been enforced.

- On reporting, the lack of consistency and low quality of noise maps in the first reporting period led the Commission and the EEA to develop an ad hoc mechanism, the END Reporting Mechanism (ENDRM)[4] which aims to facilitate and streamline data collection, quality control and compliance assessment. The effectiveness of the ENDRM was further improved with the additional linkage to the EEA's "Reportnet" Reporting Obligations Database (ROD).[5]

- The Directive provides that until common noise assessment methods are established, Member States could use interim methods or their own methods. An assessment by the Commission showed that national assessment methods differ from the interim methods for 13 Member States.

- Action plans were submitted according to the timetable only in five cases. Most of the Member States sent their plans more than a year after the deadline[6]. As regards quiet areas, the END left it largely to Member States to delimit these areas, hence very different approaches were taken.

- Finally, on public information, consultation and data management, all reports submitted by Member States have been made publicly available by the Commission.[7] Information gathering and publication have also been facilitated by "Reportnet" and the EEA Noise Observation and Information Service for Europe (N.O.I.S.E.).

3.1.2. Achievements

Ten years after approval, the implementation of the END shows some successes in addressing the objectives described in Chapter 2.1. The Eurocities evaluation concludes that:

"*The END has brought real benefits. It is thanks to noise mapping that we know the extent of urban populations exposed to noise. The common indicators used in all noise maps have enabled the comparison of the noise burden between Member States. And lastly every competent body has drafted or is still drafting a noise action plan. These are significant successes*" [8].

The Commission's implementation report highlights the following as main achievements of the Directive:

- Introduction of a management system of environmental noise in all Member States;
- Progress in mapping and assessing noise pollution in the EU leading to an overview on the extent of noise pollution problems;
- Improved comparability of strategic noise mapping including common indicators;

[4] European Environment Agency (EEA). Electronic Noise Data Reporting Mechanism. Technical report No 9/2012. Available at: http://www.eea.europa.eu/publications/noise-handbook.

[5] ROD is the EEA's reporting obligations database. It contains records describing environmental reporting obligations that countries have towards international organisations. ROD is part of Reportnet. Reportnet is group of web applications and processes developed by the EEA to support international environmental reporting : http://rod.eionet.europa.eu/.

[6] COM(2011) 321 final.

[7] CIRCA: http://circa.europa.eu/Public/irc/env/d_2002_49/library.

[8] Eurocities Working Group Noise, Evaluation of the Environmental Noise Directive, 2009. Available at: http://www.eurocities.eu/eurocities/documents/EUROCITIES-Evaluation-of-the-Environmental-Noise-Directive-WSPO-8UTHYY.

- Establishment of a comprehensive set of noise data at the EU level;
- EU-wide drafting of noise action plans addressing the noise "hot spots" identified by the Member States;
- Identification of gaps with regard to EU legislation on sources of noise[9].

3.1.3. Challenges

However, several implementation problems have been identified, which need to be adequately dealt with in the future to improve the effectiveness of the END. The main issues with implementation are summarised below on the basis of on an analysis carried out by Milieu as part of a study commissioned by the Commission on the state of implementation of the END[10]:

1. **Delays to implementation:** Several Member States experienced problems with meeting the deadlines for the generation of strategic noise maps and action plans. The reasons for these delays are manifold. First of all, coordinating the activities of the bodies involved in data collection and action planning represented a challenge in many countries. Also, such delays are partly due to a lack of political will to address noise at local and national level, as a reflection of the low awareness of the health impacts of noise. Lastly, many Member States highlighted timing as an issue, arguing that the timeframe for the preparation of noise maps and action plans was not realistic since only one year was left for action planning (including public consultation) after the generation of noise maps. According to the Commission implementation report, the experience gained in the reporting process led progressively to a more timely, comparable and manageable reporting in 2010 compared to 2005.

2. **Non-enforcement of existing noise limit values:** Noise limit values are not a requirement under the END. However, the different approaches taken by Member States on establishing limit values and the problems related to enforcement are relevant to the discussion on the effectiveness of the END. In the majority of Member States, noise limits are mandatory and legally enforced. Nevertheless, the noise maps highlight that the noise limit values are often not respected and that measures (e.g. actions to insulate exposed populations or impose penalties) have not been implemented to enforce them. Again, the failure of many Member States to ensure the enforcement of noise limit values reflects a general lack of political will to prioritise noise reduction over the economic gains from the private activities that generate noise.

3. **Poor quality of strategic noise maps:** The first exercise of map reporting in 2007 showed that the quality of strategic noise maps was not consistent across the Member States. This was mainly due to difficulties in identifying the responsible authorities as explained earlier, but also to gaps in the available data and lack of technical experience in mapping noise in many countries. As a result, the value of the maps in serving as a basis for assessing noise levels and developing action plans was undermined.

[9] COM(2011) 321 final.
[10] Milieu (2010).

4. **Inconsistent approaches to mapping noise:** So far, Member States have used different noise assessment methods when generating strategic noise maps. The END Directive establishes common indicators (L_{den} and L_{night}) but does not set common assessment methods. In Annex II, it rather provides for interim methods based on current methodologies applied by the different countries. Inconsistent approaches to mapping noise have led to a lack of comparability of noise maps across the EU. Estimates of population exposure resulting from strategic noise mapping studies are currently incomparable due to the significant differences in estimation methodology[11]. Progress in the direction of a common noise calculation methodology has been made with the publication of the CNOSSOS-EU report (see above, Chapter 2.1.2). However, a standardised approach for measuring population exposure at the most exposed façade as required in Annex I of the END is still missing and, without it, exposure estimates remain incomparable across countries and are most likely underestimated[12].

5. **Poor quality of action plans:** The quality of the action plans produced under the first reporting cycle was generally quite low, in many cases superficial and failing to propose new solutions rather than summarising existing measures. This shows that the implementation of the END was not effective in channelling additional political attention and resources towards addressing noise. In addition to lack of political will, the poor quality of the action plans reflects a lack of experience and low technical capacity with managing noise, as well as a lack of financial resources and limited time to develop action plans from noise maps. Member States lamented insufficient guidance on the content and contextual format of the plans. Lack of coordination between different authorities in the planning exercise also had an impact on the development of quality documents and, most probably, in the subsequent implementation of the plans. Also public consultation, which is a requirement under the END, has been limited in many states. For example, public consultation has generally been limited to placing strategic noise maps on the internet while little attempt has been made to inform the public of actions to be taken as a result of noise action planning[13].

6. **Divergent approaches to identifying quiet areas:** As mentioned in Chapter 2.1.3, the definition of quiet areas in agglomerations as per Article 8 of the END leaves considerable discretion to Member States in delimitating these areas. This is justified by the need to consider and respect national and local factors in identifying and protecting quiet areas. However, the lack of a clearer definition has led to confusion on the part of some Member States as to the role of quiet areas in the END, in particular quiet areas in open country, as well as to divergent approaches across the EU. Further guidelines have been developed on the definition of quiet areas since the Commission's implementation report, and are presented in detail in Chapter 5.2.3.

7. **Confusion amongst responsible bodies regarding requirements:** The definitions of some of the END requirements are considered as unclear and confusing by Member States. For example, the definition of major roads in the END is based on the vehicle flow on the road, but Member State experience has shown that even roads with lower vehicle flows can generate noise levels above the 55dB threshold and should therefore be taken into account for a complete approach to noise disturbance from roads.

[11] E. Murphy, E.A. King, Strategic environmental noise mapping: Methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications. Environment International, 2009.
[12] Ibid.
[13] Ibid.

Member States also had problems with the definition of major agglomerations and quiet areas. This confusion led to time delays and to a lack of coherence in the approaches taken both across and within Member States in defining and designating major roads and agglomerations. Further guidance is therefore needed to improve the understanding of the END definitions.

3.1.4. Analysis of the effectiveness

As a result of the problems highlighted above, the implementation of the END has led to little progress in reaching the objectives of reducing the proportion of the EU's population suffering from noise pollution. To date, there has been little reduction from the 20% proportion of the population exposed to potential harmful noise levels estimated by the Green Paper on Noise[14]. The failure of Member States to apply even existing noise limit values, which in most cases are above the recommended values suggested by the WHO, indicates that the exposure to potentially harmful levels is likely to continue.

In addition, the challenges with implementation show that the END has not been effective in raising the political profile of noise as a priority to improve people's health and their environment. As a consequence, there will continue to be budget constraints and lack of resources to implement the necessary measures and best available technologies for the reduction of annoyance and sleep disturbance from noise.

Despite the limited effectiveness of the END in reaching its objectives to date, the Commission's implementation report acknowledges that a more comprehensive and realistic assessment can only be made after the second round of noise mapping, when the knowledge on noise pollution will have improved further and the coordination mechanisms will already be in place.

The Commission implementation's report also identifies areas for future improvement of implementation, namely: 1) the finalisation of the harmonised framework for mapping methods; 2) the development of EU implementation guidance, 3) improving synergies between air quality and noise management; and 4) facilitating reporting issues. These issues are further explored in Chapter 5. The Commission's report also calls for further improvement in the legislation regulating noise sources as a way to improve the effectiveness of the EU regulatory framework as a whole. This is discussed in more detail in chapters 4 and 5 of this study.

As a follow up to the Commission's implementation report, a stakeholder event[15] was organised in September 2011 and a public consultation[16] launched in August 2012 to gather views and additional information on the effectiveness, strengths and weaknesses of the EU environmental noise legislation.

3.2. Best practices

Despite the problems and challenges outlined above, several initiatives taken at national and local level demonstrate how creative approaches can lead to effective implementation of the END. Some examples are provided below of best practices in administrative arrangements, noise action planning, public participation, cooperation between Member States, development of strategic maps and identification of quiet areas.

[14] Green Paper on Future Noise Policy (COM(96) 540).
[15] European Commission, Stakeholder Conference on Noise, 30 September 2011. Presentations available at: http://circa.europa.eu/Public/irc/env/noisedir/library?l=/directive_200249/commissions_reports&vm=detailed&sb=Title.
[16] European Commission, Consultation on the Implementation Report of the Environmental Noise Directive (END) and on the EU Noise Policy: http://ec.europa.eu/environment/consultations/noise_en.htm.

The inventory of best practices is obviously not exhaustive, but provides a gist of ideas and solutions that have been sparked by the END to address environmental noise in the EU.

3.2.1. Administrative arrangements (Sweden)

In Sweden, the Swedish Environmental Protection Agency coordinates the work on environmental noise and reports to the Commission based on the information it receives from the responsible authorities.

For the first round of reporting, a coordination group was established where the responsible authorities and the Swedish Environmental Protection Agency could meet and discuss the implementation of the END[17]. In particular, the coordination group included representatives of the National Road Administration, the National Board of Housing, Building and Planning, the Swedish Armed Forces, the Swedish Civil Aviation Authority, the Västra Götaland County Administrative Board, the National Heritage Board, the National Maritime Administration, the Office of Regional Planning and Urban Transportation of Stockholm County Council, and the City of Stockholm[18]. The group is still meeting twice a year and now involves representatives from ten new cities that will have to prepare strategic noise maps for the second round of reporting.

The work of the group involved coordination regarding major roads through agglomerations, the exchange of traffic data between the transport authorities and the municipalities, and establishing common technical and legal interpretations of the END. Due to the lack of specific guidelines, the group met regularly to discuss the possible streamlining of the implementation. Also, the group commissioned several different studies to increase knowledge and awareness of the effects of noise exposure.

3.2.2. Support tool for noise action plans (United Kingdom)

The UK has introduced a facility, the Noise Action Plan Support Tool (NAPST)[19], to assist with implementation of noise action plans, particularly in important areas[20]. The NAPST website, which is accessible to those stakeholders who are liaising with the Department for Environment, Food and Rural Affairs (Defra) to implement noise action plans, is designed within the general noise action plan approach adopted in the UK. There, Defra is the competent authority for agglomerations, roads and rails, and airports are the competent authority for airport noise. In the noise action planning process, Defra defined the important areas, provided information on the noise mapping results and facilitated information exchange. However, the main actions were identified locally.

The NAPST website includes details on the location of the important areas (displayed in Google Maps) organised by "noise receiving authority" (e.g. a certain Borough Council). It also includes information on the status of the investigation. Stakeholders can provide their views in the initial investigation on what measures, if any, might be taken in order to assist the management of environmental noise.

The tool allows for the integration of the national and local approaches to noise management and creates a user-friendly environment optimising the involvement of local stakeholders in the implementation of noise action plans.

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[17] Milieu (2010).

[18] Swedish Environmental Protection Agency (2007), Good acoustic environment…more than just freedom from noise, 2007: http://www.naturvardsverket.se/Documents/publikationer/620-5708-1.pdf.

[19] Noise Action Plan Support Tool: http://www.noiseactionplan.co.uk.

[20] Important Areas – where the 1% of the population that are affected by the highest noise levels from roads (and separately from railways) are located in each agglomeration and separately outside agglomerations. Of those Important Areas – First Priority Locations are where the noise level is at least 76 dB, LA10,18h (for roads) and separately 73 dB, LAeq,18h (for railways) according to the mapping. Source: Defra Power Point presentation at EC Stakeholder Conference on Noise, 30 September 2011.

3.2.3. Noise action plans in agglomerations (Germany)

The noise action plan prepared by the City of Hamburg represents a good example of plan preparation for complex agglomerations[21]. Germany's second largest city is a major international transportation hub and a seaport, with half of container transportation taking place by road. Managing traffic noise in this context is challenging. However, Hamburg, which has been awarded the title of European Green Capital in 2011, has been able to adopt a comprehensive approach, as well as an integrated and participative planning strategy on noise.

Hamburg selected a two-stage model in drawing up the noise action plan. First, a strategic noise action plan was prepared for the city as a whole, thus providing an overall framework. Secondly, detailed specific noise reduction measures were elaborated at a city district level. Also, other existing plans with an impact on environmental noise have been taken into consideration, for example the traffic development plan, the air pollution control plan, the urban plan, the bicycle traffic strategy etc. Integrated noise reduction measures have therefore been included, thus ensuring acceptance and compatibility of the noise action plan in the city without giving rise to additional costs. In essence, the measures foreseen in the plan include the promotion of environmentally-friendly modes of transport, i.e. local public transport and cycling, as a way to reduce noise pollution in the city as well as to improve air quality. Also, the development of a citywide speed concept would address noise, air and road safety at the same time. In addition, it is planned to develop a lorry route network to shift cargo traffic to comparatively insensitive areas and protect noise-sensitive roads with high residential densities. Along with noise relief for the affected citizens, this move would also address the safety issues related to the transported hazardous materials. The Strategic Noise Action Plan for Hamburg also indicates methods for effective reduction of noise on rail routes.

3.2.4. Public participation (Germany)

Another interesting experience from Germany is that of the City of Norderstedt[22], particularly as regards effective public participation in noise action planning. A broad information campaign on noise via Internet, TV, local press, mail and ad-hoc flyers promoted citizens' participation in the development of the noise action plan. The process for public involvement in drafting the action plan started with a large public forum in 2004. During this forum, four working groups were established on 1) public traffic and bicycle riding, 2) street traffic and life quality, 3) noise mitigation in old and new living areas and 4) protection of quiet areas in the city. More than 100 people worked intensively and on a voluntary basis for a year to identify problems and to elaborate a number of specific concrete points to improve the situation, which were included in the plan. With the public presentation of the noise action plan in 2007 the participation process was formally completed[23]. The experience of Norderstedt shows that providing clear and accessible information which is easily understood by the public is fundamental to ensure effective participation.

[21] Umweltbudesamt, Noise action planning in agglomerations. Reduction potentials based on the example of Hamburg, 2011: http://www.uba.de/uba-info-medien-e/4090.html.

[22] City of Norderstedt website section on noise : http://www.norderstedt.de/index.php?La=1&NavID=1087.120&object=tx%7C1087.692.1&kat=&kuo=1&sub=0

[23] Brüning H., Noise action plan – the strategic approach to advance sustainable transport. The example of "Quiet Norderstedt. Worth living". Werner Gronau, Karl Reiter & Robert Pressl (Ed.): Transport and Health Issues. Mannheim 2011, 159-180.

3.2.5. Cooperation between Member States (Germany-The Netherlands)

The END Article 8 indicates that neighbouring Member States should cooperate on noise mapping near borders. A report by Arcadis[24] describes the experience with this type of cooperation between Germany (Nordrhein-Westfalen region) and The Netherlands (Gelderland region). The two regions have a collaboration agreement and decided to exchange ideas and strategies to improve the implementation of the END and reduce noise exposure. Implementation issues such as action planning, data gathering through Geographic information Systems (GIS), public participation and the relation to the national framework for environmental noise control are addressed.

The outcome of the project showed that, in this case, there was hardly any noise spreading across the border between the two countries. In other cases, noise propagation across borders may be more relevant. However, the joint project of the German and Dutch regions shows the importance to stimulate cooperation between neighbouring Member States on noise mapping near borders.

3.2.6. Strategic noise mapping (United Kingdom)

As part of the EU-funded SILENCE project[25], the City of Bristol has published online noise maps of the city that show the levels of environmental noise in neighbourhoods. The maps include noise from road and rail traffic, are expressed in terms of L_{den}, and are available in Google Maps and other formats. The noise emission levels are assigned to roads based on a combination of factors such as traffic speed, composition and road surface type. An assessment of the population exposed to noise levels above an action level can also be made, as population is estimated in each building[26].

3.2.7. Identifying quiet areas (The Netherlands)

In the Netherlands two noise prediction models have been used for the mapping of quiet areas[27]. The national model for noise mapping is called EMPARA (Environmental Model for Population Annoyance and Risk Analysis). EMPARA calculates and accumulates the contributions from each of the major noise sources, road, rail and aircraft. A second model, RURIS, was developed by the Netherlands Institute for Applied Research, TNO. RURIS takes the noise from industrial and recreational activities into account as well as transportation noise. RURIS also calculates temporal distributions of the noise levels, which allows the model to determine the probability of hearing man-made sounds when in a quiet area. The predictions of these models have been shown to give reliable results for the relatively continuous noise sources. Modelling random intermittent sources remains challenging.

[24] Arcadis. 2008. Implementation directive on environmental noise (2002/49/EC); Dutch regions compared with Nordrhein-Westfalen. 10623/CE8/074/000652:Provincie Gelderland. Available at: http://www.gelderland.nl/Documenten/Themas/Milieu_Klimaat_en_Water/Geluid/Report_Noise.pdf.
[25] SILENCE website: http://www.silence-ip.org/site/.
[26] Bristol Noise Map: http://www.bristol.gov.uk/page/environmental-traffic-noise-mapping-bristol.
[27] Dassen T, 2002, A brief overview of the Dutch policy and research on the area of 'quiet zones', RIVM, Bilthoven, Netherlands.

4. IMPROVING EU LEGISLATION ON SOURCES OF NOISE

KEY FINDINGS

- The most effective road traffic noise control strategies involve noise control at source. This can only be achieved by stricter and more ambitious targets for reduction in permissible noise levels.
- The test method for motor vehicles must be reflective of real-world driving conditions. If the new test method is instituted without a corresponding reduction in permissible noise levels, it will effectively allow manufacturers to produce louder vehicles.
- For aircraft noise, it may not be technically feasible (at the moment) to achieve significant noise reductions at source. Alternative strategies for noise control must be adopted as part of a balanced mitigation approach around airports.
- Freight trains are the main source of railway noise. Further research needs to be aimed at addressing this source.
- Further research is needed to establish new noise limits for different outdoor machinery types.
- The impacts of recreational craft on humans are not excessive. However, further research is needed to establish the impact on parklands and conservation areas.

This chapter investigates the potential for improving existing legislation on sources of noise. It focuses specifically on the key noise sources: road, air, rail as well as outdoor noise and recreational craft. It deliberately excludes airborne noise emitted by household appliances as the END does not apply to noise caused by domestic activities. Moreover, with the exception of fan and ventilation noise, noise emitted by household appliances is of marginal health concern with respect to environmental noise when compared with other sources.

4.1. Road traffic noise

Effectiveness of existing legislation

As explained in section 2.1.1, EU Directive 70/157/EEC introduced the first harmonised noise requirements for road vehicles in Europe. This Directive presented permissible noise limits for different vehicle categories and specified a measurement method to be used to determine if vehicles were within those permissible limits. This Directive has been amended several times since, in an effort to account mainly for the changing vehicle fleet composition in Europe. The amendments were targeted at making the type-approval noise limits more robust. In this sense, they focused mainly on a reduction in permissible noise limits with the most recent occurring in 1995. However, the 1995 reductions did not have the expected effect and subsequent studies have shown that the measurement procedure described in the standard no longer reflects the real life driving behaviour[1], i.e. the measurement procedure does not accurately represent the real noise characteristics of traffic. In particular, the contribution of tyre rolling noise to total noise emission was underestimated in the original test method.

[1] TNO, VENOLIVA – Vehicle Noise Limit Values – Comparison of two noise emission methods – Final Report, 30 March 2011. Available at: http://ec.europa.eu/enterprise/sectors/automotive/files/projects/report-venoliva_en.pdf.

Overall, noise levels from road traffic vehicles have reduced over the last few decades, but the level of reduction has not been enough. Interior noise levels have reduced in cars but the same reduction has not been achieved for exterior noise. This may be driven by market forces; car owners will benefit from lower interior noise levels but exterior noise levels would not be a major factor influencing purchasing decision because noise from driving vehicles is an environmental externality not experienced by the driver.
In the case of motorcycles, current legislation is not sufficient. Motorcycles are often a major source of complaint and stricter legislation is required. It must also be noted that motorcycle owners often alter or change the silencer so the desired noise reduction is often not achieved at source despite legislation. Some countries outside Europe have introduced roadside enforcement and it may be prudent to consider similar legislation in the EU. Examples of this include the Australian New South Wales government that have introduced on-the-spot fines for vehicles that exceed noise emission[2].

Revision of EU legislation

Given the aforementioned problems with the existing test method, the UNECE Working Group on Noise[3] published a new test method in 2007. To monitor its application, the new method was used in parallel with the existing test method and results from both methods were submitted to the European Commission as a means of evaluating the appropriateness of the new method[1]. The new test method involves both an acceleration test and a constant speed test and the aim is to better represent today's general urban driving conditions. UNECE Regulation No. 51 specifies two type-approval test methods that would be evaluated over a period of two years[4] - the existing test method (Method A) and the proposed new test method (Method B) - to determine the potential applicability of Method B and quantify the impact that using Method B would have on existing permissible noise limits. In this regard, a recent study examined the differences between the current type approval test (Method A) and the proposed method (Method B). It found that the test results of the new method are, depending on the vehicle category, up to 2 dB(A) less than those obtained under the old method[5]. This means that if the new test method was used in conjunction with the older limits, the limits would effectively be increased by up to 2 dB(A).

The study also assessed five separate policy options for the future test method and corresponding permissible limit values. Each option was evaluated in terms of its environmental noise impact by taking different road types, traffic compositions and population exposure into account. In terms of environmental noise levels, the research concluded that the greatest overall benefit was associated with policy options utilising the new test method. As a result, reductions in the existing permissible noise limits were recommended using a two-step approach. For light and medium size vehicles, the approach is to lower the limit values in two steps of 2 dB(A) each; for heavy vehicles, the limit is to be lowered in a first step of 1dB(A) followed by a second step of 2 dB(A). The VENOLIVA study suggested introducing these two steps over two years while the Commission proposes introducing the steps two years after publication and then five years after publication i.e. 3 years later[4]. The research argues that such an option would result in L_{den} and L_{night} reductions of 3.1 dB on average, thus increasing the quality of life for millions of EU citizens[6].

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2 See: http://www.environment.nsw.gov.au/noise/motorvehiclenoise.htm
3 United Nations Economic Commission for Europe Working Party on Noise (GRB): http://www.unece.org/trans/main/wp29/meeting_docs_grb.html.
4 Regulation No 51 of the Economic Commission for Europe of the United Nations (UN/ECE) - Uniform provisions concerning the approval of motor vehicles having at least four wheels with regard to their noise emissions, Regulation UN/ECE, Geneva, Switzerland, 30 May 2007.
5 Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the sound level of motor vehicles /* COM/2011/0856 final - 2011/0409 (COD).
6 TNO, VENOLIVA (2011).

In December 2011, the Commission published a proposal for a Regulation on the sound level of motor vehicles[7]. This proposal (currently under consideration) takes cognisance of the new test method and the permissible limit values. New permissible noise limits are being proposed. However, these new limits are only applicable to new vehicles and will have no impact on the existing fleet in Europe. Effectively, the reduction in the noise level at the source would have no real impact on environmental noise levels until new vehicles start to dominate the fleet which could take five to ten years. Furthermore, the two-step approach being adopted under the proposal will further delay the impact of the proposed measures. Limits during phase one, to be enforced two years after publication of the new regulations, only introduce a moderate reduction in permissible noise levels. An earlier introduction of the stricter limits would be more beneficial. However, it is also important that policymakers and legislators consider noise in terms of exposure as well as emission. Although noise emission limits have become more stringent over the years, this has not had any significant impact on exposure levels. In fact, the evidence available suggests the problem of environmental noise is one of the only environmental problems in the EU that is dis-improving[8] despite 'quieter' vehicles.

Furthermore, some stakeholders have suggested that, following draft changes, the limits proposed by the European Parliament's Environment Public Health and Food Safety Committee (ENVI) together with reclassifications of vehicle classes actually lead to much weaker and ineffective standards[9]. They suggest that some vehicles may now qualify for different categories allowing higher noise limits that were originally intended for much larger or high performance vehicles and warn against allowing flexibilities in the test method that may be exploited by vehicle manufacturers[7]. However, manufacturers have suggested that it is not yet possible to achieve more than 1 or 2dB reductions at source and more stringent noise limits would require modifications to today's vehicle architecture[10].

Concern also exists over the use of ultra-quiet tyres in tests. It has been suggested that limit values for trucks should be reduced by 1dB(A) when trucks are tested with ultra-quiet tyres that are rarely used in real world driving conditions[11]. This certainly should be the case or the use of ultra-quiet tyres should not be permitted during the testing procedure i.e. a standard tyre should be used. At the moment the use of ultra-quiet tyres effectively enables manufacturers to make louder cars.

There is also an issue surrounding the relative quietness of electric vehicles particularly for the disability impaired e.g. blind and low-vision individuals. Plans are currently being formulated to introduce artificial noise into these vehicles and a working group on minimum sound levels for silent vehicles has been established by UNECE[4]. An Acoustic Vehicle Alerting System (AVAS) has been proposed which will generate noise for vehicles from rest to a speed of approximately 20 km/h and when reversing. The proposal correctly notes that the AVAS should be harmonised and lists certain types of sounds that should be avoided. However, it also states that the fitting of systems should remain an option at the discretion of the vehicle manufacturers[4]. This is a cause for concern and it will be important that such a system is tightly controlled.

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7 Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the sound level of motor vehicles /* COM/2011/0856 final - 2011/0409 (COD).

8 Murphy, Enda, King, Eoin A., Rice, Henry J. (2009) Estimating human exposure to transport noise in central Dublin, Ireland, Environment International, 35, 298-302.

9 Transport and the Environment, Briefing: New EU vehicle noise limits, June 2011.

10 Pardo LF and Steven H, Monitoring Procedure in the vehicle noise regulation, report number UTAC_10/06370, prepared for the European Automobile Manufacturers' Association, August 2010

11 Amendments 95-143, Proposal for a Regulation of the European Parliament and of the Council on the sound level of motor vehicles. 12th June 2012.

More definite restrictions on the permissible acoustic signal will be required to ensure that artificial noise levels do not compromise the considerable environmental and public health benefits associated with quiet vehicles. It should also be noted that an excessive increase in diverse warning sounds on the streets might even have a disorienting effect; thus defeating the original purpose of the AVAS. Further research in this area is required and should eventually inform tight and effective regulatory and noise control strategies.

A further issue is that public knowledge of environmental noise is still limited. In this sense, it may be useful to inform the public more clearly about the different noise levels associated with tyre types. A recent report by the Forum of European National Highway Research Laboratories (FEHRL) suggests that tyres should be stamped with the noise level achieved in the type-approval test[12] but a more intuitive system, e.g. similar to the way electrical appliances have energy ratings, could be established for different tyre types. The new rating system introduced by Regulation 1222/2009 as shown in Figure 2 (chapter 2.1.1) is coming into force in November 2012. However, this system lists the dB value associated with tyres but may not be intuitive enough for the general public. In this regard, encouraging programs across the EU, such as the De Nieuwe Band campaign[13] in the Netherlands, may help to raise awareness around more 'noise friendly' tyres as well as raise awareness of noise as an environmental issue more generally.

In overall terms, the most effective road traffic noise control strategies involve noise control at source. Roadside mitigation measures (e.g. noise barriers) or mitigation at the receiver (e.g. acoustic glazing) only provides localised mitigation; they do not provide sufficient protection for the general population in Member States. Imposing stricter limits at source would force vehicle manufacturers to develop quieter vehicles. Alternatively, introducing a noise tax on manufacturers that might influence the purchase of different vehicles may force manufacturers to develop quieter vehicles; but such a measure would likely be highly controversial. In any case, the goal must be to develop quieter vehicles. This can only be achieved by stricter and more ambitious targets for reduction in permissible noise levels. The test method must also be reflective of real world driving conditions and 'workarounds' such as ultra-quiet tyres must be eradicated through legislative amendment. Vehicle categories must also be stringently defined; it may be prudent to base noise limits for different vehicle categories on prevalence in the fleet in an effort to control the actual noise levels on the street. This may be particularly relevant in the classification of high performance vehicles or 'sports cars'. The production of high performance vehicles is a niche area for Europe's car industry and enforcing tighter noise limits may have an adverse impact on this area[14].

As mentioned in chapter 2, noise levels from motorcycles are dealt with under a separate Directive that sets limits for the permissible sound level of motorcycles and requirements for exhaust or intake silencer[15]. It also describes a relatively simple harmonised testing procedure. In general motorcycles fitted with standard silencers give the lowest type approval. However, given the high levels of annoyance associated with motorcycles it may be prudent to lower the permissible noise levels further.

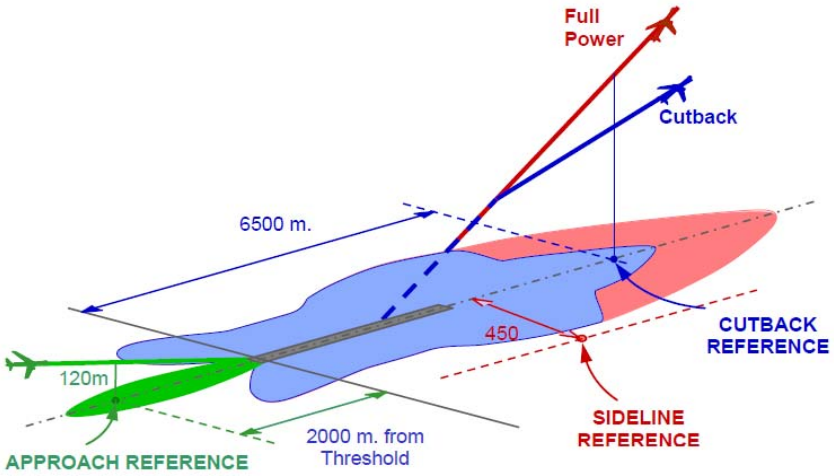
[12] FEHRL Report, Final Report SI2.408210 Tyre/Road Noise – Volume 1.
[13] See: http://www.destilleband.nl/.
[14] Opinion of the European Economic and Social Committee on the Proposal for a Regulation of the European Parliament and of the Council on the sound level of motor vehicles COM(2011) 856 final — 2011/0409 (COD).
[15] OJ L 226, 18.8.1997, p. 1.

4.2. Air traffic noise

Effectiveness of existing legislation

Aircraft noise arises mainly as a result of airframe noise and jet engine noise (or propeller noise on propeller driven aircraft) [16]. Permissible noise levels from individual aircraft are set out by the International Convention on International Civil Aviation (ICAO)[17] as presented in Chapter 2. This document identifies the Effective Perceived Noise Level (EPNL) as the parameter to assess aircraft noise within the noise certification process. The measurement procedure involves three monitoring points for which different noise limits are set; along the approach path, along the take-off path and at a sideline position (Figure 3).

Figure 3:Location of noise certification points



Source: Proceedings of the 14th International Congress of Sound and Vibration, Australia[18]

In September 2001, the ICAO[19] Council adopted a new noise certification standard, namely 'Chapter 4' (Annex 16, Volume 1 of the Chicago Convention), that would come into force from 2006 for newly designed aircraft. However, at that time, most of the production aeroplanes were already compliant with the Chapter 4 standard, so the new standard was not sufficient to improve the already existing noise environment around airports because the phase out of Chapter 2[20] aircraft had already been completed[21].

The strengthening of regulations on community noise near airports has ensured that the reduction of noise generated by aircraft at take-off and approach remains an essential consideration in the design of new commercial aircraft[13]. As mentioned in Chapter 2, the EC issued Directive 2002/30/EC aimed at dealing with procedures concerning the introduction of noise related operating restrictions at community airports.

[16] ISO 1996-1 (2003) Acoustics – Description, Measurement and Assessment of Environmental Noise – Part 1: Basic Quantities and Assessment Procedure.
[17] International Civil Aviation Organization, Annex 16 to the Convention on International Civil Aviation, Environmental Protection, Volume 1 Aircraft Noise, July 2008.
[18] R J Astley, A Agarwal, K R Holland, P F Joseph, R Sugimoto, R H Self, M G Smith, B J Tester, Predicting and reducing aircraft noise, proceedings of the 14th International Congress of Sound and Vibration, Cairns Australia, July 2007.
[19] International Civil Aviation Organisation: www.icao.int.
[20] EU Directive 92/14/EEC required the phase out of Chapter 2 aircraft by April 2002.
[21] Report from the Commission to the European Parliament and the Council concerning existing Community measures relating to sources of environmental noise; pursuant to article 10.1 of Directive 2002/49/EC relating to the assessment and management of environmental noise, March 2004.

The Directive took cognisance of international principles on noise management including the International Civil Aviation Organization's (ICAO) concept of a 'balanced approach'[22]. The introduction of operating restrictions may have a substantial impact on business and operations, as it restricts access to an airport. Hence, the process leading to a decision on noise-related operating restrictions should be consistent, evidence-based and robust to be acceptable for all stakeholders[23]. Such restrictions may include the withdrawal of certain aircraft types, land use planning and management measures, or the use of 'hush kits', i.e. devices for reducing noise emissions from aircraft engines.

It should be noted that significant improvements have been achieved in noise levels from aircraft. Aircraft being produced today are 75% quieter than those manufactured 50 years ago[24]. European legislation in this area has been proactive and has phased out noisy aircraft. In 2002 the EC issued Directive 2002/30/EC which set out procedures regarding the introduction of noise related operating restrictions at airports. The Directive also allowed competent authorities to restrict marginally compliant aircraft i.e. aircraft that meet the noise standard by only 5dB or less[25]. While the Directive did have some positive effects, it introduced a level of consistency to the balanced approach and ensured that all interests were taken into account when considering operation restrictions, its impact has been minimal. In 2008, the Commission published a report on the application of Directive 2002/30/EC[26] which, in general, showed that the Directive had not directly influenced noise management around the airports concerned. Some authorities reported that the Directive merely reflected what was already possible under national legislation. Furthermore, several authorities expressed concerns about the requirements for a consultation and a cost/benefit analysis of alternative means of reducing noise around the airport[22]. Overall, the report predicts that the number of people affected by aircraft noise will continue to grow.

Revision of EU legislation

In 2000, the Advisory Council for Aeronautics Research in Europe (ACARE) was established. This developed a Strategic Research Agenda (SRA) that would help to achieve the goals of the Vision for European Aeronautics in 2020[27] which, in terms of noise, was to cut the perceived noise level per flight by 50%. ACARE established a target of a 10dB reduction in aircraft noise between 2000 and 2020 which was being achieved on a 'pro rata' basis in the first half of that period[13]. However, maintaining this rate of reduction is proving difficult. Further research is required to identify potential noise reduction measures at source that can be feasibly obtained. In this regard, novel aircraft design that emphasises noise reduction should be encouraged.

[22] The "balanced approach" concept of aircraft noise management comprises four principal elements and requires careful assessment of all different options to mitigate noise, including reduction of aeroplane noise at source, land-use planning and management measures, noise abatement operational procedures and operating restrictions, without prejudice to relevant legal obligations, existing agreements, current laws and established policies (Directive 2002/30/EC).

[23] Proposal for a Regulation of the European Parliament and of the Council on the establishment of rules and procedures with regard to the introduction of noise related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC of the European Parliament and of the Council, 1st December 2011.

[24] ICAO, Aviation Outlook, ICAO Environmental Report 2010.

[25] Marginally compliant aircraft meet the certification limits by a cumulative margin of less than 5dB (in terms of the Effective Perceived Noise Level).

[26] COM (2008) 66 final.

[27] Vision for European Aeronautics 2020: http://ec.europa.eu/research/growth/aeronautics2020/en/aero03.html.

Given the highly technical nature of noise generation in aircraft and the difficulties associated with achieving reductions, it is not appropriate to consider aircraft noise control in a legislative context similar to the permissible noise limits for road vehicles. Instead more legislative focus should be placed on noise at sensitive receivers in the vicinity of airports, i.e. not necessarily on noise at source. Of course noise reductions at source are very desirable and further research in the area should also be supported.
In December 2011, a proposal was announced with regard to the introduction of noise-related operating restrictions at airports thus repealing Directive 2002/30/EC[28]. It aims to revise existing noise strategies in the vicinity of European airports. The proposal outlines three items that are encouraged through the balanced approach[16]:

1. To mitigate aviation noise using the optimum local combination from a range of measures: (a) reducing noise at source (i.e. quieter aircraft); (b) better land use management in the vicinity of airports; (c) introducing operational noise abatement procedures (i.e. using specific runways, routes or procedures); and (d) imposing noise-related operating restrictions (such as a night-time ban or phasing out of noisier aircraft);
2. To select the most cost-effective range of measures;
3. Not to introduce noise-related operating restrictions unless the authority is in a position, on the basis of studies and consultations, to determine whether a noise problem exists and having determined that an operating restriction is a cost-effective solution to the problem.

Thus, any discussion on aircraft noise mitigation must take cognisance of the knock-on effects that any noise reduction recommendations might have. This is particularly relevant for options 1(b), (c) and (d).
The proposal also summarises a record of its public consultation period. Respondents called for a wider definition of marginally compliant aircraft. These types of aircraft only just comply with the current noise standards and would generate more noise than aircraft that comfortably comply with the standards. This means that they significantly contribute to the noise problem around airports. Noise control strategies should focus on these aircraft types and future legislation should focus on a phase-out of such aircraft.

4.3. Railway traffic noise

Effectiveness of existing legislation

Railway noise is the second most dominant source of environmental noise in Europe, with approximately 9 million people exposed to levels in excess of 50 dB(A) at night throughout the EU[29]. However, in assessments of annoyance from different sources, aircraft noise has been found to be most annoying type of environmental noise, followed by road traffic noise and noise from railways was found to be least annoying. Thus, the International Standard Organization (ISO) standard 1996-1(2003)[30] recommends a railway noise 'bonus' of between 3dB(A) to 6dB(A) while a 3dB(A) to 6dB(A) 'penalty' should be applied to aircraft noise to account for differing annoyance levels.

[28] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Union airports within a Balanced Approach and repealing Directive 2002/30/EC of the European Parliament and of the Council, COM/2011/0828 final - 2011/0398 (COD).

[29] Report from the Commission to the European Parliament and the Council on the implementation of the Environmental Noise Directive in accordance with Article 11 of Directive 2002/49/EC, 1st June, 2011.

[30] ISO 1996-1:2003 defines the basic quantities to be used for the description of noise in community environments and describes basic assessment procedures. It also specifies methods to assess environmental noise and gives guidance on predicting the potential annoyance response of a community to long-term exposure from various types of environmental noises: http://www.iso.org/iso/catalogue_detail?csnumber=28633.

Three main sources contribute to overall noise levels from a moving train: rolling noise, traction noise and aerodynamic noise. Railway freight traffic is the main contributor to noise problems along European railways but high-speed and inner-urban railway lines are also significant[31].

As mentioned already (section 2.2.3), European legislation on noise from railways is addressed primarily in interoperability Directives and further specified in Technical Specifications for Interoperability (TSI)[32]. In a similar fashion to permissible noise limits for motor vehicles these Technical Specifications set noise limit values for new and upgraded rail vehicles under different modes of operation. The current standards came into force in 2002 and 2006 for high-speed and conventional-speed trains respectively.

Overall, railway noise has been reduced over the last few decades with particular improvements in both the internal and external noise levels. Railways have a long history of research on noise control and mitigation and since the late 1980's, in particular, numerous studies have developed and analysed various abatement possibilities[33]. Yet there still exists further scope for enhanced noise reduction and this may be driven by future legislation.

Revision of EU legislation

A revision to the current TSI for rail noise is planned for 2013 and is led by the European Railway Agency (ERA). As part of the revision ERA is collecting the contribution of different stakeholders. Three essential requirements have been identified for the update of the current TSI[34, 35]. These include: (1) a reduction in noise emission limits for rail vehicles; (2) including the existing rail fleet in the noise regulations; and (3) extending noise regulations to address both vehicles and infrastructure[25].

In relation to (1), it has been suggested that it is possible to test rail vehicles on a low noise test track which may bypass the current limit values as there is a considerable spread of noise emission values on these reference tracks[25]. This suggests that vehicles may comply with noise limits on a test track but, when operating on another track, noise levels may be higher. This spread is likely to be due to the quality of the test tracks and not to the spread of the test process[36]. Thus, it seems that a more rigid definition of the test track would go a long way towards introducing more consistency in the testing process for rail vehicles. However, the Community of European Railway (CER) has noted that such an (expensive) option would provide minimal benefit. The CER, the European Infrastructure Managers (EIM) and the International Union of Railways (UIS) are currently building a complete dataset of wagons under the Technical Specification CR NOI TSI:2006[26]. When this dataset is available, it will be possible to draw more conclusions on the best way to proceed. Irrespective of this, more consistency in the test method, perhaps with the introduction of back-end corrections to account for deviations from a defined reference track, should be carefully considered.

[31] WG Railway Noise of the European Commission, Position Paper on the European strategies and priorities for railway noise abatement, Version 19403, 2003.
[32] Technical Specifications for Interoperability identify the specifications of each rail subsystem (or part of each subsystem) to ensure the interoperability of the trans-European rail systems.
[33] ERRAC Roadmap WP01 – The Greening of Surface Transport, Towards 2030 – Noise and Vibration Roadmap for the European Railway Sector, December 2011.
[34] Transport and Environment, Revision of EU rail noise standards (TSI), Input to the ERA Working Party TSI Noise.
[35] Transport and Environment is an NGO working in the area of smart and green transport policies. For more information the reader is referred to http://www.transportenvironment.org/.
[36] Community of European Railway (CER), CER position on the T&E input to the ERA WP TSI Noise, February 2012.

For (2), given that freight trains are the biggest contributor to railway noise and these types of trains operate primarily at night, the noise issues from the existing fleet must be addressed together with new rail vehicles[25]. Significant reductions in average daily noise exposure levels will only be achieved when a substantial portion of the existing operating fleet is retrofitted. This issue is compounded by the relatively long life span of railway vehicles in comparison to motor vehicles. Therefore, some form of incentive (e.g. a financial subsidy from the EU) should be put in place to promote silent vehicles and further technical developments must be supported in this area[37]. The European Working Group on Railway Noise also recognises freight trains as the most important railway noise source and recommends setting new limits for new vehicles as well as the retrofitting of the existing cast iron block-braked freight wagons[21]. The Working Group also recommends an implementation schedule of no longer than 10 years which is reasonable.

For (3), it is important to note that noise limits at the source currently only apply to manufacturers but a number of noise mitigation measures may be also implemented by the rail operator. Thus, legislation should be extended to include infrastructure as there is currently no incentive for operators to reduce noise emissions. These limits might be set at sensitive receivers in the vicinity of the rail line; this is common in a number of Member States at present, although the noise limit varies from State to State. Sub-optimal economic solutions such as noise barriers should be discouraged and alternative strategies for noise mitigation should be investigated.

There are a number of new developments in design and testing techniques which have the potential to significantly reduce noise from railways. To name but a few potential reduction measures:

- The SILENCE project showed potential improvements of up to 10dB(A) in the design of a cooling system used in railway vehicles by introducing the concept of a radial fan[38].
- Retrofitting with K-blocks and LL-brake blocks across the entire network may have the potential to achieve overall reductions of 8 to 10 dB(A)[39].
- In future, more sophisticated type testing methods (including more rigid specifications of track conditions) are required for low noise vehicle identification and for better separation of the noise emission contribution from vehicles and tracks[40].

The preconditions for the implementation of noise-differentiated track access charges have been identified[41]. Such charges would provide stakeholders with an incentive to retrofit freight wagons.

[37] International Union of Railways (UIC), Railway Noise in Europe A 2012 report on the states of the art, September 2010.
[38] Frid A and Fehse KR, Improved design of a diesel engine cooling system, Deliverable Number E.D17 of the Silence Project, 19th October 2007.
[39] International Union of Railways (UIC), Railway Noise in Europe A 2012 report on the states of the art, September 2010.
[40] Calm Network, Research for a Quieter Europe in 2020, October 2004.
[41] Analyses of preconditions for the implementation and harmonisation of noise-differentiated track access charges, Project Number TREN/E2/287-2008 Final Report submitted to the European Commission, October 2009.

Similarly to road traffic noise, European citizens would benefit from more ambitious targets for permissible noise levels. A priority research area for the future would be achieving noise reductions in freight trains as these are noisiest and tend to travel predominantly at night time. Noise reductions aimed at the source would provide the greatest benefit; however, management strategies such as scheduling of train journeys have the potential to improve the noise environment as well. Such strategies would be more effective for rail traffic as opposed to road traffic given the nature of rail operations.

4.4. Noise emitted by outdoors equipment

As explained in Chapter 2, Directive 2000/14/EC is the main legislation relating to noise emission in the environment by equipment for use outdoors[42]. Its purpose is to improve the health and well-being of the population by reducing the noise emitted by outdoor equipment and therefore the annoyance caused by outdoor equipment. In total the Directive requires noise marking (with a guaranteed sound power) for 57 equipment types ('Article 13' Equipment) and sets noise limit values for 22 of these ('Article 12' Equipment). Appropriate measurement methods are specified in the Directive. Since Directive 2000/14/EC came into force, Declarations of Conformity have been collected by the Commission and these have been used to assemble a database of measured and guaranteed noise levels.

In 2007, the Dutch research organisation TNO conducted a study on the experience in the implementation and administration of the Outdoor Noise Directive (commonly referred to as the NOMEVAL Report)[43]. Overall, TNO concluded that the data collected by the Commission could be used for a statistical analysis although insufficient data was present for some equipment types. In the future such errors may be avoided by implementing an automated data input check procedure. The TNO NOMEVAL report identifies 16 equipment types that should be re-designated as Article 12 instead of Article 13 equipment. Thus, these equipment types should be subject to permissible noise limits[44]. Furthermore, it was found that 11 of 22 new equipment types assessed during the study should be designated as Article 13 equipment. The report also notes that since the Directive came into force, new international standards have been established for a number of equipment types, and others are at the final stage of being approved and/or being discussed. Thus any revision of the Directive should take cognisance of the latest international standards. These new standards partly reflect the original measurement procedure of the Directive. However the report notes that existing test procedures are inadequate for a number of Article 13 equipment types.

Key recommendations from the TNO NOMEVAL report include:

- Market surveillance is essential for the Directive to be effective;
- Focus should be put onto equipment with a high or very high environmental impact;
- EN or ISO standards should be used wherever possible;
- The noise label should be made more understandable for consumers;
- The market for low noise products should be stimulated;
- Noise reduction should be balanced with requirements for gas emission, public health and costs;
- Similar equipment types should be combined into groups;

[42] Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors (OJ L 162, 3.7.2000, p. 1–78).

[43] TNO report MON-RPT-033-DTS-2007-03482 Study on the experience in the implementation and administration of Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors - Final Report. Available at: http://ec.europa.eu/enterprise/newsroom/cf/_getdocument.cfm?doc_id=5009.

[44] Article 12 equipment types are subject to permissible noise limits.

- Non-standardised test codes and definitions should be improved in cooperation with industry and notified bodies;
- Lawnmower limits may be reduced by an improved formula and further research is needed;
- Engine and truck manufacturers should be given incentives to offer quieter engines and carrier vehicles.

The European Materials Handling Federation (FEM) has commented on the TNO report and they have observed that the proposed economic analysis needs to be completed[45]. They have also requested the Commission to consider Directive 2000/14/EC in a broader regulatory context and agenda, and in particular within the set of Directives already applying to FEM products and setting environmental and safety requirements[46]. Finally, FEM fully supports the statements relating to the lack of market surveillance and the need for such surveillance.

In 2010, the European Commission launched a public consultation to gather views on its proposal for revising the Directive[47]. It was noted that the majority of the participants agreed that the noise data contained in the database should not be used for possible revisions of the Directive without additional research efforts and gathering of noise data, although many contributions found the database a useful market surveillance tool. Furthermore, a slight majority agreed that the intervention of an external verification organisation (notified body) adds to the credibility of the EC Declaration of conformity.

There is little doubt that further research is needed with regard to establishing new noise limits for different machinery types. The Directive groups machinery into different type and size categories. Further research should be conducted on the acoustic characteristics of each equipment type as it may be appropriate to set different parameters for different source types, particularly in terms of noise annoyance. This should be completed prior to revision of the existing legislation. Furthermore, the manner in which multiple equipment types (i.e. noise sources) operating together contribute to overall annoyance is another area in which further research is needed and this not catered for at all in the Directive. It must be recognised also that the Outdoor Noise Directive is highly dependent on a number of other Directives (i.e. Engines Emissions Directive and the Machinery Directive) and, therefore, any revision must take cognisance of the impact it will have across a much wider spectrum.

[45] The European Materials Handling Federation (FEM), Initial Comments on the NOMEVAL Technical Report presented by TNO, Study on the experience in the implementation and administration of Directive 2000/14/EC relating to the noise emission in the environment by equipment for use outdoors, November 2007.
[46] Ibid.
[47] DG Enterprise and Industry, Report on the results of the public consultation on the revision of Directive 2000/14/EC on noise from outdoor equipment, 2010.

4.5. Noise from recreational craft

Noise levels from recreation craft, or craft intended for water sport or leisure purposes, are discussed in Directive 2003/44/EC. Article II of this Directive specifies that the Commission had to undertake and submit a report on the possibilities of further improving the environmental characteristics of engines and to consider the need to revise boat design categories. Thus, a study on further improving the environmental characteristics of recreational craft engines was conducted by TNO[48].

The study reports that further reduction of engine noise can only be effective for low power craft. The noise impact is greater for high power craft due to the combined effect of engine and hull noise. To reduce the noise impact for high power craft, measures are required to address both the engine and hull sources. As the latter are not always technically feasible, the study concludes that noise abatement in environmentally sensitive areas should be achieved by other means, such as operational measures regulating the use of such craft[49]. Given that low power craft has already the lowest noise impact, future research should focus on how noise levels could be reduced for both engine and hull noise. The stocktaking study also evaluated the impact that noise levels from recreational craft had on humans and wildlife. It found that the impact on humans varied between 38dB(A) and 56 dB(A)[50] which, when relative to other environmental sources, is not excessive. However, for parklands and conservation areas these levels may indeed be considered high. In 2007, a complementary impact assessment on possible emission reduction measures was conducted[51]. This examined emission requirement applied in other parts of the world as well as assessing the effectiveness of potential mitigation measures.

With regards to current legislation, the current fleet of recreational craft are not considered to be a key contributor to environmental noise. Given that further noise reductions will require significant research, it may be most appropriate to introduce operation restrictions in areas that require protection instead of reducing noise at the source. Measures such as speed limits, use restrictions, or outright bans may be appropriate for conservation areas but these should be assessed at a local level on a case-by-case basis. With regard to the impact on wildlife, no firm conclusions can be drawn at present and significant research is needed in the area.

[48] TNO Report, Stocktaking study on the current status and developments of technology and regulations related to the environmental performance of recreational marine engines, January 2005: http://ec.europa.eu/enterprise/sectors/maritime/files/regulatory/rc_study_exec_sum_en.pdf.

[49] Communication from the Commission to the council and the European Parliament, Report on the possibilities of further improving the environmental characteristics of recreational craft engines, submitted pursuant to Article 2 of Directive 2003/44/EC, amending Directive 94/25/EC relating to recreational craft.

[50] TNO Report (2005).

[51] See: http://ec.europa.eu/enterprise/sectors/maritime/files/regulatory/ia_rcengines_finreport_en.pdf.

5. FEASIBILITY AND ADDED VALUE OF FURTHER EU ACTIONS ON ENVIRONMENTAL NOISE

KEY FINDINGS

- The most cost-effective noise control and regulation measures are those targeted at the noise source. However, an effective policy-mix between mitigation of noise at the source (e.g. through legislation on noise sources) and noise abatement strategies at the receiver (e.g. through mitigation measures such as noise barriers, noise insulation, low-noise road surfaces) is desirable.
- On EU implementation guidance, good progress has been made, in particular on the development of the common methodology CNOSSOS-EU for noise assessment as well as on quiet areas.
- Although further EU guidance on the development of the national action plans is still needed, EU action to develop harmonised measures that Member States would have to include in their plans encroaches significantly on the principles of proportionality and subsidiarity.
- Improving synergies between air quality and noise management has been frequently proposed. However, so far the comparison of data remains superficial and further work in this area may serve to facilitate future interaction between the two policies.
- The setting of mandatory noise limit values at the EU level would touch upon subsidiarity issues and be difficult to implement. The introduction of health-based trigger values or recommended target values would be more feasible, politically acceptable and effective, especially if linked with stronger legislation to reduce noise at the source.
- Further research is needed to assess the appropriateness of the indicators under the END.

After reviewing the effectiveness and the gaps of the current EU legislative framework on environmental noise in previous chapters, this chapter looks into the feasibility and added value of further EU actions and provides an overview of recent developments in this direction.

First of all, section 5.1 includes a general analysis on the cost-effectiveness of selected mitigation measures, such as façade insulation, noise barriers, low-noise road surfaces etc. These measures should complement, but not replace, noise control and regulation measures targeted at the source, which remain the most effective approach for noise abatement.

The second part of the chapter considers progress made in the potential areas for improvement of the END that were identified in the Commission's 2011 implementation report, namely finalising the harmonised framework for mapping methods and developing EU implementation guidance (5.2), improving synergies between air quality and noise management (5.3) and facilitating reporting issues (5.4).

The chapter finally tackles the issues for further consideration identified in the Commission's implementation report, i.e. the establishment of EU wide limit, target or trigger values (5.5), the possible revision of noise indicators (5.6), the enforcement of the provisions in the national action plans (5.7), as well as further harmonisation of information and measures included in the action plans (5.8).

5.1. Cost-effectiveness of selected measures

The most effective noise control and regulation measures are those targeted at the noise source. Any effective noise control strategy must attempt to utilise noise control measures not only at the source but also at the point of the receiver. There is little doubt that reducing noise at the source is the most effective approach towards noise abatement and legislation targeting sources for the major modes of transport would likely be far more cost-effective than noise abatement strategies at the receiver. However, an effective policy-mix between the two is desirable. Until relatively recently, EU legislation has tended to focus almost exclusively on mitigation of noise at the source. As discussed in Chapter 2, the establishment of the current Environmental Noise Directive has been the first attempt to get a handle on legislating for exposure at the receiver. Here, the focus will only be on the key noise sources when analysing the most cost-effective mitigation measures[1].

With respect to **road-noise**, a number of key abatement measures exist and have been tested in the field with respect to their cost effectiveness. The most important measures include noise barriers, low-asphalt roads, low-noise tyres, façade insulation, traffic and land-use management measures.

In a recent Norwegian study, Klæboe et al[2] found that façade insulation was a more cost-effective measure[3] than a low-noise asphalt solution. However, in our view this solution is relatively short-sighted in that the benefits only accrue to the dwellings being treated, whereas the low-noise asphalt solutions ensure all dwellings along the treated road sections benefit from the potential noise reductions, not only those that are most affected by excessive noise. Moreover, low-noise asphalt has an additional (and considerable) advantage over façade insulation in that indoor and outdoor noise affecting all buildings near treated roads is less. Thus, the approach has the effect of improving the surrounding soundscape of the entire neighbourhood. While low-asphalt solutions can be highly effective – reducing noise by c. 4.5 dB[4] over the life-time of the surface - they also tend to be expensive. In fact, the best available double-porous asphalt is roughly twice as expensive per application compared to standard asphalt and has close to half the life-span. On a more general level, low-noise surfaces are effective mitigation measures and the recent proposal from the SILVIA project to introduce a noise classification system for roads should be considered[5].

The results from the Norwegian study found that an average equivalent noise reduction inside the dwellings of 7 dB was obtained from façade insulation[6]. These results are important because the Norwegian façade insulation programme was on a scale not undertaken before and encompassed 2500 dwellings where before and after annoyance surveys were undertaken. The results showed that annoyance was reduced from 42% being highly-annoyed before the programme to 12% afterwards.

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1 In the literature, cost-effective usually refers to cost-effectiveness analysis (CEA) which is a method of finding the least costly way of implementing particular measures. Measures more costly than the least costly approach are disregarded, even though the additional benefits may outweigh the added cost.

2 Ronny Klæboe, Knut Veisten, Astrid. H. Amundsen and Juned Akhtar (2011) Selecting Road-Noise Abatement Measures: Economic Analysis of Different Policy Objectives, The Open Transportation Journal, 2011, 5, 1-8.

3 The average cost per apartment for insulation in the Norwegian study was estimated at EUR 28,125 when applying an exchange rate in the year 2006 of 8 NOK to 1 EUR.

4 K. Veisten, and J. Akhtar, Cost-benefit analysis of low-noise pavements: dust into the calculations, Int. J. Pavement Eng., vol. 12, no. 1, pp.75-86, 2011.

5 SILVIA Project Deliverable, Classification scheme and COP method. Available at: http://www.trl.co.uk/silvia/Silvia/pdf/Main_Outputs/SILVIA-DWW-025-14-WP2-141005.PDF.

6 Astrid H. Amundsen, Ronny Klæboe, and Gunn Marit Aasvang (2011) The Norwegian Façade Insulation Study: The efficacy of façade insulation in reducing noise annoyance due to road traffic, J. Acoust. Soc. Am. Volume 129, Issue 3, pp. 1381-1389.

Yet, the study by Klæboe et al[7] suggests that a policy mix of low-noise asphalt and façade insulation is an even more efficient approach if cost-benefit analysis (CBA) rather than cost-effectiveness analysis (CEA) is used to evaluate the mitigation approaches. Similar conclusions have also been drawn in a recent study by the Forum of European National Highway Research Laboratories (FEHRL)[8]. It would certainly be more sensible to use low-noise road surfaces in more densely populated areas and perhaps façade insulation in sparsely populated areas.

Noise barriers tend to the least cost-effective approach despite being useful in specific cases. On average, noise barriers tend to reduce noise levels by 3–7 dB, depending on their design and height[9]. A recent study on cost-effectiveness of noise abatement measures in the Netherlands suggests a better performance of source measures compared to noise barriers and window insulation. The Dutch study found the most cost-effective measures for noise abatement to be the introduction of low-noise tyres because this had a considerable effect on reducing noise but no had side-effects; it would also cost very little given that the noisiest tyres could effectively be removed from the market through emission legislation[10]. The introduction of legislation on tyre labelling (effective November 1st 2012) should assist consumers in making tyre choice on the basis of their noise emission characteristics.
Other mitigation measures that have demonstrated success but have yet to be evaluated in the literature in terms of their cost-effectiveness/cost-benefit include urban traffic management[11] and land use measures. Land use management measures would seem to be particularly effective because it involves putting distance between the source of transport noise and the receivers. This can be done through thoughtful road and/or railway design.

For **railway noise**, the most cost-effective measures are once again those taken to prevent noise at source. The most commonly used approaches include improving those associated with rolling stock (brake-block technology, optimised wheels), track measures (rail absorbers[12], acoustic grinding to smooth rail tracks) and noise barriers. Results from the STAIRRS project analysing the cost-effectiveness of railway noise reduction on a European scale found that improving the braking system of rolling stock was the most cost-effective measure[13]. A more recent study for the European Commission came to similar conclusions suggesting that the most cost-efficient solution is to retrofit the fleet with low-noise brake blocks[14]; although this is dependent on the evolution of the noise abatement performance of low-noise brake blocks over time because little research has been conducted on the issue. The STAIRRS study also found noise barriers to have poor cost-efficiency especially if the barrier exceeds 2m in height. Overall, as with the case of road mitigation measures, the most cost-effective approach is to utilise a mix of measures. Track measures in combination with rolling stock measures tend to be highly cost-efficient as noise abatement measures.

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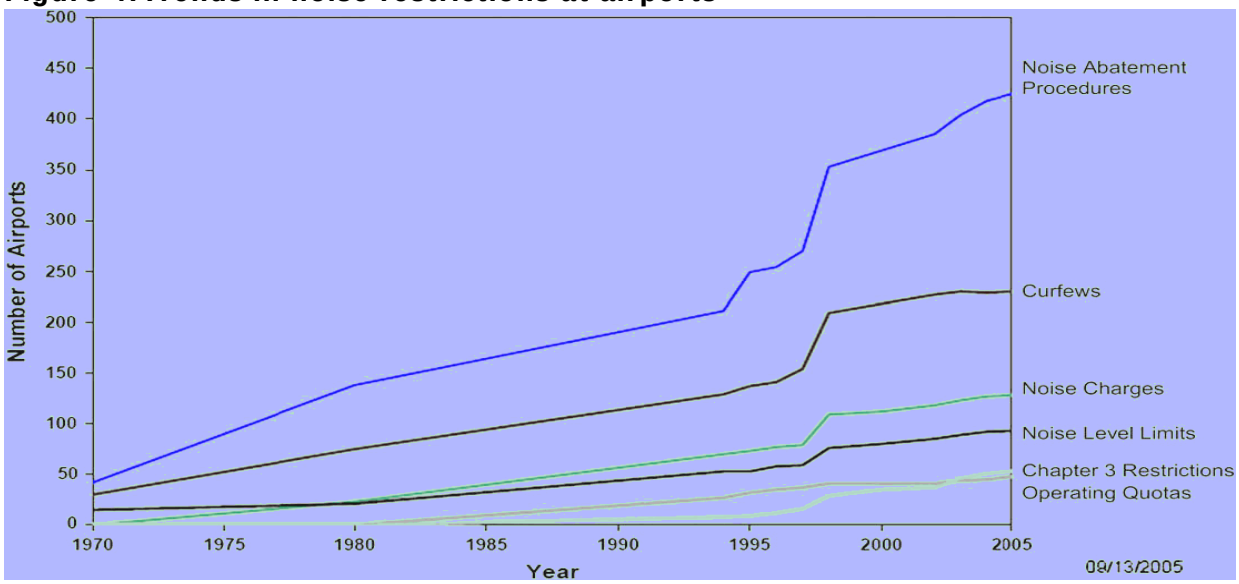
[7] Ronny Klæboe, Knut Veisten, Astrid. H. Amundsen and Juned Akhtar (2011) Selecting Road-Noise Abatement Measures: Economic Analysis of Different Policy Objectives, The Open Transportation Journal, 2011, 5, 1-8.
[8] FEHRL (2006) Sustainable road surfaces for traffic noise control: Guidance manual for the implementation of low-noise road surfaces.
[9] Jorge P. Arenas (2008) Potential problems with environmental sound barriers when used in mitigating surface transportation noise, Science of the Total Environment, 405, 173-179.
[10] H.A. Nijlanda, E.E.M.M. Van Kempena, G.P. Van Weeb, J. Jabben (2003) Costs and benefits of noise abatement measures, Transport Policy, 10 (2003) 131–140.
[11] Murphy, E. and King, E.A. (2011) Scenario analysis and noise action planning: modelling the impact of mitigation measures on population exposure. Applied Acoustics, 72 (8):487-494.
[12] Rail absorbers are fitted to tracks to reduce rolling and squealing noise.
[13] J. Oertli (2003) The STAIRRS project, work package 1: a cost-effectiveness analysis of railway noise reduction on a European scale, Journal of Sound and Vibration, 267, 431–437. Strategies and Tools to Assess and Implement noise Reducing measures for Railway Systems (STAIRRS). Available at: http://www.stairrs.org/.
[14] European Commission (2007) Impact assessment study on rail noise abatement measures addressing the existing fleet, TREN/A1/46-2005.

However, the best results can be achieved via a solution combining low-noise break blocks, optimized wheels, tuned rail absorbers, grinding and noise barriers not higher than 2m[15]. This mix of abatement measures protects close to 95% of the population and is relatively cost-efficient. Yet solutions for abatement do tend to be expensive. Oertli suggests that to reduce noise levels beneath 60 dB, annual costs of between €20,000–100,000/km may be necessary[16].

Regarding **aircraft noise**, since the late-1990s there have been dramatic increases in noise restrictions at airports (Figure 4). Figure 4 shows, in particular, the exponential increase in the use of noise abatement approaches at airports.

Figure 4: Trends in noise restrictions at airports



Source: Girvan[17] using Boeing data

The most common approaches used for abatement at airports include imposing noise limits, preferential runways and in-flight noise-abatement procedures, curfews, mandatory phase-out of noisier aircraft and other operational restrictions. However, there is no direct cost analysis of these measures in the literature so it is impossible to evaluate their cost-effectiveness adequately. However, one recent study was completed assessing the cost-benefit of the overall noise abatement strategy at O'Hare International and the results found that the benefit of implementing the programme outweighed the costs for the local community by a factor of three[18]. Most of the advances in restriction of aircraft noise at source[19] have come from improvements in aircraft design and improved engine technology[20]. In this regard there is significant research on-going for developing quieter aircraft but this has occurred mainly as a result of stricter certification standards[21].

[15] J. Oertli (2003) The STAIRRS project, work package 1: a cost-effectiveness analysis of railway noise reduction on a European scale, Journal of Sound and Vibration, 267, 431–437.
[16] J. Oertli (2006) Developing noise control strategies for entire railway networks, Journal of Sound and Vibration, 293, 1086–1090.
[17] Raquel Girvin (2009) Aircraft noise-abatement and mitigation strategies, Journal of Air Transport Management, 15, 14–22.
[18] Justin Brown, Jesse Seidman, Neil Solanki, David Neinstein, Steven Factor (2004) O'Hare International Airport Noise Pollution: A Cost-Benefit Analysis. Available at: http://www.areco.org/OhareAnalysis.pdf.
[19] Aircraft noise sources include airframe noise, jet-mixing noise, fan, compressor turbine and combustor noise.
[20] See R J Astley et al (2007) Predicting and reducing aircraft noise, ICSV14, Cairns, Australia, 9-12 July.
[21] Raquel Girvin (2009) Aircraft noise-abatement and mitigation strategies, Journal of Air Transport Management, 15, 14–22.

5.2. Developing EU implementation guidance

The review of implementation of the END published by Milieu in 2010[22] identified a number of areas where Member States called for additional guidance, including in strategic noise mapping, the identification and management of quiet areas, and developing and implementing action plans. In this section we review the need for guidance and consider whether actions are being taken to address those needs. Based on communication with the Commission, there are initiatives underway to develop guidance in these areas that will go some way to addressing the needs of Member States.

5.2.1. Guidance on strategic noise mapping

Regarding guidance on strategic noise mapping, the Joint Research Centre and the Commission have developed CNOSSOS-EU for road, railway, aircraft and industrial noise in accordance with END Art. 6.2. Following its adoption, CNOSSOS-EU is to be used by the Member States for the purpose of strategic noise mapping as required by Article 7 of the END. In particular, the implementation of the new CNOSSOS-EU methodology to perform noise assessment offers a solution to the inconsistent noise mapping undertaken in the past. The CNOSSOS-EU method will allow for comparison at EU level, and historical comparability in noise maps may be maintained if wished by back calculation.

The methodological framework at the basis of CNOSSOS-EU is based on noise assessment methods that were already being used in some Member States (e.g. Austria, Denmark, Finland, France, Germany and Sweden). In this sense, the transition to CNOSSOS-EU will not require investments in new systems and training of personnel. However, the problem is that, in some Member States, limit values are enshrined in national legislation and linked to the use of specific noise assessment methods. A change towards the new and tested CNOSSOS-EU method will eventually generate different results and limit values may then be transgressed if the new assessment method generates a higher result. In Germany for example, where noise maps show that noise values have been exceeded, measures are triggered to reduce noise with resulting cost implications[23]. CNOSSOS-EU also represents an opportunity for the calculation methodology to be coded into software by the EU and made available as freeware. This would eliminate the calculation inconsistency that currently exists between commercial vendors[24].

In order to introduce CNOSSOS-EU and support implementation, the JRC produced a report[25] in 2012 which describes the methodological framework to be applied for strategic noise mapping in Europe. Key elements of the methodological framework include the following:

- the objectives and requirements of CNOSSOS□EU;
- sections on road traffic, railway traffic, industrial noise source emission and sound propagation;
- a section on the methodology chosen for the aircraft noise prediction and its associated performance database;

[22] Milieu (2010).
[23] See requirements under the Federal Ordinance on Noise Mapping (34. BImSchV, Verordnung für die Lärmkartierung) in Federal Law Gazette vol. 2006, chapter I, pp. 516 ff.
[24] E. Murphy, E.A. King, Strategic environmental noise mapping: Methodological issues concerning the implementation of the EU Environmental Noise Directive and their policy implications. Environment International, 2009.
[25] Stylianos Kephalopoulos, Marco Paviotti, Fabienne Anfosso□Lédée (2012), Common Noise Assessment Methods in Europe (CNOSSOS□EU).European Commission Joint Research Centre - Institute for Health and Consumer Protection : http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/26390/1/cnossos-eu%20jrc%20reference%20report_final_on%20line%20version_10%20august%202012.pdf.

- a methodology to assign receiver points to the façades of buildings and to assign population data to the receiver points at the façades of buildings; and
- a summary on the outcome of the revision of the Electronic Noise Data Reporting Mechanism.

During Phase B on implementation, the JRC will develop and publish "Guidance for the competent use of CNOSSOS-EU". The guidance will focus on how the methods described in the 2012 report are to be applied in practice. The primary aim is to pull together key aspects of best practices currently set out within an array of documents and reports. The CNOSSOS-EU Guidance will be developed as an interactive web-based tool, allowing for multi-user inputs, rapid search functions, filtered viewing allowing users to tailor the viewed content to their needs and user feedback and subsequent improvements. An online community of agencies responsible for noise management in the Member States will be created around the online guidance tool, providing for the exchange of best practice and solutions to practical problems on the ground experienced during noise mapping.

5.2.2. Guidance on action planning

In their 2011 report on implementation, the Commission reported diverse results from the Member States on action plans, and noted that a comprehensive analysis was challenging. In particular, Member States took different approaches on how to establish priorities, in terms of the administrative level at which priorities were set, as well as the basis for priority setting, be it exceedance of limit or trigger values, health-based assessments, or population exposure. Many Member States felt that the minimum requirements set out in Annex V are not sufficient to help prepare these plans. Elements of action planning where guidance was called for include:

- making the leap from strategic noise maps to action plans;
- the types of concrete measures that action plans should contain to manage and reduce noise;
- the overall level of ambition of action plans;
- methodologies for evaluating action plans;
- what acoustic and non-acoustic criteria might trigger the implementation of measures; and
- when an action plan should be developed.

In addition, Member States called for guidance on the designation of quiet areas, an aspect that receives particular attention in section 5.2.3 below.

The Milieu review of implementation identified problems with the allocation of responsibilities for implementing measures in a situation where action plans are developed by a local authority, while another authority has competence over the noise source and would therefore need to be involved in implementing measures. This experience suggests that in planning actions, effective consultation and coordination with all relevant authorities is essential. It may therefore be relevant to include recommendations for coordination mechanisms and the possible establishment of a focal point for noise management in any guidance on action planning.

There was also uncertainty regarding the implementation of measures under action plans on issues that are already regulated by EU source specific legislation. It may be useful to clarify that any limits or requirements under source-based legislation have precedence and that measures under action plans can only make such requirement more stringent.

In developing the first round of action plans, several Member States elaborated national guidance on action planning that could provide a basis for developing EU level guidance, including Austria,[26] Denmark,[27] Ireland,[28] Portugal,[29] Slovakia[30] and the UK[31].

Finally, within the framework of implementing EMAS, the JRC is working on a manual of best practice for local communities, including a section on measures to address urban noise[32].

In terms of EU-level guidance on action plans, while there are currently no on-going activities focussed on generating guidance on action planning, the Commission indicated that the need is well recognised and that discussion are underway as to how the need might best be addressed. Provision is made for the development of guidance on action planning under Article 13(2) of the END. As such, the demand for guidance on action planning that elaborates on the description provided in Annex V and provides details of best practices is acknowledged and future action is desirable.

5.2.3. Guidance on quiet areas

Regarding quiet areas, the definition of quiet areas in agglomerations and in open country in the END Art. 3 leaves considerable discretion to Member States in delimitating the areas, as already discussed in Chapter 2 and 3. Likewise, while Article 8 requires that action plans for agglomerations should aim to protect quiet areas, there are no specific requirements regarding the protection of quiet areas in open country. The degree of discretion left to Member States in defining quiet areas and securing their protection led to confusion on the part of some Member States as to the role of quiet areas in the END, in particular quiet areas in open country. The result was divergent approaches across the EU. While the majority of Member States designated quiet areas in agglomerations, many have not yet done so in open country, with none citing specific plans for the protection of quiet areas in open country specifically linked to implementation of the END.

While various projects have explored the definition of quiet areas and generated reports, the approaches use different criteria for identifying quiet areas and there is no recommended harmonised EU approach. The approaches use the following criteria, in various combinations:

- acoustical criteria (thresholds), subject to limited accuracy when noise levels are low (ie screening is high);
- non- (or not only) acoustical criteria;
- distance based criteria (i.e. distance for noise sources such as major road);
- mixed criteria; and/or
- other factors, including political decisions, accessibility, urban planning, historical centres, recreational value.

[26] Austrian guidance on action planning available at: www.laerminfo.at.
[27] Danish guidance on action planning available at: http://www.mst.dk/English/Noise/noise_mapping_action_plans/.
[28] Irish guidance on action planning available at: http://www.epa.ie/downloads/advice/noisemapping/name,27056,en.html.
[29] Portuguese guidance on action planning available at: http://www.apambiente.pt/politicasambiente/Ruido/NotasTecnicas/Documents/PMRR.pdf.
[30] Slovak guidance on action planning available at: http://www.health.gov.sk/redsys/rsi.nsf/0/3e6b545e2697a78cc1256f970033e1b0/$FILE/vestnik0707.pdf.
[31] UK guidance on action planning available at: http://www.defra.gov.uk/environment/quality/noise/environmental-noise/action-plans/.
[32] Personal communication with Marco Paviotti, European Commission.

DG Environment funded a 2003 report entitled "Definition, identification and preservation of rural and urban quiet areas"[33] that was specifically intended to assist the EU Working Group on the assessment of exposure to noise (WG AEN) with developing guidance on the identification and protection of quiet areas. The report noted that research on quiet areas was limited and stressed that across the multicultural and diverse EU 27 there can be no single approach on quiet areas. However, the report does include a number of recommendations on indicators and thresholds for identifying quiet areas in urban and rural settings, as well as their role in action plans and possible labelling for visitors to rural quiet areas.

In addition, a number of Member States have generated their own guidance on procedures for identifying quiet areas under the END. A 2002 Swedish report[34] provides guidance on metrics for describing freedom from noise; indicators for freedom from noise in different categories of quiet areas; and an auditing method to map acoustic environments.

In 2006, UK Department for Environment Food and Rural Affairs (DEFRA) generated a report[35] on the identification of quiet areas, recommending the use of mixed criteria including stakeholder views and noise thresholds. The report notes that there is too little research available to allow identify quiet areas purely on the basis of acoustical criteria, noting that while noise levels below 55 dB(A) in urban areas can be identified from noise maps[36], there are further considerations relating to landscape quality and public access that need to be considered.

A Welsh report[37] described how authorities identified quiet areas in agglomerations, while the UK Environment Protection Agency published a briefing note[38] on the issue. A report[39] of the Irish Environmental Protection Agency outlines the use of mixed criteria in identifying quiet areas in open countryside, including minimum distance criteria, as well as environmental, ecological and socio–cultural factors.

A number of on-going technical projects specifically address quiet areas, including:

- QSIDE,[40] which aims to provide a calculation model that is suitable for quiet façades and quiet urban areas;
- CityHush, [41] which explores the feasibility of establishing areas in cities where a low level of traffic noise is maintained by allowing only low noise vehicles to enter; and

[33] Symonds, 2003, Definition, Identification and Preservation of Urban & Rural Quiet Areas (ENV,C, 1/SER/2002/0104R), UK, available on the CIRCA Noise library.
[34] Swedish Working Group of Authorities Concerned with Noise, 2003, Acoustic quality in natural and cultural environments - Proposal for metrics, indicators and auditing methods, 18 December 2002, Sweden, available on CIRCA Noise Library.
[35] P A Morgan, P G Abbott, G R Watts, C A Burke and C Harmer, 2006, Research into Quiet Areas: Recommendations for identification, available at: http://randd.defra.gov.uk/Document.aspx?Document=NO01109_4629_FRP.doc.
[36] Noise maps identify areas within 5 dB(A) noise bands and are based on noise calculations to 0.1dB(A) and rounded to the nearest whole number. Noise levels below 55 dB(A) will be associated with calculated noise levels that are ≤ 54.4 dB(A).
[37] Welsh Government, 2011, Implementation of environmental noise action plans in Wales Procedure for the designation of quiet areas in agglomerations, available at: http://wales.gov.uk/docs/desh/publications/110523noisequietareasen.pdf
[38] NSCA Noise Policy Briefing - Quiet Areas (now EPA UK) July 2007: http://www.environmental-protection.org.uk/assets/library/documents/Quiet_Areas_Briefing.pdf.
[39] Waugh, D., Durucan et al. 2003, Environmental Quality Objectives – Noise in Quiet Areas Environmental RTDI Programme 2000 – 2006, Irish Environmental Protection Agency, available at: http://www.epa.ie/downloads/pubs/research/land/epa_noise_in_quiet_areas_ertdi17_synthesis
[40] See QSIDE website at: www.qside.eu.
[41] See CityHush website at: www.cityhush.org.

- HOSANNAH,[42] which will, *inter alia*, permit a better description of quiet façades of buildings through the development of specific algorithms and the analysis of perception.

The outcomes of several projects addressing open spaces in urban areas also touch on noise issues, including RUROS[43], GREENSCOM,[44] Green Space[45] and URGE[46].

In addition and in response to the fragmented approaches taken by Member States under the END, a project on quiet urban areas entitled QUADMAP[47] is currently being funded under the LIFE+ programme. The main objective of this project is to develop a harmonized methodology for selection, assessment (combining quantitative and qualitative parameters) and management of quiet areas in agglomerations. Multiple criteria will be considered, including both acoustic elements and stakeholder opinion. Project outputs are expected in 2014 and aim to allow urban planners to apply standard procedures for identification, delimitation and prioritization of quiet areas in agglomerations.

Finally, in recognition of the need for overarching guidance that draws on these efforts to collate best practice in identifying quiet areas, the EEA Expert Panel on Noise (EPoN) is currently working on guidelines on the management of quiet areas under the END in the form of a green paper, with an outline expected in 2013[48]. Provisional details of the green paper were discussed at a 2011 meeting of the European Environment Information and Observation Network (EIONET) on noise and suggest that the paper will include:

- examples and shared experience/knowledge;
- examples form Member States experience, potential application in different countries;
- definitions in MS legislation;
- benefits and wellbeing; and
- awareness raising and sharing of ideas.[49]

Rather than recommending a "one size fits all" set of criteria for identifying quiet areas, the most valuable output at this stage may be in the form of a toolbox of options, recognizing the different cultural approaches to identifying quiet areas and the different geographical and acoustic contexts. Given the ongoing work on quiet areas in reviewing available approaches and best practice, we do not consider further actions to be necessary in the short term.

5.2.4. Guidance on trigger values

Within the framework of guidance on the implementation of the action plans, there is a specific need for guidance on the kinds of trigger that can be used to catalyse actions to mitigate noise. It would be relevant for any guidance to include recommendations on possible acoustic and non-acoustic triggers that would serve to catalyse the implementation of measures under an action plan in cases where noise quality deteriorates. The implication of an acoustic trigger is that noise is systematically monitored.

It would be possible to combine the two approaches by having non-acoustic factors (e.g. public complaints, the initiation of construction projects) trigger noise monitoring, with the detection of excessive noise serving to trigger the implementation of measures.

[42] See HOSANNAH website at: http://www.greener-cities.eu.
[43] See Rediscovering the Urban Realm and Open Spaces website at: http://alpha.cres.gr/ruros/.
[44] See Greenscom website at: http://www.greenscom.com/default.htm.
[45] See Green Space website at http://www.ucd.ie/greensp/index.html.
[46] See Urban Green Environment website at: http://www.urge-project.ufz.de/.
[47] See QUADMAP website at: http://www.quadmap.eu/.
[48] Personal communication with Marco Paviotti, European Commission.
[49] See EIONET website at: www.eionet.europa.eu/events/Eionet%20Noise%202011/outline.

Guidance on possible trigger mechanisms would therefore need to include a discussion of the specific parameters, i.e. dB of noise for acoustic triggers, number of complaints relative to exposed population, or the size of a planned construction project.

5.2.5. Guidance on dose-response relationships

During the 2010 review of implementation, two Member States requested additional guidance on the interpretation of the dose-response relations used to estimate the health effects of noise on populations. Existing materials included the 2002 position paper on dose-response relationships between transportation noise and annoyance,[50] as well as the 2004 position paper on dose-effect relationships for night-time noise[51].

Since then, the 2010 EEA Good Practice Guide on Noise[52] provides further clarification of exposure-response relationships for specific health endpoints, with a summary of available data on the exposure response relations between air traffic noise and annoyance, and road traffic noise and ischaemic heart disease. In addition, as already mentioned in Chapter 1, the 2011 WHO publication on the burden of disease from environmental noise also provides discussion of the exposure-response relationship with respect to particular endpoints. As such, the demand for additional guidance on dose-response relationships has been addressed.

5.3. Improving synergies between air quality and noise management

While the potential for closer co-ordination and integration of air quality and noise management has been frequently proposed, the identification of actual practices that exploit these synergies remains challenging. The implementation of the Ambient Air Quality Directive (2008/50/EC)[53] requires similar elements to the END, e.g. the data collection in agglomerations, preparation of action plans and providing information to the public and the Commission. A useful step in facilitating further comparisons between data under the END and the Air Quality Directive would be to adopt a common definition of agglomeration, so allowing for a more direct comparison of both noise and air quality for particular areas.

The most obvious link between improving air quality and reducing noise comes in reducing vehicular traffic and hence reducing both exhaust and noise emissions, or promoting the use of electric vehicles in urban areas. The CityHush project[54] provides a practical example of a measure to reduce both exhaust and noise emissions in the urban area, by creating quiet zones in city centres where only quiet low emission vehicles are permitted. Regarding implementation of the END, some Member States have reported positive experiences from integrated action planning in particular for road hot spots with noise and air pollution problems.

In research terms, some exploratory work is being conducted to measure and assess the combined reduction of air and noise pollution in urban areas through better urban design and planning[55].

[50] European Commission, 2002, Position paper on dose-response relationships between transportation noise and annoyance, available on the CIRCA Library.
[51] European Commission Working Group on Health and Socio-economic aspects, 2004, Position paper on dose-effect relationships for night-time noise, available on the CIRCA Library.
[52] EEA (2010).
[53] Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (OJ L 152, 11.6.2008, p. 1–44).
[54] See CityHush website at: www.cityhush.org.
[55] E King, E.A., Murphy, E. and MacNabola, A. (2009) 'Reducing pedestrian exposure to environmental pollutants: A combined noise exposure and air quality analysis approach'. Transportation Research Part D: Transport and Environment, 14 (5):309-316.

Attempts have also been made to develop an urban environmental quality index "City Noise-Air" aggregating data for the assessment of air and noise quality of a city and presenting results in the context of standardised legal limits for air pollution and noise[56]. Further research in this sense should be encouraged.

In terms of synergies at EU level, opportunities relate to the communication of linkages between air and noise quality concerns to the public as a means of galvanising political will to act on traffic issues. For example, the online tool "Eye on Earth"[57] presents environmental data and allows for a comparison of hot spots for both noise and air quality. In addition, the ObsAIRve[58] website provides data on air quality for a specific location that could then be compared with data on noise from the EEA's NOISE Viewer[59].

However, the comparison remains superficial and a robust correlation between noise and air quality remains impossible with current data sets. Further work in this area may serve to facilitate future comparisons, although concrete benefits to implementation on the ground remain uncertain.

5.4. Streamlining reporting and electronic reporting

As set out in Annex II of this study, the END places several cyclical reporting obligations on Member States. These create an additional administrative burden and the added value for EU action has been called into question. The Commission 2011 implementation report suggested that streamlining of reporting and the electronic reporting processes could be further optimised and used on mandatory base.

For the 2010 reporting cycle, the use of EEA's 'Reportnet' facilitated information management and reduced the time needed for assessment of the reports. Use of the reporting platform remains voluntary, with approximately 80 % of the 2010 Member State reports posted on 'Reportnet'.

The EEA has subsequently adapted Reportnet for reporting on noise to include an ad hoc mechanism, the END Reporting Mechanism (ENDRM). ENDRM aims to facilitate and streamline data collection, quality control and compliance assessment. The effectiveness of the ENDRM was further improved with the additional linkage to the EEA's "Reportnet" Reporting Obligations Database (ROD). Early in 2012, the EEA published specific guidance for delivering environmental noise data using ENDRM.[60] The ENDRM reporting formats are designed to meet a minimum achievable standard which takes into account the diversity of approaches to managing spatial data which currently exists across Member States. The use of this reporting mechanism should serve to generate higher quality, comparable data sets with an increased value to the EU. From the Member State perspective, the detailed guidance should aid an initial learning process with ENDRM, a platform that should ultimately facilitate reporting. A possible future step at EU level will be to make use of the reporting tool mandatory.

Directive 2007/2/EC establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)[61] concerns the compatibility and usability of spatial data infrastructures. The EEA guidance notes that relevant elements of ENDRM have been formatted to meet the requirements of INSPIRE.

[56] Silvia, LT, Mendes, JFT (2012) City Noise-Air: An environmental quality index for cities, 4, 1-11.
[57] See Eye on Earth website at: http://watch.eyeonearth.org/.
[58] See ObsAIRve website at: http://www.obsairve.eu.
[59] See NOISE viewer at: http://noise.eionet.europa.eu/viewer.html.
[60] EEA (2012).
[61] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE) (OJ L108 , 25/04/2007 pp. 1-14).

This includes the use of the ETRS89 geographical referencing system and the use of spatial metadata standards to accommodate delivery of noise maps, source locations, agglomeration boundaries and action planning areas, including zones delimited as quiet areas. This addresses the issue of compatibility raised in the Commission's implementation report.

5.5. EU wide limit, target or trigger values

The END does not contain EU wide noise limit values, which some see as weakening its impact since the Directive fails to set a common level of ambition for the EU with regards to noise quality. Instead, limit values are to be determined by the Member States, although their use in implementing the END is not mandatory.

As a result of this flexibility, Member States have employed a wide variety of approaches demonstrating different levels of ambition. An overview of the situation in the Member States is provided in the 2010 Milieu report[62] and is briefly summarised below. Approaches include the establishment of mandatory limit values, national target values or guidelines and trigger values in action planning.

Nineteen Member States have legally enforced noise limit values, the transgression of which should result in the implementation of measures to control noise and/or to insulate exposed populations, and/or in some countries the imposition of penalties on those responsible for the source. However, in practice the 2007 noise maps suggest that noise limit values are often transgressed without any action being taken, presumably due to disproportionate costs and a lack of political will. In six Member States, indicative or recommended noise limit values are included in legislation and serve to guide noise policy, effectively serving as soft targets. Finally, three Member States have non-binding noise trigger values, exceedance of which trigger the implementation of measures under action plans. For example, in Germany the Federal Environmental Agency (Umweltbundesamt/UBA) recommends non-binding triggering thresholds for noise action plans, which are presented in table 5 below. Action is triggered by the exceedance of one of the two values, either the 24 hour value L_{den} or the night value L_{Night}.

Table 4: Non-binding trigger thresholds for noise action plans proposed by the German UBA

Objectives	Time frame	Lden	Lnight
Avoidance of health hazard text	Short-term	65 db (A)	55 db (A)
Reduction of substantial noise disturbance	Medium-term	60 db (A)	50 db (A)
Avoidance of substantial noise disturbance	Long-term	55 db (A)	45 db (A)

Source: Milieu (2010)

Another issue was that only a limited number of Member States specifically indicated that they had used health-based assessments or drew on WHO health-based assessments in establishing noise limit values.

[62] Milieu (2010).

Due to the different conceptual foundations and categories of noise limit values and trigger values, it remains difficult to summarise and compare the different levels across the Member States. It can nevertheless be observed that the degree of protection afforded to EU citizens varies considerably across the EU. As noted by the Commission's 2011 review of implementation, the divergent approach to setting an overall goal on noise quality prevents further convergence towards a level playing field in the internal market and establishing an equal level of health protection for citizens across the EU.

However, the setting of mandatory noise limit values at EU level would touch upon subsidiarity issues by limiting the flexibility of Member State authorities to adapt the level of protection to their specific situations and, arguably, to the public tolerance of noise in particular urban settings. A practical problem that argues against noise limit values in the short term is that, as mentioned above, strategic noise maps cannot be robustly compared at the level of analysis required to enforce noise limit values. Even considering the future implementation of CNOSSOS-EU, at least one implementation cycle will be required to allow for learning and adjustment, with comprehensive application of the CNOSSOS-EU tool to the current mapping cycle due for completion in December 2012 unlikely. This suggests that it remains premature to set mandatory EU-wide limit values.

The establishment of EU noise trigger values, or EU recommended target values (soft targets) provide alternatives that may be both more politically acceptable and more practical. Trigger values could serve as minimum thresholds to trigger action on noise, with Member States free to set stricter requirements, as required. In such a case, it would be pertinent to base acoustic trigger values on WHO health-based guidelines. Noise levels would then need to be systematically monitored, with public access to data preferable. It may also be relevant to consider non-acoustic trigger values, such as complaints from stakeholders and new developments. Likewise, soft acoustic target values for specific settings (i.e. agglomerations and possible quiet areas) would provide a common EU-level goal, without penalising those Member States where the urban and transport infrastructure presents particular challenges regarding noise management.

As a final point, were limit values or trigger values to be established, their transgression at a specific location would demand action on the part of the Member State administration to reduce people's exposure to noise through abatement strategies at the receiver. However, this may lead to a situation where a Member State would be legally required to implement mitigation efforts that entailed costs disproportionate to the benefits. As stated in section 5.1, noise abatement strategies at the receiver or "end of pipe" controls tend to be considerably less cost effective than reducing noise at source. This suggests that legislation targeting noise sources for the major modes of transport would likely be far more cost-effective and preferable in a context where Member State administrations face ever tightening budgets. EU-level legislation to control noise at source has been reviewed in this study and provides a clear route for reducing exposure to noise.

Nevertheless, even with determined action on noise sources, noise hot spots will remain and can be identified using strategic noise maps. It could therefore be relevant to have a combined approach, including both legislation to reduce noise at source and EU-level health-based trigger values to ensure that additional noise mitigation measures are undertaken at noise hot spots.

5.6. Revision of noise indicator values

The recent World Health Organisation (WHO) "Night Noise Guidelines for Europe" reviewed scientific evidence on the health effects of night-time noise and established health-based guideline limit values for noise exposure at the receiver[63]. The document highlights the fact that L_{night} is a relatively new noise indicator established under the Environmental Noise Directive (END). Existing research on sleep disturbance contains studies rarely covering the entire 8-hour night-time period and data are seldom expressed in terms of the L_{night} indicator. Thus, there is a concern regarding the existing dose-effect evidence-base linking L_{night} to problems such as sleep disturbance and annoyance. This does not necessarily imply that the indicators need revision but that further research on the appropriateness of the indicator as an accurate predictor of dose-effect relationships needs to be undertaken.

Furthermore, the 2010 Milieu report on the END notes that a major limitation of the current EU exposure-response relationships is that they do not take into account the difference in exposure between the most exposed façade and the bedroom façade, as well as the difference between the outdoor exposure at the bedroom façade and the indoor exposure within the bedroom[64]. In addition to this, more research should be focussed on improving the prediction of subjective sleep disturbance by adding noise descriptors other than L_{night}. These could include, *inter alia*, descriptors for noise in the early or late parts of the night, descriptors of peak levels, or number of noise events to assess the problem of intermittent noise (e.g. SEL, L_{peax}, L_{max}).

The current L_{night} indicator likely underestimates the extent of annoyance and sleep disturbance because noise is average over a long period, effectively downgrading and removing intermittent noise events from analysis despite the fact that such events are highly problematic. In most testing studies, noise indicators are assessed on the basis of the subjects' sleep quality and none are assessed in terms of the new L_{night} indicator. While L_{night} is of interest and a potentially useful indicator, it is the indoor noise level that is most important in terms of public health assessment. An $L_{night,indoor}$ level would provide a much more accurate basis for assessing sleep disturbance and annoyance during the night-time period. Yet, the strategic noise mapping exercise only requires authorities to report noise at the outdoor façade (and not even the outdoor bedroom façade). Moreover, the END indicators do not account very well for the problem of low frequency noise despite the WHO recognising the special place of low frequency noise as an environmental problem[65].

The Eurocities Position paper[66] on the END notes that, despite the successful implementation of the END and the production of noise maps and action plans, little evidence exists to suggest that any significant progress was made in avoiding, preventing and reducing environmental noise as a public health concern either during day-time or night-time. It seems then that the problem is not yet fully understood and additional research is needed as a priority on the appropriateness of the indicators established under the END prior to revisions in legislation being considered.

[63] WHO (2009).
[64] Milieu (2010).
[65] WHO (2011).
[66] Eurocities position paper available at: http://workinggroupnoise.web-log.nl/mijn_weblog/2009/07/position-paper.html.

5.7. Enforcement of provisions of Member States action plans and role of European Commission

Although Member States are required to develop action plans, there is no legal obligation for them to implement the plans. This has led some Member States to question the objective of the END, as evidenced in Milieu's 2010 implementation report.

Arguably, clarifying the status of the action plans by making implementation obligatory would serve to direct the implementation process towards the final goal of reducing environmental noise. Member States would then need to ensure that both budgetary and personnel resources were available to support implementation and this would feed back into the planning process, making objective setting more realistic and possibly less ambitious. A number of questions would need to be addressed, including whether the action plans be implemented as a whole, or whether specific measures would be mandatory. The Member States would need to retain the flexibility to adapt the plans to changing circumstances, be they changes in noise quality or in budgetary and resource issues in the administration.

In practice, enforcing the mandatory implementation of action plans would have to focus around the achievement of noise targets, be they mandatory limit values, soft target values or trigger values against a specified timeframe. Without a specific timed goal based on acoustic parameters, enforcement by the Commission is unrealistic. Again, enforcement of an acoustic goal requires high quality EU-wide noise maps that can be reliably and robustly compared.

5.8. Harmonisation of information and measures in Member States action plans

As mentioned under section 3.1.3, the action plans produced under the END by Member States show considerable divergence in the overall level of ambition, the procedures used for establishing priorities and ultimately the measures to reduce and mitigate noise emissions. This suggests that EU citizens are reaping different results from implementation of the END in terms of improvements in their wellbeing.

While the provision of comprehensive guidance would begin to address this divergence, more detailed mandatory provisions for the depth of information and the kinds of measures to be employed in action plans would serve to harmonise activities. The minimum requirements set out under Annex V are flexible and ask authorities to provide details of measures in force, planned actions and expected impacts rather than obliging Member States to include specific measures.

However, obliging Member States to include specific measures in their action plans encroaches significantly on the principles of subsidiarity and proportionality. Local administrations are best placed to determine which noise mitigation measures might be most appropriate and cost-effective in a specific area, something that cannot be determined generically at EU level. This suggests that EU action to develop specific measures to address noise at EU-level would be disproportionate and would not serve the overall goals of the Treaty.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusions

The study indicates that a comprehensive noise strategy is urgently needed in the EU to address environmental noise as a major public health issue. For a comprehensive noise strategy a holistic approach has to be taken that brings together measures at the source and at the receiver. The main conclusions of the study can be summarised as follows:

- Environmental noise, especially traffic-related noise, has serious adverse impacts on human health. Recent findings on the burden of disease of environmental noise are alarming as they show that more than a million healthy life years are lost every year from traffic-related noise in western European countries. Although annoyance is the most widespread effect, substantial evidence reviewed in the study shows a clear linkage between environmental noise and disturbed sleep patterns, ringing in the ears, impaired cognitive functions (especially in children) and also on cardiovascular diseases. It is vulnerable groups such as children, the elderly and the poor who suffer the most. The study also shows that, on the basis of Member States' reports, a large proportion of the EU population is chronically exposed to levels of noise beyond what is considered safe by the World Health Organization (WHO), with millions of people experiencing health effects from traffic noise. In conclusion, noise is a major environment and public health issue, which has so far been underestimated in the EU in comparison with other environmental problems.

- The current EU regulatory framework has so far addressed environmental noise mainly through legislation on noise sources (road, rail and air traffic, outdoor equipment and recreational craft). Most of the measures and standards in existing source legislation are responding to internal market imperatives and are mostly outdated. The Environmental Noise Directive (END) represented a first attempt to address noise at the receiver's end with the aim of reducing population exposure. Under the END, Member States are required to prepare strategic noise maps and action plans to mitigate exposure on the basis of set indicators. At the moment, there is very little connection between the END and source legislation, and the responsibility for the various pieces of legislation is scattered in different Commission DGs (DG Environment, Mobility and Transport, Enterprise and Energy). Hence, a coherent approach to tackling environmental noise is missing, as well as a clear institutional structure at the EU level.

- Reviews of the implementation of the END show some achievements, as the Directive has to some extent contributed to the recognition of noise as an important issue and has encouraged action at national level. However, several challenges have also been identified from the first round of reporting, including delays, non-enforcement of noise limit values, poor quality of strategic noise maps and action plans, inconsistent approaches in mapping and definition of quiet areas, as well as confusion amongst responsible bodies regarding the END requirements. Inconsistent approaches to noise mapping is particularly important as this means that the population's exposure to noise cannot be compared across the Member States in a robust fashion. The introduction of a common EU methodology for noise assessment (CNOSSOS-EU) in September 2012 represents a step forward in this respect. However, it will only be applied as of the next round of strategic mapping due in 2017.

The present study concludes that the END has so far led to little progress in reaching the objectives of reducing the proportion of the EU's population suffering from noise pollution, although its full potential will only become evident after the next round of reporting of strategic noise maps due in December 2012, or probably even later - once the application CNOSSOS-EU will allow comparison of data across the EU.

- Current legislation on noise sources also needs to be further improved. Revision is already foreseen for legislation on vehicle noise standards, rail standards (Technical Specification for Interoperability - TSI), air traffic noise and outdoor noise. The present study shows that there is large scope for reduction of perceived noise levels by setting effective and more stringent noise standards using current technologies. The limits in force, mainly set to address internal market harmonisation needs, have been too weak to produce any relevant noise reduction effects so far. The latest WHO guidelines and best practices from research projects should be taken into account when discussing the revision of noise standards.

- Noise can be tackled at the source through measures normally foreseen in legislation on noise sources (e.g. quieter engines, tyres and wheels for vehicles, quieter brakes on trains etc.), or at the receiver's end through mitigation measures (e.g. sound insulation, noise barriers, quieter road surfaces etc.). The study concludes that measures at the source are more effective and cost efficient than mitigation measures. However, an effective policy-mix between mitigation of noise at the source and noise abatement strategies at the receiver is desirable to allow Member States to target noise hotspots in urban areas.

- Since the Commission's 2011 report on the END implementation, considerable progress has been made in providing guidance to Member States. In particular, a common EU methodology for noise assessment (CNOSSOS-EU) has been introduced and guidelines have been provided on the definition of quiet areas. However, EU-level guidance is still missing on action plans. On reporting, the European Environment Agency (EEA) has introduced an electronic END Reporting mechanism (ENDRM), which has been further enhanced with linkages to the EEA's Reportnet Reporting Obligations Database. Improving synergies between air quality and noise management has been frequently proposed, with several initiatives and projects aiming to highlight the linkages between the two policies. However, so far the comparison of data remains superficial and further activities in this area may serve to facilitate future interaction between the two policies.

- For future work, open questions remain on the revision of noise indicators and the establishment of EU wide limit, target or trigger values. The present study concludes that the introduction of health-based trigger values or recommended target values would be more feasible and politically acceptable than limit values. Target or trigger values would also be more effective in reducing noise exposure if linked to more stringent legislation to reduce noise at source.

6.2. Recommendations

- Give higher priority to environmental noise in health policies, including in the future EU public health strategy.

- Raise public awareness on the health effects of noise and strengthen public participation by promoting information dissemination, which is an essential but often overlooked component of the END.

- Take a more holistic approach when addressing noise and reinforce the legislative link between the END and EU legislation on sources of noise. A comprehensive noise strategy can be achieved by combining more stringent limits in source legislation (e.g. through stricter permissible levels for motor vehicles) with EU limit, target or trigger values in the END. In the short term, the introduction of health-based trigger or target values is recommended as they are more feasible and politically acceptable. However, limit values should remain a longer term objective once consistent noise mapping allows for robust comparison between Member States.

- Set stricter and more ambitious targets for vehicle noise emissions and on railway tracks in order to reduce traffic noise. With the revision of legislation on sources, EU policy makers have an opportunity to reduce traffic noise, thus achieving real health benefits for Europe's citizens.

- Promote further research on sources of noise, in particular on freight trains and outdoor machinery types, e.g. by allocating adequate funding for noise in future research programmes. Also, further research is needed to establish the impacts of recreational craft on parklands and conservation areas.

- Promote better implementation of the END by developing guidance on action plans. However, the establishment of specific noise mitigation measures should be left to Member States and local administrations. EU action to make specific measures mandatory would be disproportionate.

- Finalise work and provide guidance on the application of harmonised mapping methods (CNOSSOS-EU) to improve comparability of data. Promote the development of a standardised approach for the calculation of population's exposure at the most exposed façade.

- Promote further research on the appropriateness of the indicators under the END, in particular on the indicator value L_{night} and on the exposure-response relationship. Any future revision of indicators should take into account the latest guidelines of the WHO.

- Improve synergies between noise management and other policies, for example air quality, transport and INSPIRE (collection of spatial information).

- Ensure coordination between different Commission DGs working on noise-related legislation (DG Environment, DG Enterprise, DG MOVE and DG Energy).

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ANNEX I: OVERVIEW OF EU LEGISLATION ON ENVIRONMENTAL NOISE

Directive 2002/49/EC relating to the assessment and management of Environmental Noise (END)	
Source	**Related EU Legislation**
Road traffic noise	• Directive 70/157/EEC on the approximation of the laws of the Member States relating to the permissible sound level and the exhaust system of motor vehicle; • Directive 97/24/EC on certain components and characteristics of two or three-wheel motor vehicles; • Directive 92/23/EEC relating to tyres for motor vehicles and their trailers and to their fitting; • Regulation No 661/2009 concerning type-approval requirements for the general safety of motor vehicles, their trailers and systems, components and separate technical units intended therefor; • Regulation No 1222/2009 on the labelling of tyres with respect to fuel efficiency and other essential parameters
Aircraft noise	• Directive 89/629/EEC on the limitation of noise emission from civil subsonic jet aeroplanes; • Directive 2006/93/EC on the regulation of the operation of aeroplanes covered by Part II, Chapter 3, Volume 1 of Annex 16 to the Convention on International Civil Aviation, second edition (1988); • Regulation 216/2008/EC on common rules in the field of civil aviation and establishing a European Aviation Safety Agency; • Directive 2002/30/EC on the establishment of rules and procedures with regard to the introduction of noise-related operating restrictions at Community airports
Railway noise	• Directive 2008/57/EC on the interoperability of the rail system within the Community; • Commission Decision 2002/735/EC concerning the technical specification for interoperability relating to the rolling stock subsystem of the trans-European high-speed rail system; • Commission Decision 2002/732/EC concerning the

Directive 2002/49/EC relating to the assessment and management of Environmental Noise (END)	
Source	**Related EU Legislation**
	technical specification for interoperability relating to the infrastructure subsystem of the trans-European high-speed rail system; • Commission Decision 2011/229/EU of concerning the technical specifications of interoperability relating to the subsystem 'rolling stock – noise' of the trans-European conventional rail system
Noise caused by equipment for use outdoors	• Directive 2000/14/EC on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors
Noise caused by recreational craft	• Directive 2003/44/EC amending Directive 94/25/EC on the approximation of the laws, regulations and administrative provisions of the Member States relating to recreational craft
Airborne noise emitted by household appliances	• Directive 2009/125/EC establishing a framework for the setting of ecodesign requirements for energy-related products; • Commission Regulation No 206/2012/EU implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for air conditioners and comfort fans; • Commission Regulation No 1016/2010/EU implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household dishwashers; • Commission Regulation 643/2009/EC implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for household refrigerating appliances; • Commission Regulation 1015/2010/EU of 10 November 2010 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for household washing machines

ANNEX II: TABLE OF DATA REPORTING OBLIGATIONS

Implementation deadline	Summary description of data sets to be reported	END provision	Updates by Member States
30 June 2005	Major roads, major railways, major airports and agglomeration designated by MS and concerned by 1st implementation step	Art. 7-1	Mandatory every five years
18 July 2005	Establishment of competent bodies for strategic noise maps, action plans and data collection	Art. 4-2	Possible at any time
18 July 2005	Noise limit values in force or planned and associated information	Art. 5-4	Possible at any time
30 December 2007	Strategic noise maps related data as listed in annex VI for major roads, railways, airports and agglomerations concerned by 1st implementation step • Per agglomeration ≥ 250,000 inhab. • Per major civil airport ≥ 50,000 movts/y • For overall major roads ≥ 6 millions veh/y • For overall major railways ≥ 60,000 trains/y	Art. 10-2 Annex VI	Mandatory every five years
31 December 2008	Major roads, railways, airports and agglomerations designated by Member States and concerned by 2nd implementation step	Art. 7-2	Possible at any time
18 January 2009	Noise control programmes that have been carried out in the past and noise-measures in place • Per agglomeration ≥ 250,000 inhab. • Per major civil airport ≥ 50,000 movts/y • For overall major roads ≥ 6 millions veh/y • For overall major railways ≥ 60,000 trains/y	Art. 10-2 Annex VI 1.3 & 2.3	No update
18 January 2009	Action plans related data as listed in annex VI for major roads, railways,	Art. 10-2 Annex VI	Mandatory every

	airports and agglomerations concerned by 1st implementation step + Any criteria used in drawing up action plans • Per agglomeration ≥ 250,000 inhab. • Per major airport ≥ 50,000 movts/y • For overall major roads ≥ 6 millions veh/y • For overall major railways ≥ 60,000 trains/y	+ Art. 8-3	five years
30 December 2012	Strategic noise maps related data as listed in annex VI for major roads, railways, airports and agglomerations concerned by 2nd implementation step • Per agglomeration ≥ 100,000 and < 250,000 inhab. • For overall major roads ≥ 3 millions and < 6 millions veh/y • For overall major railways ≥ 30,000 and < 60,000 trains/y	Art. 10-2 Annex IV	Mandatory every five years
18 January 2014	Noise control programmes that have been carried out in the past and noise-measures in place • Per agglomeration ≥ 100,000 and < 250,000 inhab. • For overall major roads ≥ 3 millions and < 6 millions veh/y • For overall major railways ≥ 30,000 and < 60,000 trains/y	Art. 10-2 Annex IV 1.3 & 2.3	No update
18 January 2014	Action plans related data as listed in annex VI for major roads, railways, airports and agglomerations concerned by 2nd implementation step + Any criteria used in drawing up action plans • Per agglomeration ≥ 100,000 and < 250,000 inhab. • For overall major roads ≥ 3 millions and < 6 millions veh/y • For overall major railways ≥ 30,000 and < 60,000 trains/y	Art. 10-2 Annex VI + Art. 8-3	Mandatory every five years

Source: DG Environment website: http://ec.europa.eu/environment/noise/pdf/reporting.pdf

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