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IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

on ambient air quality and cleaner air for Europe (recast)

{COM(2022) 542 final} - {SEC(2022) 542 final} - {SWD(2022) 345 final} -
{SWD(2022) 542 final}

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GLOSSARY

Term or acronym	*Meaning or definition*
Policies and COM reports	
AAQ Directives	Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air[1] - and - Directive 2008/50/EC on ambient air quality and cleaner air for Europe[2] (Ambient Air Quality Directives)
IED Directive	Directive 2010/75/EU on industrial emissions (integrated pollution prevention and control)[3]
NEC Directive	Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants[4]
Second Clean Air Outlook (CAO2)	Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on The Second Clean Air Outlook, COM/2021/3 final.
Pollutants	
As	Arsenic
BaP	Benzo(a)pyrene
C_6H_6	Benzene
Cd	Cadmium
CO	Carbon monoxide
Ni	Nickel
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides (i.e. sum of NO and NO_2)
O_3	Ozone
Pb	Lead
$PM_{2.5}$	Fine particulate matter, aerodynamic diameter < 2.5 µm
PM_{10}	Particulate matter, aerodynamic diameter < 10 µm

1 OJ L 23, 26.1.2005, p. 3.
2 OJ L 152, 11.6.2008, p. 1.
3 OJ L 334, 17.12.2010, p.17.
4 OJ L 344, 17.12.2016, p.1.

SO_2	Sulphur dioxide
UFP	Ultrafine particles
VOC	Volatile Organic Compounds
Units	
mg/m^3	Milligram(s) per cubic metre (= 1 000 $\mu g/m^3$)
$\mu g/m^3$	Microgram(s) per cubic metre (= 1 000 ng/m^3)
ng/m^3	Nanogram(s) per cubic metre
EUR	Euro
USD	US Dollar
Abbreviations	
ACTRIS	Aerosol, Clouds and Trace Gases Research Infrastructure
AQUILA	Network of National Air Quality Reference Laboratories
ECA	European Court of Auditors
EEA	European Environment Agency
FAIRMODE	Forum for Air quality Modelling
GAINS	Greenhouse gas – Air pollution Interactions and Synergies Model of IIASA
GDP	Gross Domestic Product
IIASA	International Institute for Applied Systems Analysis
JRC	European Commission Joint Research Centre
MFR / MTFR	Maximum Technically Feasible Reduction *(note: used interchangeably in this document)*
NAPCP	National air pollution control programmes
NGO	Non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
TFEU	Treaty on the Functioning of the European Union
VOLY	Value of a life year
VSL	Value of statistical life
WHO	World Health Organization

1. INTRODUCTION: POLITICAL AND LEGAL CONTEXT

Clean air is essential to human health and sustaining the environment. Despite significant reductions of harmful air pollutant emissions over the past three decades in the EU, around 300 000 deaths per year (compared to up to 1 million per year back in the early 1990s) and a significant number of non-communicable diseases are still attributed to air pollution (and especially related to particulate matter, nitrogen dioxide and ozone).[5] The good news is that clean air policies work, and have delivered a significant reduction in the adverse impacts of air pollution during the past three decades.[6]

In November 2019 the Commission published its fitness check of the Ambient Air Quality Directives (Directives 2004/107/EC and 2008/50/EC).[7] It concluded that the Directives have been *partially* effective in improving air quality and achieving air quality standards, but that not all their objectives have been met to date.

In December 2019, in the European Green Deal, the European Commission committed to further improve air quality and to aligning EU air quality standards more closely with the recommendations of the World Health Organization (WHO), which were most recently revised in September 2021[8] and are subject to periodic scientific review, typically every 10 years. This objective of closer alignment with latest scientific findings was confirmed in the Zero Pollution Action Plan, entailing a vision for 2050 to reduce air (as well as water and soil) pollution to levels no longer considered harmful to health and natural ecosystems, and complemented by 2030 targets to reduce by more than 55% the health impacts (premature deaths) of air pollution, and by 25% the EU ecosystems where air pollution threatens biodiversity. The Commission also announced in the European Green Deal that it would strengthen air quality monitoring, modelling and planning.

The Russian military aggression against Ukraine in February 2022 led the EU leaders to agree on the need to urgently accelerate the transition to clean energy production, with a view to reduce the EU's dependence on gas and other fossil fuels imported from Russia. On 18 May 2022 an ambitious RePowerEU package of measures was adopted, aimed to assist Member States in speeding up the deployment of renewable energy production. If swiftly implemented, this package may have significant co-benefits from an air pollution perspective.

The Ambient Air Quality Directives have four key features:

First, the Ambient Air Quality Directives set common methods and criteria to assess air quality in all Member States in a comparable and reliable manner: Member States must designate zones and agglomerations throughout their territories, classify them according to prescribed assessment thresholds, and provide air quality assessments underpinned by measurement, modelling and/or objective estimation, or a combination of these.

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5 See, for example: EEA (2021), Air Quality in Europe 2021 (accessed: 13.06.2022)

6 See, for example: EEA (2018), Air Quality in Europe 2018 Report (accessed: 13.06.2022). The median estimate for all datasets available pointed to 445 000 premature deaths across Europe per year in 2015, compared to a situation 25 years earlier when the median value was 960 000 deaths per year in 1990.

7 Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air and Directive 2008/50/EC on ambient air quality and cleaner air for Europe, as amended by Commission Directive (EU) 2015/1480.

8 WHO (2021) WHO Global Air Quality Guidelines (accessed: 13.06.2022)

Second, the Ambient Air Quality Directives define and establish objectives and standards for ambient air quality for 12 air pollutants to be attained by all Member States across their territories against specific timelines. These are: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2, including NO_x), ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6), benzo(a)pyrene (BaP), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni). Reductions in concentration levels of these pollutants also depend on reductions in the emission of precursors (for example, sulphur dioxide (SO_2) and nitrogen oxides (NO_x) combine with ammonia (NH_3) to form secondary particulate matter in the atmosphere).

Third, the Ambient Air Quality Directives require Member States to monitor air quality in their territory. Member States report, to the Commission and the general public, the results of air quality assessment on an annual basis, 'up-to-date' air quality measurements, as well as information on the plans and programmes they establish. It is the responsibility of Member States to design and approve the monitoring networks, approve the measurement systems and ensure the accuracy of measurements.

Fourth, where the established standards for ambient air quality are not met, the Ambient Air Quality Directives require Member States to prepare and implement air quality plans and measures. These air quality plans need to identify the main emission sources responsible for pollution, detail the factors responsible for exceedances, and spell out abatement measures adopted to reduce pollution. Guided by the principle of subsidiarity, the Directives leave the choice of means to achieve air quality standards to the Member States, but explicitly require that exceedance periods are kept as short as possible.

The Ambient Air Quality Directives are part of a comprehensive clean air policy framework that relies on three main pillars. The first one consists of the Ambient Air Quality Directives themselves, setting quality standards as regards concentration levels of 12 ambient air pollutants. The second one is the Directive on the reduction of national emissions of certain atmospheric pollutants (the NEC Directive), which defines commitments per Member State to reduce the emissions of key ambient air pollutants and their precursors, acting within the EU to achieve a joint reduction of transboundary pollution.[9] The third one consists of source policies setting emissions standards for key sources of air pollution, such as road transport vehicles, domestic heating installations, or industrial installations.[10]

The amount of pollution from such sources is also affected by other policies that influence key activities and sectors in areas such as transport, industry, energy and climate, and agriculture. A number of these policies are part of recent initiatives taken under the European Green Deal, such as the Zero Pollution Action Plan, the European Climate Law and the Fit for 55 package with its actions on energy efficiency and renewable energy, the Methane Strategy, the Sustainable and Smart Mobility Strategy, the Biodiversity Strategy and the Farm

9 See Directive 2016/2284/EU. It should be noted that air pollutant emissions from outside EU Member States also play a role in background pollution in the EU. The UNECE Air Convention can play a key role on reducing these emissions, as well as capacity building and other support provided by the EU in the context of accession processes, in particular for Western Balkans countries.

10 Including Directives 2010/75/EU (on industrial emissions), 2015/2193/EU (on medium combustion plants) 98/70/EC (on fuel quality), 2016/802/EU (on sulphur content in liquid fuels), 2009/125/EC (on eco-design), as well as EC Regulations 443/2009 and 510/2011 (on emission standards for vehicles), Regulations (EU) 2016/427, (EU) 2016/646, and (EU) 2017/1154 (on real driving emissions), and Regulation (EU) 2016/1628 (on non-road mobile machinery).

to Fork initiative. Annex 8 maps European Green Deal policies and priorities that are of relevance for the successful implementation of the Ambient Air Quality Directives because they influence pollutant emissions. In turn, these policies are likely to be influenced by a revised Ambient Air Quality Directives.

Box 1 - Structure of this impact assessment

Section 1 introduces the **political and legal context** in which the revision of the Ambient Air Quality Directives is undertaken. To complement this, **Annex 8** offers a more detailed overview of EU Clean Air policy and how it correlates with other EU policies that affect air pollution. **Annex 9** recalls the findings of the fitness check of the Ambient Air Quality Directives published in 2019. **Annex 10** complements this by summarising the most recent recommendations by the World Health Organization.

Section 2 presents the problems that may require action, grouping them into **four problem areas**, drawing on the previous fitness check of the current Ambient Air Quality Directives, and analysing who is affected, what the main drivers are, and how likely it is that the problems will persist. This points to four problem areas, namely (1) environment and health shortcomings, (2) governance and enforcement shortcomings, (3) monitoring and assessment shortcomings, and (4) information and communication shortcomings.

Section 3 looks into **why the EU should act**, examining notably the legal basis and compliance with the principle of subsidiarity, i.e. necessity and added value of EU action and the application of the principle of proportionality. **Annex 12** gives a complementary overview of infringements and litigation under the current Ambient Air Quality Directives.

Section 4 examines **general objectives** with a view to improving air quality and limiting negative health impacts of health pollution, and **specific objectives**, to address the problem areas identified in section 2.

Section 5 outlines the **baseline, 'no-policy-change' scenario** without policy intervention, exemplarily for the years 2030 and 2050, including projections on air pollutant emissions and concentrations and their health impacts. While **Annex 11** provides a detailed overview of air quality in the EU today (in 2020), **Annex 5** provides additional detailed projections of air pollution under baseline assumptions in a 2030 and post-2030 perspective. These projections are based on the methodology described in **Annex 4**.

Section 5 also presents **all policy options** per problem area identified in section 2, including indicative **trajectories** towards closer alignment with WHO Air Quality Guidelines (as per the mandate of the European Green Deal), as well as policy options discarded at an early stage. **Annex 6** provides more detailed description of the different potential specific policy measures included in the different policy options.

Section 6 analyses the economic, social and environmental **impacts of the different policy options** and **who** will be affected by them, together with direct costs both from taking additional measures to curb air pollutant emissions and from administrative action to improve air quality management. This allows for the construction of a comparative **benefit-to-cost ratio for each policy option** considered. **Annex 6** provides further details here, including a detailed assessment per potential specific policy measure considered.

Section 7 examines **synergies, complementarities and trade-offs of different policy options across the problem areas** with regards to their effectiveness and efficiency in achieving identified objectives, their policy coherence and proportionality, as well as to how future proof they are, given long-term challenges, including the coherence with other policies.

Section 8 presents which package of **policy options** is **preferred** and **why**. It sets out main envisaged impacts of the preferred option and explores the potential to simplify and improve the efficiency of the legislation, examining administrative burden also with regards to the application of the 'one in, one out' approach. **Annex 3** describes in more detail who is affected and how.

Section 9 outlines the arrangements for **future monitoring and evaluation**.

A more in-depth analysis of stakeholder views is provided in **Annex 2** (synopsis report of the stakeholder consultation) and **Annex 6** (with views per potential specific policy measure).

Finally, not all shortcomings identified – especially several of those that relate to monitoring and assessment shortcomings – require legislative changes. Thus, this impact assessment has also considered non-legislative measures to strengthen air quality monitoring, modelling and air quality plans as summarised in **Annex 7**.

2. PROBLEM DEFINITION

2.1 What is/are the problems?

The fitness check of the current Ambient Air Quality Directives concluded that they have been *partially effective* in improving air quality across the European Union. Clearly, the Directives have led to the establishment of a representative high-quality monitoring of air quality, set precise air quality standards and contributed to a downward trend in air pollution across the EU. The number and magnitude of exceedances have decreased for most pollutants throughout the EU between 2008 and 2017 (and 2020) – see Figure 1, and Annex 11.

In 2020, for example, fine particulate matter ($PM_{2.5}$) concentrations were reported to be higher than the EU annual limit value at least at one sampling point in three EU Member States. Such concentrations above the limit value were registered in 2% of all the reporting stations and occurred primarily in urban or suburban areas. For nitrogen dioxide (NO_2), seven EU Member States recorded concentrations above the annual limit value concentrations, with exceedances at 2% of all reporting stations.

Fewer Member States report exceedances today, and the highest pollution peaks for particulate matter and nitrogen dioxide have decreased substantially in most Member States. Similarly, the number of people exposed to air pollution above EU air quality standards has declined steadily. Overall, air quality is better now than 10 years ago but substantial impacts remain, and EU air quality standards are not as protective as those recommended by the World Health Organization (referred to WHO from here onwards – see below).

The fitness check also found that the Ambient Air Quality Directives have been less successful in ensuring that public authorities and economic actors in Member States take sufficient action to meet air quality standards, to keep exceedance periods as short as possible, and to go beyond these standards to align with more re health recommendations as warranted.

Four types of significant shortcomings in the air quality policy remain, and point to scope for improvements to the existing framework:

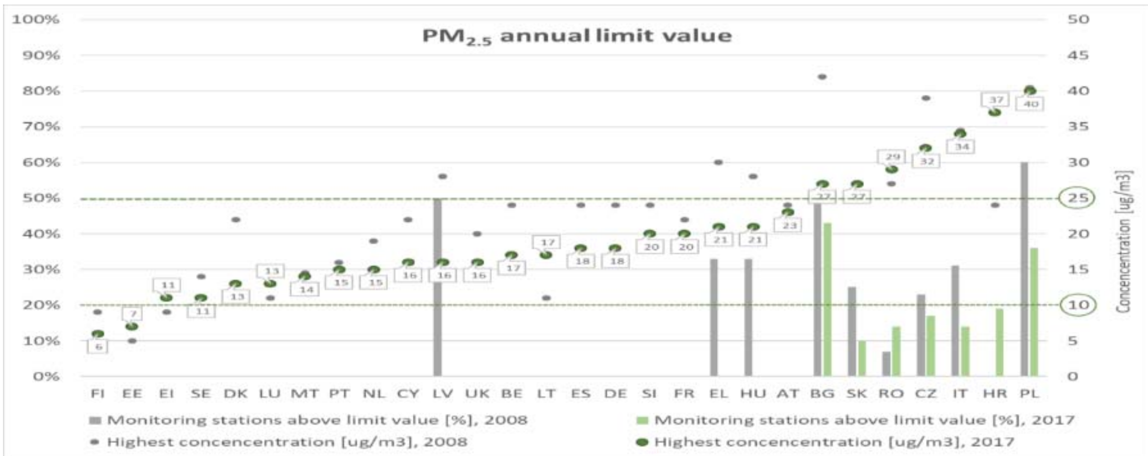
Problem I: Environment and health shortcomings

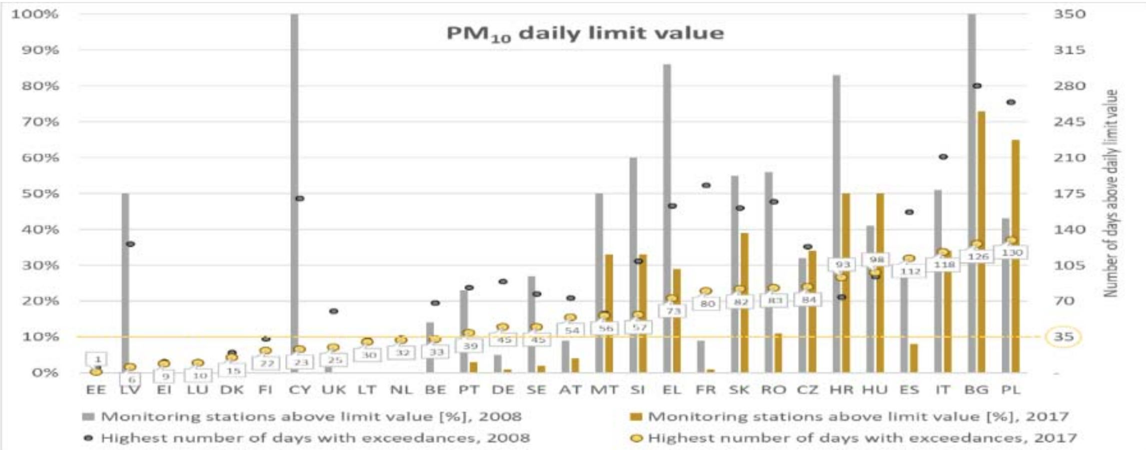
Over the past two decades, the overall health impacts due to air pollution have decreased by more than half.[11] Even so, significant mortality and morbidity continues to be associated with air pollution (estimates point to more than 300 000 attributable premature deaths related to air pollution).[12] Furthermore, eutrophication limits are exceeded in two thirds of ecosystem areas across the EU, with significant environmental impact.[13]

At the same time, scientific evidence of harmful effects of air pollution is well established and has further developed over the past decade – as documented via regularly updated editions of the Air Quality Guidelines published by the World Health Organization, which

[11] See, for example: EEA (2018) Air Quality in Europe 2018 Report (accessed: 13.06.2022)
[12] See, for example: EEA (2021) Health impacts of air pollution in Europe 2021 (accessed: 10.06.2022)
[13] See, for example, *The Second Clean Air Outlook*, COM(2021) 3 *final*

provide recommendations based on a systematic review of relevant scientific evidence. The 2021 edition of these guidelines confirms that for several air pollutants adverse health impacts occur at concentration levels below what had been stated in previous editions – see Annex 10.





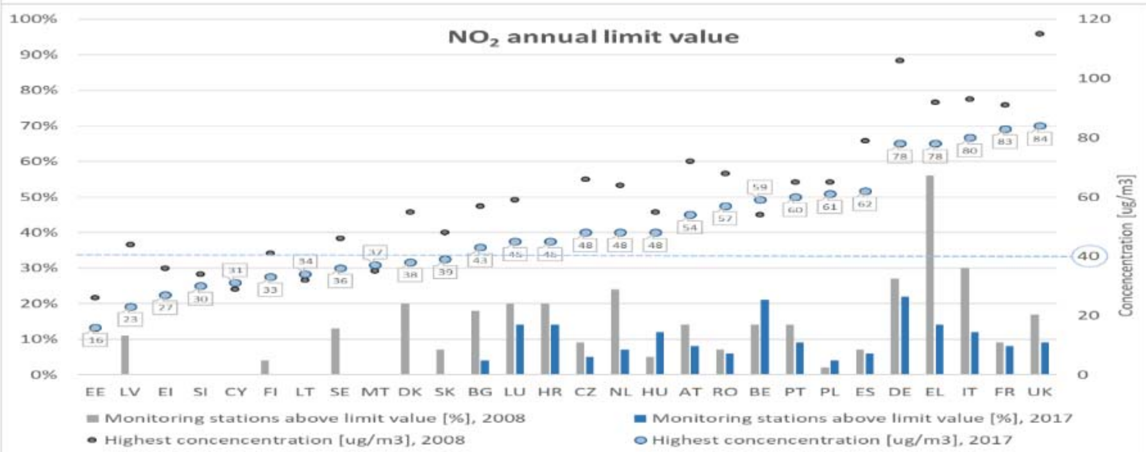


Figure 1 – Percentage of sampling points for fine particulate matter $PM_{2.5}$ (top) and PM_{10} (middle), and for nitrogen dioxide NO_2 (bottom), with exceedances above the annual limit value (columns, left axis), and highest concentration (points, right axis shows $\mu g/m^3$), as reported for each Member State for 2008 and 2017.[14]

In addition, a growing body of research points to the relevance of considering various components of particulate matter, such as black carbon or ultrafine particles.[15] However to date the World Health Organization has not proposed guideline values for these additional air pollutants, also due to a lack of sufficient measurement data – see Annex 10.

As noted above, legislation sets EU-wide air quality standards for 12 key air pollutants (for a typology of different standards see Box 2). For several of these air pollutants, these standards are not as stringent as recommended by the updated World Health Organization Air Quality Guidelines (also in the past they have not been aligned with previous recommendations of the World Health Organization) and cannot be flexibly adjusted to evolving scientific knowledge without a full revision of the Directives themselves.[16]

Box 2 – A typology of EU Air Quality Standards

The Ambient Air Quality Directives deploy a number of different types of air quality standards for the different pollutants they cover. Their differences were motivated in part by different levels to which public authorities are able to address the respective air pollutants and their underlying emissions on their own territories.

Limit values are to be attained within a given period and not to be exceeded once attained – set for particulate matter, sulphur dioxide, nitrogen dioxide, benzene, carbon monoxide, and lead.

Target values are to be attained *where possible* over a given period by taking all necessary measures *not entailing disproportionate costs* – set for ozone, benzo(a)pyrene, arsenic, cadmium, nickel (also for fine particulate matter standards were initially established as target values before becoming limit values).

Critical Levels refer to concentrations above which direct adverse effects may occur on some receptors, such as trees, other plants or natural ecosystems but not on humans – set for sulphur oxides and for oxides of nitrogen.

Long-Term Objectives are set to be attained in the long term, save where not achievable through proportionate measures – set for ozone only.

In addition, the *Average Exposure Indicator* provides an average level, determined on the basis of measurements at urban background locations, which reflects population exposure. It is used to calculate national exposure reduction targets (in percent) for each Member State.

Problem II: Governance and enforcement shortcomings

Exceedances of the air quality standards and instances of insufficient implementation of the Ambient Air Quality Directives have progressively decreased in their frequency, extent and magnitude (see Figure 1 which illustrates this for three air pollutants). Nevertheless,

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[14] Member States are sorted according to highest exceedance reported in 2017. Data for Croatia shows 2013 (i.e. not 2008) and 2017. Data for Romania shows 2010 (i.e. not 2008) and 2017. For $PM_{10,}$ data for Malta shows 2009 (i.e. not 2008) and 2017. For NO_2, data for Cyprus and Malta shows 2009 (i.e. not 2008) and 2017. For some Member States, for example Poland, this figure also reflects significant changes in the air quality network, in particular adding of new stations in areas of exceedances (thus increasing the number of stations above the limit value between 2008 and 2017).

[15] The 2021 WHO Air Quality Guidelines note both short-term and long-term effects of exposure to ultrafine particles, including cardiovascular, ischemic heart disease and pulmonary health impacts – but also conclude that the body of epidemiological evidence was not yet sufficient to formulate guideline levels.

[16] See Annex 10 for a comparison of current EU air quality standards and WHO recommendations.

significant (and persistent) exceedances above current EU limit values remain, now, more than 10 to 15 years after the Directives entered into force.[17]

The Ambient Air Quality Directives include a specific requirement to take action when air quality does not meet the established standards in a particular geographical zone or agglomeration designated by the Member State for the purposes of managing and reporting air quality. Such action requires both the preparation and implementation of air quality plans. Stakeholder feedback and case studies confirm that the requirements to adopt air quality plans or all necessary measures are among the most fundamental and compelling elements of the Ambient Air Quality Directives for incentivising remedial action by the Member States.[18]

While the Ambient Air Quality Directives establish a common format and key elements that such plans need to cover, they do not prescribe a clear timeframe and the measures that need to be taken or considered: this is left to the competent authorities which must choose appropriate measures with a view to keeping the exceedance period as short as possible. Improvements in air quality critically depend on action taken by Member States to address the sources of air pollution that lead to the exceedances in the specific circumstances, and typically require action in the transport, energy (incl. domestic heating) and agricultural sectors, or by industry actors.[19]

As of May 2022, there were 28 ongoing infringement cases addressing exceedances in 18 Member States (plus one case addressing air quality monitoring insufficiencies).[20] This in itself shows a significant implementation gap. Proceedings before both the Court of Justice of the EU and national courts confirm that air quality plans were in many instances not adequate and/or insufficient measures were adopted to address air pollution problems. Accordingly, existing air quality plans have in many instances not been effective – the underlying problem in this respect is that often they fail to outline decisive measures to reduce air pollution, but also delayed implementation and lack of enforcement of measures adopted. In addition, in some instances also external factors play a role: such as natural sources of air pollution, meteorological conditions, and pollution transported from outside the local areas.

The fact that air quality plans required by the Ambient Air Quality Directives often are insufficient to prevent exceedances or minimise their duration, point to implementation challenges and related governance and enforcement shortcomings.

Problem III: Monitoring and assessment shortcomings

Across the EU, Member States have established more than 4 000 monitoring stations (which each can host one or several air quality sampling points)[21], based on common criteria and

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[17] Directive 2008/50/EC - Entry into force: 11/06/2008; Date of transposition: 10/06/2010
Directive 2004/107/EC - Entry into force: 15/02/2005 + 20 days; Date of transposition: 15/02/2007

[18] See Annex 2 for a synopsis of the stakeholder consultation.

[19] Furthermore, evidence of public participation during the adoption of air quality plans is not always apparent. It is often unclear which aspects of the planning process have been open to public consultation, if at all, and who has been involved and how.

[20] In addition, there is also an infringement case against the United Kingdom addressing exceedances of NO_2. See Annex 12 for an overview of infringement and litigation under the Ambient Air Quality Directives.

[21] Where the sampling point means the exact place where pollutants are captured in a known volume of air, and the monitoring station the infrastructure in which several sampling points may be placed.

using common approaches defined by the Ambient Air Quality Directives. This includes criteria for determining the minimum numbers of sampling points, for their macroscale and microscale siting, as well as for data quality and acceptable uncertainty in monitoring and modelling.

The monitoring network, set up by the competent authorities at national level, largely adheres to the provisions of the Ambient Air Quality Directives, and ensures that reliable and representative air quality measurements and data are available. The current set-up of monitoring stations by and large provides air quality data of reliable and of comparable quality across the EU. There have been and still are instances when and where, in specific air quality zones or agglomerations, air quality monitoring does not respect the criteria set by the Ambient Air Quality Directives.[22]

The criteria, set out by the Directives, offer some flexibility to competent authorities so that monitoring networks are optimally set up depending on the respective local circumstances. These flexibilities are limited by the requirement to provide information both for where the highest concentrations of air pollutants occur and for other areas which are representative of the exposure of the general population. Both are difficult to verify objectively.

A number of ambiguities as regards the siting criteria have been identified, but these have not been found to have led to systemic shortcomings in the monitoring network.[23] Concerns have been raised that the criteria as defined offer too much leeway to competent authorities and that more restrictively defined siting criteria or (additional) guidance would help ensure a higher degree of confidence in the comparability of monitored air quality. Furthermore, there are no requirements related to the monitoring of additional air pollutants, such as black carbon or ultrafine particles, and related hotspots (such as ports or airports).

In addition, the use and quality of modelling has improved in the last years and is recognised as a cost efficient and reliable source of information. It is, however, currently underutilised for both air quality assessment and planning, and to date focusses on a limited number of air pollutants only (and thus in most instances does not address additional air pollutants).[24]

Problem IV: Information and communication shortcomings

There is a growing body of information on air quality, associated health impacts and measures to address exceedances. However, and despite rapidly evolving communication

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[22] The fitness check of the Ambient Air Quality Directive noted that *'an analysis of the monitoring and assessment regimes in each [Member State] for particulate matter and nitrogen dioxide did not point to fundamental gaps in the number of monitoring stations in Member States: in 2015, more than 98% of the required sampling points for nitrogen dioxide reported data (and this has since increased further). For particulate matter, this number was slightly lower at just under 96%: here, traffic oriented $PM_{2.5}$ sampling points are missing in some cases.'*

[23] European Parliament (2019). 'Sampling points for air quality: Representativeness and comparability of measurements in accordance with Directive 2008/50/EC on ambient air quality and cleaner air in Europe' (study requested by the ENVI Committee). This study pointed to 22 'ambiguities' in the provisions laid down in the Ambient Air Quality Directives related to macroscale and microscale siting of sampling point.

[24] In 2020, 13 Member States reported data from air quality models to the data repository hosted by the European Environment Agency – however which pollutants where included differed between Member States. For example, nine Member States reported modelled data (alongside monitored data) for NO_2, seven Member States for $PM_{2.5}$; and 5 Member States for O_3. For details, please see: Eionet - Air Quality Models and Objective Estimations (data flows D1b/E1b) (accessed: 13.06.2022)

technology, this information is not always readily available to the public or in an accessible format (or in a format that allows sensitive and/or vulnerable populations to adapt their behaviour to air quality concerns in a timely manner). As such, the public feels uninformed. A 2019 Eurobarometer survey found that more than half of Europeans (54%) say they are not informed about air quality problems.[25]

Even where there is a wealth of information concerning air quality reported and made available online already, information seems not always publicly accessible. The fitness check points to air quality data available at EU level (via online viewers that provide access to the EEA Air Quality e-Reporting database, or via the digital available European Air Quality Index), but also notes that this information is not presented consistently at Member State level.

Further harmonisation of the way air quality information is presented, especially at Member State level, would provide further EU added value, and help ensure even higher comparability of information across all geographical scales and all regions of the EU.

2.2 What are the problem drivers, and what are their consequences?

The above shortcomings and problems can be linked to ten underlying problem drivers, and to a series of environmental, economic and social consequences. They also link to other EU policy priorities, and they entail administrative burden. 12 specific consequences can be highlighted here – Figure 2 provides an overview, and each driver and consequence is described in more detail below.[26] Also see Box 3 on stakeholder views on the current Directives.

[25] COM (2019), press release on special Eurobarometer 497 (accessed: 13.06.2022)

[26] For additional detail, please see underpinning support study on the revision of the Ambient Air Quality Directives (especially section 8).

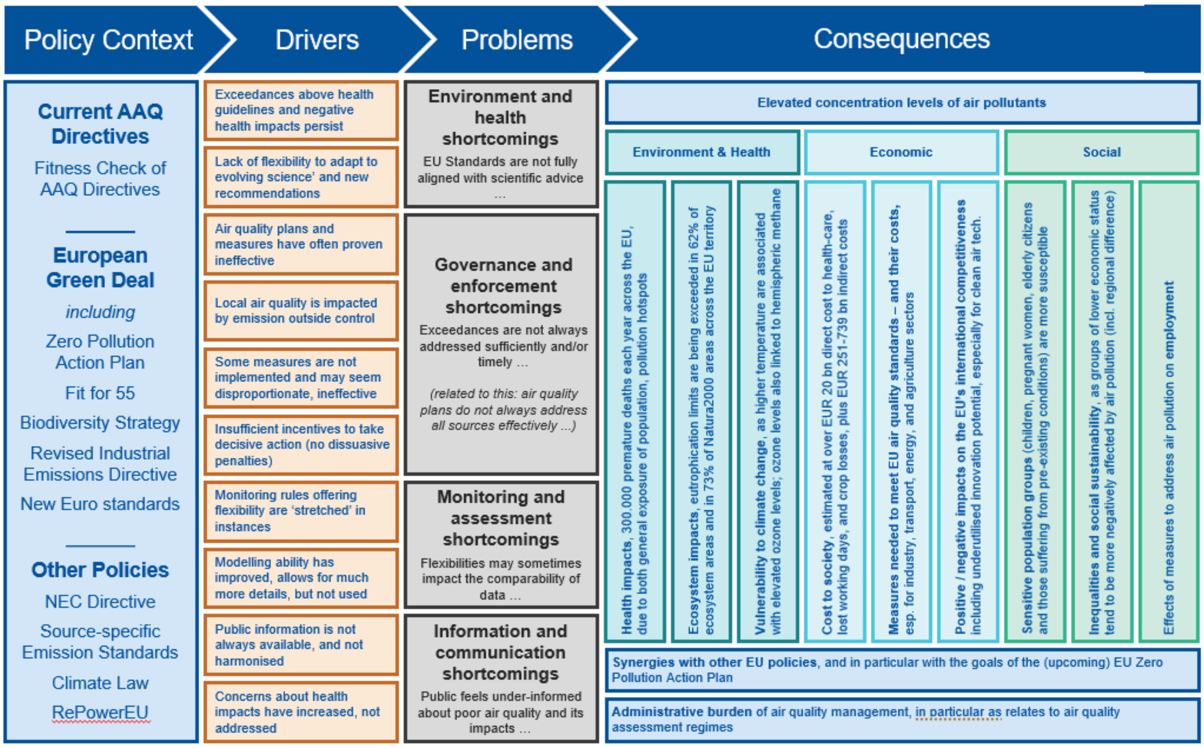

Figure 2 – Ambient Air Quality Directives: four problems, their drivers and consequences

Key drivers related to Problem I: Environment and health shortcomings are:

1. **Driver I-a:** Regulatory failure; negative impacts on health and environment persist under existing EU air quality objectives that are not aligned with scientific recommendations.

2. **Driver I-b:** Regulatory failure; there is a lack of flexibility within the legislative framework to adapt to evolving science and new health recommendations.

Key drivers related to Problem II: Governance and enforcement shortcomings are:

3. **Driver II-a:** Regulatory failure; air quality plans and measures taken to address air quality exceedances are often insufficiently effective.

4. **Driver II-b:** Regulatory failure; local air quality is impacted by emissions both within and outside of the control of authorities tasked with implementing air quality plans.

5. **Driver II-c:** Regulatory failure; air quality plans and potentially effective measures are not implemented or are delayed as they are perceived as being disproportionate.

6. **Driver II-d:** Regulatory failure; insufficient incentives to take decisive action in air quality plans (i.e. no sufficiently dissuasive penalties and/or access to justice provisions).

Key drivers related to Problem III: Monitoring and assessment shortcomings are:

7. **Driver III-a:** Regulatory failure; air quality monitoring rules offer (necessary) flexibilities to competent authorities, but these are in some instances 'stretched'.

8. **Driver III-b:** Regulatory failure; improved air quality modelling is underutilised to provide reliable information to inform air quality assessments.

Key drivers related to Problem IV: Information and communication shortcomings are:

9. **Driver IV-a:** Imperfect information; concerns about the adverse health and environment impacts of air pollution have increased in society.

10. **Driver IV-b:** Imperfect information; public information on air pollution and its adverse impacts is not always accessible or is not fully comparable.

These shortcomings and their underlying drivers can be linked to a series of environmental, economic and social consequences – they also link to other EU policy priorities, and they entail administrative burden. 12 specific consequences can be highlighted here.[27]

1. **Increased concentration levels** of air pollutants overall, as monitored both at background locations (representative of larger areas), and at 'hot-spot' locations (in proximity to specific sources of pollution, incl. traffic and industry-related).[28]
2. **Health impacts** of air pollution, with around 300 000 premature deaths each year across the EU,[29] due to both general exposure of population and pollution hotspots.
3. **Ecosystem impacts** of air pollution, with eutrophication limits being exceeded due to air pollution in 62% of ecosystem areas and in 73% of Natura2000 areas across the EU.[30]
4. **Vulnerability to climate change**, as higher temperatures are associated with elevated ozone levels; ozone levels also linked to hemispheric methane.
5. **Cost to society**, estimated at over EUR 20 billion direct cost to healthcare, lost working days, and crop losses, plus EUR 330-940 billion indirect costs.[31]
6. **Measures needed to meet EU air quality standards – and their costs,** esp. for industry sector, transport sector, energy sector, and agriculture sector.
7. **Positive and negative impacts on the EU's international competitiveness** including underutilised innovation potential, especially for clean air technologies.
8. **Sensitive population groups** (children, pregnant women, elderly citizens and those suffering from pre-existing conditions) are more susceptible to air pollution.
9. **Inequalities and (lack of) social sustainability**, as groups of lower economic status tend to be more negatively affected by air pollution (incl. regional difference).
10. **Employment** may be impacted by measures taken to address air pollution, at the same time air pollution has also been shown to lead to decreased labour productivity.
11. **Synergies with other EU policies** need to be secured, including most notably the EU Zero Pollution Action Plan, the EU Biodiversity Strategy, and Fit for 55.
12. **Administrative burden** of air quality management, in particular as relates to air quality assessment regimes.

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[27] For additional detail, please see underpinning support study on the revision of the Ambient Air Quality Directives (especially section 8).
[28] See Annex 11 for an overview of concentration levels for all air pollutants, based on EEA data.
[29] See, for example, *Health impacts of air pollution in Europe 2021*, EEA Web Report.
[30] See, for example, *The Second Clean Air Outlook*, COM(2021) 3 *final*
[31] See SWD(2013) 531 *final*. For the impact assessment underpinning the *Clean Air Programme for Europe*, COM(2013) 918 *final*, external costs due to health impacts of air pollution were estimated. The number depends on whether a low or high range of possible health impact valuations is assumed.

A key measure of success for any policy option and/or measure to address air pollution is whether it alleviates the above adverse consequences of air pollution, or not.

Stakeholder views confirmed the overall intervention logic and need for an impact assessment to underpin the revision of the Ambient Air Quality Directives in general, and the EU air quality standards in particular. See Box 3 for a summary of views expressed during the stakeholder consultation process conducted to inform this initiative.

Box 3 – Stakeholder views on EU air quality standards and air quality monitoring, modelling and plans

A wide range of stakeholders was consulted in the preparation of this impact assessment through a variety of public and targeted consultations and meetings. The result of this process can be summarised as follows:

Public authorities [up to 53 responses to targeted survey – the exact number of responses varied by question] called for a closer alignment with the WHO recommendations but largely were not favouring a full alignment with the guideline levels recommended in the 2021 WHO Air Quality Guidelines (in particular for $PM_{2.5}$ and NO_2), indicating that it would not be feasible to achieve these levels in a 2030 perspective. They stressed also the importance of transboundary cooperation and largely welcomed clearer requirements for air quality plans, the monitoring network and on modelling quality objectives.

Representatives of **civil society & NGOs** [up to 12 responses to targeted survey] were largely in favour of the most ambitious air quality standards and measures to protect human health and the environment: accordingly, a majority called for a full alignment of EU standards with the WHO Air Quality Guidelines by 2030, a better access to justice for citizens as well as ensuring compensation for health damage caused by air pollution. They also called for increased monitoring requirements and the establishment of short–term EU air quality, for example for $PM_{2.5}$.

Industry & businesses [up to 26 responses to targeted survey] stakeholders were mostly in favour of keeping EU air quality standards at current levels or only support moderate increases in ambition for 2030. They were also largely in favour of applying revised and more stringent $PM_{2.5}$ annual levels at selected sampling points only and not necessarily in all territory. In addition, they were not in favour of establishing short-term air quality standards such as for $PM_{2.5}$. Furthermore, industry stakeholder stressed the importance of unambiguous and comparable air quality data across the EU.

Representatives from **academia & research** [up to 42 responses to targeted survey] call for a closer alignment with the WHO Air Quality Guidelines but many saw the recommended WHO levels as not feasible in the foreseeable future, in particular for $PM_{2.5}$. Several called for a stronger focus on air pollution exposure related health targets. They largely were in favour of the periodically update of a list for emerging air pollutants to ensure monitoring of those and were very supportive of exploring policy options to strengthen further air quality monitoring, modelling and transboundary cooperation.

EU citizens at large [615 responses to the open public consultation] emphasised the need for action to protect human and environmental health. A large majority indicated that EU air quality standards should be fully aligned with the latest WHO recommendations by 2030. There was also strong support for ambitious measures to strengthen monitoring, improve information, and provide access to justice and compensation for health damage.

For a more in-depth analysis of stakeholder views, see Annex 2 (consultation synopsis report) and Annex 6 (potential policy measures).

2.3 How likely is the problem to persist?

Table 1 - Assumptions on whether / how the identified shortcomings will persists	
Problem	**Assumptions on whether / how this problem persists**
(I) Environment and health shortcomings are likely to persist (even if some further air quality improvements can be expected as air emissions decrease)	• Further reduction in air pollutant concentrations will lead to continued reduced exposure to air pollution and reductions in health burden. • However, EU air quality standards remain significantly above WHO recommendations, resulting in health (and environmental) challenges. • Without updated EU air quality standards (and associated requirement to take action when there are exceedances) there is little incentive to act. • As scientific understanding of health impacts of air pollution is further updated, EU air quality standards may need corresponding updates.
(II) Governance and enforcement shortcomings are very likely to persist, leading to continued persistent air quality exceedance situations	• Continued (limited) air quality improvement in air quality will reduce pressure on Member States to act (despite continued health impacts). • Low level of coordination when designing and implementing air quality plans between different levels of governance hampers additional action. • Air quality plans and measures contained therein are neither being reviewed, nor updated, even if plans are deemed insufficient. • Member States continue to interpret EU rules differently leading to different approaches to implementation and limited enforcement action.
(III) Monitoring and assessment shortcomings are likely to persist (at least partially), even if some aspects of this can be addressed by non-legislative measures	• While air quality monitoring and assessment continues to deliver a sound basis for policy action, scope for inconsistencies remains. • Without further guidance or legislation, there remains an incentive to stretch existing rules in order to avoid monitoring all exceedances. • Spatial representativeness of sampling points is likely to remain an issue hampering the reliability and comparability of air quality assessments. • The use of models is likely to remain variable, and modelling associated with air quality plan development is not used to its full potential.
(IV) Information and communication shortcomings are likely to persist (at least partially), even if some aspects of this can be addressed by non-legislative measures	• A wealth of information on current air quality, and the health and environment impact of air pollution, is collected and made available. • Accessibility of information on air quality will continue to improve, but authorities are not expected to go beyond the mandatory requirements. • There is a risk of continued lack of comparability of air quality data and health assessments (especially when disseminated by third parties). • General public (and vulnerable populations) will continue to feel insufficiently informed regarding air quality and its impact on health.

3. WHY SHOULD THE EU ACT?

3.1 Legal basis

The legal basis for the EU to act on air quality lies in Articles 191 and 192 of the Treaty on the Functioning of the European Union (TFEU), regarding the area of environment. These Articles *inter alia* empower the EU to act to preserve, protect, and improve the quality of the environment, protect human health and promote measures at international level to deal with regional or worldwide environmental problems. The same legal basis underpins the current Ambient Air Quality Directives. Given that this is an area of shared competence between the EU and the Member States, EU action must respect the subsidiarity principle.

3.2 Subsidiarity: Necessity of EU action

The objectives of this initiative cannot be sufficiently achieved at Member State level alone. This is due, firstly, to the transboundary nature of air pollution. Secondly, the TFEU requires policies aiming for a high level of protection taking into account the diversity of situations across the EU. Thirdly, fairness and equality must be ensured as regards the economic implications of air pollution control and the ambient air quality experience by citizens across the Union. Therefore, the nature and scale of the problem requires that air quality be addressed at EU level.

3.3 Subsidiarity: Added value of EU action

The Ambient Air Quality Directives establish the same air quality objectives for all Member States with the freedom to go further. In this way, they help create a level playing field between the Member States and more efficiently tackle the contribution of transboundary air pollution as part of air quality assessments and the explicit links to other EU legislation tackling air pollutant emissions. The EU's policy framework delivers ambient air quality objectives (including assessing and managing air quality, and reporting information) more efficiently compared to a situation where national, regional and local authorities implement their own individual approaches.

The principle of proportionality requires EU action to be limited in its content and form to what is necessary to achieve the objectives of the Treaties it intends to implement. The application of this principle is linked to the principle of subsidiarity and the need to match the nature and intensity of a given measure to the identified problem. The principle of proportionality is considered throughout the impact assessment and will be addressed in particular in section 7 and 8 when comparing the different policy options and presenting a preferred package of options.

4. OBJECTIVES: WHAT IS TO BE ACHIEVED?

4.1 General objective

The general objective of the initiative is to further improve air quality in the European Union and reduce the negative consequence of air pollution for human health and the environment.

4.2 Specific objectives

Accordingly, this initiative aims to enhance the effectiveness of EU air quality legislation thereby contributing to relevant Treaty objectives and to the aspirations of the European Green Deal and the Zero Pollution Action Plan.

Against the above shortcomings and their underlying drivers, and drawing on lessons learnt from the fitness check of the current air quality legislation, the above general objectives translate into five specific objectives:

Specific objective 1: Revise EU air quality standards to align them more closely with WHO recommendations, to the extent possible take into account the latest scientific advice, feasibility, costs, and benefits – and ensure legislation can respond in an appropriate and effective manner to future changes in underlying evidence base.[32]

Specific objective 2: Assure air quality plans are an effective means of identifying, planning and mitigating an exceedance situation (by taking relevant, effective and proportionate measures) – and include clearer provisions on stakeholder participation, access to justice, penalties and compensation linked to clean air in EU legislation.

Specific objective 3: Further strengthen provisions on air quality monitoring, air quality modelling and air quality plans to help local authorities achieve cleaner air – and improve monitoring and modelling as an effective and reliable tool which is consistently applied to identify exceedance areas and underpin the development of plans.

Specific objective 4: Provide information to citizens around health impacts of air pollution issues (targeting the concerns of citizens) – and ensure that the public in all Member States receive the same high quality and timely information about their air quality.

Specific objective 5: Simplify existing provisions where feasible to improve the effectiveness and efficiency of air quality management – and decrease associated administrative burden if and where possible.

5. WHAT ARE THE AVAILABLE POLICY OPTIONS?

5.1 What is the baseline from which options are assessed?

Air pollution in Europe is a well-understood environmental problem, with an advanced analytical framework and established forward-looking assessment capacities. The Commission regularly publishes a Clean Air Outlook, which provides projections on how air pollution in the EU is expected to develop over the coming years and decades.

The projections put forward in the most recent Clean Air Outlook[33] provide the backdrop for the quantitative impact assessment. The corresponding baseline projections, with a time horizon of up to the year 2050, have been updated for this assessment to also include policies proposed by the Commission since, specifically incorporating the consequences of the Fit for 55 package as well as of preliminary assumptions for the introduction of the Euro 7 emission standard for road vehicles.[34/35]

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[32] In line with Article 193 of the Treaty on the Functioning of the European Union (TFEU), the implementation of the policy objectives above should not prevent any Member State from maintaining or introducing more stringent protective measures, as long as they are compatible with the Treaties.

[33] The most recent edition is the Second Clean Air Outlook, COM(2021) 3 *final*, published in January 2021. The Third Clean Air Outlook is planned to be published towards the end of 2022, building again on the GAINS model. Efforts are made to ensure that the analytical work for the Third Clean Air Outlook and the present impact assessment is developed coherently, by aligning key assumptions used for the concentration of pollutants and the assessment of the health and economic impacts of air pollution.

[34] Have Your Say page: European vehicle emissions standards – Euro 7 for cars, vans, lorries and buses (accessed: 13.06.2022)

Furthermore, as they depend on an uptake over time of Best Available Techniques (BAT), the air pollution benefits stemming from the continuous improvement of BAT performance under the Industrial Emissions Directive (IED) cannot be, at this stage, fully quantified.[36] This is also the case regarding the emission reductions expected from the recent proposal to revise the IED, notably its higher ambition to reduce industrial emissions and to expand its scope to the EU's largest livestock farms significantly contributing to ammonia (NH_3) emissions. In addition, contributions to the baseline are taken into account qualitatively, in line with the impact assessment underpinning the proposed revised Industrial Emissions Directive.

Potential effects of the revised IED have been tested through sensitivity analysis[37] representing in a broad manner the full implementation of the revised IED and evolving BAT by assuming a decrease of 20 % of $PM_{2.5}$, SO_2 and NO_x emissions from industrial installations falling into the remit of the revised IED and reflected into the model, compared to their emission levels in 2030 in the core baseline; as well as a gradually increasing penetration of agricultural techniques to lower ammonia emissions towards the end of the decade, on farms above the proposed IED threshold of 150 livestock units. This additional analysis indicates that the results are rather stable compared to the baseline without the additional reductions resulting from the IED. The pollutant most affected is SO_2, (for which industry is the main source of emissions) with total EU emissions reduced by 10 % in 2030 compared to the core baseline, but overall, the IED sensitivity analysis translates into very small changes when looking at $PM_{2.5}$ and NO_x concentration levels, station exceedances and population exposure.

Similarly, the impacts stemming from a sound implementation of the recent RePowerEU package are factored in from a qualitative perspective, with initial analysis (prepared in the context of the forthcoming Third Clean Air Outlook) showing that this will require additional mitigation measures in some countries where air pollutant emissions may increase up to 2030 given continued reliance on solid (fossil) fuels, whereas in others additional reductions of pollutants can be expected, depending on the national mix.

Finally, subject to the outcome of the on-going negotiations, the implementation of the Nature Restoration Law[38] can deliver on clean air aspects. This includes more indirect benefits accruing from policies that improve the state of certain ecosystems while having co-benefits for air, such as moving to more extensive forms of agriculture. It is likely that most expected co-benefits would materialise only after 2030. This implies that, especially in a post-2030 perspective, the air pollutant emission reduction estimated in the impact assessment is likely to be underestimated from the perspective of the Nature Restoration Law.

Box 4 - Agricultural emissions in the baseline

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[35] This quantitative modelling is based on a state-of-the-art modelling framework, including the Greenhouse gas and Air pollution Interactions and Synergies (GAINS) model, and MET Norway's chemical transport model (EMEP CTM) with the uEMEP downscaling extension for fine resolution (see Annex 4).

[36] See detailed discussion of improvements expected under the Industrial Emission Directive and its revision in SWD COM(2022)111 containing the impact assessment accompanying the proposal for revising the Industrial Emission Directive (COM(2022)156). See in particular sections 6.1 and Annex 4 therein.

[37] See Annex 5.8, and the underpinning support study, for more details on the IED sensitivity.

[38] Proposal for a Regulation on nature restoration (COM/2022/304).

The Commission proposal for a revised Industrial Emission Directive was adopted on 5 April 2022, after the cut-off date of the central modelling work underpinning this impact assessment on the revision of the air quality legislation. This entails that the proposal for a revised Industrial Emissions Directive is not included in the modelling baseline on which quantitative results are presented here.[39] For some pollutants, the longer-term projections in the baseline used for this impact assessment therefore under-estimate future emissions reductions; this is the case in particular for ammonia emitted by the agricultural sector, since the Industrial Emissions Directive proposal foresees to include the EU's 10% largest cattle farms, 18% largest pig farms and 15% largest poultry farms (excluding subsistence farms). This means that 41% of total cattle heads, 80% of total pig heads and 87% of total poultry heads, will be covered by the obligations of the IED.[40] This proposal, if adopted by the co-legislators, could lead to reduce ammonia emissions by 12%, 7%, and 20% respectively for cattle, pigs and poultry farms (i.e. this is equivalent to about 4.4% of EU latest total emissions).[41] Under the proposed revision of the Industrial Emissions Directive, these emission reductions would materialise from 2030 onwards,[42] considering the time needed to develop environmental requirements (Best Available Techniques - BAT) and for livestock farms to then comply with these requirements. Furthermore, over time the effectiveness of BAT is expected to improve which will further increase the emission reductions.

The modelling suite applied in this impact assessment allows to translate the projected emissions of air pollutants into projections of air quality concentrations, and their related health and environmental impacts.[43]

Air pollutant emission projections

Projections of emissions of key air pollutants in the EU for the period 2015 to 2050 show significant reductions for all air pollutants and from most sectors (Figure 3).

A key driver for this projected decline is the expected reduced reliance on fossil fuels in line with the Fit for 55 legislative proposals. The RePowerEU package of measures of 18 May 2022 may have significant co-benefits from an air pollution perspective, too. For emissions of primary $PM_{2.5}$, the residential sector drives the decline owing to reductions in coal and biomass use as well as an expected transition to cleaner technologies. Also for SO_2 and NO_x, both key precursors for secondary $PM_{2.5}$, sharp reductions are expected.[44] Note that a much slower decline is expected for ammonia (NH_3), also a precursor for secondary $PM_{2.5}$.[45]

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39 The forthcoming Third Clean Air Outlook will however include elements of the Industrial Emission Directive proposal in its baseline, as its modelling work could work for a longer period.

40 SWD(2022) 111 final

41 According to COM(2022) 156 final/3, the Industrial Emission Directive would bring a reduction of EU ammonia emissions of 155 kt per year. If this number is put in perspective with overall EU ammonia emissions this reduction would be equivalent to about 4.4% of total EU ammonia emissions. See EEA (2021), National air pollutant emissions data viewer 1990 – 2019 (accessed: 15.06.2022)

42 From mid-2029 according to the Industrial Emission Directive Impact Assessment.

43 More details on the modelling set up and the baseline assumptions are included in Annexes 4 and 5.

44 Note that emission reductions in the transport sector are due to electrification of the fleet and the assumption that $DeNO_x$ technology works and is enforced.

45 Note that the Commission proposal for a revised Industrial Emission Directive (IED) and its provisions on large farms are not included in the modelling baseline (see Box 4 above for further details).

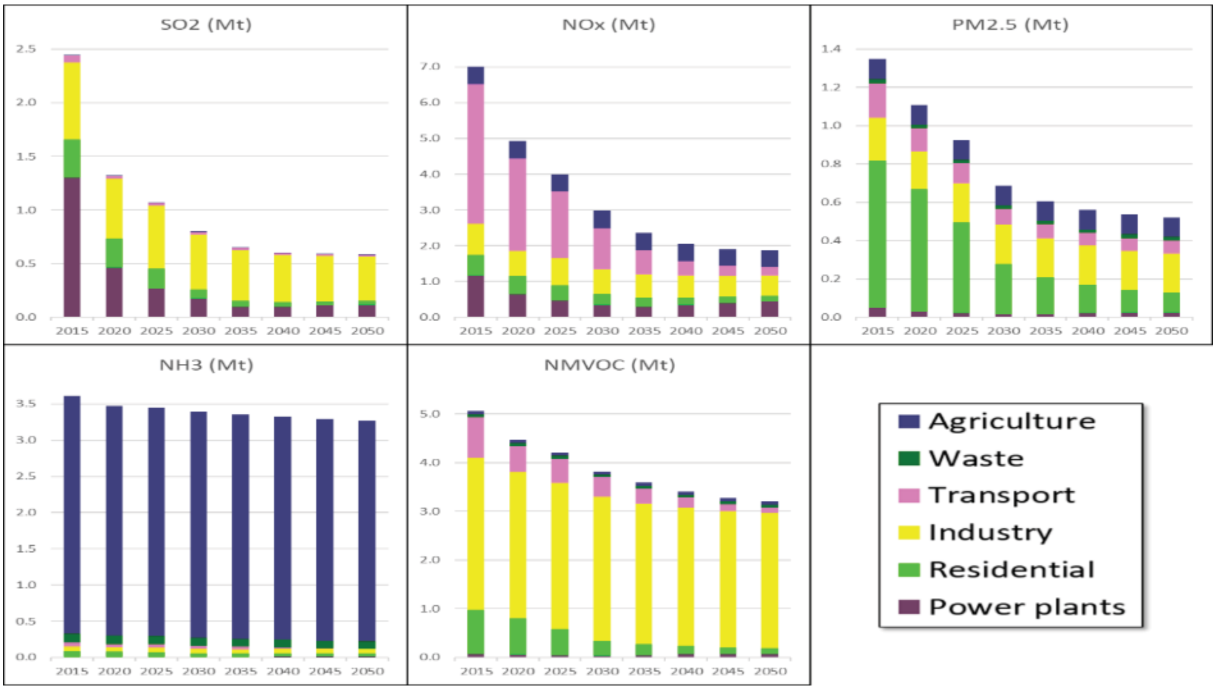

Figure 3 - Emissions of key air pollutants in the EU in the baseline scenario.[46]

Air pollutant concentration projections

Air pollutant concentrations are calculated based on the corresponding emissions for the EU (at 250 m resolution) and for existing air quality sampling points (25 m resolution). Figure 4 provides a geographically explicit depiction of how the emission reductions translate into reduced concentrations of $PM_{2.5}$ under baseline assumptions. This illustrates that large areas of the EU are expected to continue to experience annual mean concentrations above the WHO Air Quality Guideline levels of 5 $\mu g/m^3$ in 2030 (850 out of 994 sampling points) – with remaining areas even above the WHO Air Quality Guideline interim target of 10 $\mu g/m^3$ (153 out of 994 sampling points). Figures 4 and 5 show the expected number of sampling points above selected threshold concentrations for the baseline scenario (for $PM_{2.5}$ and NO_2).

For $PM_{2.5}$, compliance with the existing EU annual air quality standard of 25 $\mu g/m^3$ (for which today there is only a small compliance gap) is anticipated to have already happened (or happen very soon) under baseline assumptions. Concentrations of $PM_{2.5}$ are anticipated to continue to improve under the baseline, such that by 2030, and even more so by 2050, almost all areas across the EU will achieve compliance with existing EU standards. But further effort will be required to achieve broader compliance with more stringent targets.

[46] See the underpinning support study on the revision of the Ambient Air Quality Directives. Note that trends depicted here do not fully include possible positive effects due to the revised Industrial Emission Directive (IED), which are expected to deliver additional reductions in the medium- to long-term perspective.

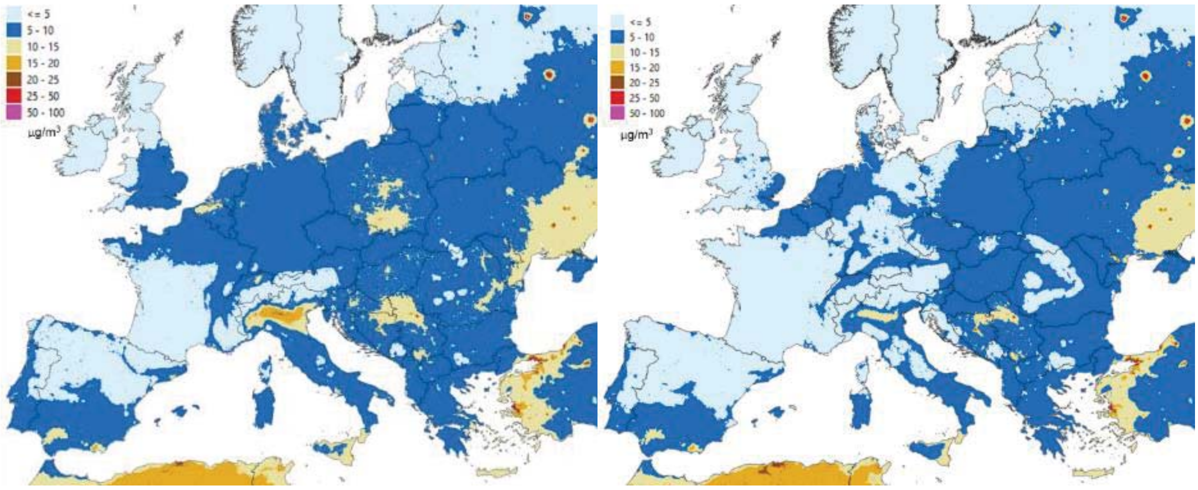

Figure 4 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under baseline scenario assumptions (for additional maps, including for other pollutants, please see Annex 5).[47]

Under baseline assumptions, by 2030 still around 25 million people are expected to continue to live in areas exceeding 10 µg/m³, and more than 300 million in areas exceeding 5 µg/m³.

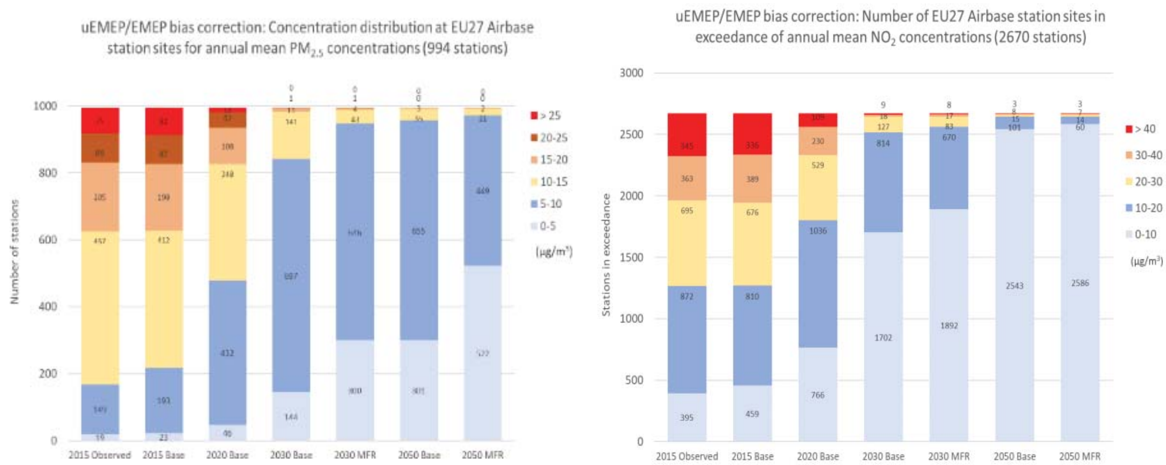

Figure 5 – $PM_{2.5}$ (left) and NO_2 (right) concentration modelling outputs for EU under baseline assumption.[48]

Figure 6 illustrates the main source contributions to annual mean concentration per Member State for $PM_{2.5}$ – and highlights the significant contribution of secondary organic and inorganic particulate matter (i.e. formed in the atmosphere from precursor air pollution emission of SO_2, NO_x, NH_3, and volatile organic compounds (VOCs)). The main primary $PM_{2.5}$ emission are due to residential heating.

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[47] Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

[48] A *'bias adjustment'* was implemented to some of the modelling to calibrate modelled concentrations and concentration monitored at sampling points for the year 2015 (i.e. at Airbase station sites). Notably, such bias adjustment was implemented for the station exceedance calculations for $PM_{2.5}$ and NO_2. This is based on the assumption that such bias is caused either by downscaling dispersion bias, or residual bias in emissions reported on a country basis. For the population exposure estimates this bias adjustment has not been applied. See the underpinning support study on the revision of the Ambient Air Quality Directives.

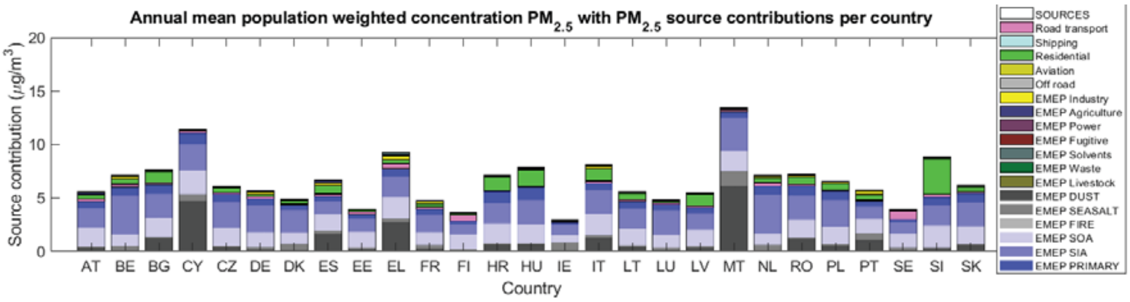

Figure 6 – $PM_{2.5}$ annual mean population weighted concentration under baseline assumption for 2030. [49]

For NO_2, compliance with the current EU annual air quality standard of 40 µg/m^3 will continue to improve under the baseline assumptions, and broad compliance is expected by 2030 (at this point only a very small number of sites and population exceed the standard under baseline assumptions, i.e. at 9 out of 2 670 sampling points). There is also broad compliance with a 20 µg/m^3 target by 2030 in the baseline (i.e. at all but 154 out of 2 670 sampling points). However, in 2030, a large number of sites and share of population are expected to be exposed to NO_2 levels in excess of 10 µg/m^3 (i.e. at 968 out of 2 670 sampling points). These figures reduce significantly towards 2050. Figure 7 illustrates the main source contributions to annual mean concentration per Member State for NO_2 – and highlights the continued significant contribution of road transport and, for coastal areas, shipping to local NO_2 concentration in many Member States.

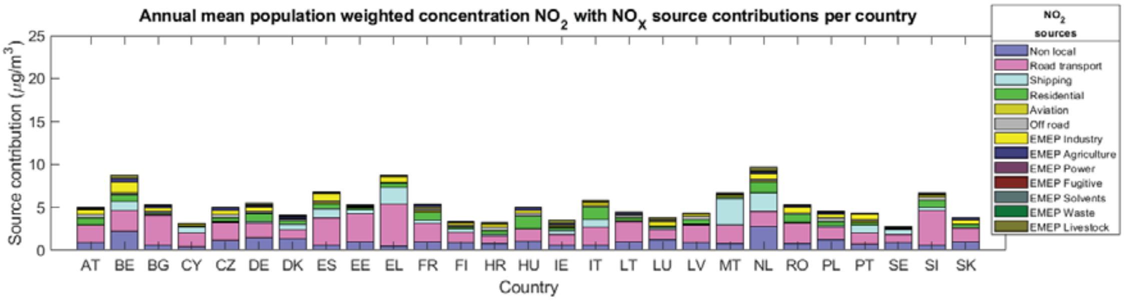

Figure 7 – NO_2 annual mean population weighted concentration under baseline assumption for 2030.[50]

Health and environment impact projections

Based on the scenario analysis of air pollutant concentrations, the health impacts are calculated by quantifying the impact of air pollution concentrations in excess of the 2021 WHO Air Quality Guidelines. While the approach does not prejudge that even the current version of the WHO Air Quality Guidelines cannot be seen as a final, zero pollution vision from a clean air perspective (not least given that they themselves are subject to periodic scientific reviews), it provides a robust order of magnitude and allows a comparison of the relative health benefit of different scenarios (also see Box 5).[51, 52]

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49 See the underpinning support study on the revision of the Ambient Air Quality Directives.

50 See the underpinning support study on the revision of the Ambient Air Quality Directives.

51 The 2021 WHO Air Quality Guidelines, nor their underpinning systematic reviews of available evidence, do not provide a quantified health effect assessment of pollutant concentrations below the guideline levels. Hence, this study calculates health impacts only above the guideline levels. However, pollution levels below

Under baseline assumptions, an important health impact is observed in all the years under consideration (Figure 8). Although air pollution related mortality is expected to decrease from 2015 to 2030, a significant number of premature deaths attributed to air pollution above the 2021 WHO Air Quality Guideline level would still be observed in 2030. This number decreases by a further 50% (or more) between 2030 and 2050.[53]

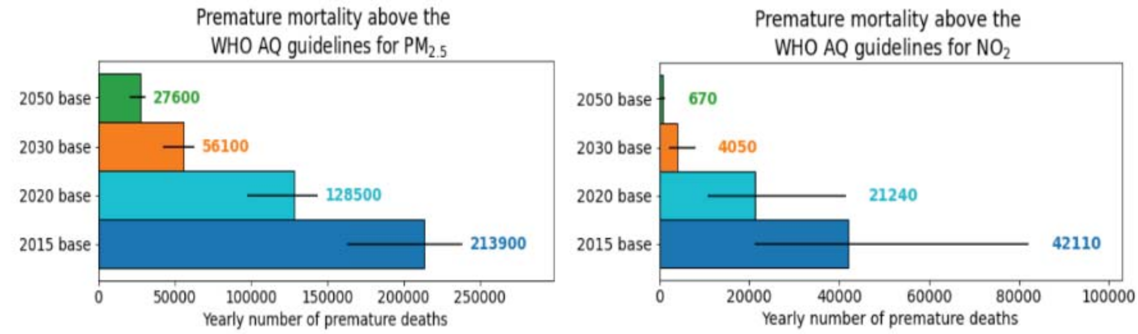

Figure 8 – Projection of premature mortality due to air pollutant concentrations above 2021 WHO Air Quality Guidelines levels for $PM_{2.5}$ (left) and NO_2 (right).[54]

This expected decrease in mortality corresponds quantitatively with decreases for chronic morbidity related to $PM_{2.5}$ exposure (including chronic bronchitis, cardiovascular and respiratory hospital admissions, stroke, lung cancer, asthma in children). A reduction of around 75% is observed for most of the morbidity health outcomes between 2015 and 2030 under baseline assumptions.

As regards environmental impacts, eutrophication due to air pollution still remains a significant issue in a 2030 perspective with up to 70% of EU-wide ecosystem areas exceeding the critical load under baseline assumptions (i.e. from an estimated 74.2% of ecosystem area in 2020 to 69.2% in 2030). This pollution pressure can aggravate situations of nitrogen surplus via water pollution. Acidification levels are much lower, and are also expected to decrease (i.e. from an estimated 4.8% of ecosystem area in 2020 to 3.1% in 2030).

Box 5 – Sensitivity of this assessment to health impact assessment assumption

This impact assessment includes calculations of the health impacts of air pollution, both in absolute terms (to assess the necessity of taking additional action on air pollution in the first place) and in relative terms (to assess

these levels may have some health effects, even though the WHO has not quantified them and considers them to 'not occur or [to be] minimal below these concentration levels'. Also see Box 5.

52 Also note that this approach focusses only on a subset of air pollutants for which current epidemiological evidence allows the robust quantification of health impacts. It does thus not include the potential health impacts of additional air pollutants (such as ultrafine particles).

53 These quantifications do not take into account the potential effects of the Commission proposal for a revised Industrial Emissions Directive, and of the RePowerEU package of measures published on 18 May 2022.

54 Note that due to other methodological choices (including that the method applied here is based on modelled air quality data and considers only the impact of air pollution above the WHO Air Quality Guidelines levels), this estimate is lower than the around 300 000 premature deaths referred to, for example, in Health impacts of air pollution in Europe 2021. See the underpinning support study on the revision of the Ambient Air Quality Directives for details.

the relative merits of different policy options considered). These calculations are based on the latest available evidence consolidated in the 2021 WHO Air Quality Guidelines and their underpinning scientific reviews. Since their publication, however, additional epidemiological studies have been published, including studies that focus on the risk of exposure to relatively low levels of air pollution. These point to a possibly quantifiable health impact also below guideline exposure levels recommended by the World Health Organization (i.e. the ‘cut-off value’), as well as to a supra-linear form of the exposure-response relationship (i.e. the ‘relative risk’, with a higher effect per additional exposure at low pollutant concentrations than at high concentrations).[55]

The underpinning support study on the revision of the Ambient Air Quality Directives therefore assessed the sensitivity of the results presented in this impact assessment to key assumptions (i.e. related to ‘cut-off value’ and the ‘relative risk’). This confirms that the assumptions made have a significant impact on the absolute impact of air pollution, and the health impact figures presented in this impact assessment underestimate the total health impact of air pollution. For the health impacts of $PM_{2.5}$ in 2015, for example, the estimates of premature mortality range from 213.900 to 524.200. This range of estimates of absolute impacts widens further (based on the relative difference between low and high estimates) for calculation for future years, as more and more people are expected to be exposed to air pollution at lower concentration levels only. Reassuringly, this sensitivity analysis also indicates that the effect on the relative benefits between policy options analysed in this impact assessment is only affected minimally. Under all sensitivity tests, the ranking of the net benefits or benefit-cost ratios between the scenarios does not change.

5.2 Description of policy measures assessed in this impact assessment

This impact assessment considers a total of 69 potential specific policy measures based on the mandate provided via the European Green Deal, and to address the general and specific objectives of the revision of the Ambient Air Quality Directives – see Annex 6. These measures are based on WHO recommendations (including as published in 2021), as well as stakeholder feedback to the Inception Impact Assessment and preliminary expert consultations (including with public authorities responsible for air quality monitoring, modelling and planning).

A first potential specific measure, namely the merging of the two existing Ambient Air Quality Directives[56] into a single legislation (and the deletion of now redundant provisions) is seen as a no regret option and provides a de-facto starting point for a future policy (and is therefore not further assessed here).[57] The remaining 68 of these potential specific policy measures are assessed both individually, and in combination with other potential policy measures. Four clusters of policy options to address the shortcomings are considered below.[58]

Each of these four clusters maps uniquely to one the four problems identified earlier and each set of options is assessed independently given that the four problems are quasi-independent from each other. However, the aggregate effect of the preferred option takes account of any synergies and trade-offs when bringing together the results of these separate analyses.

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55 Hoffmann B, Brunekreef B, Andersen Z, Forastiere F, Boogaard H (2022) Benefits of future clean air policies in Europe. Environmental Epidemiology. 6(5):e221

56 Directive 2008/50/EC and Directive 2004/107/EC

57 The fitness check of the Ambient Air Quality Directives identified a number of redundant provisions.

58 The *Inception Impact Assessment* framing the revision of the Ambient Air Quality Directives had pointed to three policy areas for action, namely (1) a closer alignment of the EU air quality standards with scientific knowledge including the latest WHO recommendations, (2) improving the air quality legislative framework, including provisions on penalties and public information, in order to enhance effectiveness, efficiency and coherence, and (3) strengthening of air quality monitoring, modelling and plans. While this framing has guided the initial analysis and stakeholder consultation, for the purpose of assessing different policy options in this *Impact Assessment* policy measures are grouped by shortcoming they seek to address.

(I) Policy options to address environment and health shortcomings

Policy options to address health and environmental shortcomings focus on revising the current EU air quality standards with a view to enhance the level of protection of human health and the environment as a whole, taking account of latest scientific knowledge and the European Green Deal developments. This includes the 12 air pollutants already covered by the existing Ambient Air Quality Directives, as well as potentially developing objectives for air pollutants not yet addressed by them (i.e. ultrafine particles, black carbon and ammonia).

Such EU air quality standards may either cover long-term mean concentrations (usually defined as annual mean or, for ozone, as peak-season mean) or short-term mean concentrations (usually defined either as 24-hour, 8-hour or 1-hour mean concentrations, depending on the characteristics of the air pollutant in question – also see Box 2 for a typology of EU air quality standards). For most air pollutants, setting air quality standards can be based on well-established evidence as regards their health and/or environmental impacts (see Annex 10).

The air pollutant considered to cause the greatest harm to the European population is fine particulate matter ($PM_{2.5}$). This pollutant can either be a result of primary emissions (mainly from combustion of fossil fuels or biomass), or a secondary product of precursor pollutants, namely nitrogen oxides (NO_x) and sulphur dioxide (SO_2) (both mainly stem from fossil fuel combustion) which combine with ammonia (NH_3) (which mainly stems from agriculture). Thus, concentrations of $PM_{2.5}$ lend themselves as an overall headline indicator of air pollution, as significant reductions of $PM_{2.5}$ can only be achieved by taking measures that reduce emissions of a range of air pollutants across a range of activities, including domestic heating and agriculture, but also transport, power generation and industry (see Figure 3).

Distinct policy options can thus be identified based on the 2021 WHO recommendations on $PM_{2.5}$ levels, and then translated into corresponding ambition levels for NO_2 and for all other air pollutants (based on the corresponding interim targets suggested by the 2021 WHO Air Quality Guidelines). This is admittedly a somewhat simplified approach, as the range of air pollutants covered by the Ambient Air Quality Directives spans wider than pollutants directly related to $PM_{2.5}$ and NO_2 levels (such as airborne heavy metals). For these additional pollutants, concentrations at levels of comparable stringency are included in the options, i.e. for each level of $PM_{2.5}$ analysed in an option, a comparably stringent and protective level of each of the other air pollutants is analysed as part of that same option – see Table 2.

It is worth noting that for fine particulate matter ($PM_{2.5}$), the current EU air quality standards are considerably less strict than those set in other OECD countries, while for most other pollutants they are within the range established elsewhere, i.e. higher than in some, lower than in others. For instance, standards for annual mean concentration of fine particulate matter ($PM_{2.5}$) range from 8 $\mu g/m^3$ in Australia, 10 $\mu g/m^3$ both in Switzerland and in Canada, 12 $\mu g/m^3$ in the United States, and 15 $\mu g/m^3$ in Japan and Norway. See Annex 10 for a comparison of air quality standards in place in other OECD countries.

It is also worth stressing that, consistent with the principle established in Article 193 of the Treaty on the Functioning of the European Union, the Ambient Air Quality Directives do not prevent Member States to set more stringent standards in national legislation – as is the case, for example, in Austria (for particulate matter (PM_{10}) and nitrogen dioxide), or Sweden (most notably for nitrogen dioxide).

Table 2 – Assumption for EU air quality standards for different policy options					
	Current EU standards	Current WHO guidelines	Policy option I-1 (2030) *	Policy option I-2 (2030) *	Policy option I-3 (2030) *
$PM_{2.5}$ (annual) [µg/m³]	**25 / 20**	**5**	**5**	**10**	**15**
$PM_{2.5}$ (daily) [µg/m³]	-	(99%) **15**	(99%) **15**	(95%) **25**	(95%) **37.5**
PM_{10} (annual) [µg/m³]	**40**	**15**	**15**	**20**	**30**
PM_{10} (daily) [µg/m³]	(35 days) **50**	(99%) **45**	(99%) **45**	(95%) **45**	(90%) **50**
NO_2 (annual) [µg/m³]	**40**	**10**	**10**	**20**	**30**
NO_2 (daily) [µg/m³]	-	(99%) **25**	(99%) **25**	(95%) **50**	(90%) **50**
NO_2 (hourly) [µg/m³]	(18 hours) **200**	(99.98%) **200**	(99.98%) **200**	(99.98%) **200**	(99.98%) **200**
O_3 (peak-season) [µg/m³]	-	**60**	**60**	**70**	**100**
O_3 (8-hour mean) [µg/m³]	(25 days) **120**	(99%) **100**	(99%) **100**	(95%) **120**	(95%) **120**
SO_2 (annual) [µg/m³]	**20**	**-**	**20**	**20**	**20**
SO_2 (daily) [µg/m³]	(3 days) **125**	(99%) **40**	(99%) **40**	(95%) **50**	(95%) **50**
SO_2 (hourly) [µg/m³]	(24 hours) **350**	-	(99.98%) **350**	(99.98%) **350**	(99.98%) **350**
CO (daily) [mg/m³]	-	(99%) **4**	(99%) **4**	(95%) **4**	(95%) **7**
CO (8-hour) [mg/m³]	**10**	**10**	**10**	**10**	**10**
Benzene (annual) [µg/m³]	**5**	**1.7**	**1.7**	**3.4**	**5**
BaP (annual) [ng/m³]	**1**	**0.12**	**0.12**	**1.0**	**1.0**
Lead (annual) [µg/m³]	**0.5**	**0.5**	**0.5**	**0.5**	**0.5**
Arsenic (annual) [ng/m³]	**6**	**6.6**	**6.0**	**6.0**	**6.0**
Cadmium (annual) [ng/m³]	**5**	**5.0**	**5.0**	**5.0**	**5.0**
Nickel (annual) [ng/m³]	**20**	**25**	**20**	**20**	**20**
(*) Analysis of the policy options is supplemented by an equivalent sub-option analysis for standards with a later target year.					
Note: For daily air quality standards reference is made in parentheses to allowed exceedances expressed as number of days or percentiles. For a full year of measurements, 99% translates into the standard not to be exceeded on more than 3 days, 95% to no more than 18 days, and 90% to no more than 36 days. For hourly air quality standards, 99.9% translates into the standard not to be exceeded for more than 8 hours, 99.98% not to be exceeded for more than 1 hour. [59]					

Achieving EU air quality standards will require action from almost all economic sectors and segments of society, from businesses to public authorities and citizens/consumers. Action is in particular required for activities that lead to air pollution in the energy, transport, industry and agricultural sectors. Such action will be required at all scales, i.e. at local, regional, national and transboundary levels.

Note that, while the policy options I-1 to I-3 are mutually exclusive, policy options I-4 to I-6 could complement either of the three other policy options – see Table 3. Also, it would be possible to combine either of policy options I-1 to I-3 (for 2030) with any of the sub-options of achieving more ambitious EU air quality standards at a later date (indicatively quantified for 2050 to offer a longer-term perspective).

Table 3 – Policy options to address environment and health shortcomings

[59] As per analysis provided by the underpinning support study on the revision of the Ambient Air Quality Directives, this assumes a statistical relationship between annual mean concentrations and the respective percentiles, resulting in indicative conversion factors:
- for $PM_{2.5}$ a factor of 1.96 for 90%, a factor of 2.54 for 95%, and a factor of 3.96 for 99% percentiles;
- for PM_{10} a factor of 1.79 for 90%, a factor of 2.26 for 95%, and a factor of 3.47 for 99% percentiles;
- for NO_2 a factor of 1.86 for 90%, a factor of 2.22 for 95%, and a factor of 2.97 for 99% percentiles;
- for SO_2 a factor of 1.77 for 90%, a factor of 2.43 for 95%, and a factor of 4.61 for 99% percentiles.

Policy options	Specific measures included in the respective policy option (+ specific measures assessed as sub-options)[60]
I-1 Full alignment with WHO recommendations	Revise and/or introduce standards for target year **2030** for **12 air pollutants:** $PM_{2.5}$, PM_{10}, NO_2, O_3, SO_2, CO, BaP, C_6H_6, Pb, As, Cd, Ni (see Table 2) + Sub-options to align further with WHO recommendation in a **post-2030** perspective, i.e. [I-1a], [I-2a], or [I-3a]
I-2 Closer alignment with WHO recommendations	
I-3 Partial alignment with WHO recommendations	
I-4 Additional air pollutants	**Ø1** Introduce standards for additional air pollutants
I-5 Average exposure reduction	**B3** Revise definition of average exposure standards **O3** Revise average exposure standards for $PM_{2.5}$ + **P3** Introduce average exposure standards for PM_{10} [I-5a] + **Q3** Introduce average exposure standards for NO_2 [I-5b] + **R3** Introduce average exposure standards for O_3 [I-5c]
I-6 Regular review air quality standards	**A1** Introduce review triggered by scientific progress **A3** Introduce option to notify stricter standards + **A2** Introduce review triggered by technical progress [I-6a] + **A4** Introduce a list of priority pollutants [I-6b]

This offers scope to combine EU air quality standards for a target year of 2030 with more stringent ambition levels in a post-2030 perspective, and put the EU on a trajectory towards a zero pollution vision by 2050 (assuming also that the scientific case for air pollution measures is kept under regular review) – see Figure 9.

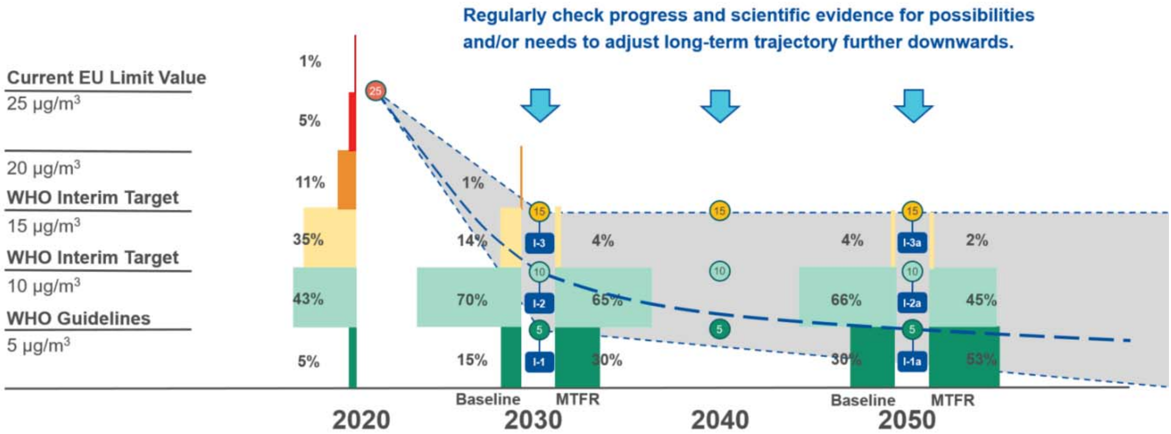

Figure 9 – INDICATIVE trajectories towards alignment with the 2021 WHO Air Quality Guidelines in 2030 / post-2030, based on the three policy options assessed (I-1, I-2, I-3). This figure also indicates for 2020, 2030 and 2050 the percentage of air quality sampling points that is projected to experience annual mean $PM_{2.5}$ concentration levels within the respective ranges (e.g. 5 to 10 µg/m³ or 10 to 15 µg/m³) under both baseline and MTFR assumptions (using the bias-corrected estimates provided by the underpinning support study on the revision of the Ambient Air Quality Directives).[61]

[60] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[61] Note that the percentage of sampling points in the concentration ranges in the scenarios assessed will be between the baseline and MTFR values and depend on the level of ambition assumed. It is important to note that over time both the scientific understanding of health impacts of air pollution, as well as the options to manage air quality will evolve, and may make more ambitious action possible and/or necessary.

Policy option I-1: ‘Full alignment with the 2021 WHO recommendations’ by 2030 (accompanied by a trajectory towards a zero pollution vision for air by 2050)
Establish stricter objectives equivalent to annual mean $PM_{2.5}$ at 5 µg/m³

A first policy option in this cluster is to *fully* align EU air quality standards with WHO recommendations as detailed in the 2021 WHO Air Quality Guidelines (see Annex 10), by the target year of 2030. Concretely, this implies a policy objective to reach annual mean concentrations of $PM_{2.5}$ at 5 $\mu g/m^3$ and NO_2 at 10 $\mu g/m^3$ throughout the territories of all Member States of the EU by the target year. Table 2 gives details per pollutant-time combination for each of the 12 air pollutants considered (including a possible number of exceptions for daily and hourly air quality objectives in line with scientific recommendations). For heavy metals this policy option builds on 2000 WHO Air Quality Guidelines (as the corresponding recommendations have not been updated since then), and where current EU air quality standards are more stringent than those, does not dial back the level of ambition.

Policy option I-2: ‘Closer alignment with the 2021 WHO recommendations’ by 2030 (accompanied by a trajectory towards full alignment in a post-2030 perspective)
Establish stricter objectives equivalent to annual mean $PM_{2.5}$ at 10 µg/m³

A second policy option in this cluster is to *more closely* align EU air quality standards with 2021 WHO recommendations (see Annex 10) by the target year of 2030, whilst considering a sub-option to design a trajectory for full alignment in a post-2030 perspective. But under this policy option, rather than aligning with the 'guideline exposure levels’ in full, EU air quality standards are guided by the interim targets that are closest to the guideline exposure levels (i.e. ‘WHO interim target 4 for $PM_{2.5}$’).[62] For $PM_{2.5}$ this translates into a 10 $\mu g/m^3$ objective to be met throughout the territories of all Member States of the EU by the target year, and for NO_2 into a 20 $\mu g/m^3$ objective – see Table 2 for details. For heavy metals current objectives are maintained, and for benzene and benzo(a)pyrene (BaP) objectives are roughly half-way between current objectives and guideline levels.

Policy option I-3: ‘Partial alignment with the 2021 WHO recommendations’ by 2030 (accompanied by a trajectory towards full alignment in a post-2030 perspective)
Establish stricter objectives equivalent to annual mean $PM_{2.5}$ at 15 µg/m³

A third policy option in this cluster is to *partially* align EU air quality standards with WHO recommendations by the target year of 2030, and to do less so than under policy options I-1 or I-2, whilst considering a sub-option to design a trajectory for full alignment in a post-2030 perspective. Accordingly, EU air quality standards are here broadly guided by WHO interim targets that are two steps away from the actual guideline exposure levels (i.e. ‘WHO interim target 3 for $PM_{2.5}$’). For $PM_{2.5}$ this translates into a 15 $\mu g/m^3$ objective to be met throughout

[62] The 2021 WHO Air Quality Guidelines define an interim target as *‘[a]n air pollutant concentration associated with a specific decrease of health risk. Interim targets serve as incremental steps in the progressive reduction of air pollution towards the air quality guideline levels and are intended for use in areas where air pollution is high. In other words, they are air pollutant levels that are higher than the air quality guideline levels, but which authorities in highly polluted areas can use to develop pollution reduction policies that are achievable within realistic time frames. The interim targets should be regarded as steps towards ultimately achieving air quality guideline levels, rather than as end targets.’*

the territories of all Member States of the EU by the target year, and for NO_2 into a 30 µg/m^3 objective – see Table 2 for details. For heavy metals, and for benzene and benzo(a)pyrene, current objectives are maintained.

Policy option I-4: 'Additional pollutants'
Establish air quality objectives for additional air pollutants

A fourth policy option in this cluster is a potential complementary addition of EU air quality standards for air pollutants of emerging concern, beyond what the WHO has been in a position to recommend based on the 2021 review of its Air Quality Guidelines. Potential objectives for ultrafine particles could be set at levels initially determined by the WHO as the threshold for 'low' (<1 000 particles per cm^3, 24-hour mean) or 'high' (>10 000 particles per cm^3, 24-hor mean) particle number concentration, subject to revision after more comprehensive monitoring results will become available. For black carbon, the WHO refers to studies that find statistically meaningful health impacts at levels of 1.08 to 1.15 µg/m^3, but does not endorse these in its good practice recommendation. For ammonia, no WHO recommendations for its concentrations in ambient air related to health impacts exist;[63] experts have suggested a long-term critical level for vegetation (higher plants) at 3 µg/m^3.[64]

Policy option I-5: 'Average exposure reduction'
Revise average exposure reduction obligations

The Ambient Air Quality Directives require reducing average population exposure to fine particulate matter ($PM_{2.5}$), using an average exposure indicator defined in the Directives. This indicator is calculated at national level on the basis of air quality measurements at urban background locations, i.e. at locations where air quality is not influenced much above average by a single source of pollution. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. This policy option would expand the application of the exposure reduction targets (relative reduction in exposure compared to a base year) by introducing targets also at regional or local scale (rather than at national level only), revise the current average exposure reductions targets for $PM_{2.5}$, and broaden the metric to include locations other than urban background (such as rural background locations). Note that the level of ambition of such metrics would need to be set relative to other air quality standards.

Three sub-options explore the possibility to introduce additional average exposure indicators and reduction targets for PM_{10} (I-5a), NO_2 (I-5b) and O_3 (I-5c).

Policy option I-6: 'Regular review of air quality standards'
Introduce a mechanism for a regular review of EU air quality standards.

This policy option would introduce into the legislation a more explicit obligation for the Commission (or a body designated to perform this on its behalf) to periodically (for example,

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[63] Note however that an indirect health impact of ammonia is well-documented, as ammonia emissions contribute to the formation of secondary $PM_{2.5}$, for which also WHO Air Quality Guidelines exist.

[64] UNECE (2007), Report on the Workshop on Atmospheric Ammonia : Detecting Emission Changes and Environmental Impacts (accessed: 13.06.2022)

every five years) review latest scientific advice and WHO recommendations on air quality standards with a view to propose possible updates in a flexible and adaptive manner, to be responsive to evolving scientific evidence and technological opportunities. Member States would be allowed to continue to adopt more stringent air quality standards in line with the minimum harmonisation requirements under Article 191 of the TFEU, but coupled with a more explicit obligation to notify the Commission if they do so (and why).

Note that two sub-options are also analysed, i.e. to check viability to link regular review requirements (also) to technical progress (I-6a) and to assess the benefits of establishing a list of priority air pollutants to ensure air pollutants of emerging concern are monitored (I-6b).

(II) Policy options to address air quality governance and enforcement shortcomings

The policy options in this cluster seek to achieve a clearer attribution of responsibilities and tasks in air quality governance – see Table 4.

Table 4 – Policy options to address governance and enforcement shortcomings

Policy options	Specific measures included in the respective policy option (+ specific measures assessed as sub-options)[65]
II-1 Responses to exceedances	**B4** Introduce (technical) guidance on addressing exceedances **C1** Revise obligations triggered by exceedances **C3** Revise coordination of short-term action plans & air quality plans **D1** Revise requirements to involve stakeholders **N1** Revise the information in air quality plans + **D2** Introduce a 'one zone, one plan' requirement [Sub-option II-1a]
II-2 Additional limit values	**B1** Introduce additional short-term standards **B5** Introduce limit values for additional air pollutants
II-3 Implementation timeline & short-term action plans	**C2** Revise/clarify definition of 'as short as possible' **C5** Introduce requirement to update air quality plans **B2** Introduce additional alert/information thresholds **C4** Introduce additional short-term action plans
II-4 Enforcement tools	**C1** Revise obligations triggered by exceedances **E1** Introduce minimum levels for financial penalties **E2** Introduce right to health damage compensation **E4** Introduce an explicit 'access to justice' provision + **E3** Introduce a fund to be fed by penalties paid [Sub-option II-4a]
II-5 Transboundary air pollution	**M1** Introduce methodology to assess transboundary **M2** Revise obligations for transboundary cooperation

These policy options aim to provide additional clarity, tools and support to Member States' authorities so that air quality plans (and short-term action plans) effectively address local and regional sources of pollution. To do so policy options look at introducing additional provisions on what to do in case of an exceedance, revising the number of air pollutants covered by limit values (as opposed to other less strict types of standards), as well as introducing a clearer implementation timeline for measures to be taken. Additional policy options seek to ensure that the development of air quality plans includes all relevant stakeholders, and all relevant government levels (including, where relevant, those responsible for transboundary contributions to exceedance situations). Furthermore, options look at defining more clearly the legal air quality requirements and where/when they apply, as well as at introducing explicit provisions on access to justice (granting legal standing), on compensation of (health) damages, and on penalties. Table 4 provides a summary.

[65] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

Note that the below policy options II-1 to II-5 are complementary, and somewhat independent from each other. This means that any of these policy options could be assessed as viable, or any combination of these. Possible synergies and trade-offs are analysed below.

Policy option II-1: 'Additional responses to exceedances'
Introduce additional provisions of what to do in case of an exceedance

This policy option seeks to add provisions on what kind of action is to be taken in case of exceedance of different types of standards, including which policy areas are to be considered when drawing up an air quality plan. This will require an update also of minimum information to be included in an air quality plan, including explicit requirements to *inter alia* estimate the effect of concentration reduction of planned air quality measures in µg/m³ at all sampling points in exceedance as well as a clear compliance perspective. This policy option would also establish a requirement for public authorities to involve specific actors in air quality plan development and to specify coordination arrangements for the development and implementation of air quality plans. This would ultimately result in changes in the minimum information to be included in an air quality plan to include a clear summary of related stakeholder consultation processes. Part of this would also be to establish a clearer link between short-term action plans and air quality plans (or even combine them) to avoid the double burden placed on public authorities to develop these separately.

A sub-option looks at how to clarify the requirements for drawing up air quality plans so that each air quality zone only features one plan, and vice-versa (II-1a).

Policy option II-2: 'Additional limit values'
Revise the number of air pollutants subject to 'limit values'

The fitness check of the Ambient Air Quality Directives concluded that limit values have been more effective in facilitating downward trends than other types of air quality standards, such as target values. This policy option would establish limit values for air pollutants currently subject to target values, in particular for air pollutants that tend to correspond to specific point source emissions (for example, most heavy metals), air pollutants that tend to correspond to emissions from specific widespread practices (for example, most poly-aromatic hydrocarbons). Furthermore, it would set short-term limit values standards (daily or hourly mean) also for all relevant pollutants for which currently only long-term standards (annual mean) exist and for which latest scientific and technological guidance recommends short-term standards (for example, fine particulate matter).

Policy option II-3: 'Implementation timeline and short-term action plans'
Introduce an implementation timeline for measures and revise short-term action plans

This policy option would add clarification of how quickly any air quality exceedance situation would need to be resolved. Currently the term *'as short as possible'* leaves room for interpretation. It could be clarified by adding *'and by no later than (2 to 5) years'*.[66,67] To

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[66] See Article 23(1), second subparagraph of Directive 2008/50/EC: *"In the event of exceedances of those limit values for which the attainment deadline is already expired, the air quality plans shall set out appropriate measures, so that the exceedance period can be kept as short as possible. […]"*

[67] The Court of Justice of the EU held that, in any case, that Article 23(1) [of Directive 2008/50/EC] does not justify a particularly long deadline and that this should be assessed in light of the temporal references

prevent exceedances, an air quality plan and corresponding measures could be required several years before new air quality standards enter into force, to ensure that they will be met when they become binding. Coupled to this, an obligation might be introduced to evaluate and update any air quality plan that has not succeeded to resolve exceedance situations within this timeframe. This option would also look to expand the concept of alert thresholds[68] to also include particulate matter, including an obligation to adopt effective short-term action plans to prevent and/or tackle pollution events.

Policy option II-4: 'Enforcement tools'
Revise the legal tools available to address breaches of obligations

Penalties, damages and access to justice provisions related to air quality exceedances have been insufficient. This policy option would further define the type of measures that competent authorities must take to ensure that exceedance periods can be kept as short as possible – and expand the current provisions on penalties to specify the magnitude of the financial penalties to be paid in case of breaches of air quality standards by establishing a minimum level for such and better linking breaches to EU source legislation[69] to breaches to the Ambient Air Quality Directives. In addition, it would introduce the right to a compensation for damage to health caused by breaches to the Ambient Air Quality Directives (as well as making a clearer a priori link between air pollution and health damage it causes) – coupled with an explicit provision on 'access to justice' in the Directives.[70]

A sub-option would require setting up a fund based on penalties when rules established by the Directives are infringed, and to be used to compensate damage caused (II-4a).

Policy option II-5: 'Transboundary air pollution'
Revise the approach to exceedances due to transboundary air pollution

This policy option would establish the use of an agreed methodology when assessing transboundary air pollution/contributions to local/regional air pollution. Based on this, transboundary cooperation and joint action on air quality would be seen as mandatory if assessments of transboundary air pollution indicate that contributions exceed certain thresholds. In practice this would require the establishment and implementation of joint air quality plans, possibly developed in close interaction with, and facilitated by the Commission. This should also be considered in instances of cross-border pollution and air pollution concerns shared with neighbouring countries that are not part of the European Union (including the Western Balkans).

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provided for in the Directive within which to comply with its obligations […] and in the light of the importance of the objectives of protection of human health and the environment pursued by that directive. See for example Cases C-730/19, *Commission v Bulgaria and* C-573/19, *Commission v Italy.*

68 Alert thresholds are levels beyond which there is a risk to human health from brief exposure for the population as a whole and at which immediate steps are to be taken by the Member States – set for sulphur dioxide, nitrogen dioxide, and ozone.

69 EU source legislation refers to EU legislation setting emissions standards for key sources of air pollution, such as road transport vehicles, domestic heating installations, industrial installations.

70 In line with Article 47 of the EU Charter of Fundamental Rights on the right to an effective remedy and to a fair trial.

(III) Policy options to address air quality monitoring and assessment shortcomings

Policy options in this cluster seek to ensure more reliable and comparable air quality assessment and would require Member States to make further improvements in the monitoring of air quality and greater use of refined air quality models when assessing ambient air quality – see Table 5.

Table 5 – Policy options to address air quality monitoring and assessment shortcomings

Policy options	Specific measures included in the respective policy option (+ specific measures assessed as sub-options)[71]
III-1 Air quality assessments	**G1** Revise rules related to indicative sampling points **G2** Introduce requirements for air quality modelling **H1** Revise minimum number of sampling points **H2** Simplify combined PM_{10}/$PM_{2.5}$ monitoring **L1** Introduce concept of monitoring at 'super-sites' + **G3** Revise rules for regular review of air quality assessment [III-1a] + **H3** Simplify the definitions of sampling points types [III-1b] + **K2** Introduce up-to-date data at all sampling points [III-1c] + **J3** Introduce obligation for spatial representativeness [III-1d]
III-2 Monitoring continuity	**I1** Introduce obligations to maintain sampling points **I3** Introduce a protocol for relocated sampling points + **I2** Introduce obligations to monitor long-term trends [III-2a]
III-3 Additional sampling points	**L1** Introduce concept of monitoring at 'super-sites' **L2** Introduce obligations to monitor more pollutants + **L3** Revise and expand list of VOC to monitor [III-3a]
III-4 Monitoring data quality	**J1** Revise macro-scale siting of sampling points **J2** Revise micro-scale siting of sampling points **K1** Revise air quality monitoring data quality objectives + **K4** Revise approach to air quality assessment uncertainty [III-4a]
III-5 Modelling data quality	**G2** Introduce requirements for air quality modelling **K3** Introduce air quality modelling data quality objectives

The Ambient Air Quality Directives spell out clear criteria for determining minimum numbers of sampling points, for data quality and acceptable uncertainty in monitoring and modelling, as well as for macroscale and microscale siting of sampling points. These criteria set limits to the flexibility that Member States have in setting up their respective air quality monitoring regimes, but within these limits leave the design, establishment and maintenance of the network to national, regional or local authorities. This flexibility ensures that siting of sampling points is based on local expertise and/or local circumstances. Policy options in this cluster seek to enhance the reliability and comparability of air quality data measured and/or modelled by competent authorities.

Note that the below policy options III-1 to III-5 are complementary, and somewhat independent from each other. This means that any of these policy options could be assessed as viable, or any combination of these. Possible synergies and trade-offs are analysed below.

Policy option III-1: 'Air quality assessments'
Revise the requirements for air quality assessment

This policy option looks at ways to further improve (and where necessary expand) air quality monitoring and assessment. This includes changing the minimum number of sampling points that are required per air quality zone to align with the latest scientific understanding of air pollution (and, as part of this, de-couple the minimum number of sampling points for $PM_{2.5}$

[71] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

and PM_{10} from each other). In several instances this will likely lead to a need for additional air quality monitoring sampling points. This would usefully be coupled with requiring a minimum number of monitoring stations that have sampling points to measure a wider spectrum of air pollutants (at so called "supersites"[72] across the Member States).

In some instances also air quality modelling and additional indicative measurements would be made mandatory, so that results from modelling and indicative measurements can better support optimal air quality monitoring. Furthermore further improved satellite observation data as provided via the Copernicus Atmosphere Monitoring Service (CAMS) could provide complementary data for all the locations where in-situ instrumentation is lacking. This would be especially relevant on the topic of transboundary air pollution where air pollutants can move long distances and across continents (including aerosols, dust, and precursors to secondary particulate matter and/or ozone. Such additional measurements and data would however not replace in-situ fixed monitoring but complement it.

Sub-options would address the need for regular review of the air quality assessment networks in Member States (III-1a), simplify the typology of sampling points to assure background and pollution hotspots are clearly identified (III-1b), and add requirements to provide up-to-date monitoring data at a fixed number of locations per air quality zone (III-1c). An additional sub-option could be considered to include a provision to estimate and report an area of representativeness for every sampling point (III-1d).

Policy option III-2: 'Monitoring continuity'
Introduce requirements to ensure continuity in air quality monitoring

Except for particulate matter, the Ambient Air Quality Directives do not include a requirement to maintain sampling points that have reported exceedances for a minimum time period, which would always allow verifying whether an exceedance has ended. This policy option would specify that sampling points with exceedances of limit values for any of the pollutants measured under the Ambient Air Quality Directives should be maintained for at least three years after the last exceedances was reported. If and when such sampling points need to be relocated due to exceptional circumstances this should be based on a protocol to ensure any air quality exceedance continues to stay under observation.

A sub-option is to include the requirement to monitor long-term trends if fixed monitoring stations are discontinued via indicative measurements or air quality modelling (III-2a).

Policy option III-3: 'Additional sampling points'
Establish a requirement to expand monitoring (of additional pollutants)

For the pollutants covered by the Ambient Air Quality Directives an extensive monitoring network of more than 4 000 monitoring stations that report data to the Commission today

[72] A 'supersite' is a monitoring location that combines multiple sampling points to gather long term data on all air pollutants covered by the Ambient Air Quality Directive, including an extended number of air quality parameters (such as an extended list of volatile organic compounds (VOCs), additional air pollutants of emerging concern (such as ultrafine particles (UFP), black carbon (BC), ammonia (NH_3) and others), as well as additional metrics (such as particle numbers (PN) or oxidative potential).

includes at least 600 sampling points for each of the pollutants.[73] The monitoring of additional air pollutants, including those of emerging concern, is less well established and not necessarily harmonised or always reported to the EU level. This policy option would require sampling points to measure continuously certain air pollutants of emerging concern (including at so-called "supersites" across the Member States), at a minimum number of stations and to agreed measurement standards.

A sub-option explores the virtue of expanding the list of required and/or recommended VOCs to measure (III-3a).

Policy option III-4: 'Monitoring data quality'
Revise the criteria for air quality sampling points

The placement and measurement quality of sampling points is critical to assure a reliable and comparable air quality monitoring network in all Member States. This policy option further clarifies (and reduces flexibilities related to) the macro-siting criteria for sampling points. It also further clarifies (and reduces flexibilities related to) the micro-siting criteria for sampling points. This would necessarily be coupled with further defined data quality requirements for sampling points / measurements used for air quality assessments.

A sub-option to consider is to modify the definition of measurement uncertainty by defining it in absolute values and not in percentage values (or a combination of both) (III-4a).

Policy option III-5: 'Modelling data quality'
Introduce requirements modelling quality objectives.

This policy option considers making air quality modelling a mandatory part of all air quality assessment. Modelling techniques can provide valuable information to supplement fixed measurements. Possibilities under which circumstances should air quality modelling be mandatory include: underpinning of air quality plans, forecasting of air pollution events, air quality mapping, evaluation of monitoring network design, estimation of population exposure, and others. To assure the reliability and comparability of air quality data derived from modelling standardized 'modelling quality objective' as a quality control mechanism to assess whether a modelling based assessment is fit for purpose would need to be introduced.

(IV) Policy options to address air quality information shortcomings

Policy options in this cluster seek to improve access to clear and objective air quality information – see Table 6. They aim to facilitate that the information that is disseminated by Member State competent authorities to the public is the same in all Member States in relation to potential impacts on health. For all policy options under this cluster the administrative burden of implementing the corresponding measures would fall upon public authorities (and in some cases would require the more active involvement as well of health sector authorities).

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[73] Monitoring stations can contain sampling points for several different pollutants – but do not necessarily include sampling points for every pollutant. This is due, for instance, to requirements to monitor different pollutants in different locations. See also SWD(2019) 427 *final* for number of sampling point per pollutant.

Note that the below policy options IV-1 to IV-3 are complementary, and somewhat independent from each other. This means that any of these policy options could be assessed as viable, or any combination of these. Possible synergies and trade-offs are analysed below.

Table 6 – Policy options to address air quality information shortcomings

Policy options	Specific measures included in the respective policy option (+ specific measures assessed as sub-options)[74]
IV-1 Up-to-date air quality data	**F1** Revise provisions related to up-to-date data **K2** Introduce up-to-date data at all sampling points
IV-2 Health related air quality data	**F2** Introduce requirement to provide air quality health data + **F3** Introduce specific communication channels [Sub-option IV-2a]
IV-3 Harmonised air quality indices	**F4** Introduce requirements for harmonised air quality index

Policy option IV-1: 'Up-to-date air quality data'
Introduce more specific requirements to provide up-to-date data

This policy option looks at introducing additional and more specific requirements to ensure regular digital reporting of up–to–date data / information (instead of allowing Member States to report data as available). This would include a mandatory provision of up-to-date information for certain air pollutants for all sampling points, or for a minimum number of sampling points, per air quality zone to a wider public, and via bespoke communication channels.

Policy option IV-2: 'Health related air quality data'
Introduce requirements to provide health related air quality data

This policy option is to require that public authorities in Member States provide specific health and health protection information to the public as soon as exceedances occur. Such information would necessarily need to be developed jointly between environmental and public health authorities, and build on scientific advice and WHO recommendations. Furthermore, additional mechanism to inform a wider public of the health risk triggered by air pollution are to be considered.

A sub-option is considered to mandate specific communication channels with citizens, including user-friendly tools for public access to air quality and health risks information and monitoring (for example, smartphone apps and/or dedicated social media pages).

Policy option IV-3: 'Harmonised air quality indices'
Introduce a requirement to use harmonised air quality index bands

The Commission and the European Environment Agency have introduced a European Air Quality Index in 2017,[75] which is regularly maintained and builds on available up-to-date data. Also Member States maintain air quality indices, but the absence of a common metric used for publicised indices often means that the same data is evaluated, and presented, in different ways in different locations. This policy option would require Member States to use harmonised air quality index bands, or make clear reference to EU agreed bands if alternative metrics are used at local or national scale.

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[74] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[75] See EEA, European Air Quality Index (accessed: 15.06.2022)

5.3 Options discarded at an early stage

From the outset the notion to fundamentally change the scope of the Ambient Air Quality Directives was discarded. The fitness check of the Ambient Air Quality Directives concluded, based on 10 years of experience in implementation of these Directives in their current form, that they have been *partially* effective in achieving their overall objectives of reducing air pollution and curbing its adverse effects.[76]

While this fitness check identified a number of lessons learned and potential for improving the legislation further, it did not point to fundamental flaws in the legislative framework as such. Also, stakeholder feedback to the Inception Impact Assessment and feedback received during the consultation phase did not point to the need for a structural change.[77] All options to drastically alter the scope of the Directives as such were thus discarded at an early stage.

This also includes discarding any consideration to merge EU clean air policy into a single legislative instrument, for example by combining the Ambient Air Quality Directives, the NEC Directive,[78] and relevant source legislation for key emission sources under a single umbrella. The NEC Directive, adopted in 2016, has now entered a key implementation phase, and will benefit from following its own timelines to achieve 2030 targets for emission reductions. At that stage a combined reflection on a post 2030 framework may be warranted, including based on a review of the NEC Directive in 2025. In the meantime, Member States already have to take into account the local air quality situation when preparing and implementing their National Air Pollution Control Programme, to reflect, inter alia, the effects of past and future national-level measures on air quality, if possible at the level of air quality zones.

A consequence of retaining this overall framework is also that, while EU legislation to reduce emissions from key air pollution sources will continue to reduce background concentration levels, the responsibility to meet EU air quality standards throughout their territories primarily lies with the Member States and the competent authorities they designate. Guided by the principle of subsidiarity, the Directives leave the choice of appropriate means to achieve air quality standards to the Member States, but explicitly require that exceedance periods are kept as short as possible.

Furthermore, the revision of the Ambient Air Quality Directives only considers air pollutants covered by recent WHO recommendations, or that are known to be major precursors to fine particulate matter ($PM_{2.5}$).[79] All policy options to include standards for the concentrations of additional air pollutants were discarded at an early stage. This notably concerns pollutants for which the WHO did not consider scientific evidence to be sufficient to establish guideline concentration levels. For some of them, such as ultrafine particles and black carbon/elemental carbon, additional monitoring is considered instead (based on corresponding good practice statements issued in the WHO Air Quality Guidelines). Note that mercury as an environmental pollutant is instead addressed by the Minamata Convention on Mercury and

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[76] See Annex 9 and SWD(2019) 427 *final*.
[77] See Annex 2 for a summary assessment of stakeholder feedback received.
[78] Directive (EU)2016/2284 on the reduction of national emissions of certain atmospheric pollutants
[79] Major precursors to fine particulate matter include sulphur dioxide, nitrogen oxides, ammonia, and volatile organic compounds – these are also covered by NEC Directive.

the corresponding EU Mercury Regulation.[80] And while some air pollutants are also climate forcers (such as black carbon), most greenhouse gas emissions, and especially carbon dioxide (CO_2), are addressed via EU climate legislation. Similarly, methane (CH_4), which contributes to elevated ozone concentrations, requires a comprehensive emission and concentration management strategy, and is not included here – and is instead covered by a bespoke methane emission strategy.[81]

The fitness check of Ambient Air Quality Directives also explicitly highlighted that, over the past decades, across the EU, Member States have established an air quality monitoring network with more than 4 000 monitoring stations based on common criteria defined by the Ambient Air Quality Directives. This extensive network can be considered a success in itself, and is the product of continuous investments into an EU-wide air quality monitoring framework to secure objective, comparable and reliable air quality data. Options to *fundamentally* rethink the monitoring strategy have consequently also been discarded (which does not preclude policy options to improve specific aspects of the monitoring network).

The latter also includes discarding considerations to designate a formal role to citizen science approaches as part of the air quality monitoring and assessment strategy, for example via low-cost air quality sensors. While these approaches currently offer a useful complement to air quality monitoring carried out to the criteria of the Ambient Air Quality Directives, they do not offer the same level of quality assurance as data collected by public authorities. For these types of measurement devices, further harmonisation and standardisation may be warranted.[82]

Finally, expanding the scope of the Ambient Air Quality Directives to include indoor air quality was also discarded. Most pollutants affecting indoor air quality originate from sources inside buildings (for more limited pollutants originating outdoors, action on ambient air quality will bring co-benefits), which requires a bespoke policy response. The Commission has agreed to 'assess pathways and policy options to improve indoor air quality, and propose legislative measure as relevant' as from 2023 in its Zero Pollution Action Plan.

6. WHAT ARE THE IMPACTS OF THE POLICY OPTIONS?

Each policy measure is assessed as regards its expected environmental, social, and economic consequences, as well as the costs and administrative burden it is likely to incur. This is based on a qualitative and, where possible quantitative assessment against a set of 12 more detailed assessment criteria described in Annex 4, and assessed in Annex 6. This more detailed assessment allows a summary assessment of each potential policy option along four dimensions: environmental, social, economic, and costs/administrative burden.[83]

Environmental consequences refer to the primary objectives of the Ambient Air Quality Directives, namely to protect human health and the environment from the adverse effects of

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[80] See Minamata Convention on mercury, and Regulation (EU) 2017/852 on mercury.
[81] Building upon the EU strategy to reduce methane emissions COM(2020) 663 *final*.
[82] See Annex 13. Also see: JRC (2019) Review of sensors for air quality monitoring (accessed: 13.06.2022)
[83] Approach based Better Regulation Tool #62: Multi-Criteria Decision Analysis. For simplification, the assessment of these impacts is summarised using +++ (very high), ++ (high), + (some significant) for positive impacts or benefits, and --- (very high), -- (high), - (some significant) for negative impacts or costs.

air pollution. Assessment criteria include the impact of the policy option on air pollutant concentrations; the resulting health impact on mortality and morbidity; the impacts on ecosystems including acidification, eutrophication, and ozone damage; and whether or not measures taken are in synergy with climate action and climate change adaptation efforts.[84]

Social consequences refer to whether the policy option alleviates the impact of air pollution on sensitive population groups, including children, pregnant women, elderly citizens and those suffering from pre-existing conditions. At the same time, this dimension necessarily also considers whether the related measures increase or decrease social and economic inequalities (i.e. by considering who is most affected, who bears the costs), including as relates to the likely effect of measures to address air pollution on employment.[85]

Economic consequences of policy options are two-fold. On the one hand, the overall economic implications of air pollution action entail both direct and indirect costs and benefits. The latter include benefits by reducing health-related and healthcare costs, lost working days, crop and animal value loss. On the other hand, taking measures to curb air pollutant emissions to meet EU air quality standards will generate costs (often: direct and short-term ones, including costs for key economic operators in some sectors, and in some cases with clear regional distributional differences across the EU; indirect costs could result from effects such as reduced investments in certain sectors but are unlikely). This assessment of the economic consequences focusses on the net effect on the broader economy – while short-term and implementation costs (including for key economic operators in some sectors) are highlighted separately, below.[86]

Direct costs include costs both from taking additional measures to curb air pollutant emissions and from administrative action to improve air quality management, in particular related to air quality assessment regimes (including monitoring, modelling, and digital reporting of related data) – i.e. beyond the current established practice resulting from the existing Ambient Air Quality Directives. The administrative cost / burden on public authorities will depend on the degree to which they can rely on existing air quality assessment structures.[87]

The assessment of the environmental, social and economic consequences alongside the direct costs allows for the construction of a comparative ***benefit-to-cost ratio***. If the expected benefits outweigh the expected costs, this is assessed as 'Medium'; if they do so significantly they are assessed as 'High'. Conversely, if the expected benefits do not outweigh the expected costs, the ratio is 'Low'. In some instances, the expected benefits would potentially justify a 'High' benefit-to-cost ratio, but it is questionable whether these expected benefits could be attained with only end-of-pipe measures (i.e. without rapid technological shift and

[84] See Indicators #1 to #4, as well as #11, in Annexes 4 and 6, and the underpinning support study on the revision of the Ambient Air Quality Directives.

[85] See Indicators #8 to #9 in Annexes 4 and 6, and the underpinning support study on the revision of the Ambient Air Quality Directives.

[86] See Indicators #5 to #7 in Annexes 4 and 6, and the underpinning support study on the revision of the Ambient Air Quality Directives (note that indicator #6 also features as a cost dimension).

[87] Expanding air quality monitoring networks comes at a cost that almost directly correlates with the number of additional monitoring required: annual operating costs, per monitoring station, are estimated at ranging between 7 500 and 70 000 EUR per year, depending what is measured. See SWD(2019) 427 *final*.

behavioural change) at all: in this case, to remain cautious, the benefit-to-cost ratio is regarded as 'Uncertain'.[88]

A general assessment of stakeholder views per policy option is also presented below, with a particular focus on views expressed by public authorities, as the burden of implementing the majority of these policy options, and the related administrative costs, would primarily fall upon public authorities at EU and national levels. For a more in-depth analysis of stakeholder views, see Annex 2 (synopsis report of the stakeholder consultation) and Annex 6 (potential policy measures). Impacts on UN sustainable development goals are summarised in Annex 3.

6.1 Impact of policy options I-1 to I-6 (and related sub-options)

Policy options I-1 to I-3 related to the level of ambition for EU air quality standards

Three distinct policy options that reflect three different degrees of alignment with WHO recommendations have been assessed in detail – assuming EU air quality standards are set at ambition levels that correspond to 5 $\mu g/m^3$, 10 $\mu g/m^3$, or 15 $\mu g/m^3$ (see Table 2). The key criteria assessed are to what degree setting standards at the respective levels is expected to result in tangible environmental, social and economic benefits, and at which costs (see Annex 4 for the description of the model and of its optimisation process).

This assessment places particular focus on emission reductions needed to achieve (revised) EU air quality standards, the number of exceedances above EU air quality standards expected to remain even if all end-of-pipe measures are taken, how many people are expected to be exposed to levels above these standards, and what the resulting health and environmental impacts would be (including whether sensitive populations are disproportionally impacted). Also an economic analysis is undertaken to assess the expected benefits to society (including from reduced health damage) in comparison to the expected costs of taking measures.

The presented impacts of **policy options I-1, I-2 and I-3** allow for comparing the options with each other, and also with both a baseline scenario and a theoretical 'maximum technically feasible reductions (MTFR or MFR)' scenario. The MTFR scenario minimises emissions by taking into account all available end-of-pipe technologies irrespective of costs and thus represents the lower limit of emissions reduction achievable with technical measures only).[89]

Figure 10 shows the projected emissions in the years 2030 and 2050, respectively, for key air pollutants under the different scenarios analysed, both in total and by sector.[90] These projections assume cost-optimal emission reduction measures for each policy option (meaning the most cost-effective technical measures to reduce air pollution and notably $PM_{2.5}$

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[88] Where in the assessment table the expected positive impacts ('+') outweigh the expected negative impacts ('-') by at least two (or a ratio of 3:1), the benefit-to-cost ratio is assessed as 'high'. Where they outweigh them by less than two, it is assessed as 'medium'. And where they are even, or the costs ('-') are higher than the benefits ('+') it is assessed as 'low'.

[89] Note, lifestyle changes (such as reduced energy consumption and shifts towards other dietary patterns), activity reductions, circular economy options and fuel switches (such as further electrification) beyond the baseline scenario are not included in the MTFR scenario.

[90] See Annex 5 and the underpinning support study on the revision of the Ambient Air Quality Directives for further detail about assumptions and disaggregation of results.

concentration levels are taken first, regardless of which economic sector would bear these costs and of where in the EU such would need to occur - see Annex 4 for a description of the optimisation process).

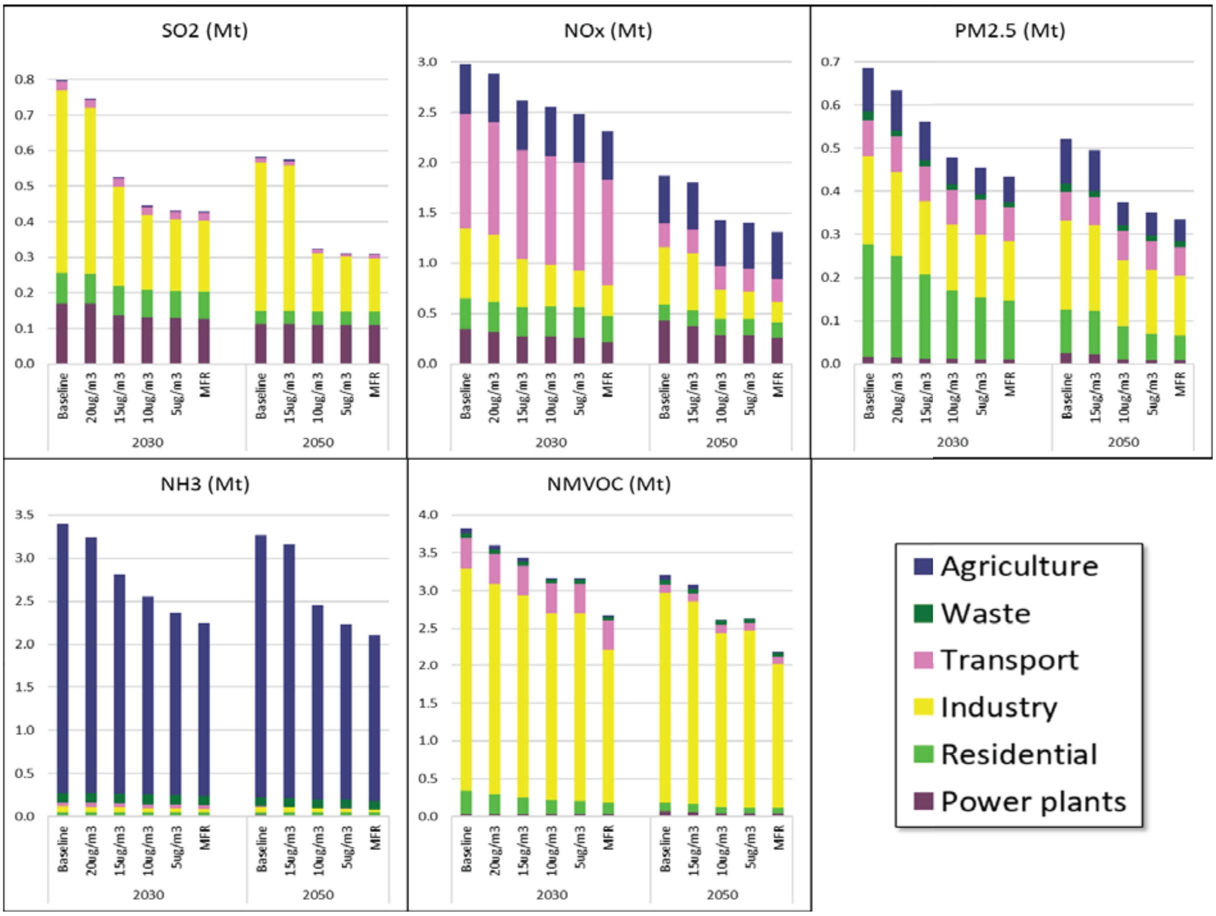

Figure 10 – EU emission in 2030 and 2050 for key air pollutants, and by key sector, under baseline assumption and for three policy options (I-1 at 5 µg/m^3, I-2 at 10 µg/m^3, I-3 at 15 µg/m^3), and MTFR scenarios.[91]

EU air quality standards that correspond to **policy option I-1** (*incl. annual mean $PM_{2.5}$ at 5 µg/m^3 by 2030) or* **policy option I-2** (*incl. annual mean $PM_{2.5}$ at 10 µg/m^{3}by 2030)* require significant additional effort. In some locations this would require the implementation of all measures assumed in the MTFR scenario – or, especially for policy option I-1, the standards are likely not even fully attainable based on current technology alone, and would require specific local measures that address specific local emission sources. The main driver of emission reductions (especially for direct emissions of $PM_{2.5}$) in the cost-optimal scenario to reach the 10 µg/m^3 and 5 µg/m^3 targets are measures to be taken in industry, residential heating and agriculture. Reduction of industrial emissions are relevant for several pollutants, while $PM_{2.5}$ emissions from residential heating can be reduced in the model optimisation by addressing biomass burning, since the role of coal is declining and so abatement potential around coal becomes less and less relevant (assuming effective implementation of the climate related targets for reduced reliance on fossil fuels; the recent RePowerEU approach also aims to reduce fossil fuel use).

[91] See Annex 5 and the underpinning support study on the revision of the Ambient Air Quality Directives.

Meanwhile, EU air quality standards that correspond to **policy option I-3** and its sub-options *(incl. annual mean $PM_{2.5}$ at 15 µg/m^3 by 2030)* appear to be feasible with only technical abatement measures (i.e. end-of-pipe measures that do not require a rapid technological shift or behavioural change). They require only some additional emission reduction at the EU level, compared to the baseline trajectory (which, however, already includes ambitious policy developments notably for greenhouse gas emission reductions that support strong reduction of air pollutant emissions associated with reduced fossil fuel use, as explained above). Attaining such targets would thus not require disproportionate reductions in emissions of individual Member States (see Annex 5 and the underpinning support study on the revision of the Ambient Air Quality Directives, which include more disaggregated data).

These reductions in air pollutant emissions translate into a significant reduction in concentrations for all air pollutants across the EU – see Figure 11.

Figure 11 - Number of stations above selected annual mean concentrations in the EU for $PM_{2.}$ and NO_2. Note that I-1 is labelled OPT05, I-2 is OPT10, and I-3 is OPT15 – also see Annex 5 for similar estimates for population exposed to different levels of air pollution under the different scenarios.

Under **policy option I-3**, the projected emission reductions described above result in that the fraction of sampling points exceeding annual $PM_{2.5}$ levels of 15 µg/m^3 is reduced from 16 % in 2020 to 0.8 % (8 out of 994 sampling points in the EU) in 2030 (compared to a baseline of 1.2 % in 2030); some 0.4 million people would continue to be exposed to levels above the target of 15 µg/m^3. For NO_2, the fraction of sampling points above the target of annual mean concentrations of 30 µg/m^3 reduces from 13% in 2020 to around 1% (27 out of 2 670 sampling points) in 2030 (note that this brings no improvement compared to baseline assumptions which also see 27 out of 2 670 sampling points above this level in 2030).

Under **policy option I-2**, the projected emission reductions described above result in that the fraction of sampling points exceeding annual $PM_{2.5}$ levels of 10 µg/m^3 is reduced from 52% in 2020 to 6% (60 out of 994 sampling points) in 2030 (compared to a baseline of 15% in 2030); 11.6 million people would continue to be exposed to levels above the target of 10 µg/m^3, but only 0.1 million would still be exposed to levels above 15 µg/m^3. For NO_2, the fraction of sampling points above the target of annual mean concentrations of 20 µg/m^3 reduces from 33% in 2020 to around 4% (110 out of 2 670 sampling points) in 2030 (i.e. compared to 144 sampling points under baseline assumptions for 2030).

Under **policy option I-1**, the projected emission reductions described above result in that the fraction of sampling points exceeding annual $PM_{2.5}$ levels of 5 µg/m^3 is reduced from 95% in 2020 to 71% (710 out of 994 sampling points) in 2030 (compared to a baseline of 85% in 2030). In other words, even if the EU air quality standards are set in full alignment with the 2021 WHO Air Quality Guidelines, by 2030 more than 225 million people in the EU would continue to be exposed to levels above the target of 5 µg/m^3 (if only technical abatement measures are considered). Out of these, 11.5 million people would even continue be exposed to levels above 10 µg/m^3 in 2030. In a 2050 perspective, due to reductions in air pollution resulting, inter alia, from co-benefits with EU climate policies the number people exposed above the target of 5 µg/m^3 would further reduce to 111 million. For NO_2, the fraction of sampling points above the target of annual mean concentrations of 10 µg/m^3 reduces from 71% in 2020 to around 31% (more than 821 out of 2 670 sampling points) in 2030 (compared to 968 sampling points above this level under baseline assumptions in 2030).[92]

None of the three policy options indicate a pathway to meet a target of 5 µg/m^3 throughout the EU in either a 2030 or even 2050 perspective if only technical abatement measures are considered in addition to the co-benefits from other existing policy initiatives considered in the baseline. A sensitivity study shows that additional measures resulting from revised IED full implementation lead to only relatively small changes in population weighted exposure to $PM_{2.5}$ and NO_2 of up to 0.2 µg/m^3 (see Annex 5.8 for details). Even with this full implementation assumption, this corresponds to a comparatively small number of additional stations (i.e. 35 out of 994 sampling points) that would attain a target of 5 µg/m^3 in 2030 under baseline assumptions. This indicates that fully implementing the proposed revisions of the IED will be required to affect the air quality improvements assumed by each of the three policy options (note that these additional improvements can be expected to intensify after 2030, given that the gradual roll-out, including of strengthened BAT, will accelerate post 2030).

[92] See Annex 5.4 for further details.

This assessment might change, and further reductions may be possible, if also more fundamental assumptions about changing economic activity, dietary patterns, technological breakthroughs or major shifts in our energy systems were to be considered (but this was beyond the scope of this impact assessment – also because any related assumptions would be at risk to be speculative, especially in a 2030 perspective). Such more fundamental assumptions would also have likely co-benefits for other environmental and climate policies.

Nevertheless, all three policy options translate into significant positive health impacts (due to the reduced exposure to air pollution above WHO Air Quality Guideline levels). Under baseline assumptions, compared to 2020, premature mortality in 2030 due to air pollution in areas in excess of the WHO Air Quality Guidelines reduces by -57% linked to $PM_{2.5}$ (at least 56 100 premature deaths) and by -81% linked to NO_2 (at least 4 050 premature deaths). **Policy option I-1** would by 2030 reduce these figures by a further -53% for $PM_{2.5}$ and -20% for NO_2, respectively. For **policy option I-2** the additional reduction by 2030 would still be -49% for $PM_{2.5}$ and -16% for NO_2 – and for **policy option I-3** the reduction by 2030 would be limited to a further -38% for $PM_{2.5}$ and 12% for NO_2. This shows that there is a clear gradient in the positive health impact of the three policy options (with a larger increase from policy option I-3 to I-2, than from I-2 to I-1).[93]

Also as regards impacts on the environment, and on **ecosystem area exceeding critical loads** for eutrophication from deposition of nitrogen, the policy options show a gradient. Under baseline assumption, by 2030, 69% of ecosystem area in the EU is subject to such levels above critical loads. By 2030, **policy option I-3** reduces this share of ecosystem area suffering from high loads to 61%. **Policy-option I-2** reduces it to 58% and **policy-option I-1** to 55%. In a post-2030 perspective, policy-option I-1a reduces this to 50%.[94]

Table 7 – Direct benefits of policy options, relative to the baseline – per year in million Euro (2015)

Policy Option / Scenario			2030 ($PM_{2.5}$ at 20 $\mu g/m^3$)	2030 I-3 ($PM_{2.5}$ at 15 $\mu g/m^3$)	2030 I-2 ($PM_{2.5}$ at 10 $\mu g/m^3$)	2030 I-1 ($PM_{2.5}$ at 5 $\mu g/m^3$)	2050 I-3a ($PM_{2.5}$ at 15 $\mu g/m^3$)	2050 I-2a ($PM_{2.5}$ at 10 $\mu g/m^3$)	2050 I-1a ($PM_{2.5}$ at 5 $\mu g/m^3$)
Human health benefits	Mortality (VOLY[95])		9 505	25 182	32 394	34 734	2 897	16 287	16 935
	Mortality (VSL[96])		33 486	85 697	110 517	118 764	11 097	63 194	65 804
	Morbidity		2 343	6 141	7 992	8 610	529	3 121	3 310
Environmental benefits	Material		29	181	196	204	12	156	160
	Crops		67	188	254	276	44	259	258
	Forests[97]	Low	69	222	287	316	52	292	293
		High	69	222	287	316	127	712	716
	Ecosystems	Low	101	448	706	863	83	790	931
		High	302	1 345	2 117	2 588	250	2 370	2 794
TOTAL gross benefits	Low (based on VOLY)		12 114	32 362	41 829	45 003	3 617	20 905	21 887
	High (based on VSL)		36 296	93 774	121 363	130 758	12 059	69 812	73 042

These health and non-health impacts can be translated into monetised benefits and costs.

[93] See Annex 5.5 on health impacts for further details.
[94] See Annex 5.6 on ecosystem impacts for further details.
[95] VOLY (value of a life year) represents an estimate of damage costs based on the potential years of life lost, which takes into account the age at which deaths occur (i.e. higher weighting for younger people).
[96] VSL (value of statistical life) represents an estimate of damage costs based on how much people are willing to pay for a reduction in their risk of dying from adverse health conditions.
[97] Note that there is no difference between High and Low estimate for forest damage in 2030 as only after 2030 different assumptions are used to monetise the reduced carbon sequestration potential due to forest damage.

Table 7 shows the direct benefits that result from better air quality and associated reduced impacts on human and environmental health.[98/99] This does not include macro-economic knock-on effects (shown in Table 9).

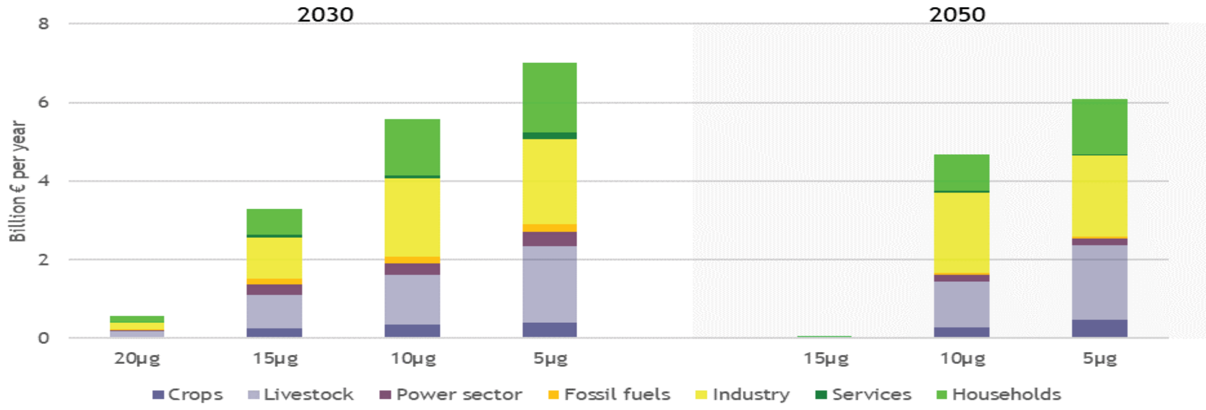

Figure 12 – Air pollution mitigation or adjustment costs (EU total) beyond the baseline, for different policy scenarios (I-1 at 5 µg/m³, I-2 at 10 µg/m³, I-3 at 15 µg/m³).[100]

The gradient of ambition translates into a gradient of the air pollution mitigation (or adjustments) costs applied in the different policy options. Such costs, which represent *additional* costs compared to the baseline scenario costs, are shown in Figure 12.

Consistent with the results for emission reductions associated with the policy options analysed in this work, the additional annual costs (compared to cost under baseline assumptions) of reaching the 15 µg/m³ target for annual mean $PM_{2.5}$ (**policy option I-3**) amount to 3.3 billion Euro in 2030 (this would become close to zero by 2050). A 10 µg/m³ target for annual mean $PM_{2.5}$ (**policy-option I-2**) amounts to costs of 5.6 billion Euro in 2030 (this would reduce to 4.7 billion Euro by 2050). And a 5 µg/m³ target for annual mean $PM_{2.5}$ (**policy-option I-1**) translates into 7.0 billion Euro in 2030 (this would reduce to 6.1 billion Euro in 2050. For the latter a strong caveat remains that, at around half of the stations in the EU, it may not be possible to meet the objectives set at all, at least in a 2030 perspective, even as virtually all technology options are explored without considering other abatement options, such as behavioural change or fuel shift.

Table 8 compares the mitigation costs and administrative costs to the expected benefits (from Table 7), showing large net benefits for all policy options.

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98 See Annex 4.5 for the methodology of monetising health and non-health impacts, and Annex 5 for detailed results.

99 Direct benefits are derived by subtracting the impacts resulting from the different scenario modelling runs from the impacts resulting from the baseline run.

100 See the underpinning support study on the revision of the Ambient Air Quality Directives.

Table 8 – Costs and net benefits of policy options, relative to the baseline – per year in million Euro (2015)

		2030				2050		
Policy Option / Scenario		($PM_{2.5}$ at 20 µg/m³)	I-3 ($PM_{2.5}$ at 15 µg/m³)	I-2 ($PM_{2.5}$ at 10 µg/m³)	I-1 ($PM_{2.5}$ at 5 µg/m³)	I-3a ($PM_{2.5}$ at 15 µg/m³)	I-2a ($PM_{2.5}$ at 10 µg/m³)	I-1a ($PM_{2.5}$ at 5 µg/m³)
Total gross benefits	Low (based on VOLY)	12 114	32 362	41 829	45 003	3 617	20 905	21 887
	High (based on VSL)	36 296	93 774	121 363	130 758	12 059	69 812	73 042
Total mitigation / adjustment costs		-560	-3 280	-5 580	-7 020	-50	-4 670	-6 080
Total administrative costs (*)		-75	-76	-79	-106	-75	-75	-75
Total net benefits	Low (based on VOLY)	11 479	29 006	36 170	37 877	3 492	16 160	15 732
	High (based on VSL)	35 661	90 418	115 704	123 632	11 934	65 067	66 887

(*) Total administrative costs include costs for all policy options that are not linked to the level of ambition of revised EU air quality standards (i.e. for the preferred policy options (section 8.1), which adds up to about 75 million Euro per year) plus the costs linked to the development of air quality plans which depends on the number of exceedances above EU air quality standards to be expected in the target year 2030 (note: this depends on the level of ambition assumed via policy options I-1, I-2 or I-3, which adds up to between 1 and 31 million Euro per year). For simplicity, no remaining exceedances in the target year 2050 are assumed here (note: this is likely an underestimate).

Air pollution has detrimental welfare impacts by affecting health outcomes. In addition, related healthcare expenditures, crop yield losses due to ozone, absence from work due to illness (including of dependent children) and lower productivity at work can imply a drag on the economy. Improving air quality is therefore expected (despite gross cost resulting from costly investments and purchases of abatement equipment) to bring economic gains. Annex 5 provides a detailed macro-economic assessment as to whether air pollution control policies lead to net economic gains or losses, and how these are distributed across economic sectors.

This analysis focuses on productivity gains from clean air, leaving aside other ‘market’ benefits, such as reduced healthcare expenditures and increased crop yields, as well as ‘non-market’ benefits (such as reduced premature mortality, improved ecosystem health).[101] The more ambitious the EU air quality standards, the larger the net gains, as reflected by the positive impact on gross domestic product (GDP) and private consumption. Net GDP gains by 2030 are expected for all policy options, in the range of 0.26% to 0.44%. Except for livestock-based agriculture, all sectors displayed in Table 9 raise output compared to the baseline assumptions when productivity gains of clean air are accounted for (second number in Table 9). Zooming in on option I-2, output increases by 0.53% in 2030 compared to the baseline for industry – the sector shown to bear the largest share of costs (Figure 12), by 0.45% for crop production, by 0.44% for the power sector, and by 0.38% for the services sector.

These macroeconomic developments translate into very small (especially in relative terms) employment changes by sector that are consistent across scenarios. Focusing on the net effects, the number of jobs in industry increases in response to increased production of abatement equipment. The agricultural sector experiences job losses compared to the baseline, which relates to output losses (livestock sector) or a transition of workers into industry (crops sector).[102]

[101] See Annex 5.7 on macroeconomic modelling as well as the underpinning support study on the revision of the Ambient Air Quality Directives.

[102] The results are under the assumption of flexible wages that fully accommodate labour market adjustments, as explained further in Annex 5. The specificity of the results for the agricultural sector is due to that putting in place abatement measures is not compensated for by an increased demand within the sector (for industry, for example some sub-sectors benefit from a new or increased demand for abatement technologies).

Table 9 - Economic outcomes of clean air policy in the EU – expressed as percentage change relative to reference baseline. Note that the first number in a cell represents the effect of gross costs only. The second number (after the vertical line) represents the net effect, i.e. benefits minus costs.[103]

>>> Option analysed >>>	W/ current standards	Option I-1 ($PM_{2.5}$ at 5 $\mu g/m^3$)	Option I-2 ($PM_{2.5}$ at 10 $\mu g/m^3$)	Option I-3 ($PM_{2.5}$ at 15 $\mu g/m^3$)		Sub-option I-1a	Sub-option I-2a	Sub-option I-3a
Cost only | Net effect (benefit-cost) % change relative to reference	2030	2030	2030	2030		2050	2050	2050
Gross Domestic Product	0.00 | 0.10	-0.05 | 0.44	-0.04 | 0.38	-0.02 | 0.26		-0.03 | 0.36	-0.02 | 0.29	0.00 | 0.03
Private Consumption	0.00 | 0.12	-0.04 | 0.57	-0.03 | 0.49	-0.02 | 0.34		-0.02 | 0.46	-0.02 | 0.37	0.00 | 0.04
Sector output								
Crops	-0.02 | 0.15	-0.32 | 0.50	-0.26 | 0.45	-0.19 | 0.30		-0.30 | 0.36	-0.17 | 0.38	0.00 | 0.06
Livestock	-0.09 | 0.05	-1.01 | -0.36	-0.62 | -0.05	-0.45 | -0.06		-0.91 | -0.37	-0.54 | -0.10	-0.01 | 0.05
Power sector	0.00 | 0.11	0.01 | 0.50	0.01 | 0.44	0.00 | 0.30		0.02 | 0.41	0.02 | 0.34	0.00 | 0.04
Fossil fuels	-0.01 | 0.08	-0.11 | 0.32	-0.10 | 0.28	-0.09 | 0.18		-0.03 | 0.29	-0.04 | 0.24	0.00 | 0.03
Industry	0.00 | 0.13	0.02 | 0.63	0.01 | 0.53	0.02 | 0.38		0.01 | 0.51	0.00 | 0.40	0.00 | 0.05
Services	0.00 | 0.09	0.00 | 0.45	0.00 | 0.38	0.0 | 0.26		0.00 | 0.37	0.00 | 0.29	0.00 | 0.03

When it comes to social impacts, sensitive population groups (including children, pregnant women, elderly citizens and those suffering from pre-existing conditions) will in most instances benefit the most from reduced air pollution impacts on their health, notably under **policy options I-1, I-2 and I-3**. This is because the health of members of this group is most affected by air pollution today. The degree of benefits correlates with the different levels of ambition of the three policy options. Whether different population groups (e.g. regarding income or education) will bear higher or lower shares of the costs air pollution abatement can vary substantially depending on what measures are taken. Based on assessment of **policy options I-1, I-2 and I-3** it is possible to conclude that they offer three different levels of ambition that translate into both corresponding increasing positive impacts (highest for I-1), as well as corresponding increasing costs (highest for I-1). Nevertheless, all three options point to a high benefit-to-cost ratio. An important caveat, however, is that, based on the assessment, the feasibility to actually reach the EU air quality standards implied by the three policy options differs significantly when only considering technical abatement options. While standards implied by **policy option I-3** seem reachable with only technical measures throughout the EU, requiring only some additional emission reduction at the EU level compared to the baseline trajectory, those implied by **policy option I-2** may be unattainable with only technical measures in up to 2% of the sampling points by 2030. The standards implied by **policy option I-1** appear unattainable in around half of the stations in the EU, if only technical abatement measures are considered (see section 8.2 for further details which regions face particular challenges). Additional measures at local level (such as local restrictions to biomass burning, or promotion of active mobility) or wider societal changes (such as changes in dietary patterns) would be needed to achieve such levels.

Stakeholder feedback pointed to a desire to opt for a high level of ambition. In the public consultation, 73% percent of all respondents expressed a clear preference to align with the 2021 WHO Air Quality Guidelines. In particular, a large majority of *civil society & NGOs* (93%) and *EU citizens* (79%) confirmed that EU air quality standards should be fully aligned with the latest WHO recommendations (i.e. **policy option I-1**). This view was only shared by a minority of *public authorities* (36%), with a majority of them (62%) calling for partial

[103] Based on general equilibrium modelling with the JRC-GEM-E3 model.

alignment. In a more targeted survey, *public authorities* expressed almost equal support for **policy options I-2 and I-3**. Representatives from *research & academia* largely shared this view. A clear majority of *industry & businesses* stakeholders favoured keeping EU air quality standards at current levels or only moderate increases in ambition for 2030.

Table 10.1 to table 10.3 summarises this assessment in a simplified manner – for details please also see the detailed assessment of specific potential policy measures in Annex 6.

Tables 10.1 to 10.3 – Assessment of policy options (I-1, I-2, I-3) to address environment and health shortcomings.[104]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
I-1 Full alignment with WHO recommendations *(Measures O1 to Z1)*	+++	+++	+++	---	Even if all effort is made, the related targets cannot be fully achieved everywhere (due to physical geography constraints). But at locations where achieved, they bring major health benefits.	High (Uncertain)
+ **I-1a**: by 2050	++	++	++	--	See above.	High (Uncertain)
I-2 Closer alignment with WHO recommendations *(Measures O1 to Z1)*	++	++	++	--	Current baseline policies bring most regions close to target. Achieving this target has considerable health benefits and social co-benefits – medium effort needed.	High
+ **I-2a**: by 2050	+	+	+	-	Target would be achievable with little extra effort.	High
I-3 Partial alignment with WHO recommendations *(Measures O1 to Z1)*	+	+	+	-	Current baseline policies will achieve this level in almost all of the EU. Thus setting targets at this level offers only limited added benefit (but where it triggers additional action this is of high benefit).	High
+ **I-3a**: by 2050	0	0	0	0	Likely does not require additional policy action.	NA

Policy options I-4 to I-6 to address other health and environment shortcomings

Three further policy options look at establishing objectives for other air pollutants, at revising and expanding obligations to ensure reductions in the average exposure to air pollution, and at putting in motion a regular review mechanism for EU air quality standards. This assessment of these policy options is guided by considerations as to whether they make the Ambient Air Quality Directives more effective and future proof.

A significant number of stakeholders, in particular those representing *civil society & NGOs* and those representing *research & academia*, support **policy option I-4** *(establish air quality objectives for additional air pollutants)*. However, based on a review of the scientific evidence available, it is suggested not to retain this policy option. While there is a growing body of research suggesting the relevance of various components and precursors of particulate matter, the WHO Air Quality Guidelines concluded in 2021 that, as yet, there is a consensus that the body of epidemiological evidence is not yet sufficient to formulate an guideline exposure levels for additional air pollutants – and thus offer no basis for setting EU air quality standards.[105] Furthermore, to date no harmonised monitoring approach for these pollutants exists in Europe:[106] establishing this, as per policy option III-3 should be

[104] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[105] The WHO Air Quality Guidelines suggest distinguishing between low and high particle number concentrations to guide decisions on the priorities of ultrafine particles source emission control.

[106] See support contract on "Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC (with a focus on ultrafine particles, black carbon and ammonia)".

considered a priority, to generate more knowledge on current concentrations of these air pollutants. Also, these pollutants should ideally be kept under review as per policy option I-6 via a regular review of EU air quality standards.

Table 10.4 – Assessment of policy options I-4 to address environment and health shortcomings[107]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
I-4 Additional air pollutants *(Measure Ø1)*	0/+	+/-	+/-	--	May have benefits, but to date no basis in WHO recommendations to set such air quality standards. Priority should be establishing a monitoring network for these pollutants (see III-1).	Low but uncertain

Meanwhile, already the fitness check of the Ambient Air Quality Directives concluded that limit values for fine particulate matter ($PM_{2.5}$) have been more effective in facilitating downward trends – especially where this has been done in conjunction with a requirement to reduce average exposure, as per **policy option I-5** (*revise average exposure reduction obligations)*. Generally, stakeholders showed some support for this option, especially for introducing an exposure reduction target applicable at regional or local level. This was in particular supported by a majority of *industry & businesses* respondents, as well as regional or local level *public authorities*. This is expected to have positive direct effects through better targeting exposure, thereby improving health protection of the general population. Compliance costs have the potential to be significant and depend on the ambition level.

Introducing an additional average exposure indicator for particulate matter (PM_{10}, **sub-option I-5a**) in addition to one for $PM_{2.5}$ is assessed as having low added value. This is because the measures taken to reduce PM_{10} and $PM_{2.5}$ concentrations are often the same. The concentration levels of PM_{10} and $PM_{2.5}$ correlate strongly, too (as the latter is a sub-set of the former). Conversely, establishing an additional average exposure indicator for nitrogen dioxide (NO_2, **sub-option I-5b**), could help focus measures on reducing background concentration levels affecting larger areas, in addition to reducing pollution in hotspots affecting smaller areas but with higher concentrations and limit value exceedances. For ozone pollution (O_3, **sub-option I-5c**) it is uncertain whether an average exposure indicator would be useful for reducing ozone concentrations. This is because of the specific chemical characteristics of how ozone forms in the atmosphere, and how ozone formation is linked with meteorological conditions (resulting in pronounced local and year-to-year variability).

Table 10.5 – Assessment of policy option I-5 to address environment and health shortcomings[108]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
I-5 Average exposure reduction for $PM_{2.5}$ *(Measures B3, O3)*	++	+	+	--	Can build on existing concept and monitoring, but at more appropriate regional resolution, to help assure continuous decrease in background $PM_{2.5}$.	High
+ **I-5a:** PM_{10} *(Measure P3)*	+	+	+/-	--	Low added value, if $PM_{2.5}$ is already covered.	Low
+ **I-5b:** NO_2 *(Measure Q3)*	+	+	+	--	Extra burden, NO_2 focus better be 'hotspots'.	Medium
+ **I-5c:** O_3 *(Measure R3)*	+	+/-	+/-	--	Uncertain if O_3 metric can trigger effective action.	Uncertain

[107] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[108] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

The scientific understanding of air pollution and its health impacts has evolved significantly over the past decades, and resulted in regular updates of the WHO Air Quality Guidelines. Whilst the 2021 edition of the WHO Air Quality Guidelines provides the basis for this impact assessment, it is to be expected that, over the coming decade(s), the scientific understanding will trigger future updates.[109] Against this backdrop, **policy-option I-6** *(introduce a mechanism for a regular review of EU air quality standards)* is assessed as offering a safety clause to accelerate alignment to scientific developments, whilst securing the involvement of the co-legislators. The burden of implementing this policy option would primarily fall upon public authorities at EU and national levels.

Stakeholders were generally supportive of such measures to ensure regular review triggered by scientific progress (especially *civil society & NGOs* and, to a lesser degree *research & academia*). A relative majority of *public authorities* did not support this measure.[110] There was less support to link reviews to technical progress (**sub-option I-6a**). The establishment of a list of priority substances (**sub-option I-6b**) to ensure air pollutants of emerging concern are monitored received some stakeholder support, especially from some public authorities.[111] However, the costs can be high to establish mandatory monitoring of an extensive 'gross list' of air pollutants. It may instead be more effective to expand further the number of substances of concern monitored at selected monitoring stations, as suggested by policy option III-3.

Table 10.6 – Assessment of policy option I-6 to address environment and health shortcomings[112]

Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
I-6 Review air quality standards *(Measures A1, A3)*	++	+	0	-	Regular review will ensure scientific evidence base of EU policy making, but should be spaced to allow for sufficient scientific progress and regulatory certainty.	High
+ **I-6a:** *Measure A2*	+	0	0	-	Little extra value compared to main option.	Low
+ **I-6b:** *Measure A4*	+	0	0	-	High (admin) burden for uncertain added value.	Low

6.2 Impact of policy options II-1 to II-5 (and related sub-options)

Policy options to address governance and enforcement shortcomings should in particular improve the implementation effectiveness and policy coherence of action taken by public authorities to meet the objectives of the Ambient Air Quality Directives. Costs relate especially to changing the way the Ambient Air Quality Directives are implemented (rather than them resulting from administrative burden of specific policy options suggested here). Having said that, by increasing the stringency of the existing policy framework, costs to those in breach of the provisions of the Directives would increase significantly. At the same time, such increased stringency of the legislative framework would also ensure higher compliance

[109] WHO Air Quality Guidelines (2021) note that *'participation in scientific meetings, follow-up on emerging issues, and close interaction with thematic/technical experts and stakeholders will continue so as to keep abreast of the scientific progress and gauge the need for updating the guidelines. In general, however, the recommendations made in these guidelines are expected to remain valid for a period of up to 10 years.'*

[110] In a targeted survey, some 40% of respondents from *public authorities* supported this policy measure only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[111] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[112] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

with the set objectives, and thus translate into environmental, social, and economic benefits for the wider public.

Policy option II-1 (*introduce additional provisions of what to do in case of an exceedance- see table 11.1*) is assessed as being fundamental to secure the functioning of the Ambient Air Quality Directives. This option will strongly enhance the effective implementation of current Article 23 of Directive 2008/50/EC by reinforcing and clarifying the obligation of what should be contained in air quality plans, who should be involved in their design and how they should tackle the need for short-term action.

This policy option will have an indirect but important positive impact on air quality and human health, as it will help to ensure that exceedances of air quality standards are addressed more effectively. The costs for authorities to implement these measures will depend on their current expertise and practice in the setting up of air quality plans. Given the additional implementation tools presented in this option, authorities might even experience a decrease of their administrative burden, as the implementation becomes more effective. It was pointed out by stakeholders that this would still have to leave room for manoeuvre to Member States, given that the sources of air pollution can vary strongly between countries, regions and cities- warranting more localised solutions (i.e. rather than *"one-size-fits-all"* measures). The majority of stakeholders agree that there is a benefit in further clarifying current obligations related to exceedances and that the design of effective air quality plans is a core element in ensuring the effectiveness of air quality measures. Also, the notion of refining the minimum information required by an air quality plan saw high support by all stakeholder groups. *Public authorities* have expressed strong support for the policy measure introducing guidance on how to address exceedances.[113] Contrary, the policy measure on revising obligations for measures triggered by exceedances was largely not supported by *public authorities*.[114] The burden of implementing this policy option would primarily fall upon public authorities at EU and national levels.

Conversely, a potential policy measure not to be retained is the introduction of a requirement for Member States to secure a single air quality plan for each air quality zone – as per measure D2 (*introduce a 'one zone, one plan' requirement*) considered under **sub-options II-1a**. Stakeholder response to this measure has been mixed, with more scepticism (or no opinion) than endorsement across groups. *Public authorities* have expressed particularly strong reservations about this sub-option.[115] A rethink of the scale of air quality plans (in cases where this measure would require it) could result in a significant administrative burden (as it could require re-zoning. It should also be noted that, under current provisions, Member States that wish to fully align their air quality plans and air quality zones can do so, and several have opted to do so.

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113 In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

114 In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

115 In a targeted survey, some 50% of respondents from *public authorities* supported this policy measure only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

Table 11.1 – Assessment of policy option II-1 to address governance / enforcement shortcomings[116]						
Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
II-1 Responses to exceedances *(Measures B4,C1,C3,D1,N1)*	++	+	+/-	--	This policy option will update the means by which air quality plans are developed. Costs to change existing approach compensated or even reduced by more effective air quality plans and measures.	Medium
+ **II-1a**: *Measure D2*	0	0	0	--	Added value doubtful, subsidiarity considerations.	Low

Policy-option II-2 *(revise the number of air pollutants subject to 'limit values'- see table 11.2)* is assessed as being important to enhance the effective enforcement of the Ambient Air Quality Directives. However, it may not be technically feasible to establish limit values for all pollutants (for example, ozone levels depend much on natural factors and transboundary pollution). Stakeholder feedback offered moderate to strong support for this policy option. *Public authorities* expressed strong support for the policy measure introducing additional short-term standards.[117]

Table 11.2 - Assessment of policy option II-2 to address governance and enforcement shortcomings[118]						
Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
II-2 Additional limit values *(Measures B1,B5)*	++	+	+/-	-	Fitness Check indicates that 'limit values' have been more effective than other types of air quality standards. For some pollutants (notably O_3), however the concept is unlikely to have benefits.	High

Policy options II-3 *(introduce an implementation timeline for measures & revise short-term action plans- see table 11.3*) are assessed as being beneficial to enhance the effective implementation of the Ambient Air Quality Directives.

Policy option II-3 will have an indirect positive impact on air quality and human health, as it will help to limit the exceedance period to a minimum. Regularly reviewing air quality plans will entail costs for authorities, especially for regions where exceedances occur. Stakeholders strongly support this measure and indicate that an update every three years would be considered feasible. *Public authorities* also expressed their strong support for this measure.[119]

Stakeholders indicate that replacing the term "as short as possible" with a specific timeframe might be counterproductive or ineffective which explains the low (to medium) stakeholder support for this measure. *Public authorities* were also not in favour of this measure.[120]

Meanwhile revising provisions related to alert thresholds and short-term action plans would likely have indirect positive impact on air quality and human health, although the added value might be low given that the framework currently in place has not rendered deficits (and

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[116] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[117] In a targeted survey, more than 40% of respondents from *public authorities* supported this measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[118] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[119] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[120] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

therefore might not need fundamental changes). The burden of implementing these policy options would fall upon public authorities at local level.

Table 11.3 – Assessment of policy option I-3 to address governance and enforcement shortcomings[121]

Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
II-3 Implementation timelines & short-term action plans *(Measures B2,C2,C4,C5)*	+	+	+/-	--	The key added value would be to ensure regular updates of air quality plans. Alert thresholds for particulate matter would address additional health concerns, but likely at a cost.	Medium

Policy option II-4 (*revise the legal tools available to address breaches of obligations*) will strongly enhance the effective public enforcement of the Directives and ensure coherence with other EU measures, international treaty obligations and the case law of the Court of Justice of the EU. The costs for authorities to implement these measures will largely depend on their compliance with the current Ambient Air Quality Directives. If currently compliant, then the additional costs should be zero, whereas environmental and societal benefits will be high in any case. Stakeholder feedback to this policy option has been divided, with *civil society & NGOs* strongly supporting the measures proposed under this option, whereas *public authorities* and *industry & businesses* are more hesitant; there is a consensus however that current financial penalties are not sufficiently effective, proportionate or dissuasive. Moreover, a significant majority of *public authorities* did not express their views on these policy measures.[122] The burden of implementing this policy option would primarily fall upon public authorities at EU and national levels – and would be zero if all provisions of the Ambient Air Quality Directive(s) are met.

Conversely, a policy option where the potential impact is still uncertain and where stakeholders have raised additional questions is **sub-option II-4a** *(introduce a clean air fund to be fed by penalties paid- see table 11.4).* The potential benefits of this sub-option will largely depend on which air quality measures will be eligible for funding and who is going to manage such a fund (the EU or Member States). The political feasibility of this measure seems to be limited as Member States might find that there is a risk of interference with their national funding competencies. Also, on EU level there might be hesitation given that there is a general movement towards mainstreaming EU environmental and climate expenditure, thus moving away from dedicated funding for specific issues. Stakeholder feedback to this policy sub-option has been divided, with a medium to high support from *civil society & NGOs*, whereas *public authorities* and *industry & businesses* were more negative about it.

Table 11.4 – Assessment of policy option II-4 to address governance and enforcement shortcomings[123]

Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
II-4 Enforcement tools *(Measures C1,E1,E2,E4)*	++	+	+/-	0/-	Penalties and damages have not been sufficiently dissuasive. Adding additional clarity will help set priorities and incentives. Note that if there is compliance the related costs do not manifest.	High
+ **II-4a:** *Measure E3*	+	+	0	-	Subsidiarity to be considered, unclear how.	Uncertain

[121] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[122] In a targeted survey, more than 60% of respondents from *public authorities* expressed "no opinion" or had no view on this measure. See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[123] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

Policy option II-5 (*revise the approach to exceedances due to transboundary air pollution- see table 11.5*) is assessed as being useful to potentially enhance the effective implementation of the Ambient Air Quality Directives. This option will indirectly contribute to reducing air pollution concentrations, especially for Member States currently suffering from transboundary air pollution. Stakeholders point out that transboundary air pollution is already the focus of the NEC Directive and that further cooperation would be desirable but difficult to enforce. A stronger role for the Commission to support transboundary cooperation, including via additional technical guidance (e.g., by introducing a common methodology on assessing transboundary air pollution) is supported by all stakeholder groups.

Table 11.5 – Assessment of policy option II-5 to address governance and enforcement shortcomings[124]

Policy option	Consequences / Impacts				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
II-5 Transboundary air pollution *(Measures M1,M2)*	+	0	+/-	-	Transboundary air pollution is already the focus of the NEC Directive. Further cooperation is desirable but difficult to enforce. Additional guidance helpful.	Medium

6.3 Impact of policy options III-1 to III-5 (and related sub-options)

Policy options to address air quality monitoring, assessment shortcomings and data quality should in particular improve the efficiency and effectiveness of the assessments performed by public authorities to meet the objectives of the Ambient Air Quality Directives. This cluster of policy options would entail (rather indirect) health and environmental benefits next to costs, mainly related to the additional monitoring and assessment requirements, translating into needs for monitoring equipment, targeted training and expertise development. Improvements in this area constitute however a fundamental pillar for meeting the objectives of the Ambient Air Quality Directives.

Policy option III-1 *(revise the requirements for air quality assessment- see table 12.1)* is considered to contain critical policy measures to address monitoring and assessment shortcomings identified. This policy option increases the use of key tools for assessing air quality, including complementary use of indicative measurements or mandatory use of models to support fixed monitoring and air quality planning, as well as expanding monitoring for pollutants already covered by the Directives as well as for pollutants of emerging concern. This option presents a particularly significant opportunity to improve the effectiveness and efficiency of an already well-established air quality monitoring regime in all Member States of the EU (as confirmed by the fitness check in 2019). This will result in an increase of the costs for monitoring air quality (in particular due to additional one-off investments). The highest costs relate to the increase of tools used, and capacity needed, to assess air quality and the requirement to monitor pollutants of emerging concern. However, the exact extent of these costs, will depend on the current practice of Member States as in many cases complementary tools are already being used to augment mandatory monitoring.

While there is a broad strong support for the need to clarify and enhance the circumstances where additional tools (indicative measurements and modelling) are to be employed for supplementing fixed monitoring, *public authorities*, and *civil society & NGOs* expressed a clear view these should not translate in a decrease of fixed monitoring stations or replace

[124] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

them, and modelling should not be made mandatory to all its possible uses. Stakeholders across all groups, especially those working on air quality monitoring *research & academia,* generally expressed support for increasing the number of sampling points and reviewing them in specific situations (for example, in highly urban populated areas), decoupling the minimum number of sampling points for measuring fine particulate matter ($PM_{2.5}$) and particulate matter (PM_{10}), and requiring public authorities to install monitoring stations that measure continuously pollutants of emerging concern.[125] Contrary, *public authorities* have expressed reservations about the policy measure revising the minimum number of sampling points.[126]

Regarding the sub options contained under this policy option, **sub-option III-1d** (*introduce the obligation for a spatial representative area),* is considered as the most beneficial supporting measure. This would significantly contribute to the overall comparability and harmonization of air quality data and would support the use of monitoring data in the assessment process. Not having spatial representativeness of measuring sites defined in the legislation, in some instances currently hinders in the effectiveness of the monitoring network design and suitability to assess actual population exposure. Stakeholder feedback indicated this measure would generally be useful but would need further guidance to support it.

On the contrary several sub-options have been assessed to only have a limited benefit-to-cost ratio. **Sub-option III-1a** (*revise rules for regular review of air quality assessment)* and **sub-option III-1b** *(simplify the definitions of sampling points types*) would bring low additional benefits for a low cost. Stakeholders across groups generally felt the current requirement to review assessment regimes every five years was sufficient. *Public authorities* support maintaining the current system,[127] while *civil society & NGOs* in particular would welcome improvements that allow better identification of hotspots (especially those due to household heating – note, however, that this can also be addressed via policy option III-4). **Sub-option III-1c** *(introduce up-to-date data at all sampling points)* would allow for increased transparency of digitally available up-to-date pollutant information but at a potential high cost if required at all sampling points (and with limited added value to requiring it a well-defined sub-set of stations).

Table 12.1 – Assessment of policy option III-1 to address monitoring and assessment shortcomings[128]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
III-1 Air quality assessments *(Measures G1, G2, H1, H2, L1)*	+	+	+	--	Will significantly improve air quality monitoring and assessment, allowing for more targeted air quality measures, and make better use of avail. methods. Costs related to the expansion of the monitoring network and adding ‘super-sites’.	Medium
+ **III-1a:** *Measure G3*	0	0	0	0	Minor admin. simplification only, but at (low) cost.	Low
+ **III-1b:** *Measure H3*	0	0	0	-	Minor admin. simplification only, but at (low) cost.	Low
+ **III-1c:** *Measure K2*	+	0	0	-	Will improve data, but at potentially high cost.	Low
+ **III-1d**: *Measure J3*	+	+	+	--	Will allow more targeted air quality management.	High

125 This includes support the network of National Air Quality Reference Laboratories (AQUILA).

126 In a targeted survey, some 50% of respondents from *public authorities* supported this policy measure only “to some extent” or “not at all”. See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

127 In a targeted survey, more than 50% of respondents from *public authorities* supported this policy measure only “to some extent” or “not at all”. See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

128 Individual potential specific policy measures have each received a ‘letter + number’ identifier (e.g.: A1), a complete overview is available in Annex 6.

Policy option III-2 (*introduce requirements to ensure continuity in air quality monitoring)* represents a no-regret option that would guarantee an improvement of air quality monitoring and assessment. This would effectively be done by specifying that sampling points with exceedances of limit values for any of the pollutants measured under the Ambient Air Quality Directives should be maintained for a defined number of years, and by developing a protocol to follow should a sampling point have to be re-located due to, for example, infrastructure development or changes in the assessment regimes. A broad majority of stakeholder showed support for long term continuity of sampling points, with *public authorities*[129] acknowledging that relocation should only be allowed under specific circumstances and *civil society & NGOs* suggesting relocation should not be allowed at all if and where exceedances persist. The development of a clear protocol for relocation is considered as essential to guide instances in which sampling points are relocated. Costs involved are expected to be low (as it this should be limited to exceptional circumstances). The burden primarily lies with public authorities.

Sub-option III-2a *(Introduce obligations to monitor long-term trends- see table 12.2)* would result in a more complete long-term data set, improving air quality assessments. Even if long-term trends are seen as important by stakeholders in general, many of them, particularly *public authorities* and *civil society & NGOs*, considered that neither indicative measurements nor modelling could fully replace a discontinued fixed monitoring station, as the uncertainty of the results is too high.

Table 12.2 – Assessment of policy option III-2 to address monitoring and assessment shortcomings[130]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
III-2 Monitoring continuity *(Measures I1, I3)*	+	+	0	-	Will significantly improve air quality monitoring and assessment, allowing for more targeted air quality measures.	Medium
+ **III-2a**: Measure I2	+	0	0	-	Minor admin. simplification only, but at (low) cost.	Low

Policy option III-3 *(establish a requirement to expand monitoring to additional pollutants)* is assessed as increasing the understanding of current levels of any additional pollutants and their health effects, and a prerequisite for future reviews of the legislation – and to be crucial to better anticipate possible future related health risks. A majority of stakeholders suggested new pollutants should be located at 'supersites' to facilitate research on pollutant interactions and trends in both urban and rural locations (with one such 'supersite' monitoring station per 5 to 10 million inhabitants). There is general support to include monitoring of ultrafine particles, ammonia, oxidative potential and fine combustion particles but less generalised support for additional heavy metals, hydrogen sulphide, nitro-PAHs and pesticides monitoring. Monitoring of ammonia would benefit from coordination with monitoring efforts under the National Emission reduction Commitments Directive[131], and a focus on locations where ammonia concentrations could particularly impact ecosystems. Moreover, *public*

[129] In a targeted survey, more than 40% of respondents from *public authorities* supported a key policy measure under this policy option (i.e. policy measure I1 to *introduce obligation to maintain sampling points*) "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[130] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[131] Directive (EU) 2016/2284, Article 9

authorities have also expressed strong support for this policy option.[132] The burden primarily lies with public authorities at regional and/or national level.

Sub-option III-3a *(revise and expand list of VOCs to monitor)* received strong support by all stakeholders, insofar that VOCs should be monitored based on latest scientific knowledge, especially for their health impacts, but also for their oxidative potential and their role as ozone precursors, as well as their role as particulate matter precursors. However, there was no consensus on which pollutants such an expansion of the list of VOCs should make mandatory (which specific VOCs to monitor in specific circumstances will vary depending on the location and on emission sources in the proximity).[133] Moreover, a relative majority of public authorities have not expressed their views on this sub-option.[134] The cost of continuous VOCs measurements are potentially high and any further monitoring should be accompanied by data quality and siting specifications (see table 12.3).

Table 12.3 – Assessment of policy option III-3 to address monitoring and assessment shortcomings[135]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
III-3 Additional sampling points *(Measures L1, L2)*	++	0	+	--/---	Clarifies current levels of these air pollutants, as a requisite for verifying health effects and need for taking action. Costs related to the expansion of the monitoring network and adding 'super-sites'.	Medium
+ **III-3a**: Measure L3	+	0	0	--/---	No agreed subset of VOC to monitor at all stations.	Low

Policy option III-4 (*revise the criteria for air quality sampling points - see table 12.4)* aims to improve the siting of sampling points and their data quality, with significant impact on the accuracy of air quality levels measured. Clarification on the application of the macro-siting criteria for sampling points (and a reduction of flexibilities in this regard) will further increase comparability of air quality data. A majority of stakeholders indicate support to this measure, but especially *public authorities* point to the need for some flexibility to be able to deal with practical and administrative challenges in establishing a monitoring network.[136] Also related to micro-siting criteria, a number of *public authorities* argue that current requirements are clear and any change could hamper long-term comparability of air quality data; nevertheless especially *civil society & NGOs* call for reducing flexibilities afforded. National Air Quality Reference Laboratories stressed that data quality objectives can be updated to secure greater data quality of monitored data.

A majority of stakeholders (regardless of stakeholder group) favoured to define measurement uncertainty in absolute values alongside percentage values, as per **sub-option III-4a** (*revise approach to air quality assessment uncertainty*), to assure the reliability of air quality measured at lower concentrations than is commonly monitored today.

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[132] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[133] The network of National Air Quality Reference Laboratories (AQUILA) suggested to expand the list but without mandating which ones to monitor: this should be left to the decision of the competent authorities.

[134] In a targeted survey, some 50% of respondents from *public authorities* expressed "no opinion" or had no view on this policy measure. See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[135] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[136] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

Table 12.4 – Assessment of policy option III-4 to address monitoring and assessment shortcomings[137]						
Policy option	**Consequences / Impacts** Env.	Soc.	Eco.	Cost	**Assessment and key considerations**	**Benefit to cost**
III-4 Monitoring data quality *(Measures J1,J2, K1)*	+	+	0	-	Additional clarity will enhance reliability and comparability of air quality data – but may also result in significant cost to update existing air quality monitoring and assessment networks.	Medium
+ **III-4a**: *Measure K4*	+	0	0	-	Will increase confidence in air quality further.	Medium

Policy option III- 5 *(introduce requirements on modelling quality objectives- see table 12.5)* is a prerequisite to an effective implementation of policy option III-1. However, little other direct consequences are identified. Any modelling application used in support of the implementation of the Ambient Air Quality Directives should be of sufficient quality and be fit for purpose (assured via a standardized modelling quality objective metric[138]). This would provide for robust modelling data, and therefore support and increase its use and was largely supported by stakeholders, especially *public authorities*[139] and *research & academia*. Cost may vary depending on the starting point on the use of modeling by public authorities.

Table 12.5 – Assessment of policy option III-5 to address monitoring and assessment shortcomings[140]						
Policy option	**Consequences / Impacts** Env.	Soc.	Eco.	Cost	**Assessment and key considerations**	**Benefit to cost**
III-5 Modelling data quality *(Measures G2, K3)*	+	+	0	--	This policy option is a prerequisite to an effective implementation of policy option III-1. Important for robust data, but little other direct consequences.	Medium

6.4 Impact of policy options IV-1 to IV-3 (and related sub-options)

Policy options to address air quality information shortcomings should in particular improve access to clear and objective air quality information – and thus make the Directive more effective. For all policy options under this cluster the administrative burden of implementing the corresponding measures would fall upon public authorities (and in some cases would require the more active involvement of health sector authorities also).

Policy option IV-1 *(introduce more specific requirements to provide up-to-date data- see table 13.1)* and **policy option IV-2** *(introduce requirements to provide health related air quality data- see table 13.2)* are assessed as being useful to enhance the quality and quantity of the air quality information communicated to the public and thereby make the Ambient Air Quality Directives more effective.

Policy option IV-1, will indirectly benefit public health, in particular that of the sensitive population. Moreover, most Member States already publish (nearly) real-time data, therefore the costs of this policy option would be low.

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[137] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[138] The Forum for Air Quality Modelling (FAIRMODE) recommends the use of standardised Modelling Quality Objective as a quality control mechanism, as defined by FAIRMODE.

[139] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[140] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

Table 13.1 – Assessment of policy option IV-1 to address information and communication shortcomings[141]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
IV-1 Up-to-date air quality data *(Measures F1, K2)*	+	+	0	-/--	Up-to-date data provision will allow more for additional societal responsiveness to pollution peaks. Related costs will vary, and include a punctual expansion of the monitoring network.	Medium

Policy option IV-2, would allow EU citizens to take timely action and thereby have significant indirect health and societal benefits. However, there would be initial costs of setting this up. The stakeholder survey showed that views on these policy options are mixed. *Public authorities* were divided about these policy options,[142] *civil society & NGOs* were particularly positive and *industry & business* mostly not supportive. Conversely, there is little added value seen in **sub-option IV-2a** *(mandate the use of specific communication channels),* as the use of those by the public can vary strongly between regions/population groups and can evolve rapidly.

Table 13.2 – Assessment of policy option IV-2 to address information and communication shortcomings[143]

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
IV-2 Health related air quality data *(Measure F2)*	+	+	0	-	Potentially impactful measure, will require closer interaction between health practitioners and policy makers to inform a wider public (and vulnerable populations) better. Likely significant initial costs.	Medium
+ **IV-2a**: Measure F3	0	0	0	-	No added value of specifying channels in law.	Low

Policy option IV-3 (*introduce a requirement to use harmonised air quality index bands- see table 13.3*) is assessed as being very beneficial to improve clear communication of air quality information to the public, in line with the overarching objectives of the Ambient Air Quality Directives. This option will strongly enhance the effective implementation of the current Article 27 of Directive 2008/50/EC and Annex XVI to the Directive by introducing a common metric system for indices (i.e. harmonised air quality index bands) or by ensuring that, where alternative metrics are used at national level, clear reference is made to EU agreed air quality index bands (for example, via the online European Air Quality Index).

Policy option IV-3 would have an indirect positive impact on the health of citizens, in particular that of more vulnerable populations, because it will enable them to take informed decisions based on the air quality data available to them. Moreover, the costs would be low, as the technology is already developed and being used. The stakeholder survey showed there is very high support for this measure particularly from *civil society & NGOs* followed by *public authorities*.[144] However, *public authorities* also expressed doubts around the effectiveness of the European Air Quality Index on its own (for example, around its ability to represent multi-pollutant effects), and complete harmonization may restrict the ability of Member States to tailor advice and information to the specific situations.

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[141] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[142] In a targeted survey, more than 40% of respondents from *public authorities* supported a key policy measure under this policy option (i.e. policy measure F1 to *revise provisions related to up-to-date data*) only "to some extent" or "not at all". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

[143] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6.

[144] In a targeted survey, more than 40% of respondents from *public authorities* supported this policy measure "fully" or "to a large extent". See Annexes 2 and 6 for a more in-depth analysis of stakeholder views.

Table 13.3 – Assessment of policy option IV-2 to address information and communication shortcomings[145]						
Policy option	Consequences / Impac3s				Assessment and key considerations	Benefit to cost
	Env.	Soc.	Eco.	Cost		
IV-3 Harmonised air quality indices *(Measure F4)*	+	+	0	-	Harmonisation of air quality data saves costs for developing and updating separate indices. Provides clarity for citizens across the EU.	Medium

7. How do the options compare?

Following the comparison of policy options within each of the problem area in section 6, this section analyses synergies, complementarities and trade-offs of different policy options across the problem areas with regards to their effectiveness and efficiency in achieving identified objectives, to their policy coherence and proportionality, as well as to how future-proof they are, given long-term challenges, including in terms of coherence with other policies.

Table 14 provides a comparison of the environmental, social and economic consequences of each policy option, and an indication of the costs the respective policy options are expected to entail. This allows a comparison of the relative benefit to cost ratio of different options.

Table 14 – A comparison of policy options assessed					
Policy option	Consequences / Impacts				Benefit to cost
	Env.	Soc.	Eco.	Cost	
I-1 Full alignment with WHO recommendations	+++	+++	+++	---	High (*)
I-2 Closer alignment with WHO recommendations	++	++	++	--	High
I-3 Partial alignment with WHO recommendations	+	+	+	-	High
I-4 Additional air pollutants	0/+	+/-	+/-	--	Low (*)
I-5 Average exposure reduction	++	+	+	--	High
I-6 Review air quality standards	++	+	0	-	High
II-1 Responses to exceedances	++	+	+/-	--	Medium
II-2 Additional limit values	++	+	+/-	-	High
II-3 Implementation timelines & short-term action plans	+	+	+/-	--	Medium
II-4 Enforcement tools	++	+	+/-	0/-	High
II-5 Transboundary air pollution	+	0	+/-	-	Medium
III-1 Air quality assessments	+	+	+	--	Medium
III-2 Monitoring continuity	+	+	0	-	Medium
III-3 Additional sampling points	++	0	+	--/---	Medium
III-4 Monitoring data quality	+	+	0	--	Medium
III-5 Modelling data quality	+	+	0	-/--	Medium
IV-1 Up-to-date air quality data	+	+	0	-/--	Medium
IV-2 Health related air quality data	+	+	0	-	Medium
IV-3 Harmonised air quality indices	+	+	0	-	Medium
(*) The assessment raises questions as to whether this is attainable at all based on available measures and current knowledge					

While policy options developed here are largely self-standing (and have been assessed as such), there are some important interdependencies between the policy options aimed at addressing the four problem areas I though IV.

[145] Individual potential specific policy measures have each received a 'letter + number' identifier (e.g.: A1), a complete overview is available in Annex 6 to the SWD.

A key interdependence in this regard is between the level of ambition enshrined in air quality standards (problem area I) and their enforceability (problem area II). The fitness check of the Ambient Air Quality Directives concluded that legally binding and enforceable limit values have been more effective in facilitating downward trends than other types of air quality standards. The level of ambition of revised air quality standards will require corresponding reductions in air pollution and health impacts to meet these standards. On the other hand, enforceable binding standards must be set at levels that remain attainable. A very ambitious standard that is hard to attain but is not enforceable, risks not being effective.

In addition, policy option II-1 supports more targeted, and hence more efficient air quality measures by ensuring that the effect of air quality measures on pollutant concentrations be estimated in air quality plans. Policy options III-1, III-4 and III-5 on air quality assessment, monitoring and modelling quality also support more efficient clean air measures through improved knowledge on the state and development of air quality. By avoiding a double burden on public authorities to develop short-term action plans and air quality plans separately, policy option II-1 improves efficiency.

The effectiveness of air quality standards (problem area I) and of their governance and enforcement (problem area II), as well as public information (problem area IV), also depend on effective assessment of air quality (problem area III): without solid knowledge about the state and development of air quality, the attainment of air quality standards cannot be properly checked in a reliable and comparable manner – and in such circumstances actions to improve air quality risk being insufficiently and/or unsuitably justified and/or not well targeted.

Finally, legal action on air quality monitoring and assessment rules of the current Ambient Air Quality Directives at EU and national level has demonstrated that enforceability (problem area II) is an important safeguard for solid air quality assessment (problem area III).

Proportionality: The proportionality of the policy option to revise the number of pollutants subject to 'limit values' (II-2) as the most binding type of standard depends on the strictness of air quality standards (I-1 to I-3, also see the discussion on effectiveness above). All policy options that improve knowledge on the state and development of air quality, notably III-1, III-4 and III-5, support proportionality of clean air measures and air quality plans.

Policy coherence and future-proofing: The main analysis of policy coherence between different policy options for the revision of the Ambient Air Quality Directives is covered in the considerations on synergies, complementarities and trade-offs presented above.

When it comes to coherence with other policies, coherence with climate policy, in particular the European Climate Law, is central due to the many common sources of greenhouse gas and pollutant emissions. In combination with an effective overall legislative framework (policy options under problem areas II, III and IV), an ambitious revision of EU air quality standards by 2030, combined with a trajectory towards a post-2030 perspective to achieve a zero pollution vision for clean air are coherent with the Climate Law and its 2030 and 2050 targets, as measures to achieve clean air will lead to greenhouse gas emission reductions as well.

Coherence with the Zero Pollution Action Plan was assessed with a focus on policy options I-1 to I-3 to ensure that the preferred policy option is in line with the 2030 goals of the Action Plan to reduce by more than 55% the health impacts (premature deaths) of air pollution, and supports, through a trajectory path, the 2050 vision of the Action Plan to reduce air, water and soil pollution to levels no longer considered harmful to health. Also, the implementation of the Nature Restoration Law can deliver on clean air aspects.

Policy coherence is also crucial when it comes to various policies that address pollutant emissions at sources such as energy generation, transport, industrial installations, domestic heating and agriculture. This concerns, for instance, the recent proposal for revising the Industrial Emissions Directive[146], and the proposal for Euro 7 emission standards for road vehicles. These and other existing source policies have been considered in this impact assessment, notably regarding the impacts of policy options I-1 to I-3 on air quality standards.[147]

Policy option I-6 on the regular review of EU air quality standards ensures that the standards are future-proof with regards to possible future changes in scientific knowledge or technological development.

8. PREFERRED OPTION(S) (AND WHAT IS THE PREFERRED POLICY PACKAGE)

8.1 Preferred policy options, and options that are not retained

This impact assessment considers a total of 69 potential specific policy measures, combined in 19 potential policy options (and with additional 15 sub-options that might be considered), to address the four problem areas in the existing air quality legislation (see section 2) – and to align more closely with the WHO Air Quality Guidelines. Of the 19 potential policy options assessed, 16 are complementary and somewhat independent from each other, even if there are some co-benefits to consider across options.

Table 15 gives an overview of the preferred policy option(s), based on the comparison of options within each problem area (section 6), and the analysis of synergies and complementarities across problem areas (section 7).

[146] The impact of the proposal for a revised Industrial Emission Directive (COM/2022/156 final/3) has been assessed with a sensitivity analysis. For more details, see Section 5.1, Annex 5.8, and the underpinning support study.

[147] Annex 8.3 provides an overview of coherence with other major EU strategies and policies, focusing on benefits of improved air quality for other policies and vice versa.

Table 15 – Preferred policy options			
PREFERRED Policy options	**Benefit to cost**	**PREFERRED Policy sub-options**	**Benefit to cost**
I-5 Average exposure reduction	High	**III-1** Air quality assessments	Medium
+ Sub-option **I-5b** Average exposure indicator NO_2	Medium	+ Sub-option **III-1d** Spatial representativeness	Medium
I-6 Review of air quality standards	High	**III-2** Monitoring continuity	Medium
II-1 Responses to exceedances	Medium	**III-3** Additional sampling points	Medium
II-2 Additional limit values	High	**III-4** Monitoring data quality	Medium
II-3 Implement timelines & short-term action plans	Medium	+ Sub-option **III-4a** Approach to uncertainty	Medium
II-4 Enforcement tools	High	**III-5** Modelling data quality	Medium
II-5 Transboundary air pollution	Medium	**IV-2** Health related air quality data	Medium
IV-1 Up-to-date air quality data	Medium	**IV-3** Harmonised air quality indices	Medium

Meanwhile, Table 16 summarises the policy options that would not be retained to their full extent (these may be still addressed partially, also due to positive spill-over effects from preferred policy options).

Table 16 – Policy options that are not retained			
DISCARDED Policy options / sub-options	**Benefit to cost**	**DISCARDED Policy options / sub-options**	**Benefit to cost**
I-4 Additional air pollutants	Low (*)	Sub-option **III-1a** - Review of assessment regime	Low
Sub-option **I-5a** – Avg. exposure indicator PM_{10}	Low	Sub-option **III-1b** - Simplify sampling points types	Low
Sub-option **I-5c** – Avg. exposure indicator O_3	Unclear	Sub-option **III-1c** - Up-to-date data at all points	Low
Sub-option **I-6a** – Technical progress review	Low	Sub-option **III-2a** - Monitor long-term trends	Low
Sub-option **I-6b** – List of priority pollutants	Low	Sub-option **III-3a** - Revise list of VOC to monitor	Low
Sub-option **II-1a** - 'One zone, one plan'	Low	Sub-option **IV-2a** - Specific comm. channels	Low
Sub-option **II-4a** - Fund to be fed by penalties	Low		

The remaining three policy options, namely those contrasting different levels of alignment with the WHO Air Quality Guidelines (I-1, I-2 or I-3), will require a political choice. This outcome of this choice will have environmental, economic, social and health implications.

Indeed, when considering the degree of alignment with WHO Air Quality Guidelines, it is important to bear in mind that the overall objective of the guidelines is to provide quantitative health-based recommendations for air quality, primarily based on epidemiological evidence. They do not take into account whether it is feasible to reduce air pollution to these recommended levels. Instead, the guidelines recognise that this may not be possible for some time in many locations. Hence the guidelines also provide interim targets to guide reduction efforts towards full alignment with the recommended air quality levels. The guidelines also point out that setting standards may require taking into account additional factors, such as costs and technical feasibility, and that these should be considered during the policy-making process.

All three of these options, i.e. 'full alignment' (I-1), 'closer alignment' (I-2) and 'partial alignment' (I-3), would render significant health and environment benefits – albeit to varying degrees. Even under relatively 'low' assumptions regarding the value of health benefits (using 'VOLY', see section 6.1), the total benefits are assumed to outweigh the implementation costs by 2030 for all three policy options - see Table 17 for details.

This analysis shows that policy option I-3 ('partial alignment' with the 2021 WHO Air Quality Guidelines by 2030) has the highest benefit-to-cost ratio (between 10:1 and 28:1). Most air quality sampling points in the EU might be expected to meet the corresponding air quality standards with little additional effort. The net benefits amount to more than 29 billion Euro.

For policy option I-2 ('closer alignment' with the 2021 WHO Air Quality Guidelines by 2030) the benefit-to-cost ratio is expected to be slightly lower (between 7.5:1 and 21:1). Some 6% of sampling points would not be expected to meet the corresponding air quality standards without additional effort at local level (or may need time extensions or exceptions). The net benefits amount to more than 36 billion Euro, i.e. 25% more than policy option I-3.

Under policy option I-1 ('full alignment' with the 2021 WHO Air Quality Guidelines by 2030) the benefit-to-cost ratio remains significantly positive also (between 6:1 and 18:1). However, 71% of sampling points would not be expected to meet the corresponding air quality standards without additional effort at local level (and in many of these instances would not be able to meet these standards at all with technical feasible reductions only). The net benefits amount to more than 38 billion Euro, i.e. 5% more than policy option I-2.

For all three policy options (i.e. independent of the political choice made) there is a clear case for embracing a staged approach towards setting current and future EU air quality standards: (1) establish clear EU air quality standards for the **mid-term**, i.e. the year 2030 (with a limited number of temporary exceptions where these are clearly warranted – see also Section 8.2); (2) develop a **long-term**, post-2030 perspective for a full alignment with the 2021 WHO Air Quality Guidelines, whilst getting on track towards alignment also with future WHO Guidelines to achieve the zero pollution vision by the year 2050; (3) a **regular review** mechanism to assure that the latest scientific understanding of air quality guides future decisions, and retains flexibility elements given potential (future) geo-political challenges.

Table 17 – A Comparison of policy options on level of alignment with the WHO Air Quality Guidelines (2030)

		Baseline	Policy Option I-3	Policy Option I-2	Policy Option I-1
Air Quality standard	**$PM_{2.5}$**	**25 µg/m3**	**15 µg/m3**	**10 µg/m3**	**5 µg/m3**
	NO_2	40 µg/m3	30 µg/m3	20 µg/m3	10 µg/m3
Exposed > WHO levels	**$PM_{2.5}$**	**333 million**	**267 million**	**243 million**	**226 million**
	NO_2	52 million	46 million	44 million	42 million
Is the standard achievable with available measures? [a]		**For >99%** of $PM_{2.5}$ sampling points	**For 99%** of $PM_{2.5}$ sampling points	**For 94%** of $PM_{2.5}$ sampling points	**For 29%** of $PM_{2.5}$ sampling points
Key economic impacts					
Mitigation costs	**Central**	**0**	**€3.3 bn**	**€5.6 bn**	**€7.0 bn**
	If corrected for 'border cell effect' [b]	0	€1.0 bn	€5.1 bn	€7.0 bn
Gross benefits	**Low** [c]	**0**	**€32.4 bn**	**€41.8 bn**	**€45.0 bn**
	High [d]	0	€93.8 bn	€121.4 bn	€130.8 bn
Net benefits	**Low** [c]	**0**	**€29.0 bn**	**€36.2 bn**	**€37.9 bn**
	High [d]	0	€90.4 bn	€115.7 bn	€123.6 bn
Benefit-cost ratio	**Low** [c]	**-**	**10:1**	**7.5:1**	**6:1**
	High [d]	-	28:1	21:1	19:1
Net GDP impact		**+ /- 0%**	**+ 0.26 %**	**+ 0.38 %**	**+ 0.44 %**
Key health impacts [e]					
Annual premature mortality compared to 2020 / baseline	**Due to $PM_{2.5}$**	**-56.3%**	**-73.1%** -38% vs baseline	**-77.9%** -49% vs baseline	**-79.5%** -53% vs baseline
	Due to NO_2	**-80.9%**	**-83.3%** -12% vs baseline	**-84.0%** -16% vs baseline	**-84.7%** -20% vs baseline

[a] This analysis assesses technical feasible reductions only and does not include assumptions on fundamental changes in economic activity, dietary patterns, technological breakthroughs or major shifts in our energy systems.
[b] If 'border cell effects' were excluded in the analysis, mitigation costs (and benefits) would be lower (see section 8.2, Box 6).
[c] Based on VOLY (value of a life year), i.e. damage cost calculations based on the potential years of life lost.
[d] Based on VSL (value of statistical life), i.e. damage cost calculations based on how much people are willing to pay for a reduction in their risk of dying from adverse health conditions.
[e] Note this study calculates health impacts only above the WHO Air Quality Guideline levels. However, pollution levels below these levels may have some health effects, even though the WHO has not quantified them. Also see Box 5.

8.2 Consideration for specific regions and for specific economic sectors

Air pollution is an EU-wide challenge and is considered the biggest environmental health risk in Europe. However, the degree to which air pollution affects individuals, and regions, differs significantly across the EU – and depends on a range of factors from meteorology and orography (which affect air pollution dispersion patterns) to the proximity to air pollution sources and different structural emission patterns.

This translates into an air quality management challenge. On the one hand, air pollution and elevated air pollutant concentration levels affect human physiology and health in a similar manner no matter where it occurs – and require the same level of protection across the EU. On the other hand, which and how much air pollution occurs, and which options are available to manage air quality, will depend much on regional and local circumstances – and, in instances where exceedances persist, will require devising tailor-made national, regional and local approaches and responses in addition to EU policy and measures.

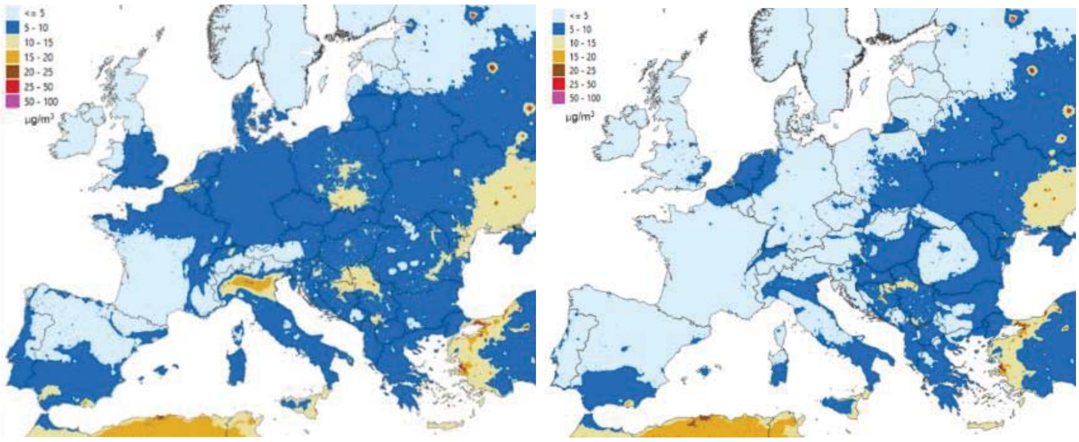

Figure 13 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, EU overview (for additional maps, including for other pollutants, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

Figure 13 provides an overview of expected changes of fine particulate matter ($PM_{2.5}$) concentrations between 2020 and 2030 under the preferred policy option I-2. This highlights specific challenges to meet the levels recommended by the World Health Organization Air Quality Guidelines in some parts of the EU, including Northern Italy (see also Figure 14), the border region of Czechia, Poland and Slovakia (see also Figure 15), as well as southern regions along the Mediterranean coast of the EU.

For Northern Italy (see Figure 14), specific meteorological and orographic circumstances lead to reduced dispersion, and thus accumulation of air pollution. This is aggravated by elevated emission levels from residential heating (including biomass burning) as well as agricultural emissions across the Po Valley region. While under the preferred policy option the area exposed to $PM_{2.5}$ concentration levels above 10 $\mu g/m^3$ reduces significantly by 2030, some hotspots would be expected to remain, and may require additional time to reach this level.

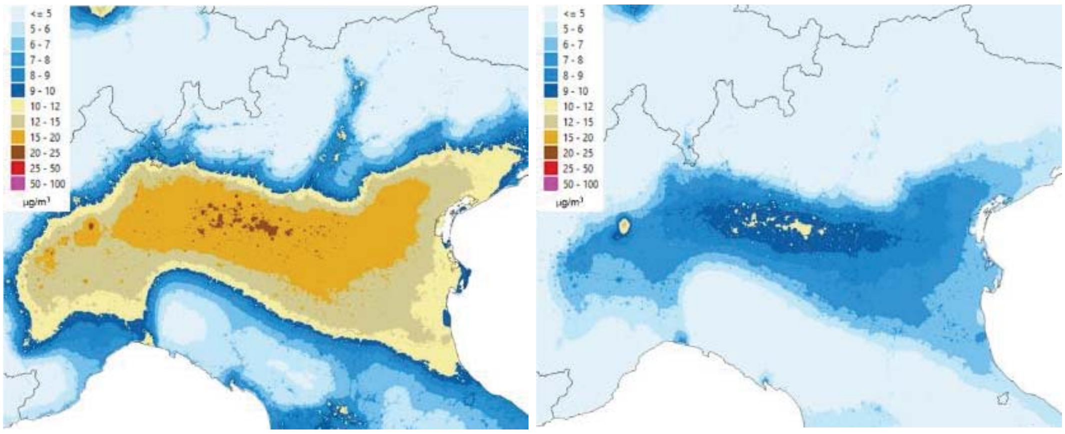

Figure 14 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, example Northern Italy (for additional maps, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

Similarly, for much of Eastern Europe (see, for example, Figure 15), residential heating (often reliant on fossil fuel combustion) and industry production facilities today lead to elevated $PM_{2.5}$ concentration levels. Under the preferred policy option and based on the measures taken to address these emissions, the area exposed to $PM_{2.5}$ concentration levels above 10 µg/m^3 reduces almost to zero by 2030. However, Annex 5 shows that in many areas across this region, elevated levels of benzo(a)pyrene remain to be a concern in a 2030 perspective.

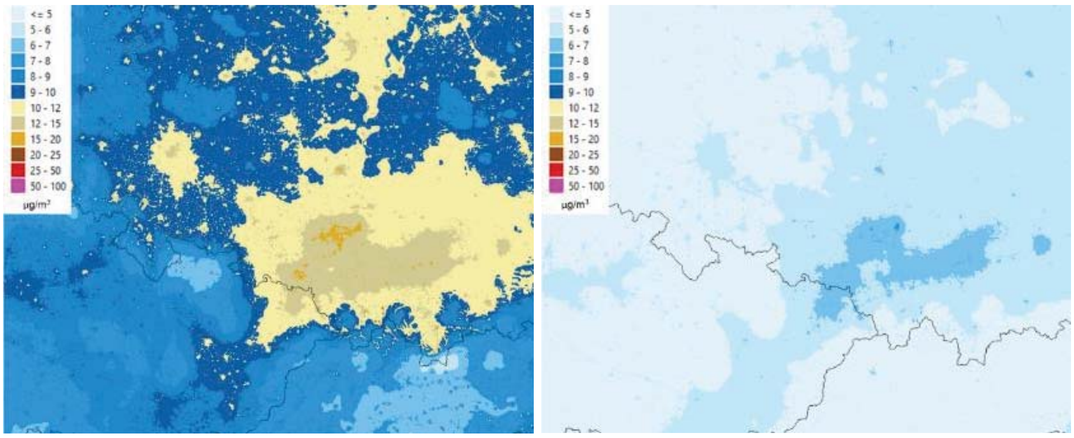

Figure 15 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, example border region between Poland, Czechia and Slovakia (for additional maps, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

Elevated levels of fine particulate matter ($PM_{2.5}$) in Southern Europe are much linked to the occurrence of air pollution due to natural sources, and Sahara dust and sea spray in particular (which the current Ambient Air Quality Directives allow to be deducted from air pollution levels reported). A particular challenge for this region is the handling of elevated ozone concentration levels, which climate change (in particular rising and increasingly longer heat patterns) may further exacerbate, and for which air quality management would require additional measures on ozone precursors (incl. methane).

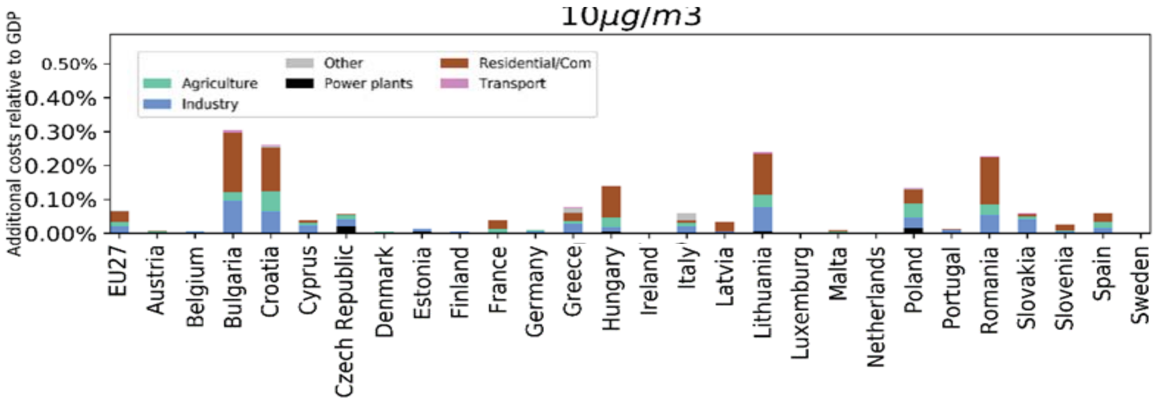

Figure 16 – Additional (compared to baseline) air pollution control costs in 2030 for the preferred policy option, shown as % of GDP. Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

As with the impacts of air pollution under the preferred policy option, also the adjustment costs (i.e. the air pollution mitigation or adjustment costs required in addition to baseline assumptions) differs across Member States and economic sectors. Figure 16 offers an overview of additional air pollution mitigation or adjustment costs in 2030 for the preferred policy option. These amount to below 0.1% of GDP in total, with up to 0.3% of GDP in some Member States. Costs are expected to be higher (relatively speaking) for those Member States that either see persistent air pollution challenges today, or where specific measures would be required. In particular, for the residential heating sector additional costs would occur, as well as, to a lesser degree for the industry and agriculture sectors. Note that this Figure 16 likely overestimates the costs for some Member States, due to 'border cell effects' (see Box 6).

Box 6 – Correcting for 'border cell effects' results in lower mitigation costs

The modelling performed for this impact assessment includes two main aspects. First, it assesses in which parts of the EU different (more ambitious or less ambitious) air quality standards can be achieved. Second, it assesses the costs that achieving such standards would entail. Both aspects are assessed for each geographical grid cell of the model. Each cell has a size of 7x7 km².

As the external borders of the EU do not have the shape of squared grid cells, some of the cells analysed cover territory both within and outside the EU. In order to cover the whole EU territory, the model optimisation for reaching air quality standards includes these cells as well – and therefore also the part of them that is located outside the EU. In some of these cross-border cells, where the level of pollution in the neighbouring country is particularly high, this entails a much higher level of effort needed for the whole cell to achieve an air quality standard than what would be needed if the model optimisation were restricted to EU territory only. This is for instance the case for border cells in Lithuania and Poland, at the border with Belarus and Ukraine, as well as for border cells in Bulgaria, Croatia, Hungary and Greece.

In such cases, in order to provide a more realistic representation of the level of effort (and hence costs) needed in the EU, where the proposed air quality standards will apply, an additional analysis has been carried out, excluding border cells with cities on the non-EU side. This can result in a significant cost decrease compared to the central analysis, varying across options: The differences are most pronounced in Option I-3 ($PM_{2.5}$ at 15 ug/m^3), where, by the year 2030, costs drop by 70% (from €3.3 bn to €1.0 bn), while benefits would drop by just over 50%. The differences are smaller for Option I-2 ($PM_{2.5}$ at 10 ug/m^3), where the costs drop by 9% and the benefits by 5%, and in the case of Option I-1 ($PM_{2.5}$ at 5 ug/m3), the effect disappears, as the stringency of the target requires such enhanced efforts in that the border cities do no longer lead to skewed results.

Without the border cell adjustment (i.e. in the main set of results of this impact assessment), costs are hence likely to be overestimated (in Figure 16), depending on the policy option, and the extent of the overestimation is most significant for certain Member States (incl. Poland, Lithuania, Hungary, Greece, Croatia and Bulgaria).

8.3 Administrative costs and REFIT (simplification and improved efficiency)

In light of the Commission's better regulation agenda (and REFIT programme), it is proposed to merge Directive 2008/50/EC and Directive 2004/107/EC into one Directive regulating all relevant air pollutants.

When Directive 2008/50/EC was adopted, it replaced Council Directive 96/62/EC on ambient air quality assessment and management, Council Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air, Directive 2000/69/EC relating to limit values for benzene and carbon monoxide in ambient air, Directive 2002/3/EC relating to ozone in ambient air and Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States. Their merging into a single Directive was done in the interest of clarity, simplification and administrative efficiency. At the time, the co-legislators also set out that consideration be given to merging Directive 2004/107/EC with Directive 2008/50/EC, once sufficient experience had been gained in relation to the implementation of Directive 2004/107/EC.

After more than a decade of implementing Directive 2008/50/EC and Directive 2004/107/EC in parallel, the revision of the Ambient Air Quality Directives provides an opportunity to incorporate the latest scientific knowledge and the experience gained on their implementation by merging them into a single Directive. In addition to streamlining relevant provisions in one integrated legal text, several updates and revisions aim to further simplify the rules applicable to different air pollutants covered by the previous Directives.

Notably, monitoring and assessment requirements for heavy metals would be aligned with those for other air pollutants in a single, more harmonised air quality assessment regime. Similarly, monitoring and assessment requirements on ozone, thus far largely separate and often different from the ones for other air pollutants, would be more integrated and aligned within a generalised monitoring approach.

These steps would accomplish consolidation of air quality legislation, while simplifying rules applying to competent authorities, enhancing overall consistency and clarity, and thus rendering implementation more efficient.

Adjustment (or mitigation) costs have been estimated to be substantial in absolute terms (annually 5.6 billion Euro in 2030 for the preferred option, and decreasing therafter), but in relative terms remain well below 0.1% of EU GDP, as shown in the previous section.

Administrative costs also need to be analysed in order to assess the potential administrative burden placed on different actors. For this, the EU's Better Regulation Toolbox Standard Cost Model[148] (SCM) was used to estimate additional costs of the policy options compared to the baseline scenario.[149] Aggregating the costs yields an estimated range of total

148 Tool #60 The standard cost model for estimating administrative costs

149 See also Annex 6 with detailed cost estimates per policy measure, as well as the underpinning support study on the revision of the Ambient Air Quality Directives.

administrative costs of 75 to 106 million Euro per year – see Table 18 for costs per policy option.[150,151]

This includes a fixed cost component independent of the level of ambition assumed via policy options I-1, I-2 or I-3, and a cost component linked to the development of air quality plans, which depends on the number of exceedances above EU air quality standards to be expected in the target year 2030 and hence varies by scenario (ranging between 1 and 31 million Euro). Policy options on developing (or, to a lesser extent, updating) air quality plans, air quality assessments and introducing additional sampling points come with important costs, which include both one-off and recurrent costs.[152] All these are costs borne by **public authorities**.

It is important to note that the Ambient Air Quality Directives **do not impose any direct administrative costs on consumers and businesses** (but these sectors do bear important adjustment costs, i.e. due to measures needed to achieve EU air quality standards).

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150 As also shown in section 6, see also Annex 3 for more details.

151 In order to be able to compare costs across policy options, they need to be expressed in a common manner, in this case per year. One-off costs are therefore expressed in their annualised version, where the cost is spread over 20 years assuming a 3% discount rate (as per the Better regulation toolbox Tool 64).

152 There is some overlap when looking at costs per option, however, as the options are a package of measures. Annex 3 contains a table that lists the individual measures contained in the preferred package. On that basis, the estimate of total administrative costs of 75 to 106 million Euro per year was derived.

Table 18 – Assessment of administrative costs and burden for preferred policy options – based on a central estimate (note: one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)

	Total cost	For public authorities (€)		For consumers & business (€)		
Policy option		One-off	Recur.	One-off	Recur.	
I-2 + I-1a Closer alignment with WHO recommendations	--	Medium < 3m	(High) or none	-	-	*For authorities:* Costs for more action to assure exceedance periods are kept as short as possible *For consumers/business:* Estimates point to adjustment costs <u>BUT</u> no administrative burden
I-5 + I-5b Average exposure reduction for $PM_{2.5}$ and NO_2	--	Medium up to 1m	-	-	-	*For authorities:* Limited direct costs in setting up the metric, but one-off costs if this requires new plans *For consumers/business:* Indirect costs only, and only if it accelerates action to be taken anyway
I-6 Review of air quality standards *(Measures A1,A3)*	-	-	Low	-	-	*For authorities:* Very low recurrent costs only, as such regular reviews require administrative efforts *For consumers/business:* Indirect costs only, if the outcome of such review leads to tighter standards
II-1 Responses to exceedances *(Measures B4,C1,C3,D1,N1)*	--	Medium 1.5m	Low < 0.1m	-	-	*For authorities:* Annualized one-off costs for **C1** 600k € + **C3** 30k € + **D1** 320k € + **N1** 600k € + low recurring costs only. *For consumers/business:* No immediate costs
II-2 Additional limit values *(Measures B1,B5)*	-	Low < 0.1m	Low < 0.1m	-	-	*For authorities:* Low annualized one-off costs and low recurring costs only for **B1**, **B5** (COM only) *For consumers/business:* Potentially high, i.e. if this results in more costly action to improve air quality
II-3 Implementation timelines & short-term action plans *(Measures B2,C2,C4,C5)*	--	Medium 0.65m	Medium 2.4m	-	-	*For authorities:* Annualized one-off costs for **C2** 600k € + **C4** 50k € + recurring costs **C5** 2.4m € *For consumers/business:* Indirect costs only, and only if it accelerates action taken anyway
II-4 Enforcement tools *(Measures C1,E1,E2,E4)*	0/--	Medium 0.6m	(High) or none	-	-	*For authorities:* Annualized one-off costs for **C2** 600k € + **E1, E2, E4** are expected to have no cost if compliance is assured (but high cost if not) *For consumers/business:* No immediate costs
II-5 Transboundary air pollution *(Measures M1,M2)*	-	Medium 0.6m	Low < 0.1m	-	-	*For authorities:* Annualized one-off costs for **M1** 600k € + **M2** is expected to have low costs only *For consumers/business:* No immediate costs
III-1 + III-1d Air quality assessments *(Measures G1,G2,H1,H2,L1)*	--	Medium 15.5m	Medium 8.2m	-	-	*For authorities:* Annualized one-off costs (+ recurring costs) for **G1** 1m € + **G2** 2.5m € (+2.2m €) + **H1** 2.5m € (+2.8m €) + **H2** 3m € + **L1** 6.5m € (+ 5.4m €), esp. where there is no modelling capacity today. *For consumers/business:* No immediate costs
III-2 Monitoring continuity *(Measures I1,I3)*	-	Low <0.1m	-	-	-	*For authorities:* Annualized one-off costs for **I3** 50k €, no costs for **I1** - generally no costs expected unless sampling points are not relocated. *For consumers/business:* No immediate costs
III-3 Additional sampling points *(Measures L1,L2)*	--/---	Medium 10.8m	High 50m	-	-	*For authorities:* Annualized one-off costs (+ recurring costs) for **L1** 6.5m € (+5.4m €) + **L2** 4.3m € (+45m €) *For consumers/business:* No immediate costs
III-4 + III-4a Monitoring data quality *(Measures J1,J2,K1 + J3)*	-/--	Low 0.9 m	Medium 2.2 m	-	-	*For authorities:* Annualized one-off (+ recurring costs) for **J1** 150k € + **J2** 150k € + **K1** 100k € + **J3** 400k € (+ 2.2m €) *For consumers/business:* No immediate costs
III-5 Modelling data quality *(Measures G2,K3)*	--	Medium 2.5 m	Medium 2.2m	-	-	*For authorities:* Annualized one-off costs (+ recurring costs) for **G2** 2.5m € (+2.2m €) + **K3** 20k €, esp. where there is no modelling capacity today. *For consumers/business:* No immediate costs
IV-1 Up-to-date air quality data *(Measures F1,K2)*	-/--	Low 0.3 m	Medium 1.2 m	-	-	*For authorities:* Annualized one-off (+ recurring costs) for **F1** 130k € (+ 640k €) + **K2** 130k € (+ 640k €) *For consumers/business:* No immediate costs
IV-2 Health related air quality data *(Measure F2)*	-	Low <0.1 m	Low <0.1 m	-	-	*For authorities:* Annualized one-off + recurring costs for **F2** < 100k € *For consumers/business:* No immediate costs
IV-3 Harmonised air quality indices *(Measure F4)*	-	Low <0.1 m	-	-	-	*For authorities:* Annualized one-off for **F4** < 100k € *For consumers/business:* No immediate costs

8.4 Application of the 'one in, one out' approach

This impact assessment has assessed the changes in administrative costs for public authorities, businesses and citizens with a view to minimise/mitigate any increase. Administrative costs for public authorities are assessed for each policy measure analysed, and quantified for the preferred option, using the EU's Better Regulation Toolbox Standard Cost Model (cf. section 8.3 above and Annex 3).

The policy measures analysed in this impact assessment do not generate significant new administrative costs for businesses and citizens, and there is no need to look at potential off-setting measures as part of the Commission's commitment to the 'one-in-one-out' scheme.

The main costs businesses and citizens may incur stem from measures decided by Member State authorities to achieve the air quality standards set in the Directives. Such mitigation/adjustment costs are analysed throughout this impact assessment – see in particular sections 6 and 8.3 above, as well as Annex 3 for a detailed account, including quantifications.

The proposed merging of the current Ambient Air Quality Directives 2008/50/EC and 2004/107/EC into a single Directive is expected to reduce administrative burden for public authorities, in particular competent authorities in the Member States, by simplifying rules, enhancing consistency and clarity, and rendering implementation more efficient.

9. How will actual impacts be monitored and evaluated?

The current framework established under the Ambient Air Quality Directives already offers high-quality representative monitoring of air quality, as demonstrated in the fitness check of the Directives, and provides key data for environmental monitoring under the Zero Pollution Monitoring and Outlook and the 8th Environment Action Programme, and it will be further enhanced through specific actions that would result from several of the preferred policy options. Across the EU, Member States have established an air quality monitoring network with some 16 000 sampling points for specific pollutants (often grouped at more than 4 000 monitoring stations) based on common criteria defined by the Directives. Overall, the monitoring network by and large adheres to the provisions of the Directives and ensures that reliable and representative air quality data is available.

The existing provisions on reporting as per Commission Decision 2011/850 guided the development of an effective and efficient digital e-reporting system, hosted by the European Environment Agency.[153] The air quality data reported by Member States is made available to the public as a digital service by the European Environment Agency, including via the European Air Quality Index based on near-real time data. This means that reliable, objective and comparable air quality data and information are online available across the EU for all pollutants covered by the Directives. In addition, monitoring of pollutants of emerging concern as per policy option III-4a will make it possible to keep under observation several air pollutants for which to date no harmonised EU-wide air quality monitoring exist.

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[153] See also fitness check on monitoring and reporting in environmental policy, SWD(2017) 230 *final*

Improvements to air quality monitoring, modelling and assessment regimes – including for additional near-real time data reporting – under policy options III-1 to III-5 will provide additional comparable and objective information that allows to regularly monitor and evaluate the development of air quality in the EU. The availability of this data, and more precise requirements for information to be included in air quality plans as per policy option II-1, will also allow to keep the effectiveness of specific (often local) air quality measures under constant review. Clearer specific requirements on public information as put forward by policy options IV-1 and IV-2 will make it easier and faster for citizens to access the outcomes of monitoring and evaluation of air quality data and related policy action.

All this will usefully inform future evaluations of a revised Ambient Air Quality Directive.

EUROPEAN
COMMISSION

Brussels, 26.10.2022
SWD(2022) 545 final

PART 2/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

on ambient air quality and cleaner air for Europe (recast)

{COM(2022) 542 final} - {SEC(2022) 542 final} - {SWD(2022) 345 final} - {SWD(2022) 542 final}

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ANNEX 1: PROCEDURAL INFORMATION

1. LEAD DG, DECIDE PLANNING/CWP REFERENCES

The revision of the Ambient Air Quality Directives is led by the Directorate General for Environment. It was included as items PLAN/2020/8962 and PLAN/2020/8636 in the Agenda Planning.

This impact assessment started in December 2020.

An Interservice Group to steer the evaluation was set up in June 2020 with representatives from the Secretariat-General (SG); Legal Service (SJ); Directorates-General for Budget (BUDG); Economic and Financial Affairs (ECFIN); Internal Market, Industry, Entrepreneurship and SMEs (GROW); Defence Industry and Space (DEFIS); Competition (COMP); Employment, Social Affairs and Inclusion (EMPL); Agriculture and Rural Development (AGRI); Mobility and Transports (MOVE); Energy (ENER); Environment (ENV); Climate Action (CLIMA); Research and Innovation (RTD); Joint Research Centre (JRC); Maritime Affairs and Fisheries (MARE); Regional and Urban Policy (REGIO); Structural Reform Support (REFORM); Taxation and Customs Union (TAXUD); Health and Food Safety (SANTE) and Neighbourthood and Enlargement Negotiations (NEAR).

The Interservice Group met eight times during the impact assessment process.

Timeline

5 Mar 2020	(Other)	**Conclusions of the Council of the European Union** on Improvement of air quality[1]
26 Jun 2020	(COM)	1st **ISG meeting**: discussion of overall process, draft roadmap and draft terms of reference for the support study
12 Aug 2020	(Other)	**Launch of the service request for "Strengthening of air quality monitoring modelling and plans under the Ambient Air Quality Directives"** to the contractors under the Framework Contract ENV.C.3/FRA/2017/0012 (Ares(2020)4231895) (closing date to submit offers: 14 Sep 2020)
7 Oct 2020	(MS)	**Ambient Air Quality Expert Group** meeting with a session dedicated on the follow-up to the Fitness check of the Ambient Air Quality Directives

[1] Council (2020), Council conclusions 6650/20 (accessed: 10.06.2022)

27 Oct 2020	(Other)	**Signature of contract for "Strengthening of air quality monitoring modelling and plans under the Ambient Air Quality Directives"** with the consortium led by Ricardo
13 Nov 2020	(COM)	2nd **ISG meeting**: discussion of draft inception impact assessment and draft consultation strategy; planned work under the contract to support strengthening of air quality monitoring, modelling and plans
17 Dec 2020	(EXT)	Publication of the **Inception impact assessment**[2] on the Better Regulation Portal (feedback period closing date: 14 Jan 2020)
19 Jan 2021	(COM)	3rd **ISG meeting**: discussion on the framing of the underpinning study for the impact assessment
1 Feb 2021	(EXT)	**Launch of the targeted expert survey under the contract for "Strengthening of air quality monitoring modelling and plans under the Ambient Air Quality Directives"** (feedback period closing date: 22 February 2021)
22 Feb 2021	(Other)	**Launch of the service request for "Study to support the impact assessment for the revision of the EU Ambient Air Quality Directives"** ('the support study')[3] to the contractors under the Framework Contract ENV.F.1/FRA/2019/0001 (Ares(2021)1395608) (closing date to submit offers: 22 March 2021)
25 Mar 2021	(Other)	**European Parliament resolution** on the implementation of the Ambient Air Quality Directives: Directive 2004/107/EC and Directive 2008/50/EC[4]
22 Apr 2021	(MS)	**Ambient Air Quality Expert Group** meeting with a dedicated session on the revision of the Ambient Air Quality Directives
29 Apr 2021	(Other)	**Signature of contract for "Study to support the impact assessment for the revision of the EU Ambient Air Quality Directives"** with the consortium led by Trinomics
12 May 2021	(Other)	**Publication of the EU Action Plan: 'Towards Zero Pollution for Air, Water and Soil'** (COM(2021)400)

2 COM (2022), Have your say - Air quality - revision of EU rules (accessed: 10.06.2022)
3 Contract no. 09029901/2021/848269/SFRA/ENV.C.3, implementing Framework Contract no. ENV.F.1/FRA/2019/0001
4 European Parliament (2021), resolution of 25 March 2021 on the implementation of the Ambient Air Quality Directives (accessed: 10.06.2022)

20 May 2021	(COM)	4th **ISG meeting**: presentation and discussion of inter-institutional developments relevant for the revision of the Ambient Air Quality Directives and of the planned and ongoing work to support the impact assessment
2 June 2021	(Other)	**EU Green Week 2021** session on **"Upgrading the ambition of EU Air Quality legislation"**[5]
10 Jun 2021	(COM)	Upstream meeting with the **Regulatory Scrutiny Board**
23 Sep 2021	(EXT)	First **stakeholder meeting** on 'Air quality – revision of EU rules'
23 Sep 2021	(EXT)	Launch of the **open public consultation**[6] on 'Air quality – revision of EU rules' (feedback period closing date: 16 Dec 2021)
23 Sep 2021	(EXT)	Publication of the **2021 World Health Organization: WHO Global Air Quality Guidelines**[7]
30 Sep 2021	(COM)	5th **ISG meeting**: update on stakeholder consultation and on the preparatory work to support the impact assessment
19 Oct 2021	(MS)	**Ambient Air Quality Expert Group** meeting with a dedicated session on updates on the revision of the Ambient Air Quality Directives
29 Oct 2021	(Other)	**Launch of the service request for "Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC (with a focus on ultrafine particles, black carbon and ammonia)"** to the contractors under the Framework Contract ENV.C.3/FRA/2017/0012 (Ares(2020)6691085) (closing date to submit offers: 30 Nov 2021)
18-19 Nov 2021	(Other)	**Third Clean Air Forum**[8] in Madrid, Spain with two dedicated sessions on: "Revision of the Ambient Air Quality Directives" and "Access to justice and the right to clean air"
29 Nov 2021	(Other)	**European Parliament exchange of views on new WHO Global Air Quality Guidelines** (ENVI Committee)
13 Dec 2021	(EXT)	Launch of the **targeted stakeholder survey part 1** (feedback period closing date: 11 Feb 2022)

[5] COM (2021), Upgrading the ambition of EU Air Quality legislation (accessed: 10.06.2022)
[6] COM (2021), public consultation on Air quality- revision of EU rules (accessed: 10.06.2022)
[7] WHO (2021), WHO global air quality guidelines (accessed: 10.06.2022)
[8] COM (2021), EU third Clean Air Forum (accessed: 10.06.2022)

23 Dec 2021	(Other)	**Signature of the contract for "Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC** (with a focus on ultrafine particles, black carbon and ammonia)" with the consortium led by IIASA
13 Jan 2022	(Other)	Launch of the **targeted stakeholder survey part 2** (feedback period closing date: 11 Feb 2022)
27 Jan 2022	(COM)	6th **ISG meeting**: update on progress in the stakeholder consultation process, discussion of first results of analysis for the impact assessment and the list of potential interventions to be considered for the revision of the Ambient Air Quality Directives
4 Apr 2022	(EXT)	Second **stakeholder meeting** on 'Air quality – revision of EU rules'
5 Apr 2022	(MS)	**Ambient Air Quality Expert Group** meeting with a dedicated session on the latest updates on the revision of the Ambient Air Quality Directives
5 May 2022	(COM)	7th **ISG meeting**: update on the progress in finalising the impact assessment support study and the policy options to be considered for the revision of the Ambient Air Quality Directives.
7 Jun 2022	(COM)	8th **ISG meeting**: update on the progress in finalising the impact assessment staff working document and the preferred policy options for the revision of the Ambient Air Quality Directives.
19 Jul 2022	(COM)	Meeting with the **Regulatory Scrutiny Board**
22 Jul 2022	(COM)	**Opinion** of the Regulatory Scrutiny Board
24 Oct 2022	(COM)	**Finalisation of the support study**
30 Sep 2022	(COM)	Launch of the **Inter-service consultation** on the final Staff Working Document

LEGEND	(COM)	Interservice Group or Regulatory Scrutiny Board
	(MS)	Member States input via Ambient Air Quality Expert Group
	(EXT)	(External) stakeholder input (including stakeholder consultation)
	(Other)	Other key events or input

2. CONSULTATION OF THE REGULATORY SCRUTINY BOARD (RSB)

An upstream meeting with the RSB took place on 10 June 2021.

After final discussion with the ISSG, a draft of the impact assessment was submitted to the RSB on 20 June 2022 and discussed at a meeting with the RSB on 19 July 2022.

In relation to this impact assessment, the Regulatory Scrutiny Board (RSB) delivered a positive opinion with reservations on 22 July 2022. The following table provides information on how the comments made have been addressed in this Staff Working Document:

Follow-up to recommendations of the Regulatory Scrutiny Board

Topic of RSB comment	RSB recommendation	Improvement made	Corresponding section(s) of the SWD
(1) Interaction with other initiatives	Include projected quantified impact of proposed revision of the Industrial Emissions Directive (IED) in the baseline.	Potential effects of the revised IED have been tested through sensitivity analysis representing in a broad manner the implementation of the revised IED. This additional analysis indicates that the results are rather stable compared to the baseline without the additional reductions resulting from the IED.	Section 5.1 Section 6.1
	Clarify whether upcoming proposal for Euro 7 road vehicle emission standard is included in the modelling.	A clarification is provided that the upcoming proposal is included in the modelling.	Section 5.1
	Make qualitative references to other legislation expected to deliver co-benefits, notably the Nature Restoration Law.	Potential co-benefits of the Nature Restoration Law and the REPowerEU package are analysed qualitatively.	Section 5.1 Section 7
	Clarify whether the level of air pollutant emission reduction forecast under the baseline is likely to be underestimated or not.	Additional sensitivity analyses on several elements examine this question, including quantitative analysis of the impact of the revised Industrial Emissions Directive (IED), of correcting for 'border cell effects', and of different health impact assumptions.	Section 5.1 Section 8.2
(2) Presentation of policy options	Provide a clear balanced, and open presentation of the options, in particular regarding the WHO alignment choices and their different technical feasibility. Present upfront all option design parameters (e.g. review clause, exemptions, inclusion of flexibility elements given geo-political challenges) and justify if these are not integrated for all alignment options	The presentation of policy options has been improved and enhanced, including by adding a summary comparison table presenting key figures on achievability of different WHO alignment choices, indicating where flexibility elements may be needed, and adapting the description for more clarity and openness.	Section 8.1
	Consider an explicit staged policy option consisting of a long-term political alignment commitment, concrete short-term measures (perspective 2030) and a regular review mechanism.	An explicit staged policy option has been included, which features measures for the 2030 perspective, a long-term alignment commitment, and a regular review mechanism.	Section 8.1
(3) Justifying the chosen preferred	Reflect better the feasibility concerns of the	The presentation of policy options has been improved and enhanced, including by adding a summary comparison table	Section 8.1

	option	preferred option.	presenting key figures on achievability of different WHO alignment choices,	
(4)	Drivers of the identified problems	Clarify why the existing air quality plans are not effective, and whether this is due to a lack of enforcement, financing or monitoring.	A clarification on the reasons for ineffective air quality plans has been added.	Section 2.1
		Set out clearly the current set-up of monitoring stations and sampling points and be transparent about the extent to which existing air quality data is reliable and of comparable quality across the EU.	A clarification on the reliability and comparability of air quality data has been added.	Section 2.1

3. EVIDENCE, SOURCES AND QUALITY

Support study

To support the analysis of different policy options, the European Commission awarded a specific support contract to external consultants on "Study to support the impact assessment for the revision of the EU Ambient Air Quality Directives". The consortium comprised Trinomics (consortium lead), in collaboration with Ricardo, VITO, IIASA and MET Norway.

Two further support contracts provided input on specific aspects related to the revision of the Ambient Air Quality Directives:

- Support contract on "Strengthening of air quality monitoring, modelling and plans under the Ambient Air Quality Directives". The consortium comprised Ricardo (consortium lead), NILU, VITO and Trinomics.

- Support contract on "Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC (with a focus on ultrafine particles, black carbon and ammonia)". The consortium comprised IIASA (consortium lead), Umweltbundesamt, EMISIA and RIVM.

Consultation strategy

Guided by the consultation strategy,[9] a broad range of stakeholders was consulted for the revision of the Ambient Air Quality Directives, including:

- *Public authorities* – i.e. EU Member States and their public authorities, at different governance levels (national, regional, local) and other institutions;

[9] COM (2021) AAQDs revision - consultation strategy - final (accessed: 04.08.2022)

- *Civil society & NGOs* – i.e. non-governmental organisations (NGOs) and civil society representatives;
- *Industry & businesses* – i.e. private economic sector operators such as business associations, organisations, trade unions, companies;
- *Academia & research* – i.e. research community, academia, medical professionals, and patient organisations;
- *EU citizens* – i.e. citizens not directly affiliated with the above stakeholder groups, but with a keen interest in the topic of air pollution.

Consultation activities included an open public consultation, a targeted stakeholder survey, stakeholder meetings, interviews and further outreach, such as through the third EU Clean Air Forum. Stakeholders also provided ad hoc contributions. A detailed overview is presented in Annex 2.

Bespoke modelling

Quantitative modelling has been conducted, focusing in particular on the impacts of different air quality standards, with a state-of-the-art modelling framework including: the *Greenhouse gas – Air pollution Interactions and Synergies* (GAINS) model and MET Norway's chemical transport model (EMEP CTM) with the uEMEP downscaling extension for fine resolution. This modelling assesses a number of effects, in particular: air pollutant emissions, concentrations, ecosystem impacts, feasibility to attain particular air quality targets as well as respective measures and their costs. A detailed overview of the modelling framework is included in Annex 4.

Evidence from air quality monitoring and reporting

Under the two Ambient Air Quality Directives, Member States make available the information they use for reporting and reciprocal exchange of information via and air quality data repository (http://www.eionet.europa.eu/aqportal), including:

- monitoring and assessment regimes, including assessment methods: http://aidec.apps.eea.europa.eu and http://aided.apps.eea.europa.eu
- attainment of environmental objectives, including information on exceedance situations: http://aideg.apps.eea.europa.eu
- air quality plans and programmes, as well as air quality measures: http://aideh.apps.eea.europa.eu and http://aidek.apps.eea.europa.eu
- information on source apportionment in zones and agglomerations: http://aidei.apps.eea.europa.eu
- information on air data and aggregated validated assessment data as summarised in the annual air quality reports published by the European Environment Agency
- online EEA indicators, such as:
    - Exceedance of air quality standards in urban areas: https://www.eea.europa.eu/ims/exceedance-of-air-quality-standards

Evidence from selected studies and policy documents

- COM(2005)446. ‘Thematic Strategy on air pollution’
- COM(2013)918. ‘A Clean Air Programme for Europe’, including, in particular: SWD(2013)531. ‘Clean Air Programme for Europe Impact Assessment’
- COM(2017)312. ‘Actions to Streamline Environmental Reporting’
- COM(2018)446. ‘The First Clean Air Outlook’
- COM(2018)330. ‘A Europe that protects: Clean air for all’
- COM(2019)149. ‘Environmental Implementation Review 2019’
- SWD(2019)427. ‘Fitness Check of the Ambient Air Quality Directives’
- COM(2021)3. ‘The Second Clean Air Outlook’
- EEA Annual Air Quality Reports and briefings published from 2011 to 2022, including
    - https://www.eea.europa.eu/publications/status-of-air-quality-in-Europe-2022
    - https://www.eea.europa.eu/publications/air-quality-in-europe-2021
    - https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report
    - https://www.eea.europa.eu/publications/air-quality-in-europe-2019
    - https://www.eea.europa.eu/publications/air-quality-in-europe-2018
- EEA Briefing 9/2018. ‘Improving Europe’s air quality — measures reported by countries’
- EEA Report 11/2014. ‘Effects of air pollution on European ecosystems’
- EEA Report 6/2018. ‘European Union emission inventory report 1990-2016’
- EEA Report 22/2018. ‘Unequal exposure and unequal impacts’
- EEA Report 24/2018. ‘Europe’s urban air quality’
- EEA Briefing 19/2021. ‘Managing air quality in Europe’
- ETC/ACC Technical paper 2010/1. ‘The state of the air quality in 2008’
- ETC/ACM Technical paper 2011/20. ‘Co-benefits of climate and air pollution regulations’
- European Commission (2013). Flash Eurobarometer 360: ‘Attitudes of Europeans towards air quality’
- European Commission (2017). Special Eurobarometer 468: ‘Attitudes of European citizens towards the environment’
- European Commission (2019). Special Eurobarometer 497: ‘Attitudes of Europeans towards Air Quality’
- European Court of Auditors Special Report 05/2018 on Renewable Energy
- European Court of Auditors Special Report 23/2018 on Air Pollution
- European Parliament (2017). ‘Report on the inquiry into emission measurements in the automotive sector’

- European Parliament (2019). ‘Sampling points for air quality: Representativeness and comparability of measurements in accordance with Directive 2008/50/EC on ambient air quality and cleaner air in Europe’ (study requested by the ENVI Committee)
- EUROSAI (2019). ‘Joint report on air quality by the European Organisation of Supreme Audit Institutions’
- IIASA (2014). ‘Complementary Impact Assessment on interactions between EU air quality policy and climate and energy policy’
- IIASA (2017). ‘Costs, benefits and economic impacts of the EU Clean Air Strategy and their implications on innovation and competitiveness’
- IIASA (2018). ‘Progress towards the achievement of the EU’s air quality and emissions objectives’
- JRC (2013). ‘Assessment on siting criteria, classification and representativeness of air quality monitoring stations’
- JRC (2017). ‘Urban $PM_{2.5}$ Atlas: Air Quality in European Cities’
- JRC (2017). ‘Global Energy and Climate Outlook 2017: How climate policies improve air quality’
- JRC (2019). ‘Urban NO_2 Atlas’
- JRC (2021). ‘Urban $PM_{2.5}$ Atlas: Air Quality in European Cities’
- Nationale Akademie der Wissenschaften Leopoldina (2019). ‘Saubere Luft. Stickstoffoxide und Feinstaub in der Atemluft: Grundlagen und Empfehlungen’
- OECD (2016). ‘The Economic Consequences of Outdoor Air Pollution’
- OECD (2020). ‘The economic cost of air pollution – Evidence from Europe’
- World Health Organization (2006). ‘Air quality guidelines – global update 2005’
- World Health Organization (2013). ‘Review of evidence on health aspects of air pollution’
- World Health Organization (2021). ‘WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.’

Additional sources of evidence, including relevant academic literature and scientific articles, reports and conference papers, online and data sources, as well as further policy documents and guidelines, are listed in the respective Annex 4, and also in the support study informing this impact assessment or cited as footnotes where referred to.

ANNEX 2: STAKEHOLDER CONSULTATION (SYNOPSIS REPORT)

1. AIM OF THE CONSULTATION

This annex summarises the results of the stakeholder consultation activities undertaken as part of the revision of the Ambient Air Quality Directives. The stakeholder consultation aimed to collect supporting information, data and knowledge in order to provide input for the different policy options for the revision of the Ambient Air Quality Directives, with a view to fill any potential information/data gaps and gather views of stakeholders on the different policy options and the feasibility of their implementation. The thorough stakeholder consultation ensures that the view from different stakeholder groups are duly represented and considered in the impact assessment.

1.1 Consultation strategy[10]

The consultation focused on gathering stakeholders' responses on the following:

- extent and feasibility of a closer alignment of EU air quality standards with the latest recommendations of the World Health Organization *(policy area 1);*
- ways to improve legislative provisions and their coherence, including in relation to penalties, public information and air quality assessments *(policy area 2);*
- ways of strengthening of air quality monitoring, modelling and air quality plans *(policy area 3).*

A broad range of stakeholders was consulted for the revision of the Ambient Air Quality Directives, including:

- *Public authorities* – i.e. EU Member States and their public authorities, at different governance levels (national, regional, local) and other institutions;
- *Civil society & NGOs* – i.e. non-governmental organisations (NGOs) and civil society representatives;
- *Industry & businesses* – i.e. private economic sector operators such as business associations, organisations, trade unions, companies;
- *Academia & research* – i.e. research community, academia, medical professionals, and patient organisations;
- *EU citizens* – i.e. citizens not directly affiliated with the above stakeholder groups, but with a keen interest in the topic of air pollution.

[10] COM (2021) AAQDs revision - consultation strategy - final (accessed: 04.08.2022)

1.2 Consultation activities

As outlined in the *consultation strategy*, the following activities were applied as complementary activities that formed the core of the stakeholder consultation:

- **Open public consultation** allowing the interested public and stakeholders to express their views *(see section 2.1);*
- **Targeted stakeholder consultation** addressing selected stakeholders in all Member States and at EU level via a targeted survey *and* interviews *(see section 2.2);*
- **Stakeholder meetings** aimed at assisting in the identification and confirmation of the policy measures and at receiving feedback that would support its completion (see *section 2.3*).

Table A2.1: Stakeholder groups

Stakeholder groups	Consultation activity			
	Open public consultation	Targeted survey	Interviews	Stakeholder meetings
See section	*(2.1)*	*(2.2)*	*(2.2)*	*(2.3)*
Public authorities	X	X	X	X
Civil society & NGOs	X	X	X	X
Industry & businesses	X	X		X
Academia & research	X	X	X	X
EU citizens	X			X

2 SUMMARY OF CONSULTATION ACTIVITIES

2.1 Open public consultation[11]

The open public consultation ran for 12 weeks, from 23 September 2021 to 16 December 2021.[12] The online questionnaire contained 13 introductory and 31 specific questions and was hosted on the EU Survey tool. The questionnaire aimed to confirm the issues identified for the impact assessment and gather initial views on the ambition level and potential impacts of certain options for the revision of the Ambient Air Quality Directives.

A total of 934 responses were received, and 116 position papers were submitted. In the general part of the questionnaire, respondents could choose whether they wished to respond further to a targeted section. The targeted section received a total of 555 responses. On average, open questions received 124 individual responses, with a minimum of 11 and a maximum of 406 individual responses. 23 Member States were represented in the responses.

[11] COM (2021), OPC- Factual summary report - final (accessed: 04.08.2022)
[12] COM (2021), Have your say portal (accessed: 04.08.2022)

The stakeholder types of respondents, their country of origin and other information about their profile was collected for the analysis. The distribution of stakeholder groups and countries is presented below in Box A2.1.

Box A2.1: Open public consultation – Stakeholders per group and country

Stakeholder per stakeholder group (descending):

EU citizens (=615), Civil society & NGOs (=106), Industry & businesses (=103), Public authorities (=53), Academia & research (=25) + Others (=32).

Stakeholder per country (descending):

DE (=225), IT (=191), FR (=78), PL (=69), BE (=67), RO (=56), ES (=48), SE (=38), AT (=22), NL (=21), BG (=13), PT (=12), IE (=9), CZ (=8), LI (=7), DK (=7), SI (=6), SK (=6), HU (=6), EL (=5), FI (=4), LU (=3), ES (=2) + 32 EEA and non-EU countries and international organisations.

On policy area 1, stakeholder feedback pointed to a desire to opt for a high level of ambition. 72% (n=673) of all respondents expressed a preference to align with WHO Air Quality Guidelines. In particular, a large majority of *civil society & NGOs* (93%, n=98) and *EU citizens* (79%, n=485) indicated that EU air quality standards should be fully aligned with the latest WHO recommendations. This view was only shared by a minority of *public authorities* (36%, n=19), with a majority of *public authorities* (62%, n=32) here calling for partial alignment. Furthermore, *civil society & NGOs*, *academia & research* and *EU citizens* were largely in favour of meeting the current EU air quality standards as soon possible, while *public authorities* and *industry & business* representatives were less in favour of meeting current EU air quality standards as soon as possible. Nevertheless, there was a general agreement across the stakeholder groups that meeting current air quality standards is the most feasible and the most important policy measure. Regarding the extent of applicability of air quality standards, *civil society & NGOs* and *EU citizens* thought these should apply everywhere while some *public authorities* were also of the opinion that these should apply only at selected locations.

On policy area 2, the majority of *civil society & NGOs* and *EU citizens* were of the opinion that legislative changes in regards to air quality should include a provision ensuring access to justice for citizens as well as a provision ensuring compensation for health damage caused by air pollution. To expand requirements for action by national / regional / local authorities in case of exceedances as deemed as highly important by 65% (n=607) of respondents. Regarding the availability of information on air quality, *public authorities* and *industry & businesses* felt the most informed while *civil society & NGOs* thought there was a room for improvement. In addition, this measure was thought to be highly feasible to implement by 58 % (n=541) of respondents. In general, regarding the feasibility and importance of new policy measures, there was quite a divide between the stakeholder groups, though there was a general agreement that making it easier for EU air quality standards to update to scientific progress would be an important measure.

On policy area 3, regarding monitoring the majority of *civil society & NGOs*, *academia & research* and *EU citizen* representatives were of the opinion that there is a need for additional monitoring everywhere, while there was a lesser support for this additional monitoring from *public authorities* and an even lesser support from *industry & business* representatives. To establish more detailed rules on the location of sampling points was seen to be highly important by 60% (n= 560) of respondents as well as the expansion of monitoring requirements to a broader set of harmful air pollutants (60%, n=560). There was a general agreement across most of the stakeholder groups that the clarity of air quality plans needs to be improved, especially when addressing specific sources and origins of air pollution. Additionally, regarding the clarity of air quality plans, *public authorities* believed that responsibility across different tiers of governance and stakeholders need to better clarified. Addressing specifically the proposed policy measures, the option considered most important and feasible across all stakeholder group was to establish more detailed rules on the location of sampling points.

2.2 Targeted stakeholder consultation

Targeted survey

The targeted survey was published on EU survey in two parts *(i.e. part 1 on policy area 1 on 13 December 2021, and part 2 on policy area 2 and 3 on 13 January 2022),* both with a deadline for contributions by 11 February 2022.

The targeted survey was seeking in-depth views by organisations with an interest in, or working with EU rules on air quality. Therefore, the survey was specifically disseminated to targeted stakeholders, including competent authorities at different levels, private sector organisations, academics and civil society organisations. The targeted survey was distributed to a large network of relevant stakeholders to reach a great number of interested stakeholder in all EU Member States and all targeted stakeholder groups.

Part one of the targeted stakeholder survey received in total 139 replies representing 24 Member States. Part two of the survey received 93 replies representing 22 Member States. The number per stakeholder group and Member State for part one (i.e. policy area 1) and for part two (i.e. policy area 2 and 3) is listed in the boxes (A2.2 and A2.3) below.

Box A2.2: Targeted survey part 1 - Stakeholders per group and country

Stakeholder per stakeholder group (descending):

Public authorities (=53), Academia & research (=42), Industry & businesses (=26), Civil society & NGOs (=12) + Others (=6).

Stakeholder per country (descending):

DE (=23), BE (=17), IT (=17), ES (=13), SE (=7), RO (=7), AT (=4), FR (=4), HU (=4), NL (=4) PL (=4), CZ (=3), DK (=3), FI (=3), EL (=3), HR (=3), IE (=3), PT (=3), LU (=2), LV (=2), SI (=2), CY (=2), SK (=1), EE (=1) + 3 EEA and non-EU countries.

On **policy area 1**, the majority of stakeholders saw difficulties to reach the recommended $PM_{2.5}$ annual and peak concentrations by the WHO Air Quality Guidelines in the foreseeable future, while *civil society & NGO* representatives were the most optimistic and *public authorities* and *research & academia* the least optimistic. A majority was in favour of stricter $PM_{2.5}$ annual limit values (60%, n=83) and short-term limit values (62%, n=86) that apply in all the territory and not at selected locations only *(policy measure O1 and O2)*. For PM_{10} a relative majority (44%, n= 61 for annual and 48%, n= 66 for daily) of stakeholders saw the recommended PM_{10} levels by the WHO Air Quality Guidelines as feasible with significant additional effort, while *civil society & NGOs* were generally more optimistic. In addition, a relative majority of stakeholders (37%, n=51) were in favour of more stringent PM_{10} EU standards (especially on a long-term basis) and introducing an average exposure indicator target for short and long-term PM_{10} concentrations at a regional level *(policy measure P1 to P3)*.

For NO_2, 38% (n=53) of the stakeholders saw the recommended annual levels by the WHO Air Quality Guidelines as feasible but only with significant effort and for the NO_2 hourly concentrations which mirror the current EU standard a small relative majority of 31% (n=43) saw it feasible but only with some additional effort *(policy measure Q2)*. A majority of 66% (n=93) of respondents were in favour of more stringent EU standards of the NO_2 annual mean in a short-term timeframe *(policy measure Q1)*. Also a relative majority indicated a full alignment with the WHO recommendation for a long-term standard (37%, n=51)). Again *public authorities, civil society & NGOs* and *academia & research* were the most ambitious stakeholders, whereas *industry & business* voted for less ambitious levels. As for $PM_{2.5}$ and PM_{10}, stakeholders are of the opinion that an average exposure indicator target at a more regional level would be appropriate. However, a low response rate for the question on NO_2 average exposure indicates a low level of certainty across all stakeholder groups *(policy measure Q3)*. On ozone (O_3) a relative majority (38%, n=53) of stakeholders sees the 2021 WHO recommendations for annual ozone levels as feasible without additional effort. *Public authorities* and *research & academia* were the most optimistic stakeholder groups. A relative majority (26%, n=37) replied for being in favour of an ozone limit value, while 21% (n=28) replied for a target value. A relative majority of the stakeholders (31%, n=43) regarded the recommended ozone peak concentrations by the WHO as being feasible. However, for the short to medium term, 41% (n=57) of the respondents were in favour for the ozone short-term concentration that mirrors the current EU target value and only 43% (n=59) agreed to a full alignment with the WHO recommendation for long-term *(policy measure R1 to R3)*.

Box A2.3: Targeted survey part 2 - Stakeholders per group and country

Stakeholder per stakeholder group (descending):

Public authorities (=42), Academia & research (=22), Industry & businesses (=14), Civil society & NGOs (=12) + Others (=3).

Stakeholder per country (descending):

BE (=15), DE (=15), ES (=10), IT (=8), SE (=8), FR (=4), FI (=4), RO (=4), PT (=3), AT (=2), CZ (=2), EL (=2), IE (=2), HR (=2), HU (=2), PL (=2), DK (=1), SI (=1), SK (=1), LV (=1), EE (=1), NL (=1) + 3 EEA and non-EU countries.

On **policy area 2**, 83% (n=10) of the stakeholder group *civil society & NGOs* were strongly in favour of adjusting EU air quality standards upon publication of new scientific evidence while the other stakeholder groups and in particular *industry & businesses* but also *public authorities* were less supportive of this policy measure *(policy measure A1)*. However, the policy measure to adjust EU air quality standards based on technical progress didn't find full support across all stakeholder groups *(policy measure A2)*. To establish short-term EU air quality standards for additional air pollutants found no majority as respondents of the different stakeholder groups answered with great variety (i.e. *civil society & NGOs* and *research & academia* largely in favour of this policy measure *(B1)* while *industry & businesses* and *public authorities* were less ambitious). With a relative majority (32%, n=30) of all replies, all stakeholders were largely in favour of the expansion of the exposure reduction target *(B3),* with *public authorities* the most supportive of this policy measure. The regular update of air quality plans was also supported by a relative majority of stakeholders (41%, n=38) while *industry & business* were the only stakeholder group being less supportive of this policy measure *(C5).*

A policy measure that received minor support across most stakeholder groups (besides *civil society & NGOs*) was the further specification of the obligation to take measures to keep the exceedance period as short as possible with almost half of the respondents (45%, n=18) among *public authorities* that didn't support this policy measure *(C2). Public authorities* with a majority (50%, n=21) of replies among *public authorities* respondents replied that they are not or largely not in favour of harmonising air quality plans *(policy measure D2)*, while they were more supportive (38%, n=16) of establishing a requirement for Member States to involve specific actors in the air quality plan development *(policy measure D1).* This policy measure also found support across the other stakeholder groups. Regarding the policy measures about transboundary air pollution, a large relative majority (48%, n=45 for policy measure M1 and 36%, n=34 for policy measure M2) of all replies and across all stakeholder groups are in favour to use an agreed methodology when assessing transboundary air pollution and when it comes to cooperation and joint action on transboundary air pollution (noting that the response rate from *industry & business* was very low for those interventions).

Policy measures regarding additional enforcement tools *(policy measures E1 to E4)* in case of non-compliance had a very low response rate (27%, n= 44). The policy measure E2 on a specific provision that guarantees a right to compensation for damage and health found no support among *public authorities* while *civil society & NGOs* where largely supportive. Least support in this policy area was the introduction of an "access to justice" provision which was only largely supported by *civil society & NGOs (policy measure E4)*. Policy measures regarding public air quality information was supported across all stakeholder categories with only minor reservations in regards to the regular up-to-date information from *industry & business* representatives *(policy measure F1).* A relative majority (40, n=38) of replies was in favour of requiring Member States to use harmonised air quality indices while comments from *public authorities* requested that this would be preferred as an additional index to the national index *(policy measure F4).*

On **policy area** 3, the mandatory use of modelling as part of air quality assessment did not find large support, and comments made by stakeholders point to the current large uncertainty of harmonised model criteria *(policy measure G2)*. To allow the use of indicative measurements to substitute fixed measurements as part of the air quality assessment was with a relative majority (43%, n=40) of all replies not supported among all stakeholder groups *(policy measure G1)*, whereas the highest support (21%, n=12) was found in the stakeholder group of *public authorities*. More supported was the policy measure *H2* that considers sampling points for $PM_{2.5}$ and PM_{10} independently, especially among *public authorities*, *research & academia* and *civil society & NGOs*. The change of minimum number of sampling points was more favoured by *civil society & NGOs* (42%, n=5) and *academia & research* (41%, n=9) and by *public authorities* (14%, n=6) and found no support among *industry & businesses (policy measure H1)*. To specify that sampling points with exceedances of limit values should be maintained *(policy measure I1)* found large support across the different stakeholder groups (noting that *industry & businesses* only had one reply). This result is similar to the policy measure that foresees the establishment of a protocol when a sampling point has to be relocated. *Public authorities* (43%, n=18) and *academia & research* (50%, n=11) were fully or largely agreeing to this policy measure *(I3)*.

To include a requirement to monitor long-term trends if the fixed sampling point is discontinued with other techniques, such as indicative measurements, found less support, and stakeholders pointed to the uncertainty that occurs when different monitoring techniques are used for one measurement *(policy measure I2)*. For the policy measure to further clarify macro-siting criteria for sampling points, a larger number of respondents (31%, n=29) was fully or more in favour, whereas a relative majority (44%, n=41) did not answer to this question. Also *public authorities* were more in favour (43%, n=18) of these policy measure, however a large number of respondents (31%, n=13) from *public authorities* did not reply *(policy measure J1)*. For the policy measure to further clarify micro-siting criteria the same number of respondents from *public authorities* (n=13) either fully and to a large extend in favour of this policy measure or was to some extend or not at all supporting this policy measure as some indicated that current rules suffice, while *NGOs & civil society* were more supportive of this measure *(policy measure J2)*. On the data quality requirements for sampling points to be further defined, a relative majority of replies to this policy measure (30%, n=27) were in favour, and *academia & research* and *public authorities'* respondents were the largest supporters *(policy measure K1)*. The mandatory up-to-date information on pollutant concentration was only to some extent or not at all supported across the stakeholder groups (29%, n=27). Various comments from *public authorities'* stakeholders pointed out that up-to-date data would be important but it needs to be quality assured to present correct data information *(policy measure K2)*. The introduction of standardized "modelling quality objectives" were supported largely (38%, n=26) with *public authorities* and *academia & research* being the greatest supporters of this policy measure *(K3)*. To measure additional emerging air pollutants and to set a minimum number of sampling points for those was supported by a clear relative majority (43%, n=40 and 39%, n=37) from all stakeholders except from *industry & business (policy measure L2)*. Similar support found the policy measure N1 on refining the minimum information to be included in an air quality plan (43%, n=40) across all stakeholders groups.

Interviews

Targeted interviews were conducted to complement the other consultation activities, in particular with representatives of regional and national *public authorities*, *civil society & NGOs* and *academia & research*. The interviews were conducted in April 2022 after the targeted stakeholder survey was closed and evaluated. A list of questions was sent to the stakeholders ahead of the interviews, which were then discussed during the meeting. The interviews focused on remaining gaps for policy area 2, notably on the feasibility, means of implementation and impacts of the various options considered. The main purpose of the interviews was to fill those information gaps identified from the evaluation of the targeted stakeholder survey. See Table A2.2.

Table A2.1: Interviews

Organisation name	Country	Stakeholder type
ARPA Lombardia	Italy	Public authority (regional)
AirClim	Sweden (EU scope)	Civil society & NGO
University of Helsinki	Finland	Academia & research
SenUVK (Senate Department for the Environment, Mobility, Consumer and Climate Protection, Berlin)	Germany	Public authority (regional)
Department of Air Protection and Urban Policy, Ministry of Climate and Environment*	Poland	Public authority (national)

2.3 Stakeholder meetings

First stakeholder meeting

The first stakeholder meeting took place on the 23 September 2021 and was attended by a total of 345 participants, either onsite or online according to COVID-19 restrictions at the time.

A total of 315 stakeholders from 27 Member States participated in the meeting, without considering the consultants contributing to the revision of the Ambient Air Quality Directives and EU officials involved. The aim of the first stakeholder meeting was to confirm the shortcomings identified and gather initial views on the ambition level from all stakeholder groups.[13] All relevant stakeholder groups as set out in the consultation strategy were represented during the stakeholder meeting. The stakeholder groups and the country is indicated below in box A2.4.

[13] COM (2021), First stakeholder meeting summary report- final (accessed: 04.08.2022)

Box A2.4: First stakeholder meeting - Stakeholders per group and country

Stakeholder per stakeholder group (descending):

Public authorities (=201), Industry & businesses (=40), Civil society & NGOs (=34), Academia & research (=30) + Others (=10).

Stakeholder per country (descending):

DE (=34), ES (=32), FR (=27), IT (=23), SE (=13), BE (=11), PT (=11), HU (=10), SK (=6), DK (=5), FI (=5), IE (=5), LV (=5), PL (=5), AT (=4), BG (=4), HR (=4), MT (=4), NL (=4), EL (=3), LU (=3), RO (=3), CY (=2), CZ (=2), EE (=2), SI (=2), LT (=1) + EEA and non- EU countries and international organisations.

On policy area 1, the majority of *civil society & NGOs* argued strongly for full alignment of EU air quality standards with the WHO Air Quality Guidelines levels by 2030, whereas several *public authorities* commented on the need to consider the measurability and acceptability of future measures needed to attain a closer alignment. *Industry & business* stakeholders also cautioned that uncertainties related to technical feasibility, local issues, biogenic emissions and measurements remained. Stakeholders also stressed the need to look at additional pollutants, a more regular review of air quality standards, requested a location based limit value, argued for a regional exposure reduction target, and pointed to measurement uncertainties of air pollutants.

On policy area 2, the different stakeholder groups, supported in general the proposed elements to be tackled and possible policy measures presented. The raised topics and discussions focused on adding an explicit mechanism for adjusting air quality standards to technical and scientific progress, on expansion of actions required to address exceedance, specifying provisions to guide the development of air quality plans and on governance, and expanding the provision of information requirements. The importance of access to information was underlined by stakeholders, which is deemed crucial for the protection of public health and also directly connected to other provisions, for example, on access to justice. Stakeholders also agreed that the revision should also ensure that especially vulnerable groups have access to information.

On policy area 3, the use of models to supplement assessment methods was welcomed, though it was noted this should not be at the expense of a reduced monitoring network. The importance of clear meta-data to describe a site to enable cross-city comparison was noted. *Civil society & NGOs* and *public authorities* advocated an increase in the number of $PM_{2.5}$ monitoring stations, and more broadly set clearer requirements for the proportion between different types of monitoring stations, which would entail abandoning the $PM_{2.5}$ /PM_{10} ratio. Concerns were expressed by several public authorities (both national and regional level) with regards to stability and sensitivity issues, hence participants noted that single sensors should not be used for compliance purposes and that uncertainties must be communicated transparently if such data is used.

Second stakeholder meeting

The second stakeholder meeting took place on the 4 April 2022 and was attended by a total of 285 participants, either onsite or online according to COVID-19 restrictions at the time.

A total of 257 stakeholders participated in the meeting, without considering the consultants contributing to the revision of the Ambient Air Quality Directives and EU officials involved. Stakeholders from 23 Member States were present at the meeting. The aim of the second stakeholder meeting was to collect feedback from stakeholders that would assist the Commission in its completion of the Impact Assessment. All relevant stakeholder groups as set out in the consultation strategy were represented during the stakeholder meeting.[14] The division of stakeholders per groups and per country is indicated below in Box A2.5.

Box A2.5: Second stakeholder meeting - Stakeholders per group and country

Stakeholder per stakeholder group (descending):

Public authorities (=135), Industry & businesses (=56), Civil society & NGOs (=26), Academia & research (=23) + Others (=17).

Stakeholder per country (descending):

DE (=42), ES (=37), IT (=20), FR (=20), SE (=16), BE (=10), NL (=7), HU (=7), RO (=6), AT (=6), PL (=5), FI (=5), DK (=4), SK (=2), MT (=2), HR (=2), LU (=1), LT (=1), LV (=1), IE (=1), EE (=1), CZ (=1), BG (=1) + EEA and non- EU countries and international organisations.

On policy area 1, *public authorities* and *civil society & NGO* representatives expressed their preference for binding air pollutant standards. Several NGOs reiterated their preference for full alignment with the WHO Air Quality Guidelines levels by 2030 while one *public authorities* also expressed the same view. It was also raised by *civil society & NGO* representatives that they would be interested to see analysis of the percentiles for daily exceedances. Especially regarding NO_2, one NGO stressed the future focus should be on daily limit values. *Civil society & NGOs* also expressed opinions on the relative effectiveness of target or limit values. It was pointed out that in certain Member States target values do not provide an effective incentive and as such the revised air quality rules should turn to limit values. Stakeholders from all stakeholder groups expressed their views regarding the definition of ‘short’ and ‘long’ term standards. Generally, *civil society & NGO* representatives were of the opinion that 2030 should already be considered as a ‘long term’ timeframe, while *public authorities* were more reserved and stated that 2040 might also be an appropriate long-term target. *Industry & business* pointed out that the transition in their sector would take time, and there is a need for the long-term targets to reflect that and align with sector plans and roadmaps. As such, *industry & business* expressed their preference for 2050 to be considered as the long-term target.

On policy area 2, representatives of *public authorities* stressed the importance of transboundary cooperation, which they proposed should be addressed by harmonisation of

[14] COM (2022), Second stakeholder meeting briefing paper (accessed: 04.08.2022)

rules on air quality plans. This suggestion was also supported by certain *civil society & NGO* representatives. Furthermore on air quality plans it was suggested that their drafting starts with emission factors and should include absolute numbers. *Civil society & NGO* representatives also touched upon the topic of improvement of public information. They discussed that there is a need to harmonise the available information as well as to provide a link between the information provided and the health impacts of air pollution (e.g. by relying on colour coding of different health impacts). Linking health impacts with air quality will allow citizens to make more informed decisions. Making informed decisions can further be supported by providing citizens with real-life data, namely allowing citizens to limit their exposure levels. The list of pollutants on which real-life data are provided should be expanded and include pollen, for example. Furthermore, the topic of access to justice was also touched upon, namely that both the provisions on access to justice and on public information remain the largest gaps in the current Ambient Air Quality Directives. One attendee from *research & academia* stressed that penalties have to be more drastic in order to encourage Member States to take action. However, at the same it was highlighted that any legal action will be difficult if one relies on target values rather than limit values.

On policy area 3, *public authorities'* representatives highlighted the importance with regards to sampling points of Annex III to Directive 2008/50/EC. One attendee from *civil society & NGO* pointed out that there can be issues with accuracy of modelling, due to the availability of data. As such, one has to approach modelling with caution. It is thus important to use data that is fit for purpose and regularly updated emission inventories. *Civil society & NGOs* also highlighted that clarification on the procedures for moving monitoring sites was crucial, as there are contentious cases where public authorities have shifted sites. One participant highlighted that there is a need for good real-time monitoring to be in place, ideally composed of several solutions (e.g. satellite and ground monitoring). Representatives of *academia & research* highlighted the need for monitoring requirements for ammonia, which are currently not present despite the potential severe impacts on biodiversity and ecosystems. This would also be beneficial for coherence with the NEC Directive. It was also pointed out that there is a need for monitoring both in urban and in rural areas, and for sampling points in residential areas, as wood burning still takes place and is subsidised in some Member States.

3 RESULTS OF THE STAKEHOLDER FEEDBACK

3.1 Feedback by stakeholder groups – Policy Area 1

Representatives from **public authorities** largely consider it is "not feasible, for the foreseeable future" that the recommended levels from the WHO Air Quality Guidelines for $PM_{2.5}$ of 5 µg/m³ annually *(incl. 36 out of 53 replies to the survey)* or that the daily levels of 15 µg/m³ *(incl. 25 out of 53 replies to the survey)* are achievable. Further some representatives think that the $PM_{2.5}$ annual level should be set on 10 µg/m³ *(incl. 17 out of 53 replies to the survey)* while more representatives favour an annual level of 15 µg/m³ for $PM_{2.5}$ *(incl. 19 out of 53 replies to the survey).*

For the average exposure indicator target, respondents from public authorities have no preferred approach but differ strongly. On PM_{10} levels, the representatives largely think the WHO recommended levels are not feasible in the foreseeable future *(incl. 22 out of 53 replies* *to the survey)* and there representatives are mostly favouring 20 µg/m³ or 30 µg/m³ for a PM_{10} annual level. The majority within this group is in favour of an average exposure indicator target of PM_{10} of an "ECO[15] at national level" for both short and long-term. For NO_2 levels, public authorities think that 30 µg/m³ is the most feasible option and that the WHO recommended levels are only feasible with significant effort. The large majority is in favour that the NO_2 levels and also $PM_{2.5}$ and PM_{10} levels should apply in all territory, and is in favour that the type of standard should be a limit value. For ozone levels the representatives think that the most recent WHO recommendation is feasible, without additional effort and the majority is in favour for a level of 100 µg/m³ *(incl. 13 out of 53 replies to the survey).* For all heavy metals this stakeholder group thinks that the most recent WHO recommendations are feasible without additional effort. For benzo(a)pyrene, stakeholders don't think that the WHO recommendations are feasible for the foreseeable future.

Representatives from **civil society & NGOs** largely think that the WHO recommended levels for $PM_{2.5}$ are feasible with some additional effort *(incl. 10 out of 12 replies to the survey).* The representatives' opinion on the levels are divided with around half favouring a $PM_{2.5}$ level of 5 µg/m³ and the other half favouring a $PM_{2.5}$ level of 10 µg/m³ *(incl. 6 out of 12 replies for to the survey for each value).* This stakeholder group thinks that $PM_{2.5}$ levels should apply in all territory and a large majority is in favour to set a limit value as the type of standard. The representatives have the same opinion concerning the $PM_{2.5}$ short-term standards; around half of the stakeholder group is in favour of a short-term $PM_{2.5}$ level of 15 µg/m³ and the other half favours 25 µg/m³ *(incl. 6 out of 12 replies for to the survey for each value).* The respondents didn't express many opinions about the favoured approach on the $PM_{2.5}$ average exposure indicator target.

Concerning PM_{10} levels, respondents from civil society & NGOs expressed that the WHO recommendations are feasible, with some additional effort *(incl. 11 out of 12 replies to the survey)* and a majority is in favour of a PM_{10} annual level of 20 µg/m³. For the PM_{10} short-term concentrations, the majority is in favour for a level of 50 µg/m³ for short to medium term and for 45 µg/m³ in the long-term. Regarding NO_2 annual levels around half of this stakeholder group is in favour of a NO_2 level of 10 µg/m³ and the other half is favour of a NO_2 level of 20 µg/m³. Similar to $PM_{2.5}$ and PM_{10} the representatives think that the levels should apply in all territory and limit values is the preferred type of standard. For ozone levels the representatives believe that the WHO recommended levels are feasible, with some additional effort *(incl. 11 out of 12 replies to the survey)* and are equally in favour of an ozone level of 60 µg/m³ or 70 µg/m³ *(incl. 6 out of 12 replies to the survey for each option).* The ambition for heavy metals in regards of concentration levels are mostly quite low i.e. with the majority being in favour of a level for arsenic of 6 µg/m³.

A large majority of representatives from **industry & business** put forward that air quality standards for $PM_{2.5}$ annual should be regulated by the EU. However, a majority also thinks that $PM_{2.5}$ short-term concentrations should not be regulated by EU standards. This

[15] ECO=Exposure concentration obligation

stakeholder group finds that the recommended $PM_{2.5}$ annual levels by the WHO are feasible, but only with significant effort and a large majority *(incl. 16 out of 26 replies to the survey)* think that the $PM_{2.5}$ level should be set at 25 µg/m³. Only one representative of this group expressed the opinion that $PM_{2.5}$ level should be lower than 5 µg/m³ and another one expressed that the level should be set at 5 µg/m³. A majority of this stakeholder group is largely in favour of applying the $PM_{2.5}$ annual levels at selected stations only *(incl. 12 out of 26 replies to the survey)*, while only a minority is in favour of applying the levels in all territory. For the $PM_{2.5}$ short-term levels the majority of this group thinks that the recommended levels by the WHO are not feasible, for the foreseeable future and are also largely in favour to not set a standard at all *(incl. 14 out of 26 replies to the survey)*. However, asking the representatives what type of standard should apply only a minority repeated that no standard should be set while a majority expressed that they favour a limit value.

Most respondents from industry & business indicated that an "ECO at a more regional level" for both, short term and long term should be set *(incl. 14 (short) and 16 (long) out of 26 replies to the survey)*. On PM_{10} levels, the majority in this group thinks that the WHO recommended levels are feasible, but only with significant effort and opinions were expressed that the PM_{10} annual level should be set at 30 µg/m³ and only applies at selected locations *(incl. 12 out of 26 replies to the survey)*. For PM_{10} peak concentrations the majority of representatives is in favour of a level of 50 µg/m³, which corresponds to the current EU standard, but find that the standard should apply at selected locations only. Industry & business stakeholders are largely agreeing for PM_{10} on a "national emission ceiling at more regional level" for the average exposure indicator target for short and for long-term. For NO_2 annual levels this stakeholder group largely expressed the view that the WHO recommended levels are not feasible, for the foreseeable future *(incl. 17 out of 26 replies to the survey)* and some expressed their opinion of being in favour of a NO_2 annual level of 30 µg/m³. Some stakeholders expressed their opinion that the NO_2 annual level should only apply at selected stations. Stakeholders also expressed that they are against an EU standard for NO_2 short-term concentrations *(incl. 13 out of 26 replies to the survey)*. Stakeholders think that a NO_2 short-term level of 200 µg/m³ should apply i.e. which means no change to the current EU standard.

The representatives of **academia & research** largely believe that the recommended WHO levels for $PM_{2.5}$ are not feasible, for the foreseeable future and are in favour of $PM_{2.5}$ annual levels of 10 µg/m³ or 15 µg/m³. This stakeholder group is largely in favour of applying the levels in all territory and set a limit value as the type of standard for $PM_{2.5}$. For the $PM_{2.5}$ short-term concentrations the stakeholder group largely favours a $PM_{2.5}$ short-term level of 25 µg/m³ for short-term and 15µg/m³ for long-term *(incl. 16 out of 42 replies to the survey)*. On the average exposure indicator target, the opinions differ in this stakeholder group and also many didn't express their opinion at all *(incl. 24 out of 42 representatives didn't reply to the survey on this matter)*. For PM_{10} annual values for short to medium term, a large share of representatives is in favour of 20 µg/m³, while many expressed of being in favour of 30 µg/m³ for PM_{10} levels. For long-term levels (with a view on year 2050), a large majority is in favour of 15 µg/m³. For long-term PM_{10} short-term concentrations this stakeholder group is the most ambitions with a large majority for a PM_{10} level of 45 µg/m³ and to a lesser extend for less than 45 µg/m³. The recommended NO_2 levels recommended by the WHO are seen as feasible by the majority of this group *(21 out of 42 replies to the survey)*, but only with significant effort. The majority thinks that a NO_2 annual level of 30 µg/m³ for short-term and 10 µg/m³ for long-term should be put forward. Representatives of this stakeholder group think that NO_2 levels should apply in all territory and the type of standard should be a limit value. For ozone the opinions of short term ozone levels differ strongly, while for the long-term levels a clear majority is in favour of ozone levels of 60 µg/m³. For heavy metals, this stakeholder group is in general more ambitious than other stakeholder groups in regards of air pollutant levels.

Representatives of **EU citizens** thought the most important option was to ensure achievement of the existing EU air quality standards. Regarding feasibility, EU citizens thought the most feasible option was to establish legally enforceable limit values for all air pollutants, while the least feasible option was to mandate that all air quality standards are met, either in general or everywhere. Representatives made some remarks, respectively on the need to act to protect human and environmental health, and the need to try to minimise economic impacts. Several EU citizens made comments linked to revising the Ambient Air Quality Directives, namely: the need to clearly assign responsibilities, setting targets for additional pollutants (indoor air quality, pollen), prioritising locations where people spend most of their time, strengthening monitoring in residential areas and strengthening enforcement to ensure compliance with standards. Finally, some stakeholders advocated for the ban of wood burning in residential areas.

3.2 Feedback by stakeholder groups – Policy Area 2

Representatives of **public authorities** expressed largely positive feedback and a majority was in favour on policy measures regarding the periodically update of a list containing air pollutant of emerging concern, the establishment of additional short-term EU standards i.e. for $PM_{2.5}$, the expansion of exposure reduction targets, an agreed methodology for transboundary air pollution and the obligation for Member States to provide specific health information to the public. Across all intervention areas[16] different levels of ambition and opinions were expressed by this stakeholder group, besides on topics that touch upon intervention area E, where only a minority from public authorities expressed their opinions *(incl. 29 out of 43 no replies to the survey)*. In addition, the feedback that was received on those topics was mostly negative. Other policy measures that found only little consent among the public authorities were the introduction of a mechanism to adjust air quality standards based on technical progress, the obligation to introduce short-term action plans for each pollutant and the requirement for Member States to harmonise air quality plans.

Representatives from **civil society & NGOs** were more in favour of policy measures in area M and E and lesser to measures in area A and B. Representatives in particular expressed stronger opinions for topics related to intervention area A, B and F and to a lesser extent on topics that touch upon the other intervention areas. The large majority of this stakeholder group favoured the introduction of a mechanism to adjust EU air quality standards based on scientific advice. In comparison, no representative expressed to be largely in favour to adjust the EU air quality standards based on technical progress. Other policy measures that found

[16] For a complete overview of all intervention areas, see Annex 6 to the SWD.

high support among the stakeholder representatives touch on the following interventions: establishing short–term EU air quality for example for $PM_{2.5}$, establish additional limit values for additional air pollutants, the introduction of an short-term action plan for each pollutant, the regular update of air quality plans, both policy measures regarding transboundary air pollution, the introduction of an explicit "access to justice" provision and the requirement to ensure more regular up-to-date data reporting. The policy measures that are included in intervention area A found in general the least support among the civil society & NGO representatives, i.e. the provision for Member States to adopt more stringent standards *(2 out of 12 replies to the survey being in favour)*.

Representatives from **industry & businesses** favoured to a large extend the policy measure that introduces a mechanism to adjust EU air quality standards based on scientific advice *(incl. 8 out of 14 replies to the survey)*. This stakeholder group expressed largely opinions in relation to topics that touch upon intervention area A and B, while other policy measures didn't receive many (different) opinions. Only three policy measures (B1, B2 and D1) found some support expressed by the representatives from industry & businesses while other policy measures didn't found strong support during the consultation period. This stakeholder group in particular not in favour of the establishment of short-term air quality standards such as for $PM_{2.5}$. In addition, A1, A4 and B4 were the interventions where a large majority of representatives expressed not being in favour of those policy measures.

Representatives from **academia & research** expressed in general higher support for policy measures that touch upon intervention areas C and M and didn't express strong support on policy measures that are included in intervention area E. Across all policy measures that were discussed, this stakeholder group expressed strong opinions for all policy measures except for those in area E *(incl. 18 out of 22 no replies to the survey)*. A large majority of respondents are in favour to the periodically update of list for emerging air pollutants to ensure monitoring of those *(13 out of 22 replies to the survey)*. Also policy measures regarding transboundary air pollution found among this stakeholder group large support *(incl. 13 for M1 and 14 for M2 out of 22 replies to the survey)*. Defining alert thresholds and information thresholds for all air pollutants to alert the public was the policy measure that found least support in this stakeholder group.

The representatives of **EU citizens** thought all policy measures related to policy area 2 that were presented were almost equally important. They expressed a similar view regarding feasibility, citizens thought that all the measures presented were almost equally feasible (i.e. adjust EU air quality standards to the evolving technical and scientific progress, further define the different types of air quality standards and the actions their exceedances would trigger' etc.). Respondents from EU citizens pointed out that better information (on air pollution in certain areas, on effects of air pollution and on what citizens can do to reduce pollution in their cities) is needed. Other measures EU citizens focused on: legally binding EU standards; extending the scope of air quality standards and monitoring to cover other pollutants harmful to health (e.g. mercury, black carbon, ultrafine particles and ammonia, and indoor air pollution) and restricting the right of corporations and individuals to make profits by conducting activities that curtail the right of current and future generations to a healthy, sustainable and naturally biodiverse environment. With regards to measures supporting implementation, this stakeholder group also supported improvements to the current provision on penalties.

3.3 Feedback by stakeholder groups – Policy Area 3

Representatives of **public authorities** were largely in favour of the policy measure that foresees the introduction of standardised modelling quality objectives *(incl. 19 out of 43 replies to the survey)*. Other policy measures that found strong support among the public authorities were the policy measure that requires monitoring long-term trend via indicative measurements or modelling, the measure on establishing a protocol if a sampling point needs to be relocated and the requirement to measure continuously certain emerging air pollutants. The policy measure that refines the minimum information for air quality plans has received as well largely positive feedback and was well discussed among this stakeholder group. The policy measure that found least support by this stakeholder group was, the simplification of the definitions of monitoring stations and/or sampling points with a majority not favouring this measure and a change of the minimum number of sampling points per air quality zone.

Representatives of **civil society & NGOs** were largely in favour of the policy measure that foresees the expansion of list of required and/or recommended volatile organic compounds *(incl. 7 out of 12 replies to the survey)* and the requirement of a regular review of the assessment regime following clear criteria *(incl. 6 out of 12 replies to the survey).* In general, this stakeholder group was more supportive across all policy measures and the majority of policy measures received positive feedback and that support. However, policy measures related to policy area 3 were the least discussed or raised by this stakeholder group. Similarly, policy measures in relation to intervention area K were hardly discussed by representatives. The policy measure that allows to use of indicative measurement to substitute fixed monitoring as part of the assessment was the measure that found the least support among the stakeholder group *(incl. 7 out of 12 replies not favouring this measure in the survey)*.

Representatives from **industry & businesses** didn't strongly discuss or support policy measures that are included in policy area 3. In the targeted survey, no policy measures was replied to with "fully" agree by this stakeholder group and in general this policy area had a low response rate in particular for intervention area G, H, I and J with up to 13 "no reply" or "no opinion" from out of 14 total replies. Representatives of this group did express being in favour to a large extent of the policy measure defining further data requirements for sampling points used for air quality data assessment. The least supported policy measure was a mandatory provision for up-to-date information on the pollutant concentration for certain air pollutants for a minimum number of sampling points per air quality zone *(incl. 6 out of 14 replies to the survey).*

Representatives from **academia & research** were largely in favour of the policy measure regarding the requirement of monitoring stations that measure continuously certain emerging air pollutants at "supersites" *(incl. 16 out of 22 replies to the survey)* followed by the introduction of standardised modelling quality objectives as a control mechanism *(incl. 14 out of 22 replies to the survey)*. The policy measures that were least supported by representatives of this stakeholder group are: the policy measure which allows the use of indicative measurements to substitute fixed monitoring in some specified cases and the policy measure on simplifying the definitions type of monitoring stations and/or sampling point locations *(incl. both 13 out of 22 replies to the survey)*. The stakeholder group was in general strongly engaging in this policy area and raised and discussed many policy measures.

Representatives of **EU citizens** think that the policy measures under this policy area are all almost equally important and regarding feasibility, EU citizens think that all measures are roughly equally feasible. A general support for improved monitoring and specifically in relation to ultrafine particles and hydrogen sulphide (in areas with industrial pollution) was expressed. Additionally, the harmonising of monitored data was also strongly supported. This stakeholder group also pointed out that for air quality plans a more stringent framework should be put forward setting out clear requirements and timelines in order to maximise their effectiveness.

4 OTHER CONSULTATION ACTIVITIES

4.1 Ad-hoc contributions

In total 30 ad-hoc contributions (i.e. position papers, scientific studies and other documents) from 25 different stakeholders[17] were received throughout the duration of the revision period. Ad-hoc contributions were evaluated and analysed which policy area and policy option the ad-hoc contribution was targeting and took the information into account for the Impact Assessment and legislative proposal. The following table A2.3 lists the organisation names and further details from the received ad-hoc contributions.

Table A2.3: Ad-hoc contributions

Organisation name	*Member State*	*Stakeholder type*
WKO Austrian Federal Economic Chamber	Austria	Industry & business
Flanders Environment Agency	Belgium	Public authority
Bavarian State Parliament	Germany	Public authority
Deutsche Umwelthilfe e.V.	Germany	Civil society & NGO
Hamburg city	Germany	Public authority
Ministry of Transport, Baden-Wuerttemberg	Germany	Public authority
German Federal Environment Agency (UBA)	Germany	Public authority
Ministry of Environment	Estonia	Public authority
Finnish Atmosphere and Climate Competence Center	Finland	Academia & research
Finnish Meteorological Institute	Finland	Public authority
University of Finland	Finland	Academia & research
Po valley regions (Lombardia, Emilia-Romagna, Piemonte, Veneto)	Italy	Public authority
Environment & Resources Authority - Malta	Malta	Public authority
Dutch municipalities (Beverwijk, Heemskerk, Velsen)	Netherlands	Public authority
Dutch Ministry of Infrastructure and Water Management	Netherlands	Public authority
Province of Utrecht	Netherlands	Public authority
Polish NGOs*	Poland	Civil society & NGO
Swedish Environmental Protection Agency	Sweden	Public authority
Organisation name	*Country*	*Stakeholder type*
Ministry of Climate and Environment/ Norwegian Environment Agency	Norway	Public authority
Organisation name	**International**	**Stakeholder type**

[17] Two each from: Federal Environment Agency (UBA Germany), Ministry of Transport, Baden-Wuerttemberg (Germany), Po valley regions (Italy) and three from Client Earth.

Table A2.3: Ad-hoc contributions

Organisation name	Member State	Stakeholder type
AQUILA	Europe	Academia & research
ClientEarth	Europe	Civil society & NGO
ERS and ISEE	Europe	Academia & research
Eurocities	Europe	Public authority
FAIRMODE	Europe	Academia & research
HEAL and other civil society organisations	Europe	Civil society & NGO
**Polish Smog Alert, Frank Bold Foundation, European Clean Air Centre, Electric Vehilces Promotion Foundation, Health and Environment Alliance, Client Earth, Towarzystwo na Rzecz Ziemi, Polski Klub Ekologiczny Okręg Pomorski, Stowarzyszenie Ekologiczne EKO-UNIA, Fundacja na rzecz Efektywnego Wykorzystania Energii, Stowarzyszenie Partnerstwo dla Bezpieczeństwa Ruchu Drogowego, Rodzice dla Klimatu, Polski Klub Ekologiczny Okręg Mazowiecki, Koalicja Klimatyczna*		

4.2 Third EU Clean Air Forum

The *Third EU Clean Air Forum* took place on 18 and 19 November 2022 in Madrid with the possibility to actively engage also via a smartphone application or watch the event online per web-stream.[18] Around 200 participants were present in the venue in Madrid and more than 500 participants attended the event online across the EU and other non-EU countries.

Stakeholder groups present at the event were mainly public authorities, environmental and non-governmental organisations, business associations and organisations, research and academia institutions and citizens. During the week of the event, the hashtag "*#CleanAirEU"* reached close to 27 million accounts on the social networking applications *twitter.com* and *instagram.com* globally.

High-level interventions and panel discussions with a wide range of stakeholders groups reflected on air quality issues and solutions, expressing further scope to improve the current legislation. The event focused in two sessions in particular on the "Revision of the Ambient Air Quality Directives" and "Access to justice and the right to clean air".

4.3 Inception Impact Assessment

The inception impact assessment was published on 17 December 2020 with a feedback period until 14 January 2021. Stakeholders were invited to provide feedback on the proposed inception impact assessment as outlined in the roadmap that was made public on the EU Have-Your-Say-Portal.[19] A total of 63 stakeholders from 12 Member States provided feedback on the inception impact assessment as indicated in box A2.6.

Box A2.6: Inception impact assessment - Stakeholders per group and country

Stakeholder per stakeholder group (descending):

Industry & businesses (=25), Civil society & NGOs (=24), EU citizens (=7), Public authorities (=4), Academia & research (=2) + Others (=1).

[18] COM (2021), Third Clean Air Forum Events page (accessed: 04.08.2022)
[19] COM (2021), Have your say portal (accessed: 04.08.2022)

Stakeholder per country (descending): BE (=19), DE (=12), FR (=8), ES (=5), PL (=3), NL (=3), IT (=3), DK (=2), AT (=2), SE (=1), SI (=1), EL (=1) + EEA and non-EU countries.

On policy area 1, the expressed ambition in the replies were predominantly for a high ambition level, calling for closer or full alignment of EU standards with the WHO recommendations.

On policy area 2, addressing the enforcement and governance shortcomings, the ambition levels expressed in writing were outbalanced. Stakeholders had strong opinions of ambitions varying from the opinion that the Ambient Air Quality Directives do not need to be revised at all to the opinion that compensations for citizens who have to live surrounded by high air pollution needs to be granted.

On policy area 3, respondents addressed to a lesser extent issues in regards to this policy area. Topics that were raised by respondents with asking for high ambition was the need for more precise criteria for air quality monitoring and to consider a cooperation across different government levels when implementing air quality measures.

4.4 Fit for Future Platform opinion on the ambient air quality legislation

The Fit for Future Platform is a high-level expert group that helps the European Commission in its efforts to simplify EU laws and to reduce related unnecessary costs, so as to deliver maximum benefits to citizens and businesses, in particular small and medium-sized enterprises. On 12 November 2021 the platform adopted its opinion to the "Ambient air quality legislation" [20], which included the following suggestions (*references in brackets refer to where these suggestions have been addressed in this impact assessment*):

- Review air quality standards to reflect latest scientific evidence and supplement limit values with regional exposure reduction targets (addressed in *problem area I*);
- Ensure coherence of action between different levels of governance to improvement the effectiveness of air quality measures and the implementation of the Ambient Air Quality Directives (*addressed in problem area II*);
- Improve monitoring networks to diminish discrepancies and enhance comparability across Member States; improve design of air quality plans and promote local/regional level action *(addressed in problem area III);*
- Monitoring of pollutants not currently covered by the Ambient Air Quality Directives such as Ultrafine Particles ($PM_{0.1}$), black carbon and other components of PM, metals, and ammonia *(addressed in problem area II);*

[20] COM (2022), Fit for Future Platform Opinion reference: 2021/SBGR1/04 (accessed: 04.08.2022)

- Simplify the legislative framework by bringing together directives 2008/50/EC and 2004/107/EC in a single directive *(addressed as part of section 8.3 on administrative costs and REFIT);*
- Ensure coherence with EU legislation, including urban and road transport, renewable energy and agricultural policies *(addressed throughout this impact assessment, including modelling efforts and Annex 8)*;
- Address emission sources such as tyre and brake wear, non-exhaust traffic related particles, heavy goods vehicle refrigeration units, heating and power emissions, agriculture and wood burning *(not directly addressed in this impact assessment, as they are covered under relevant EU legislation.)*[21]

5 USE OF STAKEHOLDER FEEDBACK

All of the stakeholder feedback as outlined under the sections here above was part of an extensive data collection process. The different consultation streams highlighted in this annex, as well as the modelling of scenarios for evidence gathering were combined in order to provide input for the impact assessment. The consultation activities aimed at informing the Ambient Air Quality Directives revision process, either by collecting evidence or by gathering the views of a broad array of stakeholders. The information gathered during the open public consultation (section 2.1) contributed to building the problem definition, and to designing potential (regulatory and non-regulatory) measures, including by seeking to understand the importance and feasibility of several potential measures according to different stakeholder groups. The targeted stakeholder survey (section 2.2) built on the results of the open public consultation and asked more specialised questions on the design, feasibility and potential impacts of different measures, which contributed to the assessment of these measures. The inputs gathered during the stakeholder meetings (section 2.3) also informed the revision process, by giving participants the opportunity to comment on the presentations given on the preliminary results of the project. Lastly the interviews were undertaken to fill in the knowledge gaps identified after the analysis of preceded consultation activities (section 2.2).

The data was examined to underpin the assessment of impacts of different policy options and the feasibility of their implementation. Data was analysed to identify contradictory or supportive statements and evidence to reach to conclusions for each of the stakeholder groups individually. In this context, all widely supported views are entirely considered in the final report, with less widely supported views identified as such.

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[21] Including Directives 2010/75/EU (on industrial emissions), 2009/125/EC (on eco-design), as well as EC Regulations 443/2009 and 510/2011 (on emission standards for vehicles), Regulations (EU) 2016/427, (EU) 2016/646, and (EU) 2017/1154 (on real driving emissions), Directive (EU)2016/2284 on the reduction of national emissions of certain atmospheric pollutants, as well as relevant published or upcoming proposals, such as on the revision of the Industrial Emissions Directive, and on Euro 7 standards for road vehicles.

ANNEX 3: WHO IS AFFECTED AND HOW?

1. PRACTICAL IMPLICATIONS OF THE INITIATIVE

This annex sets out the practical implications of the preferred policy package for the various types of stakeholders concerned. It describes the possible implications for public authorities or businesses of complying with the air quality standards and other measures set out in the revised legislation and indicates the likely costs to be incurred in meeting those, or, where quantitative information is not available, the nature and magnitude of such costs. It also presents the implications for the citizens.

Public authorities / Administrations

Increasing the stringency of standards can be expected to lead to an increase in the number of sites and zones in exceedance in the short term. As such, competent authorities will be required to develop and implement new or revise existing **air quality plans** in order to put in place a strategy to meet new standards. These plans will also require ongoing review and management. Hence, increasing standards will overall imply an increase in the competent authorities' administrative burden. The degree to which this would affect each Member State would vary, provided that some would be closer to meeting new revised standards, while other would be further away from them. For those standards which could drive a large number of new exceedances with even a small change (e.g. $PM_{2.5}$, PM_{10}, NO_2 and ozone), administrative costs are likely to be high. Where there is broad compliance with existing and proposed standards (e.g. SO_2, CO, benzene, etc.), it could be assumed that administrative costs would at most be low.

Other sources of potentially high costs include the build-up of air quality **modelling capacity** where this is not developed yet as well as the **installation of new monitoring stations,** especially those for ensuring the additional monitoring of pollutants of emerging concern. The need to address poor air quality in hot spots requires **action at local level** in particular, some of which might be of non-technical nature and which would in any case differ considerably across municipalities and are therefore challenging to estimate.

Preferred policy options **addressing governance and enforcement shortcomings** will entail costs in relation to changing the way the Ambient Air Quality Directives are implemented (rather than them resulting from administrative burden of specific policy options suggested). Increasing the stringency of the existing policy framework will significantly increase the costs for those administrations currently in breach of the provisions of the Directives. Conversely, administrations currently compliant with the Ambient Air Quality Directives will have very limited additional costs other than those related to transition to the new regime.

Overall, total administrative costs are estimated to range from 75 to 106 million Euro per year in 2030, with **costs in the preferred scenario estimated at 78 million Euro**. These are costs that fall on public authorities. Some of the adjustment costs (see next sub-section) may fall on public authorities (such as through procuring materials and infrastructure, building ownership, changing vehicle fleets), but these have not been estimated separately here.

Businesses and the economy at large

Businesses and more generally employers will benefit from the reduction of negative health and (though less significant) non-health impacts associated with poor air quality. The improvement of air quality expected to follow from adopting the preferred policy package will have positive knock-on effects on the **productivity** of the EU workforce, both through reduced mortality and reduced morbidity (the latter causing absence through illness, including of dependent children, or lower productivity at work). The analysis has demonstrated that with a 10 µg/m^3 headline limit value for $PM_{2.5}$ as part of the preferred package, **monetised benefits from reduced costs of health impact** are estimated to be 40 or 119 billion EUR (2015 prices) in 2030, depending on the valuation approach chosen.[22] In either way, these represent a close to 30% decrease in costs compared to the baseline in 2030.

Material and ecosystem impacts are typically much smaller than health impacts. Benefits from reduced material damage are projected to amount to almost 200 million EUR in 2030 in the 10 µg/m^3 scenario compared to the baseline; benefits from reduced crop damage to 254 million EUR, benefits from reduced forest damage to 287 million EUR, benefits from reduced ecosystem impacts between 706 (low estimate) and 2 117 (high estimate) million EUR (all 2015 prices).

At the same time, stricter air quality standards require **investments** such as installation of abatement measures that come at a cost. The costs increase with the stringency of the new standard. For the 10 µg/m^3 standard, **mitigation (or adjustment) costs** beyond the baseline amount to around **5.6 billion EUR**. Industry bears most of the costs, followed by agriculture. These two together bear above two thirds of the total costs. There are **no direct administrative costs** falling on businesses.

Taking these two sides of the equation together, the **macroeconomic modelling** undertaken shows that the market **benefits** of improved air quality **outweigh the costs** of abatement measures and other investments needed to meet stricter EU air quality standards. The key insight is that all scenarios, including the preferred one, **improve aggregate economic outcomes** in the EU compared to a situation of unchanged policy, when productivity gains of clean air are accounted for (the positive impact on the gross domestic product, GDP, and private consumption increases with the stringency of the scenario). With the exception of livestock-based agriculture, which sees a small percentage reduction, **all sectors raise output** compared to the baseline. Results further indicate **enhanced competitiveness** of the EU economy as indicated by an improved trade balanced and higher exports, again with productivity gains from clean air factored in.

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[22] In line with the second Clean Air Outlook, results are presented for different approaches to monetising impacts: a ‘VSL’ or value of statistical life approach, which monetises the number of deaths (yielding the 119 €bn), and a VOLY or value of statistical life year approach (40 €bn), which instead monetises life years lost.

Citizens and consumers

Citizens will enjoy **health benefits** from improved air quality. The benefits increase, as expected, with the ambition of the scenario. For $PM_{2.5}$, premature death in the EU-27 caused by the exposure to air pollution at levels above the WHO guidelines reduces by around 50% under the 10 µg scenario compared to the baseline in 2030. In the same scenario, the additional reduction for NO_2 compared to the baseline is 16%. Citizens will further enjoy benefits from reduced morbidity. A 10 µg headline limit value is projected to reduce the number of yearly cases of a range of health outcomes caused by the exposure to air pollution at levels above the WHO guidelines by around 50% in 2030 compared to the baseline.[23]

Citizens residing in **hot spots** areas are particularly vulnerable as a result of high exposure to air pollution and can thus be expected to benefit most from stricter air quality standards. Also citizens with existing medical conditions and citizens in **sensitive groups** may be at higher risk due to exposure and will therefore have more to gain on average from improved air quality. The analysis undertaken shows little distributional differences across scenarios. In other words, impacts on different age groups remain consistent across scenarios. Citizens vulnerable due to their lower **socio-economic status** (based on household income, unemployment rate and lack of higher education) have been shown to be disproportionately affected by poor air quality and will likewise benefit more on average from reduced air quality.[24] As with the analysis for sensitive groups, impacts on socio-economic groups remain consistent across scenarios, with the effects varying by pollutant and socio-economic group.

To meet the targets associated with the preferred package, some of the **overall adjustment costs** will be borne by households by switching to lower polluting devices such as for domestic heating. Some change in behaviour would likely be triggered by national or local strategies to abate pollutant emissions (such as a switch to cleaner modes of transport, including public transport). The extent of the costs borne by households for such measures will depend ultimately also on public policy choices made in Member States as regards financial and investment support mechanisms. There are **no direct administrative costs** falling on citizens.

The **macroeconomic modelling** undertaken shows that on an aggregate level, private consumption increases compared to the baseline in 2030 across scenarios, including the preferred one, when productivity gains from clean air are factored in. When taking into account further market and also non-market effects (avoided health care costs, years of life lost, loss of utility due to sicknesses etc.), which could not be taken into account in the macroeconomic modelling undertaken but is addressed separately, the overall benefit would become even larger.

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23 These include infant mortality, (chronic) bronchitis in children (in adults), cardiovascular as well as respiratory hospital admissions, restricted activity days, lost working days, stroke, lung cancer and asthma in children.

24 EEA (2019), EEA Report No 22/2018 (accessed: 10.06.2022)

An **increased stringency of the legislative framework**, as per the preferred policy options addressing governance and enforcement shortcomings will ensure higher compliance with the set objectives, and thus translate into environmental, social, and economic benefits for the wider public.

Other

The preferred policy package will **improve** air quality assessments done through monitoring and modelling, as well as **data availability** on air quality. This will be helpful for **researchers** that work on air quality monitoring and modelling, as well as for **civil society organisations** that work on improving air quality through awareness raising campaigns and other actions.

2. SUMMARY OF COSTS AND BENEFITS

Table A3.1 - (I) Overview of Benefits (total for all provisions) compared to the baseline – Preferred Option		
Description	***Amount***	***Beneficiaries***
Direct benefits		
Reduced health impacts	**40 or 119 billion EUR** (2015 prices) in 2030, depending on the valuation approach chosen.[25] These represent a close to 30% decrease in costs compared to the baseline in 2030.	Direct health benefits for citizens; reduced public costs due to less health care spending; benefits for businesses from increased productivity / reduced lost working days.
Reduced material damage	**196 million EUR** (2015 prices) in 2030	Beneficiaries depend on ownership of buildings, including of historic ones, and on who incurs their running costs.
Reduced crop damage	**254 million EUR** (2015 prices) in 2030	Increased crop yields benefit the agricultural sector and possibly consumers if productivity gains are passed on through lower prices.
Reduced forest damage	**287 million EUR** (2015 prices) in 2030	In the case of productive forests, increased productivity of forests benefits forest owners/managers and possibly consumers if productivity gains are passed on through lower prices for wood-based products.
Reduced ecosystem impacts	Between **706** (*low estimate*) and **2 117** (*high estimate*) **million EUR** (2015 prices) in 2030	Benefits for biodiversity, benefits for those sectors relying on ecosystem services.
Indirect benefits / co-benefits for other policies		

[25] See previous section.

This part of the table summarises the likely indirect benefits of more ambitious clean air policy including the co-benefits for other EU policy objectives. This is done in a qualitative way, as the quantification undertaken here has focused on estimating the direct benefits, indirect ones being much more uncertain.		
Climate	Generally, more action will be needed to clean energy supply and mobility to attain limit values. A move to clean, renewable energy sources and propulsion systems will reduce air pollutants and greenhouse gas emissions in parallel. Stricter air quality standards bring co-benefits in the form of reduction of black carbon (BC), a short-lived climate forcer (SLCF), mostly achieved in residential heating sector, introducing cleaner burning technology, and effective enforcement of ban of field burning of agricultural residues.	Society at large will benefit
Noise	As above, a move to cleaner modes of transport will trigger co-benefits for noise (electric power trains being significantly less noisy than internal combustion engines, and soft transport modes being less noisy than motorised ones).	Those currently most affected by noise pollution notably from road transport, i.e. those living along busy roads.
Indoor air quality	Indoor air quality depends to a large extent on the quality of ambient (outdoor) air and would therefore improve with stricter air quality standards.	*As for direct health impacts.*
Equality	Poor air quality disproportionally affects citizens of lower socio-economic status, as well as those with pre-existing conditions and children.[26] Consequently, introducing stricter air quality standards can be expected to have indirect redistributional effects in benefitting these groups most.	Groups of society of lower socio-economic status, vulnerable groups.
Quality of life	European citizens care strongly about air quality.[27]/[28] Besides the quantified health impacts of clean air, indirect benefits are likely to accrue from citizens awareness of breathing cleaner air and living in a more healthy environment.	*As for direct health impacts.*
Administrative cost savings related to the 'one in, one out' approach		
The Ambient Air Quality Directives **do not impose any direct administrative costs on consumers and businesses** (while these do bear important adjustment costs, i.e. due to measures needed to achieve EU air quality standards), therefore the one-in-one-out approach is not applicable (as explained in the main report section 8.4).		

II. Overview of administrative costs and the one-in-one-out scheme – Preferred option

[26] EEA (2019), EEA Report No 22/2018 (accessed: 10.06.2022)
[27] Special Eurobarometer 497 (accessed: 10.06.2022)
[28] COM (2021), Open Public Consultation on "Air quality – revision of EU rules" (accessed: 10.06.2022)

The following provides an overview of the costs of the different policy options that form part of the preferred package. As presented in Section 6 of the main report, a 10 µg/m^3 target for annual mean $PM_{2.5}$ (policy-option I-2) amounts to **adjustment or mitigation costs of 5.6 billion Euro per year in 2030**, with the most impacted sectors being industry, households and livestock.

To assess the potential administrative burden placed on different actors, the EU's Better Regulation Toolbox Standard Cost Model (SCM) [29] was used. The SCM uses information on: number of activities required, with the time required per activity and the cost per unit of time spent. The aim is to estimate additional costs (or cost reductions) of new policy options compared to the baseline scenario.

The following tables provides an overview of administrative costs related to monitoring, assessment, implementation and enforcement. The **total administrative costs are estimated to range from 75 to 106 million Euro per year in 2030**, increasing with the stringency of the scenario, with costs in the preferred scenario estimated at 78 million Euro per year.

Administrative costs estimates include:

- costs for all policy options and their individual measures included in the set of preferred policy options that are not linked to the level of ambition of revised EU air quality standards, which add up to about **75 million Euro** per year – this includes approximately **4.8 million Euro** per year related to better implementation and communication (see Table A3.1), and a further **70.3 million Euro** per year related to improved monitoring and assessment (see Table A3.2);

- costs linked to the development of air quality plans, which depend on the number of exceedances above EU air quality standards to be expected in the target year 2030. This component hence depends on the level of ambition assumed via policy options I-1, I-2 or I-3, which adds up to **between 1 and 31 million Euro** per year. Table A3.3 provides an overview of costs related to exceedances per pollutant – based on assumption of residual exceedances based on the modelling that underpins this impact assessment.

Costs for consumers and businesses are represented jointly as there are no direct regulatory requirements for businesses stemming from the Ambient Air Quality Directives. This also means that there are **no direct administrative costs to be borne by business or citizens**. This means there is no need to look at potential off-setting measures as part of the Commission's commitment to the **'one-in-one-out'** scheme, and therefore the tables below do not contain the part of the template reserved for "costs related to the 'one in, one out' approach".

Hence, most costs for consumer and businesses are ***indirect costs*** that cannot always be broken down into who will bear what share. The costs most clearly attributable are ***direct***

[29] COM (2022), Tool #60 - the standard cost model for estimating administrative costs (accessed: 10.06.2022)

administrative and enforcement costs falling on the competent authorities in Member States.

Table A3.2 – (II.1) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[30]

		For public authorities (€)		For consumers & business (€)		Total administrative costs (€)
		One-off	Recurrent	One-off	Recurrent	
A1: Introduce review triggered by scientific progress	Direct administrative and enforcement costs	Low	Low	-	-	Low
A2: Introduce review triggered by technical progress	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
A3: Introduce option to notify stricter standards	Direct administrative and enforcement costs	Low	Low	-	-	Low
A4: Introduce a list of priority pollutants	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
B1: Introduce additional short-term standards	Direct administrative and enforcement costs	Low	Low	-	-	Low
B2: Introduce additional alert/information thresholds	Direct administrative and enforcement costs	Low	Low	-	-	Low
B3: Revise definition of average exposure standards	Direct administrative and enforcement costs	Low	Low	-	-	Low
B4: Introduce guidance on addressing exceedances	Direct administrative and enforcement costs	Low	Low	-	-	Low
B5: Introduce limit values for additional air pollutants	Direct administrative and enforcement costs	Low	Low	-	-	Low
C1: Revise obligations triggered by exceedances	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
C2: Revise/clarify definition of 'as short as possible'	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
C3: Revise short-term	Direct administrative and	30k	Low	-	-	**30 000**

30 This and following tables categorise costs as follows: 'low' means costs of <100k, 'medium' 100k to 1 million, high >1 million EUR.

Table A3.2 – (II.1) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[30]						
		For public authorities (€)		For consumers & business (€)		Total administrative costs (€)
		One-off	Recurrent	One-off	Recurrent	
action plans & air quality plans	enforcement costs					
C4: Introduce additional short-term action plans	Direct administrative and enforcement costs	50k	Low	-	-	**50 000**
C5: Introduce requirement to update air quality plans	Direct administrative and enforcement costs	Low	2400k	-	-	**2 400 000**
D1: Revise requirements to involve stakeholders	Direct administrative and enforcement costs	320k	Low	-	-	**320 000**
D2: Introduce a 'one zone, one plan' requirement	Direct administrative and enforcement costs	600k	Low	-	-	Not part of preferred option
E1: Introduce minimum levels for financial penalties	Direct administrative and enforcement costs	Low	Low	-	-	Low
E2: Introduce right to health damage compensation	Direct administrative and enforcement costs	Low	Low	-	-	Low
E3: Introduce a fund to be fed by penalties paid	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
E4: Introduce an explicit 'access to justice' clause	Direct administrative and enforcement costs	Low	Low	-	-	Low
F1: Revise provisions related to up-to-date data	Direct administrative and enforcement costs	140k	640k	-	-	**780 000**
F2: Introduce requirement to provide AQ health data	Direct administrative and enforcement costs	Low	Low	-	-	Low
F3: Introduce use of specific communication channels	Direct administrative and enforcement costs	60k	1280k	-	-	Not part of preferred option
F4: Introduce requirements for harmonised AQ index	Direct administrative and enforcement costs	10k	Low	-	-	**10 000**
	SUB-TOTAL					**4 790 000**

Table A3.3 – (II.2) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[31]						
		For public authorities (€)		For consumers & business (€)		Total administrative costs (€)
		One-off	Recurrent	One-off	Recurrent	
G1: Revise rules related to indicative sampling points	Direct administrative and enforcement costs	1 070k	Low	-	-	**1 070 000**
G2: Introduce requirements for AQ modelling	Direct administrative and enforcement costs	320k	2 230k	-	-	**2 550 000**
G3: Revise rules for regular review of AQ assessment	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
H1: Revise minimum number of sampling points	Direct administrative and enforcement costs	540k	2 100k	-	-	**2 640 000**
H2: Simplify combined PM_{10}/$PM_{2.5}$ monitoring	Direct administrative and enforcement costs	230k	2 780k	-	-	**3 010 000**
H3: Simplify the definitions of sampling points types	Direct administrative and enforcement costs	200k	Low	-	-	Not part of preferred option
I1: Introduce obligations to maintain sampling points	Direct administrative and enforcement costs	Low	Low	-	-	Low
I2: Introduce obligations to monitor long-term trends	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
I3: Introduce a protocol for relocated sampling points	Direct administrative and enforcement costs	50k	Low	-	-	**50 000**
J1: Revise macro-scale siting of sampling points	Direct administrative and enforcement costs	150k	Low	-	-	**150 000**
J2: Revise micro-scale siting of sampling points	Direct administrative and enforcement costs	150k	Low	-	-	**150 000**
J3: Introduce obligation for spatial	Direct administrative and enforcement costs	370k	2 230k	-	-	**2 600 000**

[31] This and following tables categorise costs as follows: 'low' means costs of <100k, 'medium' 100k to 1 million, high >1 million EUR.

Table A3.3 – (II.2) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[31]						
representativeness						
K1: Revise AQ monitoring data quality objectives	Direct administrative and enforcement costs	100k	Low	-	-	**100 000**
K2: Introduce up-to-date data at all sampling points	Direct administrative and enforcement costs	140k	640k	-	-	**780 000**
K3: Introduce AQ modelling data quality objectives	Direct administrative and enforcement costs	20k	Low	-	-	**20 000**
K4: Revise approach to AQ assessment uncertainty	Direct administrative and enforcement costs	100k	Low	-	-	**100 000**
L1: Introduce concept of monitoring at 'super-sites'	Direct administrative and enforcement costs	1 080k	5 400k	-	-	**6 480 000**
L2: Introduce obligations to monitor more pollutants	Direct administrative and enforcement costs	4 390k	45 000k	-	-	**49 390 000**
L3: Revise list of VOC to monitor	Direct administrative and enforcement costs	1 690k	25 310k	-	-	Not part of preferred option
M1: Introduce methodology to assess transboundary	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
M2: Revise obligations for transboundary cooperation	Direct administrative and enforcement costs	Low	Low	-	-	Low
M3: Revise the information in air quality plans	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
	SUB-TOTAL					**70 290 000**

Table A3.4 – (II.3) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[32]			
	For public authorities (€)	**For consumers & business (€)**	**Total administrative costs (€)**

32 This and following tables categorise costs as follows: 'low' means costs of <100k, 'medium' 100k to 1 million, high >1 million EUR.

Table A3.4 – (II.3) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[32]								
		One-off	**Recurrent**	**One-off**	**Recurrent**	**High (I-1)**	**Central (I-2)**	**Low (I-3)**
O1: Revise standards for annual $PM_{2.5}$	Direct administrative and enforcement costs	200k	-	-	-	6870k	**200k**	10k
O2: Introduce standards for daily $PM_{2.5}$	Direct administrative and enforcement costs	200k	-	-	-	6870k	**200k**	10k
O3: Revise average exposure standards for $PM_{2.5}$	Direct administrative and enforcement costs	240k	-	-	-	340k	**240k**	140k
P1: Revise standards for annual PM_{10}	Direct administrative and enforcement costs	200k	-	-	-	760k	**200k**	20k
P2: Revise standards for daily PM_{10}	Direct administrative and enforcement costs	200k	-	-	-	760k	**200k**	20k
P3: Introduce average exposure standards for PM_{10}	Direct administrative and enforcement costs	240k	-	-	-	340k	**240k**	150k
Q1: Revise standards for annual NO_2	Direct administrative and enforcement costs	80k	-	-	-	5 540k	**80k**	50k
Q2: Revise/introduce standards for hourly/daily NO_2	Direct administrative and enforcement costs	80k	-	-	-	5 540k	**80k**	50k
Q3: Introduce average exposure standards for NO_2	Direct administrative and enforcement costs	240k	-	-	-	340k	**240k**	135k
R1: Introduce standards for peak-season O_3	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
R2: Revise standards for 8-hour O_3	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
R3: Introduce average exposure standards for O_3	Direct administrative and enforcement costs	240k	-	-	-	340k	**240k**	135k
S1: Revise standards for annual SO_2	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low

Table A3.4 – (II.3) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[32]								
S2: Revise standards for daily/hourly SO_2	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
T1: Revise standards for daily/8-hour CO	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
U1: Revise standards for annual benzene	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
V1: Revise standards for annual benzo(a)pyrene	Direct administrative and enforcement costs	1 210k	-	-	-	3 350k	**1 210k**	390k
W1: Revise standards for annual lead	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
X1: Revise standards for annual arsenic	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Y1: Revise standards for annual cadmium	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Z1: Revise standards for annual nickel	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Ø 1: Introduce standards for additional air pollutants	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option		
	SUB-TOTAL					31 050k	**3 130k**	1 110k

3. RELEVANT SUSTAINABLE DEVELOPMENT GOALS

Table A3.5 – (III) Overview of relevant Sustainable Development Goals (SDG) – Preferred Option(s)		
Relevant SDG	**Expected progress towards the Goal**	**Comments**
SDG 3 – Establish Good Health and Well-Being	A more effective Ambient Air Quality Directive would lead to better health outcomes, and thereby directly contribute to SDG 3.	Note specifically the direct contribution to the 2030 goal target for this SDG to "substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination"
SDG 7 – Grow Affordable and Clean Energy	More ambitious air quality standards will require investing in clean energy, which will contribute to SDG 7.	Note specifically the contribution to the 2030 goal targets for this SDG to improve energy efficiency and increase the share of renewable and clean energy
SDG 10 Reduce Inequality	While more ambitious air quality standards will not reduce income inequality, they can address consequences of these inequalities, namely ensuring cleaner air in particular for socioeconomically disadvantaged and vulnerable groups, who often live in more polluted areas.	Note that this is an indirect contribution
SDG 11 – Mobilize Sustainable Cities and Communities	More ambitious air quality standards will require investment in attractive, affordable, clean public transport and infrastructure for safe walking and cycling; in upgrading the energy efficiency of buildings, implementing renewable heating and cooling, and in improvements to urban planning. All of these measures contribute to SDG 11.	Note specifically the 2030 goal targets for this SDG to • reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management • provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport
SDG 13 – Organize Climate Action	Measures needed to attain more ambitious air quality standards have important co-benefits for climate action, e.g. implementing non-combustion renewable energy and improving energy efficiency.	Note in particular the goal target for this SDG to integrate climate change measures into national policies, strategies and planning

Annex 4: Analytical methods

1. Overview

A range of interventions (or policy measures) have been defined to revise various elements of the Ambient Air Quality Directives. Each intervention would have a number of associated impacts, with the exact impacts, their size and significance depending on each individual intervention. Based on the Better Regulation Guidelines,[33] these interventions have been compared on the basis of how they address the objectives considering their effectiveness, efficiency and coherence.

Twelve indicators (see Table A4.1) have been defined to capture and present the key economic, environmental, and social impacts associated with the interventions being considered. All interventions have been appraised against this set of indicators, to ensure consistency in the analysis and presentation of results.

Table A4.1 - Twelve indicators used as basis for in-depth assessment

Broad impact category	Indicator	Indicator #
Air pollutant concentrations	Concentration levels of air pollutants, at (a) background locations, and (b) 'hot-spot' (incl. both traffic and industry-related) locations, and their development over time.	1
Environmental impacts	Health impacts of air pollution, for example the health impacts resulting from exposure to particulate matter ($PM_{2.5}$ and/or PM_{10}), nitrogen dioxide and ozone.	2
	Ecosystem impacts of air pollution, including acidification, eutrophication, ozone damage to vegetation and agricultural yields.	3
	Links between air pollution and climate change, including increased ozone levels due to global warming, and co-benefits or trade-offs between climate and air pollution abatement measures.	4
Economic impacts	Cost to society due to air pollution, including health and healthcare impacts and costs, lost working days, crop and animal value loss, losses to other assets and other costs avoided by taking action to reduce air pollution.	5
	Measures needed to meet EU air quality standards - and their costs, including costs for key economic sectors, and regional differences across the EU of the costs and benefits of the air pollution abatement measures.	6
	Positive and negative impacts on the EU's international competitiveness, including tapping into innovation potential for clean air technologies.	7
Social impacts	Effects of air pollution on sensitive population groups, including children, pregnant women, elderly citizens and those suffering from pre-existing conditions.	8
	Societal impacts of air pollution and societal impacts of air pollution abatement measures, including resulting inequalities (i.e. who is most affected, who bears the costs).	9
	Effects of measures to address air pollution on employment.	10
Synergies	Synergies with other goals of the EU Zero Pollution Action Plan on air, water and soil. This includes premature death reduction (indicator 2) and ecosystem impact (indicator 3) goals. It additionally reflects the synergic role of indoor air pollution (notably in terms of exposure and health impacts) or co-benefits in reducing noise pollution. Also considers synergies with climate action.	11
Administrative burden	Administrative burden of air quality management, in particular as relates to air quality assessment regimes (including monitoring, modelling, and reporting of related data)	12

[33] SWD(2021) 305 final

Across each of these specific indicators, available evidence on the effectiveness, efficiency and coherence of the interventions has been collated, assessed and, where possible, quantified in comparison to the baseline. Where quantification was not possible, impacts were assessed in a qualitative way, clearly indicating the type of the most important impacts and their likely magnitude.

To support the assessment of impacts, three main sources of evidence were used: quantitative modelling, in particular focusing on the impacts of different air quality standards, detailed literature review and extensive stakeholder engagement. The remainder of this Annex focuses on presenting in further detail the approach taken to the quantitative modelling.

2. QUANTITATIVE MODELLING OF AIR POLLUTANT STANDARDS

This section contains a general introduction to the modelling framework deployed in the support study for this impact assessment and a description of the most important elements of relevance for the assessment of policy options. More detailed descriptions including data sources for various underlying assumptions used in the modelling can be found in the annexes to the support study.

2.1 Introduction of the modelling framework

Quantitative modelling has been conducted with a state-of-the-art modelling framework, including: the *Greenhouse gas – Air pollution Interactions and Synergies* (GAINS) model and MET Norway's chemical transport model (EMEP CTM) with the uEMEP downscaling extension for fine resolution. This modelling assesses a number of effects, in particular: air pollutant emissions, concentrations, health and ecosystem impacts, feasibility to attain particular air quality targets as well as respective measures and their costs.

The ***GAINS integrated assessment model***, developed at the International Institute for Applied Systems Analysis (IIASA), addresses air pollution impacts on human health from fine particulate matter ($PM_{2.5}$) and ground level ozone (O_3), vegetation damage caused by ground level ozone, the acidification of terrestrial and aquatic ecosystems and excess nitrogen deposition on soils. GAINS brings together data on economic development and structure, control potential and costs of emission sources, the formation and dispersion in the atmosphere of - as well as the inter-relations between - pollutants such as sulphur dioxide (SO_2), nitrogen-oxides (NO_x), particulate matter (PM), non-methane volatile organic compounds (NMVOCs) and ammonia (NH_3). GAINS assesses more than 1 000 emission control measures for all EU Member States, computes the atmospheric dispersion of pollutants and analyses the costs and environmental impacts of pollution control strategies. In its optimisation mode, GAINS identifies the cost-effective emission control strategies that can be used to inform policy processes and international negotiations on mitigation of atmospheric air pollutants.

The ***EMEP CTM*** is a state of the art atmospheric chemistry transport model, and includes a recently developed novel, but well documented, [34]/[35]/[36] uEMEP downscaling module that allows the estimation of ambient air pollution concentrations down to a grid resolution of approximately 250x250 m^2 for the whole of Europe. Downscaling is carried out where suitable high resolution emissions proxies are available. This includes the emissions from traffic, shipping, stationary combustion, off road combustion and aviation.

Annual mean concentrations are calculated with the EMEP model under different policy scenarios for the following pollutants and indicators: SO_2, NO_2 and NO_X, $PM_{2.5}$, PM_{10}, NMVOC, O_3, SOMO35, NH_3, BaP, benzene and carbon monoxide (CO). Downscaling is applied to a selection of these pollutants ($PM_{2.5}$, PM_{10}, NO_2, BaP, Benzene, CO and ozone) on annual mean concentrations. BaP is not normally explicitly modelled by the EMEP modelling suite. However, a BaP emissions inventory is available for present day emissions, though no scenario trends are available. By applying the same trends used for $PM_{2.5}$ emissions to the BaP emissions, BaP can then be modelled explicitly by the EMEP modelling suite for all scenarios. Heavy metals, regulated under the Ambient Air Quality Directives cannot be quantitatively assessed with the EMEP CTM modelling suite. Therefore, these have been considered outside of the integrated modelling system through statistical analysis, by comparing different concentration thresholds to monitoring data for 2019.[37]

The integrated GAINS and EMEP models provide analysis of many of the impacts considered here. That said, some further calculations and post-processing was required to bring out further impacts associated with the interventions. This was the case for the assessment of health, social cost, and impacts on vulnerable groups. This also includes analysis by linking the GAINS model with the ***JRC-GEM-E3 model*** to explore macro-economic, GDP and employment effects. GEM-E3 is an applied general equilibrium model that covers the interactions between the economy, the energy system and the environment. It represents the whole economy and the interactions between key actors: firms, households and governments in the EU and in the rest of the world. Annex 5 (section 7 on macro-economic impacts) provides some further details on how GAINS results feed into GEM-E3.

All impacts are assessed compared to the baseline, in both a mid-term (2030) and long-term (2050) time horizon. The overall quantitative modelling flow is summarised in Figure A4.1.

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[34] Denby, B. R., Gauss, M., Wind, P., Mu, Q., Grøtting Wærsted, E., Fagerli, H., Valdebenito, A., and Klein, H. (2020): Description of the uEMEP_v5 downscaling approach for the EMEP MSC-W chemistry transport model, Geosci. Model Dev., 13, 6303–6323, Description of the uEMEP_v5 downscaling approach for the EMEP MSC-W chemistry transport model, Geosci. Model Dev., 13, 6303–6323 (accessed: 10.06.2022)

[35] Mu, Q., Denby, B. R., Wærsted, E. G., and Fagerli, H. (2022): Downscaling of air pollutants in Europe using uEMEP_v6, Geosci. Model Dev., 15, 449–465, Downscaling of air pollutants in Europe using uEMEP_v6, Geosci. Model Dev., 15, 449–465 (accessed: 10.06.2022)

[36] Transboundary particulate matter, photo-oxidants, acidifying and eutrophying components. EMEP Status Report 2020 (accessed: 10.06.2022)

[37] See annex 4 of the underlying support study for more detail.

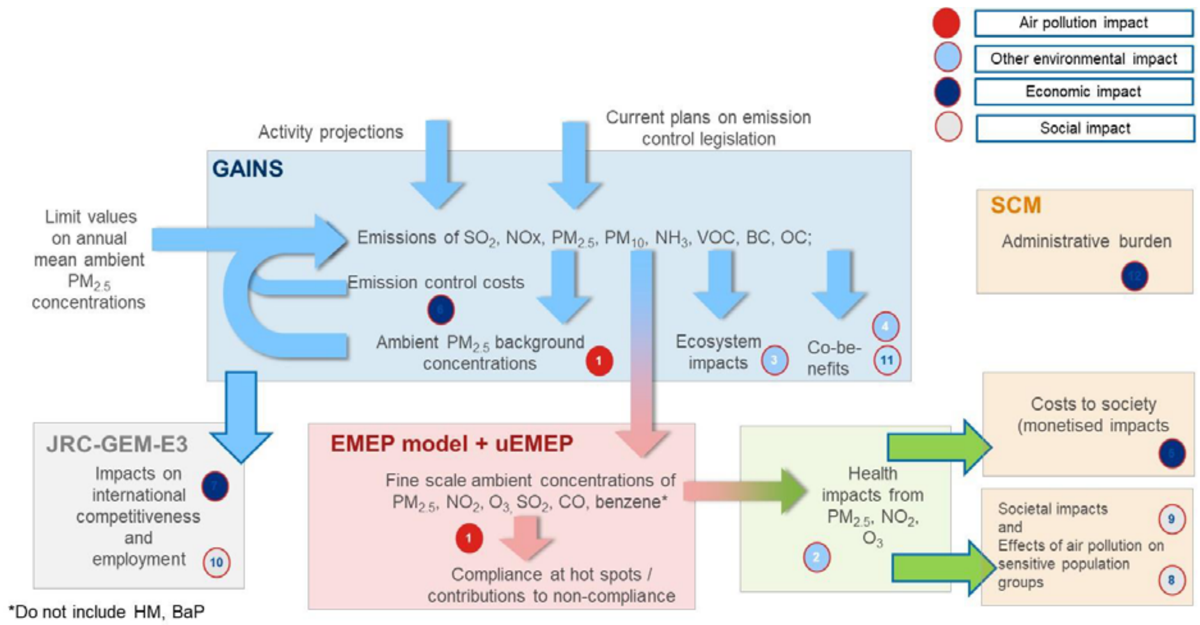

Figure A4.1 – Modelling framework applied to assess the twelve indicators

2.2 Application of GAINS

The policy options defined to address health and environmental outcome shortcomings (corresponding to policy area 1 in the support study) aim to attain closer alignment of air quality standards with the recently published WHO Air Quality Guidelines. The underlying analysis has assessed different **policy scenarios** (in line with the different policy options presented in this impact assessment) corresponding to different ambition levels. In addition, a Maximum (technically) Feasible Reductions **(MFR,** or **MTFR) scenario** was generated for both target years 2030 and 2050, which minimises emissions taking into account all available technologies irrespective of costs and thus represents the lower limit of emissions achievable with technical measures only.

The 'headline indicator' of the extent of the alignment with the revised WHO Air Quality Guidelines (and for expressing the level of ambition of different scenarios assessed) is the annual mean concentration of fine particulate matter ($PM_{2.5}$), as this air pollutant at its current levels is associated with the most harmful effects on human health. The scenarios are defined based on assumptions of different $PM_{2.5}$ levels as a headline indicator, but will also include assumptions for each pollutant covered by the current Ambient Air Quality Directives.

Results for the different policy scenarios have been assessed against a **baseline**, which includes existing and (in line with the Better Regulation guidelines) policies proposed. Annex 5 describes the baseline assumptions including the policies included.

The emission scenarios have been developed with the optimisation module of the GAINS model, which has been applied to identify cost-optimal strategies to achieve ambient $PM_{2.5}$ concentrations in compliance with ambient air quality standards, where this is technically feasible through the model optimisation. The GAINS model includes a linearised approximation of the EMEP atmospheric model relating emissions of PM precursor pollutants to ambient concentrations on a (roughly) 7x7 km^2 grid. GAINS can determine the cost optimal solution to achieve certain targets on ambient air quality. For the present analysis, the optimisation analysis is constrained to achieve $PM_{2.5}$ compliance at this grid level. In case the model finds no feasible solution for achieving compliance in all grid cells, the constraints are relaxed to allow for a certain fraction of exceeding areas where additional local policy measures will be needed to achieve compliance. For such grid cells, the optimisation requires at least a 90% improvement of ambient $PM_{2.5}$ concentrations towards the concentration levels attained in the maximum feasible reductions (MTFR) case. The cost optimisation is thus used to suggest the most cost effective national or EU wide emission control measures to bring ambient concentrations close to the ambient air quality limit values.

Given GAINS contains simplified atmospheric calculations based on a linear approximation of the EMEP CTM at 7 km resolution, it can only assess compliance at background level. It is important to note that compliance at hot spots, e.g., in busy street canyons, may require supplementary local measures (e.g., traffic restrictions, which cannot always be reflected in the GAINS model). To some degree, the question of compliance at hot spots may be addressed by adding a margin to the background $PM_{2.5}$ concentration levels in the cost optimisation.

For any of the scenarios, if a feasible solution for attaining $PM_{2.5}$ standards at background level is found, GAINS quantifies the related emissions of, at least, $PM_{2.5}$, SO_2, NO_X, NH_3, NMVOC, and CO in each Member State and economic sector. These are then fed into the EMEP CTM and uEMEP downscaling scheme to calculate ambient concentrations of air pollutants at fine resolution.

While the $PM_{2.5}$ objectives are the driving indicator defining the different scenarios, different ambition levels for $PM_{2.5}$ will have implications for the concentration levels of other air pollutants. Optimising for concentrations of multiple pollutants has not been considered feasible in the framework of this impact assessment. However, from the high-resolution calculations of the EMEP CTM, ambient concentrations of all pollutants covered in the model are estimated for the scenarios optimising around $PM_{2.5}$. This allows quantification of the range of feasible concentration limits for other pollutants under each scenario.

2.3 Concentration modelling methodology

Concentration modelling of the emission scenarios provided by GAINS is carried out using the EMEP CTM and uEMEP models. uEMEP calculates only annual mean concentrations.

Exposure calculations using the modelled concentrations are carried out at grid resolution of approximately 250x250 m^2, matching the resolution of the available population density data, and these are used for the health impact assessment. Further to the exposure calculations, additional calculations at higher resolution, 50x50m2, are carried out to ascertain the impact of the emission scenarios at measurement station sites across Europe. Changes in concentrations at measurement sites are used to assess the possible level of attainment at these sites, in relation to the currently observed concentrations. All scenario simulations were using meteorological conditions for 2018.[38]

Concentrations at individual stations cannot be expected to be perfectly matched with a Europe wide modelling approach. However robust statements about the likely distribution of concentration levels across stations can be made. Although no specific street canyon module was employed, experience has shown that concentrations generated with uEMEP for $PM_{2.5}$, PM_{10}, NO_X and NO_2 are comparable to measured roadside concentrations. For this impact assessment, the downscaling was extended to include O_3, benzene and CO.

The analysis was limited to annual mean concentrations. For SO_2 and the indicators that require temporal resolutions higher than annual mean, the EMEP model is used without downscaling. For the downscaled compounds of NO_2, $PM_{2.5}$ and PM_{10}, statistical relationships based on observed concentrations are used to infer statements about likely compliance with short-term daily limit values, such as done in previous work for the Commission on the Thematic Strategy on Air Pollution[39]. No assessment of hourly indicators is carried out.

Benzo(a)pyrene (BaP) remains a problem in several countries in Europe and is mostly related to residential sector emissions (wood and coal combustion in stoves and small boilers). While BaP is not normally explicitly modelled by the tools used for this analysis, the analysis did include BaP using current day BaP emission inventories and linked them to $PM_{2.5}$ emission scenarios to provide a quantitative assessment of BaP concentrations. This approach assumes that the ratio of BaP in $PM_{2.5}$ will not change for any of the scenarios.

2.4 Assessment of health impacts

The assessment includes premature mortality caused by long-term exposure to particulate matter (PM) and nitrogen dioxide (NO_2), mortality caused by ozone (O_3) peaks, and an estimate for the morbidity related to long-term and short-term exposure to particulate matter.

The WHO updated its Air Quality Guidelines in 2021. In the process of the update, also the systematic reviews on the current scientific knowledge concerning the ***mortality*** related to exposure to air pollution have been updated, leading in turn to updated concentration response functions. The latest WHO relationships are deployed in this analysis. The premature mortality are also estimated per age group (one-year interval). The analysis combines these estimates with the life expectancy (which can vary across Member States) from Eurostat, to assess the number of years of life lost (YLL). For future years, the evolution of the population is considered via the Eurostat projections.

To assess impacts on ***morbidity***, the approach taken here is based on that taken in the second Clean Air Outlook, which in turn based its method on the health pathways and concentration

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[38] In addition, control runs for the 2015 baseline scenario were performed using meteorological data for 2015.
[39] See IIASA, Thematic Strategy on Air Pollution (TSAP) Reports (accessed: 15.06.2022)

response functions (CRF) recommended by the WHO in its Health risks of air pollution in Europe (HRAPIE) reports.[40] Acknowledging that there have been developments in the underlying evidence base since HRAPIE, but that the WHO has not undertaken a comprehensive recent review of morbidity pathways, a targeted review of literature was undertaken in preparation of the support study to explore whether there are other pathways for which evidence is stronger. The analysis only considers morbidity pathways associated with exposure to $PM_{2.5}$.

In summary, this yields a three-tiered health impact assessment:

1. premature mortality caused by the long-term exposure to air pollution using the concentration response functions (CRF) recommended by the WHO;

2. morbidity caused by long-term and short-term exposure based on the HRAPIE recommendations from 2013 (chronic bronchitis in adults, bronchitis symptoms in children, cardiovascular hospital admissions, respiratory hospital admissions, infant mortality, restricted activity days and lost working-days);

3. morbidity effects beyond HRAPIE, to incorporate new insights that became apparent after the 2013 HRAPIE study, and to provide a more complete overview of the health impact due to air pollution. This covers three additional health outcomes in the primary analysis (asthma in children, lung cancer, stroke (CVA)), and three additional health effects in sensitivity analysis (COPD[41], Diabetes Mellitus Type 2 and myocardial infarction).

For the main scenario analysis, quantification of health impacts for comparing the benefits of different policy options **is limited to the impact of air pollution concentrations in excess of the revised WHO Air Quality Guidelines** (from 2021). This approach has been adopted given that:

- The guideline exposure levels have been subject to extensive review work from WHO and represent an up-to-date overview of scientific knowledge on the subject, including on levels above which the health impacts are well documented;

- There is added uncertainty in the applicability of concentration response functions below the guideline exposure levels suggested by the WHO (also note that below these levels the contribution of natural sources of air pollution becomes more significant).

It is acknowledged, however, that this approach likely **underestimates** the total impact of air pollution on health (and thus also the likely benefits of action to improve air quality). For this

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[40] See WHO (2013), Health risks of air pollution in Europe – HRAPIE project Recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide (accessed: 15.06.2022)

[41] Chronic obstructive pulmonary disease; COPD impacts are not included in the aggregated results for the valuation of health impacts (as per Annex 5.5) given concerns about the overlap with chronic bronchitis.

reason, further quantification has been carried out to inform sensitivity runs (results of which are available in the support study).

This approach of assessing impacts above WHO Air Quality Guidelines levels is consistent with the approach the EEA adopts in its latest briefings on air quality in Europe[42]. It is also consistent with the approach followed in the preparation of the forthcoming Third Clean Air Outlook (publication foreseen for end 2022).

2.5 Monetisation of health and non-health impacts

Calculating the costs to society of air pollution is a means of monetising the effects of air pollution, such that they can be more readily compared to the costs of mitigation action. To estimate the costs to society, the health impacts calculated in the previous step (such as number of deaths and of adverse health outcomes) were combined these with monetary impact values to capture the impact on: lost utility or welfare, lost labour (or productivity) and health care costs.

For **human health impacts**, the monetary values applied in the second Clean Air Outlook are used. The values are based on an extensive literature review of the latest approaches by organisations such as the OECD. The second Clean Air Outlook involved an extensive review of the literature available at the time,[43] and concluded in December 2020. Some of the health outcomes of the third tier go beyond what was covered in the second Clean Air Outlook. For these, a targeted literature review was undertaken to support the selection of appropriate monetary impact values for these pathways (available in the underlying support study). Also in line with the second Clean Air Outlook, results are presented for different approaches to monetising impacts: a VSL (value of statistical life) approach, which monetises the number of deaths, and a VOLY (value of statistical life year) approach, which instead monetises life years lost. For the aggregate assessment, the mortality effects associated with NO_2 are excluded to avoid the risk of overlap with the mortality effects of $PM_{2.5}$.

Materials damage has long been associated with emissions of SO_2 and NO_X. Damage values per unit emission for SO_2 and NO_x have been taken from the CASES study (CASES, 2008), and applied to the emissions changes observed in the integrated modelling.

Air pollution is also associated with a range of **ecosystem impacts**. Several of these impact pathways (but not all) have been monetised in the literature, most commonly: crop damage, forest damage and damage to ecosystems. Methods to monetise such effects stem from the ECLAIRE study[44] and are in line with what was done in the second Clean Air Outlook. For **crops** and forests, impacts from exposure to ozone on yields or productivity were taken into account. **Forest** damage reflects in addition reductions in carbon sequestration potential. For

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[42] EEA (2022), Europe's air quality status 2022 (accessed: 10.06.2022)
[43] Available in the annex to the support study for the Second Clean Air Outlook report, as well as in the annex of the support study underlying this impact assessment.
[44] Europa.eu (2015), Effects of Climate Change on Air Pollution Impacts- final. -nr. 282910 (accessed: 10.06.2022)

this, two different estimates of carbon mitigation costs were assumed, resulting in a low and high variant of forest damage (but only after 2030 do the assumptions for Low and High diverge). Impacts on **ecosystems** tend to be most significant out of the three. The analysis was limited to terrestrial ecosystems and the focus was on exceedance of the critical load for nitrogen in Natura 2000 sites, with valuation applied to the area subject to critical loads exceedance. No account was taken of exceedance of the critical load for acidification, because the area concerned is far less than that affected by eutrophication and there is potential for double counting if results for both effects are combined. A *willingness to pay* approach to valuation is adopted consistent with that used for other impacts assessed. A Low and High estimate is adopted to reflect uncertainty in the underlying valuation techniques.

3. SHORTCOMINGS OF THE MODELLING APPROACH AND SOURCES OF UNCERTAINTY

One of the major uncertainties in air quality modelling remains the correct representation of emissions, including how they are distributed in space. Modelling quality suffers where emission inventories (submitted by Member States) are deficient, e.g. because emissions are underestimated or unknown emission sources are not included. To some extent, these effects are reflected in the underlying modelling work when running sensitivity analyses with a bias adjustment. Modelling uncertainties in methodologies also lead to limitations. It is worth noting the EMEP and uEMEP models have been applied in countries where emissions are better known. Under these conditions the model performance is much improved.

During the course of the modelling some clear challenges in emissions have been found. These include:

- Separation and spatial distribution of national and international shipping emissions;
- Individual industries with large and uncertain emissions that can dominate the exposure in a whole city;
- Incorrect allocation of some residential heating emissions;
- Reported non-exhaust emissions that may not be adequately spatially distributed or quantified.

For the estimation of chronic mortality, the following limitations are observed:

- Only the mortality related to long-term exposure to PM, NO_2 and O_3 is considered. Other pollutants and mortality due to short-term exposure are not considered.
- Results for mortality are not corrected for overlaps between the different pollutants. As an indicative estimate for the order of magnitude of the overlap, HRAPIE suggests an overlap of 33%.[45] This number is, however, associated with a large uncertainty.
- Since the meteorological data is the same for each year under consideration, the impact of climate change is not considered (*also holds for morbidity estimates*).
- The uncertainty on the results is larger for the results reported per individual country, than for EU-27 total estimate (*also holds for morbidity estimates*).

For the estimation of morbidity, the following additional limitations are observed:

- Only the morbidity related to exposure to particulate matter is considered. Other pollutants are not considered.
- Future projections for the baseline incidence are unavailable for most health outcomes. The analysis therefore relies on the morbidity rates for the most recent year for the future baseline morbidity. Impacts due to improvements in health care, more / less healthy lifestyle etc. are hence not considered.
- In general, the uncertainty on the morbidity estimates is larger than the uncertainty on the mortality estimates, mostly due to more pronounced uncertainty in the input datasets (concentration response functions, baseline morbidity). When interpreting the results, the focus should therefore lie on relative differences between scenarios.

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[45] See WHO (2013), Health risks of air pollution in Europe – HRAPIE project recommendations for concentration–response functions for cost–benefit analysis of particulate matter, ozone and nitrogen dioxide (accessed: 16.06.2022)

ANNEX 5: BASELINE, MAXIMUM TECHNICALLY FEASIBLE REDUCTION AND POLICY SCENARIOS – MODELLING RESULTS

This annex complements the description of baseline development in chapter 5 and of policy scenario developments in chapter 6 of the main report by providing further detailed results from the quantitative modelling. This means that modelled results that are already included in the main report are not repeated here. The underlying support study contains further, more disaggregated results, including tables with results per Member State.

1. DESCRIPTION OF THE BASELINE SCENARIO

The starting point for the quantitative analysis is the **baseline scenario**, which provides a critical reference point against which to assess changes and impacts of the formulated policy options. It serves as the counterfactual for examining how the situation is expected to change in the case of no further changes to the Ambient Air Quality Directives. The baseline is defined by the current status of implementation of different obligations under the existing EU Directives relevant for air pollutant releases as well as national legislation, if stricter than the EU law. This defines the existing political and legal context at the EU and at the national level. The current status of implementation is well defined in several existing studies, not least the second Clean Air Outlook. This baseline builds on the backdrop of existing measures and policies already committed (including some which might require introduction of further measures in the near term).

In line with the Commission's Better Regulation guidelines, policy proposals (even though still subject to modifications in the course of the policy making cycle) form part of the baseline assumptions. Policies and measures included in the baseline are considered to continue over the duration of the analysis period. Key **elements of the baseline scenario** that have been updated since the Second Clean Air Outlook include:[46]

- The broader EU policy environment and potential changes - including revised European Commission climate targets and related legislative proposals (Fit for 55) as well as of preliminary assumptions for the introduction of Euro 7;
- Confirmed changes at Member State level (i.e. adopted policies and measures as set out in National Air Pollution Control Programmes);
- Sulphur Emissions Control Area (SECA) in the Mediterranean Sea from 2025;
- Assumptions about the development in the non-EU countries, which are of relevance owing to the impact of transboundary pollution, in particular, new data and projections (energy and agriculture) for Western Balkan, Ukraine, Moldova, and Georgia from a recently completed EU funded project.[47]

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[46] See Appendix 3 of the support study for a full list of policies included in the baseline.
[47] Extension of the EU Energy and Climate Modelling Capacity to include the Energy Community and its Nine Contracting Parties (ENER/2020/OP/0005)

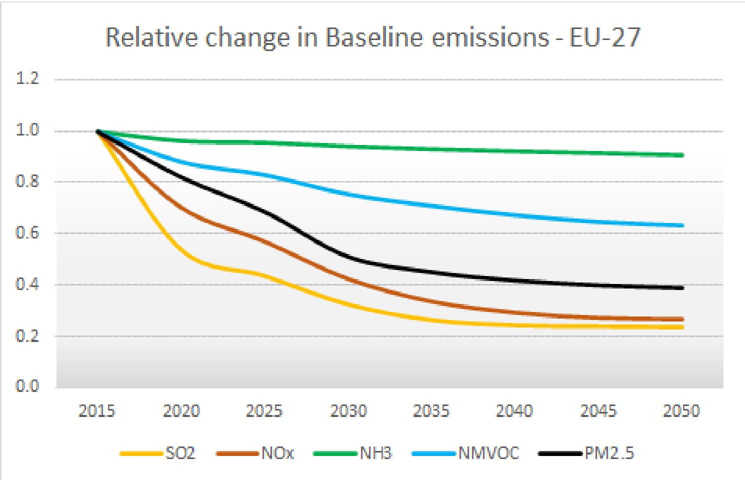
2. AIR POLLUTANT EMISSIONS: BASELINE DEVELOPMENT AND SCOPE FOR MTFR REDUCTIONS

Considering current economic and environmental policies included in the baseline for the EU-27 will result in continued decline in emissions of key air pollutants (Figure A5.1). Compared to 2015, emissions of $PM_{2.5}$, NO_x, and SO_2 are estimated to drop by 50 to 70%, NMVOC by 25%, while for ammonia (NH_3) only about 5% reduction is calculated by 2030. The trends are expected to continue towards 2050 but with much smaller further reductions.

The key drivers of emissions change towards 2030 are different for each pollutant:

- for $PM_{2.5}$ most of the reduction is due to reduced use of coal and biomass in the residential sector and transition to cleaner technologies;
- for NO_x recent legislation and fuel trends (less diesel and increase of hybrid and full electric vehicles) are the key drivers;
- for SO_2, first strong reduction in coal use in power plants and then residential coal use decline are among major factors;
- For NMVOC, reduction in residential heating sector (see $PM_{2.5}$) and transport (see NO_x) are key contributors;
- For NH_3, the (limited) decline is mostly driven by structural changes (livestock numbers), including reduction of mineral nitrogen fertilizer application.

Figure A5.1 – Trends of air pollutant emissions in the EU-27; baseline scenario (GAINS)



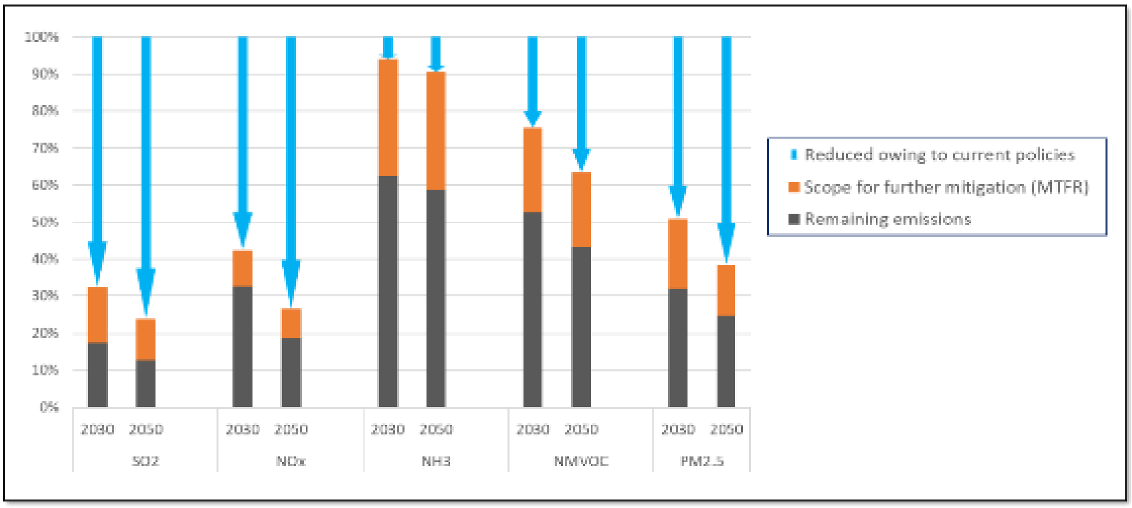
For NH_3, further emission reductions are expected from recently proposed revision of the IED, including cattle and reducing the farm size threshold for pigs and poultry.[48] While the modelling baseline used here does not include this proposal (implementation in the GAINS model is under way within the study supporting the third Clean Air Outlook), the impact assessment study of the revised IED estimated the potential ammonia reductions at about 155 kt per year, about 4.4% of total EU ammonia emissions.

[48] COM(2022) 156 final/2 (accessed: 04.08.2022)

To define the scope of the maximum mitigation potential *based on available technologies*, a **maximum technically feasible reduction (MTFR) scenario** for 2030 and 2050 was modelled in GAINS (Figure A5.2). Key elements to note:

- Lifetime of installed capacity is respected, i.e. no premature scrapping of existing equipment is considered;
- No further structural (e.g. fuel switch) or behaviour-driven (e.g. lifestyle choices of reducing meat/diary intake) measures are considered beyond what is included in the baseline, neither at the local nor regional level;
- Potential local and technological constraints are taken into account to the extent that they are reflected in the model drawing on previous Member State consultations and technology information;
- Any potential financial constraints are ignored (in other words do not hinder the take-up of measures).

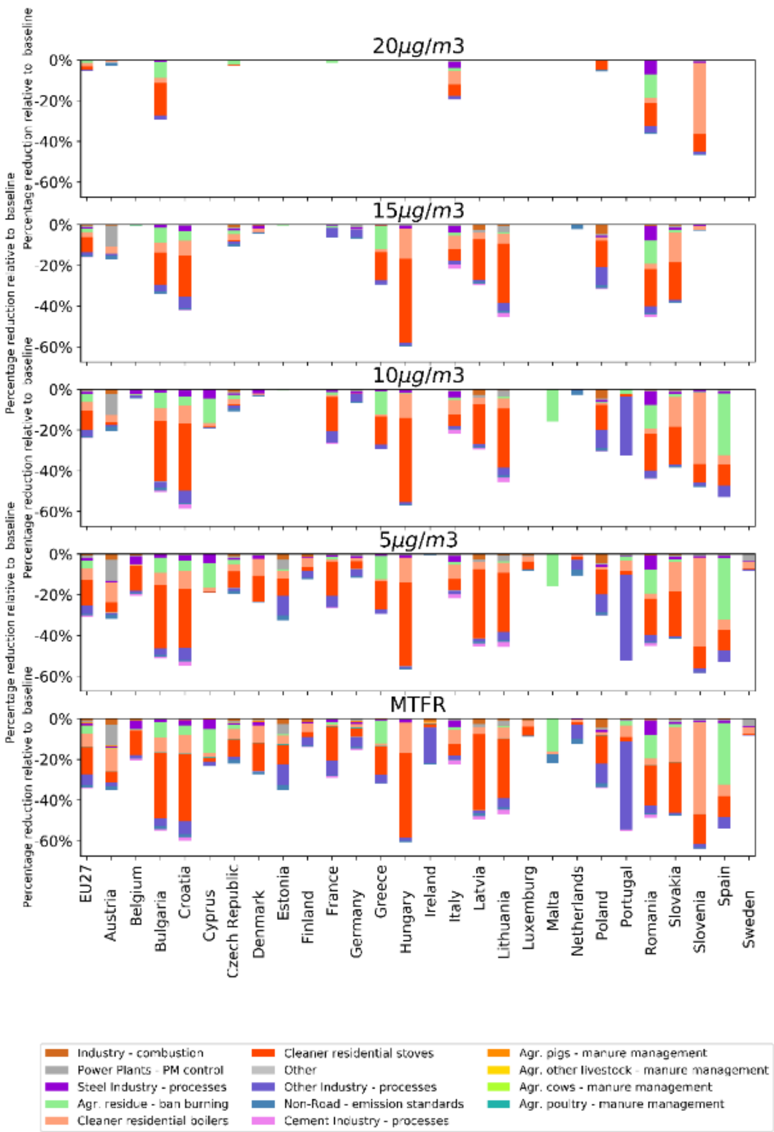
Figure A5.2 – Scope for further emission mitigation of air pollutant emissions in 2030 and 2050 in the EU-27. Changes shown relative to 2015 (GAINS model)



Since current legislation is expected to reduce emissions of **SO_2** and **NOx**, further potential is rather limited and even declines in the long-term owing to the reduced used of fossil fuels already in the baseline. Remaining limited potential has been identified for industrial process. For **$PM_{2.5}$**, key further mitigation can be achieved in the residential sector and also by enforcing bans on open burning of various agricultural residues that in spite of existing legislation are still burned, while there would remain very limited, if any, potential to further reduce emissions from power or industrial sectors. For **NMVOC**, apart from some potential in residential sector and agricultural burning, further reductions in solvent use applications were estimated. For **ammonia**, mitigation of emissions from mineral nitrogen fertilizer application and livestock offer significant reduction potential assuming that measures addressing housing, storage, and application of manures on land would be introduced in an integrated manner (as proposed in the revised IED), but for a much larger number of farms than is currently the case as per baseline assumptions, especially for cattle.

The mitigation potential shown above (as well as the results that include sectoral breakdown shown in chapter 6 of the main SWD) vary strongly between Member States depending on structure of emission sources and local constraints.[49] The following figures (A5.3 to A5.7) reflect this variation. They present the reduction of emissions of $PM_{2.5}$ and its precursors *compared to the baseline* as calculated in the GAINS model for policy and MTFR scenarios, showing a disaggregated sector/measure resolution and with results per Member State.

Figure A5.3 – Reduction of **$PM_{2.5}$** emissions, split by Member State (2030)



[49] See main report of the underlying support study for estimates per Member State.

Figure A5.4 – Reduction of **SO_2** emissions, split by Member State (2030)

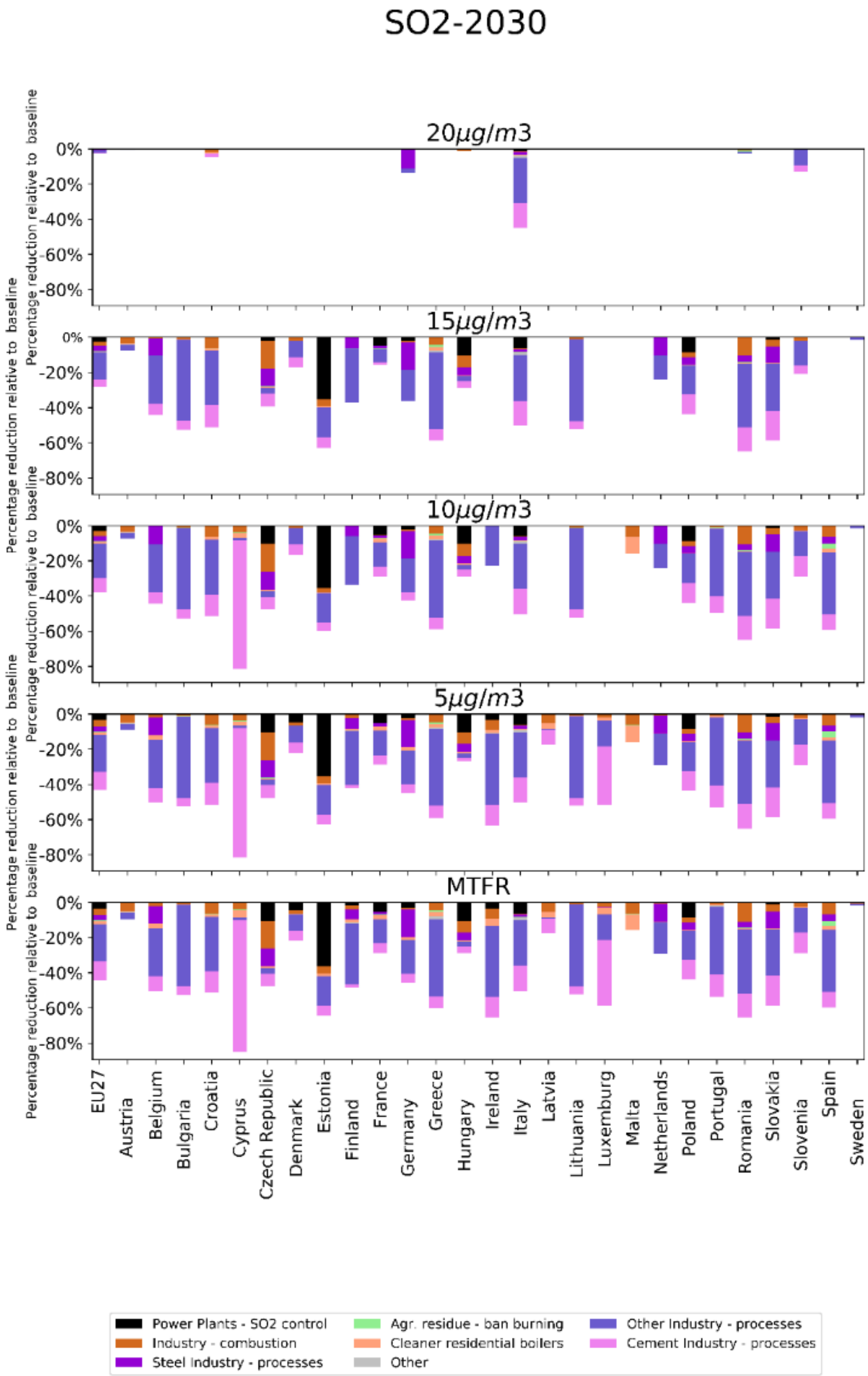


Figure A5.5 – Reduction of NO_X emissions, split by Member State (2030)

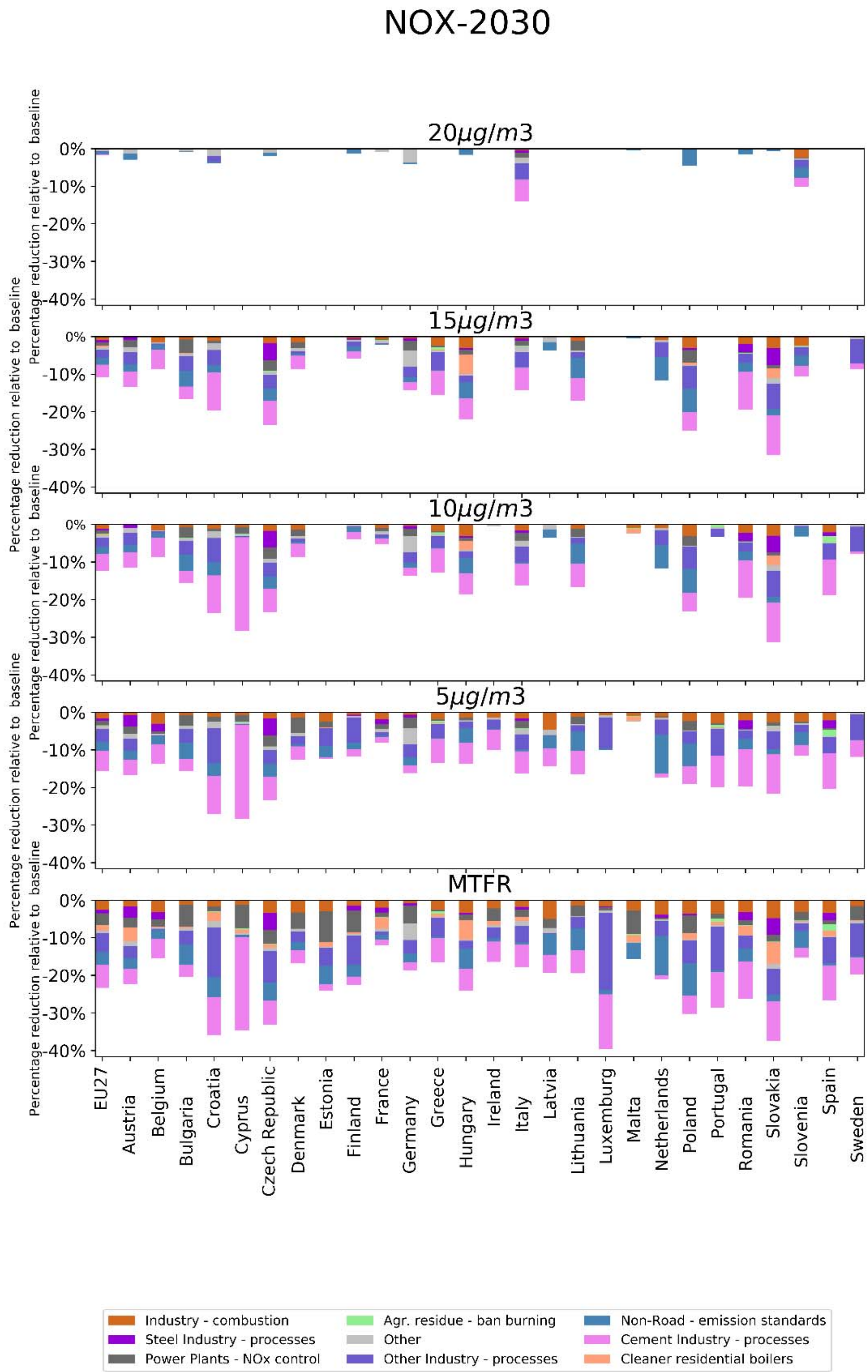


Figure A5.6 – Reduction of **NH_3** emissions, split by Member State (2030)

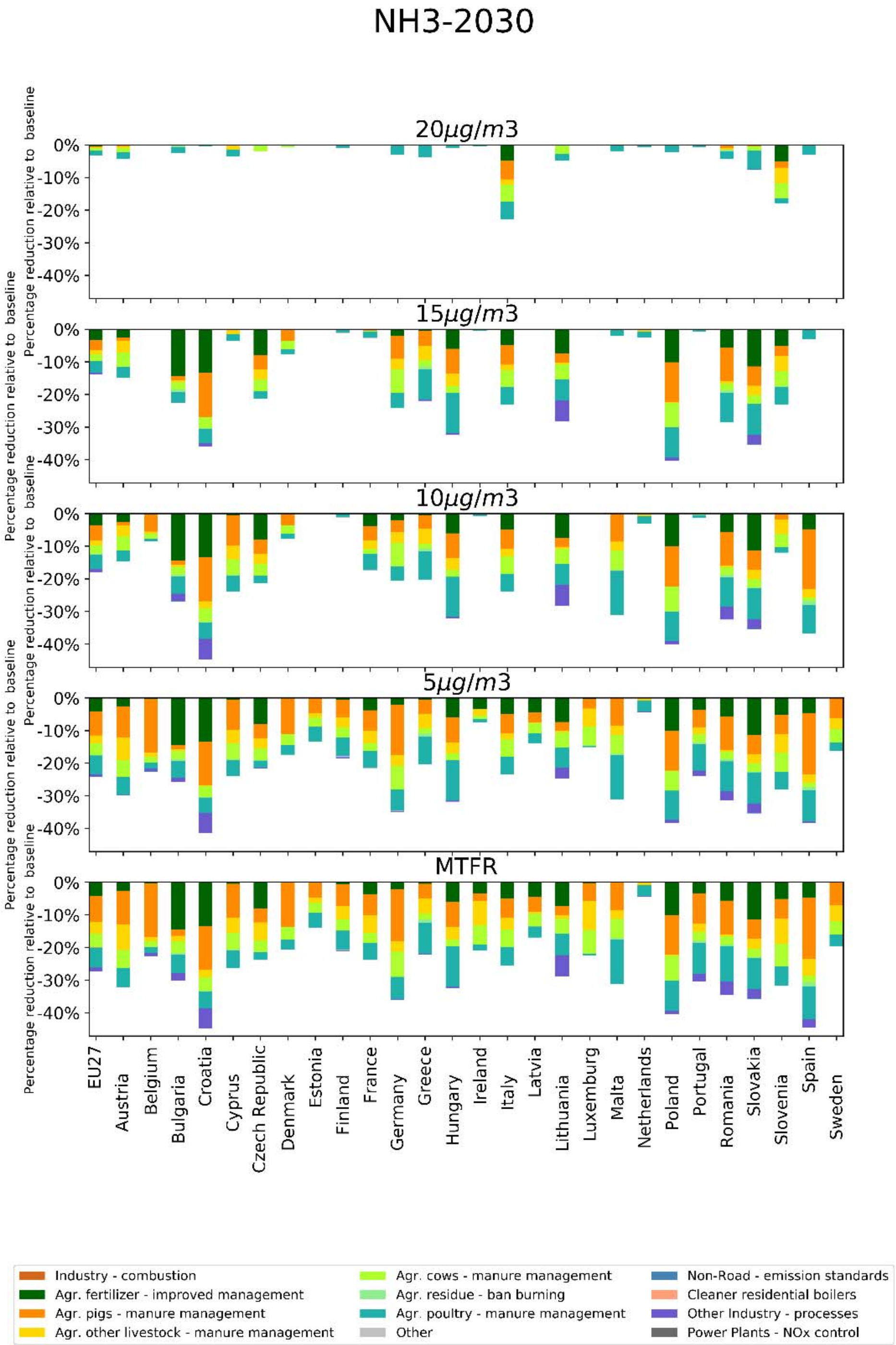
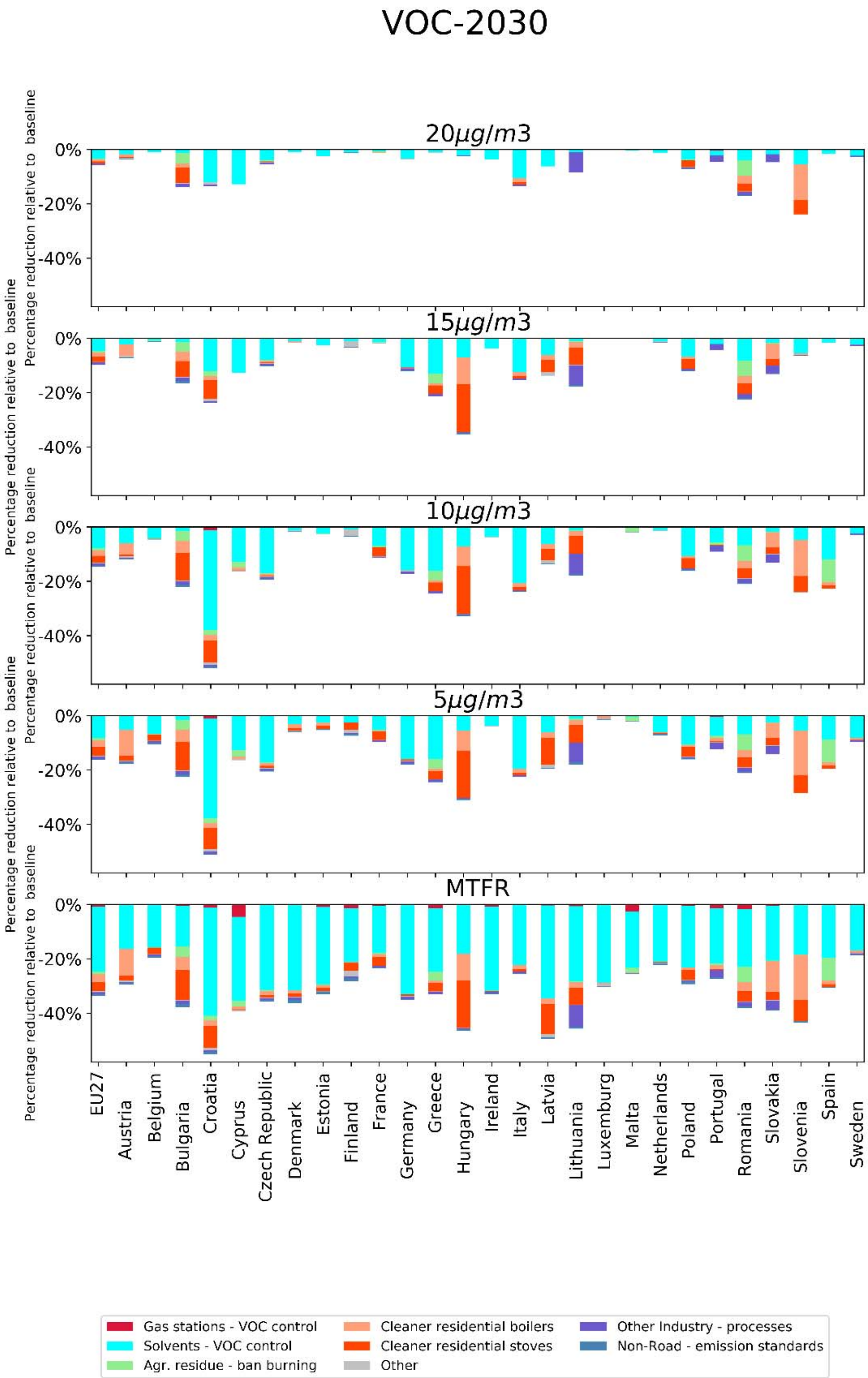


Figure A5.7 – Reduction of **VOC** emissions, split by Member State (2030)



3. AIR POLLUTANT CONCENTRATION PROJECTIONS

The main report includes detailed results for the baseline and policy scenarios showing the number of stations with remaining exceedances above different limit values. To complement these results, this section includes a number of maps that show the geographical distribution of air pollutant concentrations in the baseline, various optimisation and MTFR scenarios.

The below maps (Figures A5.8) show concentrations of **fine particulate matter ($PM_{2.5}$)** in 2030 indicate that already under baseline assumptions substantial improvements in air quality over the coming decades can be expected, with most of Europe reaching concentration levels below 10 µg/m^3. Areas including parts of Central Europe, the Baltics, Italy and Northern parts of France move even to concentration levels of below 5 µg/m^3.

The optimisation scenarios bring further improvements. Significant parts of Europe remain above 5 µg/m^3 in the OPT-5 scenario (which corresponds to policy option I-1), including Northern Italy (Figure A5.10), the border region of Czechia, Poland and Slovakia (see also Figure A5.11), as well as southern regions along the Mediterranean coast of the EU. This remains the case in the MTFR scenario, which would bring little additional improvements.

Going to 2050 (Figure A5.9), additional areas reach concentration levels below 5 µg/m^3, notably most remaining parts of Poland and Hungary, as well as of Belgium and the Netherlands. Elevated levels of fine particulate matter ($PM_{2.5}$) in Southern Europe are rather persistent, which is explained by the fact that much of the pollution is due to natural sources, and Sahara dust and sea spray in particular (which the current Ambient Air Quality Directives allow to be deducted from air pollution levels reported).

Figure A5.10 highlights the specific dynamics in the Po Valley region in Northern Italy, where specific meteorological and orographic circumstances lead to reduced dispersion, and elevated emission levels from residential heating (including biomass burning) as well as agricultural emissions represent particular challenges. While under the preferred policy option the area exposed to $PM_{2.5}$ concentration levels above 10 µg/m^3 reduces significantly by 2030, some hotspots would be expected to remain across optimisation scenarios (and significant parts remain are just below 10 µg/m^3).

Similarly, for much of Eastern Europe (see for example Figure A5.11), residential heating (often reliant on fossil fuel combustion) and industry production facilities today lead to elevated $PM_{2.5}$ concentration levels. Under the preferred policy option and based on the measures taken to address these emissions, the area exposed to $PM_{2.5}$ concentration levels above 10 µg/m^3 reduces almost to zero by 2030.

As regards the concentration levels of **particulate matter (PM_{10})** for the baseline and MTFR, most areas in the EU reach concentration levels of below 15 µg/m^3 in 2030 already in the baseline when looking at background concentration levels (Figure A5.12). The remaining areas above 15 µg/m^3 are along the Mediterranean cost and as such can be explained by pollution from natural sources.

Zooming in to a finer resolution, however, indicates that local peaks of concentration levels of particulate matter (PM_{10}) can be expected to remain under all scenarios analysed. These can be linked, for example to constant levels of non-exhaust emissions from transport: Figure A5.13

illustrate the particular case of Stockholm, where pollution peaks can be seen along the main road traffic axes.

The baseline assumptions related to improved vehicle emissions standards and increased electrification of road transport lead to reductions of **nitrogen dioxide (NO_2)** concentration levels in urban centres across the EU from 2020 to 2030, with further reductions in the MTFR and towards 2050 (Figure A5.14). A large area with noticeable improvements in NO_2 concentration levels is the area spanning parts of Belgium and the Netherlands as well as the Ruhr area in Germany. Zooming into this region (Figure A5.15) shows that areas with an annual mean concentration of over 20 µg/m^3 are markedly reduced in 2030, already in the baseline scenario, with remaining areas above 20 µg/m^3 being situated mainly around ports.

Moving from 2020 to 2030 in the baseline already brings marked improvements to **ozone (O_3)** (26th highest maximum 8-hour daily running mean) concentrations levels with large areas where concentrations levels are reduced to below 100 µg/m^3, and few remaining areas with levels above 120 µg/m^3 (in Northern Italy). Further reductions are observed in the MTFR in 2030 and even more pronounced in baseline and MTFR in 2050, when most parts of the EU have levels of 80 to 100 µg/m^3, with levels above 100 µg/m^3 remaining primarily in Romania, Northern Italy, in some parts around the Mediterranean cost as well as parts of North-Western Europe (Figure A5.16).

Figure A5.17 shows low levels of **sulphur dioxide (SO_2)** concentrations levels of below 40 µg/m^3 prevailing throughout the EU. This is explained by the strong reduction in coal use in power plants as well as in residential coal use in line with EU energy and climate policy that form part of the baseline assumptions.

Carbon monoxide (CO) concentration levels are below 1 mg/m^3 in most of the EU, with little changes between baseline and MTFR. Smaller patches are between 1 and 2 mg/m^3.

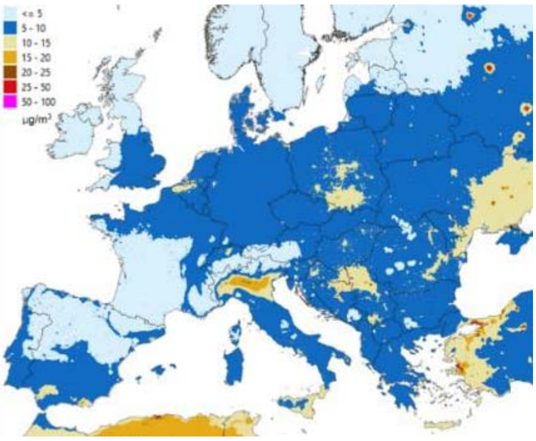
Most of the EU has concentration levels for **benzene (C_6H_6)** below 0.8 mg/m^3 already in the baseline in 2020. Parts of Northern Italy show more elevated levels between 0.8 and 3.4 mg/m^3. This area is reduced significantly already in the baseline in 2030.

Concentrations levels for **benzo(a)pyrene (BaP)** are above 1 ng/m^3 in significant parts of the EU in the baseline in 2020, notably in Poland, in Northern Italy and in more localised places in Southern, Central and Eastern Europe. Already the baseline assumptions reduce these areas in 2030 to a good extent, most notably in Poland. In the MTFR in 2030 and going towards 2050, there are very limited areas left with concentration levels exceeding (in Poland, Northern Italy and Greece) 1 ng/m^3.

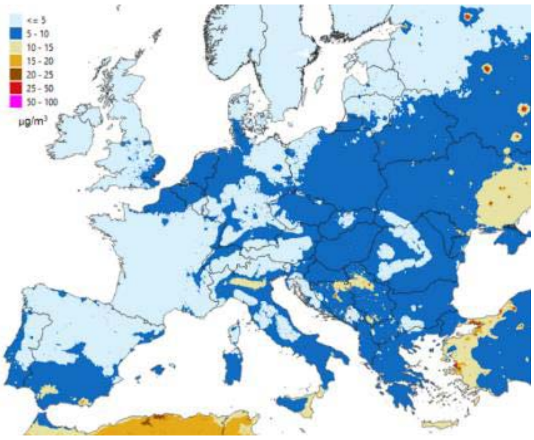
Maps for fine particulate matter - $PM_{2.5}$

Figure A5.8 - $PM_{2.5}$ concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for **2030**. Calculations are made on the EMEP 0.1° grid For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

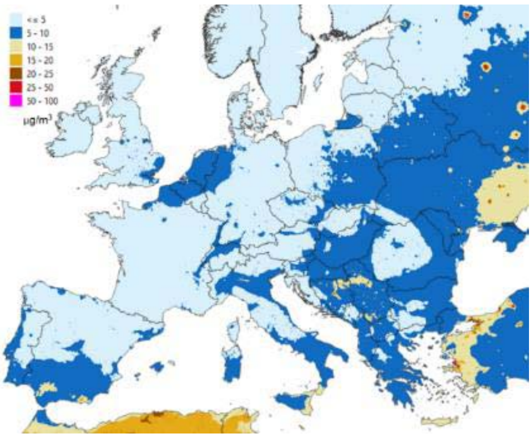
Base 2020



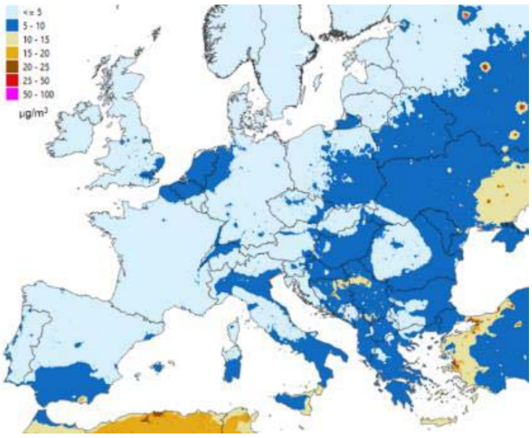
Base 2030



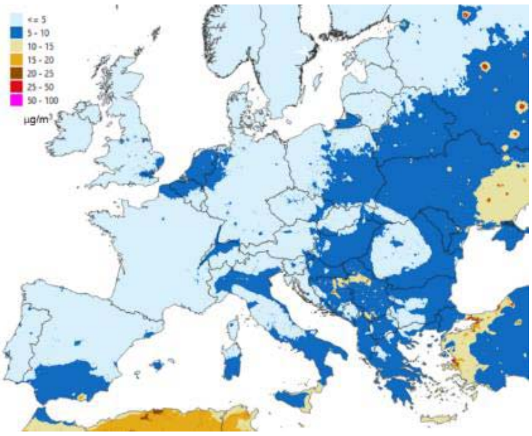
OPT-15 2030 (Policy Option I-3)



OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



MTFR 2030

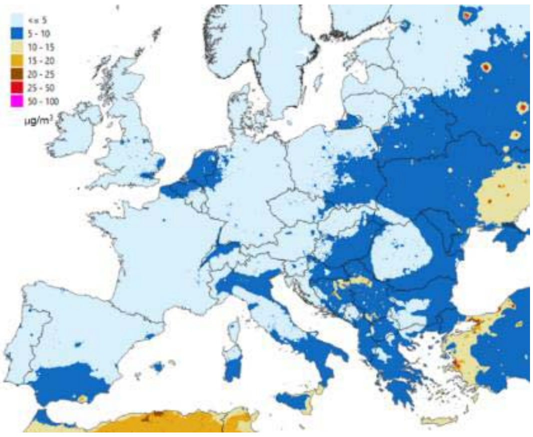
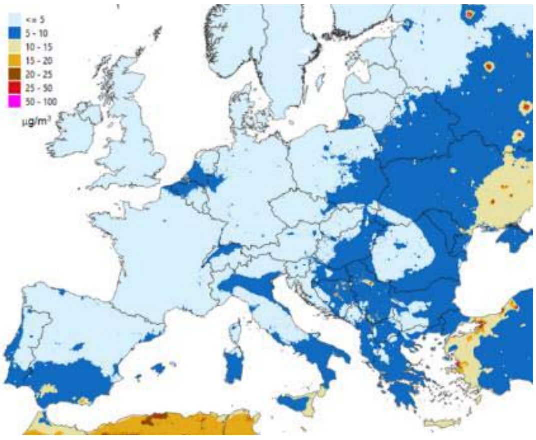
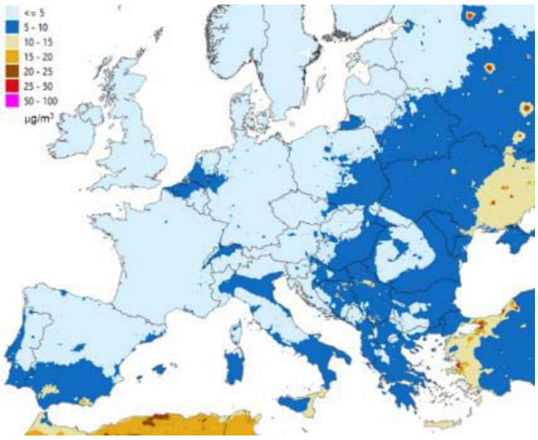


Figure A5.9 - $PM_{2.5}$ concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for **2050**. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

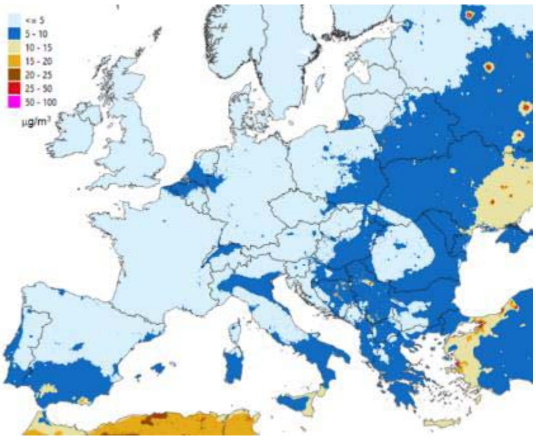
Base 2020



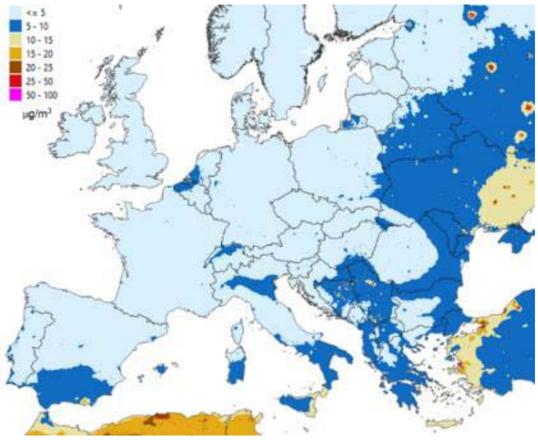
Base 2050



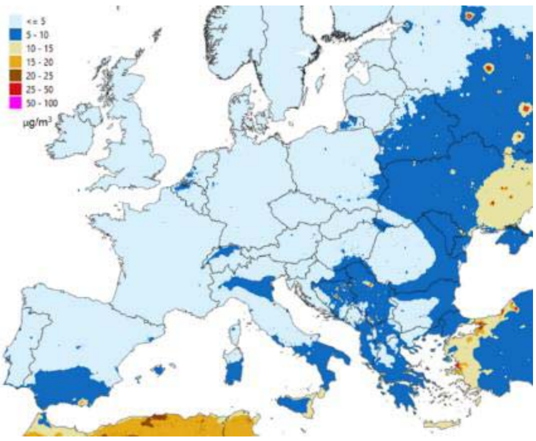
OPT-15 2050 (Policy Option I-3a)



OPT-10 2050 (Policy Option I-2a)



OPT-05 2050 (Policy Option I-1a)



MTFR 2050

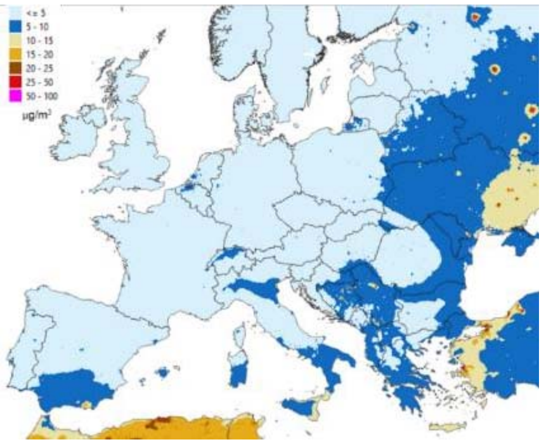
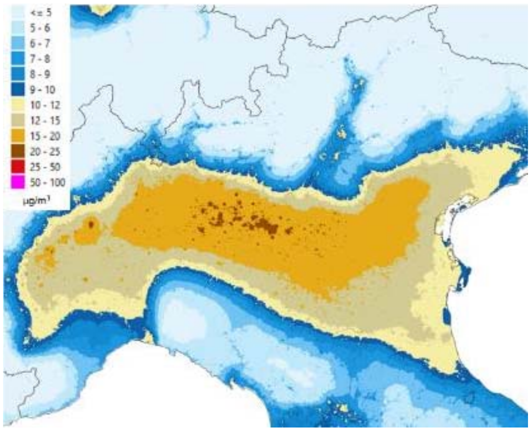
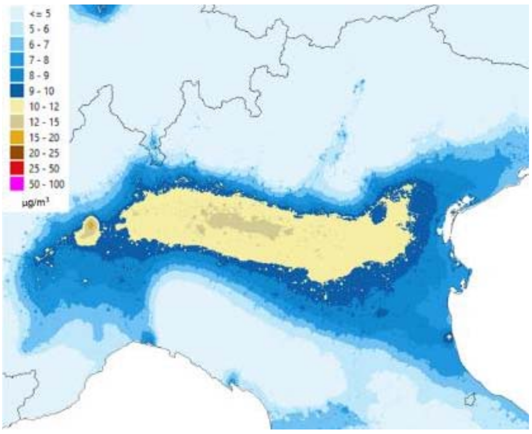


Figure A5.10 - Focus: Region in Northern Italy. $PM_{2.5}$ annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 5 and 12 µg/m³. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

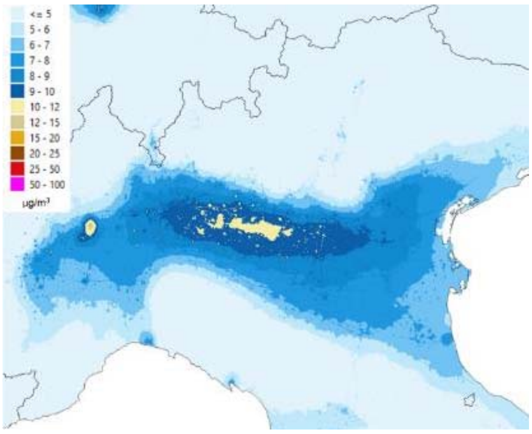
Base 2020



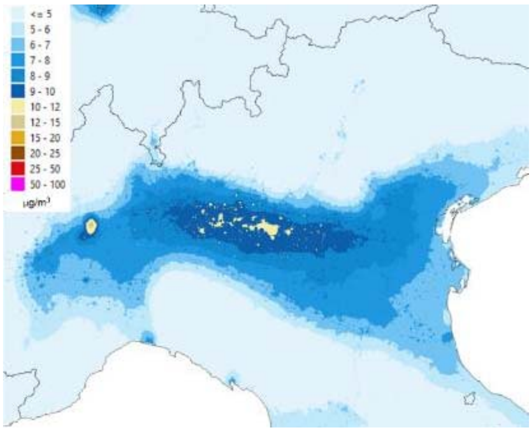
Base 2030



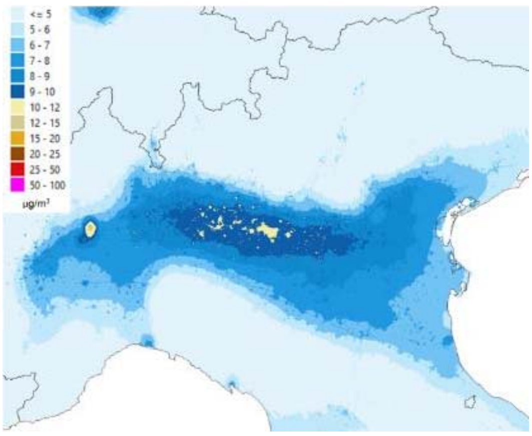
OPT-15 2030 (Policy Option I-3)



OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



MTFR 2030

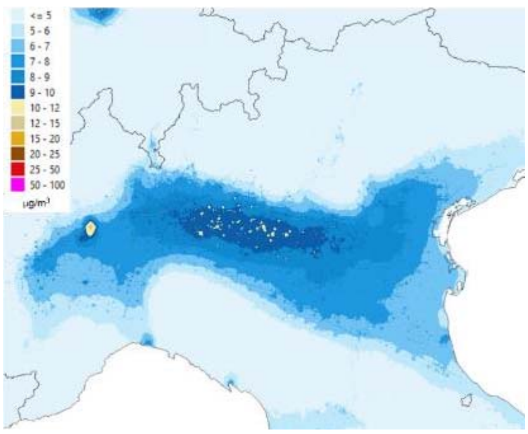
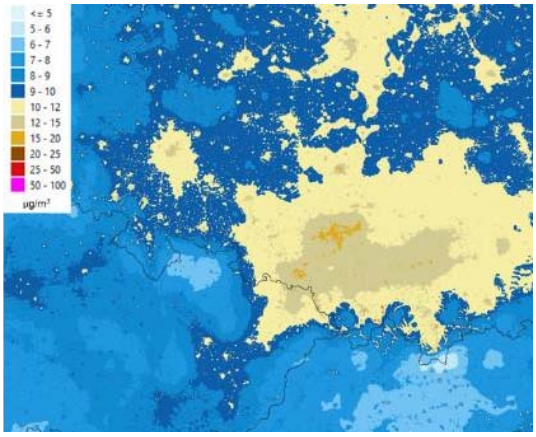
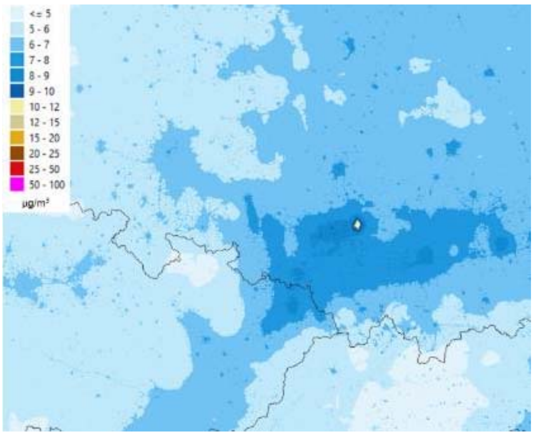


Figure A5.11 – **Focus: Region in Central Europe**. $PM_{2.5}$ annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 5 and 12 µg/m³. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

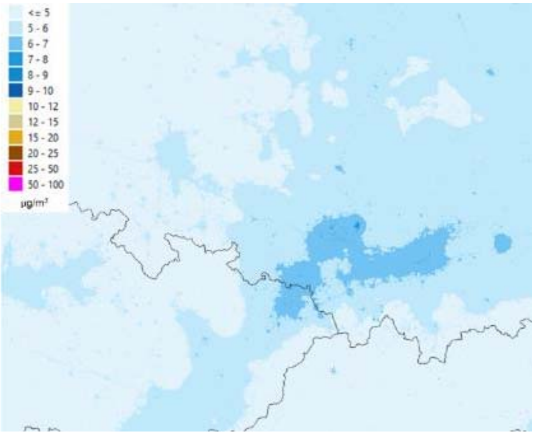
Base 2020



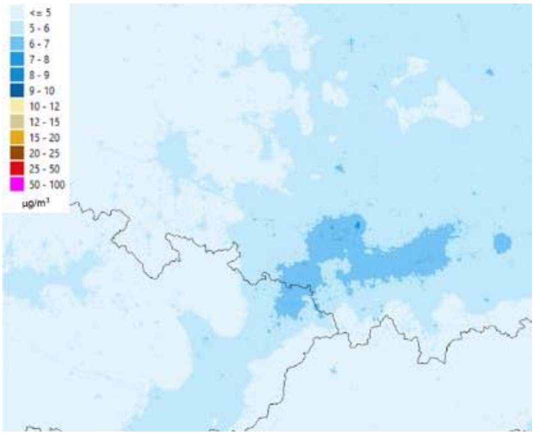
Base 2030



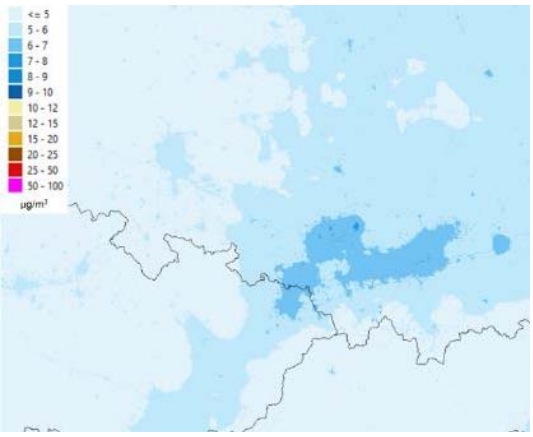
OPT-15 2030 (Policy Option I-3)



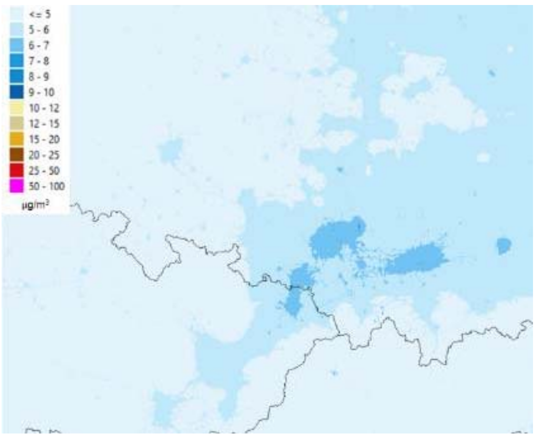
OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



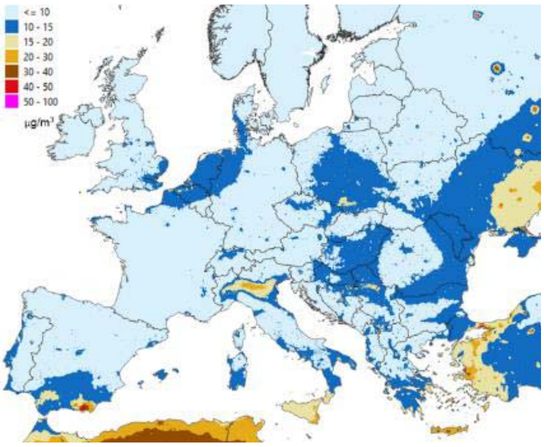
MTFR 2030



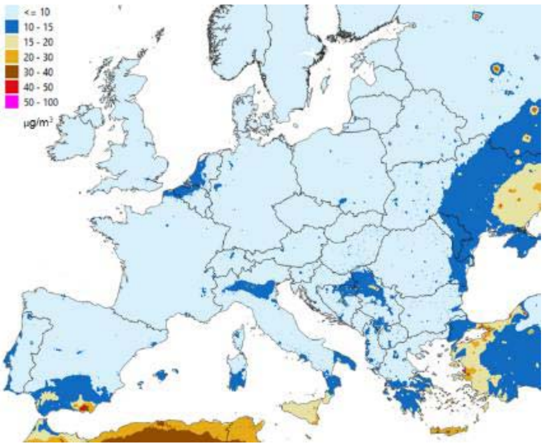
Maps for particulate matter - PM_{10}

Figure A5.12 - PM_{10} annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

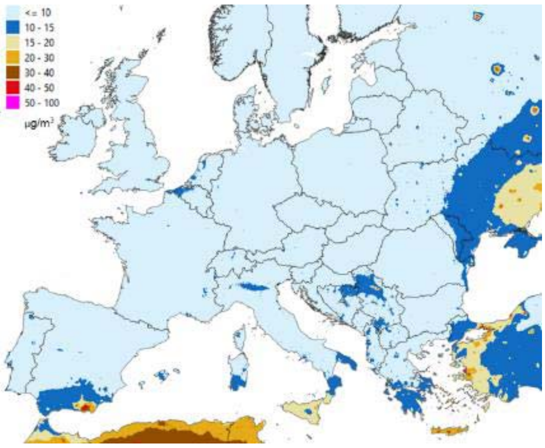
Base 2020



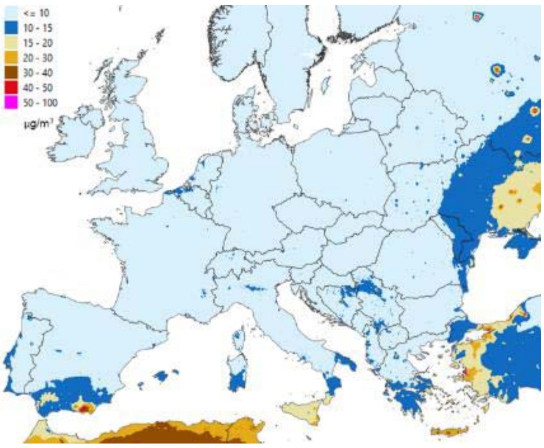
Base 2030



MTFR 2030



Base 2050



MTFR 2050

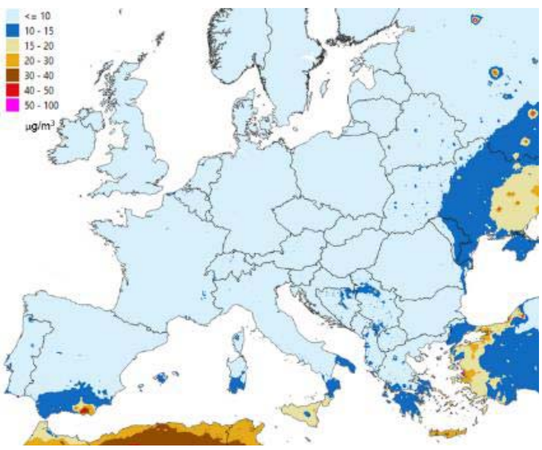
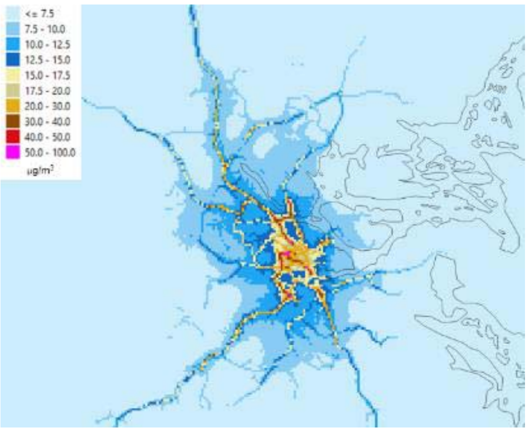
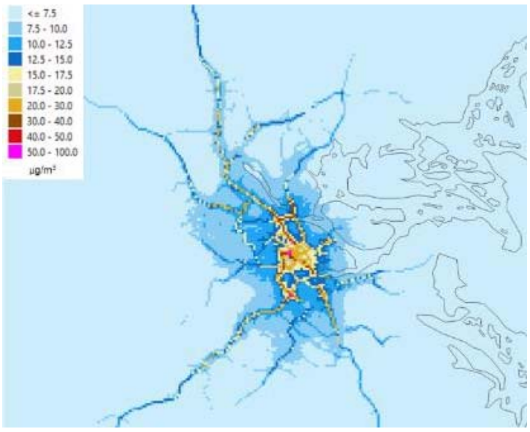


Figure A5.13 – **Focus: Region in Scandinavia.** PM_{10} annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Region shown is the city of Stockholm in Sweden. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 7.5 and 20 µg/m³. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

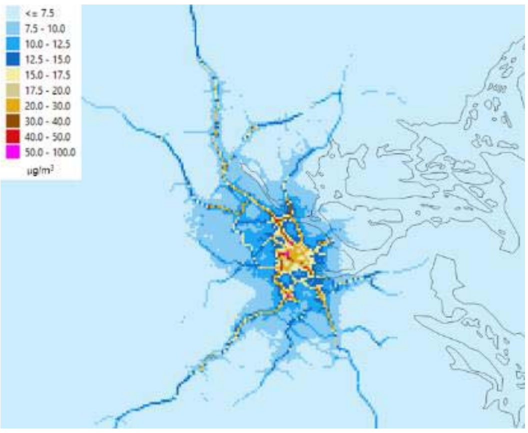
Base 2020



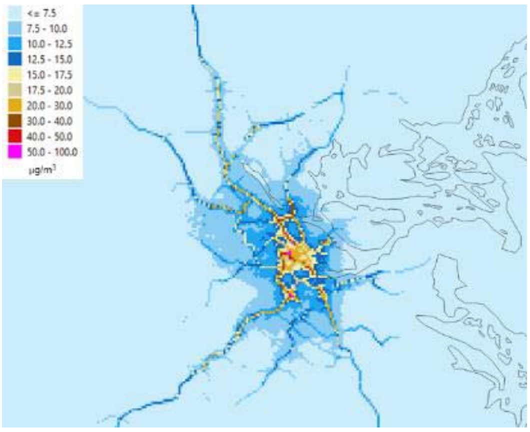
Base 2030



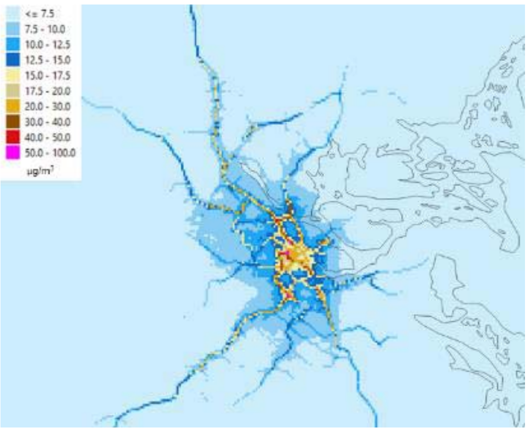
OPT-15 2030 (Policy Option I-3)



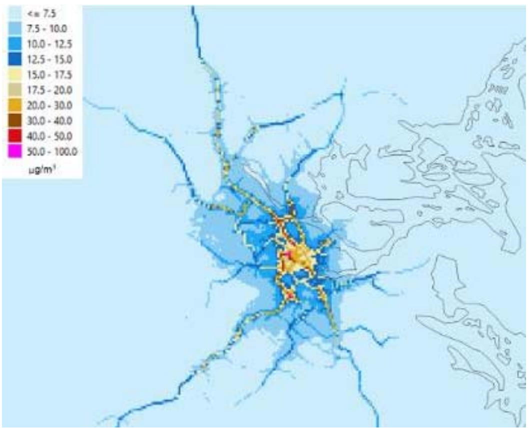
OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



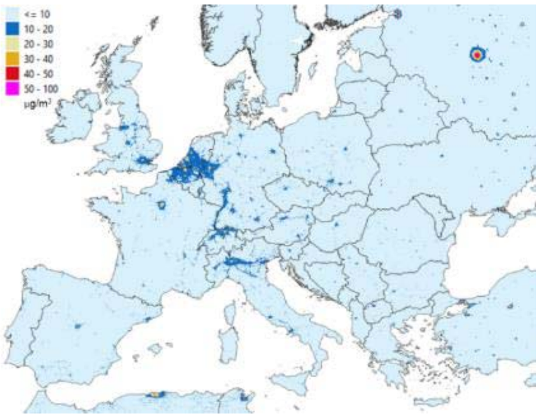
MTFR 2030



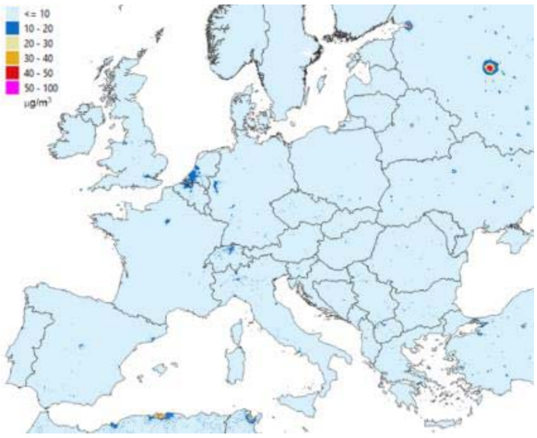
Maps for nitrogen dioxide - NO_2

Figure A5.14 - NO_2 concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

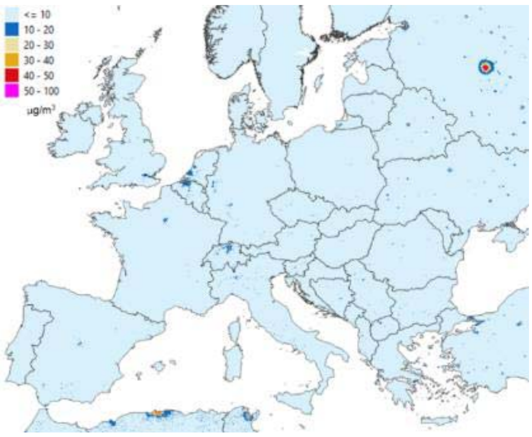
Base 2020



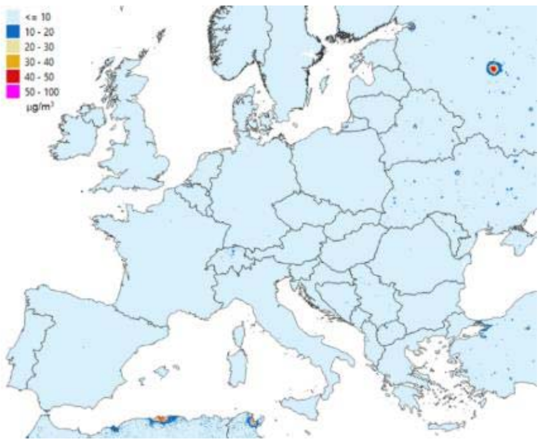
Base 2030



MTFR 2030



Base 2050



MTFR 2050

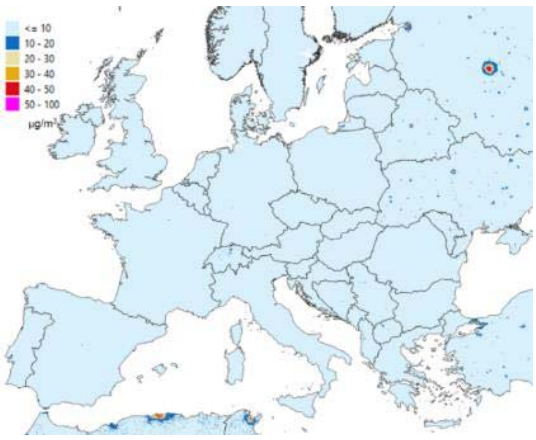
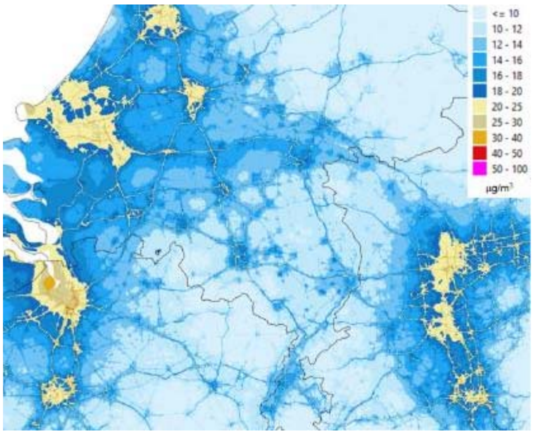
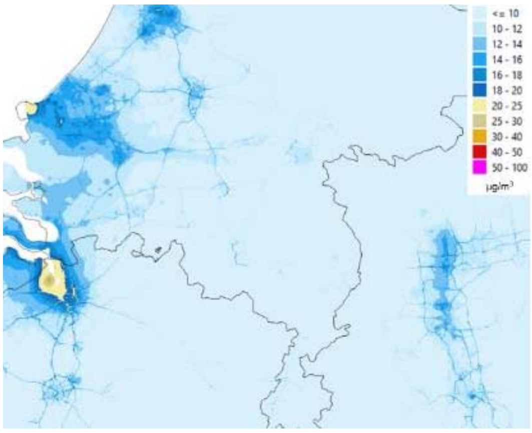


Figure A5.15 – **Focus: Region in North-Western Europe.** NO_2 annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Region in North-Western Europe including Belgium, Germany and The Netherlands. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 10 and 25 µg/m³. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

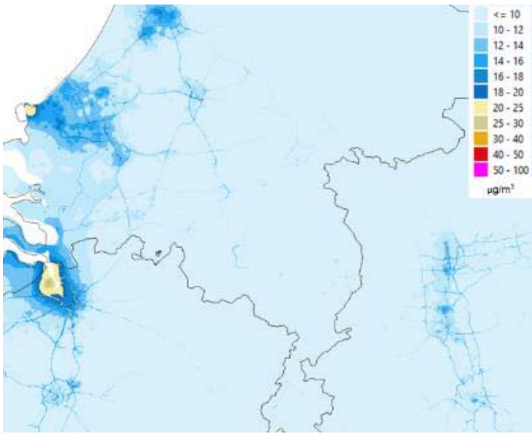
Base 2020



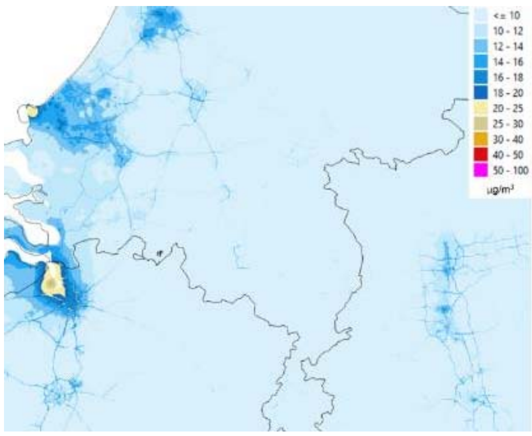
Base 2030



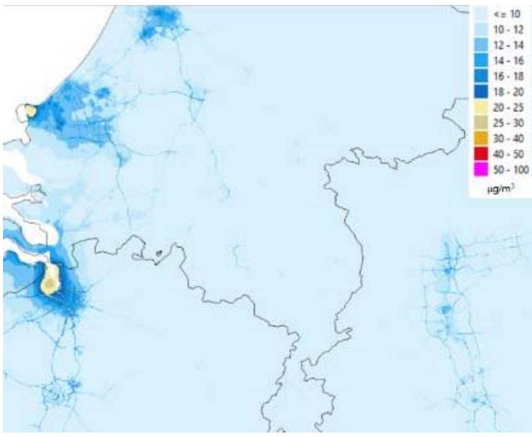
OPT-15 2030 (Policy Option I-3)



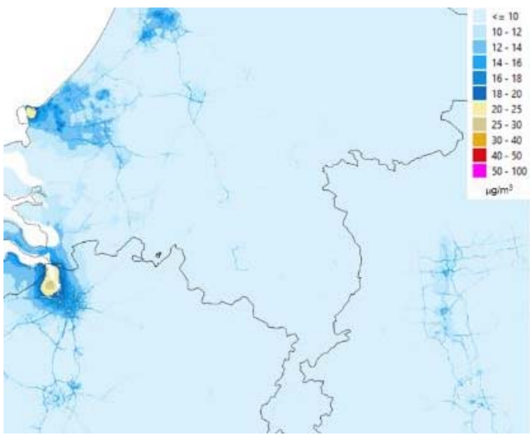
OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



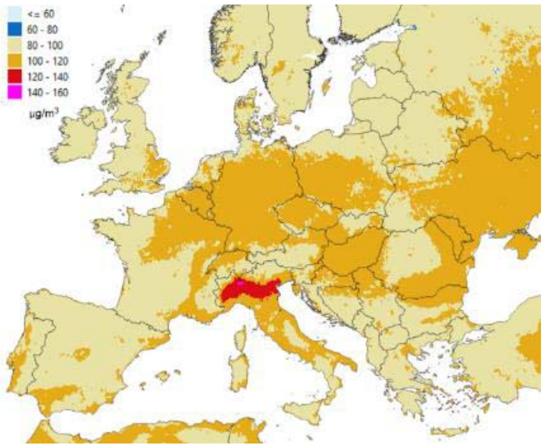
MTFR 2030



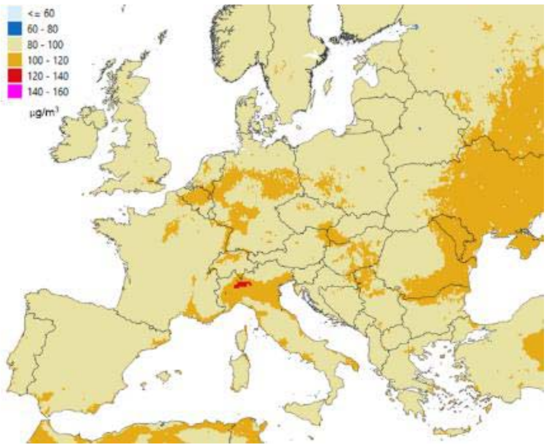
Maps for ozone – O_3

Figure A5.16 - O_3 (26th highest maximum 8 hour daily running mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

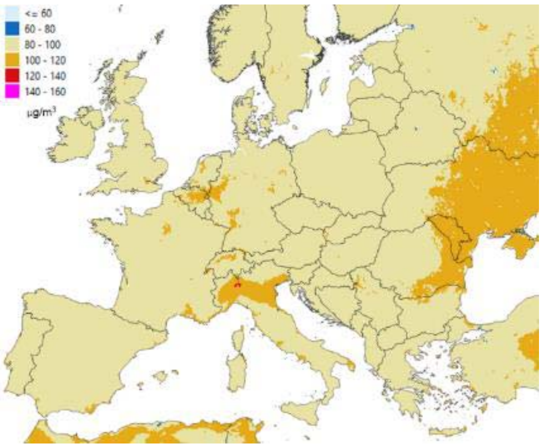
Base 2020



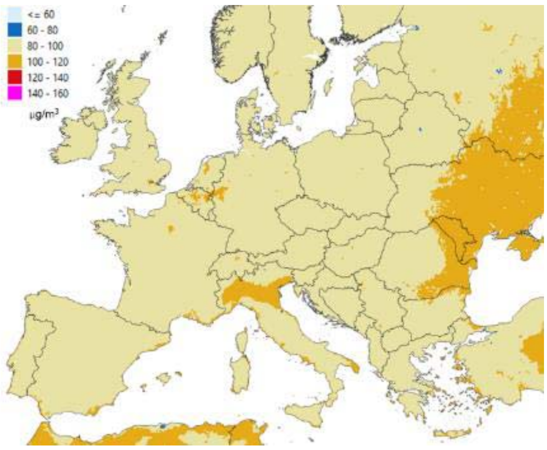
Base 2030



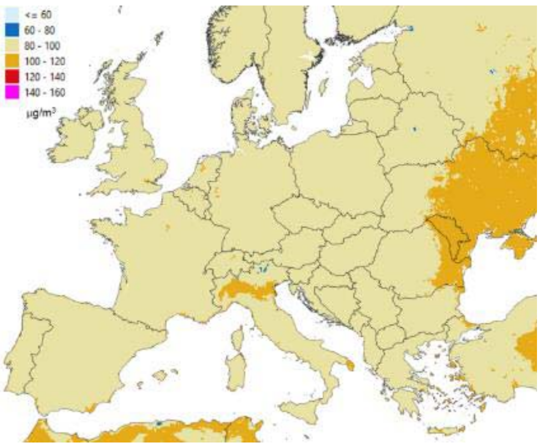
MTFR 2030



Base 2050



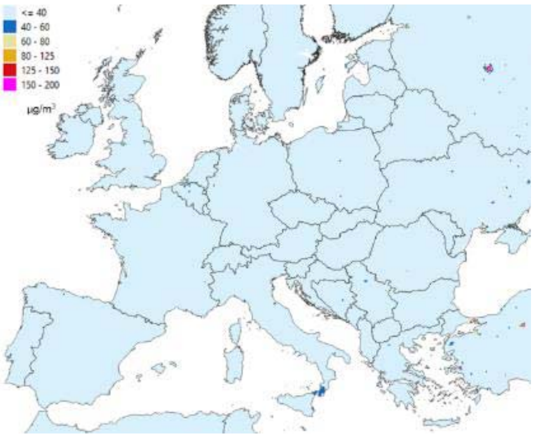
MTFR 2050



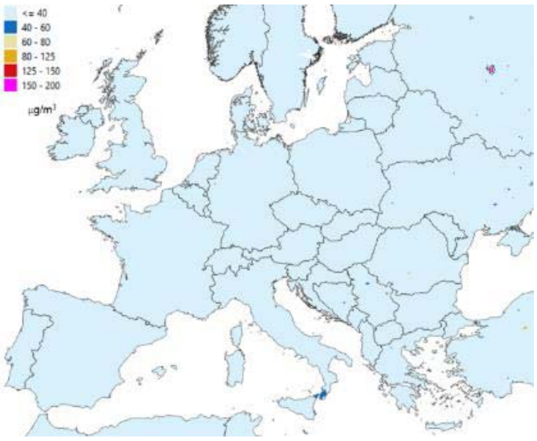
Maps for sulphur dioxide - SO_2

Figure A5.17 - SO_2 (99th percentile daily mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Annual means are calculated and converted to 99th percentiles. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

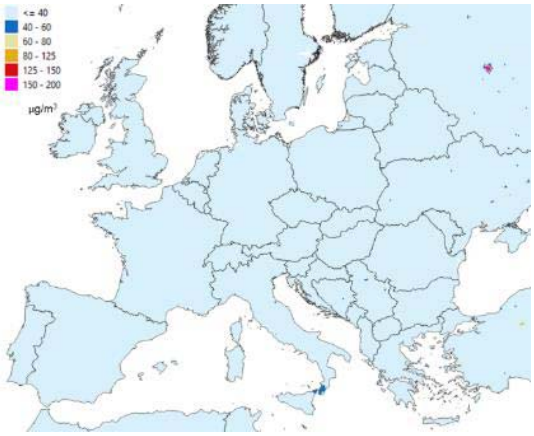
Base 2020



Base 2030

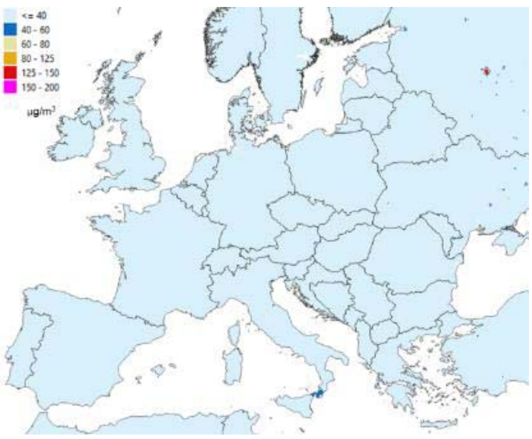


MTFR 2030



Base 2050

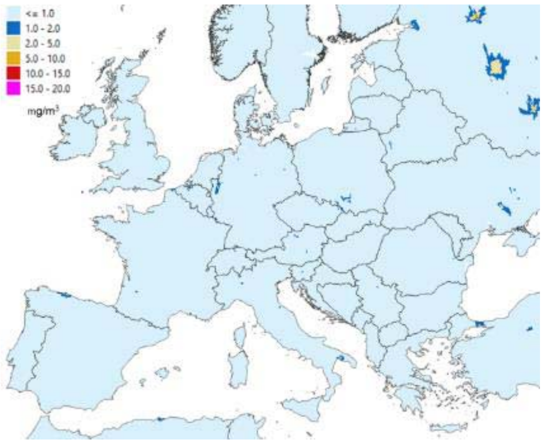
MTFR 2050



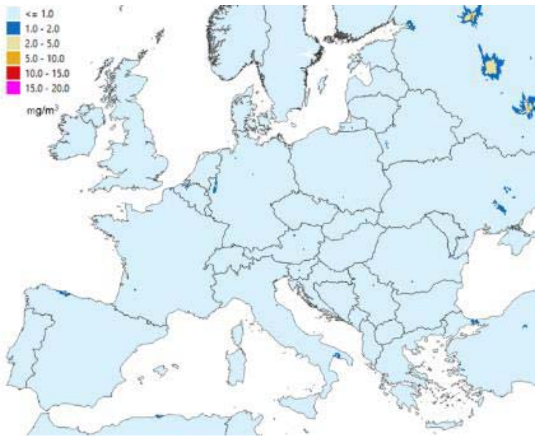
Maps for carbon monoxide - CO

Figure A5.18 - CO (highest maximum 8 hour daily running mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

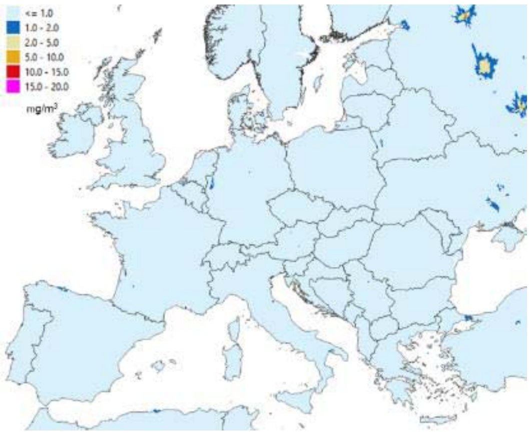
Base 2020



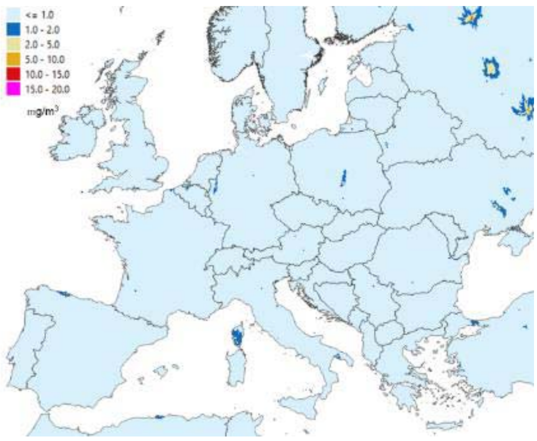
Base 2030



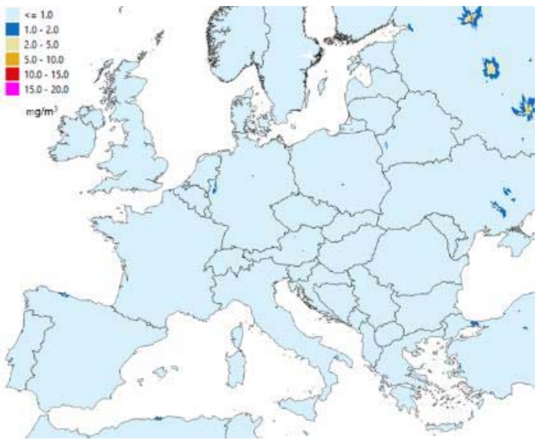
MTFR 2030



Base 2050



MTFR 2050



EUROPEAN
COMMISSION

Brussels, 26.10.2022
SWD(2022) 545 final

PART 3/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

on ambient air quality and cleaner air for Europe (recast)

{COM(2022) 542 final} - {SEC(2022) 542 final} - {SWD(2022) 345 final} - {SWD(2022) 542 final}

EN EN

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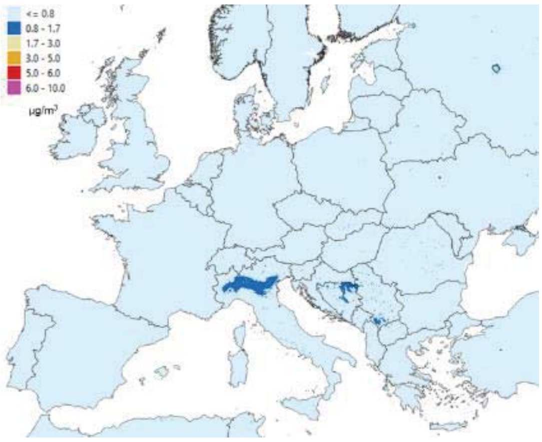
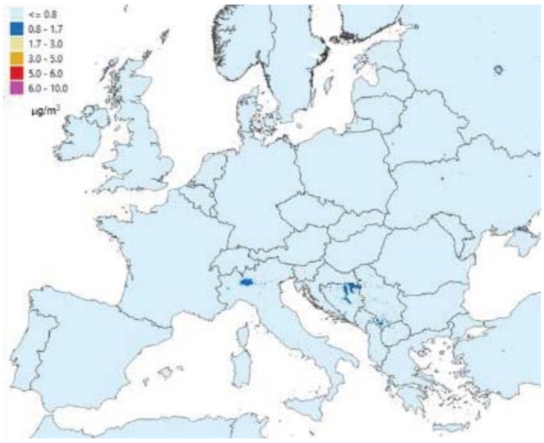
Maps for benzene – C_6H_6

Figure A5.19 - Benzene annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

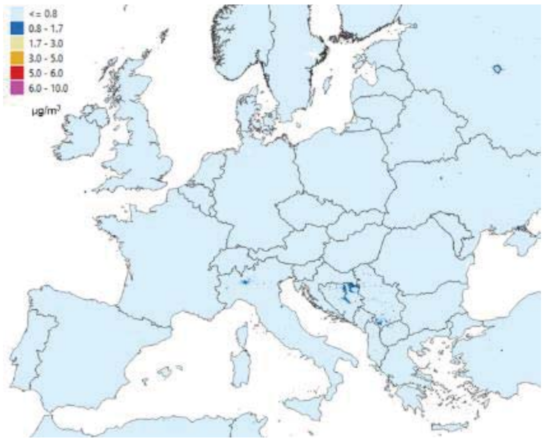
Base 2020



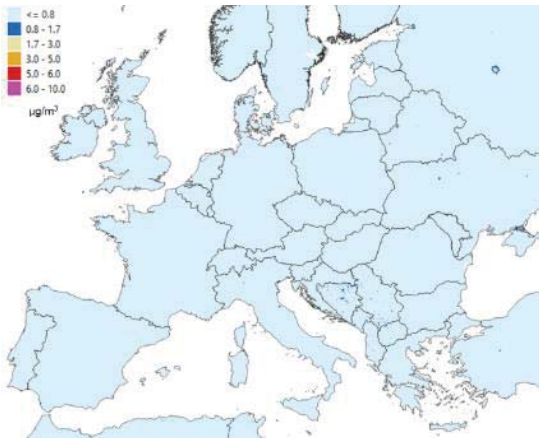
Base 2030



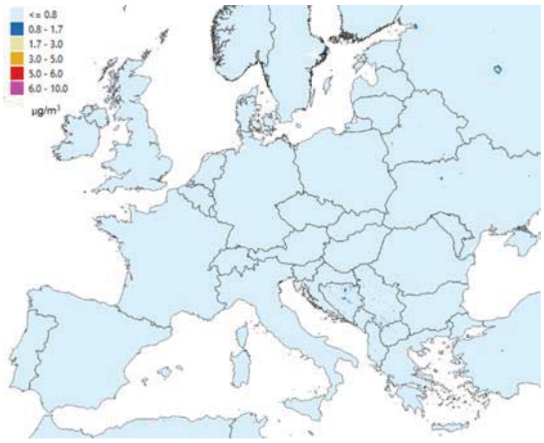
MTFR 2030



Base 2050



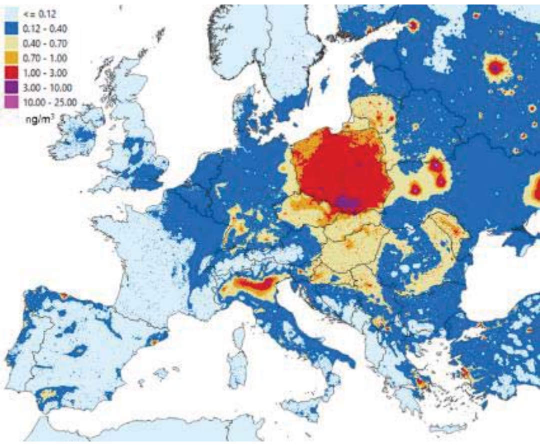
MTFR 2050



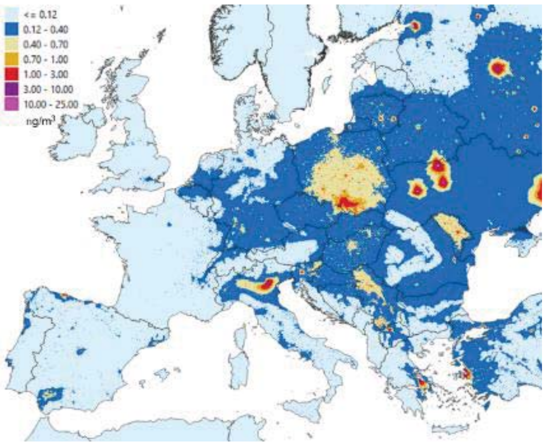
Maps for benzo(a)pyrene - BaP

Figure A5.20 - BaP annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

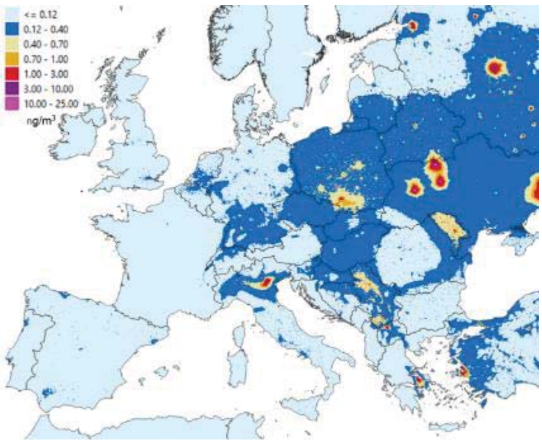
Base 2020



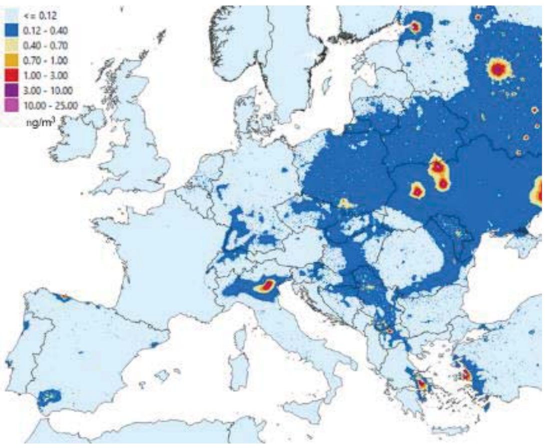
Base 2030



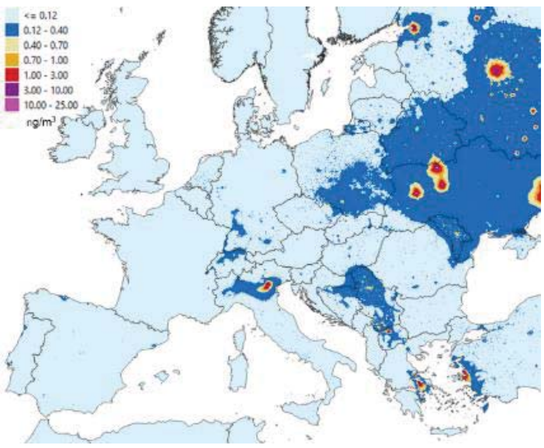
MTFR 2030



Base 2050



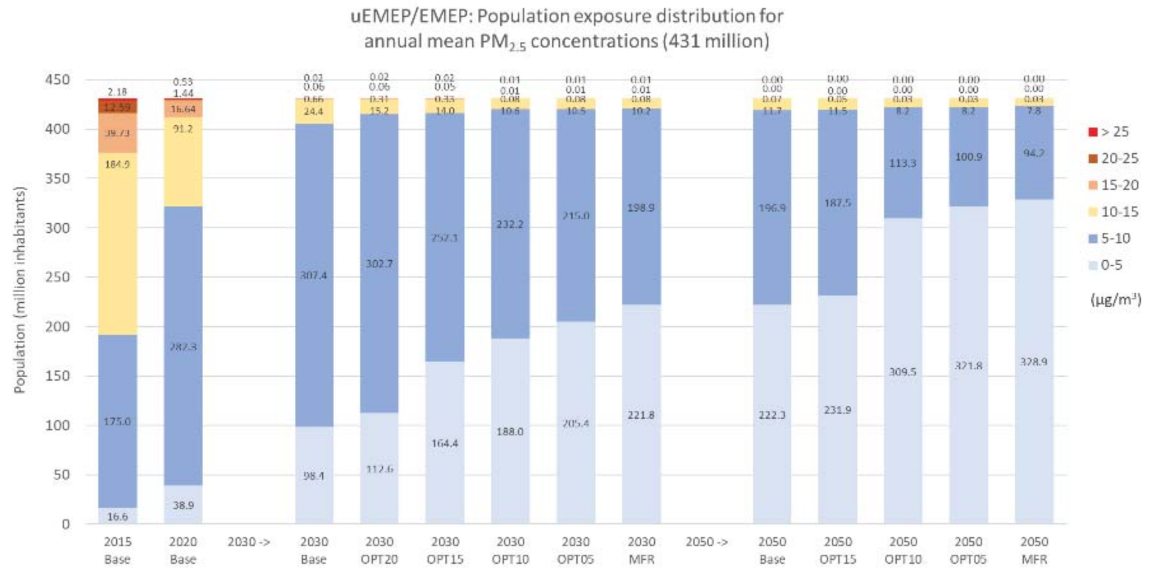
MTFR 2050

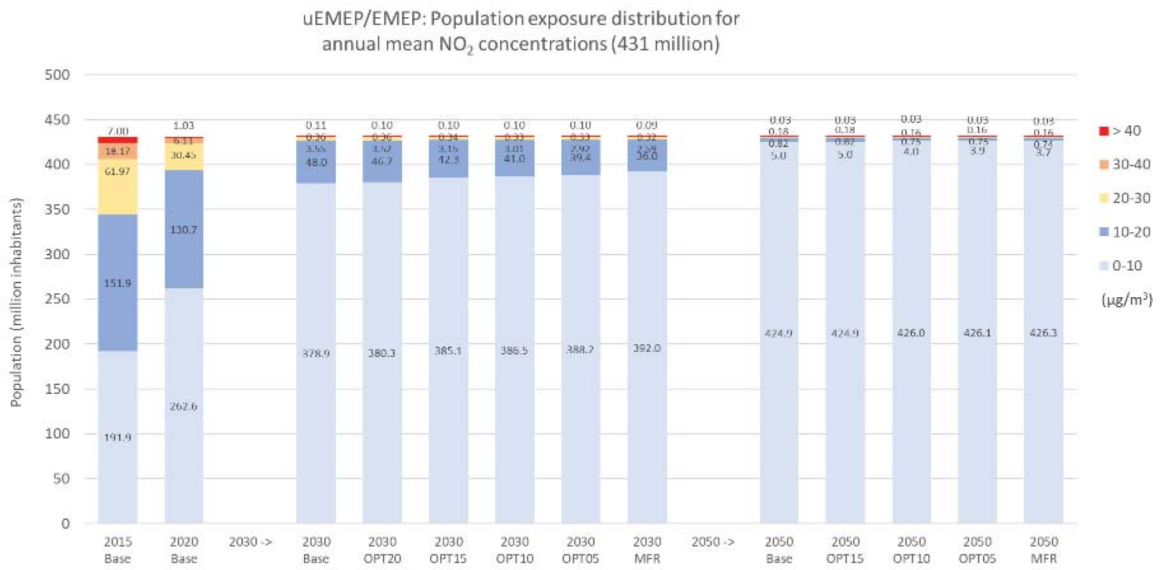


4. POPULATION EXPOSURE

In the next step of the analysis, the air pollutant concentrations have been translated into estimates for population exposure. The number of people exposed in the EU-27 above selected annual mean concentration ranges is presented for the pollutants $PM_{2.5}$ and NO_2. All Baseline, MTFR (or MFR) and optimised (OPT) scenarios are presented. The exposure calculations follow the same trends as seen for the station site calculations (results of which are included in the main SWD).

Figure A5.21– Number of people exposed above selected annual mean concentrations in the EU-27 for $PM_{2.5}$ and NO_2





As in the station calculations, the optimised scenarios do not attain their goals, with the exception of the less ambitious optimisations of 20 and 15 µg/m³ with less than 80 thousand inhabitants exposed above 15 µg/m^3. This is well within the uncertainty of the calculations. By 2050, all scenarios come close to attaining the WHO recommended NO_2 concentration level of 10 µg/m^3 but still with four to six million inhabitants exposed above this level.

Population exposure and source contributions

The results on population exposure are further broken down to show the split into the different sources of pollution at different levels of annual mean concentration.[50] The following points can be noted:

$PM_{2.5}$

- 530 000 inhabitants are exposed to $PM_{2.5}$ concentrations higher than 25 µg/m^3 in 2020 and this is chiefly attributable to residential emissions of primary $PM_{2.5}$;
- 16 000 inhabitants are exposed to $PM_{2.5}$ concentrations higher than 25 µg/m3 in 2030 but this number is well within the uncertainty of the methodology;
- In 2030, remaining high annual mean concentrations are mainly caused by residential emissions;
- Where low annual mean concentrations prevail, the relative importance of secondary sources as well as natural sources increases;
- In 2030, non-exhaust $PM_{2.5}$ emissions from road transport become a significant source contribution in some cities, notably Nordic countries. Non-exhaust emissions remain unchanged for all scenarios;
- Local primary $PM_{2.5}$ sources (i.e. all sources in lower case letters in figures below) that are emitted from within the ± 0.4° window, account for 22% of the total $PM_{2.5}$ European exposure in 2020.

NO_2

- In 2020, the major source of NO_X contributing to NO_2 concentrations for all exposure levels is local road traffic, i.e. emitted from within the ± 0.4° window;
- In 2030, road traffic contributes very little and the dominant source leading to exposures above 10 µg/m^3 is shipping. There is a large degree of uncertainty in these local emission sources at ports.

BaP

- In 2020, the dominant source for BaP is residential heating, followed by some individual industrial emissions;
- In 2020, around 80 million inhabitants were exposed above the current EU limit value of 1 ng/m^3. This was mostly in Poland and in Northern Italy. In 2030, this is reduced to 15 million;

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[50] The underlying support study contains graphics showing the population exposed over a range of annual mean concentration, as well as the relative source contributions for the given exposure level.

- In 2030, residential heating remains the dominant source at concentration levels of up to 2 ng/m^3, with industrial sources dominating above 2 ng/m^3;
- With respect to industrial sources these exceedances are chiefly the result of one individual industrial plant in Northern Italy, Vicenza, and some lesser contributions in Spain and Poland. These emissions remain uncertain, both in present day and how they will evolve in the future.

The optimised calculations show similar results to the baseline scenario and MTFR scenarios but with a general reduction in concentrations from baseline scenario to MTFR.

5. HEALTH IMPACTS

Results for attributable mortality (Tier 1)

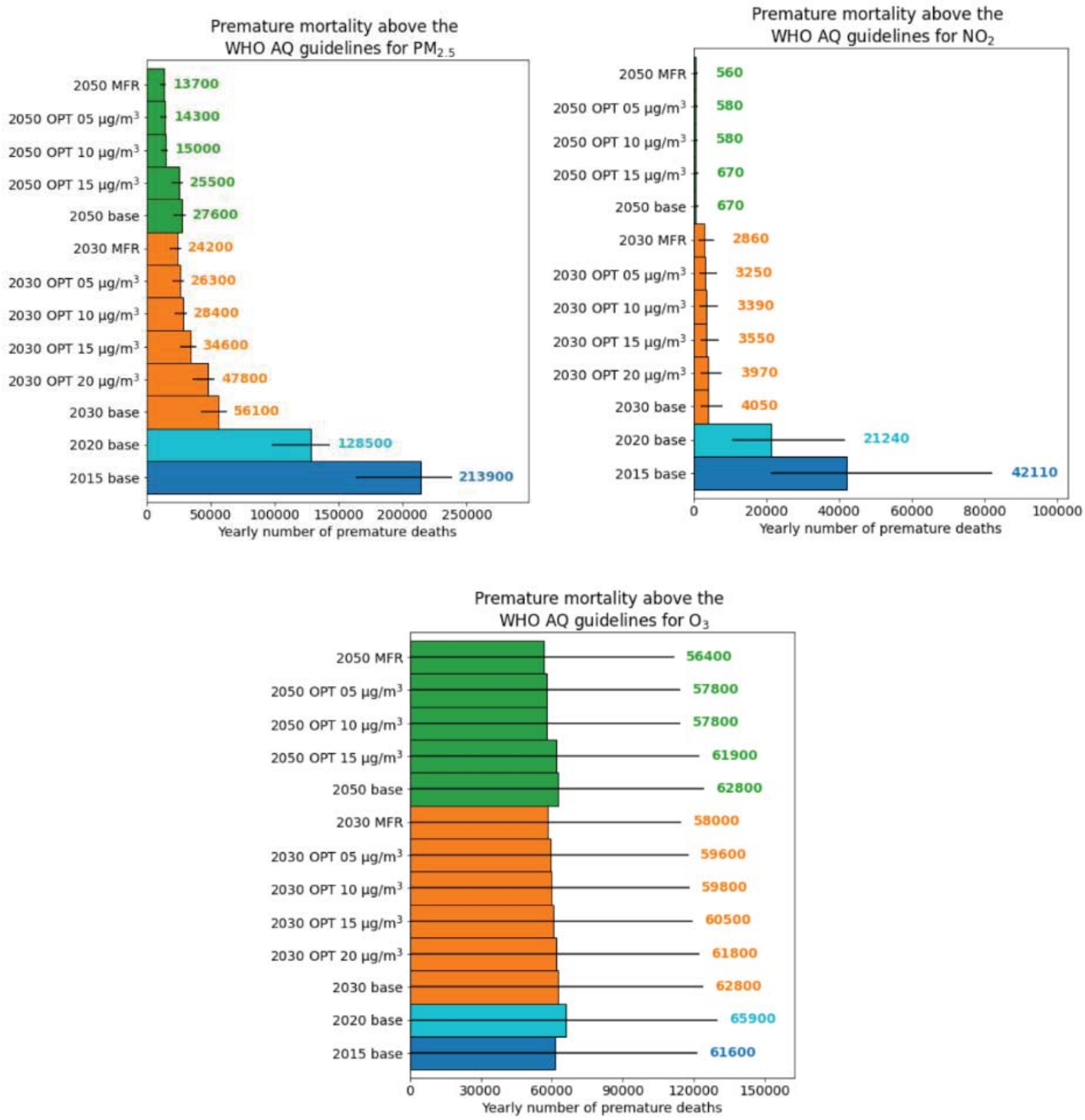
The impact of the various scenarios on the total number of yearly attributable deaths in the EU-27 for the three pollutants under consideration ($PM_{2.5}$, NO_2, O_3) is shown in the bar graphs in Figure A5.22 (total number of premature deaths) and Figure A5.23 (relative differences between the baseline and the scenarios). These charts and numbers refer to the health impact *above* the WHO air quality guideline concentration levels; all excess mortality caused by concentrations *below* these cut-offs is not taken into account.

For **particulate matter**, the relative impact of the policy scenarios depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios (as e.g. for the 20 µg/m^3 scenario in 2030 and the 15 µg/m^3 in 2050), the health impact of the scenarios is rather limited (15% for the 20 µg/m^3 scenario in 2030 and 8% for the 15 µg/m^3 scenario in 2050). For all other scenarios, the health impact for the OPT scenarios is significant (at least 38% in 2030 and at least 46% in 2050), and in many cases the difference between the health impact of the policy scenarios and the MTFR scenario is rather limited. As an example, the difference in health impact between the 10 µg/m^3 on the one hand, and the MTFR on the other hand is only 8% in 2030 and only 4% in 2050.

For **nitrogen dioxide**, the impact (relative to the baseline) for the policy scenarios depends on the year under consideration. For 2030, the 20 µg/m^3 has only a limited impact (2%), while the impact gradually increases for the more stringent scenarios (12%, 16%, and 20% respectively for 15 µg/m^3, 10 µg/m^3 and 5 µg/m^3). In 2050, the impact (relative to the baseline) of the 15 µg/m^3 scenario is small (1%), while the impact for the other policy scenarios is very similar to the impact of the MTFR scenario (14% reduction for both the 10 µg/m^3 and 5 µg/m^3, compared to 16% for MTFR). Finally, for ozone, the impact of the policy scenarios is small, with especially only marginal reductions for the 20 µg/m^3 and the 15 µg/m^3 scenario.

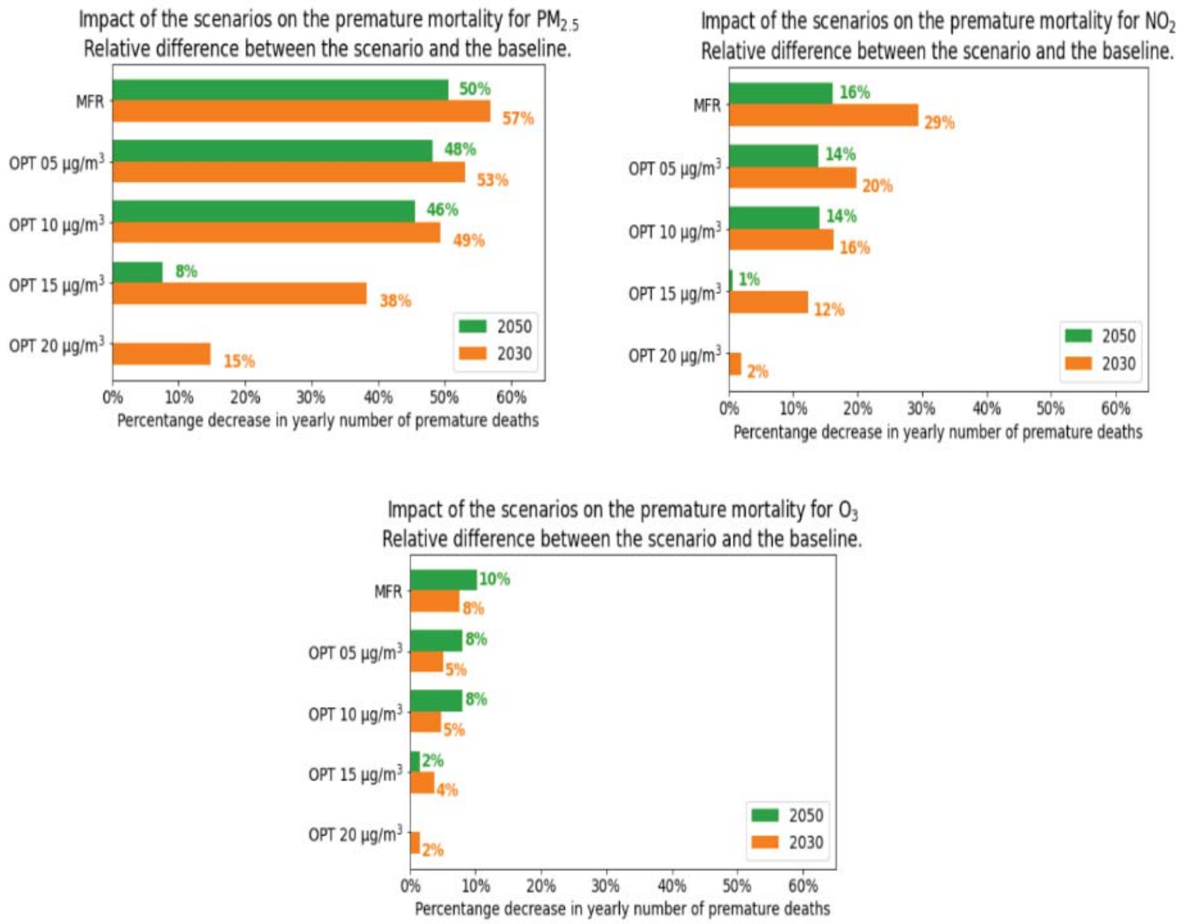
The support studies in its annexes provides further geographical breakdown of the results reported here at aggregate EU-27 level, indicating a rather stable spatial pattern across scenarios.

Figure A5.22 – Number of yearly premature deaths in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for all scenarios for three pollutants ($PM_{2.5}$, top-left, NO_2, top-right, O_3, bottom) based on the outcome of the modelling applied for this impact assessment[51]



[51] Notes: Impacts for the four reporting years considered in the study (2015 in blue, 2020 in cyan, 2030 in orange and 2050 in green) are included. The filled bars and the numbers refer to the central estimate (rounded to the nearest 100 for NO_2 and the nearest 1000 for $PM_{2.5}$, respectively), while the black lines provide the 95-percentage uncertainty estimate based on the uncertainty on the relative risks.

Figure A5.23 – Relative impact of the scenario on the number of yearly premature deaths in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for three pollutants ($PM_{2.5}$, top-left; NO_2, top-right; O_3, bottom) based on the outcome of the modelling applied for this impact assessment [52]

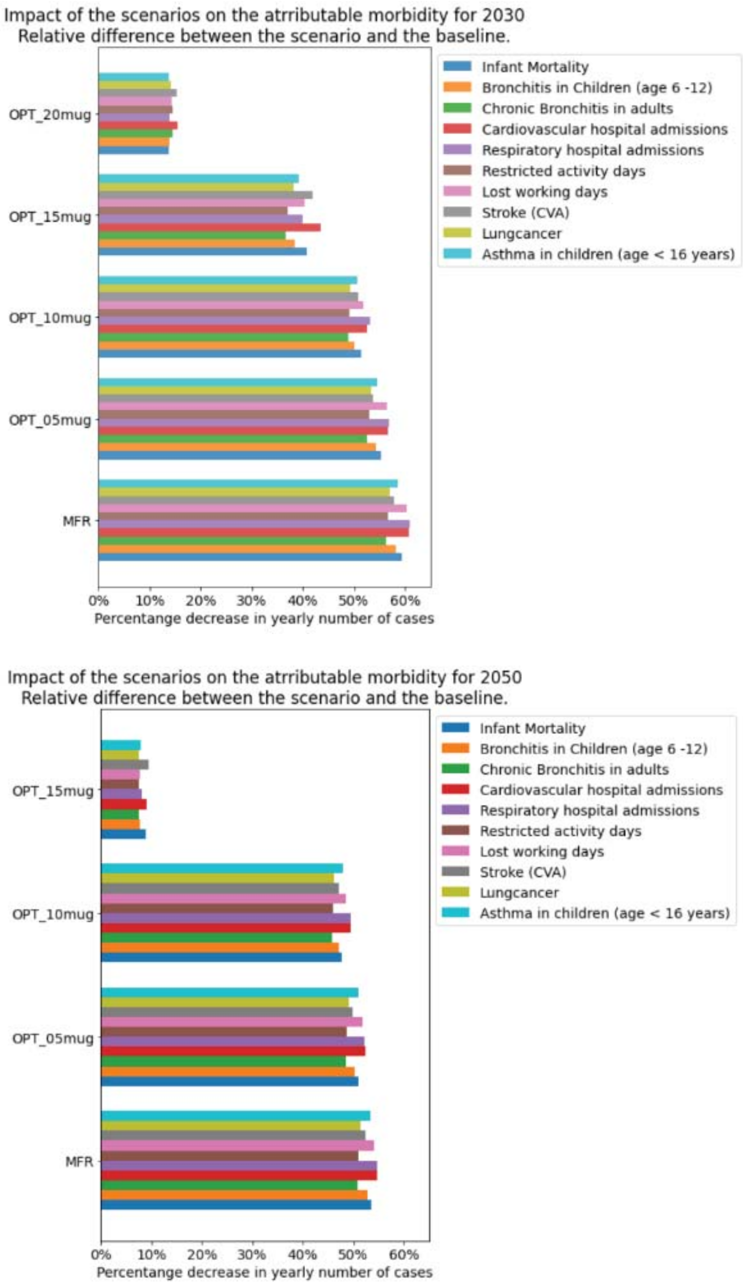


Results for attributable morbidity (Tier 2 and Tier 3)

Figure A5.24 provides an overview of the relative impact of the scenarios on the morbidity from the second (morbidity according to HRAPIE) and third tiers (additional health outcomes beyond HRAPIE: stroke, lung cancer and asthma in children). For all health outcomes, the results correspond qualitatively and quantitatively with those for the chronic mortality caused by $PM_{2.5}$ exposure. The relative impact of the policy scenarios depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios, the health impact of the scenarios is rather limited, in line with the results for mortality. For all other scenarios, the health impact for the policy scenarios is significant, and in many cases the difference between the health impact of the policy scenarios and the MTFR scenario is rather limited.

[52] Notes: Impacts for the two future reporting years considered in the study (2030 in orange and 2050 in green) are included.

Figure *A5.24 – Relative impact of the scenarios on the morbidity in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for 2030 (top) and 2050 (bottom)*[53]



Health impacts - summary results

From this analysis, several conclusion can be drawn regarding the health impacts of the scenarios:

[53] Notes: The various bars correspond to the various morbidity outcomes considered in the main analysis of the study (Tier 2 and Tier3).

- Under the **baseline scenario**, the mortality caused by exposure to $PM_{2.5}$ and NO_2 decreases significantly from 2015 to 2030. However, there would still be a considerable number of premature deaths each year observed in 2030, with tens of thousands of attributable deaths per year caused by the exposure to $PM_{2.5}$ and thousands of deaths caused by the exposure to NO_2:
    - For **particulate matter**, the baseline attributable mortality is larger in Eastern and Southern European countries, in comparison with the impact in most Northern and Western European countries (which is in line with the spatial pattern of the baseline emissions and the natural contribution).
    - The results for **nitrogen dioxide** reflect the nature of the nitrogen dioxide pollution: because concentration hotspots are mostly linked to important local shipping and traffic emissions, also the highest baseline mortality is observed at these locations.
- The measures taken under the **MTFR scenario** have a significant impact on the health impact caused by the exposure to particulate matter (reductions with more than 55% in 2030, and with approximately 50% in 2050). Despite these strong reductions, a significant health impact remains under the application of the MTFR scenario, with more than 20 000 yearly attributable deaths in 2030 and more than 10 000 yearly attributable deaths in 2050. The impact of the MTFR scenario is somewhat more limited for the mortality caused by nitrogen dioxide pollution (relative reductions of 29% (2030) and 16% (2050) scenario).
- The relative impact of the different **policy scenarios** depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios (e.g. 20 $\mu g/m^3$ scenario in 2030 and the 15 $\mu g/m^3$ in 2050), the health impact of the scenarios is rather limited. For all other scenarios, the difference in health impact for the policy scenarios is similar to the health impact of the MTFR scenario:
    - For **particulate matter**, a strong regional difference in the impacts of the MTFR scenario is observed, as smaller relative impacts are observed in Southern Europe in comparison with other regions (due to the impact of the natural contribution and the minor reductions in shipping emissions).
    - For **nitrogen dioxide**, the highest reduction in attributable mortality is observed at the hotspots for which the emissions are reduced by the greatest margin;
- Results for **morbidity** show similar pattern to the results for mortality.

Economic valuation – benefits from reduced health impacts

In line with the valuation methods described in Annex 4, the costs of air pollution arising from impacts on human health and ecosystems were monetised. Comparing the costs estimated for the policy scenarios to the baseline scenario, yields a monetised estimate of the benefits associated with the reduced impacts observed in the policy scenarios. These benefits are summarised in chapter 6 of the main document, whereas Table A5.1 below presents the underlying results per scenario for **health impacts**. The annexes to the support study contain further detailed breakdown of estimates per health outcome and pollutant.

As can be seen from the results, there is a marked difference in the monetised human health benefits depending on the approach taken and on the scenario. Monetised benefits are smaller under the VOLY than VSL approach. The benefits increase, as expected, with the ambition of the scenario. The benefits reduce over time as more progress is made in the baseline, which erodes the additional benefit of further action under the mitigation scenarios.

Across all scenarios, mortality effects contribute the vast majority of the overall valued effects: the share of morbidity effects in the total valuation of human health benefits ranges from 1-6% across scenarios and years under the VSL approach, to 5-19% under the VOLY approach.

Approach to valuing mortality	Scenario	2020	2030	2050
VSL	Baseline	739	444	332
VSL	($PM_{2.5}$ at 20 µg/m³)	-	408	-
VSL	**I-3** ($PM_{2.5}$ at 15 µg/m³)	-	352	320
VSL	**I-2** ($PM_{2.5}$ at 10 µg/m³)	-	325	266
VSL	**I-1** ($PM_{2.5}$ at 5 µg/m³)	-	317	263
VSL	MTFR	-	303	256
VOLY	Baseline	251	140	90
VOLY	($PM_{2.5}$ at 20 µg/m³)	-	128	-
VOLY	**I-3** ($PM_{2.5}$ at 15 µg/m³)	-	109	87
VOLY	**I-2** ($PM_{2.5}$ at 10 µg/m³)	-	100	71
VOLY	**I-1** ($PM_{2.5}$ at 5 µg/m³)	-	97	70
VOLY	MTFR	-	92	68
Net VSL	*($PM_{2.5}$ at 20 µg/m³)*	-	*36*	-
Net VSL	***I-3** ($PM_{2.5}$ at 15 µg/m³)*	-	*92*	*12*
Net VSL	***I-2** ($PM_{2.5}$ at 10 µg/m³)*	-	*119*	*66*
Net VSL	***I-1** ($PM_{2.5}$ at 5 µg/m³)*	-	*127*	*69*
Net VSL	*MTFR*	-	*141*	*77*
Net VOLY	*($PM_{2.5}$ at 20 µg/m³)*	-	*12*	-
Net VOLY	***I-3** ($PM_{2.5}$ at 15 µg/m³)*	-	*31*	*3*
Net VOLY	***I-2** ($PM_{2.5}$ at 10 µg/m³)*	-	*40*	*19*
Net VOLY	***I-1** ($PM_{2.5}$ at 5 µg/m³)*	-	*43*	*20*
Net VOLY	*MTFR*	-	*48*	*22*

Table A5.1 – Costs and benefits ("Net" values) to society (valuation of health impacts – both mortality and morbidity, with approach to valuing mortality indicated in the first column) per year – central estimate (all values €bn 2015 prices, EU-27)

6. ECOSYSTEM AND OTHER NON-HEALTH IMPACTS

Results for ecosystem areas exceeding critical loads for acidification and eutrophication

The following table presents the monetised impacts of air pollution on ecosystems (incl. productive ones) as well as material damage (mainly built environment) under the baseline, policy and MTFR scenarios. The size of the damage in the baseline and scenarios reduces over time alongside further emissions reductions delivered through current policy. The monetised benefits increase with the ambition under each scenario, as further reduction in air pollutant emissions are delivered. The scenarios and MTFR can deliver substantial benefits for ecosystems and from reduced material damage, however the aggregate size of these benefits is still smaller than the human health benefits.

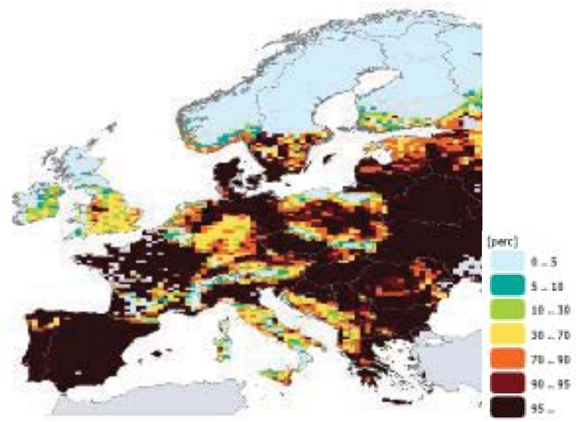
This section presents indicators on ecosystem impacts in terms of acidification and eutrophication from excess deposition of nitrogen (for acidification and eutrophication) and sulphur (for acidification). Results are calculated with the GAINS model using critical loads approved by the Air Convention in 2017.

Maps of ecosystem areas exceeding critical loads for acidification and eutrophication (percentages of area above critical load) from deposition of nitrogen and sulphur are shown in Figures A5.25 and A5.26 for the Baseline and MTFR scenarios and the years 2020, 2030 and 2050. Eutrophication is still a widespread problem in Europe, with an estimated 74% of all ecosystem areas exceeding critical loads. Despite improvements in 2030 and even further in 2050, still ~65% of ecosystem areas are expected to exceed critical loads for eutrophication in 2050 under the baseline scenario. Under the MTFR scenario, this is reduced to 48% in 2050. Acidification is much less of an issue, with 4.8% of ecosystem areas currently exceeding the critical loads, decreasing to 3.1% in 2030 and 2.4% in 2050 under the Baseline scenario (1.2% in 2050 under the MTFR scenario).

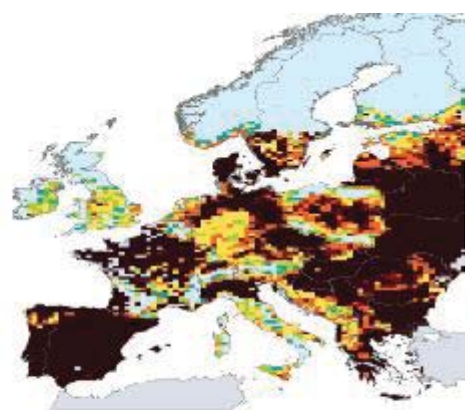
The support study includes tables that differentiate the impacts of the different scenarios in terms of area shares of different types of ecosystems where critical loads for eutrophication and acidification are exceeded by Member State.

Figure A5.25 – Shares of ecosystem area exceeding critical loads for **eutrophication**

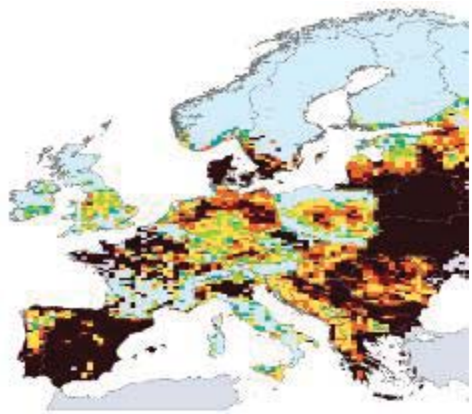
Baseline 2020



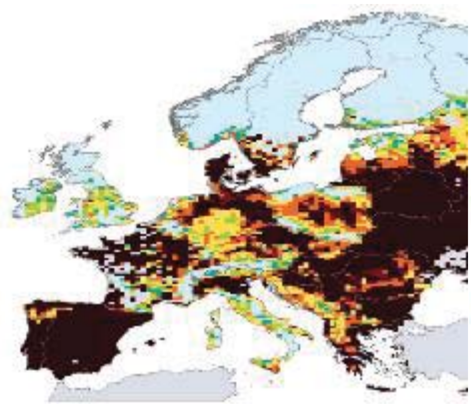
Baseline 2030



MTFR 2030



Baseline 2050



MTFR 2050

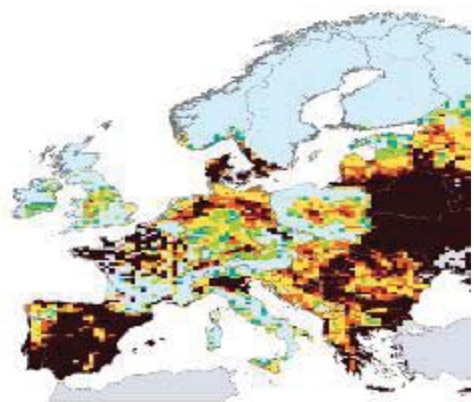
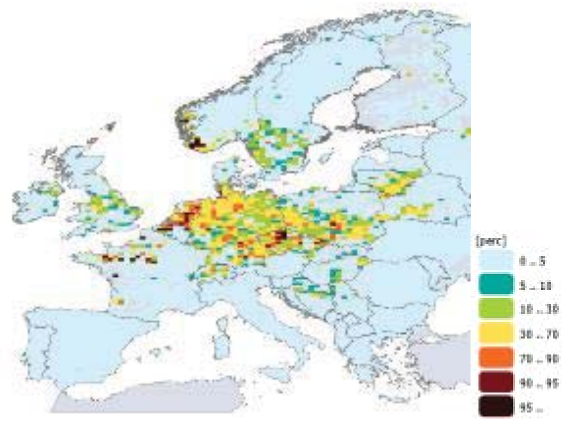
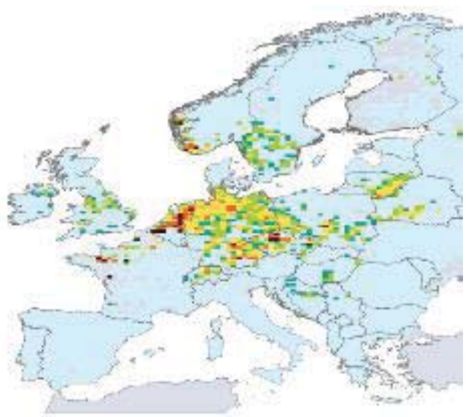


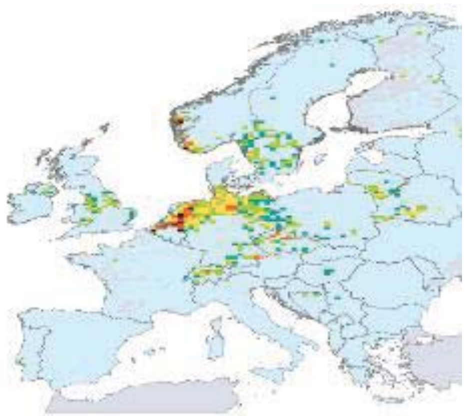
Figure A5.26 – Shares of ecosystem area exceeding critical loads for **acidification**

Baseline 2020

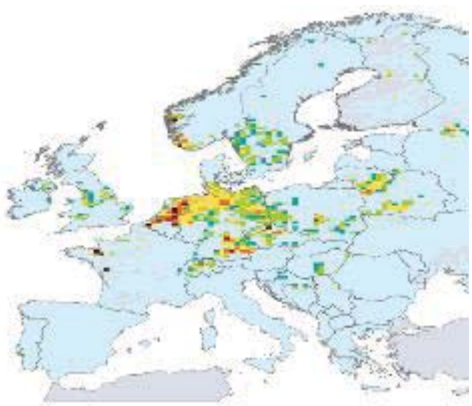


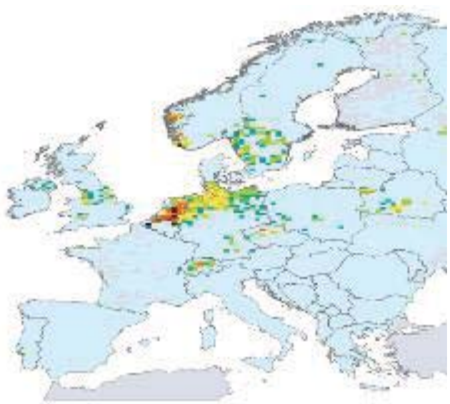
Baseline 2050 ***MTFR 2050***





Baseline 2050 ***MTFR 2050***





Economic valuation – benefits from reduced material damage and impacts on ecosystems

Table A5.2 presents the monetised impacts of air pollution on crops, productive forests and other ecosystems as well as material damage (mainly built environment) under the baseline, policy and MTFR scenarios. The size of the damage in the baseline and scenarios reduces over time alongside further emissions reductions delivered through current policy. The monetised benefits increase with the ambition under each scenario, as further reduction in air pollutant emissions are delivered. The scenarios and MTFR can deliver substantial benefits from reduced damage, however the absolute size of these benefits is several orders of magnitude smaller than the human health benefits.

Table A5.2 – Monetised material, crop and forest damage impacts per year. Gross values (upper part) and *benefit from reduced damage relative to baseline* (lower, NET part of table) – EUR million 2015 prices

	2020	**2030**	**2050**	**2020**	**2030**	**2050**	**2020**	**2030**	**2050**
	Material damage			*Crop damage*			*Forest damage (LOW)*		
Baseline	1,136	662	442	10,691	9,877	9,459	19,050	17,975	17,374
($PM_{2.5}$ at 20 µg/m^3)		633			9,809			17,906	
I-3 ($PM_{2.5}$ at 15 µg/m^3)		481	430		9,689	9,415		17,752	17,321
I-2 ($PM_{2.5}$ at 10 µg/m^3		466	286		9,623	9,200		17,688	17,082
I-1 ($PM_{2.5}$ at 5 µg/m^3)		458	281		9,600	9,201		17,659	17,080
MTFR		436	269		9,472	9,110		17,486	16,954
NET at 20 µg/m3)		*29*			*67*			*69*	
NET at 15 µg/m3)		*181*	*12*		*188*	*44*		*222*	*52*
NET at 10 µg/m3)		*196*	*156*		*254*	*259*		*287*	*292*
NET at 5 µg/m3)		*204*	*160*		*276*	*258*		*316*	*293*
NET MTFR		*226*	*172*		*404*	*348*		*488*	*420*
	Ecosystem damage (LOW)			*Ecosystem damage (HIGH)*			*Forest (HIGH)* [54]		
Baseline	3,901	3,588	3,375	11,702	10,765	10,124			42,217
($PM_{2.5}$ at 20 µg/m^3)		3,488			10,463				
I-3 ($PM_{2.5}$ at 15 µg/m^3)		3,140	3,291		9,420	9,874			42,090
I-2 ($PM_{2.5}$ at 10 µg/m^3		2,883	2,585		8,648	7,754			41,505
I-1 ($PM_{2.5}$ at 5 µg/m^3)		2,726	2,443		8,177	7,330			41,501
MTFR		2,588	2,328		7,765	6,984			41,194
NET at 20 µg/m3)		*101*			*302*				
NET at 15 µg/m3)		*448*	*83*		*1,345*	*250*			*127*
NET at 10 µg/m3)		*706*	*790*		*2,117*	*2,370*			*712*
NET at 5 µg/m3)		*863*	*931*		*2,588*	*2,794*			*716*
NET MTFR		*1,000*	*1,047*		*3,000*	*3,140*			*1,023*

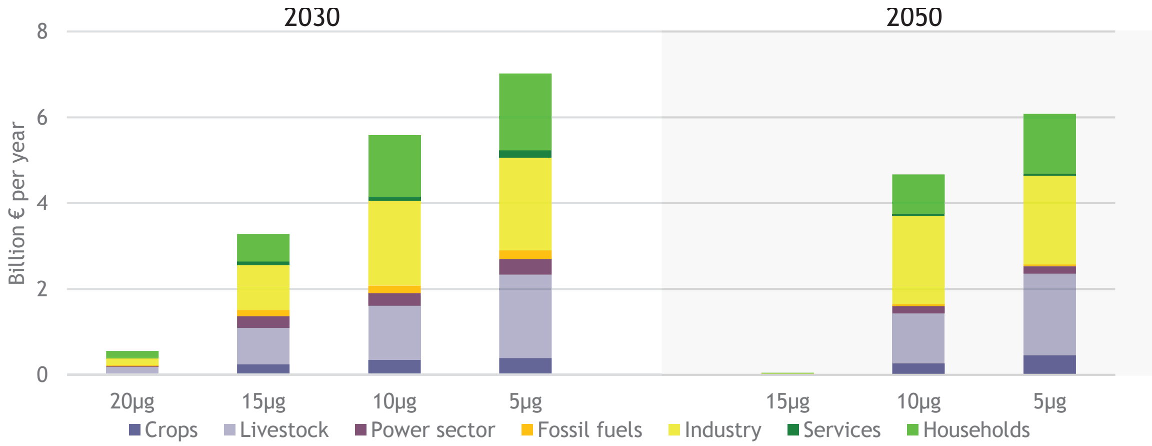
[54] Note that there is no difference between HIGH and LOW estimate for forest damage in 2020 and 2030 as only after 2030 different assumptions are used to monetise the reduced carbon sequestration potential due to forest damage.

7. MACRO-ECONOMIC IMPACTS

Air pollution has detrimental welfare impacts by affecting health outcomes. In addition, related healthcare expenditures, crop yield losses in particular due to ozone, absence from work due to illness (including of dependent children) and lower productivity at work (presenteeism) can imply a drag on the economy. Improving air quality can therefore bring economic gains. However, air pollution control comes at a gross cost, as it requires costly investments and purchases of abatement equipment. A priori, it is unclear whether air pollution control policies therefore lead to net economic gains or losses, and how these are distributed across stakeholders.

To shed some light on these trade-offs, a macro-economic benefit-cost analysis was conducted by linking the GAINS model with the JRC-GEM-E3 model. This has been done in previous work, such as the First and Second Clean Air Outlook, and both models feature in a broader modelling toolbox e.g. in the assessment of the EU long-term climate strategy[55]. The key information that flows from GAINS to JRC-GEM-E3 is the abatement cost associated to further air pollution controls induced by more ambitious policy measures and targets. These costs serve as inputs into the JRC-GEM-E3 analysis (Figure A5.13).

Figure A5.13 – Air pollution mitigation or adjustment costs (EU total) beyond the baseline, for different policy scenarios. Source: GAINS model, IIASA (support study).



The JRC-GEM-E3 model represents the whole economy and the interactions between key actors: firms, households and governments in the EU and in the rest of the world. End-of-pipe abatement costs from GAINS are treated as costly (intermediate) expenditures on abatement goods and services, and therefore generate additional demand for the sectors that deliver these goods and services. Furthermore, the model captures the potential loss in competitiveness of firms that need to incur abatement costs by reflecting price-driven international trade flows. For households, a loss of income or raised expenditure on abatement technologies implies that less means are available to purchase other goods. The

55 Weitzel, M., et al. (2019). Model-based assessments for long-term climate strategies. Nature Climate Change, 9(5), 345-347.

economic modelling framework covers these interactions to provide an economy-wide picture of the implications of additional air pollution control costs.

On the benefit side, this analysis concentrates on productivity gains from clean air. The empirical basis stems from recent OECD work[56] that quantifies the causal impact of $PM_{2.5}$ pollution on productivity in the EU for the period 2000-2015. More specifically, labour productivity gains are derived by combining the point estimate on the impact of $PM_{2.5}$ on GDP per worker, with the changes (compared to the baseline) in population-weighted $PM_{2.5}$ concentrations from the GAINS model. The corresponding changes in labour productivity are fed into the JRC-GEM-E3 model, where labour constitutes an input the production process of the various economic sectors.

The results are displayed in Table A5.3. The key insight is that all scenarios improve aggregate economic outcomes in the EU compared to a situation of unchanged policy. The most ambitious 5 µg/m³ scenarios imply larger gross costs, but these are more than compensated by productivity gains, as reflected by the positive impact on GDP and private consumption. With the exception of livestock-based agriculture, all sectors displayed raise output compared to the reference when productivity gains of clean air are accounted for.

Table A5.3 – Economic outcomes of clean air policy in the EU – expressed as percentage change relative to reference baseline. Note that the first number in a cell represents the effect of gross costs only. The second number (after the vertical line) represents the net effect, i.e. benefits minus costs.[57]

<table>
<tr><th>>>> Option analysed >>></th><th>W/ current standards</th><th>Option I-1 (PM2.5 at 5 µg/m³)</th><th>Option I-2 (PM2.5 at 10 µg/m³)</th><th>Option I-3 (PM2.5 at 15 µg/m³)</th><th></th><th>Sub-option I-1a</th><th>Sub-option I-2a</th><th>Sub-option I-3a</th></tr>
<tr><td>Cost only | Net effect (benefit-cost) % change relative to reference</td><td>2030</td><td>2030</td><td>2030</td><td>2030</td><td></td><td>2050</td><td>2050</td><td>2050</td></tr>
<tr><td>Gross Domestic Product</td><td>0.00 | 0.10</td><td>-0.05 | 0.44</td><td>-0.04 | 0.38</td><td>-0.02 | 0.26</td><td></td><td>-0.03 | 0.36</td><td>-0.02 | 0.29</td><td>0.00 | 0.03</td></tr>
<tr><td>Private Consumption</td><td>0.00 | 0.12</td><td>-0.04 | 0.57</td><td>-0.03 | 0.49</td><td>-0.02 | 0.34</td><td></td><td>-0.02 | 0.46</td><td>-0.02 | 0.37</td><td>0.00 | 0.04</td></tr>
<tr><td>Sector output</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Crops</td><td>-0.02 | 0.15</td><td>-0.32 | 0.50</td><td>-0.26 | 0.45</td><td>-0.19 | 0.30</td><td></td><td>-0.30 | 0.36</td><td>-0.17 | 0.38</td><td>0.00 | 0.06</td></tr>
<tr><td>Livestock</td><td>-0.09 | 0.05</td><td>-1.01 | -0.36</td><td>-0.62 | -0.05</td><td>-0.45 | -0.06</td><td></td><td>-0.91 | -0.37</td><td>-0.54 | -0.10</td><td>-0.01 | 0.05</td></tr>
<tr><td>Power sector</td><td>0.00 | 0.11</td><td>0.01 | 0.50</td><td>0.01 | 0.44</td><td>0.00 | 0.30</td><td></td><td>0.02 | 0.41</td><td>0.02 | 0.34</td><td>0.00 | 0.04</td></tr>
<tr><td>Fossil fuels</td><td>-0.01 | 0.08</td><td>-0.11 | 0.32</td><td>-0.10 | 0.28</td><td>-0.09 | 0.18</td><td></td><td>-0.03 | 0.29</td><td>-0.04 | 0.24</td><td>0.00 | 0.03</td></tr>
<tr><td>Industry</td><td>0.00 | 0.13</td><td>0.02 | 0.63</td><td>0.01 | 0.53</td><td>0.02 | 0.38</td><td></td><td>0.01 | 0.51</td><td>0.00 | 0.40</td><td>0.00 | 0.05</td></tr>
<tr><td>Services</td><td>0.00 | 0.09</td><td>0.00 | 0.45</td><td>0.00 | 0.38</td><td>0.0 | 0.26</td><td></td><td>0.00 | 0.37</td><td>0.00 | 0.29</td><td>0.00 | 0.03</td></tr>
</table>

A few caveats are important to take into consideration when interpreting these results. Here, we focus exclusively on productivity benefits from clean air. This implies that other 'market' benefits are not included, such as reduced healthcare expenditures and increased crop yields. Furthermore, additional 'non-market' benefits, such as ecosystem impacts and reductions in premature mortality or life years lost due to air pollution, are not included in the results displayed in the table below. While these benefits are not included in the economy-wide assessment in this section, they are discussed in other sections of this report. The JRC-GEM-E3 modelling results furthermore include outcomes on employment changes by sector. In these simulations, it was assumed that wage setting is flexible such that it can fully

[56] Dechezleprêtre, A., Rivers, N., & Stadler, B. (2019). The economic cost of air pollution: Evidence from Europe. OECD Economics Department Working Papers.

[57] Based on general equilibrium modelling with the JRC-GEM-E3 model.

accommodate labour market adjustments. This implies that aggregate, national unemployment levels are driven by fundamental factors that are unaffected by clean air policy. In other words, this assumption implies that the results will not pick up any potential aggregate net job creation associated with increased GDP and output levels as shown, and the results may therefore be interpreted as conservative estimates.

The results displayed in Table A5.4 indicate two consistent findings across all scenarios and years. First, we observe a creation of jobs in industry, which relates directly to the production of equipment required to abate emissions and the associated investments. While industry also faces increased abatement costs, in terms of net effect on jobs this is more than offset by increased demand for abatement goods from all sectors (including households). Second, the agricultural sector experiences job losses compared to the reference, which relates to output losses (livestock sector) or a transition of workers into industry (crops sector). Overall, the magnitude of the employment changes is limited in relative terms such that they may be largely absorbed by ongoing labour market dynamics (entry into and exit from the labour market). One caveat worthwhile mentioning here is that the productivity benefits are applied uniformly across all sectors. A stronger empirical evidence base would help refining (the sector-specific elements of) the analysis, e.g. by differentiating productivity impacts of air pollution for vulnerable workers.

Table A5.4 – Employment transition across sectors in the EU. Source: JRC-GEM-E3. Given the assumption of flexible wage setting, positive and negative employment effects balance out for a given year and scenario. Adding of numbers in a given column of this table does not yield zero in all cases due to rounding.

>>> Option analysed >>>	($PM_{2.5}$ at 20 μg/m³)	Option I-1 ($PM_{2.5}$ at 5 μg/m³)	Option I-2 ($PM_{2.5}$ at 10 μg/m³)	Option I-3 ($PM_{2.5}$ at 15 μg/m³)		Sub-option I-1a	Sub-option I-2a	Sub-option I-3a
Cost only | Net effect (benefit-cost) 1000 jobs, change rel. to reference	2030	2030	2030	2030		2050	2050	2050
Employment								
Crops	-1 | -2	-19 | -19	-18 | -18	-15 | -17		-17 | -16	-10 | -9	0 | 0
Livestock	-2 | -3	-25 | -31	-23 | -29	-20 | -24		-19 | -22	-17 | -20	0 | -1
Power sector	0 | -2	0 | -8	0 | -7	0 | -6		0 | -5	0 | -4	0 | -1
Fossil fuels	0 | 0	0 | -1	0 | 0	0 | 0		0 | 0	0 | 0	0 | 0
Industry	3 | 24	34 | 115	30 | 104	25 | 81		23 | 81	15 | 66	0 | 7
Services	1 | -17	10 | -57	11 | -49	10 | -33		13 | -38	12 | -33	0 | -6

8. SENSITIVITY ANALYSIS FOR IED IMPLEMENTATION

In order to quantify to the extent possible the impact of the proposal for a revised IED on air quality, a sensitivity analysis was conducted. Since it is not possible to precisely project the speed and scope of the IED implementation[58], as this depends on the development and uptake of BAT across economic sectors, a series of assumptions was taken:

- For all non-agriculture sectors covered by the proposal for a revised IED, a 20% reduction in $PM_{2.5}$, SO_2, and NOx emissions in 2030 (additional to the reduction already

[58] See explanations in the Impact Assessment accompanying the proposal for a revised Industrial Emission Directive (SWD COM(2022)111)

foreseen in the baseline), reflecting the likely best-case scenario of the IED implementation and based on assumptions presented in the impact assessment underpinning the revision of the IED.

- For agriculture sectors covered by the proposal for a revised IED, country-specific and livestock category-specific NH_3 reduction rates estimated with the GAINS model for the third Clean Air Outlook, assuming an entry into force of the proposal in 2027. Typically, this results in about 1% to 4% reduction of national NH_3 emissions (about 2% for the EU27 as a whole) beyond the baseline used in this impact assessment.

The modelling approach followed the following steps:

- projection of the impact on country specific industrial emissions of $PM_{2.5}$, SO_2, NOx for the year 2030;
- projection of the impact on country specific NH_3 emissions from agriculture for the year 2030;
- these newly estimated emissions of all pollutants were used in the EMEP model simulations for 2030 to estimate $PM_{2.5}$ and NO_2 concentrations and station compliance and exposure.

The following table present the change in station concentrations from the 2030 Baseline to the 2030 IED sensitivity.

	Average change in mean concentration levels at sampling points		Number of sampling points that fall into / drop out of the respective concentration bands under IED sensitivity assumptions					
$PM_{2.5}$	Mean absolute change (µg/m^3)	Mean relative change (%)	0 – 5 (µg/m^3)	5 – 10 (µg/m^3)	10 – 15 (µg/m^3)	15 – 20 (µg/m^3)	20 - 25 (µg/m^3)	> 25 (µg/m^3)
	-0.13	-1.6	35	-29	-6	0	0	0
NO_2	Mean absolute change (µg/m^3)	Mean relative change (%)	0 – 10 (µg/m^3)	10 – 20 (µg/m^3)	20 – 30 (µg/m^3)	30 – 40 (µg/m^3)	> 40 (µg/m^3)	
	-0.09	-0.89	17	-15	-2	0	0	

It should be noted that, due to the methodological limitations of any sensitivity analysis, these results cannot be used for drawing exact conclusion on impacts. They do however provide a useful indication of the impact of the revised IED implementation on pollution concentration, and show that these impacts are likely to be very small compared to the baseline used in the core of this impact. For more information, see the underpinning support study.

Annex 6: Potential policy measures (or interventions)

1. Policy Measures in the Different Policy Options

This impact assessment considers a total of 69 potential specific policy measures - these measures are based on WHO recommendations (including as published in 2021), as well as stakeholder feedback to the Inception Impact Assessment and preliminary expert consultations (with those responsible for air quality monitoring, modelling and planning).

Table A6.1 – Overview of all 69 specific measures considered in this impact assessment

		Focus on AQ legislative framework	35	**J1**	Revise macro-scale siting of sampling points
1	**-**	Merge provision of Directives 2008/50 and 2004/107	36	**J2**	Revise micro-scale siting of sampling points
2	**A1**	Introduce review triggered by scientific progress	37	**J3**	Introduce obligation for spatial representativeness
3	**A2**	Introduce review triggered by technical progress	38	**K1**	Revise AQ monitoring data quality objectives
4	**A3**	Introduce option to notify stricter standards	39	**K2**	Introduce up-to-date data at all sampling points
5	**A4**	Introduce a list of priority pollutants	40	**K3**	Introduce AQ modelling data quality objectives
6	**B1**	Introduce additional short-term standards	41	**K4**	Revise approach to AQ assessment uncertainty
7	**B2**	Introduce additional alert/information thresholds	42	**L1**	Introduce concept of monitoring at 'super-sites'
8	**B3**	Revise definition of average exposure standards	43	**L2**	Introduce obligations to monitor more pollutants
9	**B4**	Introduce guidance on addressing exceedances	44	**L3**	Revise list of VOC to monitor
10	**B5**	Introduce limit values for additional air pollutants	45	**M1**	Introduce methodology to assess transboundary
11	**C1**	Revise obligations triggered by exceedances	46	**M2**	Revise obligations for transboundary cooperation
12	**C2**	Revise/clarify definition of 'as short as possible'	47	**N1**	Revise the information in air quality plans
13	**C3**	Revise short-term action plans & air quality plans			**Focus on EU air quality standards**
14	**C4**	Introduce additional short-term action plans	48	**O1**	Revise standards for annual $PM_{2.5}$
15	**C5**	Introduce requirement to update air quality plans	49	**O2**	Introduce standards for daily $PM_{2.5}$
16	**D1**	Revise requirements to involve stakeholders	50	**O3**	Revise average exposure standards for $PM_{2.5}$
17	**D2**	Introduce a 'one zone, one plan' requirement	51	**P1**	Revise standards for annual PM_{10}
18	**E1**	Introduce minimum levels for financial penalties	52	**P2**	Revise standards for daily PM_{10}
19	**E2**	Introduce right to health damage compensation	53	**P3**	Introduce average exposure standards for PM_{10}
20	**E3**	Introduce a fund to be fed by penalties paid	54	**Q1**	Revise standards for annual NO_2
21	**E4**	Introduce an explicit 'access to justice' clause	55	**Q2**	Revise/introduce standards for hourly/daily NO_2
22	**F1**	Revise provisions related to up-to-date data	56	**Q3**	Introduce average exposure standards for NO_2
23	**F2**	Introduce requirement to provide AQ health data	57	**R1**	Introduce standards for peak-season O_3
24	**F3**	Introduce use of specific communication channels	58	**R2**	Revise standards for 8-hour O_3
25	**F4**	Introduce requirements for harmonised AQ index	59	**R3**	Introduce average exposure standards for O_3
		Focus on AQ monitoring, modelling, plans	60	**S1**	Revise standards for annual SO_2
26	**G1**	Revise rules related to indicative sampling points	61	**S2**	Revise standards for daily/hourly SO_2
27	**G2**	Introduce requirements for AQ modelling	62	**T1**	Revise standards for daily/8-hour CO
28	**G3**	Revise rules for regular review of AQ assessment	63	**U1**	Revise standards for annual benzene
29	**H1**	Revise minimum number of sampling points	64	**V1**	Revise standards for annual benzo(a)pyrene
30	**H2**	Simplify combined PM_{10}/$PM_{2.5}$ monitoring	65	**W1**	Revise standards for annual lead
31	**H3**	Simplify the definitions of sampling points types	66	**X1**	Revise standards for annual arsenic
32	**I1**	Introduce obligations to maintain sampling points	67	**Y1**	Revise standards for annual cadmium
33	**I2**	Introduce obligations to monitor long-term trends	68	**Z1**	Revise standards for annual nickel
34	**I3**	Introduce a protocol for relocated sampling points	69	**Ø1**	Introduce standards for additional air pollutants

2. ASSESSMENT OF POTENTIAL POLICY MEASURES AND THEIR IMPACTS

Assessment criteria and indicators

Broad impact category	Indicator	Indicator #
Environmental impacts *(including air pollutant concentrations)*	Concentration levels of air pollutants, at (a) background locations, and (b) 'hot-spot' (incl. both traffic and industry-related) locations, and their development over time;	#1
	Health impacts of air pollution, for example the health impacts resulting from exposure to particulate matter ($PM_{2.5}$ and/or PM_{10}), nitrogen dioxide and ozone;	#2
	Ecosystem impacts of air pollution, including acidification, eutrophication, ozone damage to vegetation and agricultural yields;	#3
	Links between air pollution and climate change, including increased ozone levels due to global warming, and co-benefits or trade-offs between climate and air pollution abatement measures;	#4
Economic impacts	Cost to society due to air pollution, including health and healthcare impacts and costs, lost working days, crop and animal value loss, losses to other assets and other costs avoided by taking action to reduce air pollution;	#5
	Measures needed to meet EU air quality standards - and their costs, including costs for key economic sectors, and regional differences across the EU of the costs and benefits of the air pollution abatement measures;	#6
	Positive and negative impacts on the EU's international competitiveness, including tapping into innovation potential for clean air technologies;	#7
Social impacts	Effects of air pollution on sensitive population groups, including children, pregnant women, elderly citizens and those suffering from pre-existing conditions;	#8
	Societal impacts of air pollution and societal impacts of air pollution abatement measures, incl. resulting inequalities (i.e. who is most affected, who bears costs);	#9
	Effects of measures to address air pollution on employment;	#10
Synergies	Synergies with other goals of the (upcoming) EU Zero Pollution Action Plan on air, water and soil. This includes premature death reduction (indicator 2) and ecosystem impact (indicator 3) goals. It additionally reflects the synergic role of indoor air pollution (notably in terms of exposure and health impacts) or co-benefits in reducing noise pollution.	#11
Administrative burden	Administrative burden of air quality management, in particular as relates to air quality assessment regimes (including monitoring, modelling, and reporting of related data) – for a detailed assessment see Annex 3.	#12

Each of the above indicator is scored for each specific potential policy measure in a qualitative manner, taking into account the quantitative assessment provided in Annex 3 and Annex 5 where possible. Note that for several indicators no extensive quantification has been possible, due to the lack of available data per specific potential policy measure. In these cases the assessment is based on expert judgement provided via the underpinning support study.

Score	Description
+++	Very significant direct positive impact or benefit
++	Significant direct positive impact or benefit
+	Small direct positive impact or benefit
(+)	Indirect positive impact or benefit
+/-	Both direct positive and negative impacts, and balance depends on how implemented
0	No impact or only very indirect impacts
(-)	Indirect negative impact or cost
-	Small direct negative impact or cost
- -	Significant direct negative impact or cost
- - -	Very significant direct negative impact or cost
High	Benefits significantly outweigh costs of measure
Medium	Benefits on balance outweigh costs of measure
Low	Benefits close to or even below costs of measure
High (*)	Potential high benefits, but significant questions as to whether the measure can deliver outcome

For a summary overview the scoring of the twelve indicators for each specific potential policy measure is presented via an overview table, as per the following logic. Note that indicator #6 features twice, i.e. under economic impact and under cost.

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Code	Short-hand description of policy measure	**#1** #2 #3 #4	#8 #9 #10	#5 #6 #7	(#6) #12	#11	**High** **Medium** **Low** High (*)	Reference to which policy options and/or sub-options include this measure
		See above for indicator code, see legend below for scoring					*See legend*	

Note that indicator #12 on the administrative burden is based on the estimates presented in Annex 3. Combined additional annualised one-off and recurring administrative burden in the category of less than 10 000 Euro per year are marked '(-)', between 10 000 and 100 000 Euro as '-', between 100 000 and 1 000 000 Euro as '--', and above 1 000 000 Euro as '---'.

Stakeholder views

A targeted stakeholder survey asked for views on each potential specific policy intervention (see Annex 2 for details), and consulted with public authorities, civil society & NGOs, industry & businesses, and research & academia. The number of responses differed by policy are consulted upon.

For intervention areas A through N, in total 93 replies were received from:

- Public authorities (43);
- Civil society & NGOs (12);
- Industry & businesses (14);
- Research & academia (22).

For intervention areas O to Ø, in total 139 replies were received from:

- Public authorities (53);
- Civil society & NGOs (12);
- Industry & businesses (26);
- Research & academia (42).

Stakeholder views per potential specific policy intervention are summarised below.

2.1 Intervention area A: Regular review of EU air quality standards

A1 Introduce review of EU air quality standards triggered by scientific progress

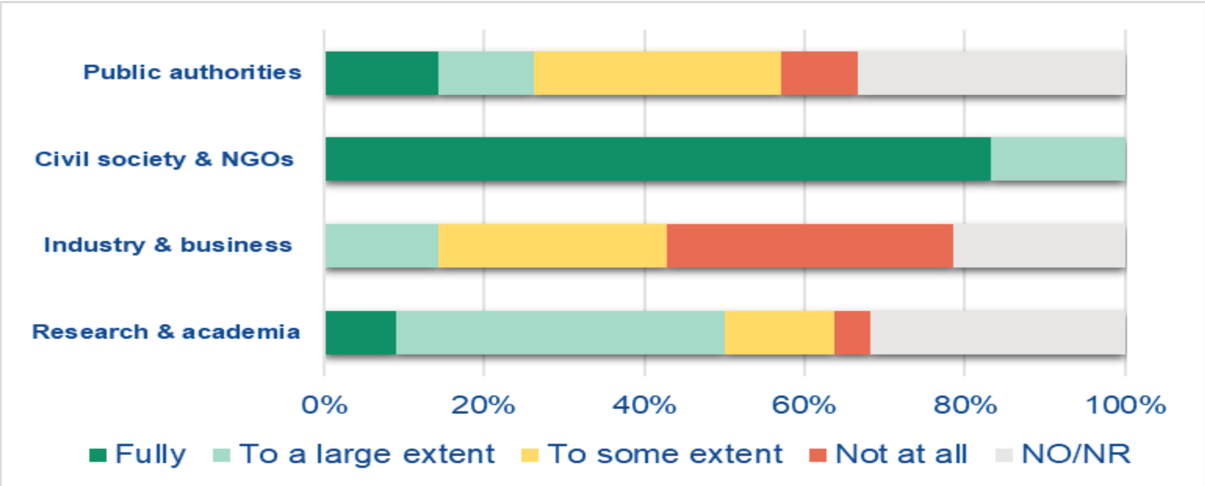
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A1	Introduce review triggered by scientific progress	++ (+) (+) +	(+) (+) 0	0 0 0	0 (-)	+	High	Policy option I-6

Focus of measure: Introduce a mechanism for adjusting EU air quality standards upon publication of new scientific advice (including, but not limited to, the publication of new WHO Air Quality Guidelines).

Description of measure: Appropriate mechanisms are needed to flexibly adapt to evolving science to protect human health. Article 32 of Directive 2008/50/EC and Article 8 of Directive 2004/107/EC provided grounds for once-off reviews on the basis of specific evidence (e.g. WHO Air Quality Guidelines or reduction potentials in Member States), but do not provide a mandate or obligation for regular reviews. Three possible intervention variants exist under this intervention to ensure that Ambient Air Quality Directives reflect latest scientific advice:

1. Introduce a binding schedule of reviews of scientific progress to be undertaken by the Commission - under this variant the Commission would undertake a periodic review of scientific progress related to air pollutants.
2. Introduce a mechanism for adjusting EU air quality standards upon publication of new WHO Air Quality Guidelines - under this variant the Commission would undertake a WHO Air Quality Guidelines related review of scientific progress related to air pollutants, with a view to presenting a proposal to amend the Directives to the European Parliament and the Council.
3. Introduce a mechanism for adjusting air quality standards based on (other) latest scientific advice - under this variant the Commission would undertake a review of new scientific knowledge of related to air pollutants, with a view to presenting a proposal to amend the Directives to the European Parliament and the Council.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Introduction of a mechanism that will provide a basis for the alignment of the Ambient Air Quality Directives with the latest scientific knowledge will directly contribute towards reductions in air quality concentrations. Meeting the direct objective of air quality reduction will subsequently indirectly protect EU population from harmful exposure to air pollution and indirectly benefit ecosystems. Direct costs estimated for this intervention are small administrative costs for the Commission.

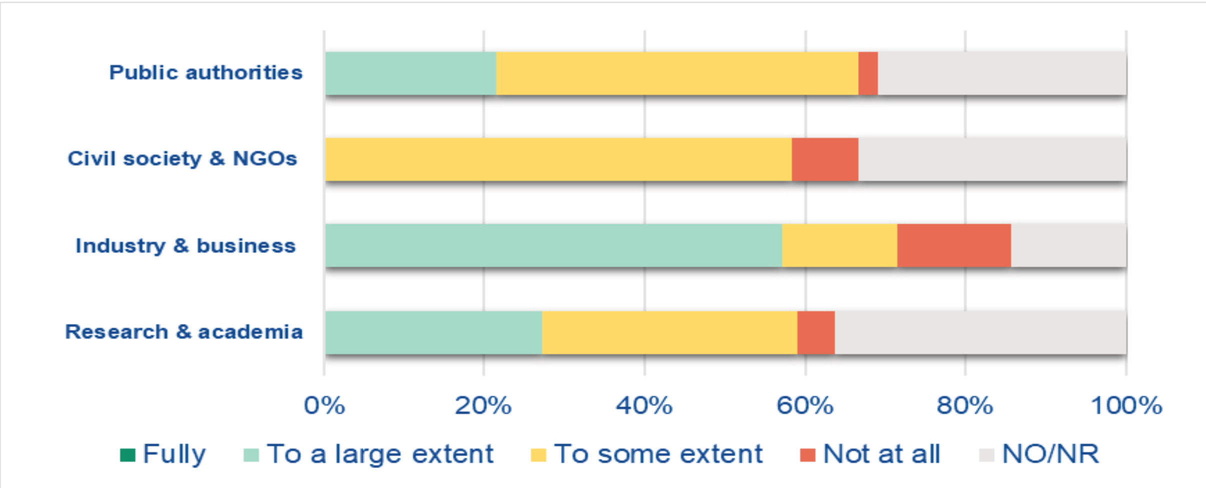
A2 Introduce review of EU air quality standards triggered by technical progress

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A2	Introduce review triggered by technical progress	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Low**	**Sub-option I-6a**

Focus of measure: Introduce a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction.

Description of measure: This intervention would introduce a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction. Accordingly, the Commission would undertake regular reviews of technical progress related to abatement techniques for air quality pollutants and the cost of implementing standards that are more stringent.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure introduces a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction. This intervention would formalise consideration of technological progress in the Ambient Air Quality Directive and could have a small positive indirect impact on improvements in air quality concentrations as advances in the technological knowledge might lead to revisions in the Ambient Air Quality Directive due to the enhanced technical feasibility of its implementation. However, the process would be driven by technology considerations, not health considerations, and therefore addresses the objective of protecting human health only to some extent. Direct costs estimated for this intervention are small administrative costs for the Commission.

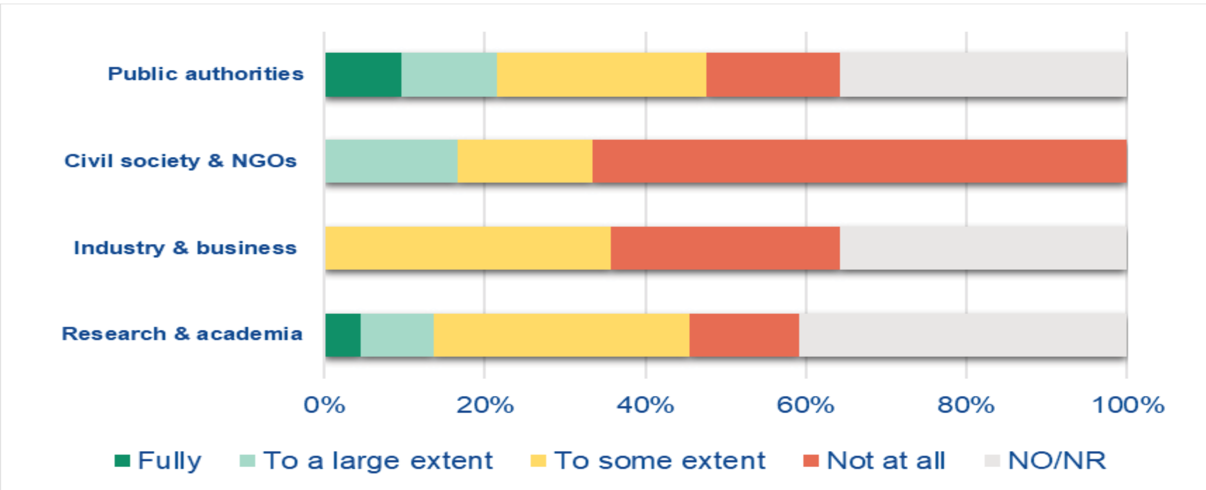
A3 Introduce option to notify stricter standards by Member States

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A3	Introduce option to notify stricter standards	(+) (+) (+) (+)	(+) 0 0	0 0 0	0 (-)	0	High	Policy option I-6

Focus of measure: Introduce a provision in the Ambient Air Quality Directives to allow for EU Member States to adopt more stringent standards in light of the new technical and scientific progress coupled with an obligation to notify the Commission.

Description of measure: The European Commission would introduce a requirement to ensure that EU Member States notify the Commission if they adopt more stringent standards within their jurisdiction in light of the new technical and scientific progress. EU Member States already have the possibility to adopt more stringent protective measures in accordance with Article 193 TFEU which must be notified to the Commission. The intervention would explicitly enshrine this possibility with regard to stricter air quality standards in secondary legislation and elaborate on the obligation to notify the European Commission with a view to collecting information on technical and scientific knowledge and national/local standards surpassing the EU standard and enabling information sharing across Member States.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure introduces a provision to allow EU Member States to adopt more stringent standards in light of the new technical and scientific progress coupled with an obligation to notify the Commission. This intervention has a potential to have a small indirect impact on reducing air pollution concentrations as it would contribute to sharing of information, including on scientific and technical data that can be used by the EU and other EU Member States. This intervention has been assessed under the assumption that it will enhance the Commission's evidence base regarding Member State policy action at EU level.

Direct costs estimated for this intervention are small administrative costs for EU Member State competent authorities. The benefit cost ratio of this measure is considered high as low administrative burden would lead to an improved knowledge base.

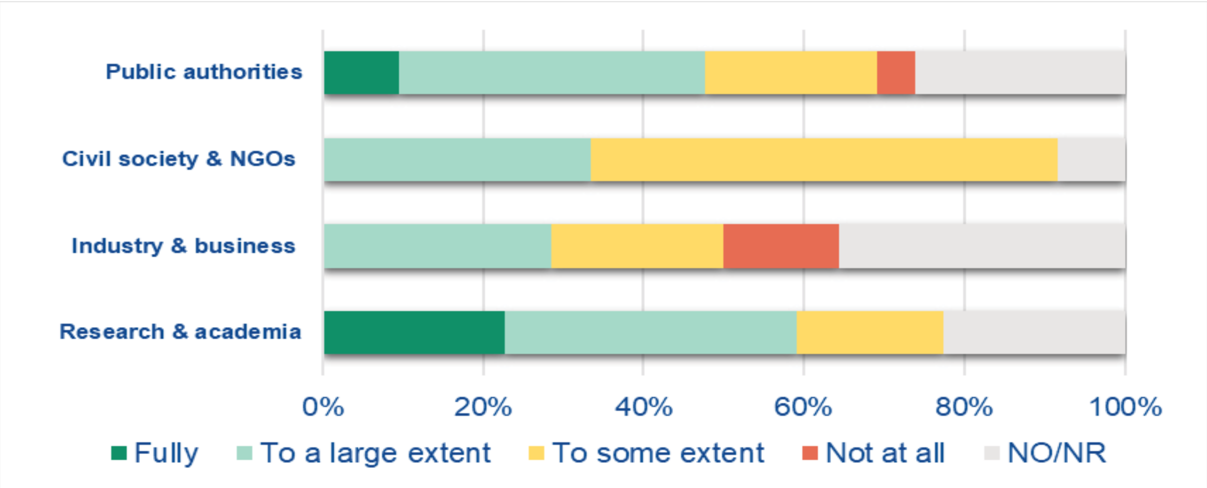
A4 Introduce a list of priority air pollutants

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A4	Introduce a list of priority pollutants	(+) (+) (+) (+)	0 0 0	0 0 0	0 -	0	**Low**	**Sub-option I-6b**

Focus of measure: Keep and periodically update a list of priority air pollutants with a view to monitoring air pollutants of emerging concern.

Description of measure: Directives 2004/107/EC and 2008/50/EC establish standards and objectives for a number of air pollutants, namely $PM_{2.5}$, PM_{10}, SO_2, NO_2, NO_x, Pb, CO, C_6H_6, O_3, As, Cd, Ni and polycyclic aromatic hydrocarbons, to protect human health and the environment. This intervention would mandate the Commission to establish and periodically update a list of additional priority air pollutants with a view to monitoring air pollutants of emerging concern. Accordingly, the Commission would regularly update a "watch list" for emerging substances as part of the latest technical and scientific review and to demand their monitoring at Member State level. This measure would provide a first step for improving knowledge of and developing standards for air quality pollutants that are currently not covered in the Ambient Air Quality Directives. The Commission would be responsible for the watch list, but Member States would carry out the monitoring.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to keep and periodically update a list of priority air pollutants with a view to monitoring air pollutants of emerging concern. This intervention is likely to have a small indirect impact on air quality as the monitoring of identified priority pollutants could eventually lead to regulating them in the Ambient Air Quality Directive. Black carbon (BC), Ultrafine particles (UFP), ammonia (NH_3), PFAS (Per- and polyfluoroalkyl substances), dioxins and PCB (polychlorinated biphenyl) have been specifically highlighted as possible priority air pollutants. Direct costs estimated for this intervention are small administrative costs for the Commission. Additional burden would potentially be borne by the EU Member States if they were required (or voluntarily choose) to monitor priority emerging air pollutants, in particular if the content of the list changed frequently.

2.2 Intervention area B: Type of EU air quality standards

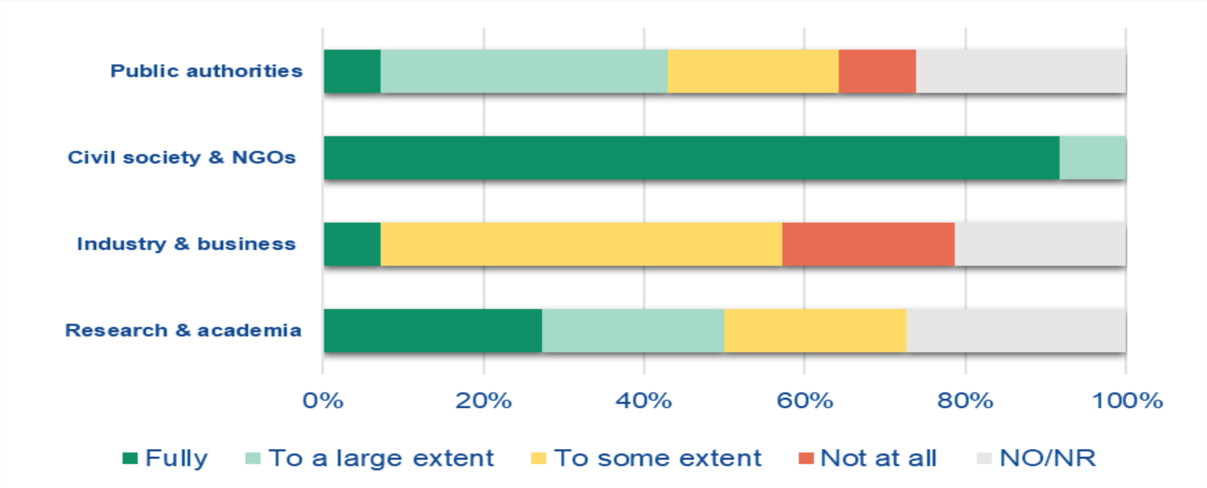
B1 Introduce additional short-term standards

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B1	Introduce additional short-term standards	+ 0 0 0	0 0 0	0 0 0	0 (-)	0	**High**	**Policy option II-2**

Focus of measure: Establish short-term EU air quality standards (daily or hourly) for additional air pollutants that currently only have annual or seasonal standards e.g. $PM_{2.5}$.

Description of measure: The Ambient Air Quality Directives sets short-term standards only for certain pollutants. There are cases where the WHO Air Quality Guidelines provide a recommendation for short-term exposure levels for additional pollutants. For example, for $PM_{2.5}$ there is an EU annual limit value, but no 24-hour standard; for SO_2 there are EU standards for 1-hour and 24-hour periods, but no 10-minute standard; for NO_2 there is an EU standard for 1-hour exposure, but no 24-hour standard. This intervention explores the regulatory change needed to underpin the formulation of additional short-term standards for various pollutants for which currently only long-term standards (annual-mean) exist, or alternative short-term averaging periods, to achieve greater alignment with the latest WHO Air Quality Guidelines.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This is a facilitating measure. It goes hand-in-hand with (and the true impacts are determined by) the ambition of the standards set under other interventions (O2, P2, Q2, R2, S2 and T1). This intervention provides the facilitating legal basis for such standards to be set, and hence is an important component of a wider solution that could be effective in improving air quality and thereby improving health protection. As such this measure has only low direct costs, but the potential for high benefits. Stakeholders showed fairly strong support for this intervention, with 60% of respondents across all categories showing support at least to some extent.

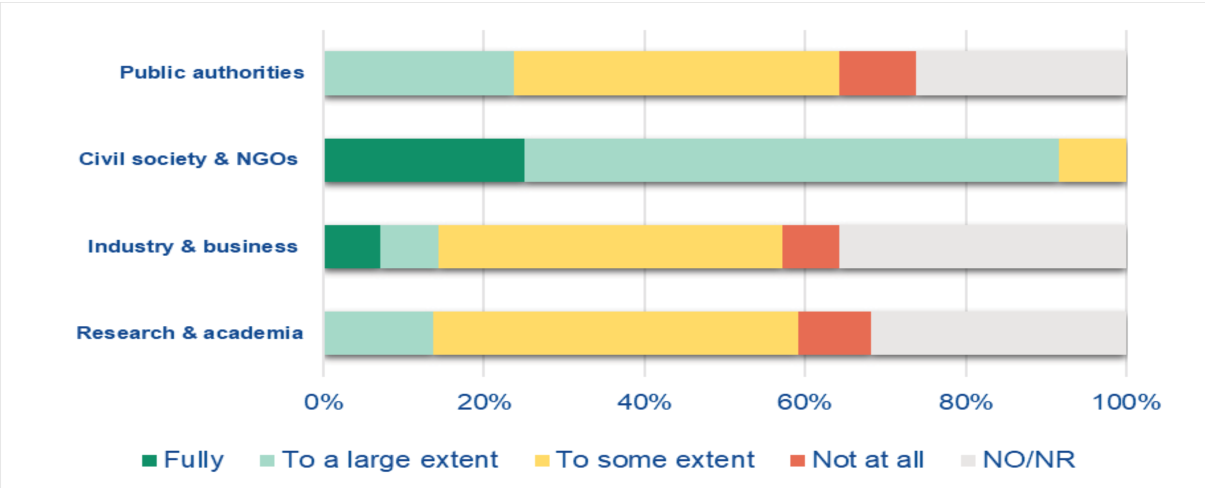
B2 Introduce additional alert/information thresholds

	Policy Measure	Env. impact	Soc. Impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B2	Introduce additional alert/information thresholds	+ + (+) (+)	+ 0 0	0 0 0	0 (-)	(+)	**Medium**	**Policy Option II-3**

Focus of measure: Define alert thresholds and information thresholds for all air pollutants as triggers for alerting the public and taking short-term action.

Description of measure: This intervention would establish alert thresholds and information thresholds for some or all air pollutants that currently do not have alert thresholds or information thresholds, as triggers for alerting the public and taking short-term action.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Alert and information thresholds provide a trigger for alerting the public and developing short term action. Short-term action is expected to benefit air quality indirectly to a small extent. Better information (on all relevant air pollutants) for the public would enable citizens, in particular vulnerable groups to take more targeted and effective personal measures to reduce their exposure to harmful air pollution, thereby having a direct small positive impact on human health. This intervention is expected to have small direct administrative costs for the Commission and competent authorities.

B3 Revise definition of average exposure standards

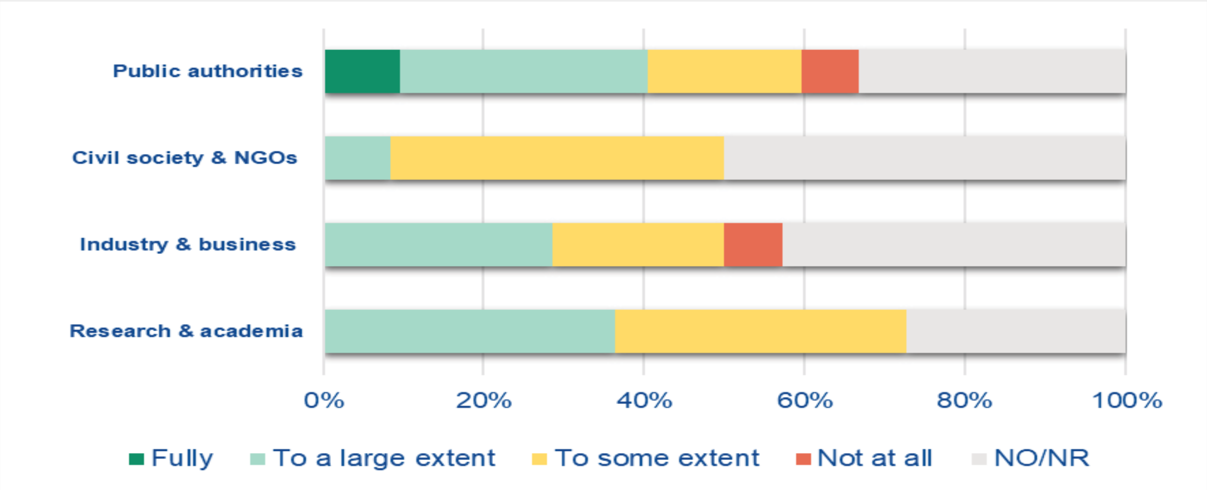
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B3	Revise definition of average exposure standards	(+) (+) (+) (+)	(+) 0 0	(+) 0 0	0 (-)	(+)	**High**	**Sub-option I-5**

Focus of measure: Expand the application of the exposure reduction targets (relative reduction in exposure).

Description of measure: The Ambient Air Quality Directives include average exposure obligations among the current provisions to regulate $PM_{2.5}$ concentrations. These complement the emission limit value for $PM_{2.5}$ by targeting average concentration values across larger areas. Accordingly, the Ambient Air Quality Directives set national $PM_{2.5}$ exposure reduction targets to protect human health (Article 15). The reduction target is a percentage reduction based on the initial concentration. To determine the initial concentration, an average exposure indicator is used (an average level determined on the basis of measurements at urban background locations throughout the territory of a Member State and which reflects population exposure). This intervention explores whether the formulation of the average exposure reduction targets and obligations should be changed. According to Article 15 of Directive 2008/50/EC, the distribution and the number of sampling points on which the average exposure indicator for $PM_{2.5}$ is based should reflect the general population exposure adequately. Annex XIV to Directive 2008/50/EC specifies Average Exposure Indicators (AEI) for $PM_{2.5}$. The AEI is currently measured at urban background stations, which might not always be reflective of the general population exposure. The following variants are explored:

1. Introduce an exposure reduction target at regional or local level (rather than at national level only).
2. Broaden the "average exposure indicator" metric to include locations other than urban background (e.g. rural background locations).
3. Establish requirements for Member States to adopt air quality plans to meet exposure concentration obligations.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention may improve the way that the average general population exposure reduction is monitored and addressed. The average exposure indicator is currently measured in urban background stations, which might not always be reflective of general population exposure. As a result, this measure is likely to provide better targeting of general air pollution exposure reduction measures, thereby contributing to further protection of public health from harmful air pollution and reducing the air quality cost to society. It could also improve the effectiveness of implementing mitigation measures. Direct costs estimated with this intervention are small administrative costs for the Commission and Member States.

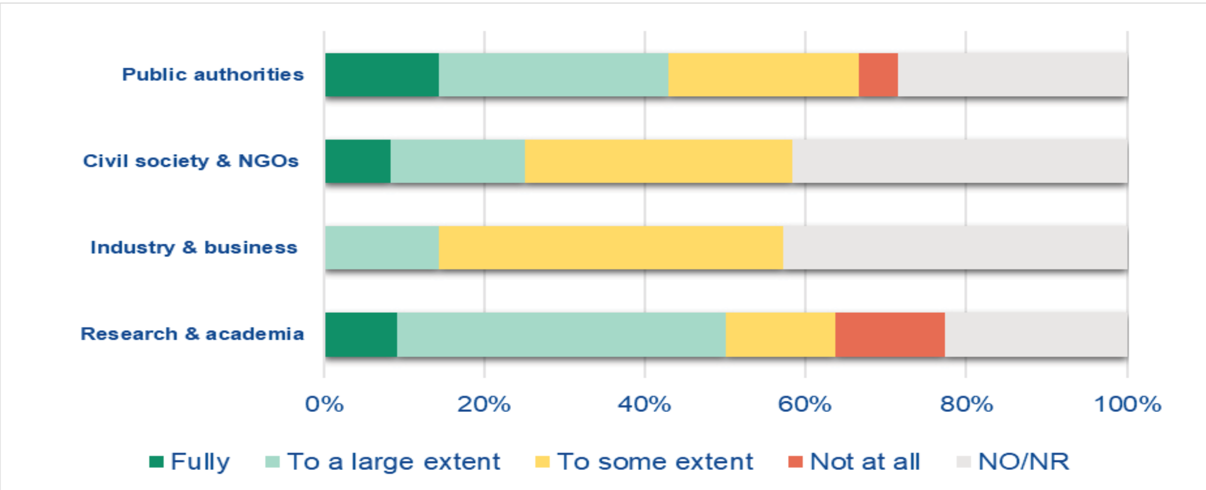
B4 Introduce guidance on addressing exceedances

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B4	Introduce guidance on addressing exceedances	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Medium**	**Policy option II-1**

Focus of measure: Provide guidance on the provisions concerning types of EU air quality standards and on the action to be taken in case of exceedance of different types of standards

Description of measure: This intervention would include guidance on how to respond to exceedances in terms of suitable air pollution response measures in case of exceedances, and on types of plans to be used. It would aim to enable clearer coordination with the development and implementation of short-term action plans under Article 24 of Directive 2008/50/EC and air quality plans under Article 23 Directive 2008/50/EC by clarifying the information to be provided in short-term action plans and ensure the requirements under short-term air quality plans do not overlap with the requirements for air quality plans set in Annex XV to the Directive 2008/50/EC.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: While varying circumstances across different EU member states are a challenge for developing effective guidelines, guidance could overall contribute towards better targeting of air pollution action, thereby contributing towards either more cost-effective response to exceedances or reducing the air quality cost on society by further protecting the general population from harmful air pollution. It is difficult to estimate indirect compliance and potential mitigation costs. Direct costs estimated with this intervention are small administrative costs for the Commission.

B5 Introduce limit values for additional air pollutants

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Synergies with other measures	Included in policy options
B5	Introduce limit values for additional air pollutants	++ + + +	+ 0 0	+ - 0	- (-)	0	**Medium**		**Policy option II-2**

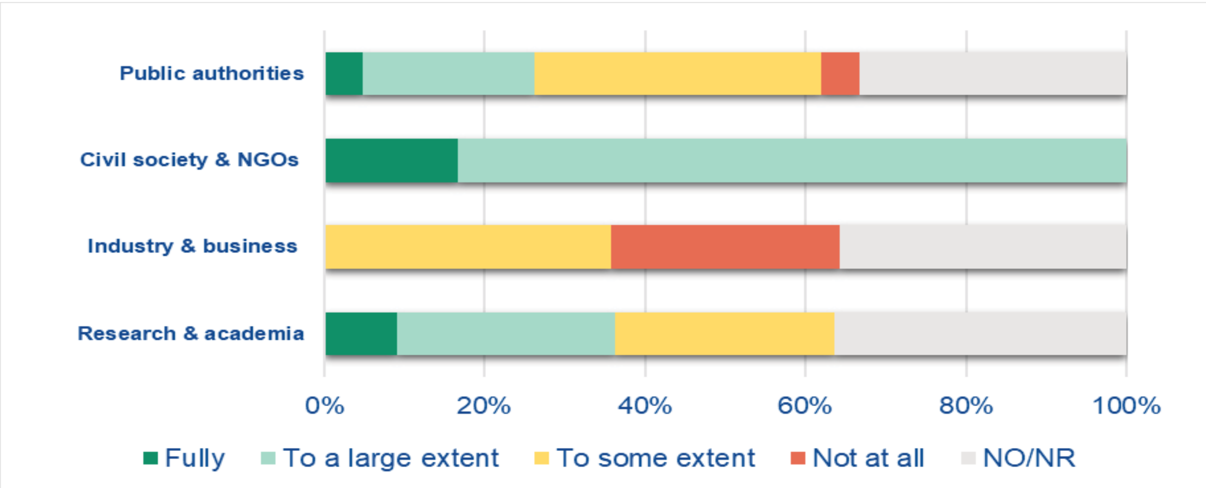
Focus of measure: Establish limit values for additional air pollutants (i.e. for air pollutants currently subject to target values).

Description of measure: The Fitness Check of the Ambient Air Quality Directives found that limit values have been more effective in facilitating downward trends than other types of air quality standards, such as target values. This intervention explores the establishment of limit values for additional air pollutants (i.e. for air pollutants currently subject to target values).

Intervention options for additional limit values include:

1. Establish limit values also for air pollutants that tend to depend on transboundary precursors and /or annual variations in meteorology (e.g. as is the case for ozone);
2. Establish limit values also for air pollutants that tend to correspond to specific point source emissions (e.g. as is the case for most heavy metals);
3. Establish limit values also for air pollutants that tend to correspond to emissions from specific widespread practices (e.g. as is the case for most poly-aromatic hydrocarbons).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Limit values have proved most effective in reducing air pollutant concentrations. Introduction of limit values for all pollutants, where these would prove feasible, would strengthen the Ambient Air Quality Directive. Direct costs estimated with this intervention are medium administrative costs for the Commission, associated with the review of the Ambient Air Quality Directive as well as additional monitoring needs (which would depend on the selection of pollutants for which limit values would be defined). One reason for setting target values rather than limit values is to take account of the specific formation mechanisms, for example in the case of ozone (also due to a strong role of transboundary sources and annual variations in meteorology for this air pollutant).

2.3 Intervention area C: Actions when exceedances occur

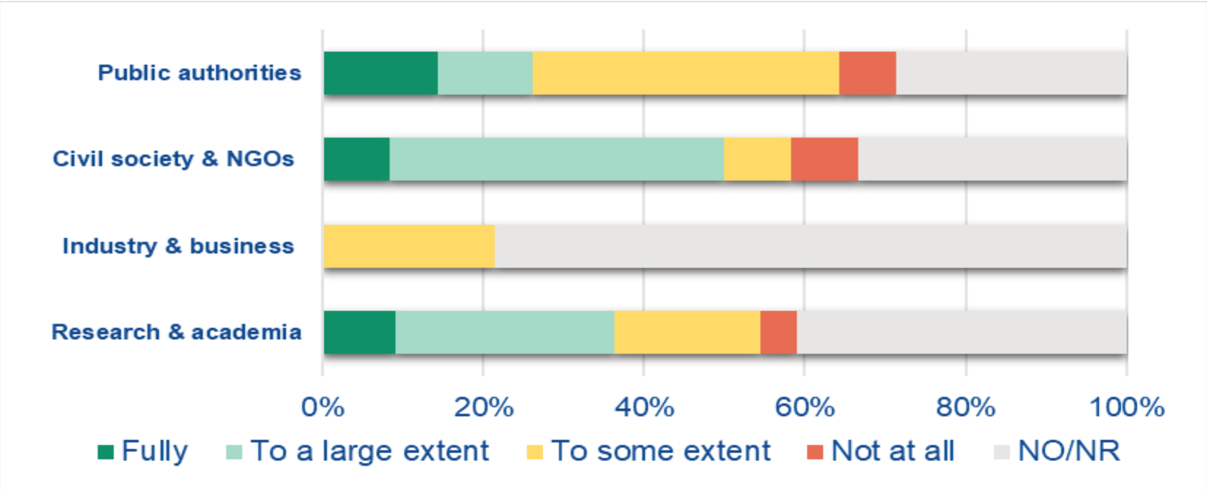
C1 Revise obligations for measures triggered by exceedances of air quality standards

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium	Policy option II-1 Policy option II-4

Focus of measure: Further specify the obligations to take measures to keep exceedance periods as short as possible.

Description of measure: This intervention would maintain the obligation to set out "appropriate measures, so that the exceedance period can be kept as short as possible" while further specifying the 'type of measures' that competent authorities must take to ensure that exceedance periods can be kept as short as possible. The type of measures to consider will depend on the type of pollutant, the source of pollution, and other factors. To this purpose the revised Ambient Air Quality Directives would contain a checklist of relevant abatement measures that competent authorities can consider and select from. The measures set out currently in section B of Annex XV could be updated and applied to air quality plans. Competent authorities would have to demonstrate that they have considered all relevant measures in the checklist of measures and if they decided not to implement a relevant measure, this should be justified (unlike currently, where air quality plans are not required to include reasoning behind the measures adopted). This means that this intervention would provide for a systematic assessment of measures and strengthen the information requirements that competent authorities need to make available in air quality plans. This intervention would build on requirements of Article 23(1) of Directive 2008/50/EC linked to exceedances of limit or target values. It could be extended to the Exposure Concentration Obligation (ECO) and Average Exposure Indicator (AEI), should the revision lead to establishing requirements in case of not complying with those standards. The rationale behind this intervention is that air quality plans have often proven ineffective due to inadequate or not sufficiently ambitious measures to reduce air pollution to achieve compliance.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure would specify the 'type of measures' that competent authorities must take to ensure that exceedance periods can be kept as short as possible. Since authorities would be provided with a long-list of measures to select from, this would lead to a systematic approach to developing an air quality plan and reduce time to explore potential measures. The intervention holds the potential to result in more effective measures which in turn can bring positive benefits in terms of air quality and related impacts, depends however also on funds for implementation of measures and properly trained staff on the side of competent authorities. The fact that the type of measures to be included in air quality plans is further defined does not guarantee these measures will be taken. The success of this intervention relies on the capability (knowledge, skills, competences) of competent authorities in charge of designing air quality plans to develop effective plans. This intervention will not result in any additional relevant direct costs for competent authorities as the obligation to develop air quality plans already exists.

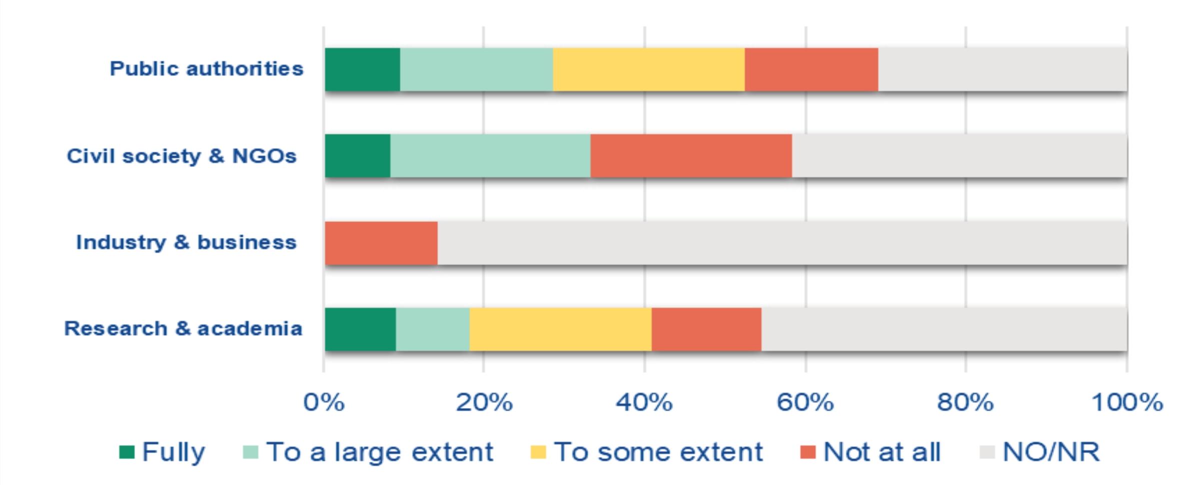
C2 Revise/clarify the term 'as short as possible'

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C2	Revise/clarify definition of 'as short as possible'	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	**Medium**	**Policy option II-3**

Focus of measure: Reformulate the term "as short as possible" including a defined time period.

Description of measure: This measure would entail amending the text of Article 23 of Directive 2008/50/EC to define the specific time period within which competent authorities must bring emissions down below the exceedance threshold. This would replace the current wording "as short as possible". This current provision is open to interpretation and therefore risks that exceedances remain systematic and persistent. In practice, since air quality plans must be prepared within two years from the exceedance at the latest, measures are often implemented only after three years at the earliest. Thus, the purpose of this intervention is to prompt competent authorities to take measures to reduce air pollution to a safe level in a timely manner. Where measures are implemented slowly, this intervention could contribute to ensuring that action is taken faster and that there is no room for different interpretations of what 'as soon as possible' means, as also voiced in the targeted stakeholder survey.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Specifying a clear time period within which air quality standards have to be respected holds the potential to result in faster action which in turn can bring indirect positive benefits in terms of air quality and related impacts. Introducing a fixed timeframe will provide a maximum time span within which results have to be achieved, improving the speed of response rates in many cases. However, as there is no one-size-fits-all timeframe, there is a risk that a fixed timeframe will slow down action in some cases where compliance could be achieved before the end of the fixed term. There may also be effective long-term measures that cannot be fully implemented within the given timeframe. A fixed timeframe may also weaken previous interpretations of the term 'as short as possible' by the courts.

C3 Revise short-term action plans and air quality plans

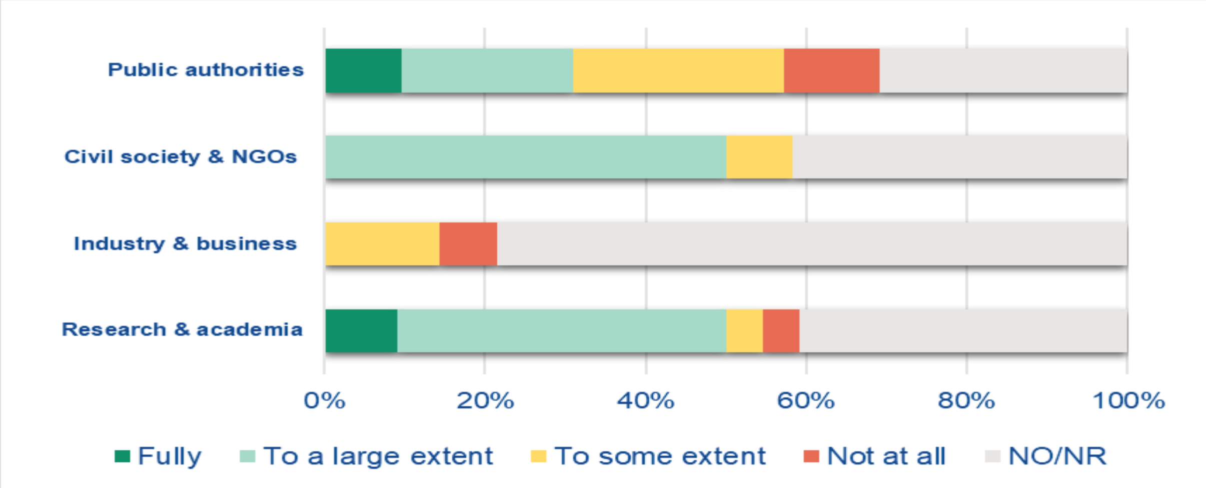
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C3	Revise short-term action plans & air quality plans	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 -	0	Medium	Policy option II-1

Focus of measure: Require a clearer coordination between short-term action plans and air quality plans.

Description of measure: This intervention consists of requiring clear coordination between the development and implementation of short-term action plans (under Article 24 of Directive 2008/50/EC) and air quality plans (under Article 23 and in Annex XV to Directive 2008/50/EC). It should be noted that this intervention is particularly relevant for Member States in which alert thresholds are exceeded but could apply to any Member State where there is a risk of exceeding limit or target values.

Coordination between short term action plans and air quality plans is not a requirement in the current Directive. As a result, not all Member States coordinate these. Since short term action plans and air quality plans may be under the responsibility of authorities at different levels (for example, the former may be under the responsibility of local authorities, while the latter of regional authorities), coordination may require additional efforts.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Coordination between short term action plans and air quality plans would lead to synergies among actions and avoid inefficiencies or inconsistencies. Small administrative costs may be incurred for Member State competent authorities related to coordination activities which are expected to be more than off-set by efficiency gains. According to several respondents to the targeted stakeholder survey, the revised Directive could require that short term action plans are included in air quality plans. Also, to facilitate this linkage between the two types of plans, the Ambient Air Quality Directives should include the minimum content that short-term action plans should contain.

C4 Introduce additional short-term action plans

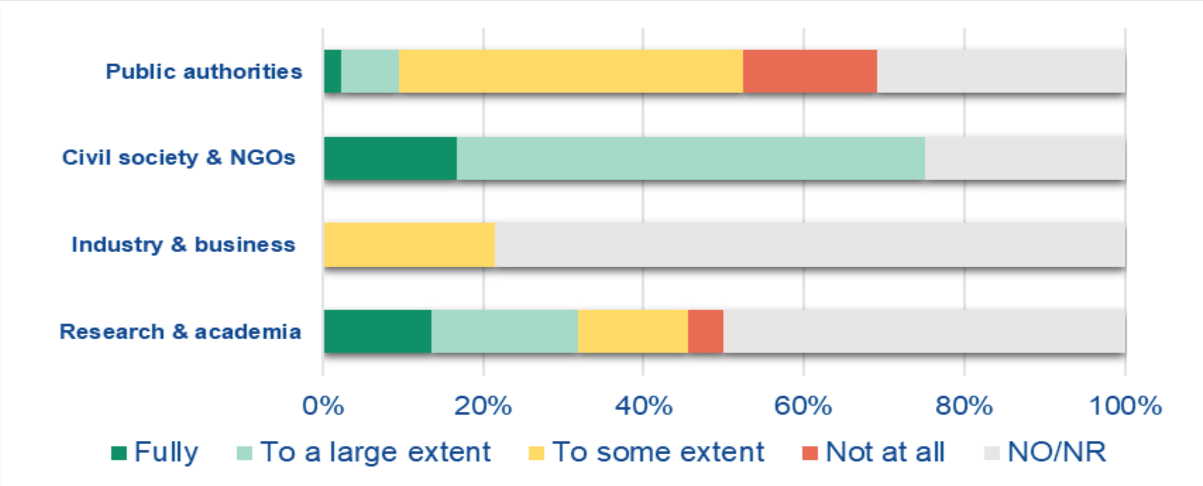
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C4	Introduce additional short-term action plans	+ + + (+)	+ (+) (-)	(+) 0/- (-)	0/- -	(+)	**Medium**	**Policy option II-3**

Focus of measure: Introduce an obligation for effective short-term action plans for each pollutant to prevent / tackle air pollution events.

Description of measure: This intervention consists of introducing in the revised Ambient Air Quality Directives the obligation to adopt effective short-term action plans for all pollutants to prevent and tackle pollution events.

Directive 2008/50/EC requires that action plans are drawn up indicating the measures to be taken in the short term "where there is a risk of an exceedance of one or more alert thresholds" (in order to reduce the risk of the duration of such an exceedance). However, alert thresholds as defined in Annex XII of Directive 2008/50/EC only exist for NO_2, SO_2 and O_3, and therefore short-term action plans are not required for other pollutants such as PM_{10}.[59]

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: An obligation for effective short-term action plans for each pollutant would prompt further action to bring emissions and concentrations down compared to the current situation, thus expected to benefit air quality and protect in particular sensitive groups from immediate health risks. Additional administrative burden is expected from this intervention as it imposes new requirements to Member State competent authorities. Risks linked to this intervention have to do with time-lag and separation of source from pollution. Short-term action plans may be effective only to a limited extent where pollution episodes cannot be influenced by local measures or in case of secondary pollutants for which it is not straight forward to identify immediate measures.

C5 Introduce a requirement to update air quality plans

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C5	Introduce requirement to update air quality plans	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- ----	(+)	**Medium**	**Policy option II-3**

Focus of measure: Mandate regular updates of air quality plans.

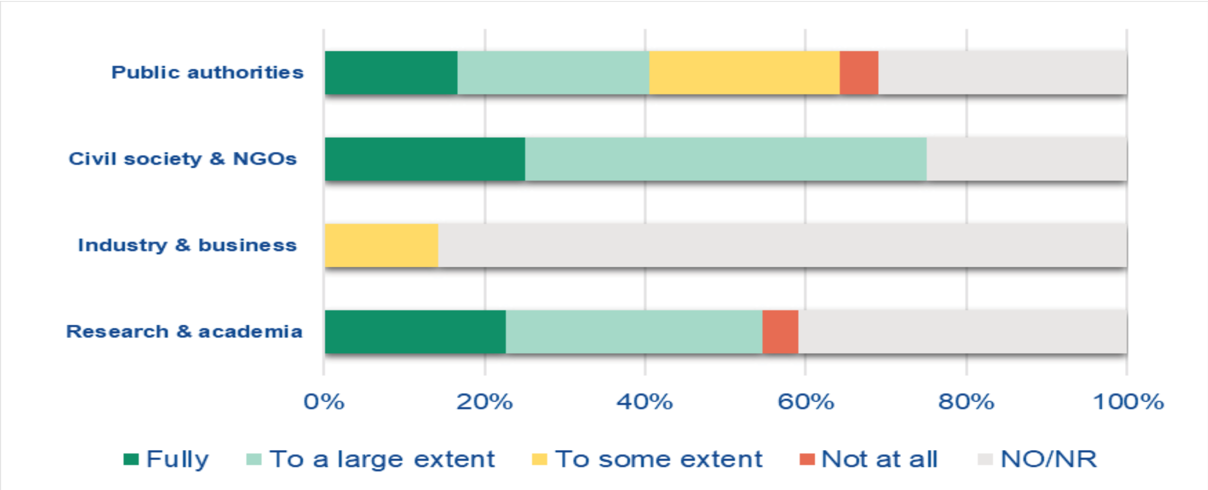
Description of measure: This measure would introduce an obligation for competent authorities to update air quality plans at regular intervals to keep exceedance periods as short as possible. Specific frequency of the update would take into account the administrative burden such updates entail. Based on feedback received from the Targeted Stakeholder

[59] COM (2019), Fitness Check of the Ambient Air Quality Directives- final

Survey, updating air quality plans every three years is seen as reasonable by stakeholders.[60] This measure is intended to enhance effectiveness of air quality plans by ensuring the relevance of air quality plans and associated measures in a changing air quality context for a specific location (i.e. to ensure that measures in air quality plans address new challenges for air quality). It would be important to define the scope of updates. Feedback from regional authorities received in response to the Targeted Stakeholder Survey note that:

- updates should not necessarily require an update of all underpinning data/studies on emissions/sources and of scenario model runs but evaluate the effectiveness of the implemented measures and consider whether more measures are needed;
- new measures to tackle emerging exceedances could be adopted within existing plans, without having to draft a new plan;
- updates should contain an evaluation of measures included in previous plans, and, if relevant, a motivation why these have not been taken or have not achieved the envisaged effects.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Requiring regular updates of air quality plans would increase the effectiveness of plans and thus have an 'indirect' positive effect on air quality. Mitigation costs and administrative burden are expected to directly impact Member State competent authorities responsible for the updating of air quality plans and implementation of measures. A risk identified for this measure relates to the fact that the process of drafting air quality plans tends to be long.

[60] Based on responses to Targeted Stakeholder Survey where replies ranges from requiring revisions yearly to every ten years, with a few stakeholders - including national and regional authorities - mentioning three years as adequate.

2.4 Intervention area D: Air Quality Plan Involvement

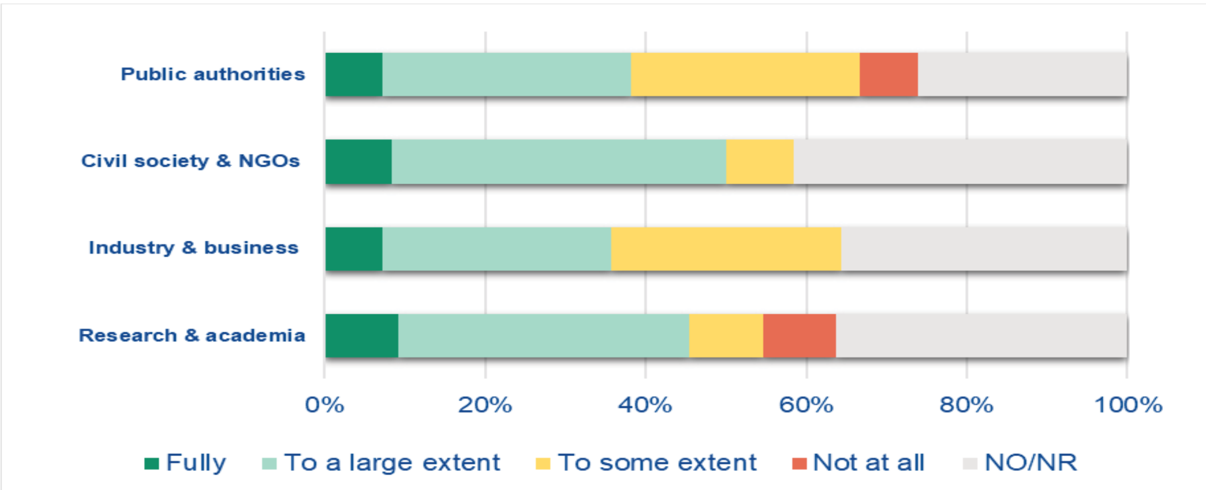
D1 Revise requirements to involve stakeholders

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D1	Revise requirements to involve stakeholders	(+) (+) (+) 0	0 0 0	0 0/- 0	0/- --	0	**High**	**Policy option II-1**

Focus of measure: Establish a requirement for Member States to involve specific actors in air quality plan development and to specify coordination arrangements for the development and implementation of air quality plans.

Description of measure: This measure would require Member States to involve all relevant actors in the drafting of air quality plans and coordinate better with these. Actors may include national/regional/local competent authorities, sectoral representatives from polluting industries, research institutes, civil society and local citizens. To this purpose, the revised Ambient Air Quality Directives should include the following concerning the preparation of air quality plans (1) a requirement for consulting and involving government authorities at various levels, and (2) a new ‘public participation’ clause for the development of air quality plans. The revised Directive should specify which aspects of the planning process should be open to public consultation and what this should involve. The problem that this measure is trying to address is that since there are no requirements on how to allocate roles and responsibilities in air quality plans, cooperation between government authorities at various levels is not a given. This can lead to insufficient action being taken by public authorities or to a mismatch of action, and therefore to air quality plans and measures being insufficient, inefficient and/or ineffective. In addition, while air quality remains a top environmental concern for EU citizens, citizens are not systematically consulted in the development of air quality plans.

Stakeholder views: A targeted survey provided feedback on *‘to which extent would this specific intervention address the identified (related) shortcomings’*.



Summary: This measure seeks to improve the involvement of all relevant actors in the design and implementation of air quality plans. This may be done by possibly adding a requirement for consulting and involving government authorities at various levels, and by introducing a new 'public participation' clause for the development of air quality plans.

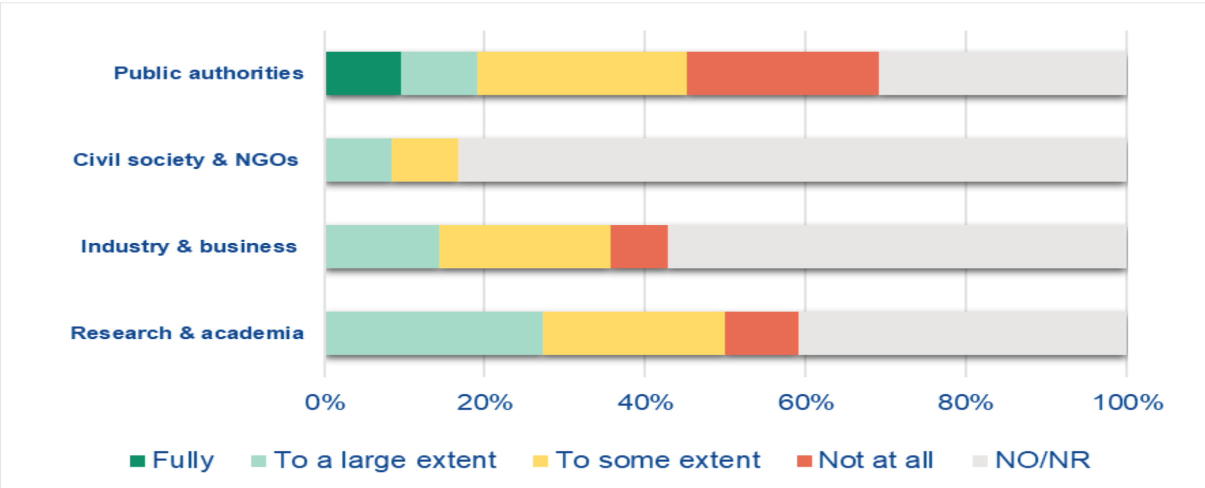
D2 *Introduce a 'one zone, one plan' requirement*

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D2	Introduce a 'one zone, one plan' requirement	0 0 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub-option II-1a**

Focus of measure: Introduce a requirement for Member States to harmonise air quality plans and air quality zones (and require a 'one zone, one plan' approach).

Description of measure: This measure would further define the requirements for drawing air quality plans in Article 23 of the Directive 2008/50/EC to require that one zone has to fully overlap with one plan (and hence avoiding zones with multiple plans and plans for multiple zones). This measure aims to increase the effectiveness of the Ambient Air Quality Directives by tackling the current mismatch between the zones of air quality monitoring and air quality plans.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to increase the effectiveness of the Ambient Air Quality Directives by tackling the current mismatch between the zones of air quality monitoring and air quality plans. However, the benefits and added value of this intervention are unclear while it would generate some costs (and considerable administrative burden). Overall it is unclear what the added value of this intervention would be and a global approach does not seem helpful as air quality plans and air quality zones are very specific to local conditions. Arguments against this intervention in the Targeted Stakeholder Survey revolve around changes that would be needed in terms of governance / responsibilities as well as around additional administrative burden that the intervention would lead to.

2.6 Intervention area E: Enforcement tools

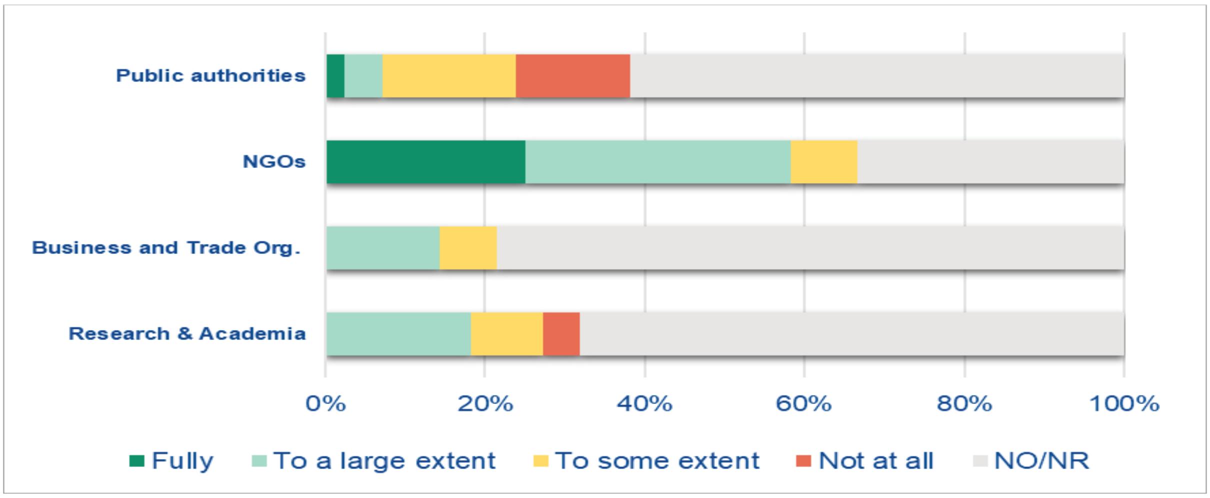
E1 Introduce minimum levels for financial penalties

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E1	Introduce minimum levels for financial penalties	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) (-)	(+)	**Medium / High**	**Policy option II-4**

Focus of measure: Introduce minimum levels for financial penalties decided at national level.

Description of measure: This measure aims to expand the current provisions on penalties in the Ambient Air Quality Directives (Article 30 of Directive 2008/50/EC and Article 9 of Directive 2004/107/EC) to specify the magnitude of the financial penalties to be paid. In cases of failure to comply with air quality standards by establishing a minimum level for such. These penalties would be directed to competent authorities as well as industry or other private entities and should lead to penalties or sanctions that are high enough to be effective and dissuasive. The number of continued exceedance situations can be seen as an indication that Member State penalties are not sufficiently effective, proportionate nor dissuasive, with the effect that the legislation has not been adequately implemented. Further, currently financial sanctions differ from Member State to Member State leading to leading to discrepancies in terms of level of penalties and their application across the EU. While penalties are to be laid down by Member States, there is potential for more clearly framing the use and scope of penalties in the Ambient Air Quality Directives following the examples of other EU legislation.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Effective minimum penalty levels should discourage competent authorities and industry or other private entities from breaching provisions of the Directives or measures adopted pursuant to the Directives, thus indirectly benefiting air quality, ecosystems and health. If effective, it would lead to competent authorities and industry implementing more measures to avoid breaches (and therefore avoid the high fines). This would indirectly generate additional costs for these actors, though related to achieving compliance. The additional administrative burden of clarifying levels of financial penalties is low and would facilitate their implementation. The risks for implementation have to do with determining penalty levels applicable across the EU and, more indirectly, with difficulties with enforcement of breaches.

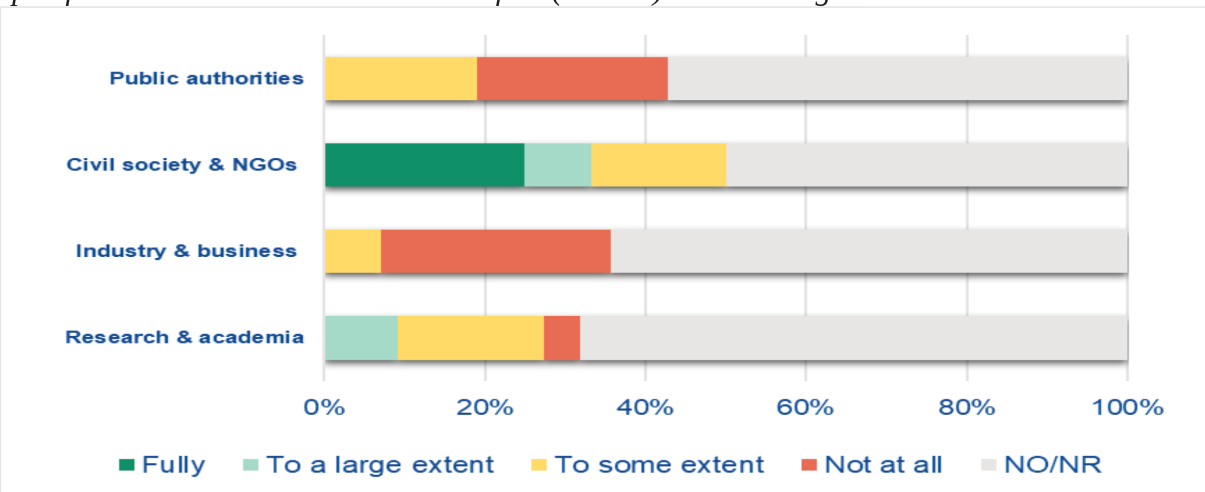
E2 Introduce right to health damage compensation

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E2	Introduce right to health damage compensation	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- 0	(+)	**Medium**	**Policy option II-4**

Focus of measure: Introduce an explicit provision that provides a right to compensation for damage to health caused by air pollution.

Description of measure: This measure would introduce an explicit provision within the Ambient Air Quality Directives on the right to compensation for damage to health caused by breaches of the Ambient Air Quality Directives. The principle of state liability allows for individuals to seek compensation under certain conditions for harm suffered as a result of Member State non-compliance with EU law.[61] Such a provision would clarify and facilitate compensation for harm suffer to health from air pollution. The reason for this measure is that while there is overwhelming epidemiologic evidence on the negative health impacts of air pollution on the population, exceedances still take place (albeit the frequency, extent and magnitude of these have generaly improved since 2008) and damages linked to these are not always addressed sufficiently.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



[61] The application of this principle of state liability to breaches of Member States' obligations pursuant to Articles 13 and 23 under the Ambient Air Quality Directives is the subject of a preliminary reference currently before the Court of Justice of the EU in Case C-61/21, *Ministre de la Transition écologique and Premier ministre*. See Annex 12 for more detail on the case.

Summary: This measure would work as an incentive for competent authorities and industry/business to implement more effective measures, which in turn would benefit air quality, health and ecosystems. This measure, if implemented, would require competent authorities and/or industry (polluters) to pay compensation to those who have suffered damage to health from air pollution and would therefore carry mitigation costs for those who are held accountable for breaches of air quality standards. It would also carry administrative burden for competent authorities and/or industry (polluters) as they would need to put in place and manage the compensation scheme and deal with a potentially increasing number in lawsuits by citizens / civil society, though only in case of continued non-compliance. Implementation challenges include the difficulty to prove the causal link between pollution and long-term health effects and the question of accountability (who is held responsible).

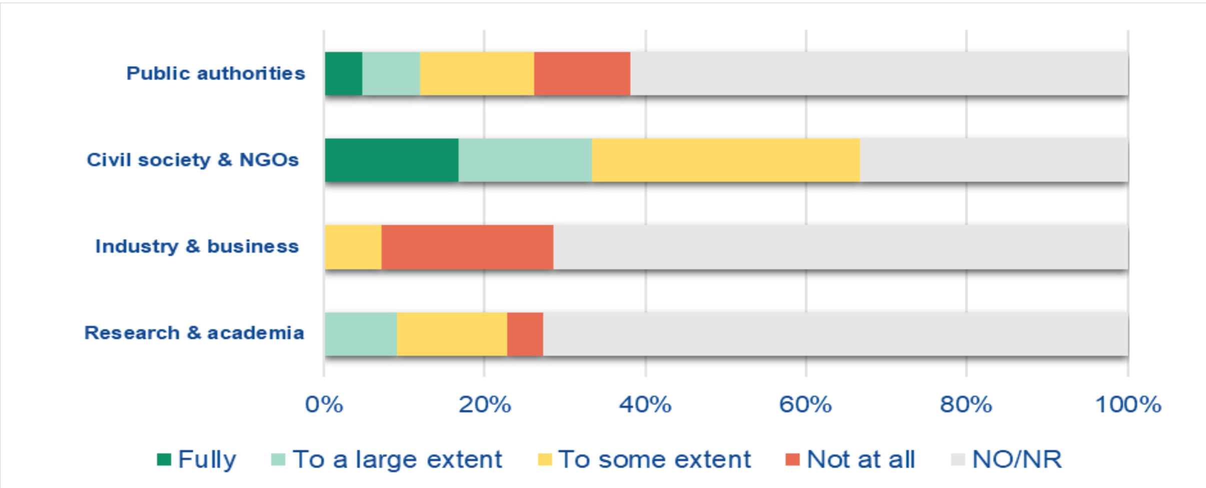
E3 Introduce a fund to be fed by penalties paid

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E3	Introduce a fund to be fed by penalties paid	0/(+) 0/(+) 0/(+) 0/(+)	0 (+) 0	0 0/(+) 0	0/+ (-)	0/(+)	**Low**	**Sub-option II-4a**

Focus of measure: Set up a fund to be fed by the payment of penalties which can be used to compensate material damage or finance air quality measures.

Description of measure: This measure consists of setting up a “clean air fund” to be fed by the payment of penalties when the rules established by the Ambient Air Quality Directives, or possibly other rules addressing air pollution, are infringed. It would be used to compensate victims of air pollution as well as to finance air quality measures. The fund could be established either at EU-level (an EU-wide fund) or at national level (with each Member State having their own fund).

Stakeholder views: A targeted survey provided feedback on *‘to which extent would this specific intervention address the identified (related) shortcomings’*.



Summary: A dedicated fund would make available funding for compensation for health damage suffered and facilitate access to funding of the implementation of mitigation measures (leading to measures being more readily implemented). However, it could also lead to competent authorities using the fund to finance measures that they would implement in any case, without leading to 'more' (i.e. additional) measures being implemented, which is a risk the governance of the fund would have to address. Setting up and administering such a fund will generate additional burden. Risks for implementation include a potential conflict of interest in the case the authority that has to pay also administers the fund and alignment with national budgetary rules. The organisation of the fund could provide safeguards to avoid that the budget from which the penalty is paid into the fund is not the one benefiting from it.

E4 Introduce an explicit 'access to justice' provision

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E4	Introduce access to justice provision	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) 0	0	**High**	**Policy option II-4**

Focus of measure: Introduce an explicit provision in the Ambient Air Quality Directives that grants the public concerned 'access to justice'.

Description of measure: This measure introduces a new explicit provision on 'access to justice' in the Ambient Air Quality Directives. The Fitness Check of the Ambient Air Quality Directives found that enforcement action by civil society actors in front of national courts has proven to be important to accelerate downward trends for air pollution. This has been confirmed by the Inception Impact Assessment, which notes that "the effectiveness of legal enforcement action by civil society is linked to the functioning of access to justice at national level".[62] However, studies have shown that rules on access to justice rules vary widely between Member States and that there exist still significant hurdles to effective access to justice at national level.[63]

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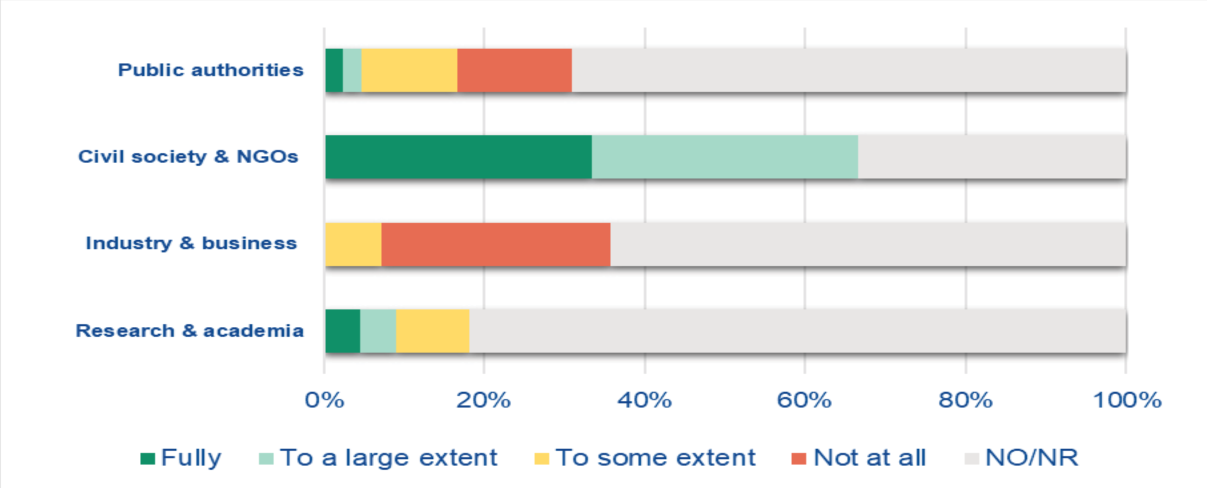
[62] COM (2020), Inception impact assessment - Ares(2020)7689281 (accessed: 04.08.2022)

[63] For example: 2013 access to justice report on the Implementation of Articles 9.3 and 9.4 of the Aarhus Convention in the Member States of the European Union and 2019 Milieu Study on EU implementation of the Aarhus Convention in the area of access to justice in environmental matters. (accessed: 10.06.2022)

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There is a gap in the Ambient Air Quality Directives with regard to 'access to justice' and including such a provision in the legislation would be a coherent step, in line with other environmental Directives,[64] Article 47 of the EU Charter of Fundamental Rights, the Aarhus Convention[65] and the case law of the Court of Justice of the EU.[66] Public judicial enforcement of the obligations under the Ambient Air Quality Directives has so far already lead to multiple national rulings (in several Member States) mandating national authorities to take action to improve air quality. Introducing an explicit provision would enable such action by citizens that are currently unable to do so because of strict national procedural requirements.[67] In turn, this would indirectly benefit air quality and human health as a whole. Additional administrative costs for Member States (probably central / national government) and industry may occur as an increase in lawsuits may be expected; this would largely depend on whether national authorities have already taken the necessary measures to comply with the Aarhus Convention and the relevant case law of the Court of Justice of the EU. The implementation of the intervention carries risks in terms of capacity for Member States to deal with additional legal claims.

[64] For example: Article 6(2) of Directive 2003/4/EC, Article 13 of Directive 2004/35/EC, Article 11 of Directive 2011/92/EU, Article 25 of Directive 2010/75/EU and Article 23 of Directive 2012/18/EU.

[65] UNECE (1998), Convention on access to information, public participation in decision-making and access to justice in environmental matters (accessed: 10.06.2022)

[66] For an overview see: Commission Notice on Access to Justice in Environmental Matters (accessed: 10.06.2022)

[67] See Annex 12 for an illustrative overview of clean air cases before national courts.

2.7 Intervention area F: Information to the public

F1 Revise provisions related to up-to-date data

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F1	Revise provisions related to up-to-date data	0 (+) 0 0	(+) 0 0	0 0 0	0 --	0	Medium / High	Policy option IV-1

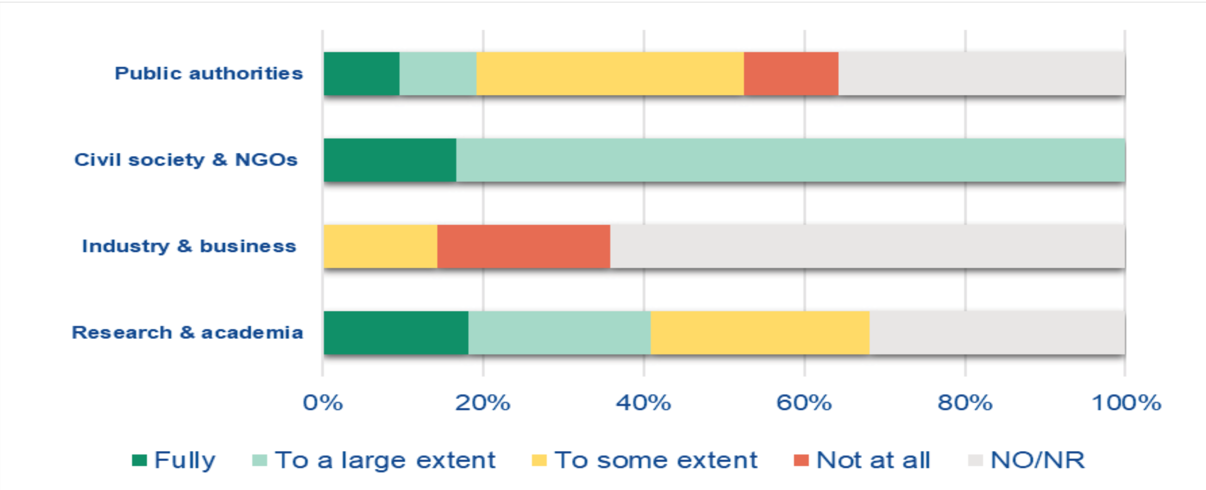
Focus of measure: Introduce more specific requirements to ensure regular reporting of up–to–date data / information (instead of allowing Member States to report data as available).

Description of measure: This intervention aims to tackle the problem that the general public is not always sufficiently informed regarding current air quality, and the problem that public information on air quality in Member States is not always timely. In addition, NGO stakeholders have consistently raised the issue that the current discretion given to Member States to determine when and how they provide information is sometimes leading to Member States reporting only on days on which air quality is good.

The intervention explores further specifying Article 27 of the Directive 2008/50 by **i**ntroducing regular reporting requirements to ensure up-to-date data and that information is made available to the public, specifying:

- the timeframe for reporting;
- the data/information to be reported;
- obligation to display such information / data on air quality on screens in key points of cities and towns.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: Up-to-date data and information on air quality would allow citizens to make decisions that may impact on their health, such as deciding not to participate in outdoor leisure activities or opting for a cleaner transport route. Hence there is a benefit in ensuring consistent access for citizens across Member States to real-time, appropriate information, which is publicly accessible. Having such information / data would be particularly important for vulnerable groups. The benefits of the intervention are indirect while its costs are negligible but administrative burden will increase slightly for Member States. There are risks around the accuracy of real-time information.

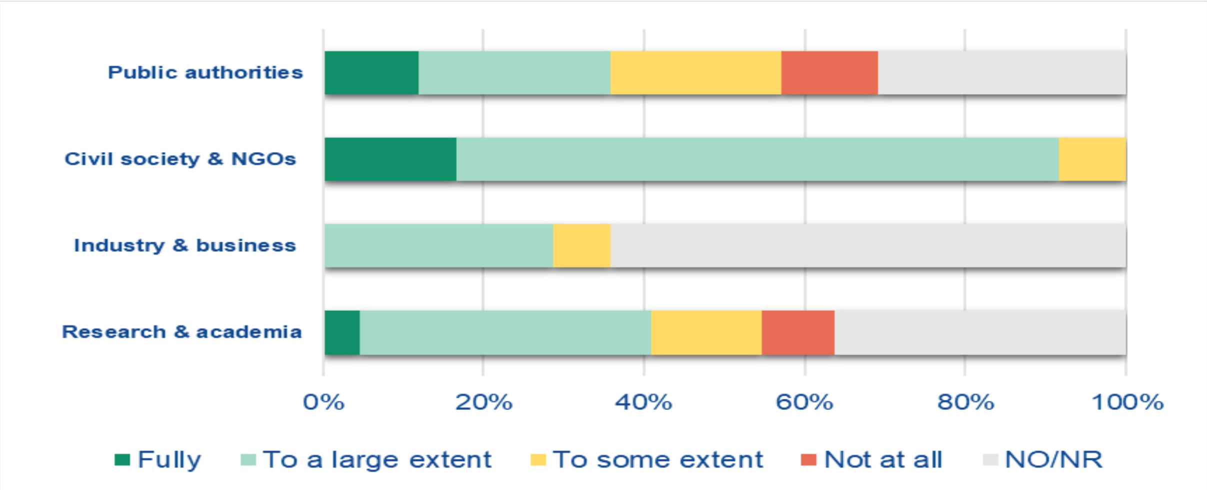
F2 Introduce requirement to provide air quality health data

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F2	Introduce requirement to provide air quality health data	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option IV-2**

Focus of measure: Require Member States to provide specific health / and health protection information to public as soon as exceedances occur.

Description of measure: This intervention would require Member States to provide information to the public as soon as exceedances of alert thresholds occur. The issue that this intervention is trying to solve is that currently when alerts are made public, it is often too late to protect the health of the population because pollution peaks often do not last long. A standardised approach to providing information about the negative health effects in a simple, understandable form may prove useful for considering under this intervention.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Information on health (protection) would allow citizens to make decisions that may impact on their health such as deciding not to exercise outdoors or opting for a cleaner transport route. Ensuring that information is provided to allow citizens to take timely action would increase the effectiveness of information provided, whilst the costs are considered negligible since relevant information and the systems to provide it are already in place.

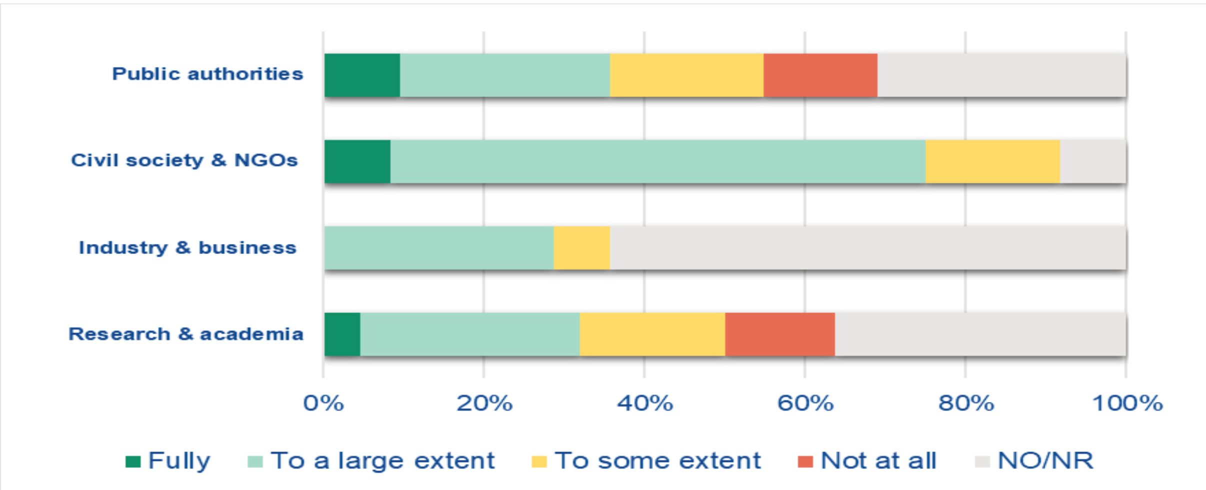
F3 Introduce use of specific communication channels

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F3	Introduce use of specific communication channels	0 0 0 0	(+/-) 0 0	0 0 0	0 ---	0	**Low**	**Sub-option IV-2a**

Focus of measure: Mandate specific communication channels with citizens, including user-friendly tools for public access to air quality and health risks information.

Description of measure: This intervention would mandate the use of specific user-friendly communication channels to reach out to citizens (for example, smartphone apps, social media, text messages, forecasts on television (similar to weather forecasts)) so that citizens have access to air quality data and information related to health risks. The issue this intervention is trying to solve is that citizens do not always know where to access (reliable) air quality information and that governments do not know how to best provide information. Tools and the quantity and quality of information provided to citizens varies between Member States.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Obliging competent authorities to use a set of information channels would lead to a better, and consistently informed public with indirect benefits on health, however given the case care has to be taken on which channels to define for use. The cost of developing (in particular where these are not currently in place) specific, high-tech channels may be more costly, which may divert resources from other, more productive, means.

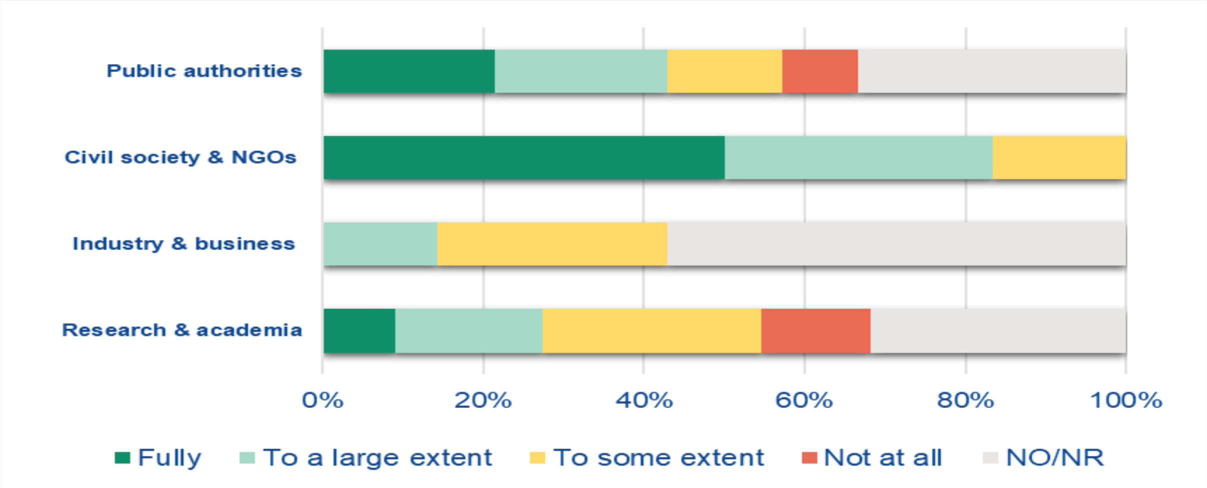
F4 Introduce requirements for harmonised air quality index

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F4	Introduce requirements for harmonised air quality index	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option IV-3**

Focus of measure: Require Member States to use harmonised air quality index bands.

Description of measure: This intervention consists of including a provision in the Directive 2008/50 to require Member States to use harmonised air quality index bands, namely those used in the European Air Quality Index. This way a one-size-fits-all where everyone adopts the same index is avoided, acknowledging that different countries and regions have their own characteristics which make different pollutants relevant. The problem that this intervention is aiming to solve is the current absence of a common metric used for publicised air quality indices. At the moment Member States (and even regions within in some cases) have different air quality indices whose bands and thresholds differ from the European Air Quality Index provided by the European Environmental Agency. This often means that the same data is presented in different ways in different locations. Although there is no consensus on whether and how air quality indices can be harmonised, what is known (from the study "*Strengthening of air quality monitoring, modelling and plans under the Ambient Air Quality Directives*") is that there is not much support for all Member States adopting the European Air Quality Index. As such adopting the bands alone seems the most feasible compromise which has obtained wide support in the stakeholder consultation activities.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Consistency in the information provided to citizens will aid clarity and uniformity in the opportunity provided to all EU citizens to take action to reduce their exposure with indirect benefits for health. However, there are concerns that the European Air Quality Index is not effective (e.g. around its ability to represent multi-pollutant effects), and that complete harmonisation may restrict the ability of Member States to tailor advice and information to the specific situation in each Member State. The intervention will increase administrative burden for competent authorities (regional or national) as it will require these to adapt their index bands.

2.8 Intervention area G: Assessment regimes

G1 Revise rules related to indicative sampling points

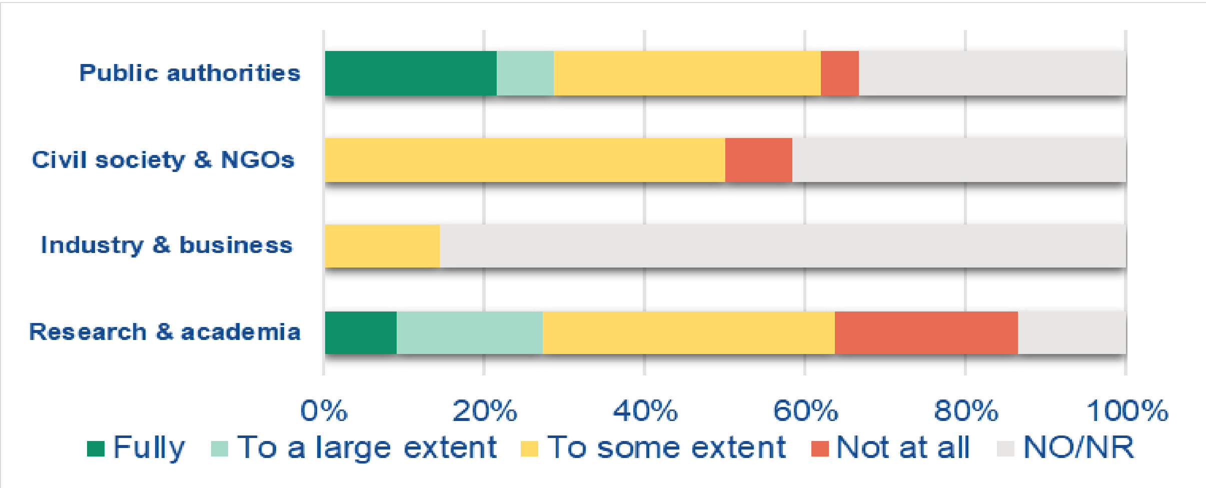
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G1	Revise rules related to indicative sampling points	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 ---	0	High	Policy option III-1

Focus of measure: Allow / continue to allow the use of indicative monitoring to substitute fixed monitoring as part of air quality assessment.

Description of measure: The use of indicative monitoring could substitute fixed monitoring stations in the air quality assessment process. However, the minimum number of fixed monitoring stations are still required to assess main temporal and spatial trends. Possibilities under which circumstances indicative measurements could substitute fixed monitoring include:

(1) Where there is a need to measure air quality but it is not possible to place a fixed monitoring station that meets the requirements of the Directive;
(2) Where the combination of different measurements (e.g. via data fusion) allows reaching data quality objectives

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: When used to supplement fixed monitoring (not substitute), such as in places where it is not possible to place a fixed monitoring station that meets the requirements of the Directive, additional indicative monitoring contributes to a better overall understanding of the air quality assessment process since additional sampling data is at hand. This contributes to an overall improved air quality assessment process with indirect benefits to air quality, health and ecosystems. However, the substitution of fixed monitoring stations by lower quality indicative monitoring devices is seen by many stakeholders as a major risk to degrade an important pillar in air quality management. The network of National Air Quality

Reference Laboratories (AQUILA), supports making the use of indicative measurements mandatory in areas where the upper assessment threshold is exceeded, supplementing fixed measurements. They should also be used for model validation.[68] Administrative burden is dependent on implementation: where used to supplement fixed monitoring, there would be an increase in costs and administrative burden, whereas substitution of fixed monitoring stations by indicative monitoring would result in cost savings.

G2 Introduce requirements for AQ modelling

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 ---	0	**Medium / High**	**Policy option III-1** and **Policy option III-5**

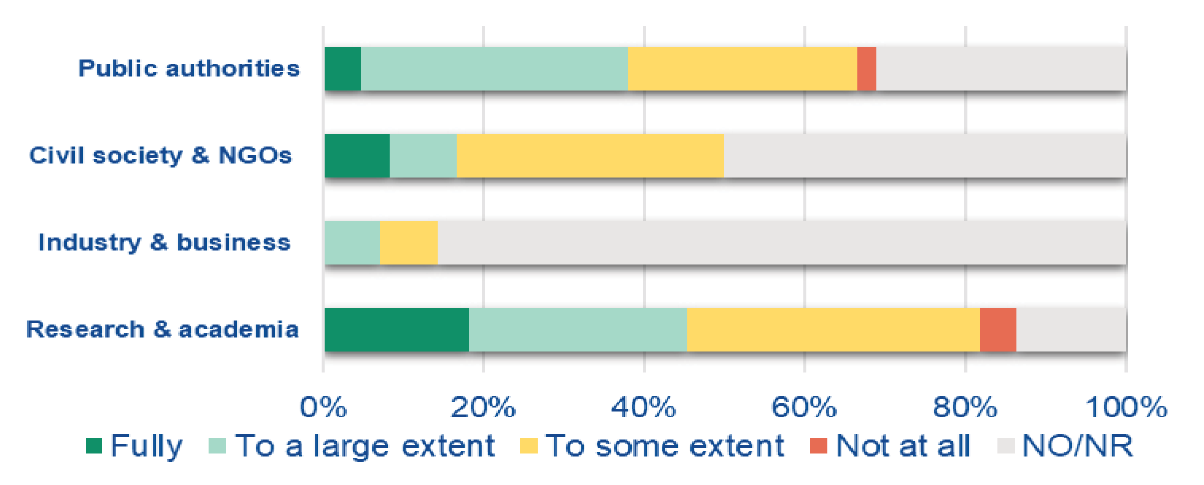
Focus of measure: Make the use of air quality modelling mandatory as part of air quality assessment (in some circumstances).

Description of measure: Modelling techniques can provide valuable information to supplement fixed measurements. Observations from fixed stations are limited to the sampling locations itself whereas modelling systems most often provide air quality maps with a full spatial coverage that can be used to derive specific indicators. Modelling can also help to disentangle the origin of the observed concentrations (source apportionment, long range transport) or extrapolate into the future (short term forecasts, future projections). Several variants exist for this intervention – related to the possible use of air quality modelling:

(1) For short term air quality forecasting (up to a few days ahead);
(2) For assessment of air quality for compliance checking purposes;
(3) For air quality near real time mapping and informing the public;
(4) For evaluation of monitoring network design;
(5) For estimation of population exposure and exceedance situation indicators;
(6) For source apportionment estimations;
(7) For assessment of long-range air pollutant transport;
(8) For future projections in support of air quality management and planning;
(9) As alternative to fixed monitoring (when placing such monitoring in line with the Directive is not possible).

[68] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Air quality modelling improves air quality monitoring and assessment, thus allowing for a better understanding of air quality concentrations, supporting a more effective and more targeted air quality management. The administrative burden may increase for competent authorities (to meet the reporting requirement). The increase is likely to depend on the current modelling capability and practices within each Member State. There are risks for implementation linked to technical capacity and potential lack of modelling guidance and/ or lack of resources for training and capacity building. There is also a risk that Member States may view the introduction of a mandatory requirement of modelling as a reason to reduce their monitoring network. There is strong support across all stakeholder types for the mandatory use of modelling for most of the nine use case variants in at least some instances. Some respondents, however, explained further that modelling should be (strongly) recommended in most of these use cases but only made mandatory for all Member States in one case, i.e. for future projections in support of air quality management and planning. The option of introducing requirements for the use of modelling for compliance checking purposes was the least favoured option among public authorities. The Forum for Air Quality Modelling (FAIRMODE) recommends the use of modelling for assessment purposes, forecasting and public information purposes, source apportionment and planning purposes, making it mandatory for air quality planning, exposure calculations, and short-term forecast.[69]

[69] Thunis P., Janssen S., Wesseling J.,Piersanti A., Pirovano G., Tarrason L., Martin F., S. Lopez-Aparicio, Bessagnet B., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerreiro C., González Ortiz A., Recommendations for the revision of the ambient air quality directives (AAQDs) regarding modelling applications.

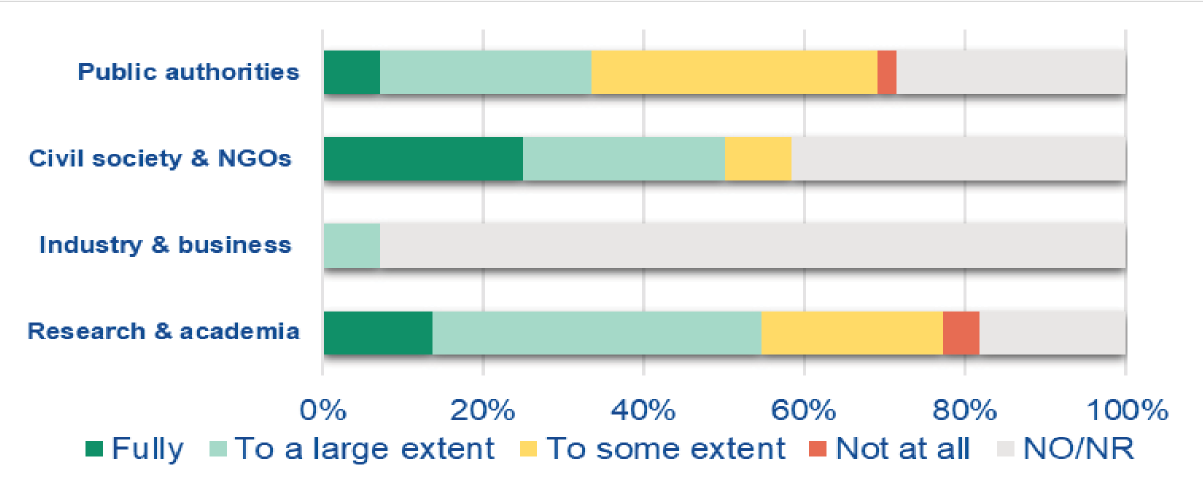
G3 Revise rules for regular review of AQ assessment

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G3	Revise rules for regular review of AQ assessment	0 0 0 0	0 0 0	0 0 0	0 (-)	0	**Low**	**Sub option III-1a**

Focus of measure: Require a regular review of the assessment regime following clear criteria defined in the Directive.

Description of measure: Regular review of the assessment regime is expected to ensure that the assessment techniques for air quality evolve with scientific advancements and knowledge. It also allows for improved and increased evidence on air quality including the use of models and more efficient monitoring networks. This would require the amendment of existing articles and Annex II point B to include set criteria. In addition, the interval at which a review should be done was queried with the options of every ten, five, three or one year(s).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention would require Member States to follow set criteria in their reviews of their assessment regime which rely on monitoring and/or modelling data. This would provide a more harmonised review of air quality assessment across Europe leading to a more transparent and coherent view of air quality status for wider public access. All Member States have ready access to fixed term monitoring, and most have modelling capability, so our expert view is that the costs for this intervention are insignificant. Administrative burden may be significant if the period for review is annual (stakeholder respondents favored the retention of five year reviews).

2.9 Intervention area H: Number and typology of sampling points

H1 Revise minimum number of sampling points

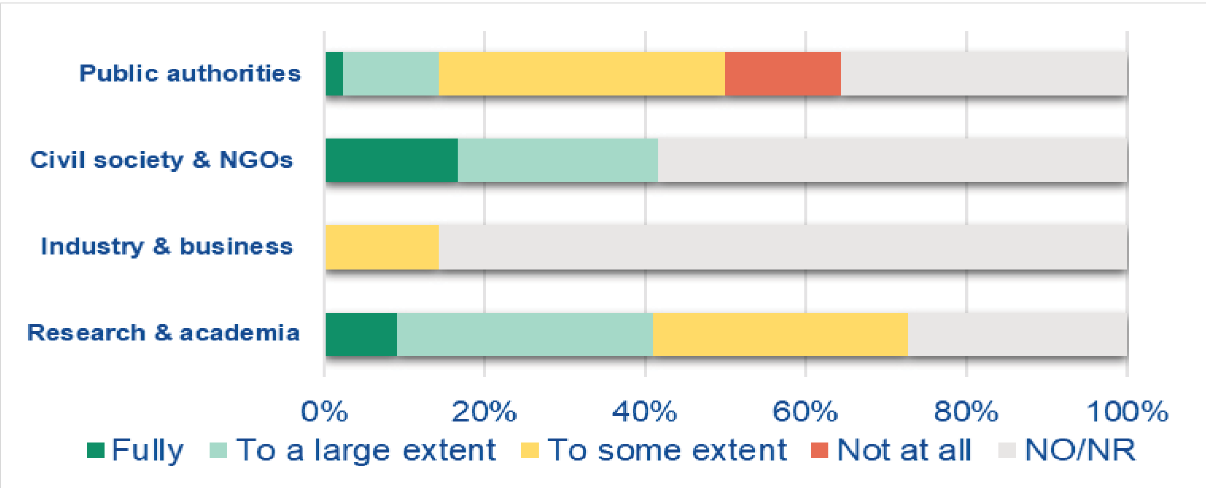
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H1	Revise minimum number of sampling points	+ + + 0	0 0 0	+/- 0 0	0 ---	0	Medium	Policy option III-1

Focus of measure: Change the minimum number of sampling points that are required per air quality zone.

Description of measure: The minimum number of sampling points per air quality zone for each pollutant should be revised with latest scientific knowledge. Possibilities to which extent would the below specific interventions address the above identified shortcomings include:

(1) Increase the minimum number of sampling points for all pollutants and all zones;
(2) Increase the minimum number of sampling points for some pollutants;
(3) Increase the minimum number of sampling points for some zones;
(4) Decrease the minimum number of sampling points for all pollutants and all zones;
(5) Decrease the minimum number of sampling points for some pollutants;
(6) Decrease the minimum number of sampling points for some zones;
(7) Require a minimum of 2 sampling points per zone per pollutant (i.e. to monitor both hotspots and background concentration levels);
(8) Establish a minimum number in the vicinity of point sources in view of emission densities;
(9) Establish a minimum number of sampling points for measuring pollution hotspots specifically;
(10) Establish a minimum number of sampling points for measuring population exposure.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: Changing the minimum number of sampling points required has potential for an increase or decrease in monitoring for the assessment of air quality (a reduction in the minimum number of monitoring stations would be detrimental to air quality, public health, ecosystems and costs to society but lessen administrative burden, while an increase in the minimum number of stations would have a positive impact on air quality, health and ecosystem but increase administrative burden). Costs arising from an increased number of stations would be incurred from greater laboratory analysis, and the additional staff needed for servicing and maintenance and data management. There is little/no support from stakeholders for any decrease in the minimum number of sampling points, while an increase of monitoring stations was favored for at least some pollutants and with a minimum to measure population exposure. The network of National Air Quality Reference Laboratories also favors an increase of sampling points and suggests as well the removal of the possibility to reduce the number of sampling points if fixed measurements are supplemented with indicative measurements.[70] While additional monitoring is associated with high costs, many Member States report monitoring above the current required number of sampling locations, and therefore in practice, an increase in monitoring required is overall beneficial.

H2 Simplify combined PM_{10}/$PM_{2.5}$ monitoring

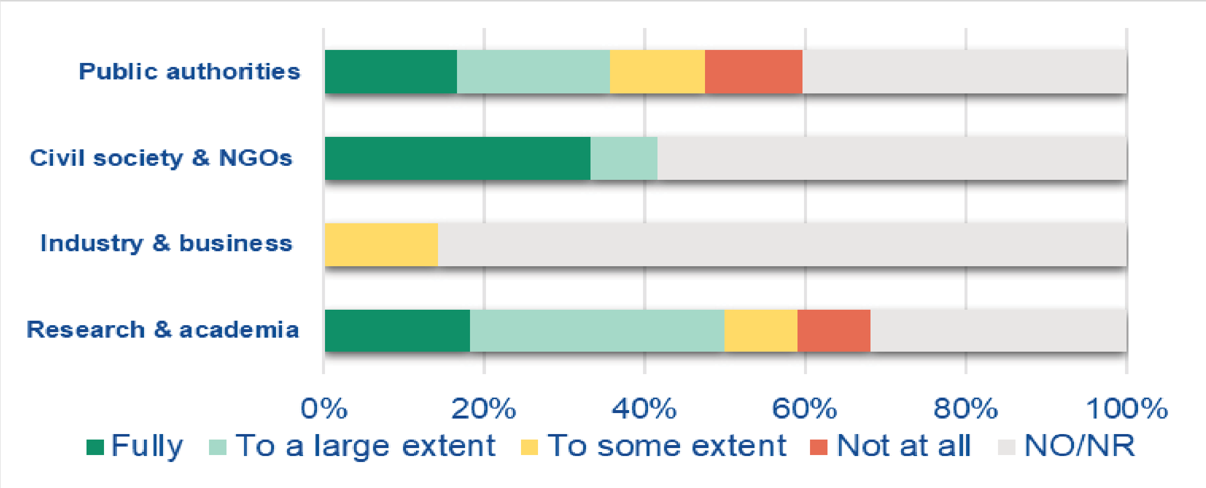
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H2	Simplify combined PM_{10}/$PM_{2.5}$ monitoring	(+) (+) 0 0	0 0 0	(+) 0 0	0 ---	0	**High**	**Policy option III-1**

Focus of measure: The minimum number of sampling points for measuring PM_{10} and $PM_{2.5}$ will be considered independently from each other.

Description of measure: This intervention de-couples of the current minimum number of sampling points for PM_{10} and $PM_{2.5}$, which should be set independently and cannot substitute one another.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.

[70] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.



Summary: This intervention de-couples the current minimum number of sampling points for PM_{10} and $PM_{2.5}$, which should be set independently and cannot substitute one another. $PM_{2.5}$ is a key pollutant for public health risk assessment. Given its important impacts on mortality and morbidity, it is essential for it to be considered and assessed independently from PM_{10}. Clarifying and giving more focus on the assessment of this pollutant in the revised Ambient Air Quality Directive would bring benefit to driving action in areas of exceedance to improve public health protection. Many Member States have already increased their sampling of $PM_{2.5}$ so in practice this intervention is unlikely to involve large costs, though for those Member States who monitor at minimum levels only, costs may be significant as those for new monitoring samplers are often high and comes with on-going maintenance costs. Public Authorities report no real increase in administrative burden to monitor PM_{10} and $PM_{2.5}$ separately. There is a time lag associated with this intervention (to establish the new sites) and this may risk air quality in the short term. Additional staff is needed to support sampler operation and data management.

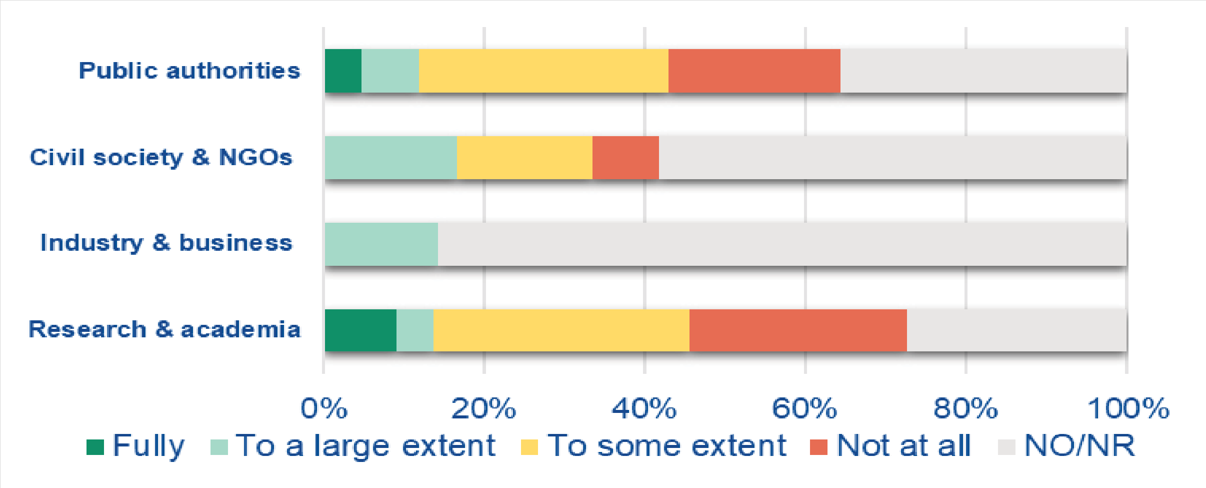
H3 Simplify the definitions of sampling points types

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H3	Simplify the definitions of sampling points types	0 0 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub option III-1b**

Focus of measure: Simplify the definitions of types of monitoring station and/or sampling point locations - and only differentiate for them to distinguish between hotspots or background concentrations.

Description of measure: Currently station classification includes a number of categories such as urban, suburban, rural, industrial, roadside etc. station classification could be simplified to identify sites as hotspots or background locations.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Currently station classification includes a number of categories such as urban, suburban, rural, industrial, traffic, background. Station classification could be simplified to identify sites only as hotspots or background locations. This may enable identifying a key source of pollution currently missing in the classification which is that due to residential combustion. As this intervention is a desk task to reclassify the current sites it is unlikely to have any real impact on administrative burden. To be effectively implemented, this intervention would require guidance. However, a more simplified classification risks loss of clarity and misunderstanding on the site differences and the main sources of pollution. The full reporting of site meta data under the IPR[71] and e-reporting by all Member States and clarification of terms further in the Ambient Air Quality Directive could greatly help to address this shortcoming.

[71] COM (2013), IPR Guidance part I and Part II (accessed 10.06.2022)

2.10 Intervention area I: Continuity of sampling points

I1 Introduce obligations to maintain sampling points

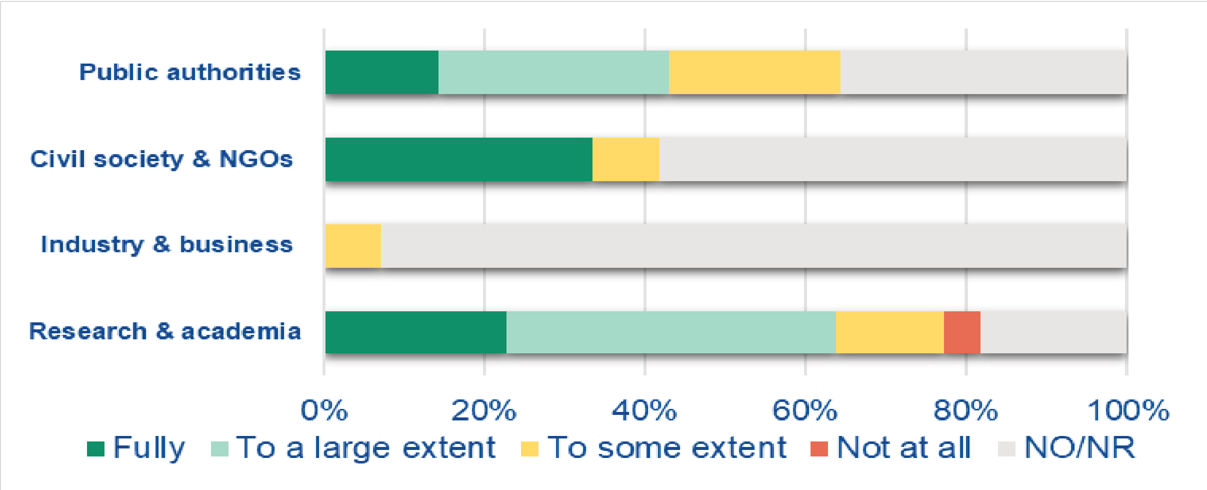
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I1	Introduce obligations to maintain sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 0	0	**High**	**Policy option III-2**

Focus: Specify that sampling points with exceedances of limit values for any of the pollutants measured under the Ambient Air Quality Directives should be maintained for a defined number of years.

Description of measure: Flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated (except for PM_{10} if exceeding limit values), but this disrupts trend analysis and causes uncertainty in areas of exceedance. This intervention would prevent sampling point closure within a defined number of years following site establishment. Possibilities under which circumstances can relocations of sampling points take place include:

(1) Due to requirements of local spatial development;
(2) If and when siting criteria are no longer met (macro-scale siting or micro-scale siting);
(3) If overlap between monitoring at 'old' and 'new' sampling point is guaranteed and reported (for a defined time period ensure monitoring at both locations to assure calibration)

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Providing clarity on the circumstances when sampling points may be relocated would reduce flexibility to close stations but allow for increased datasets for pollutant trend analysis. Requiring a set timeframe for the operation and maintenance of sampling points with exceedances of limit values for any of the pollutants under the Ambient Air Quality Directives would result in better datasets for assessment and trend analysis. This would in most cases be a prerequisite for more effective and more targeted air quality management.

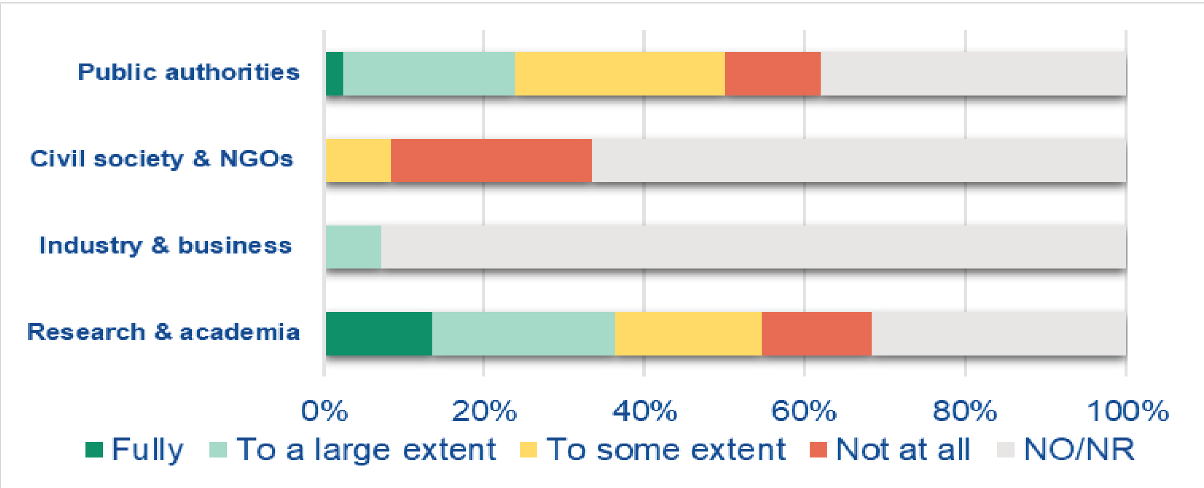
I2 Introduce obligations to monitor long-term trends

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I2	Introduce obligations to monitor long-term trends	(+) (+) (+) 0	0 0 0	0 0 0	0 (-)	0	Low	Sub-option III-2a

Focus of measure: Include the requirement to monitor long-term trends if fixed monitoring stations are discontinued (by assessing air quality via indicative measurements or air quality modelling), to not disrupt trend analysis.

Description of measure: Currently, flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated, but this disrupts trend analysis. Under the circumstances where stations are discontinued a requirement could be introduced to continue to monitor for long-term trends using indicative measurements or modelling.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Including a requirement to monitor long-term trend in the cases of relocation of fixed monitoring stations would allow for increased datasets for pollutant trend analysis. Assessing long-term trends in pollution data is important for the assessment and management of air quality. There is significant benefit to scientific understanding and policy development to protect health and the environment to have access to a long-established network of monitors. Costs for this intervention depend on the variant. Administrative burden and costs of monitoring could increase as the amount of fixed monitoring stations would remain the same, but it may be required to increase indicative measurements at all previous fixed measurement locations for long-term trend monitoring and analysis. However, where fixed monitoring stations could be replaced by indicative monitoring or modelling a cost saving is likely. For this intervention to be successful, it is important to align with those proposed interventions with the objective of improving quality of indicative monitoring and modelling.

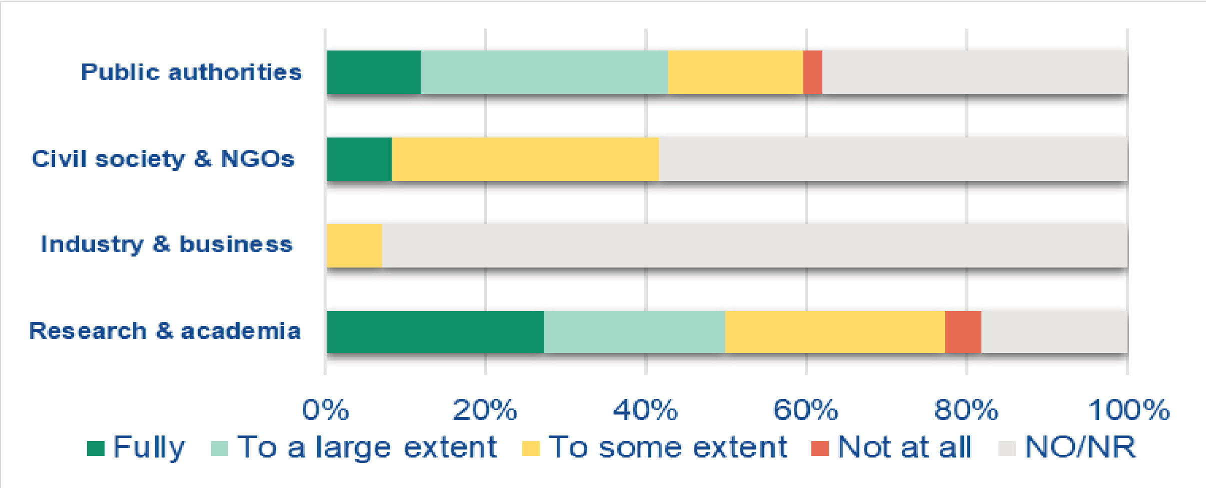
I3 Introduce a protocol for relocated sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I3	Introduce a protocol for relocated sampling points	(+) 0 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option III-2**

Focus of measure: Establish a protocol to follow should a sampling point have to be re-located due to, for example, infrastructure development or changes in the assessment regimes.

Description of measure: Currently, flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated, but this disrupts trend analysis. Whenever the circumstances of station discontinuation or sampling point relocation due to infrastructure development or changes in the assessment regime arise, a protocol establishing the requirements for such change should serve as guidance.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: A protocol could include an assessment of site representativeness, co-location of monitoring for a minimum time period, to assist in the assessment of data quality for trend analysis from the old and new sampling points and hence increase robustness and transparency especially when areas are in exceedance. This intervention, while helpful for greater assessment harmonisation is likely to have little impact on air quality and other indicators. The costs for this intervention are low. Although, reduced flexibility to relocate samplers when necessary, it may risk increased administration burden on Member States to find an alternative monitoring location.

2.11 Intervention area J: Siting of sampling points

J1 Revise macro-scale siting of sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J1	Revise macro-scale siting of sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 --	0	**Medium**	**Policy option III-4**

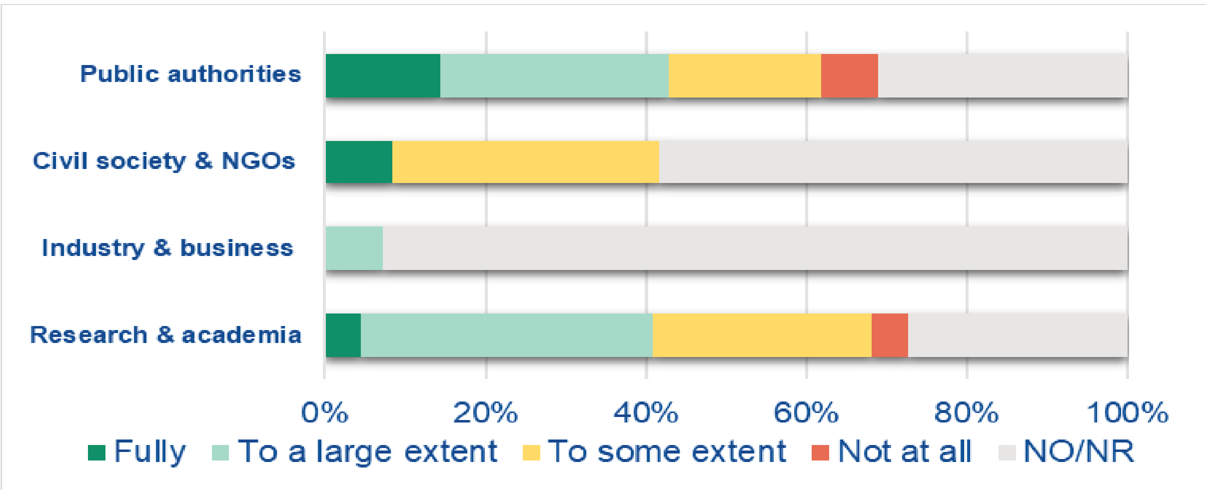
Focus of measure: Further clarify (and reduce flexibilities related to) the macro-siting criteria for sampling points.

Description of measure: The siting of sampling points can have a significant impact on the levels of air pollutants that are measured. In this intervention the macro-siting criteria for sampling points are clarified and flexibilities in the interpretation are further reduced.

This intervention has the following variants:

(1) Harmonise the macro-scale siting criteria laid down in Annex III and Annex VIII of Directive 2008/50/EC and Annex III of Directive 2004/107/EC – aligning with 2008/50/EC provisions;
(2) Clarify whether macro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements;
(3) Clarify whether specific locations should be explicitly excluded, even if there is public access to these (such as outdoor parking lots, train station platforms or street-facing café terraces).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The siting criteria are open for interpretation and not implementing the intervention could compromise the harmonisation and comparability of air quality measurement data within the EU. Inconsistencies can impact on the number of monitoring stations, the number and extent of exceedances identified, the need for measures to improve air quality, and the costs associated with these activities. This could also lead to issues of inequality and fairness in the implementation of the requirements and affect the proportionality of any potential infringement action. This intervention would increase the administrative burden for competent authorities in terms of sampling point evaluation and reporting of the relevant indicators. Most stakeholders support the implementation of this intervention since it will increase the comparability and harmonisation of air quality data over Europe. However, the same stakeholders indicate that some flexibility is still required in order to deal with practical selection and installation of sampling points. The variant with more support across stakeholders was the one clarifying whether macro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements.

J2 Revise micro-scale siting of sampling points

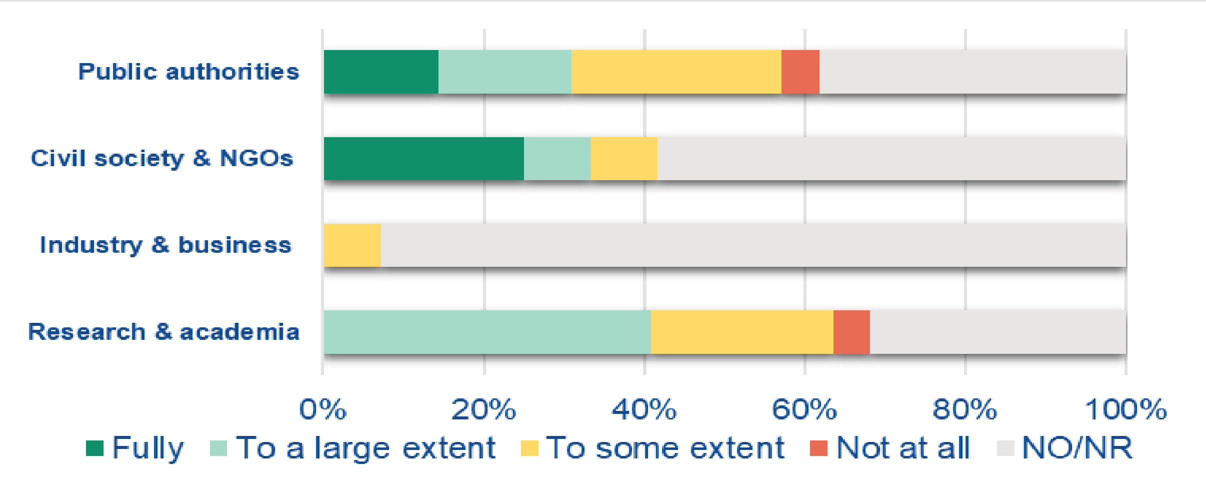
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J2	Revise micro-scale siting of sampling points	(+) 0 0 0	(+) 0 0	(+) 0 0	0 --	0	**Medium**	**Policy option III-4**

Focus of measure: Further clarify (and reduce flexibilities related to) the micro-siting criteria for sampling points.

Description of measure: This intervention has the following variants:

(1) Harmonise the micro-scale siting criteria laid down in Annex III and Annex VIII of Directive 2008/50/EC and Annex III of Directive 2004/107/EC – aligning with 2008/50/EC provisions;
(2) Clarify whether micro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements;
(3) Clarify the flexibility related the unrestricted flow around the inlet of sampling points.
(4) Clarify the flexibility related to the height of the inlet of sampling points;
(5) Clarify the flexibility related to the distance to the kerbside (or other metrics) of traffic-oriented sampling points.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revisions to micro-siting criteria which also apply to indicative monitoring may have an indirect benefit to society costs due to an indirect improvement on public health.

Where new indicative monitoring is being planned this intervention may give access to a higher quality monitoring dataset to assist air quality assessment, underpinning air quality action. There is a low administrative burden, unless the intervention leads to the disqualification of existing sites (in which case the administrative burden would be high). Costs are relatively low, particularly if this intervention does not result in the disqualification of established long-term sampling locations. The mostly favoured sub variant refers to the clarification regarding the flexibility related to the distance to the kerbside (or other metrics) of traffic-oriented sampling points. In this sense, the most concern raised by stakeholders was on the micro-siting criteria for sampling points is related to traffic sites, particularly in urban areas. However, these are complex environments with pollution concentrations varying in small micro-environments. Some level of flexibility is needed to local monitoring network managers to ensure monitoring effectiveness and efficiency.

J3 Introduce obligation for spatial representativeness

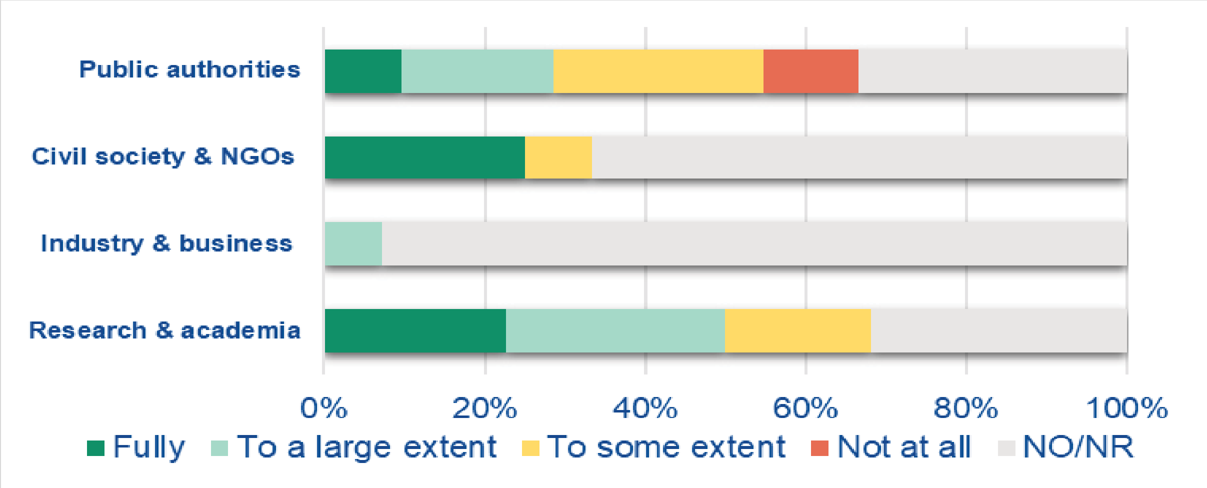
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J3	Introduce obligation for spatial representativeness	(+) (+) (+) 0	(+) 0 0	(+) 0 0	0 ---	0	**Medium**	**Sub option III-3d**

Focus of measure: Introduce the concept of a spatial representative area which should be estimated (and reported) for each sampling point (irrespective of exceedances being measured or not).

Description of measure: For every sampling location, a spatial representativeness (SR) area should be estimated and reported. This area of representativeness is an essential indicator of the sampling location. A Tiered approach is available to assess SR of monitoring sites:

- Tier 1: assessment based on expert judgement;
- Tier 2: assessment based on proxy data or indicative measurement campaigns;
- Tier 3: assessment based on fit-for-purpose modelling;
- Tier 4: assessment based on combination of modelling and indicative monitoring.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The concept of an SR area helps to clarify and harmonize air quality assessment based on monitoring data. It serves multiple purposes in this process: assessment of population exposure and exceedance situation indicators based on the monitoring data, monitoring network design and selection of stations for model validation and data assimilation. When modelling capacity is available higher Tier methods are rather straightforward to apply. Stakeholders indicate that there is a clear need for better definition for spatial representativeness and it would be useful to introduce this concept to the Ambient Air Quality Directives in order to ensure comparability between Member States.

2.12 Intervention area K: Data quality

K1 Revise AQ monitoring data quality objectives

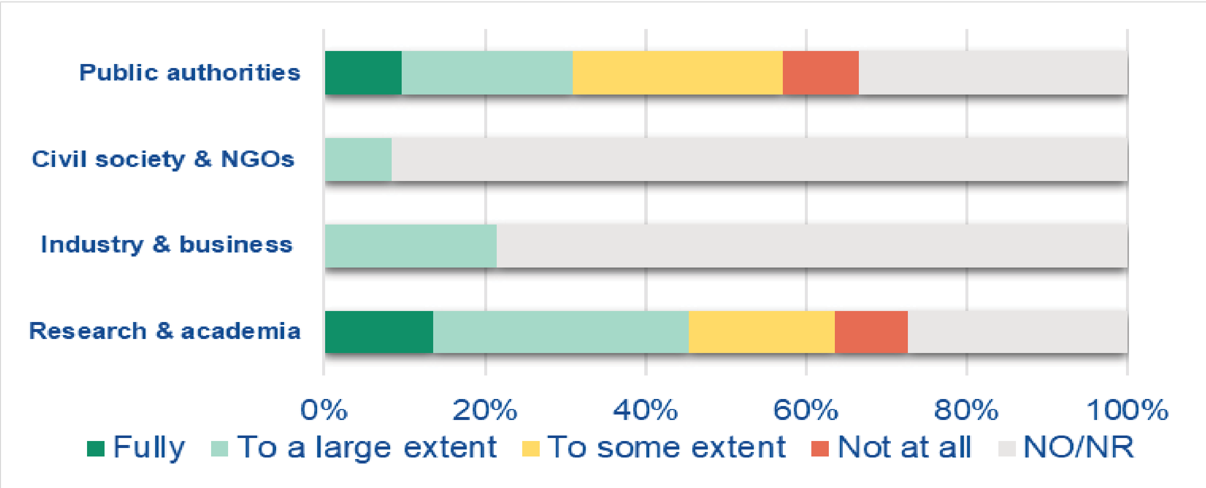
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K1	Revise AQ monitoring data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	Medium	Policy option III-4

Focus of measure: Further define the data quality requirements for sampling points / measurements used for air quality assessments.

Description of measure: To further define data quality including measurement uncertainty and data capture. Variants for this intervention include:

(1) Further align data aggregation requirements to be met for specific periods (e.g. hourly, daily, 8-hour or annual) or the whole year;
(2) Further align the data coverage (time coverage and data capture) requirements for all air pollutants;
(3) For ozone, align data coverage requirements for both for the full calendar year and for the period of April to September, as well as for the AOT40 indicator;
(4) For indicative measurements, set separate data coverage requirements for annual mean values and for short-term mean values;
(5) For calibration and validation of air quality modelling, introduce specific data quality requirements for sampling points / measurements (that are less strict than those used for air quality assessments).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: To make the full use of available data a protocol/guidance specifying appropriate methods for assessing compliance and estimating statistical parameters to account for low data coverage or significant data losses should be published. This intervention would improve data quality requirements for sampling points which is likely to increase robustness of data and may supplement evidence for trend analysis and modelling. This may lead to indirect improvements in air quality, health and ecosystems which may indirectly reduce costs to society as clarity is provided over the use of data. The costs for this are low or may even be a cost saving as administrative burden may reduce as modelling is likely to cost less than additional fixed or indicative measurements. The most favoured sub variant across all stakeholders was that introducing specific data quality requirements for sampling points / measurements. The network of National Air Quality Reference Laboratories also strongly favours a revision of data quality objectives.[72]

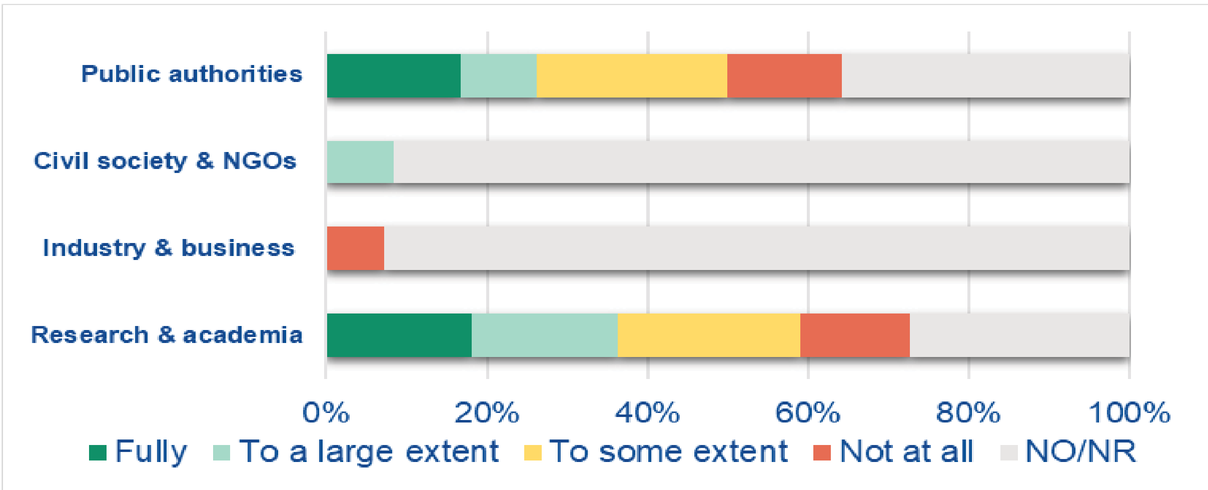
K2 Introduce up-to-date data at all sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub option III-1c** and **Policy option IV-1**

Focus of measure: Make it mandatory to provide up-to-date information on the pollutant concentration for certain air pollutants for a minimum number of sampling points per air quality zone.

Description of measure: There exists some ambiguity around the provision of up-to-date information from air quality assessment. Access to up-to-date air quality information is important for public communication on air quality. However, it is not clear what `up-to-date' means nor is it is not possible to produce real time information with the reference method for particulate matter. In addition, technical guidance could be provided for how to produce this type of data when using the reference method for particulate matter.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention would increase the harmonisation of the reporting of real-time air quality information, which during pollution episodic events, and for forecasters brings

[72] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

benefit to the public. Costs are low and those Member States already publishing real time data are unlikely to be impacted. There are risks to implementation in cases of monitoring sampler or IT system failure as this would inhibit publication of air quality data in real-time. Increased resources may be needed for some Member States to ensure immediate data quality.

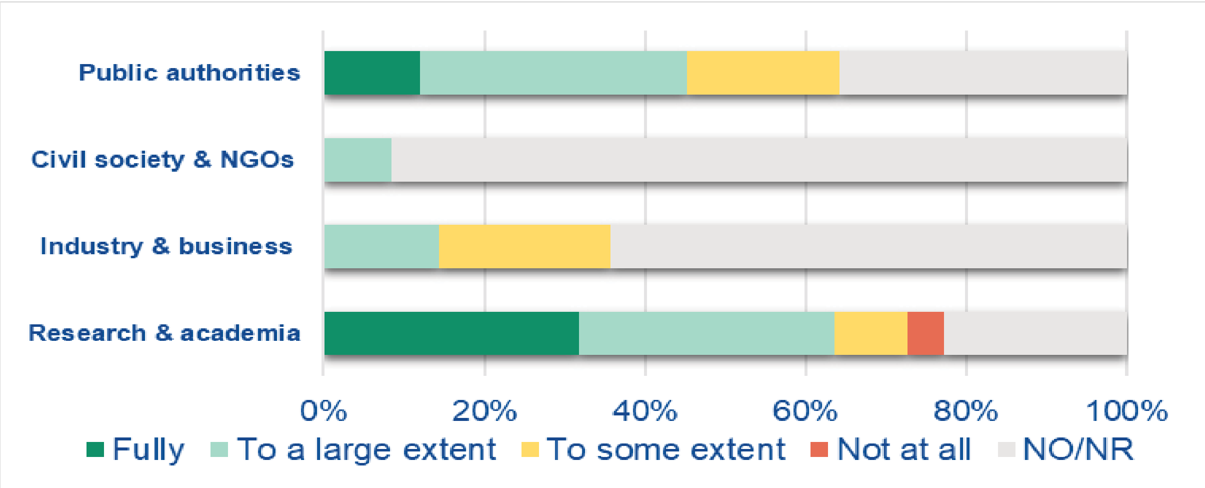
K3 Introduce AQ modelling data quality objectives

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K3	Introduce AQ modelling data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	**High**	**Policy option III-5**

Focus of measure: Introduce a standardized 'modelling quality objective' as a quality control mechanism to assess whether a modelling based assessment is fit-for-purpose.

Description of measure: Any modelling application used in support of the implementation of the Ambient Air Quality Directives should be of sufficient quality and be fit-for-purpose. This intervention is introducing a standardized Modelling Quality Objective (MQO) that should be met in the validation and QA/QC processes of modelling systems. FAIRMODE has proposed such a MQO which is currently under evaluation for becoming a CEN standard.[73]

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Modelling Quality Objective (MQO) would need to be met in the validation and QA/QC processes of modelling systems. FAIRMODE has proposed such a MQO which is currently under evaluation for becoming a CEN standard. High quality modelling

[73] Thunis P., Janssen S., Wesseling J.,Piersanti A., Pirovano G., Tarrason L., Martin F., S. Lopez-Aparicio, Bessagnet B., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerreiro C., González Ortiz A., Recommendations for the revision of the ambient air quality directives (AAQDs) regarding modelling applications.

applications will contribute to better air quality assessment and planning process. This results in high quality information for the public at large, better source allocation and source identification and eventually better air quality planning. There would be a small administrative burden as some of the modelling systems would have to be upgraded to meet the quality standards.

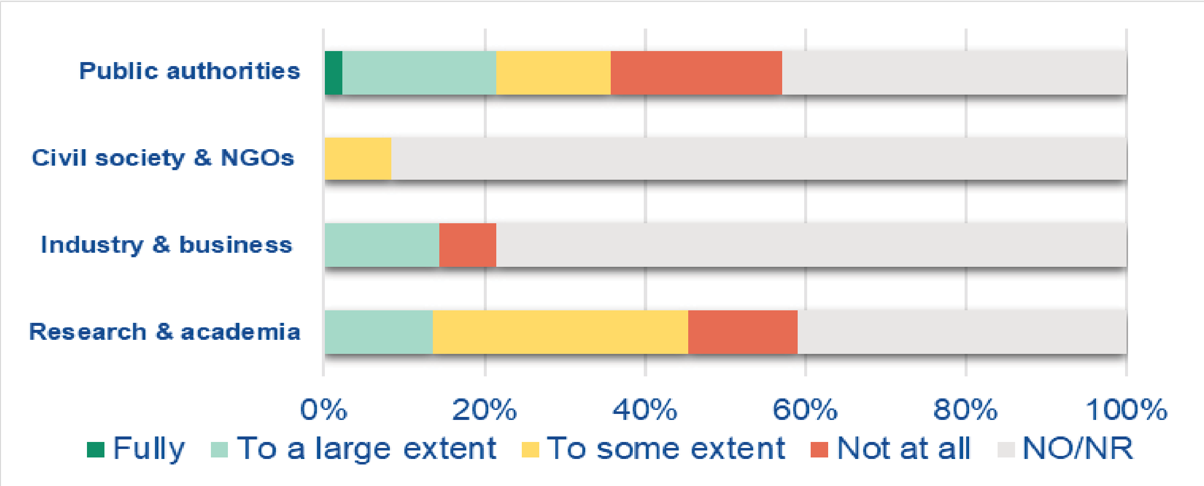
K4 Revise approach to AQ assessment uncertainty

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K4	Revise approach to AQ assessment uncertainty	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	**Medium**	**Sub option III-4a**

Focus of measure: Modify the definition of measurement uncertainty by defining it in absolute values and not in percentage values (or a combination of both).

Description of measure: Clarification in the definition of measurement uncertainty by establishing these both in absolute values and percentage values, and changes to threshold levels to be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revised monitoring uncertainty and how this is designed, particularly important particularly when air quality standards are low, could improve the quality of measurement data leading to overall improved air quality and reducing health and ecosystem impacts. While it is unlikely to bring significant benefits to air quality management it is an important aspect to clarify. Changes in the calculation for uncertainty may have a negative impact on existing long-established monitoring datasets should it not comply with uncertainty standards. This would negatively impact data quality and overall assessment of pollutant levels for those in non-compliance. Overall, stakeholders saw benefit in combining uncertainty in both absolute and percentage terms.

2.13 Intervention area L: Additional pollutants

L1 Introduce concept of monitoring at 'super-sites'

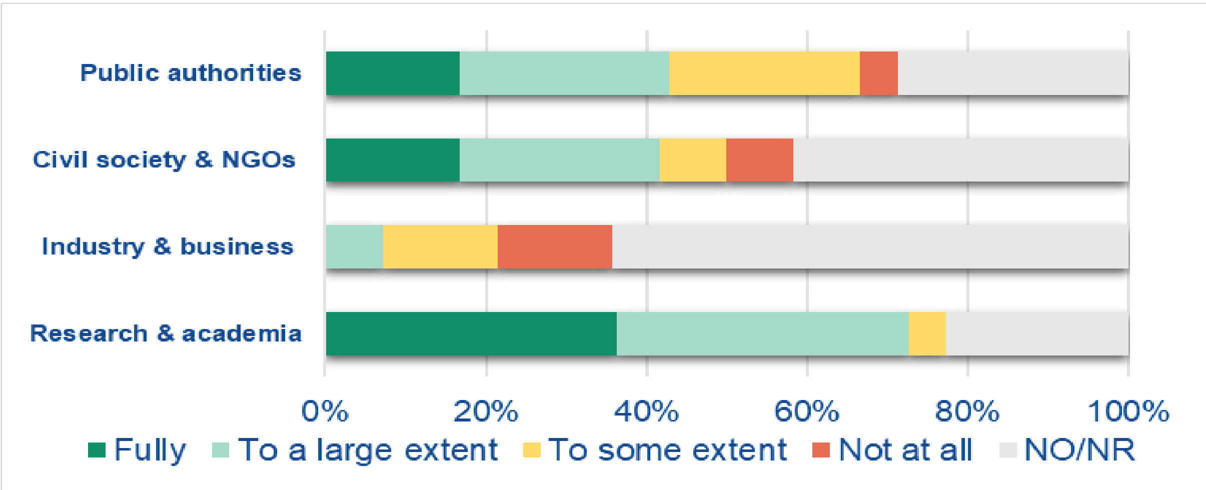
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 ---	0	Medium	Policy option III-1 and Policy option III-3

Focus of measure: Require monitoring stations that measure continuously certain emerging air pollutants (e.g. called "supersites" across the Member States).[74]

Description of measure: Specify a minimum number of monitoring stations that should monitor emerging pollutants (supersites) together with site type. Possibilities for what specific considerations should guide the establishment of such "supersites" include:

(1) Establishment of the number of supersites should be guided by potential exposure;
(2) Supersites should be located at which locations, urban, rural etc.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Further establishment of supersites across Europe, particularly for observing emerging pollutant trends would bring large benefit for their future assessment and control. Most benefit would be gained if these sites were established at both urban and rural locations. Monitoring is very costly and there is a significant administrative burden (for capital and maintenance costs as well as more staff and training needs), however some Member States already count with a supersite network in operation.

[74] A 'supersite' is a monitoring location that combines multiple sampling points to gather long term data on all air pollutants covered by the Ambient Air Quality Directive, including an extended number of air quality parameters (such as an extended list of volatile organic compounds (VOCs), additional air pollutants of emerging concern (such as ultrafine particles (UFP), black carbon (BC), ammonia (NH_3) and others), as well as additional metrics (such as particle numbers (PN) or oxidative potential).

L2 Introduce obligations to monitor more pollutants

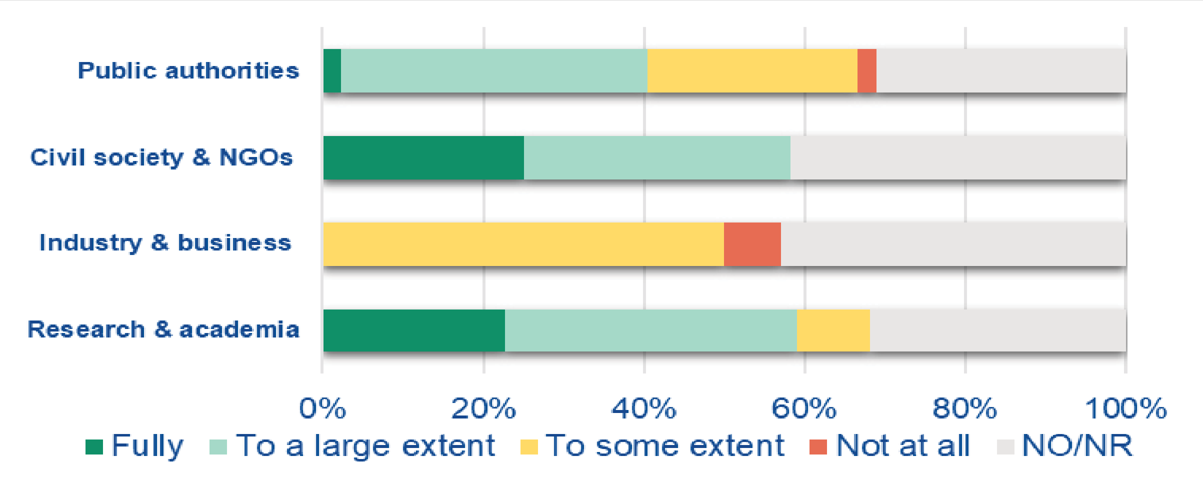
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L2	Introduce obligations to monitor more pollutants	(+) (+) (+) (+)	0 0 0	(+) 0 0	0 ---	0	High	Policy option III-3

Focus of measure: Require monitoring of additional air pollutants at a minimum number of sampling points and with relevant data quality requirements.

Description of measure: Requirements for the monitoring of additional pollutants, possibilities for which additional air pollutants should be monitored[75], and which include:

(1) Ultrafine particles;
(2) Ammonia;
(3) Fine combustion particles;
(4) Oxidative potential;
(5) Additional heavy metals;
(6) Hydrogen sulphide (H_2S) and other reduced sulphur compounds (TRS);
(7) Nitro-PAHs;
(8) Pesticides.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Possibilities for additional air pollutants to be monitored include: ultrafine particles, ammonia, fine combustion particles, oxidative potential, additional heavy metals, hydrogen sulphide (H_2S) and other reduced sulphur compounds (TRS), nitro-pahs and pesticides. Monitoring of pollutants of emerging concern is essential to advance our understanding of current pollution loads, but also to assess source apportionment and underpin modelling to assess future projected levels. This intervention would facilitate

[75] Suggested as such also by the network of National Air Quality Reference Laboratories under their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

research on these emerging pollutants and support epidemiological studies of pollutants of most concern to health. Monitoring of air pollution is costly, and even more so for pollutants which are not widely monitored. Administrative burden would be high, and likely to include capacity building to train site operators. For ammonia, monitoring would benefit from coordination with monitoring efforts under the National Emission reduction Commitments Directive[76], not least to minimise administrative burden, and a focus on locations where ammonia concentrations could particularly impact ecosystems. Monitoring of pollutants of emerging concern would be essential to setting standards for additional pollutants and the setting up of a priority watch list (links with Policy Area 1 and intervention Ø1 and Policy Area 2 and intervention A4).

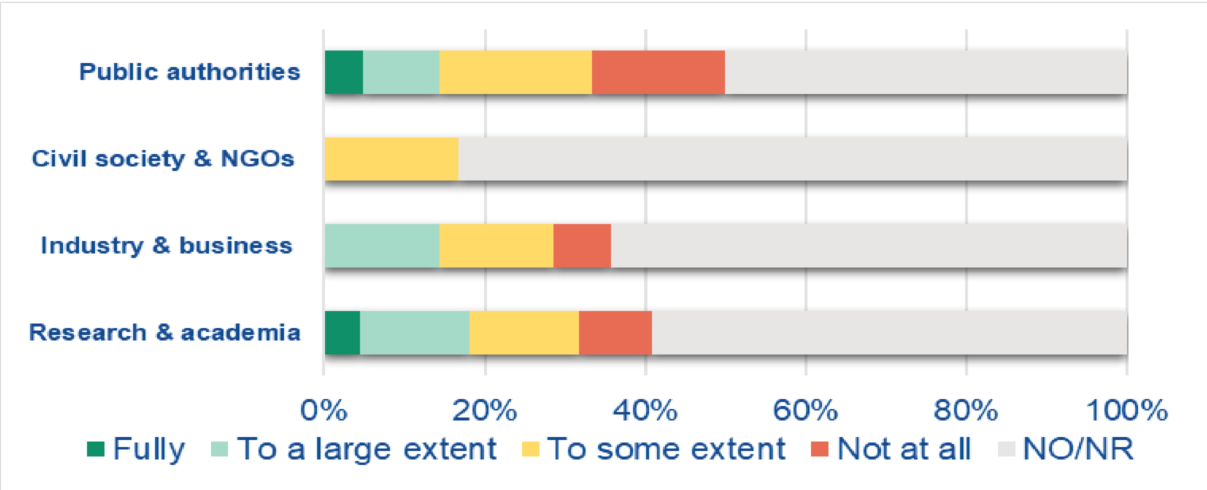
L3 Revise list of VOC to monitor

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L3	Revise list of VOC to monitor	(+) (+) (+) 0	0 0 0	0 0 0	0 ---	0	**Low**	**Policy option III-3a**

Focus of measure: Expand the list of required and/or recommended volatile organic compounds (VOCs) to measure.

Description of measure: Additional VOCs to be monitored should be specified together with monitoring methods, data quality objectives and minimum number and siting requirements and reporting of data.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: Further elaboration of VOC monitoring is necessary to develop scientific knowledge to support emission control, though costs are high (for new analysers to measure

[76] Directive (EU) 2016/2284, Article 9

more VOCs, and additional resources that may be needed to service and maintain sites, and manage and report data). The network of National Air Quality Reference Laboratories recommends the measurement of appropriate volatile organic compounds suggesting a list of 45 possible substances. Which specifically should be measured would depend on the objective sought.[77] However, the merit of monitoring more (or other) VOCs in addition to those regularly monitored is unclear. Further monitoring should be accompanied by data quality and siting specifications with appropriate guidance).

[77] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

2.14 Intervention area M: Transboundary air pollution

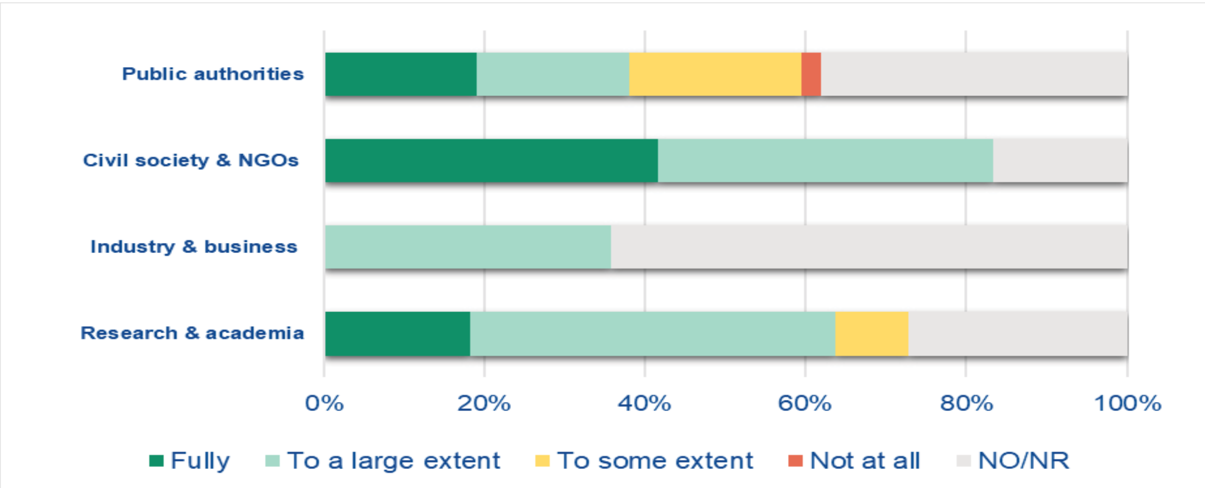
M1 Introduce methodology to assess transboundary

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M1	Introduce methodology to assess transboundary	(+) (+) (+) (+)	0 0 0	0 0/(+) 0	0/(+) -	(+)	**High**	**Policy option II-5**

Focus of measure: Require the use of an agreed methodology when assessing transboundary air pollution/contributions to local/regional air pollution.

Description of measure: Member States face intra-EU transboundary air pollution as well as air pollution from non-EU countries. Currently Article 25 of the 2008/50/EC Directive states that Member States concerned with transboundary air pollution 'shall' cooperate to mitigate air pollution (for instance through drawing joint or coordinated air quality plans). The Fitness Check findings highlight that the lack of coordination is likely to affect the understanding of which measures may prove most useful and effective. By offering a common methodology to assess transboundary air pollution, such coordination can be enhanced.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to facilitate and harmonise the used methodology when assessing transboundary air pollution/contributions to local/regional air pollution. The effectiveness of this intervention to improve air quality is impacted by the willingness of Member States to implement mitigation measures within a joint air quality plan. Implementing this intervention would imply additional costs for Member States who must align their methodology to assess transboundary air pollution. A challenge for implementation is that it may be unclear where the responsibility lies for transboundary air pollution assessment and action. In addition, assessment expertise is needed to conduct the modelling and there is a risk of limited expertise at local level.

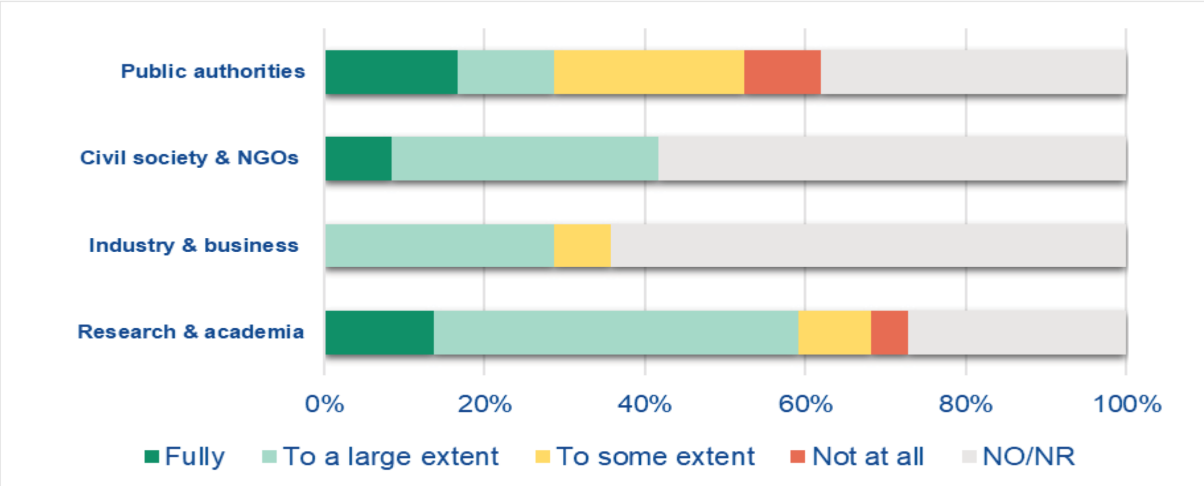
M2 Revise obligations for transboundary cooperation

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M2	Revise obligations for transboundary cooperation	(+) (+) (+) (+)	0 0 0	(+) - 0	- -	(+)	**Medium**	**Policy option II-5**

Focus of measure: Require transboundary cooperation and joint action on air quality if assessments of transboundary air pollution/contributions above certain thresholds (to be defined).

Description of measure: Under this policy measure, the Ambient Air Quality Directives would require EU Member States at bordering countries to engage in joint action on air quality with neighbouring non-EU countries in cases where air pollution reaches a certain threshold. Member States face intra-EU transboundary air pollution (as well as pollution coming from non-EU countries) which cannot be reduced by one country alone. Article 25 of the 2008/50/EC Directive states that Member States concerned with transboundary pollution 'shall' cooperate to mitigate air pollution for instance through drawing joint or coordinated air quality plans. However, such action is currently voluntary and the provision does not specify above which thresholds Member States should seek this cooperation which, in practice, results in lack of cooperation.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Requiring joint transboundary cooperation above a specific threshold would foster transboundary cooperation and in turn improve air quality in bordering regions, and benefit health and ecosystems in these areas. Implementing this intervention would imply additional costs for competent authorities especially in bordering countries were transboundary air pollution is an issue. Implementation challenges include enforcement (where one Member State cannot enforce action in another), lack of funds at local/regional authority level and acceptability of authorities and industry to implement measures to bring air improvements elsewhere.

2.15 Intervention area N: Information in air quality plans

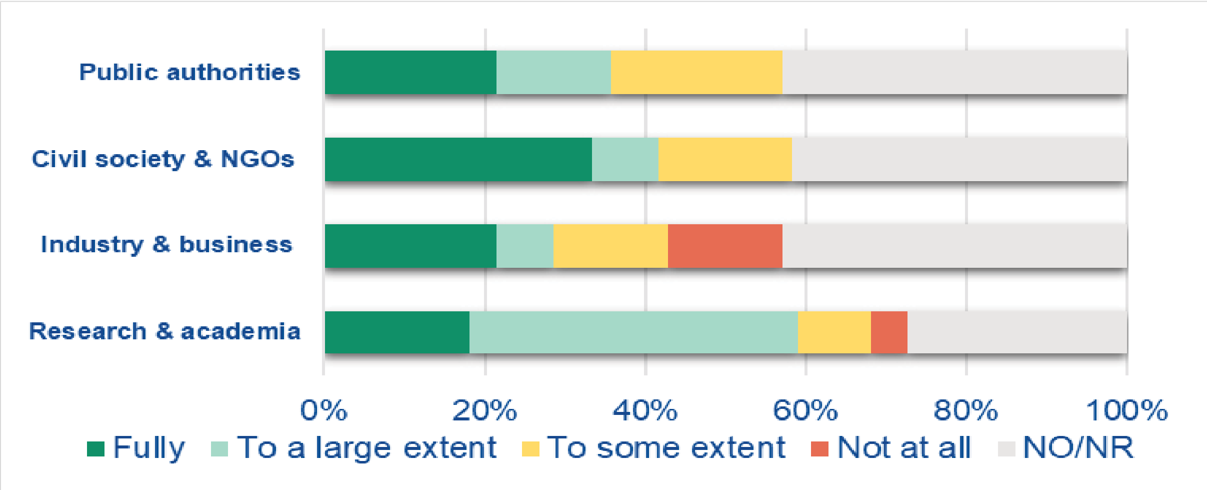
N1 Revise the information in air quality plans

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
N1	Revise the information in air quality plans	++ + + (+)	(+) 0 0	(+) - 0	- --	+	High	Policy option II-1

Focus of measure: Refine the minimum information to be included in an air quality plan.

Description of measure: This intervention refines the minimum information that is requested in an air quality plan. The current Ambient Air Quality Directive (2008/50/EC) includes in Annex XV a list of elements that need to be provided in an air quality plan. However, the current requirements lack information and is therefore not appropriate to evaluate the overall quality and eventual impact, effectiveness and efficiency of the air quality plan.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: It is expected that this intervention would provide an improved framework for air quality planning which gives rise to better air quality plans and eventually an improved air quality. Additional administrative burden expected to setup of a comprehensive and adequate air quality plan requires more resources for more in-depth analysis and more governance amongst various stakeholders involved in the planning process.

2.16 Intervention area O: EU air quality standards for particulate matter ($PM_{2.5}$)

O1 Revise standards for annual $PM_{2.5}$

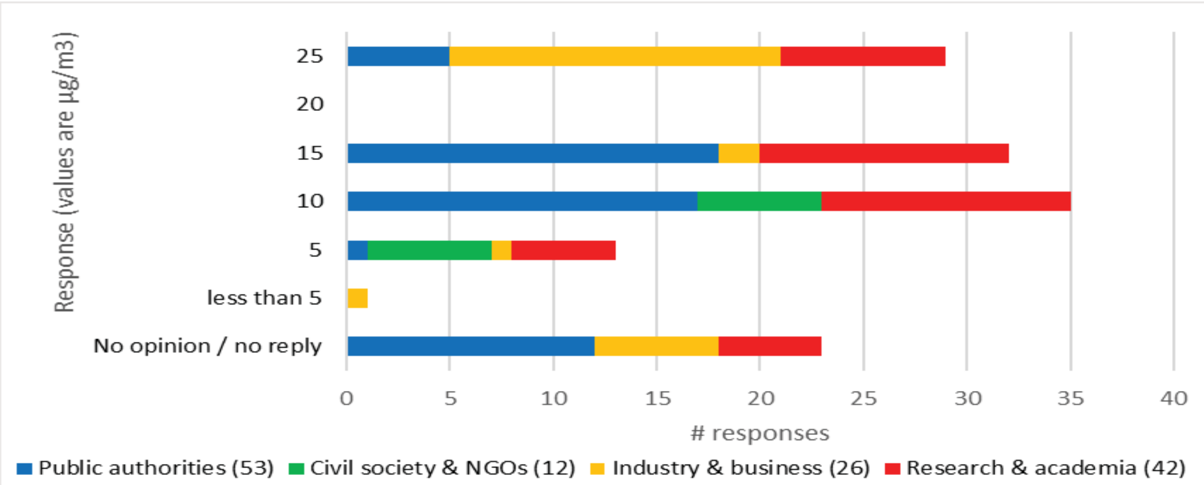
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O1	Revise standards for annual PM2.5 : **5 µg/m³**	+++ +++ +++ +++	+++ +/- +	+++ --- +	--- --- 	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
O1	Revise standards for annual PM2.5 : **10 µg/m³**	++ ++ ++ ++	++ +/- +	++ -- +	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
O1	Revise standards for annual PM2.5 : **15 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of $PM_{2.5}$

Description of measure: The current Ambient Air Quality Directives standards for annual $PM_{2.5}$ set an annual average limit value of 25 µg/m³. The WHO Air Quality Guidelines are set at 5 µg/m³, alongside higher interim targets. This intervention explores the alignment of the EU long-term standard limit values for $PM_{2.5}$ with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. A sample of variants has been selected for the modelling in distinct 5 µg/m³ steps. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: A sample of variants has been selected for the modelling in distinct 5 µg steps: The modelling performed suggests that by 2030, there will be broad compliance with both a 20 and 15 µg/m³ target, with around 400 000 people living in areas of exceedance for the 15 µg/m³ target. More ambitious standards can achieve greater improvements in air quality, with corresponding benefits for health and ecosystems. Administrative burden will also scale with ambition (impacting Member State competent authorities) as the more ambitious the standard, the more new zones will be identified as requiring measures to avoid exceedances. Similarly, mitigation/adjustment costs increase with ambition. The costs of such action are uncertain and depend on the starting point for each one, but these could imply significant change in behaviour at local or national level. As the level of ambition increases, the cost of mitigation/adjustment measures will increase on a non-linear basis. Specific to $PM_{2.5}$ is the fact that this pollutant may be emitted directly by natural sources. It is also a transboundary pollutant. The extent to which standards can address these issues is uncertain. Stakeholders firmly recognise the value of an annual average standard for $PM_{2.5}$, which applies as a limit value to all territories in the EU, but opinions vary on what level of ambition is appropriate by when.

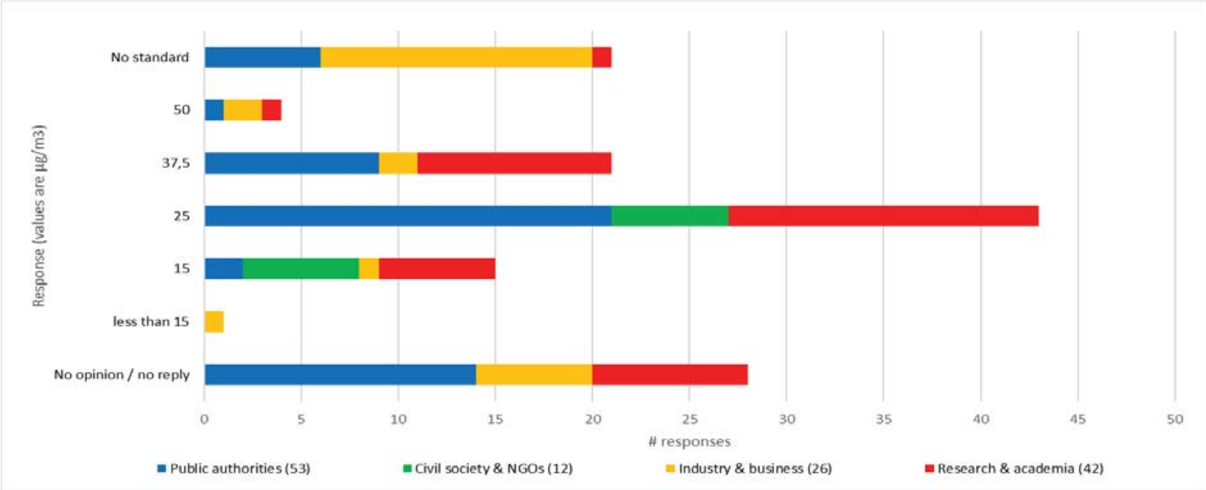
O2 Introduce standards for daily $PM_{2.5}$

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O2	Introduce standards for daily PM2.5 : **15 µg/m³** (on 99% days in a year)	+++ +++ +++ +++	++ +/- 0	+ --- +/-	--- ---	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
O2	Introduce standards for daily PM2.5 : **25 µg/m³** (on 95% days in a year)	++ ++ ++ ++	++ +/- 0	+/- -- +	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
O2	Introduce standards for daily PM2.5 : **37.5 µg/m³** (on 95% days in a year)	+ + + +	+ +/- 0	+ - +/-	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards / thresholds for daily concentrations of $PM_{2.5}$

Description of measure: The current Ambient Air Quality Directives do not contain a short-term standard for $PM_{2.5}$. The WHO Air Quality Guidelines set a recommended limit of 15 µg/m^3 over a 24-hour period (99th percentile, three to four exceedance days per year), alongside higher interim targets. This intervention explores the value of introducing a new EU short-term limit values for $PM_{2.5}$ in line with the WHO Air Quality Guidelines. Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *‘to which extent would this specific intervention address the identified (related) shortcomings’*.



Summary: The intervention considers the introduction of a new standard. Variants take the same approach as described for O1. Short-term standards are not modelled explicitly, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure (in assessment), but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. Administrative burden will also scale with ambition (impacting Member State competent authorities). In addition, short-term compliance measures to tackle peak concentrations specifically may be more disruptive in nature (albeit for a short-time) and carry a higher cost. It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the advice of the WHO, who explore that even a small number of extreme peaks could have a significant impact.

O3 Revise average exposure standards for $PM_{2.5}$

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O3	Revise standards for average exposure for PM2.5 : **5 µg/m³**	++ ++ ++ ++	+++ +/- +	++ -- +	-- --	++	**High** but uncertain	**Policy option I-5**

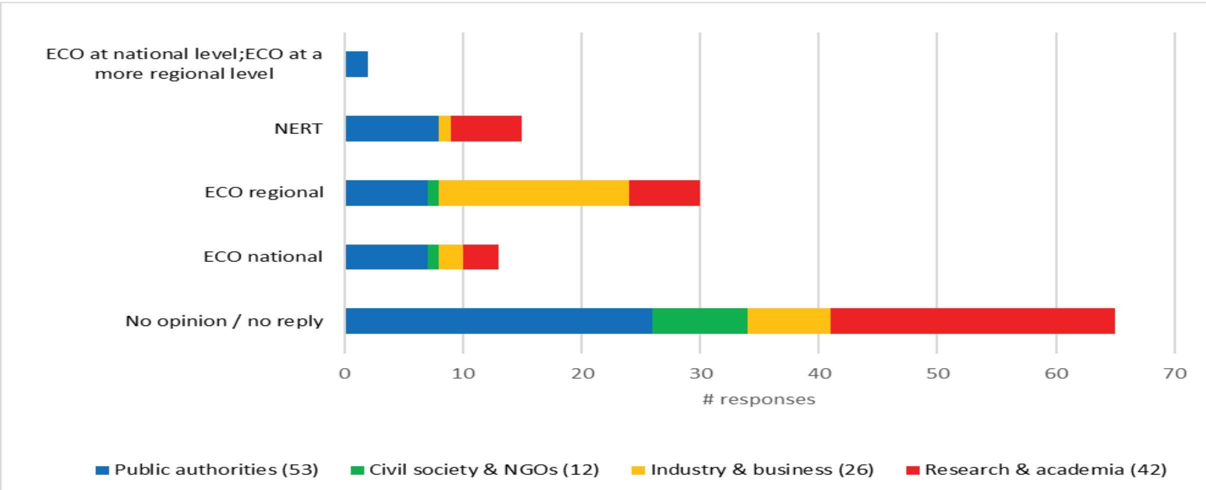
Focus of measure: Revise average exposure obligations and reduction targets for $PM_{2.5}$

Description of measure: This intervention would revise exposure reduction targets for $PM_{2.5}$ in terms of the initial concentration values and the percentage reduction target. Variants for this intervention are based on different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. The following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for $PM_{2.5}$ based on concentration values rather than exposure reduction targets. The Ambient Air Quality Directives include average exposure obligations among the current provisions to regulate $PM_{2.5}$ concentrations. This is to complement the limit value for $PM_{2.5}$ by targeting average concentration values across larger areas. Accordingly, the Ambient Air Quality Directives set a national $PM_{2.5}$ exposure reduction target to protect human health (Article 15 of Directive 2008/50/EC). The exposure reduction target is a percentage reduction based on the initial concentration. To determine the initial concentration, an average exposure indicator is used (an average level determined on the basis of measurements at urban background locations throughout the territory of a Member State and which reflects population exposure).

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for $PM_{2.5}$ is set at the WHO guideline level of 5 $\mu g/m^3$, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of $PM_{2.5}$ and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action.

2.17 Intervention area P: EU air quality standards for particulate matter (PM_{10})

P1 Revise standards for annual PM_{10}

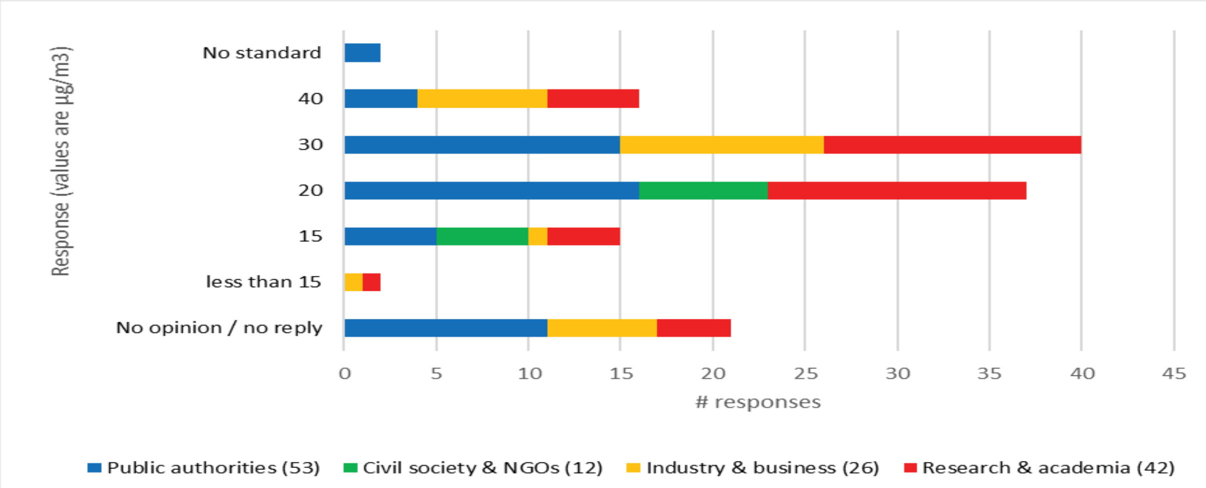
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P1	Revise standards for annual PM10: **15 µg/m³**	+++ +++ +++ +++	+++ +/- +	+ --- +	--- --	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
P1	Revise standards for annual PM10: **20 µg/m³**	++ ++ ++ ++	++ +/- +	+ -- +	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
P1	Revise standards for annual PM10: **30 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of PM_{10}

Description of measure: The current air quality standards for annual PM_{10} under the AAQ Directives set an annual average limit value of 40 µg/m³. The WHO Air Quality Guidelines set an annual average of 15 µg/m³, alongside higher interim targets. This measure explores the alignment of the EU long-term standard limit values for PM_{10} with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Modelling shows that this intervention could have a significant positive impact on air quality. The health effects across the variants will scale with the level of ambition, even if health effects are more closely associated with exposure to finer particulate matter ($PM_{2.5}$). For example the modelling performed suggests that by 2030, there will be broad compliance with a 30 µg/m³ target, with only around 13 000 people living in areas of exceedance in OPT15. Under OPT10, around 2.7 million people remain living in areas exceeding 20 µg/m³, implying a moderate level of effort would be needed at local level to meet this ambition. Under OPT5, 13.7 million remain in areas exceeding the WHO Air Quality Guidelines 15 µg/m^3. The mitigation costs of lower standards for PM_{10} have not been modelled. Many of the measures which mitigate $PM_{2.5}$ would also mitigate PM_{10} emissions, hence the measures and costs would be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities). Stakeholders firmly recognise the value of an annual average standard for PM_{10}, which applies as a limit value across all territories of the EU. Furthermore, stakeholders also affirm the additional value of a standard for PM_{10} alongside $PM_{2.5}$ and show a general interest for improvement. However, opinion varies on what level of ambition is appropriate and by when it should be achieved. .

P2 Revise standards for daily PM_{10}

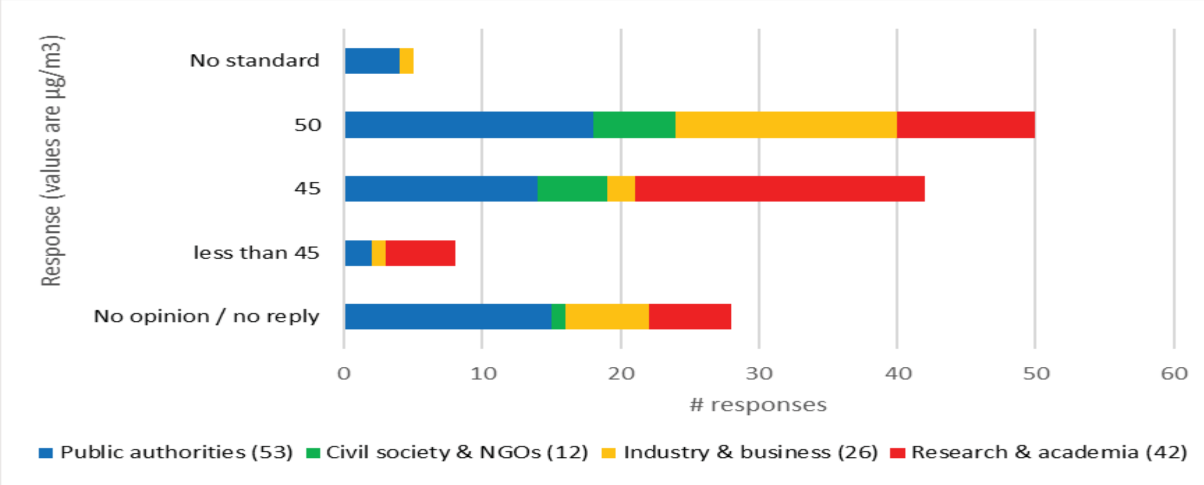
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P2	Revise standards for daily PM10 : **45 µg/m³** (on 99% days in a year)	+++ +++ + +	++ +/- 0	+ --- +/-	--- --	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
P2	Revise standards for daily PM10 : **45 µg/m³** (on 95% days in a year)	++ ++ + +	+ +/- 0	+ -- +/-	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
P2	Maintain standards for daily PM10 : **50 µg/m³** (on 90% days in a year)	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards / thresholds for daily concentrations of PM_{10}

Description of measure: The current Ambient Air Quality Directives standards for 24-hour PM_{10} set a limit value of 50 µg/m^3. The WHO Air Quality Guidelines set at limit of 45 µg/m^3, alongside higher interim targets. This measure explores the alignment of the EU 24-hour limit values for PM_{10} with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Short-term standards are not modelled, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure, but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. The mitigation costs will increase with the level of ambition and will depend on the action taken. Short-term standards have not been modelled, as such the costs of mitigation actions are more uncertain. Expert judgement suggests many of the actions taken to mitigate peak concentrations will be the same as those to tackle annual average concentrations, which means the costs will be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities). It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the advice of the WHO, who explore that even a small number of extreme peaks could have a significant impact. Stakeholders voted positively that they see additional value in a standard to manage peak concentrations of PM_{10}. However, the additional value of a short-term PM_{10} standard may be limited if set alongside a corresponding standard for $PM_{2.5}$, since both are likely to share similar sources and hence, control strategies.

P3 Introduce average exposure standards for PM_{10}

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P3	Introduce standards for average exposure for PM10 : **15 µg/m³**	++ ++ ++ ++	++ +/- +	+ -- +	-- --	++	**Low** but uncertain	**Policy option I-5**
P3	Revise standards for average exposure for PM10 : **20 µg/m³**	+ + + +	+ +/- +	+ - +	- --	+	**Low**	**Policy option I-5**

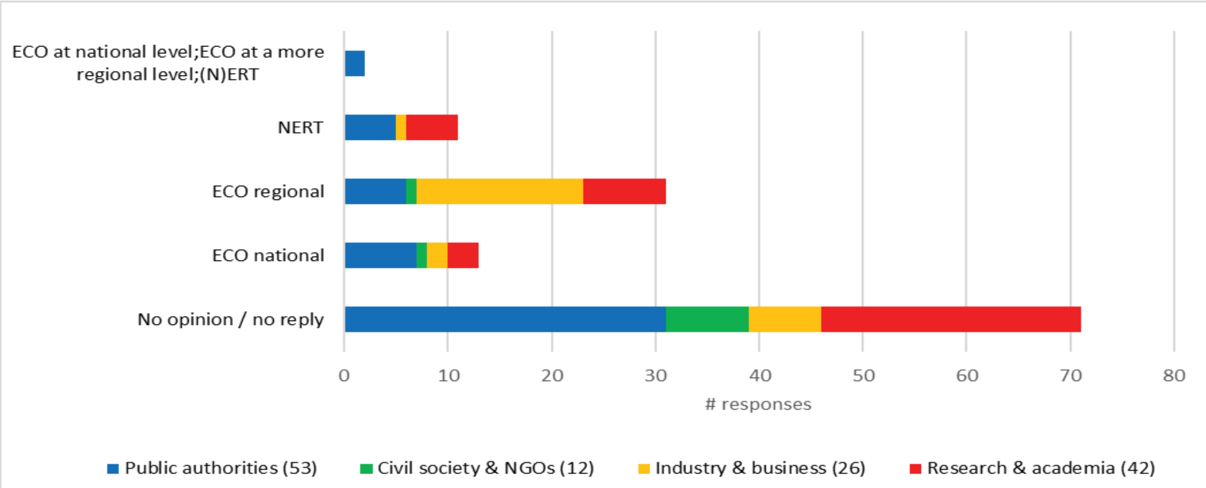
Focus of measure: Introduce average exposure obligations and reduction targets for PM_{10}.

Description of measure: This intervention would introduce average exposure concentration obligations and reduction targets for PM_{10}. Variants for this intervention are based on different initial concentrations (µg/m^3) and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for PM_{10} based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for PM_{10}.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for PM_{10} is set at the WHO guideline level of 15 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of PM_{10} and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action. An average exposure standard for PM_{10} may not offer significant additional value alongside the similar existing standard for $PM_{2.5}$, since both are likely to share similar sources and hence, control strategies.

2.18 Intervention area Q: EU air quality standards for nitrogen dioxide

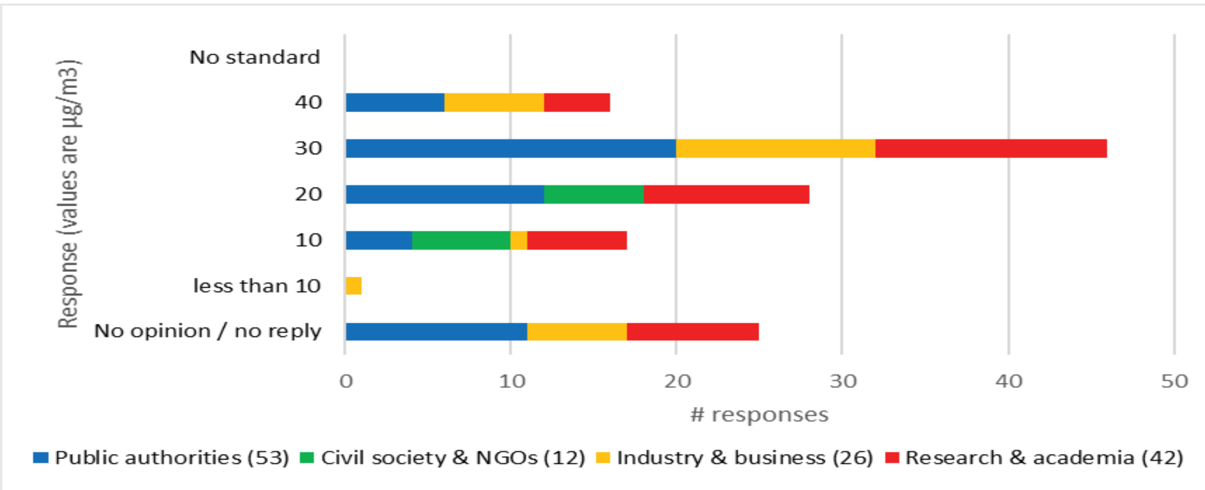
Q1 Revise standards for annual NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q1	Revise standards for annual NO2: **10 µg/m³**	+++ ++ +++ +	+ +/- +	++ -- +	-- ---	++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
Q1	Revise standards for annual NO2: **20 µg/m³**	++ + ++ +	+ +/- +	+ - +	- -	++	**High**	**Policy option I-2** and **Sub option I-2a**
Q1	Revise standards for annual NO2: **30 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of NO_2

Description of measure: The current Ambient Air Quality Directives standards for annual NO_2 set an annual average limit value of 40 µg/m^3. The WHO Air Quality Guidelines set the limit at 10 µg/m^3, alongside higher interim targets. This measure explores the alignment of the EU long-term standard limit values for NO_2 with the WHO Air Quality Guidelines updated limit values. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The health benefits of action targeting the revision of NO_2 concentrations may be smaller (assuming there are no co-benefits by way of particulate or GHG emission reductions). The mitigation costs of lower standards for NO_2 have not been modelled, as such contrasting benefits and costs is more uncertain. The modelling does show however a broad alignment with a 20 µg/m^3 standard by 2030, and with the WHO Air Quality Guidelines by 2050, with only a small number of people which remain exposed to concentrations above these levels (around four to six million respectively). The additional costs and benefits of these options are both negligible (although in practice a reduction in the standard will help reinforce this delivery). Increasing ambition above the baseline will require the uptake of measures not captured in GAINS, and hence for which the costs are uncertain. However, expert judgement would suggest that costs of localised activity may be more disruptive and imply a higher cost (albeit at a local level). Several challenges for implementation have been identified.

Stakeholders firmly recognise the value of an annual-average standard for NO_2, applying as a limit value to all territory. Furthermore, stakeholders also show a general interest for improvement but opinion varies on what level of ambition is appropriate and by when it should be achieved. The majority of stakeholders feel alignment with the WHO Air Quality Guidelines would not be appropriate by 2030, but most feel a target in the range from 20-30 µg/m³ would be achievable, with full alignment to 2050.

Q2 Revise/introduce standards for hourly/daily NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q2	Introduce standards for daily NO2:**25 µg/m³** (on 99% days in a year)	+++ + ++ +	+ +/- 0	+ --- +/-	-- ---	++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
Q2	Introduce standards for daily NO2: **50 µg/m³** (on 95% days in a year)	++ + ++ +	+ +/- 0	+ -- +/-	- -	++	**High**	**Policy option I-2** and **Sub option I-2a**
Q2	Introduce standards for daily NO2: **50 µg/m³** (on 90% days in a year)	+ + + +	+ +/- 0	+ - +/-	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**
Q2	Maintain standards for hourly NO2: **200 µg/m³** (on 99.99% hours in a year)	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

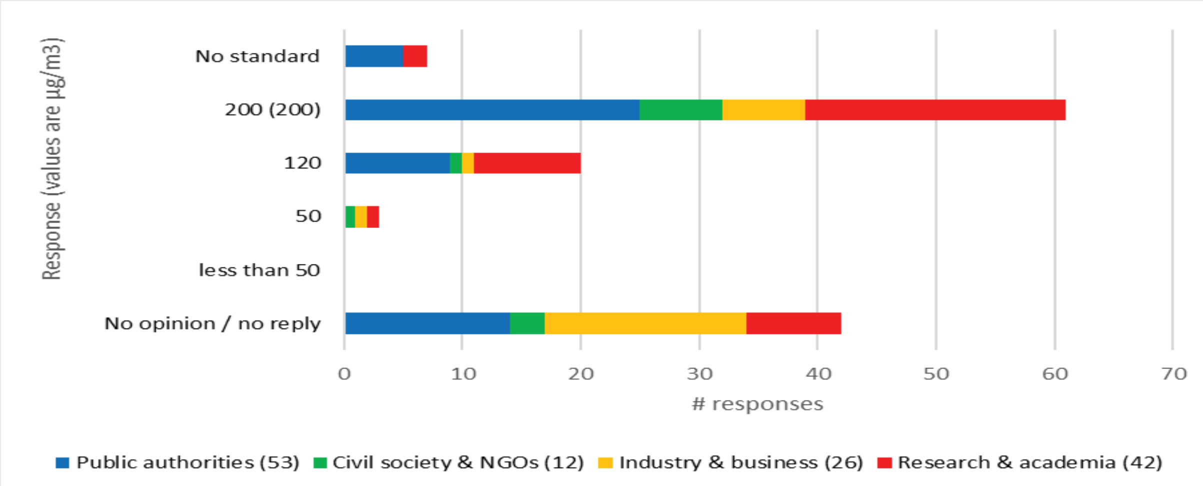
Focus of measure: EU air quality standards / thresholds for daily concentrations of NO_2

Description of measure: The Ambient Air Quality Directives sets a standard for 1-hour NO_2 at a limit value of 200 µg/m³. The WHO Air Quality Guidelines does not include a 1-hour limit for NO_2, although its 2000 Guidelines[78] included a 1-hour limit which is consistent with the EU standard. The WHO Air Quality Guidelines set a standard for 24-hour NO_2 at a limit value of 25 µg/m³, alongside higher interim targets. No current EU standard for the 24-hour period exists.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

[78] WHO (2000), Summary of the WHO guidelines (accessed: 10.06.2022)

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The measure considers both the existing standard (1-hour) and the potential introduction of a new (24-hour) standard. In isolation, there is a strong case for a standard managing NO_2 peak concentrations. It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the WHO Air Quality Guidelines, who explore that even a small number of extreme peaks could have a significant impact.[79] However, the effectiveness of a peak concentration as a safety net (and indeed its additional value over an annual standard) decreases with the number of allowed exceedance days per year.

Short-term standards are not modelled, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure, but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. The mitigation costs will increase with the level of ambition and will depend on the action taken. Short-term standards have not been modelled, as such the costs of mitigation actions are more uncertain. Expert judgement suggests many of the actions taken to mitigate peak concentrations will be the same as those to tackle annual average concentrations which means costs will be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities).

Q3 Introduce average exposure standards for NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q3	Introduce standards for average exposure for NO2: **10 µg/m³**	++ + ++ +	+ +/- +	+ -- +	-- --	+	**Medium** but uncertain	**Policy option I-5**
Q3	Introduce standards for average exposure for NO2: **20 µg/m³**	+ + + +	+ +/- +	+ - +	- --	+	**Medium**	**Policy option I-5**

[79] For more information on stakeholders views please see Annex 2.

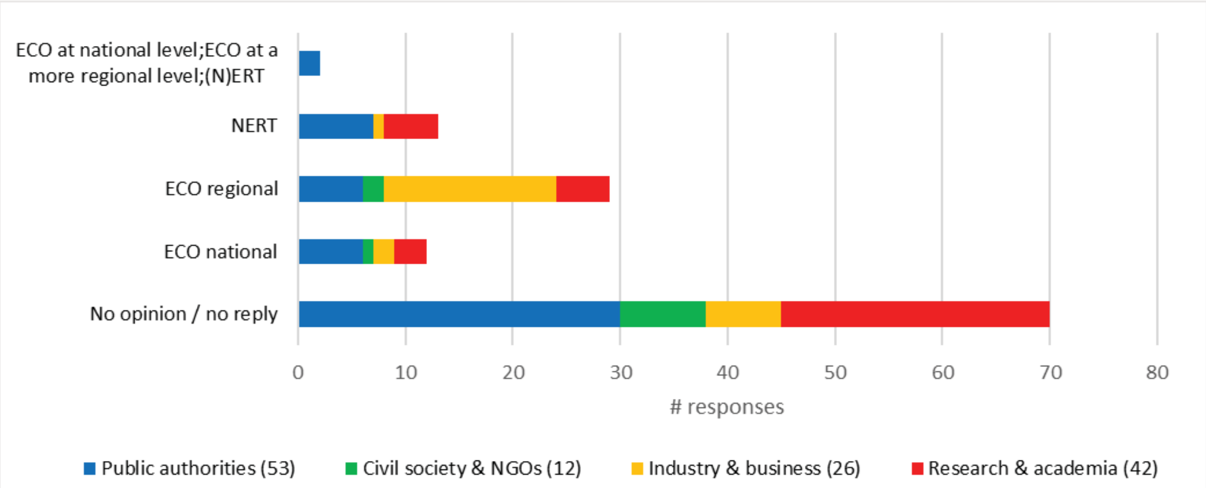
Focus of measure: Introduce average exposure obligations and reduction targets for NO_2

Description of measures: This intervention would introduce average exposure concentration obligations and reduction targets for NO_2. Variants for this measure are based on different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for NO_2 based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for NO_2.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for NO_2 is set at the WHO guideline level of 10 $\mu g/m^3$, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of NO_2, rather than limiting focus on pollution hotspots, and therefore deliver health benefits. This is also important for NO_2 as a precursor, including to PM. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action.

2.19 Intervention area R: EU air quality standards for ozone

R1 Introduce standards for peak-season O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R1	Introduce standards for peak-season O3: **60 µg/m³**	+++ + +++ +	+ +/- 0	+ --- -	--- 0	+	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
R1	Introduce standards for peak-season O3: **70 µg/m³**	++ + ++ +	+ +/- 0	+ -- -	-- 0	+	**High** but uncertain	**Policy option I-2** and **Sub option I-2a**
R1	Introduce standards for peak-season O3: **100 µg/m³**	+ + + +	+ +/- 0	+ - -	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**

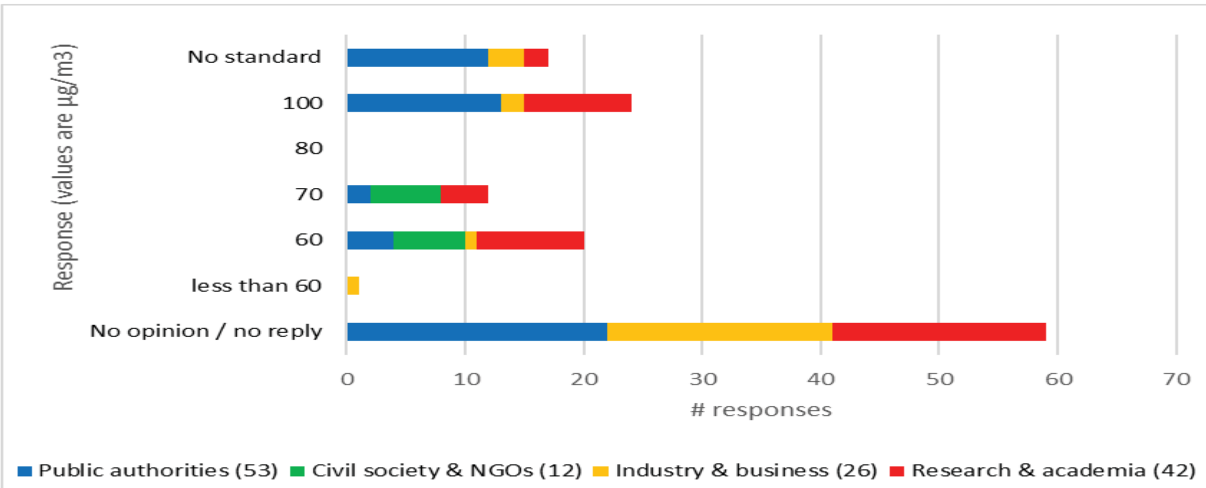
Focus of measure: EU air quality standards for peak-season concentrations of O_3

Description of measure: This measure explores the revision of the EU long-term standard for O_3.

The current Ambient Air Quality Directives have a long-term ozone standard aimed at the protection of vegetation. This target value is defined in terms of AOT40 (calculated from 1 hour values), over a May to July averaging period, at 18 000 µg/m^3 over five-year average. There is no current EU standard for long-term ozone targeting the protection of human health. The WHO Air Quality Guidelines set a peak season recommendation for average daily maximum 8-hour mean O_3 concentrations of 60 µg/m^3, in the six consecutive months with the highest six-month running-average O_3 concentration.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved, and the type of standard to be set.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: The effectiveness of the intervention will vary with the level of ambition. However, given high levels of existing exceedance, the benefit to air quality is expected to be high. Human health benefits tend to be more linked with exposure to other pollutants and hence can be small. Likewise, ecosystem effects typically comprise a lower proportion of the overall benefit of air quality action, relative to human health effects (albeit this is based on an evidence base which has predominantly focused on the valuation of human health effects, for which by extension is more well explored and understood). The cost of achieving different standards for O_3 have not been modelled directly so costs are uncertain. Costs will increase with the level of ambition.

Controlling ozone concentrations is complex and challenging, and is driven in part by control of precursors but also by the meteorological conditions. As such it is questionable whether very ambitious standards for ozone would be feasible in all locations. This is perhaps underlined by the different of opinion amongst stakeholders as to whether limit or target values would be most appropriate. Furthermore, there is currently broad exceedances of both the existing EU target value and the WHO Air Quality Guidelines, as such substantial effort would be required to meet an even stricter target, whereas the benefits of such action (at least in economic impact assessment) often rank below action taken around other pollutants.

R2 Revise standards for 8-hour O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R2	Revise standards for 8-hour O3: **100 µg/m³** (on 99% days in a year)	+++ + ++ +	+ +/- 0	+ --- -	--- ---	+	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
R2	Revise standards for 8-hour O3: **120 µg/m³** (on 95% days in a year)	++ + + +	+ +/- 0	+ -- -	-- 0	+	**High**	**Policy option I-2** and **Sub option I-2a**
R2	Revise standards for 8-hour O3: **120 µg/m³** (on 90% days in a year)	+ + + +	+ +/- 0	+ - -	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**

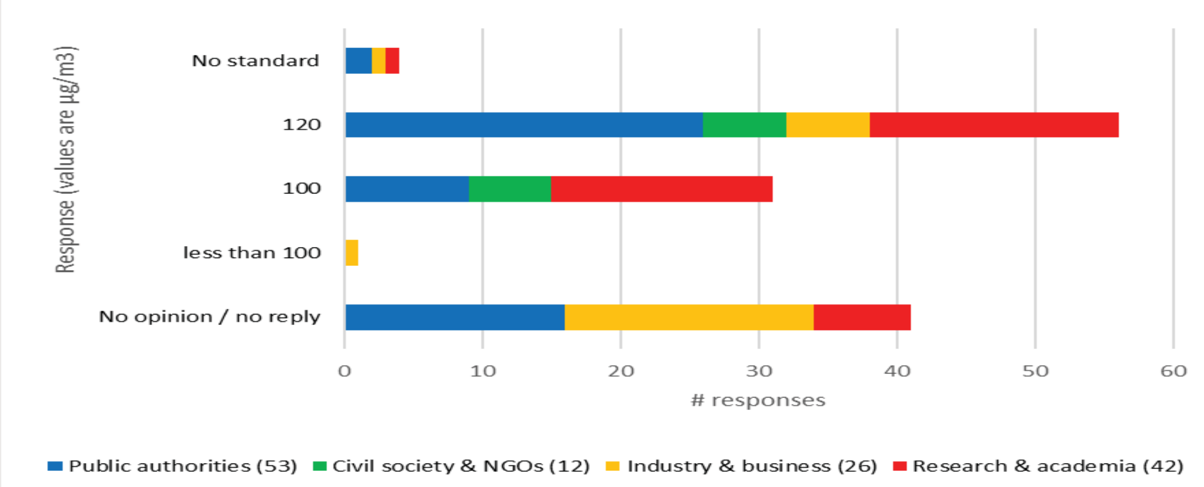
Focus of measure: EU air quality standards / thresholds for 8-hour concentrations of O_3

Description of measure: This measure explores the revision of the EU short-term standard for O_3.

The current AAQ Directives has a target value for the maximum 8-hour daily mean for ozone of 120 µg/m^3 (with 25 permitted exceedances allowed per annum averaged over 3 years). The WHO Air Quality Guidelines set a recommendation for average daily maximum 8-hour mean O_3 concentrations of 100 µg/m^3 (defined as the 99th percentile).

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved, and the type of standard to be set.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There remains a clear need for a standard to regulate peak concentrations of ozone. However, controlling ozone concentrations is complex and challenging, and is driven in part by control of precursors but also by the meteorological conditions. The modelling data suggests that there will be broad compliance with the EU standard by 2030, but still substantial non-compliance with the WHO Air Quality Guidelines both under the baseline and the maximum feasible reduction scenario. As such it is questionable whether very ambitious standards for ozone would be feasible in all locations. This is perhaps underlined by the different of opinion amongst stakeholders as to whether limit or target values would be most appropriate. Given the size of existing levels of exceedance, and the challenges in controlling ozone concentrations, the costs of increasing ambition or switching to a limit value might be significant. Human health benefits tend to be more linked with exposure to other pollutants and hence can be small. Likewise, ecosystem effects typically comprise a lower proportion of the overall benefit of air quality action, relative to human health effects (albeit this is based on an evidence base which has predominantly focused on the valuation of human health effects, for which by extension is more well explored and understood).

R3 Introduce average exposure standards for O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R3	Introduce standards for average exposure for O3 : **60 µg/m³**	++ + ++ +	+ +/- 0	+ -- -	-- --	+	**Low**	**Policy option I-5**
R3	Introduce standards for average exposure for O3 : **70 µg/m³**	+ + + +	+ +/- 0	+ - -	- --	+	**Low**	**Policy option I-5**

Focus of measure: Introduce average exposure obligations and reduction targets for O_3

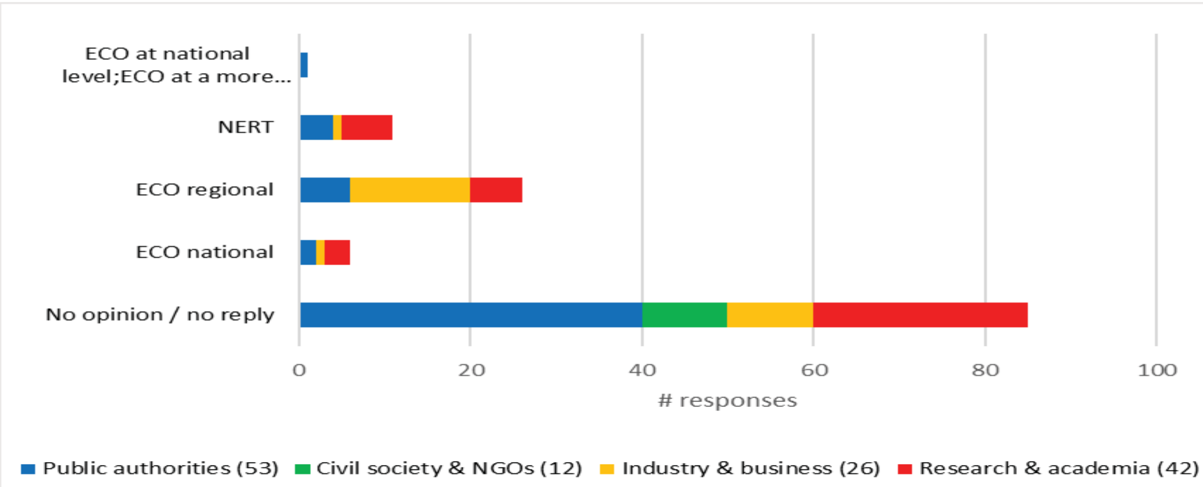
Description of measure: This intervention would introduce average exposure concentration obligations and reduction targets for ozone (O_3). Variants for this intervention are based on different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level.

In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. ‘based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period’;
- (N)ERT: (National) exposure reduction target – i.e. ‘a percentage reduction of the average exposure to be attained where possible over a given period’.

The WHO Air Quality Guidelines include targets for ozone based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for ozone.

Stakeholder views: A targeted survey provided feedback on *‘to which extent would this specific intervention address the identified (related) shortcomings’*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for O_3 is set at the WHO guideline level of 60 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of O_3 and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action. However, it is uncertain whether an average exposure standard would offer a useful complement and afford additional management options in the case of O_3, given the specific chemical characteristics of ozone generation and its links with meteorological conditions (resulting in pronounced local and year-to-year variability).

2.20 Intervention area S: EU air quality standards for sulphur dioxide

S1 Revise standards for annual SO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
S1	Revise standards for annual SO2: **20 µg/m³**	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1, I-2, I-3** and **all sub-options**

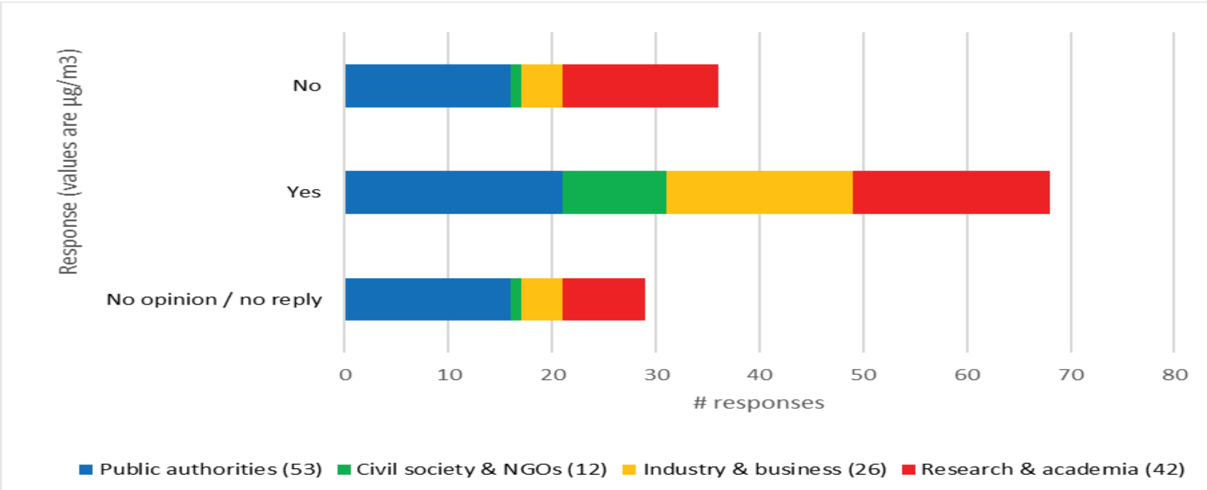
Focus of measure: EU air quality standards for annual concentrations of SO_2

Description of measure: This measure explores the revision of the EU long-term standard for SO_2.

The current Ambient Air Quality Directives set a critical level for the protection of vegetation over the calendar year and winter (1 October to 31 March) of 20 µg/m^3, with no margin of tolerance. There is no existing, long-term EU standard for SO_2 aimed at the protection of human health. Furthermore, the WHO Air Quality Guidelines do not include a recommendation for long-term exposure to SO_2.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revisions to this standard were not modelled and therefore the balance of costs and benefits is more uncertain. There has been substantial progress around SO_2 emissions and concentrations historically. This may also suggest that a majority of the low-cost actions may have already been captured. Furthermore, the benefits per ton of pollutant abated are smaller than for other pollutants (e.g. $PM_{2.5}$). The WHO did not include an Air Quality Guidelines recommendation around long-term exposure to SO_2 with which an EU standard targeting human health could align. In addition stakeholders provided limited input.

S2 Revise standards for daily/hourly SO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
S2	Introduce standards for daily SO2: **40 μg/m^3** (on 99% days in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1** and **Sub option I-1a**
S2	Introduce standards for daily SO2: **50 μg/m^3** (on 95% days in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-2, I-3** and **Sub option I-2a, I-3a**
S2	Maintain standards for hourly SO2: **350 μg/m^3** (on 99.98% hours in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards / thresholds for daily concentrations of SO_2

Description of measure: This measure explores the alignment of the EU short-term limit values for SO_2 with the WHO Air Quality Guidelines updated limit values.

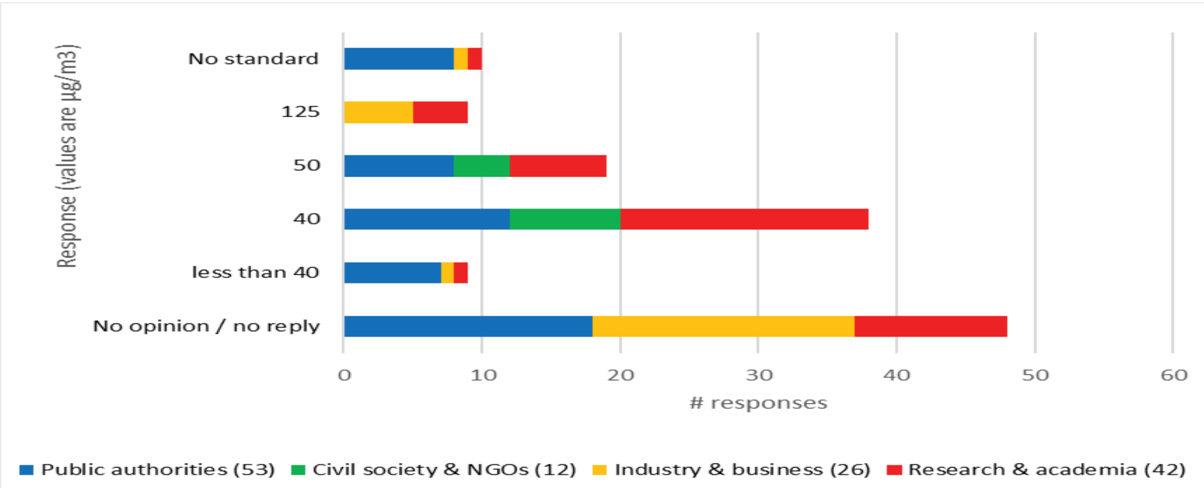
The current Ambient Air Quality Directives sets a two standards:

- A ***24-hour*** limit value of 125 μg/m^3 (can be exceeded up to three times per year), which is above the WHO Air Quality Guidelines of 40 μg/m^3 (based on 99th percentile);
- A ***1-hour*** limit value of 350 μg/m^3 (can be exceeded up to 24 times per year). The WHO does not make a recommendation of exposure over a 1-hour averaging period.

The measure also considers the revision of existing and/or the introduction of short-term standards, either alongside or instead of the existing standard.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure considers both: (a) changes to the existing EU limit values and (b) addition to or substitution of the existing EU standard with alternative short-term standards in the WHO Air Quality Guidelines. Revisions to this standard were not modelled and so the balance of costs and benefits is more uncertain. No monitoring data is available over a 10-minute period, which makes it challenging to draw conclusions around the impact of and merit to introducing a new 10-minute standard alongside, or instead of, other short-term standards for SO_2. As described for S1, historical progress for SO_2 may suggest that low-cost actions have already been captured. Stakeholders propose that the WHO standards could be met with limited additional effort.

2.21 Intervention area T: EU air quality standards for carbon monoxide

T1 Revise standards for daily/8-hour CO

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
T1	Introduce standards for daily CO: **4 mg/m³** (on 99% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-1** and **Sub option I-1a**
T1	Introduce standards for daily CO: **4 mg/m³** (on 95% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-2** and **Sub option I-2a**
T1	Introduce standards for daily CO: **7 mg/m³** (on 95% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**
T1	Maintain standards for 8-hour CO: **10 mg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for daily concentrations of CO

Description of measure: This measure explores the alignment of the EU short-term limit values for CO with the WHO Air Quality Guidelines updated limit values.

The current Ambient Air Quality Directives set a daily 8-hour mean limit value at 10 µg/m³, which corresponds to the standard set by the WHO Air Quality Guidelines. This measure considers going beyond the WHO Air Quality Guidelines for this averaging period.

The WHO Air Quality Guidelines also set several other short-term standards, for which an EU standard does not exist:

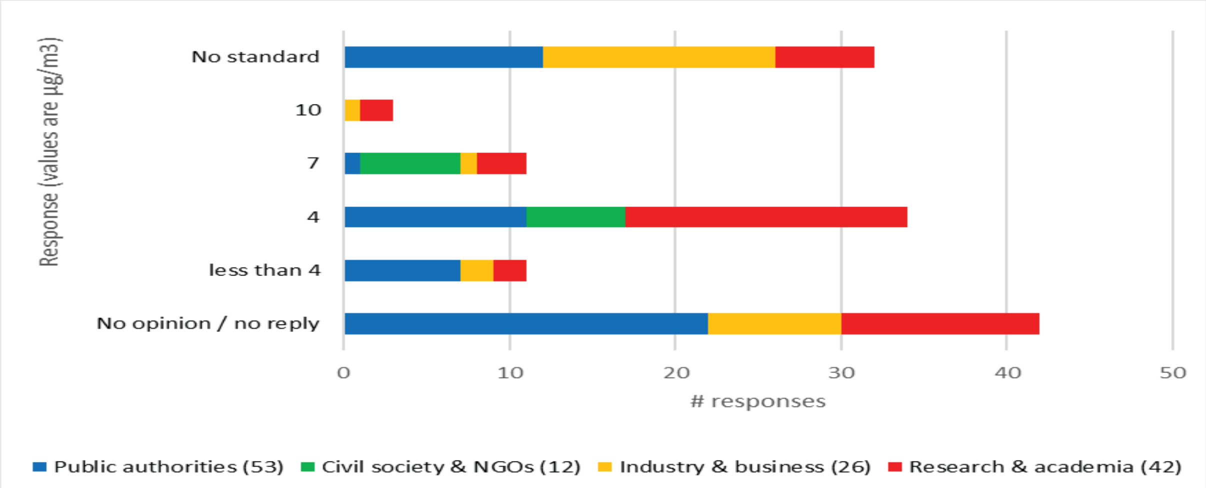
- The recommended 24-hour WHO standard is set at 4 µg/m³ (measured on the 99th percentile)
- The recommended 1-hour WHO standard is set at 35 µg/m³
- The recommended 15 minute WHO standard is set at 100 µg/m³

The 24-hour target was introduced in the 2021 WHO Air Quality Guidelines, with the other three standards being confirmed as remaining valid.

The measure also considers the introduction of short-term standards over these averaging periods, either alongside or instead of the existing standard.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure considers both: (a) changes to the existing EU limit value and (b) addition to or substitution of the existing EU standard with alternative short-term standards in the WHO Air Quality Guidelines. From the modelling performed, a certain level of improvement can be made through abatement measures for moderate cost. However, achieving further improvements going beyond the WHO Air Quality Guidelines will require the take up of non-technical or local measures not captured by the modelling, thus the costs are uncertain. Health benefits are more commonly associated with $PM_{2.5}$, as such the benefits per ton of CO reduction are relatively lower. Stakeholders propose that the existing EU standards can be met with limited additional effort and propose to remain at the existing standard. For the introduction of an additional standard the response to the targeted stakeholder was uncertain.

2.22 Intervention area U: EU air quality standards for benzene

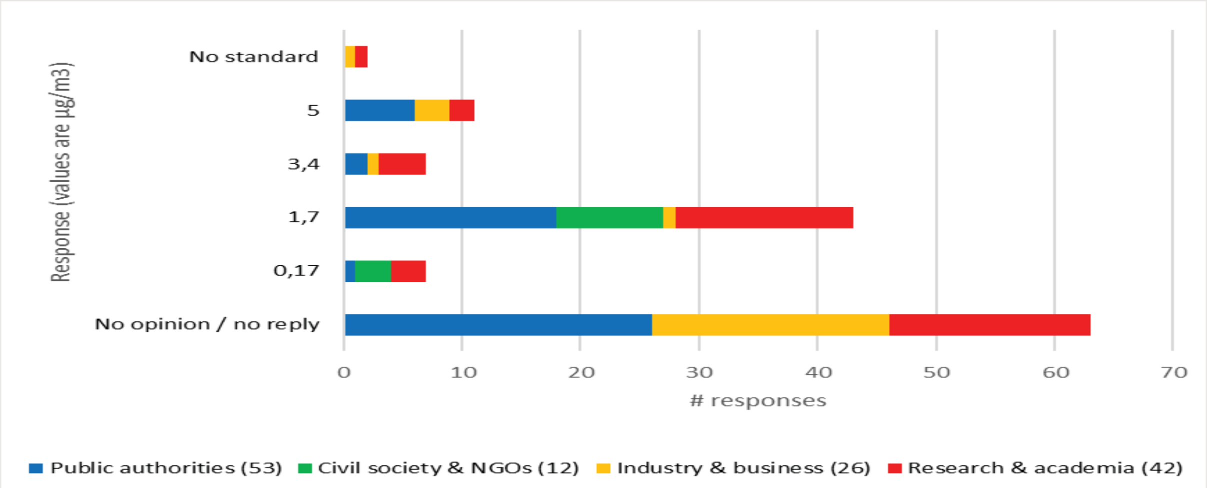
U1 Revise standards for annual benzene

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
U1	Revise standards for annual benzene: **1.7 µg/m³**	+ + 0 0	0 0 0	0 - 0	- 0	0	**Medium**	**Policy option I-1** and **Sub option I-1a**
U1	Revise standards for annual benzene: **3.4 µg/m³**	+ + 0 0	0 0 0	0 - 0	- 0	0	**Medium**	**Policy option I-2** and **Sub option I-2a**
U1	Maintain standards for annual benzene: **5 µg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: Revise EU air quality standards for annual concentrations of benzene

Description of measure: This intervention explores the alignment of the EU long-term standard limit values for benzene with the WHO Air Quality Guidelines, which for benzene were contained in the 2000 WHO Air Quality Guidelines. The current Ambient Air Quality Directives set an annual average limit value for benzene of 5 µg/m³. The WHO standard is set at 1.7 µg/m³. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There is broad compliance with the existing standard in 2019 and low exceedances relative to the WHO Air Quality Guidelines, not accounting for further improvements in the baseline. The negative impact of benzene is however also lower in relation to other pollutants.

2.23 Intervention area V: EU air quality standards for benzo(a)pyrene

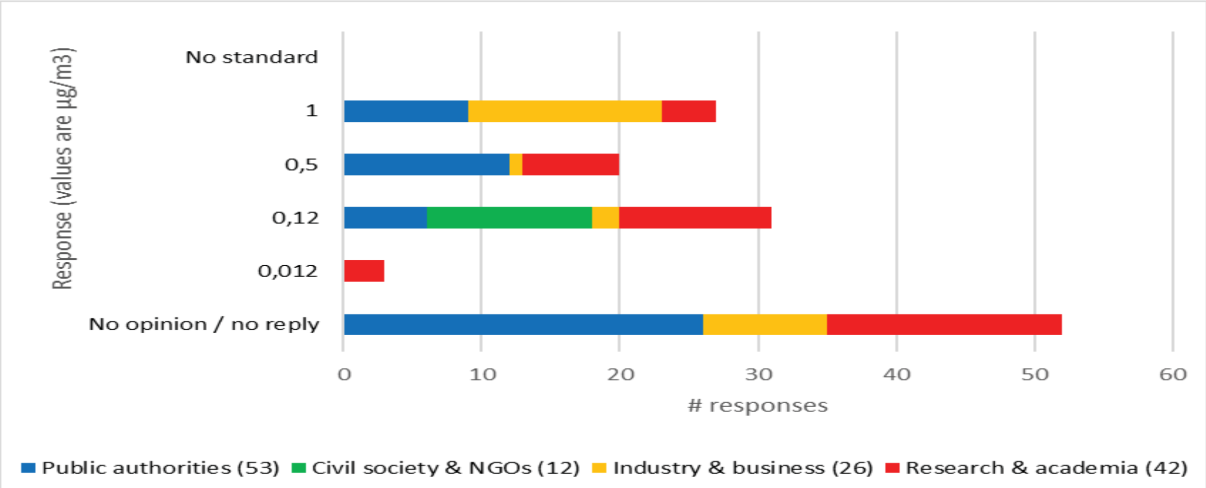
V1 Revise standards for annual benzo(a)pyrene

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
V1	Revise standards for annual benzo(a)pyrene: **0.12 ng/m³**	++ ++ 0 +	+ +/- +/-	+ - +/-	- ---	+	Medium	**Policy option I-1** and **Sub option I-1a**
V1	Revise standards for annual benzo(a)pyrene: **0.5 ng/m³**	+ + 0 +	+ +/- 0	+ - +/-	- ---	+	Medium	**Policy option I-2** and **Sub option I-2a**
V1	Maintain standards for annual benzo(a)pyrene: **1.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	NA	**Policy option I-3** and **Sub option I-3a**

Focus of measure: Revise EU air quality standards for annual mean concentrations of benzo(a)pyrene (Bap)

Description of measure: This intervention explores the possibility for the EU standard for benzo(a)pyrene to be aligned with the WHO Air Quality Guidelines, already contained in the 2000 Guidelines, and/or changing the type of standard. The current Ambient Air Quality Directives set an annual mean target value of 1 ng/m^3, relative to the WHO standard of 0.12 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on '*to which extent would this specific intervention address the identified (related) shortcomings*'.



Summary: This intervention considers both: (a) changing from target to limit value and (b) aligning the standard with the WHO Guidelines. Emissions and concentrations of BaP have been modelled directly and reductions in the baseline are anticipated to be significant compared to the baseline but smaller compared to other pollutants. A moderate number will remain in exceedance in 2030 in the baseline, with high BaP concentrations primarily occurring in specific regions in three Member States. The number of sites exceeding could be minimised through further measures. To 2050, there is broad compliance with the existing EU standard under the baseline already, and further action could achieve a lower one. BaP is mainly associated with detrimental health impacts. Likewise to comply with a lower standard would also require significant abatement action, both technical (as captured by GAINS) and non-technical or local measures (not captured by GAINS), the costs of which are uncertain.

2.24 Intervention area W: EU air quality standards for lead

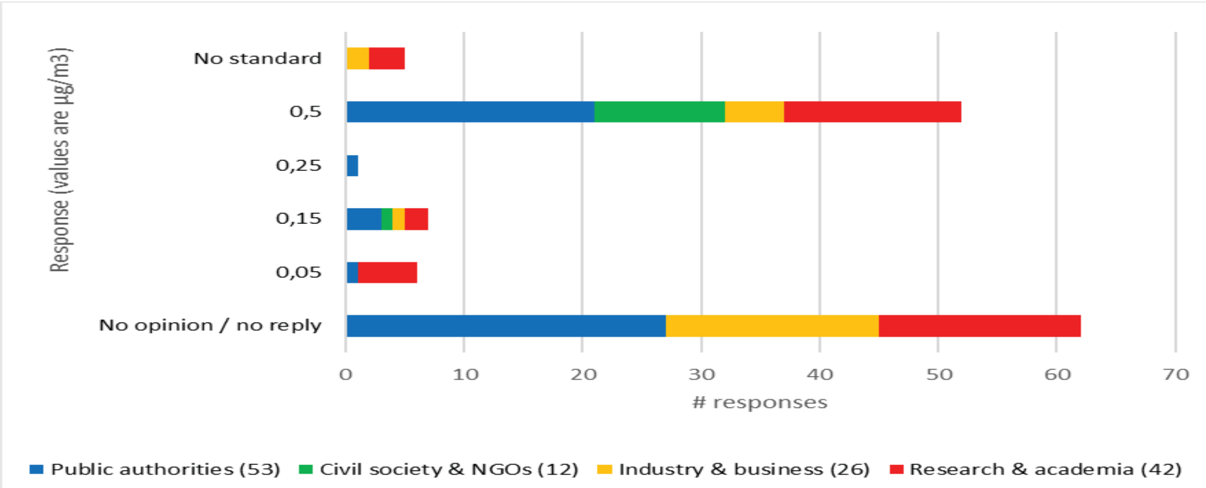
W1 Revise standards for annual lead

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
W1	Maintain standards for annual lead: **0.5 µg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for annual mean concentrations of lead

Description of measure: The measure explores the possibility for the EU annual average limit value for lead to go beyond the WHO standard contained in the 2000 Guidelines. The current Ambient Air Quality Directives sets an annual average limit value of 0.5 µg/m^3, which is consistent with the WHO standard. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The benefits of reducing concentrations would be significant on a per emission basis, but lower overall than for pollutants that are present more widely in concentrations above WHO air quality guideline levels. The costs of a stricter standard depend on the level of ambition. Compliance with the current target value is already very high, pointing to low costs also for a limit value. Costs of a stricter standard would strongly depend on the specific control measures deployed at an individual site to abate emissions. Given many sites will fall under the scope of a relevant IED BREF, many low-cost measures may already have been adopted. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.25 Intervention area X: EU air quality standards for arsenic

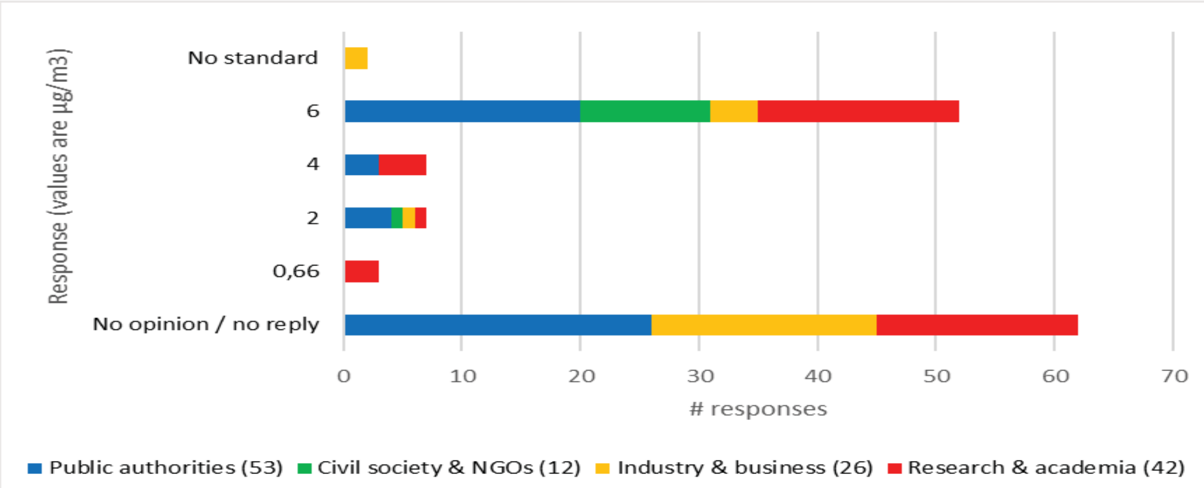
X1 Revise standards for annual arsenic

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
X1	Maintain standards for annual arsenic: **6.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for annual concentrations of arsenic

Description of measure: This intervention explores the possibility for the EU annual average target value for arsenic to be made stricter than the WHO recommendation contained in its 2000 Guidelines, and or changing the type of standard. The current Ambient Air Quality Directives set an annual average target value of 6 ng/m^3, which is already slightly below the WHO standard of 6.6 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Based on the monitoring data, only a very limited number of sites currently exceed the existing target value. As such the costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance of the few remaining sites (some of which have very high concentrations – max 21 ng/m^3 in 2019) and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission basis, but lower overall than for pollutants that are present more widely in concentrations above WHO guideline levels. Costs would strongly depend on the specific control measures deployed at an individual site to abate emissions. Given many sites will fall under the scope of a relevant IED BREF, many low-cost measures may already have been adopted. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.26 Intervention area Y: EU air quality standards for cadmium

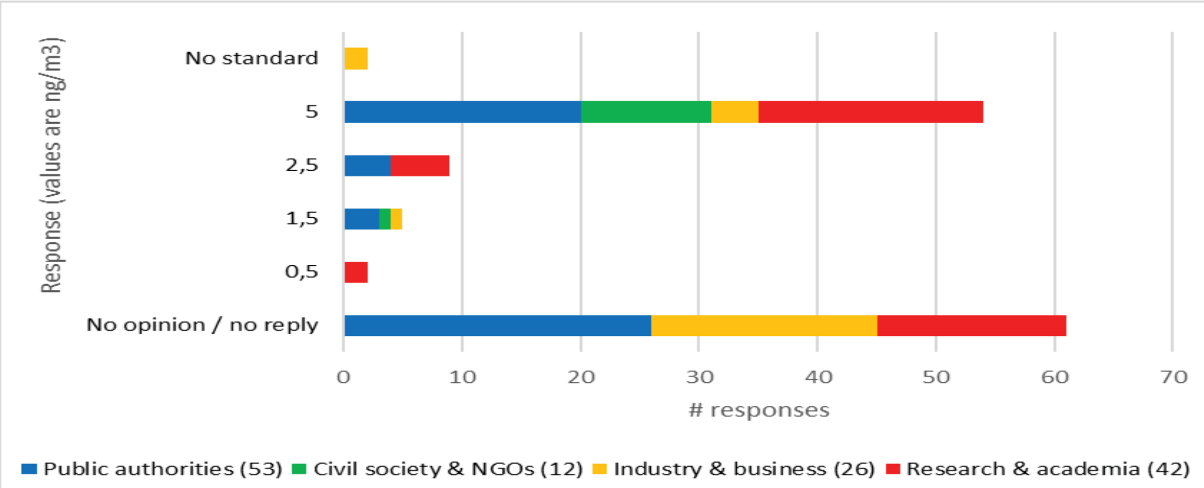
Y1 Revise standards for annual cadmium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Y1	Maintain standards for annual cadmium: **5.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: Revise EU air quality standards for annual concentrations of cadmium

Description of measure: This intervention explores the possibility for the EU annual average target value for cadmium to be made stricter than the WHO standard contained in its 2000 Guidelines, and/or to change the type of EU standard. The current Ambient Air Quality Directives set an annual average target value of 5 ng/m^3 which is equivalent to the WHO standard. Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance at the remaining sites and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission basis. There is an important link to L3 regarding monitoring of additional heavy metals to improve evidence base.

2.27 Intervention area Z: EU air quality standards for nickel

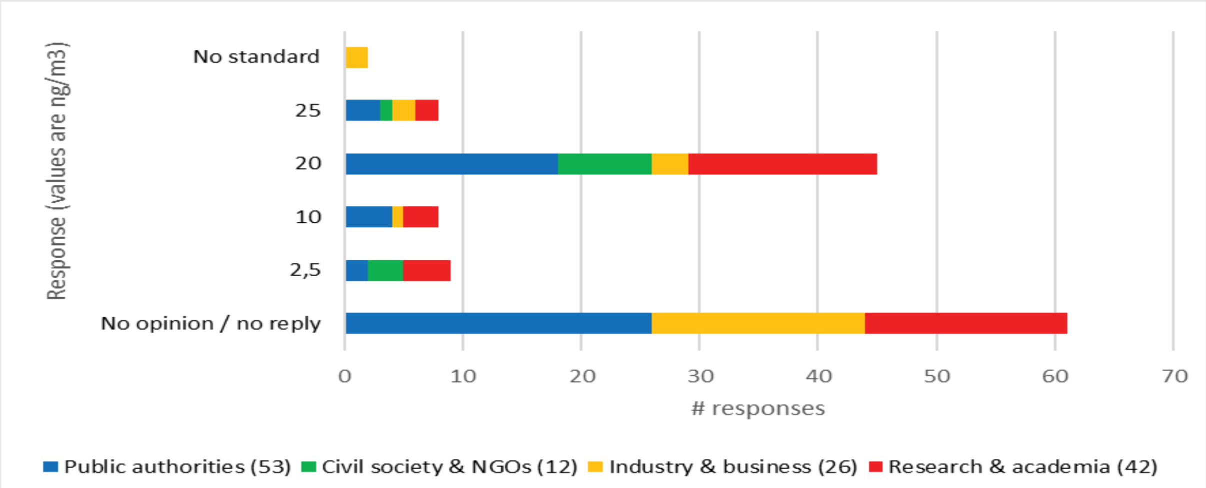
Z1 Revise standards for annual nickel

	Policy Measure	Env. impact	Soc. impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Z1	Maintain standards for annual nickel: **20 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: Revise EU air quality standards for annual mean concentrations of nickel

Description of measure: This intervention explores the possibility for the EU annual average target value for nickel to be made stricter than the WHO standard contained in its 2000 Guidelines, and/or to change the type of EU standard. The **c**urrent Ambient Air Quality Directives set an annual average target value of 20 ng/m^3, which is already slightly below the WHO standard of 25 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Based on the monitoring data, only a very limited number of sites currently exceed the existing target value. As such the costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance of the few remaining sites and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission basis, but lower overall than for pollutants that are present more widely in concentrations above WHO air quality guideline levels. Costs would strongly depend on the specific control measures deployed at an individual site to abate emissions. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.28 Intervention area Ø: EU air quality standards for additional air pollutants

Ø1 Introduce standards for additional air pollutants

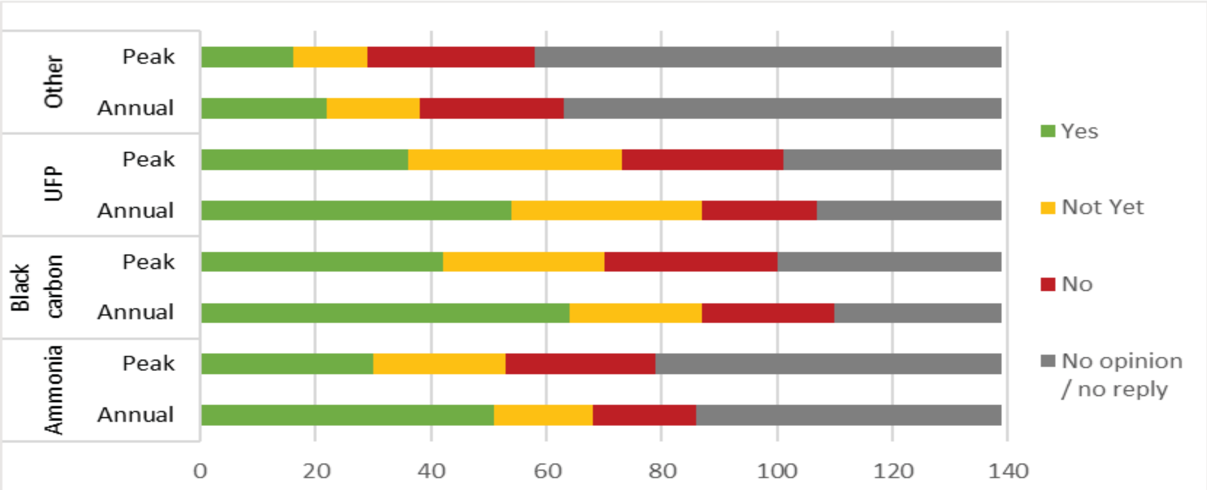
	Policy Measure	Env. impact	Soc. impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Ø1	Introduce standards for additional air pollutants	++ + + +	+ +/- +/-	+ -- +/-	-- ---	+	**Low** but uncertain	**Policy option I-1, I-2, I-3 and all sub-options**

Focus of measure: Introduce EU air quality standards for additional pollutants

Description of measure: This intervention would introduce EU air quality standards for air pollutants for which there are no WHO Air Quality Guideline levels or reference levels (e.g. ammonia, black carbon, ultrafine particles (UFP), others). These could take the form of annual or short-term standards, and could be expressed as limit, target values or otherwise.

The WHO does not recommend introducing standards at this stage (except 'where appropriate for black carbon'). The focus of WHO recommendations is on action to enhance further research on risks and approaches for mitigation. The WHO concluded that as yet, available data is insufficient to provide recommendations and interim target levels for black carbon, ultrafine particles and ammonia.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Setting standards would go beyond latest scientific advice and the extent to which they may reduce negative health impacts is therefore uncertain. A clear benefit of this intervention would be a requirement to monitor concentrations and this information could subsequently be used to gain more scientific evidence about health effects. Therefore, this intervention is strongly linked to monitoring interventions (L1 and L2). Administrative burden and would vary with ambition (with more air quality plans required in cases of the high ambition variant to account for the greater number of exceedances). There would be costs associated with additional monitoring required.

3. Policy Options

3.1 Policy options to address environment / health shortcomings

Policy option I-1 to I-3: Full / Closer / Partial alignment with WHO recommendations

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option I-1 Full alignment with WHO recommendations	+++	+++	+++	---	Even if all effort is made, the related targets cannot be fully achieved everywhere (due to physical geography constraints). But at locations where achieved, they bring major health benefits.	**High** but uncertain
+ **I-1a**: by 2050	++	++	++	--	See above.	**High** but uncertain
Policy option I-2 Closer alignment with WHO recommendations	++	++	++	--	Current baseline policies bring most regions close to target. Achieving this target has considerable health benefits and social co-benefits – medium effort needed.	**High**
+ **I-2a**: by 2050	+	+	+	-	Target would be achievable with little extra effort.	**High**
Policy option I-3 Partial alignment with WHO recommendations	+	+	+	-	Current baseline policies will achieve this level in almost all of the EU. Thus setting targets at this level offers only limited added benefit (but where it triggers additional action this is of high benefit).	**High**
+ **I-3a**: by 2050	0	0	0	0	Likely does not require additional policy action.	**NA**

Policy option I-4: Additional air pollutants

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option I-4 Additional air pollutants	+	+/-	+/-	--	May have benefits, but to date no basis in WHO recommendations to set such air quality standards. Priority should be establishing a monitoring network for these pollutants (see III-1).	**Low** but uncertain

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Ø1	Introduce standards for additional air pollutants	++ + + +	+ +/- +/-	+ -- +/-	-- --	+	**Low** but uncertain	**Policy option I-1, I-2, I-3** and **all sub-options**

Policy option I-5: Average exposure reduction

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option I-5 Average exposure reduction for $PM_{2.5}$	++	+	+	--	Can build on existing concept and monitoring, but at more appropriate regional resolution, to help assure continuous decrease in background $PM_{2.5}$.	**High**
+ **I-5a:** PM_{10}	+	+	+/-	--	Low added value, if $PM_{2.5}$ is already covered.	**Low**
+ **I-5b:** NO_2	+	+	+	--	Extra burden, NO_2 focus better be 'hotspots'.	**Medium**
+ **I-5c:** O_3	+	+/-	+/-	--	Uncertain if O_3 metric can trigger effective action.	**Uncertain**

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B3	Revise definition of average exposure standards	(+) (+) (+) (+)	(+) 0 0	(+) 0 0	0 (-)	(+)	**High**	**Policy option I-5**

Policy option I-6: Review air quality standards

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option I-6 Review air quality standards *(Measures A1,A3)*	++	+	0	-	Regular review will ensure scientific evidence base of EU policy making, but should be spaced to allow for sufficient scientific progress and regulatory certainty.	High
+ **I-6a:** Measure A2	+	0	0	-	Little extra value compared to main option.	Low
+ **I-6b:** Measure A4	+	0	0	--	High (admin) burden for uncertain added value.	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A1	Introduce review triggered by scientific progress	++ (+) (+) +	(+) (+) 0	0 0 0	0 (-)	+	High	**Policy option I-6**
A3	Introduce option to notify stricter standards	(+) (+) (+) (+)	(+) 0 0	0 0 0	0 (-)	0	High	**Policy option I-6**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A2	Introduce review triggered by technical progress	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	Low	**Sub-option I-6a**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A4	Introduce a list of priority pollutants	(+) (+) (+) (+)	0 0 0	0 0 0	0 --	0	Low	**Sub-option I-6b**

3.2 Policy options to address governance / enforcement shortcomings

Policy option II-1: Responses to exceedances

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option II-1 Responses to exceedances *(Measures B4,C1,C3,D1,N1)*	++	+	+/-	--	This policy option will update the means by which air quality plans are developed. Costs to change existing approach compensated or even reduced by more effective air quality plans and measures.	Medium
+ **II-1a**: Measure D2	0	0	0	--	Added value doubtful, subsidiarity considerations.	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B4	Introduce guidance on addressing exceedances	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	Medium	**Policy option II-1**
C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium / High	**Policy option II-1** **Policy option II-4**
C3	Revise short-term action plans & air quality plans	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 -	0	Medium	**Policy option II-1**

D1	Revise requirements to involve stakeholders	(+) (+) (+) 0	0 0 0	0 0/- 0	0/- --	0	High	**Policy option II-1**
N1	Revise the information in air quality plans	++ + + (+)	(+) 0 0	(+) - 0	- --	+	High	**Policy option II-1**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D2	Introduce a 'one zone, one plan' requirement	0 0 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub-option II-1a**

Policy option II-2: Additional limit values

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option II-2 Additional limit values *(Measures B1,B5)*	++	+	+/-	-	Fitness Check indicates that 'limit values' have been more effective than other types of air quality standards. For some pollutants (notably O_3), however the concept is unlikely to have benefits.	High

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B1	Introduce additional short-term standards	+ 0 0 0	0 0 0	0 0 0	0 (-)	0	High	**Policy option II-2**
B5	Introduce limit values for additional air pollutants	++ + + +	+ 0 0	+ - 0	- (-)	0	Medium	**Policy option II-2**

Policy option II-3: Implementation timelines

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
II-3 Implementation timelines & short-term action plans *(Measures B2,C2,C4,C5)*	+	+	+/-	--	The key added value would be to ensure regular updates of air quality plans. Alert thresholds for particulate matter would address additional health concerns, but likely at a cost.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B2	Introduce additional alert/information thresholds	+ + (+) (+)	+ 0 0	0 0 0	0 (-)	(+)	Medium	**Policy option II-3**
C2	Revise/clarify definition of 'as short as possible'	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium	**Policy option II-3**
C4	Introduce additional short-term action plans	+ + + (+)	+ (+) (-)	(+) 0/- (-)	0/- -	(+)	Medium	**Policy option II-3**
C5	Introduce requirement to update air quality plans	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- ---	(+)	Medium	**Policy option II-3**

Policy option II-4: Enforcement tools

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option II-4 Enforcement tools *(Measures C1,E1,E2,E4)*	++	+	+/-	0/-	Penalties and damages have not been sufficiently dissuasive. Adding additional clarity will help set priorities and incentives. Note that if there is compliance the related costs do not manifest.	High
+ **II-4a:** Measure E3	+	+	0	-	Subsidiarity to be considered, unclear how.	Uncertain

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium / High	**Policy option II-1** **Policy option II-4**
E1	Introduce minimum levels for financial penalties	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) (-)	(+)	Medium / High	**Policy option II-4**
E2	Introduce right to health damage compensation	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- 0	(+)	Medium	**Policy option II-4**
E4	Introduce access to justice provision	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) 0	0	High	**Policy option II-4**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E3	Introduce a fund to be fed by penalties paid	0/(+) 0/(+) 0/(+) 0/(+)	0 (+) 0	0 0/(+) 0	0/+ (-)	0/(+)	Low	**Sub-option II-4a**

Policy option II-5: Transboundary air pollution

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option II-5 Transboundary air pollution *(Measures M1,M2)*	+	0	+/-	-	Transboundary air pollution is already the focus of the NEC Directive. Further cooperation is desirable but difficult to enforce. Additional guidance helpful.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M1	Introduce methodology to assess transboundary	(+) (+) (+) (+)	0 0 0	0 0/(+) 0	0/(+) --	(+)	High	**Policy option II-5**
M2	Revise obligations for transboundary cooperation	(+) (+) (+) (+)	0 0 0	(+) - 0	- -	(+)	Medium	**Policy option II-5**

3.3 Policy options to address air quality monitoring / assessment shortcomings

Policy option III-1: Air quality assessments

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-1 Air quality assessments *(Measures G1, G2, H1, H2, L1)*	+	+	+	--	Will significantly improve air quality monitoring and assessment, allowing for more targeted air quality measures, and make better use of avail. methods. Costs related to the expansion of the monitoring network and adding 'super-sites'.	Medium
+ **III-1a:** Measure G3	0	0	0	0	Minor admin. simplification only, but at (low) cost.	Low
+ **III-1b:** Measure H3	0	0	0	-	Minor admin. simplification only, but at (low) cost.	Low
+ **III-1c:** Measure K2	+	0	0	-	Will improve data, but at potentially high cost.	Low
+ **III-1d**: Measure J3	+	+	+	--	Will allow more targeted air quality management.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G1	Revise rules related to indicative sampling points	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 ---	0	High	**Policy option III-1**
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 ---	0	Medium / High	**Policy option III-1** and **Policy option III-5**
H1	Revise minimum number of sampling points	+ + + 0	0 0 0	+/- 0 0	0 ---	0	Medium	**Policy option III-1**
H2	Simplify combined $PM_{10}/PM_{2.5}$ monitoring	(+) (+) 0 0	0 0 0	(+) 0 0	0 ---	0	High	**Policy option III-1**
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 ---	0	Medium	**Policy option III-1** and **Policy option III-3**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G3	Revise rules for regular review of AQ assessment	0 0 0 0	0 0 0	0 0 0	0 (-)	0	Low	**Sub option III-1a**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H3	Simplify the definitions of sampling points types	0 0 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub option III-1b**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub option III-1c** and **Policy option IV-1**

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	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J3	Introduce obligation for spatial representativeness	(+) (+) (+) 0	(+) 0 0	(+) 0 0	0 ---	0	Medium	**Sub option III-3d**

Policy option III-2: Monitoring continuity

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-2 Monitoring continuity *(Measures I1, I3)*	+	+	0	-	Will significantly improve air quality monitoring and assessment, allowing for more targeted air quality measures.	Medium
+ **III-2a**: Measure I2	+	0	0	-	Minor admin. simplification only, at (low) cost.	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I1	Introduce obligations to maintain sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 0	0	High	**Policy option III-2**
I3	Introduce a protocol for relocated sampling points	(+) 0 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option III-2**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I2	Introduce obligations to monitor long-term trends	(+) (+) (+) 0	0 0 0	0 0 0	0 (-)	0	Low	**Sub-option III-2a**

Policy option III-3: Additional sampling points

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-3 Additional sampling points *(Measures L1, L2)*	++	0	+	--/---	Clarifies current levels of these air pollutants, as a requisite for verifying health effects and need for taking action. Costs related to the expansion of the monitoring network and adding 'super-sites'.	Medium
+ **III-3a**: Measure L3	+	0	0	--/---	Can only be a gross list of VOC – needed in law?	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 ---	0	Medium	**Policy option III-1** and **Policy option III-3**
L2	Introduce obligations to monitor more pollutants	(+) (+) (+) (+)	0 0 0	(+) 0 0	0 ---	0	High	**Policy option III-3**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L3	Revise list of VOC to monitor	(+) (+) (+) 0	0 0 0	0 0 0	0 ---	0	Low	**Policy option III-3a**

Policy option III-4: Monitoring data quality

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-4 Monitoring data quality *(Measures J1, J2, K1)*	+	+	0	-	Additional clarity will enhance reliability and comparability of air quality data – but may also result in significant cost to update existing air quality monitoring and assessment networks.	Medium
+ **III-4a**: Measure K4	+	0	0	-	Will increase confidence in air quality further.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J1	Revise macro-scale siting of sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 --	0	Medium	**Policy option III-4**
J2	Revise micro-scale siting of sampling points	(+) 0 0 0	(+) 0 0	(+) 0 0	0 --	0	Medium	**Policy option III-4**
K1	Revise AQ monitoring data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	Medium	**Policy option III-4**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K4	Revise approach to AQ assessment uncertainty	(+) (+) (+) 0	0 0 0	0 0 0	0 --	0	Medium	**Sub option III-4a**

Policy option III-5: Modelling data quality

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-5 Modelling data quality *(Measures G2, K3)*	+	+	0	--	This policy option is a prerequisite to an effective implementation of policy option III-1. Important for robust data, but little other direct consequences.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 ---	0	Medium / High	**Policy option III-1** and **Policy option III-5**
K3	Introduce AQ modelling data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	High	**Policy option III-5**

3.4 Policy options to address air quality information shortcomings

Policy option IV-1: Up-to-date air quality data

Policy option	Consequences / Impacts Env.	 Soc.	 Eco.	 Cost	Assessment and key considerations	Benefit to cost
Policy option IV-1 Up-to-date air quality data *(Measures F1, K2)*	+	+	0	-/--	Up-to-date data provision will allow more for additional societal responsiveness to pollution peaks. Related costs will vary, and include a punctual expansion of the monitoring network.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F1	Revise provisions related to up-to-date data	0 (+) 0 0	(+) 0 0	0 0 0	0 --	0	Medium / High	**Policy option IV-1**
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub option III-1c** and **Policy option IV-1**

Policy option IV-2: Health related air quality data

Policy option	Consequences / Impacts Env.	 Soc.	 Eco.	 Cost	Assessment and key considerations	Benefit to cost
Policy option IV-2 Health related air quality data *(Measure F2)*	+	+	0	-	Potentially impactful measure, will require closer interaction between health practitioners and policy makers to inform a wider public (and vulnerable populations) better. Likely significant initial costs.	Medium
+ **IV-2a**: *Measure F3*	0	0	0	--	No added value of specifying channels in law.	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F2	Introduce requirement to provide AQ health data	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option IV-2**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F3	Introduce use of specific communication channels	0 0 0 0	(+/-) 0 0	0 0 0	0 ---	0	Low	**Sub-option IV-2a**

Policy option IV-3: Harmonised air quality indices

Policy option	Consequences / Impacts Env.	 Soc.	 Eco.	 Cost	Assessment and key considerations	Benefit to cost
Policy option IV-3 Harmonised air quality indices *(Measure F4)*	+	+	0	-	Harmonisation of air quality data saves costs for developing and updating separate indices. Provides clarity for citizens across the EU.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F4	Introduce requirements for harmonised AQ index	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option IV-3**

4. HOW DO THE OPTIONS COMPARE?

Policy option	Consequences / Impacts				Benefit to cost	Synergies, complementarities and trade-offs with other options and/or sub-options
	Env.	Soc.	Eco.	Cost		
I-1 Full alignment with WHO recommendations	+++	+++	+++	---	High but uncertain	**Consider** a variant of sub-option I-1a (i.e. more ambitious objectives in a post -2030 perspective). **Not** the preferred option for 2030 compared to I-2.
I-2 Closer alignment with WHO recommendations	++	++	++	--	High	**Preferred** option for air quality objectives for 2030. **Effectiveness** depends on policy option II-2 - [Discard sub-option I-2a]
I-3 Partial alignment with WHO recommendations	+	+	+	-	High	**Not** the preferred option for 2030 compared to I-2. - [Discard sub-option I-3a]
I-4 Additional air pollutants	0/+	+/-	+/-	-	Low but uncertain	**Efficiency** is higher discarding this policy option, but retaining monitoring of additional air pollutants via policy option III-4.
I-5 Average exposure reduction	++	+	+	-	High	**Add** complementary sub-option I-5b (NO_2), and consider a variant of sub-option I-5c (O_3) - [Discard sub-option I-51]
I-6 Review air quality standards	++	+	0	-	High	- [Discard sub-options I-6a, I-6b]
II-1 Responses to exceedances	++	+	+/-	--	Medium	- [Discard sub-option II-1a]
II-2 Additional limit values	++	+	+/-	-	High	**Proportionality** of this option also depends on whether policy option I-1, I-2, or I-3 is preferred.
II-3 Implementation timelines & revised short-term action plans	+	+	+/-	--	Medium	
II-4 Enforcement tools	++	+	+/-	0/-	High	**Consider** also complementary sub-option II-4a.
II-5 Transboundary air pollution	+	0	+/-	-	Medium	**Effectiveness and efficiency** depend on refined approaches to policy options II-4 and III-1
III-1 Air quality assessments	+	+	+	--	Medium	**Add** complementary sub-option III-1d to enhance effectiveness of this option. - [Discard sub-options III-1a, III-1b, III-1c]
III-2 Monitoring continuity	+	+	0	-	Medium	- [Discard: Sub-option III-2a]
III-3 Additional sampling points	++	0	+	--/---	Medium	- [Discard: Sub-option III-3a]
III-4 Monitoring data quality	+	+	0	--	Medium	**Add** complementary sub-option III-4a to enhance effectiveness of this option. **Efficiency** of monitoring requirement for additional pollutants is higher than standards (option I-4).
III-5 Modelling data quality	+	+	0	-/--	Medium	**Complements** option III-1.
IV-1 Up-to-date air quality data	+	+	0	-/--	Medium	**Efficiency** of this option **depends on** whether and how options III-1 and III-4 are defined.
IV-2 Health related air quality data	+	+	0	-	Medium	- [Discard: Sub-option IV-2a]
IV-3 Harmonised air quality indices	+	+	0	-	Medium	**Effectiveness depends on** options IV-1 and IV-2 being implemented also.

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PART 4/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

Proposal for a Directive of the European Parliament and of the Council

on ambient air quality and cleaner air for Europe (recast)

{COM(2022) 542 final} - {SEC(2022) 542 final} - {SWD(2022) 345 final} -
{SWD(2022) 542 final}

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ANNEX 7: NON–LEGISLATIVE MEASURES TO STRENGTHEN AIR QUALITY MONITORING AND MODELLING, AND AIR QUALITY PLANS

1. INTRODUCTION

Following the publication of the results of the Fitness Check of the Ambient Air Quality Directives, in November 2019, the European Commission launched an exercise to address the issues identified as needing additional technical support documents and/or guidance documents (below referred to as '*technical guidance documents'*) to support the implementation of the Ambient Air Quality Directives.

[80]/[81] The focus of this exercise was on making air quality monitoring and modelling, and air quality plans, more effective and efficient and is complementary to any changes to be done to the legal provisions:

(1) *Improve and further specify air quality monitoring requirements*: additional precision on monitoring requirements would consolidate the representativeness of, and confidence in, monitored data, as well as provide increased comparability of air quality data across the EU. This would include streamlining, simplifying, and increasing precision and coherence of monitoring requirements, as well as providing further technical guidance documents as necessary, in relation to assessment regimes, micro- and macro-scale siting criteria of sampling points, data quality objectives for measurements and reference measurement methods, continuity of measurements in the same location, and provision of air quality data to the public.

(2) *Improve the use of complementary air quality assessment methods*: common rules on other air quality assessment methods to complement air quality monitoring (such as air quality modelling, indicative measurements, and objective estimation), would improve the representativeness, comparability, coverage and timelines of air quality assessments. The further use of these methods may also significantly reduce the costs of air quality assessment. More concretely, the European Commission explored an enhanced role of modelling in air quality assessment, further improving the quality of modelling, the use of complementary air quality assessment methods in informing air quality network design and the needs for further guidance on indicative measurements, objective estimation and low-cost sensors.

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[80] The European Green Deal (COM(2019) 640 final) announced as the framework of a zero pollution ambition for a toxic-free environment that the Commission would draw on the lessons learnt from the Fitness Check of the Ambient Air Quality Directives and strengthen the provisions for air quality monitoring, modelling, and plans.

[81] COM (2022), Strengthening of air quality monitoring, modelling and plans under the Ambient Air Quality Directives - final (accessed: 04.08.2022)

(3) *Improve effectiveness of air quality plans*: it is essential to consider ways to address the need for more precise requirements, complemented with technical guidance documents as appropriate, to ensure that air quality plans and their implementation by competent authorities result in air quality standards being respected in the shortest time possible. This may be achieved by looking at inter alia, minimum elements required for an effective air quality plan, the process of elaboration of air quality plans, the methods used to estimate the impact of measures (including their costs and benefits) and support for the implementation of air quality plans and assessing of their impacts and effectiveness.

2. METHODOLOGY

To identify, analyse and recommend the issues needing of additional guidance for strengthening air quality monitoring, modelling and plans, a set of 15 specific questions were defined which guided the whole exercise. The questions were grouped into four topic areas: monitoring, modelling, planning, and general aspects as follows:

[Q1 - (general) administrative burden] What scope is there to reduce the administrative burden and improve the efficiency of air quality assessments, thus addressing the instances with scope for simplification and burden reduction potential as identified in the Fitness Check? What specific changes are needed for this?

[Q2 - (general) air quality assessment regimes] In view of how Member States establish, review and update air quality zoning, applicable assessment regimes, as well as classification of zones, what scope is there to make this more transparent, especially in air quality zones with a limited number of monitoring stations?

[Q3 - (monitoring) micro- and macro-scale siting of sampling points] In view of how Member States ensure adequate monitoring in areas within zones and agglomerations where the highest concentrations occur, especially around, close to or downwind from key point sources, are there significant assessment gaps related to these and what can be done?

[Q4 - (monitoring) representativeness and continuity of monitoring] In view of how Member States ensure adequate monitoring to reliably assess average exposure indicators (for fine particulate matter), how can the representativeness of sampling points and continuity of monitoring be ensured for particulate matter and would aligned requirements improve the assessment of other air pollutants with exceedances?

[Q5 - (monitoring) monitoring other air pollutants] Are Member States monitoring the concentration levels of air pollutants not covered by the AAQ Directives? If so, how, where, against which data quality objectives – and what is the scope to harmonise this?

[Q6 - (monitoring / modelling) air quality assessment methods)] What role do complementary assessment methods (i.e. modelling, indicative measurements, objective estimation, satellite measurements and low-cost sensors) play in the air quality assessment regimes applied in different Member States? Is there a need for more guidance?

[Q7 - (modelling) enhanced role of air quality modelling] What role does modelling play in the air quality assessment regimes applied in different Member States? Is there a need for guidance and for further harmonisation?

[Q8 - (modelling) improving quality of air quality modelling] Where air quality modelling is used in air quality assessment regimes, which modelling quality objectives are applied? Is there a need for, and scope to specify these further? Is more comprehensive guidance on the use of modelling (for example on fitness-for purpose, on, on modelling data quality objectives) needed and, if so, what should such guidance cover?

[Q9 - (air quality plans) elements of air quality plans] In view of how do competent authorities in Member States fulfil the requirements for an air quality plan as per Annex XV of Directive 2008/50/EC, which elements are considered essential, less essential or missing to ensure an effective air quality plan?

[Q10 - (air quality plans) role of modelling to support air quality plans] Where air quality modelling is used to support plans which approaches are applied? Is there a need for more guidance on the use of such approaches? Is there a need for, and scope to specify quality objectives (or benchmarks) for these approaches?

[Q11 - (air quality plans) air quality plan development process and engagement] Who are the main actors and stakeholders during the process of setting up an air quality plan in different Member States, and to what extent have they control and enforcement powers to ensure implementation? What further requirements would be effective?

[Q12 - (air quality plans) ex-ante impact, costs and effectiveness of air quality plans] How do competent authorities in Member States estimate the improvements in air quality expected due to air quality plans? Is there scope for further requirements in relation to ex-ante impacts and cost estimates to increase effectiveness of air quality plans?

[Q13 - (air quality plans) ex-post assessments of impacts and costs of air quality plans] Do competent authorities in Member States monitor and evaluate the effects and costs of air quality plans during and after their implementation? Is there scope for further requirements in relation to ex-post assessment of impacts and costs to increase effectiveness of air quality plans?

[Q14 - (general) public access to air quality data] How do competent authorities in Member States communicate with the public on and involve them in air quality matters, and specifically: how do they provide access to air quality data? How is the public informed about long and short term health risks of air pollution? Is there need for good practice guidance?

Q15 - (general) External factors. How do competent authorities in Member States calculate external factors contributing to the worsening of air quality in their monitoring, modelling and planning activities? How do they facto these sources into air quality planning processes?

To analyse the above-mentioned topics and be able to propose solutions for strengthening air quality monitoring, modelling and plans, the following steps were taken divided in two phases with the following activities included:

Phase 1: Scoping, mapping and analysis

1. Identification of key issues related to implementation of the provisions for air quality monitoring, modelling and air quality plans that would benefit from a further technical guidance document: a total of 271 literature sources were reviewed, of which 84 were ranked of potential relevance to the task at hand.
2. Consultation with experts, practitioners and other stakeholders on how the provisions on air quality monitoring, modelling and air quality plans have been implemented, where they are subject to interpretation and how their implementation could be further improved. This included an expert consultation that received 107 responses representing 23 Member States, four interviews of those Member States that had not responded to the expert consultation and the organisation of focus groups to deepen on the understanding of the issues identified as well as receiving feedback on the first solutions proposed. Additional inputs to the evidence base were also considered, such as those coming from a workshop hosted by the Commission on 20 April 2021. The workshop engaged the members of the Ambient Air Quality Expert Group to specifically discuss air quality assessments and assessment regimes highlighting guidance needs, and improvement potential.[82]
3. Mapping and analysis of established practice across Member States for several specific issues related to the implementation of provisions for air quality monitoring, modelling, and air quality plans.

The stakeholder engagement activities of phase 1 concluded with the identification of 72 technical issues that stakeholders are currently facing when implementing the Ambient Air Quality Directives.

Phase 2: Assessing the impacts of technical suggestions and recommendations for future

1. To address these 72 technical issues, 42 *potential* technical solutions were formulated, which could subsequently take the form of elements for technical guidance documents. The technical solutions were elaborated considering their respective consequences, their relevance, effectiveness, efficiency and coherence, as well as estimates of how long it would take to implement the possible modifications and the likelihood of their success (including in the absence of legislative changes).
2. The impacts of the different technical suggestions (including costs and efficiency gains) to strengthen the monitoring, modelling and air quality plans' provisions were assessed, as well as a quantification of any reduction potential for the administrative burden. To undertake this, a logic framework was developed to compare the evidence gathered for

[82] The workshop was attended by 40 experts from 25 Member States and from DG ENV (6), JRC (2), EEA (3) and ETC (1), plus 4 invited external experts.

each of the *potential* technical solutions. The result allowed for a comparative assessment of the 42 *potential* technical solutions.

3. As the last step a thorough review of existing technical guidance documents was done to identify those that would need to be replaced or reviewed; and which new technical guidance documents would need to be elaborated to allow the implementation of the technical solutions. *Potential* technical solutions deemed to have a low likelihood of success without changes to existing provisions were not considered in this last step.

3. TECHNICAL GUIDANCE DOCUMENTS

Most of the currently available technical guidance documents require updates to bring them in line with the current practice and knowledge, and to allow implementation of the technical solutions; or require the full replacement by new technical guidance documents.

Eight core technical guidance documents are recommended for future development by the European Commission in close cooperation with experts from AQUILA (for monitoring related guidance), FAIRMODE (for modelling related guidance) and the members of the Ambient Air Quality Expert Group:

A. Technical guidance document on air quality assessment in air quality zones.

EU air quality legislation requires Member States to designate air quality zones and report their corresponding air quality data to the European Commission. The Commission's Implementing Decision 2011/850/EU stipulates in Article 6 the information on zones and agglomerations that need to be made available by the Member States. The available guidance on the Commission's Implementing Decision specifies how and when air quality zones are to be reported while the guidance on their definition and the methods to be used in their identification is provided in the *Guidance on the Assessment under EU Air Quality Directives.*[83]

The proposal is to develop a technical guidance document to replace the current and outdated *Guidance on the Assessment under EU Air Quality Directives*.

Such new technical guidance document should focus on air quality zones and methodologies used for their determination - identifying the additional requirements necessary for their application for different air quality management purposes. This technical guidance document could specify that the definition of air quality zones applies for all assessment purposes concerning monitoring, modelling, and air quality plans. It could also identify methods to be applied so that the zones can be used for all assessment purposes. Such technical guidance document could clarify whether air quality modelling and plans are needed for a whole air quality zone or only at hot spot areas within the air quality zone, thus addressing the technical issues identified.

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83 COM (2022), Guidance on Assessment under the EU Air Quality Directives Final (accessed: 04.08.2022)

This new technical guidance on air quality assessment in air quality zones encompasses most guidance topics identified as necessary to support assessment purposes concerning monitoring, modelling, and air quality plans, which description follows.

B. Technical guidance document on exceedance and exposure indicators.

The document should provide a clear and transparent outline of how to derive and report the relevant exceedance and exposure situation indicators (ESI) and the type of input data to be used in the process to harmonise these indicators for different air quality zones, regions and at Member State level.

This proposed new technical guidance document may rely on a tiered approach that allows the combination of fixed measurements, modelling results and indicative measurements to calculate different exceedance and exposure situation indicators (see also *E. Technical guidance document on the tiered approach of assessment methods*), as well as on the by FAIRMODE suggested two-stage assessment and reporting process.

This new technical guidance document should therefore consider FAIRMODE activities in relation to the calculation of exceedance and exposure indicators and their benchmarking activities to identify best practices.

C. Technical guidance document on reference methods and data quality objectives for new pollutants.

This new technical guidance document would identify the methodologies recommended for the measurement of additional pollutants that may be included in a revised Ambient Air Quality Directive, specifying for each of the pollutants recommended reference methods, equivalence methods and methods to establish compliance with their given data quality objective. It would explain the purpose of monitoring the additional pollutants with respect to health, ecosystems and climate impacts and explain the link with the legal monitoring and reporting requirements.

This new technical guidance document would also update the currently available *Guidance report on demonstration of equivalence of ambient air monitoring methods (2010)*[84] by updating the reference methods of for the currently monitored pollutants, and addressing also the methods needed for the use of indicative measurements.

This new technical guidance document would provide examples on good practices to reduce the uncertainties related to variability and the representativeness of measurements and provide direct support to fulfilling legal monitoring and reporting requirements.

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[84] COM (2010), Guidance report on demonstration of equivalence of ambient air monitoring methods (accessed: 04.08.2022)

It would enable monitoring experts in Member States to undertake comparable measurements with specific data quality objectives in support for improved health, climate and ecosystem impact assessments. This would lead to a harmonisation of additional monitoring requirements and ensure a good standard of monitoring.

This new technical guidance document should consider other parallel activities ongoing such as AQUILA's position paper from Working Group 6 on additional pollutants and reference methods, the outcome of the support contract on "*Systematic assessment of monitoring of other air pollutants not covered under Directives 2004/107/EC and 2008/50/EC (with a focus on ultrafine particles, black carbon and ammonia)",* as well as various current activities undertaken by the European Monitoring and Evaluation programme (EMEP), the Global Atmosphere Watch Programme (GAW), the Aerosol, Clouds, and Trace Gases Research Institute (ACTRIS) and the European Committee for Standardisation (CEN).

D. Technical guidance document on use of indicative measurements/low-cost sensors.

This new technical guidance document would be designed for competent authorities involved in the setup of monitoring campaigns to complement the fixed monitoring network or validate model applications. The document would focus on the capabilities of various complementary assessment methods, including indicative measurements and objective estimation, and would clarify what method is fit for what purpose. An additional specific technical advice document should be developed for the use of modelling systems in the context of the Ambient Air Quality Directives. This technical guidance document would primarily focus on measurement techniques.

From a monitoring perspective there is special interest in indicative measurements as robust, reliable and rather low-cost complementary assessment method. Given the strong uptake of low-cost sensors by society as well as by academia and environmental experts there is also a need for additional guidance with respect to the deployment, characterisation of accuracy and the use of low-cost sensors, sensor networks as a whole and its integration in modelling applications.

Topics to include would be how to characterise and evaluate the accuracy of indicative measurements and low-cost sensors, how to setup, deploy and maintain an effective network of indicative measurements or low-cost sensors, and how to integrate sensor data in air quality models to improve overall quality of the assessment maps.

The proposed technical guidance document should consider current ongoing activities performed by the European Commission's Joint Research Centre as regards low cost sensors, FAIRMODE´s work under cross-cutting task (CT) 6 and AQUILA´s input to the revision process under Working Group 4 on indicative measurements and objective estimation.

E. Technical guidance document on the tiered approach of assessment methods.

In general, compliance checking under the Ambient Air Quality Directive is performed on the basis of data collected in the fixed monitoring networks. Fixed measurements are the basis of every monitoring network, installed following the requirements of the Ambient Air Quality Directives. However, the use of additional methods such as indicative measurements, modelling or objective estimation are used by competent authorities to complement fixed monitoring data. This allows for a better understanding of air quality, and may have different uses such as for the evaluation of the monitoring network in assessing air pollution or sampling point representativeness. These data may also be reported to the European Commission via the e-Reporting system for compliance purposes.

Such technical guidance document would clarify the tiered approach that is recommended for use for these assessment purposes. The tiered approach ranges from:

- Tier 1: the use of expert opinion;
- Tier 2: the use of proxy data or specific measurement campaign data;
- Tier 3: the application of fit-for-purpose modelling systems;
- Tier 4: the application of modelling systems complemented with additional measurement data to further improve the quality of the assessment results.

For each of the tiers a proper description of its complexity level and the added value would be described together with a related quality assurance/quality control (QA/QC) process.

For the elaboration of this technical guidance document the results of the European Commission's support contract '*SR5 Sensitivity and feasibility tests for a tiered approach - Assessing the spatial representativeness of air quality sampling points'*, as well as FAIRMODE´s work under CT8 on monitoring design and AQUILA´s position paper for the revision under Working Group 3 should be considered.

F. Technical guidance document on the use of models.

This technical guidance document would clarify the purpose and the role of modelling for its various application domains under the Ambient Air Quality Directive such as for complementary assessment; estimation of exceedance situation indicators; estimation of spatial representativeness of monitoring stations; evaluation of monitoring network design, estimation of population exposure; short term forecasting; near real time mapping; source apportionment and assessment of natural and long range transport contributions or air quality planning.

This technical guidance document would cover topics such as how to apply modelling systems in the various contexts of the Ambient Air Quality Directive, an QA/QC Protocol with recommendations to guarantee overall quality of modelling applications, including the minimum number of stations for robust model validation, criteria to evaluate the overall fitness-for-purpose of modelling applications in the context of the Ambient Air Quality Directives, information on the appropriate spatial resolution of models for the various purposes, and information on the fitness-for-purpose of modelling tools for source apportionment.

For the elaboration of this document, the following activities and reports should be considered: FAIRMODE´s work under CT2 for recommendations for QA/QC Protocol, recommendations regarding modelling applications within the scope of the Ambient Air

Quality Directives report on *'Source apportionment to support air quality management practices'*,[85] and the *'Guidance Document on Modelling Quality Objectives and Benchmarking'*.[86]

It is to be noted as well that there is currently no consensus in the modelling community regarding the definition of fitness-for-purpose, the modelling setup for planning and validation of models in planning modus. This presents a challenge and may require intensified discussions in the modelling community to solve these issues as soon as possible.

G. Technical guidance document on preparing air quality plans.

This technical guidance document would be designed for competent authorities responsible for preparing and updating air quality plans either at a national or local level, or both. It would aim to provide information for a successful preparation of air quality plans to increase the effectiveness, efficiency and coherence of air quality plans and ultimately result in air quality standards being respected in the shortest time possible.

The topics addressed would be governance and coordination, policy linkages to ensure policy coherence, the process of plan development from the analysis of the exceedance situation, source apportionment, developing a long list of possible measures to improve air quality in consultation with stakeholders, screening to a short list of measures and assessing their impact to develop a preferred policy option to implement. This technical guidance document would assist competent authorities on technical aspects of assessment and elaborate the importance of consultation and communication during the preparation and implementation phase. The technical guidance document would also elaborate post implementation assessment of the realised impacts under a monitoring and evaluation phase.

This technical guidance document should consider the current work by FAIRMODE CT5 working group preparing a best practice guide for local and regional air quality management, and the '*Catalogue of Air Quality Measures*'[87] being hosted and managed by the European Commission's Joint Research Centre.

H. Technical guidance document on air quality management best practice (governance and communication).

This technical guidance document would target the problematics concerning governance levels and responsibilities, and communication to the public. The main topics addressed would be the responsibilities at various government levels regarding the implementation of the Ambient Air Quality Directives, how to effectively communicate between national and lower levels of government for an effective implementation, how to communicate to the

[85] Fairmode (2019), Source apportionment to support air quality management practices (accessed 01.06.2022)
[86] Fairmode (2020), Guidance Document on Modelling Quality Objectives and Benchmarking (accessed 01.06.2022)
[87] JRC (2022), Catalogue of Air Quality Measures (accessed 01.06.2022)

public on the most critical air quality information, how to engage the general public in air quality planning, how to share information among municipalities / regions within a country and with other Member States, and how to cooperate with health authorities.

4. CONCLUSIONS

To summarise, these eight core technical guidance documents described previously would replace the existing documents as follows:

- Guidance report on preliminary assessment under EC air quality directives (1998) - replaced by new technical guidance document under A.
- Guidance on Assessment under the EU Ambient Air Quality Directive - replaced by new technical guidance document under A, plus embedded linkages to technical guidance document under B, D, E, F, G and H.
- Necessity to prepare action plans to reduce the duration of exceedances of alert thresholds (Art 7(3), 96/62/EC) - Note by the CAFE-Working group on Implementation Nr. 2003/1 - replaced by new technical guidance document under G.

In addition to these eight core technical guidance document, several existing guidance are recommended for review:

- Guidance on the Commission Implementing Decision laying down rules for Directives 2004/107/EC and 2008/50/EC of the European Parliament and of the Council as regards the reciprocal exchange of information and reporting on ambient air.
- Guidance on air quality assessment around point sources under the under the EU Air Quality Directive 2008/50/EC.
- Guidance report on demonstration of equivalence of ambient air monitoring methods (2010). This may also be included under the new suggested technical guidance document under B.
- Commission Staff Working Paper - Guidelines for the agreements on setting up common measuring stations for $PM_{2.5}$, SEC(2011) 77.
- Commission Staff Working Paper - Guidelines for determination of contributions from the re-suspension of particulates following winter sanding or salting of roads, SEC(2011) 207.
- Commission Staff Working Paper - Guidelines for demonstration and subtraction of exceedances attributable to natural, SEC(2011) 208 final.

ANNEX 8: EU CLEAN AIR POLICY

1. OVERVIEW

EU clean air policy rests on three main pillars.

The first pillar comprises air quality management as regulated by the Ambient Air Quality Directives (2008/50/EC and 2004/107/EC), which contain standards for the concentration levels of 12 air pollutants[88] in ambient air and the obligation for Member States to adopt effective air quality plans if limits are exceeded. As per the European Green Deal, the European Commission will propose a revised Ambient Air Quality Directive in 2022.

The second pillar consists of air pollution control through emission reduction obligations established in Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants (the NEC Directive) for five air pollutants[89] that contribute to transboundary air pollution in particular. The NEC Directive establishes national emission reduction obligations for 2020 to 2029, and more ambitious ones from 2030 onward, and obliges Member States to adopt and regularly update National Air Pollution Control Programmes (NAPCPs).

The third pillar comprises emission standards for key sources of pollution, from vehicle and ship emissions to energy and industry, agricultural practices and consumer products. The European Green Deal has proposed making source policies more ambitious, including in the context of the "Fit for 55" package, the proposal for a revised Industrial Emissions Directive[90] and the upcoming one for a Euro 7 emission standard for road vehicles[91], as well as the Zero Pollution Action Plan.

2. AIR QUALITY MANAGEMENT

The Ambient Air Quality Directives regulate air quality management along four main strands.

First, the Directives define common methods and criteria to assess air quality in all Member States in a comparable and reliable manner: Member States must designate zones and agglomerations throughout their territory, classify them according to prescribed assessment

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88 These are: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2, including NO_x), ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6), benzo(a)pyrene (BaP), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni).

89 These are: sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$)

90 COM (2022), Proposal for a Directive amending Directive 2010/75/EU (accessed 04.08.2022)

91 COM (2022), European vehicle emissions standards – Euro 7 for cars, vans, lorries and buses (accessed 04.08.2022)

thresholds, and provide air quality assessments underpinned by (fixed or indicative) measurement, modelling and/or objective estimation, or a combination of these.

Second, the Directives establish objectives and standards for ambient air quality for 12 air pollutants to be attained by all Member States across their territories against timelines laid out in the Directives. These are: particulate matter ($PM_{2.5}$ and PM_{10}), nitrogen dioxide (NO_2, including NO_x), ozone (O_3), sulphur dioxide (SO_2), carbon monoxide (CO), benzene (C_6H_6), benzo(a)pyrene (BaP), lead (Pb), arsenic (As), cadmium (Cd), nickel (Ni) (see Table 8.1).[92]

Table A8.1 – EU air quality standards for different pollutants according to the Ambient Air Quality Directives

Pollutant	Concentration	Averaging period	Legal nature	Date entering into force	Permitted exceedances each year
Sulphur dioxide (SO_2)	350 µg/m³	1 hour	Limit value	1.1.2005	24
	125 µg/m³	24 hours	Limit value	1.1.2005	3
Particulate matte (PM_{10})	50 µg/m³	24 hours	Limit value	1.1.2005 **	35
	40 µg/m³	1 year	Limit value	1.1.2005 **	n/a
Fine particulate matter ($PM_{2.5}$)	25 µg/m³	1 year	Target value Limit value	1.1.2010 1.1.2015	n/a n/a
Nitrogen dioxide (NO_2)	200 µg/m³	1 hour	Limit value	1.1.2010 *	18
	40 µg/m³	1 year	Limit value	1.1.2010 *	n/a
Lead (Pb)	0.5 µg/m³	1 year	Limit value	1.1.2005 ***	n/a
Carbon monoxide (CO)	10 mg/m³	Max daily 8 hour mean	Limit value	1.1.2005	n/a
Ozone	120 µg/m³	Max daily 8 hour mean	Target value	1.1.2010	25 averaged over 3 years
Benzene	5 µg/m³	1 year	Limit value	1.1.2010 **	n/a
Arsenic (As)	6 ng/m³	1 year	Target value	31.12.2012	n/a
Cadmium (Cd)	5 ng/m³	1 year	Target value	31.12.2012	n/a
Nickel (Ni)	20 ng/m³	1 year	Target value	31.12.2012	n/a
Benzo(a)pyrene (BaP)	1 ng/m³	1 year	Target value	31.12.2012	n/a

**Under Directive 2008/50/EU, the Member States could apply for a postponement of a maximum of five years (i.e. maximum up to 2015) in specific zones; subject to an assessment by the Commission.*

***Under Directive 2008/50/EU, Member States were able to apply for an exemption to apply these limits until 11 June 2011 in specific zones; subject to assessment by the Commission.*

**** Or 1.1.2010 in the immediate vicinity of specific, notified industrial sources; and a 1.0 µg/m3 limit value applied from 1.1.2005 to 31.12.2009.*

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92 In addition to limit values and target values, other types of air quality standards have been established in the form of critical levels, long-term objectives, alert thresholds and information thresholds, depending on the pollutant. The differences between these types of air quality standards are described in further detail below, see Table A8.1 and Box A8.1

Box A8.1 – A typology of EU Air Quality Standards

The Ambient Air Quality Directives deploy a number of different types of air quality standards for the different pollutants they cover. All these standards have been set on the basis of scientific knowledge, with the aim of avoiding, preventing or reducing harmful effects on human health and/or the environment as a whole, but their formats and purposes differ. These differences were motivated in part by different levels to which Member States were deemed to be able to address the respective air pollutants and their underlying emissions on their own territories.

Limit values are to be attained within a given period and not to be exceeded once attained – set for particulate matter, sulphur dioxide, nitrogen dioxide, benzene, carbon monoxide, and lead.

Target values are to be attained *where possible* over a given period by taking all necessary measures *not entailing disproportionate costs* – set for ozone, benzo(a)pyrene, arsenic, cadmium, nickel (also for fine particulate matter standards were initially established as target values before becoming limit values). One reason for setting target values rather than limit values can be to take account of specific formation mechanisms of the pollutant, for example in the case of ozone (also due to a strong role of transboundary sources and annual variations in meteorology for this air pollutant).

Critical Levels refer to concentrations above which direct adverse effects may occur on some receptors, such as trees, other plants or natural ecosystems but not on humans – set for sulphur oxides and for oxides of nitrogen.

Long-Term Objectives are set to be attained in the long term, save where not achievable through proportionate measures – set for ozone only.

Alert thresholds are levels beyond which there is a risk to human health from brief exposure for the population as a whole and at which immediate steps are to be taken by the Member States – set for sulphur dioxide, nitrogen dioxide, and ozone. And for ozone only, *information thresholds* set a level lower than the alert threshold beyond which there is a risk for particularly sensitive persons and for which immediate and appropriate information is necessary.

In addition, the *Average Exposure Indicator* provides an average level determined on the basis of measurements at urban background locations which reflects population exposure. It is used to calculate national exposure reduction targets (in percent) for each Member State.

Third, the Directives require Member States to monitor air quality in their territory. Member States need to report to the Commission, as well as to the general public, the results of air quality assessment on an annual basis, 'up-to-date' air quality measurements, as well as information on the plans and programmes they establish. It is the responsibility of Member States to approve the measurement systems required and ensure the accuracy of measurements.

Fourth, where the established standards for ambient air quality are not met, the Directives require Member States to prepare and implement air quality plans and measures (for the pollutants exceeding the standards). These air quality plans need to identify the main emission sources responsible for pollution, detail the factors responsible for exceedances, and spell out abatement measures adopted to reduce pollution. Abatement measures can include, for example: measures to reduce emissions from stationary sources (such as industrial installations or power plants, as well as medium and small size combustion sources, including those using biomass) or from mobile sources and vehicles (including through retrofitting with emission control equipment); measures to limit transport emissions through traffic planning or encouraging shifts towards less polluting modes (including congestion pricing or low emission zones); promoting the use of low emission fuels, or using economic and fiscal instruments to discourage activities that generate high emissions.

3. AIR POLLUTION CONTROL

Directive (EU) 2016/2284 on the reduction of national emissions of certain atmospheric pollutants ("the NEC Directive") is one of the key legislative instruments to achieve the 2030 objectives put forward in the Zero Pollution Action Plan to reduce by more than 55% the health impacts (premature deaths) of air pollution and by 25% the ecosystems where air pollution threatens biodiversity in the EU[93]. The NEC Directive sets national emission reduction commitments for each EU Member State for the period 2020 to 2029, as well as more ambitious ones as of 2030, targeting five air pollutants that are responsible for significant negative impacts on human health and the environment: sulphur dioxide (SO_2), nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) and fine particulate matter ($PM_{2.5}$).

Table A8.2 – 2030 national emission reduction commitments of the NEC Directive compared to 2005 levels (as per Annex II of the NEC Directive)

	SO_2	NO_x	NMVOC	NH_3	$PM_{2,5}$
Belgium	66%	59%	35%	13%	39%
Bulgaria	88%	58%	42%	12%	41%
Czech Republic	66%	64%	50%	22%	60%
Denmark	59%	68%	37%	24%	55%
Germany	58%	65%	28%	29%	43%
Estonia	68%	30%	28%	1%	41%
Greece	88 %	55 %	62 %	10 %	50 %
Spain	88%	62%	39%	16%	50%
France	77%	69%	52%	13%	57%
Croatia	83%	57%	48%	25%	55%
Ireland	85%	69%	32%	5%	41%
Italy	71%	65%	46%	16%	40%
Cyprus	93%	55%	50%	20%	70%
Latvia	46%	34%	38%	1%	43%
Lithuania	60%	51%	47%	10%	36%
Luxembourg	50%	83%	42%	22%	40%
Hungary	73%	66%	58%	32%	55%
Malta	95%	79%	27%	24%	50%

[93] Predating the NEC Directive, the Clean Air Programme (COM (2013)918) had put forward a target to reduce the health impacts of air pollution by half by 2030 compared to 2005.

Table A8.2 – 2030 national emission reduction commitments of the NEC Directive compared to 2005 levels (as per Annex II of the NEC Directive)

	SO_2	NO_x	NMVOC	NH_3	$PM_{2,5}$
Netherlands	53%	61%	15%	21%	45%
Austria	41%	69%	36%	12%	46%
Poland	70%	39%	26%	17%	58%
Portugal	83%	63%	38%	15%	53%
Romania	88%	60%	45%	25%	58%
Slovenia	92%	65%	53%	15%	60%
Slovakia	82%	50%	32%	30%	49%
Finland	34%	47%	48%	20%	34%
Sweden	22%	66%	36%	17%	19%
United Kingdom	88%	73%	39%	16%	46%
EU 27 + UK	**79%**	**63%**	**40%**	**19%**	**49%**

The NEC Directive entered into force on 31 December 2016, repealing Directive 2001/81/EC[94] on national emission ceilings for certain atmospheric pollutants, with effect from 1 July 2018. Under the NEC Directive, $PM_{2.5}$ was added to the pollutants for which mandatory reductions have been set, and the list of pollutants for which reporting is obligatory was expanded. The Directive also introduced a shift from emission ceilings, which prescribed a fixed maximum annual amount of emissions in kilo tonnes per pollutant, to emission reduction commitments, which set reduction obligations expressed as a percentage of the emissions of each pollutant in the baseline year 2005.

The emission reduction commitments for 2020 to 2029 under the NEC Directive correspond to the emission reduction commitments for 2020 and onwards taken by the EU and its Member States under the revised Gothenburg Protocol[95] to the United Nations Economic Commission for Europe (UNECE) Convention on Long-Range Transboundary Air Pollution (LRTAP).[96] The Directive thereby transposes those international obligations, catering for the transboundary feature of air pollution. Pollution from all countries neighbouring the EU should be sought to be reduced in order to further increase synergies. Western Balkans countries (candidate and potential candidate for EU accession) are in the front line of this objective and the EU is working with them (in particular through capacity building) in order to reduce air pollution emitted in those countries. To track progress towards the reduction commitments under the Directive, Member States report annual emission inventories (as per Article 10(2) of the NEC Directive). These inventories, which report actual emissions with a two-year time lag, are used to check compliance with the emission reduction commitments.

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[94] Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, OJ L 309, 27.11.2001, p. 22.

[95] UNECE, 1999 Protocol to Abate Acidification, Eutrophication and Ground-level Ozone to the Convention on Lang-range Transboundary Air Pollution (accessed: 10.06.2022)

[96] UNECE (2022), The Convention and its achievements, 1979 Convention on Long-Range Transboundary Air Pollution (accessed: 10.06.2022)

The year 2022 is hence the first year for the Commission to check compliance against the emission reduction commitments for the year 2020-29 of the NEC Directive. Member States also have the obligation to report every two years their *projected* emissions (as per Article 10(2) of the NEC Directive), which are compared to reduction commitments for 2020-29 and 2030 onwards to assess whether the Member State is on track to reach them.

Member States also have to draw up, adopt and implement national air pollution control programmes (NAPCP),[97] as per Article 6(1) of the NEC Directive. These should show how they will meet their emission reduction commitments for 2020-2029, and how they will reach the more ambitious commitments by 2030 and beyond.[98] The NAPCP constitutes a central governance instrument that allows Member States to coordinate and agree their policies and measures (PaMs) to ensure national emission reduction commitments are met. Its preparation requires consultation and involvement of competent authorities at different levels and of several different sectors, such as environment, agriculture, energy, climate, transport, industry or finance. A particular emphasis is put on coherence with plans and programmes developed under other, related policy areas. Furthermore, the NAPCP is a tool to communicate a Member State's pollution control policies and to involve the public in the process of policy-making. The first NAPCPs were due by 1 April 2019. NAPCPs must be updated at least every four years and earlier if new data so requires.

Member States which do not project to achieve their emission reduction commitments with current policies have to report in their NAPCPs the additional policies and measures that they considered for adoption and those actually selected in order to fulfil their commitments.[99]

The first implementation report prepared by the Commission according to Article 11(1) of the NEC Directive presented the progress made in the implementation of the Directive, including its transposition and early assessment of the efforts made by Member States towards attaining national emission reduction commitments.[100] Subsequently, the Second Clean Air Outlook presented an analysis of the prospects for achieving the emission reduction commitments under the NEC Directive up to 2030, the related contribution to improving air quality, health and the environment, and of the costs and benefits of the needed measures and expected impacts. The third edition of the Clean Air Outlook is currently being prepared for publication towards the end of 2022 and will update the assessment of compliance prospects. The modelling work underlying the Outlook is developed in coherence with this impact assessment. The third Clean Air Outlook will be part of the Zero-Pollution Outlook and will also provide early inputs that will feed into the preparation of the review of the NEC Directive due by 2025.

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97 The Commission has specified the format of the NAPCP, setting out mandatory and optional content, in Commission Implementing Decision (EU) 2018/1522 of 11 October 2018 laying down a common format for national air pollution control programmes under Directive (EU) 2016/2284 of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants.

98 The Commission has also prepared guidance for the development of NAPCPs: OJ C 77, 1.3.2019, p. 1.

99 This reporting had to be done via the (EEA PaM Tool) a web-tool developed by the EEA.

100 COM/2020/266 final

4. LINKS TO OTHER POLICIES

The following table maps European Green Deal policies and priorities that are of relevance for the successful implementation of the Ambient Air Quality Directives and which in turn are likely to be influenced by increased ambition under the Ambient Air Quality Directives.

Table A8.2 – Mapping of European Green Deal policies and priorities relevant for the implementation of the Ambient Air Quality Directives and vice versa

Policy domains	Links to Ambient Air Quality Directives
Climate Ambition	
Fit for 55 legislative proposals to deliver the increased ambition level of 55% reduction of GHG emissions by 2030	Increased climate ambition will foster uptake of low- or zero emission technologies with co-benefits for air quality (such as non-combustible renewables, energy efficiency measures, electric mobility). Proposals on increased ambition include: • increased ambition of the EU emission trading system (**ETS**)[101]; • increased ambition of the EU's **Effort Sharing Regulation**[102]; • stricter **CO_2 emission performance standards for cars and vans**[103] requiring all newly registered cars and vans to be zero-emission from 2035. Stricter AQ standards bring co-benefits for climate in the form of reduction of black carbon (BC), a short-lived climate forcer (SLCF).
Clean, affordable and secure energy	
RePowerEU	RePowerEU proposes actions to rapidly reducing Europe's dependence on Russian fossil fuels by fast forwarding the clean transition and joining forces to achieve a more resilient energy system and a true Energy Union. Those actions include an overall reduction of the energy consumption, diversify energy imports, substituting fossil fuels and accelerating the transition to renewable energy in power generation, industry, buildings and transport and smart investments. Speeding up these actions can benefit air quality, too.
Increased ambition on renewables	Increased uptake of non-combustible renewable energy sources will reduce reliance on fossil fuels and hence emissions of air pollutants, improving air quality. Biomass burning, in inefficient and old installations, as part of renewable energy use emits air pollutants and thus negatively affects air quality. Initiatives promoting renewable energy sources include the 2021 proposal to revise the **Renewable Energy Directive** (RED II)[104], which puts forward more ambitious 2030 targets, as well as the 2022 Commission Communication on **RePower EU** with a lot of emphasis on frontloading

[101] COM (2021) 551 final
[102] COM (2021) 555 final
[103] COM (2021) 556 final
[104] COM (2021) 557 final

	investments in renewables, notably solar power and wind, and in heat pumps, all of which are beneficial also for air quality.
Increased ambition on energy efficiency	Increased ambition on energy efficiency and the introduction of a binding EU energy efficiency target through the proposal on a revised **Energy Efficiency Directive**[105] will decrease energy needs overall, including of fossil fuels and hence reduce emissions of air pollutants, improving air quality.
Renovation wave	Deeper and more widespread uptake of energy efficiency measures and of on-site generation from non-combustible renewable energy sources in building renovation, such as through the proposed recast **Energy Performance of Buildings Directive**[106], will help reduce the use of fossil fuels and biomass for heating[107] and hence reduce emission of air pollutants, improving air quality.
Digitalisation	
Accelerate the digital transformation	The European Environment Information and Observation Network (Eionet) hosted by the European Environment Agency gathers and displays data as a unique digital platform used by all Member States for their reporting of air quality data. The digital service offered on the platform facilitates online reporting and coordinating between National Focal Points (NFPs) in the countries and the European Commission.
Industrial strategy for a clean and circular economy	
Sustainable Products Initiative	By making products that consume less energy, by using them more efficiently and for longer, by relying on recycled materials instead of primary raw materials, and by spreading front-runner circular economic models, indirect co-benefits can be expected for air quality, notably through a reduction of fossil energy and the related emissions.
Sustainable and Smart Mobility	

[105] COM/2021/558 final
[106] COM/2021/802 final
[107] The definition in the proposed recast EPBD of a zero-emission building accommodates use of biomass for on-site energy generation, while biomass use leads to air pollutant emissions.

Sustainable and Smart Mobility Strategy and follow-up actions	Action supporting the move towards lower-emission and public transport will bring positive co-benefits for air quality. Some actions with particular relevance for air quality include: • Proposal for more stringent air pollutant emissions standards for combustion-engine vehicles (**Euro 7**)[108]: Euro standards reduce pollutant emissions from cars, vans, trucks and buses, improving air quality. The introduction of Euro 7 will bring further benefits in this regard. • Proposal for an **alternative fuels infrastructure** regulation[109]: a comprehensive network of recharging and refuelling infrastructure is needed to facilitate the increased uptake of renewable and low-carbon fuels, including e-mobility, which would bring important air quality co-benefits. • Proposals for **ReFuelEU Aviation** and **FuelEU Maritime** include measures that promote cleaner fuels, with a potential to reduce air pollutant emissions, and to improve air quality near ports by requiring the use of on-shore power supply or zero-emission energy at berth for specific ship types. In turn, the Ambient Air Quality Directives trigger increased action in urban areas to move to lower emission mobility, introduction of low-emission zones, increased uptake of public transport and active mobility to attain limit values.
Greening the Common Agricultural Policy / 'Farm to Fork' Strategy	
CAP national strategic plans	In December 2020, the Commission sent recommendations to all Member States for the drafting of the national CAP SPs[110]. Notably, Member States were recommended to ensure sufficient ambition level and to include and promote ammonia reduction measures as ecoschemes or investment interventions in their CAP SPs, thereby contributing to improved air quality and reduced concentrations of secondary particulate matter. The Commission reviews the final CAP SPs to assess whether these recommendations have been followed.
'Farm to Fork' Strategy	The strategy and its action plan support the move towards more sustainable farming practices and address improved nutrient management and excess use of pesticides and fertilisers. This will bring positive co-benefits for air quality, notably via reduced ammonia (an important precursor of $PM_{2.5}$) and nitrogen emissions from low-pollution manure management techniques. The Ambient Air Quality Directives improve understanding of and drive action to address rural background levels of pollutant concentrations which harm crop yields (in particular of SO_2, NO_X and O_3).
CAP GAEC 6 on stubble burning	Within the Common Agricultural Policy, the Good Agricultural and Environmental Conditions include as a cross-cutting conditionality the ban on open burning of arable stubble (except for plant health reasons), contributing to the reduction of particulate matter emissions and concentrations.
Preserving and protecting biodiversity	
Addressing biodiversity loss and degradation of ecosystems	Poor air quality negatively affects vegetation and ecosystems. The Ambient Air Quality Directives define critical levels for SO_2 and NO_X for the protection

[108] COM 2022), European vehicle emissions standards – Euro 7 for cars, vans, lorries and buses (accessed 04.08.2022)
[109] COM(2021) 559 final
[110] SWD C2020/846

	of vegetation and natural ecosystems and requires measurements to improve the protection of vegetation and natural ecosystems from high ozone concentrations. In turn, policies that improve ecosystem health, such as the proposed **Nature Restoration Law** can also deliver on clean air aspects.
Towards a zero-pollution ambition for a toxic free environment	
Zero Pollution Action Plan	Stricter air quality standards are a key deliverable under the ZPAP and a key tool to move closer to the EU's zero pollution ambition. The proposed revision of the **Industrial Emissions Directive**[111] is an important deliverable under the ZPAP. The IED prevents and reduces emission of pollutants to air and hence contributes to attaining air quality standards.
Chemicals Strategy	By promoting the transition towards safe and sustainable chemicals and moving towards cleaner chemical and material production processes can generate indirect benefits for air quality.
Ecodesign requirements	Requirements for heating appliances, in particular those for solid fuel heating, are important for curbing pollutant emissions and hence attaining air quality standards particularly in densely populated areas.
Indoor air quality	Indoor air quality benefits from improved ambient air quality through ventilation.
Mainstreaming sustainability in all EU policies	
Various source legislation	The success of EU clean air policy including the attainment of the Ambient Air Quality Directives' air quality standards relies on successful mainstreaming of clean air considerations into other policies, notably when it comes to key sources of air pollution such as energy generation, transport, industrial installations, domestic heating and agriculture.
EU funding – clean air expenditures tracking	While there is no clean air spending target, clean air tracking by the Commission is meant to monitor EU funding contributing to clean air in view of a better implementation of the clean air policies (incl. the Ambient Air Quality Directives) in Member States.
Socially just transition	Poor air quality disproportionally affects citizens of lower socio-economic status, as well as those with pre-existing conditions and children[112]. Consequently, these groups of society are expected to benefit most from stricter air quality standards.
The EU as a global leader	
International cooperation	Air quality in the EU partly depends on clean air action in third countries, and vice versa. International cooperation is therefore crucial and mutually beneficial, including e.g. though the UNECE Air Convention, WHO and United Nations Environment Programme (UNEP).
Maritime transport	Progress at international level towards stricter emissions limits on SO2 emissions, including through the introduction of emission control areas (ECAs), contribute to improving air quality notably in coastal regions.
Working together – a European Climate Pact	

[111] COM(2022) 156 final
[112] EEA (2018), EEA Report No 22/2018 (accessed: 09.06.2022)

Engagement with citizens / Citizen science	European citizens care strongly about air quality.[113] Air quality is an area where citizen science[114] complements official measurements performed in accordance with the Ambient Air Quality Directives, bringing EU policy objectives closer to citizens. The European Environment Agency's European Air Quality Index[115] allows users to gain insights into the air quality where they live, through a web-based application and a new Air quality index mobile app.
UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental matters (Aarhus Convention)	The EU is party to the Aarhus Convention since February 2005 and adopted several measures since to implement the provisions therein, *inter alia*: • Directive 2003/4/EC on public access to environmental information[116] • Directive 2003/35/EC providing for public participation in respect of the drawing up of certain plans and programmes relating to the environment[117] • Regulation (EC) 1367/2006 on the application of the provisions of the Aarhus Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters to Union institutions and bodies[118] Safeguarding compliance with air quality objectives in the EU partly depends on European citizens having access to the right information, being able to participate in the decision-making process and, in case of non-compliance by Member States, having access to justice to enforce air quality objectives.

[113] COM (2019), Special Eurobarometer 497 (accessed: 09.06.2022) and COM (2021), Open Public Consultation on "Air quality – revision of EU rules" (accessed: 04.08.2022)
[114] e.g. CurieuzenAir (accessed: 09.06.2022)
[115] EEA (2022), European air quality index (accessed: 09.06.2022)
[116] OJ L 41, 14.2.2003, p.26.
[117] OJ L 156, 25.6.2003, p.17.
[118] OJ L 264, 25.9.2006, p.13.

ANNEX 9: FITNESS CHECK OF THE AMBIENT AIR QUALITY DIRECTIVES IN 2019

1. SCOPE AND METHODOLOGY

In November 2019, the European Commission completed and published its fitness check of the Ambient Air Quality Directives (Directives 2008/50/EC and 2004/107/EC).[119] The fitness check assessed whether the EU actions enshrined in these pieces of legislation have achieved their objectives without entailing disproportionate costs and continue to be justified.

The fitness check was guided by a roadmap[120] that outlined issues, looking in particular at the five evaluation criteria set out in the Better Regulation agenda. This translated into five overarching evaluation questions on the criteria of relevance, effectiveness, efficiency, coherence and EU added value. A sixth evaluation question specifically looked at the effectiveness and efficiency of air quality monitoring.

The fitness check draws on experience in, and data from, all Member States, focusing on the period from 2008 to 2018 as this is the period when both Directives were in force. The analysis covers all articles and provisions of the two Ambient Air Quality Directives, looking at the role they have played in meeting the objectives. The work was underpinned by the evidence collected in the study ‘Supporting the fitness check of the EU Ambient Air Quality Directives (2008/50/EC, 2004/107/EC)’. 121 The support study helped gather information and data through different channels, including several means to solicit stakeholder views.

The fitness check allowed the public to participate effectively through a comprehensive stakeholder consultation including an open public consultation, a targeted questionnaire and two stakeholder workshops.

The findings of the fitness check are used to inform further reflections on whether the Ambient Air Quality Directives continue to provide the appropriate legislative framework to ensure protection from adverse impacts on, and risks to, human health and the environment.

2. EXECUTIVE SUMMARY OF THE FITNESS CHECK[122]

Clean air is essential to human health. It is also essential to sustaining the environment, and provides multiple economic and social benefits. The scientific evidence of harmful effects of air pollution is well-established, robust and points to a clear need for action.

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[119] SWD (2019) 427 final.

[120] COM (2019), Have your say on the fitness check of the EU Ambient Air Quality Directives (accessed: 04.08.2022)

[121] COWI et al. (2019). ‘Supporting the fitness check of the EU Ambient Air Quality Directives (2008/50/EC, 2004/107/EC)’ – hereafter referred to as ‘Support study informing this Fitness Check’.

[122] SWD (2019) 428 final.

The current Ambient Air Quality Directives constitute the third generation of EU level air quality policies since the early 1980s, and have inherited many provisions, including many air quality standards from predecessor legislation. These policies have rendered some successes, as exemplified by the decrease of exceedances for most air pollutants over the past decade. However, the air quality challenge is far from being solved. Although the number of people exposed to air pollution decreased markedly during the past decade, persistent exceedances above EU air quality standards remain for several air pollutants, and especially for particulate matter, nitrogen dioxide, ozone and benzo(a)pyrene – with significant impacts on human health and the environment. In 2017, for example, 8% of the EU urban population was exposed to levels above the EU air quality standards for fine particulate matter ($PM_{2.5}$); but when measured against the more stringent recommendations by the World Health Organization this figure increased to around 77%.

With the Ambient Air Quality Directives, and in combination with the wider EU Clean Air Policy Framework, the European Union has the policy tools at hand to address this challenge. The fitness check, including the analysis of its underlying evidence and stakeholder views, concludes that the Ambient Air Quality Directives have been *partially effective* in improving air quality and achieving air quality standards. It also acknowledges that they have not been *fully* effective and not all its objectives have been met to date, and that the remaining gap to achieve agreed air quality standards is too wide in certain cases.

Clear EU air quality standards **–** Air quality standards have been set for a total of 12 air pollutants.[123] Their relevance and the underpinning scientific evidence on their harmful effects has been reconfirmed and reinforced. For other air pollutants, not covered by the Ambient Air Quality Directives, such as ultrafine particles or black carbon, the current scientific evidence on adverse health effects remains inconclusive and does not lend itself to setting standards. The air quality standards have been instrumental in driving concentrations downward and reducing exceedance levels. Nevertheless, two shortcomings remain: firstly, EU air quality standards are not fully aligned with well-established health recommendations (and they do not feature an explicit mechanism for adjusting air quality standards to the latest technical and scientific progress); while secondly, due to insufficiently effective air quality plans and lack of commitment to take appropriate measures by Member States, there have been and continue to be substantial delays in taking appropriate and effective measures to meet the air quality standards. Thus, while the number and magnitude of exceedances above air quality standards have decreased over the past decade, it is also clear that they have not been kept as short as possible to date.

A representative high-quality monitoring of air quality **–** Across the EU, Member States have established an air quality monitoring network with some 16 000 sampling points for specific pollutants (often grouped at more than 4 000 monitoring stations) based on common criteria defined by the Ambient Air Quality Directives. This extensive network can be considered a success in itself. Concerns have been raised that the criteria on monitoring offer

[123] Sulphur dioxide, nitrogen dioxide, particulate matter ($PM_{2.5}$, PM_{10}), ozone, benzene, lead, carbon monoxide, arsenic, cadmium, nickel, and benzo(a)pyrene.

too much leeway and present some ambiguity to competent authorities, resulting in instances where air quality monitoring does not live up to the criteria set by the Ambient Air Quality Directives. A key challenge here is to ascertain that air quality sampling points indeed provide information for where the highest concentrations of air pollutants occur. This, however, does not appear to amount to systemic shortcomings in the EU-wide monitoring network. Overall, the monitoring network by and large adheres to the provisions of the Ambient Air Quality Directives, and ensures that reliable and representative air quality data is available.

***Reliable, objective, comparable information on air quality* –** The provisions on reporting have prompted the establishment of improved and more efficient e-reporting systems to report both validated air quality data as well as up-to-date data. The air quality data reported by Member States is made available to the public by the European Environment Agency, including via an European Air Quality Index based on near-real time data. The Ambient Air Quality Directives have facilitated the availability and accessibility of objective and comparable air quality data and information across the EU. Further harmonisation of the way air quality information is presented, especially at Member State level, would be possible and provide further EU added value, and help ensure even higher comparability of air quality information across all geographical scales and all regions of the EU.

***Action to avoid, prevent, and reduce impact of poor air quality* –** The Ambient Air Quality Directives have been only partially, and therefore insufficiently, successful in meeting this objective. While action to reduce the impact of air quality has been taken, resulting in a reduced number and magnitude of exceedances, 20 Member States still report exceedances above EU limit values for at least one pollutant, and often for several. One reason for this is that improvements in air quality critically depend on action taken to address the sources of air pollution, and typically require action in the transport, energy (including domestic heating) and agricultural sectors or by industry. At national, regional and local level, this has not translated into sufficient level of commitment. At the EU level, synergies with climate, energy and transport policies have been strengthened over the past decade, and require coherent action at national, regional and local levels. Notwithstanding the important shortcoming of the remaining implementation gap to meet the air quality standards for all pollutants and throughout the EU, the clear requirement to take remedial action when and where exceedances are observed has been decisive in triggering improvement in air quality, yet often with delay.

***Conclusions* –** The Ambient Air Quality Directives have guided the establishment of a representative high-quality monitoring of air quality, set clear air quality standards, and facilitated the exchange of reliable, objective, comparable information on air quality, including to a wider public. They have been less successful in ensuring that sufficient action is taken by Member States to meet air quality standards and keep exceedances as short as possible. Nevertheless, the available evidence indicates the Ambient Air Quality Directives have contributed to a downward trend in air pollution and reduced the number and magnitude of exceedances. This partial delivery allows to conclude that the Ambient Air Quality Directives have been broadly fit for purpose – while at the same time pointing to scope for improvements to the existing framework such that good air quality be achieved across the EU. In particular, it emerges from the fitness check that additional guidance, or clearer requirements in the Ambient Air Quality Directives themselves, could help to make monitoring, modelling and the provisions for plans and measures more effective and efficient.

3. SOME LESSONS LEARNT AS HIGHLIGHTED BY THE FITNESS CHECK

The fitness check showed that over the past decade, the Ambient Air Quality Directives have guided the establishment of a representative high-quality monitoring of air quality, set clear air quality standards, and facilitated the exchange of reliable, objective, comparable information on air quality, including to a wider public.

At the same time, the Ambient Air Quality Directives have been less successful in ensuring that sufficient action is taken to meet air quality standards and keep exceedances as short as possible. Having said that, the evidence shows that they significantly contributed to a downward trend in air pollution and reduced the number and magnitude of exceedances.

This *partial* success allows to conclude that the Ambient Air Quality Directives have been broadly fit for purpose, with clear shortcomings as regards achieving the overarching ambition to *fully* meet all air quality standards for all pollutants and throughout the European Union according to the timelines established in the Ambient Air Quality Directives at the time of adoption.

This points to scope for improvements to the existing framework for air quality management. In particular, it emerges from the fitness check that additional guidance, or clearer requirements in the Ambient Air Quality Directives themselves, could help to make monitoring, modelling and the provisions for plans and measures more effective and efficient.

Specifically, the fitness check identified several lessons learnt to be considered in the follow-up to the fitness check, including the below:

- air pollution continues to be a major health and environmental concern to the citizens of the EU, and surveys show it to be one of the two most important environmental issues (the other being climate change) – a relative majority of citizens share the view that the issue of air pollution can be best addressed at the EU level: this underlines the continued relevance of the Ambient Air Quality Directives;
- the EU air quality standards have been instrumental in driving a downward trend in exceedances and of exposure of population to exceedances – however, the current air quality standards are not as ambitious as established scientific advice suggests for several pollutants, especially fine particulate matter ($PM_{2.5}$); the WHO Air Quality Guidelines are currently being reviewed, and the Commission is following this closely;
- trends in exceedance levels for fine particulate matter ($PM_{2.5}$) indicate that limit values have been more effective in facilitating downward trends than other types of air quality standards, such as target values – especially where this has been done in conjunction with an exposure concentration obligation requirement and national emission reduction commitments as established under the NEC Directive;
- enforcement action by the European Commission and in particular also by civil society actors in front of national courts (under general right to access to justice provisions, as

there are no explicit provisions in the Ambient Air Quality Directives on this) has resulted in actionable rulings, shown that the legislation is enforceable, and proven to be important to accelerate downward trends for air pollution;

- the Ambient Air Quality Directives have given flexibility to competent national authorities to ensure air quality monitoring and air quality measures optimally fit local circumstances in line with the principle of subsidiarity – yet additional guidance or implementing acts could help to further harmonise approaches applied to monitoring, information provisions, and air quality plans and measures;
- for air quality data, not all data reported is equally useful and the successful establishment of an EU-wide e-reporting based on machine-readable formats now allows for further efficiency gains – and opens the way for further up-to-date reporting of air quality data and to make further use of air quality modelling (which is increasingly reported, but would benefit from further guidance).

4. PROVISIONS OF THE AMBIENT AIR QUALITY DIRECTIVES THAT HAVE BECOME REDUNDANT

There are a number of provisions of the Ambient Air Quality Directives that have become redundant over time. This is the case with the provisions that contain a temporal component, prescribing the starting or the ending date of an obligation. In the meantime, they either have been exhausted or have lost relevance:

- Article 22, in connection with Annex XV, section B, of Directive 2008/50/EC, related to the postponement of attainment deadlines by up to five years and the exemption from the obligation to apply certain limit values until June 2011.
- Article 32 of Directive 2008/50/EC, obliging the Commission to review in 2013 provisions related to PM2.5 and, as appropriate, other pollutants. This 2013 review has occurred.
- Article 8 of Directive 2004/107/EC requiring the Commission to report by the end of 2010 on the experience with the Directive. A corresponding analysis has been prepared as part of the air policy review initiated in 2011.[124]
- Several provisions of Directive 2008/50/EC refer to margins of tolerance (allowed exceedances of limit values expressed in percentages) that were applicable until a certain date (e.g. until 1 January 2010 for nitrogen dioxide).

Furthermore, it is worth noting that the preamble to Directive 2008/50/EC refers to the possible merger of the two Directives once sufficient experience is gained in the implementation of Directive 2004/107/EC.

[124] SEC(2011)342. 'Implementation of EU Air Quality Policy and preparing for its comprehensive review'; see also underpinning analysis provided jointly by Environment Agency Austria, Ricardo-AEA, and TNO (2013) 'Review of the Air Quality Directive and the 4th Daughter Directive'.

ANNEX 10: WHO RECOMMENDATIONS AND EU AIR QUALITY STANDARDS

1. WORLD HEALTH ORGANIZATION RECOMMENDATIONS

EU Clean Air Policy bases itself on scientific evidence and sets appropriate objectives for ambient air quality taking into account relevant World Health Organization (WHO) standards, guidelines and programmes.

Since 1987,[172] the WHO has periodically issued health-based Air Quality Guidelines to assist governments and civil society in reducing human exposure to air pollution and its adverse effects. The overall objective of these Air Quality Guidelines is to offer quantitative health-based recommendations for air quality management, expressed as long- or short-term concentrations for several key air pollutants. Exceedance of the air quality guideline levels is associated with important risks to public health.

The WHO Air Quality Guidelines are not conceived as legally binding standards; however, they do provide an evidence-informed reference point that public authorities can use to inform legislation and policy. Furthermore, the WHO points out that, when translating their recommendations into policies, other features such as legal aspects, cost-benefit or cost-effectiveness, technological feasibility, infrastructural measures and socio-political considerations may also need to be examined. The WHO Air Quality Guidelines are to be seen as an input into a policy making process.

Previous versions of WHO Air Quality Guidelines were published in a 2000 edition,[173] and in a 2005 edition.[174] The 2000 edition provided recommendations on a wide range of air pollutants (including, but not limited to, all those referred to in the current versions of the Ambient Air Quality Directives), whereas the 2005 edition indicated more refined guidelines for the major health-damaging air pollutants, including particulate matter ($PM_{2.5}$ and PM_{10}), ozone (O_3), nitrogen dioxide (NO_2) and sulphur dioxide (SO_2).

In September 2021, a revised edition of the WHO global Air Quality Guidelines was published[175]. This revision focused on particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulphur dioxide and carbon monoxide – see Table A10.1. For these air pollutants, the WHO offers evidence-informed recommendations in the form of guideline levels, including an indication of the shape of the concentration–response functions in relation to critical health outcomes, as well as interim targets to guide reduction efforts.

The revised WHO Air Quality Guidelines were formulated following a rigorous process involving several groups with defined roles and responsibilities. The steps in the development

[172] WHO (1987), Air quality guidelines for Europe
[173] WHO (2000), Air quality guidelines for Europe, 2nd edition
[174] WHO (2006), Air quality guidelines – global update 2005
[175] WHO (2021), WHO global Air Quality Guidelines

included a determination of which pollutants to focus on; systematic reviews[176] of the evidence and meta-analyses of quantitative effect estimates to inform updating of the guideline levels; assessments of the level of certainty of the bodies of evidence resulting from these systematic reviews; and the identification of guideline levels, that is, the lowest levels of exposure for which there is evidence of adverse health effects.

Table A10.1 - Recommended Air Quality Guidelines levels and interim targets – 2021 edition of the WHO Air Quality Guidelines (WHO, 2021)

Pollutant	Averaging time	Interim target				AQG level
		1	2	3	4	
$PM_{2.5}$, µg/m³	Annual	35	25	15	10	5
	24-hour[a]	75	50	37.5	25	15
PM_{10}, µg/m³	Annual	70	50	30	20	15
	24-hour[a]	150	100	75	50	45
O_3, µg/m³	Peak season[b]	100	70	–	–	60
	8-hour[a]	160	120	–	–	100
NO_2, µg/m³	Annual	40	30	20	–	10
	24-hour[a]	120	50	–	–	25
SO_2, µg/m³	24-hour[a]	125	50	–	–	40
CO, mg/m³	24-hour[a]	7	–	–	–	4

[a] 99th percentile (i.e. 3–4 exceedance days per year).
[b] Average of daily maximum 8-hour mean O_3 concentration in the six consecutive months with the highest six-month running-average O_3 concentration.

The 2021 edition of WHO Air Quality Guidelines stresses that levels recommended in previous WHO Air Quality Guidelines for pollutants and averaging times not covered in the most recent update remain valid. This includes the short averaging times for nitrogen dioxide, sulphur dioxide and carbon monoxide that were included in 2005 edition. See Table A10.2.

Table A10.2 - Recommended Air Quality Guidelines levels and interim targets – not evaluated in the 2021 edition, but that remain valid (WHO, 2021)

Pollutant	Averaging time	Air quality guidelines that remain valid
NO_2, µg/m³	1-hour	200
SO_2, µg/m³	10-minute	500
CO, mg/m³	8-hour	10
	1-hour	35
	15-minute	100

[176] The systematic reviews that informed the formulation of WHO Air Quality Guidelines levels and other related evidence discussed during the process are available in a special issue of Environment International published in 2021, entitled ‘Update of the WHO global Air Quality Guidelines: systematic reviews’.

In addition, the 2021 edition also provided qualitative statements on good practices for the management of certain types of particulate matter (i.e., black carbon or elemental carbon, ultrafine particles, and particles originating from sand and dust storms for which the available information is insufficient to derive guideline levels but indicates risk – see Box A10.1 and Table A10.3).

Table A10.3 – Summary of good practice statements for black carbon or elemental carbon (BC/EC), ultrafine particles (UFP), and particles originating from sand and dust storms (SDS), as published in the 2021 edition of the WHO Air Quality Guidelines (WHO, 2021).

	Good practice statements
BC/EC	1. Make systematic measurements of black carbon and/or elemental carbon. Such measurements should not replace or reduce existing monitoring of those pollutants for which guidelines currently exist. 2. Undertake the production of emission inventories, exposure assessments and source apportionment for BC/EC. 3. Take measures to reduce BC/EC emissions from within the relevant jurisdiction and, where appropriate, develop standards (or targets) for ambient BC/EC concentrations.
UFP	1. Quantify ambient UFP in terms of PNC for a size range with a lower limit of ≤ 10 nm and no restriction on the upper limit. 2. Expand the common air quality monitoring strategy by integrating UFP monitoring into the existing air quality monitoring. Include size-segregated real-time PNC measurements at selected air monitoring stations in addition to and simultaneously with other airborne pollutants and characteristics of PM. 3. Distinguish between low and high PNC to guide decisions on the priorities of UFP source emission control. Low PNC can be considered < 1 000 particles/cm³ (24-hour mean). High PNC can be considered > 10 000 particles/cm³ (24-hour mean) or 20 000 particles/cm³ (1-hour mean). 4. Utilize emerging science and technology to advance approaches to the assessment of exposure to UFP for their application in epidemiological studies and UFP management.
SDS	1. Maintain suitable air quality management and dust forecasting programmes. These should include early warning systems and short-term air pollution action plans to alert the population to stay indoors and take personal measures to minimize exposure and subsequent short-term health effects during SDS incidents with high levels of PM. 2. Maintain suitable air quality monitoring programmes and reporting procedures, including source apportionment activities to quantify and characterize PM composition and the percentage contribution of SDS to the overall ambient concentration of PM. This will enable local authorities to target local PM emissions from anthropogenic and natural sources for reduction. 3. Conduct epidemiological studies, including those addressing the long-term effects of SDS, and research activities aimed at better understanding the toxicity of the different types of PM. Such studies are especially recommended for areas where there is a lack of sufficient knowledge and information about the health risk due to frequent exposure to SDS. 4. Implement wind erosion control through the carefully planned expansion of green spaces that considers and is adjusted to the contextual ecosystem conditions. This calls for regional collaboration among countries in the regions affected by SDS to combat desertification and carefully manage green areas. 5. Clean the streets in those urban areas characterized by a relatively high population density and low rainfall to prevent resuspension by road traffic as a short-term measure after intense SDS episodes with high dust deposition rates.

PNC: particle number concentration.

Box A10.1 - Health impacts of ultrafine particles

There is increasing, though limited epidemiological evidence of adverse health impacts of ultrafine particles (smaller than 0.1 µm) in ambient air. Such particles have been found in several organs, and recent systematic literature reviews point to short-term association with cardiorespiratory health, including pulmonary and systemic inflammation, as well as the health of the central nervous system. For other adverse health outcomes, the evidence on health effects remains inconclusive or insufficient.

To establish a correlation with illnesses is difficult due to the limited availability of specific air quality monitoring data, expressed in terms of number of particles per cubic meter or as mass of ultrafine particles ($PM_{0.1}$), which does not allow to conduct targeted epidemiological studies. The risk linked to such particles is however potentially large, due to the evidence of several sources -- notably linked to transport-- emitting large numbers of extremely small particles whose mass is extremely limited while their specific surface area is high, as is their capacity to penetrate the circulatory and nervous systems is enhanced by their small size.

World Health Organization recommendations for ultrafine particles

The 2021 WHO Air Quality Guidelines notes that *"studies demonstrated short-term effects of exposure to [ultrafine particles], including mortality, emergency department visits, hospital admissions, respiratory symptoms, and effects on pulmonary/systemic inflammation, heart rate variability and blood pressure; and long-term effects on mortality (all-cause, cardiovascular, [ischemic heart disease] and pulmonary) and several types of morbidity."* However, for these studies *"various [ultrafine particles] size ranges and exposure metrics were used, preventing a thorough comparison of results across studies. Therefore, there was a consensus in the [WHO Guideline Development Group] that the body of epidemiological evidence was not yet sufficient to formulate an [Air Quality Guideline] level."*

"At the same time, however, there is a large body of evidence from exposure science that is sufficient to formulate good practice advice. The most significant process generating [ultrafine particles] is combustion and, therefore, the main sources of the [ultrafine particles] include vehicles and other forms of transportation (aviation and shipping), industrial and power plants, and residential heating."

To address concerns about the health and environmental effects of ultrafine particles, the 2021 WHO Air Quality Guidelines formulate four good practice statements (see Table A10.3).

Previous editions of the WHO Air Quality Guidelines, and in particular the 2000 edition of the WHO Air Quality Guidelines, provide additional information for additional air pollutants. The subsequent sections summarise current understanding of the health impacts of all twelve air pollutants covered by the Ambient Air Quality Directives, and includes reference to WHO recommendations and guideline levels as relevant.

2. EU AIR QUALITY STANDARDS AS SET BY THE AMBIENT AIR QUALITY DIRECTIVES

Tables A10.4 and A10.5 compare the current EU air quality standards with the WHO Air Quality Guidelines of 2021 (including interim targets) and of 2000 (for pollutants for which guideline values have not been modified since publication).

Table A10.4 – Comparison of EU air quality (AQ) standards with WHO Air Quality Guidelines levels and interim targets covered by the 2021 edition (WHO, 2021)

	EU AQ standard	WHO AQ guideline	WHO interim target 4	WHO interim target 3	WHO interim target 2	WHO interim target 1
$PM_{2.5}$ (annual) [µg/m^3]	**25 / 20**	**5**	**10**	**15**	**25**	**30**
$PM_{2.5}$ (24-hour) [µg/m^3]	-	(1%) **15**	(1%) **25**	(1%) **37.5**	(1%) **50**	(1%) **75**
PM_{10} (annual) [µg/m^3]	**40**	**15**	**20**	**30**	**50**	**70**
PM_{10} (24-hour) [µg/m^3]	(35 days) **50**	(1%) **45**	(1%) **50**	(1%) **50**	(1%) **100**	(1%) **150**
NO_2 (annual) [µg/m^3]	**40**	**10**	-	**20**	**30**	**40**
NO_2 (24-hour) [µg/m^3]	-	(1%) **25**	-	-	(1%) **50**	(1%) **120**
NO_2 (hourly) [µg/m^3]	(18 hours) **200**	**200**	-	-	-	-
O_3 (peak-season) [µg/m^3]	-	**60**	-	-	**70**	**100**
O_3 (8-hour mean) [µg/m^3]	(25 days) **120**	(1%) **100**	-	-	(1%) **120**	(1%) **160**
SO_2 (annual) [µg/m^3]	**20**	-	-	-	-	-
SO_2 (24-hour) [µg/m^3]	(3 days) **125**	(1%) **40**	-	-	(1%) **50**	(1%) **125**
SO_2 (hourly) [µg/m^3]	(24 hours) **350**	-	-	-	-	-
SO_2 (10 min) [µg/m^3]	-	**500**	-	-	-	-
CO (daily) [mg/m^3]	-	(1%) **4**	-	-	-	(1%) **7**
CO (8-hour) [mg/m^3]	**10**	**10**	-	-	-	-

Note: For daily air quality standards reference is made in parentheses to allowed exceedances expressed as number of days or percentiles. For a full year of measurements, 1% translates into the standard not to be exceeded on more than 3 days.

Table A10.5 – Comparison of EU air quality (AQ) standards with WHO Air Quality Guidelines for pollutants covered by the 2000 edition (WHO, 2000)

	EU AQ standard	WHO AQ guideline	Excess lifetime risk	… of 1/10 000	… of 1/100 000	… of 1/1 000 000
Benzene (annual) [µg/m^3]	**5**	**1.7**		**17**	**1.7**	**0.17**
Arsenic (annual) [ng/m^3]	**6**	**6.6**		**66**	**6.6**	**0.66**
Nickel (annual) [ng/m^3]	**20**	**25**		**250**	**25**	**2.5**
BaP (annual) [ng/m^3]	**1**	**0.12**		**1.2**	**0.12**	**0.012**
Cadmium (annual) [ng/m^3]	**5**	**5.0**				
Lead (annual) [µg/m^3]	**0.5**	**0.5**				

As part of the fitness check of the Ambient Air Quality Directives published in 2019, the Commission compared current EU air quality standards and the standards in place in selected (non-EU) OECD countries. This showed alignment with the WHO recommendations in place at the time (i.e. the 2005 edition WHO Air Quality Guidelines) in some cases and large differences in other cases. For fine particulate matter, the EU air quality standards were above those set in selected OECD countries, while for most other pollutants EU levels are within the range established in OECD countries. Table A10.6 provides a comparison.

Consistent with the principle established in Article 193 of the Treaty on the Functioning of the European Union, the Ambient Air Quality Directives do not prevent Member States from setting more stringent standards in national legislation – as is the case, for example, in Austria (for particulate matter (PM_{10}) and nitrogen dioxide), or Sweden (most notably for nitrogen dioxide).

Table A10.6 – Comparison of EU air quality standards with WHO Guidelines and standards applicable in other OECD countries (Based on SWD(2019) 427 final)

	EU AQ standard	2021 WHO AQ guideline	2005 WHO AQ guideline	Selected standards applicable in other OECD countries
$PM_{2.5}$ (annual) [μg/m³]	**25 / 20**	**5**	**10**	AU: **8**; CH: **10**; CA: **10**; US: **12;** JP: **15**; NO: **15**
$PM_{2.5}$ (24-hour) [μg/m³]	-	(1%) **15**	(1%) **25**	AU: **25**; CA: **28**; JP: (2%) **35**; US: (2%) **35**
PM_{10} (annual) [μg/m³]	**40**	**15**	**20**	CH: **20**; AU: **25**; NO: **25**
PM_{10} (24-hour) [μg/m³]	(35 days) **50**	(1%) **45**	(1%) **50**	NO: (30 days) **30;** AU: **50**; NZ: (1 day) **50**; CH: (3 days) **50**; US: (1 day) **150**
NO_2 (annual) [μg/m³]	**40**	**10**	40	CH: **30**; CA: **32**; NO: **40**; AU: **57**; US: **101**
NO_2 (hourly) [μg/m³]	(18 hours) **200**	**200**	**200**	CA: **115**; US: (2%) **191**; NZ: (9h) **200**; NO: (18h) **200**; AU: **230**;
O_3 (8-hour mean) [μg/m³]	(25 days) **120**	(1%) **100**	(1%) **100**	CA: **126**; US: **140**
SO_2 (24-hour) [μg/m³]	(3 days) **125**	(1%) **40**	(1%) **20**	CH: (1 day) **100**; JP: **107** NO: (3 days) **125**; AU: (1 day) **213**;
SO_2 (hourly) [μg/m³]	(24 hours) **350**	-	-	US: (1%) **200**; JP: **266**; NZ: (9h) **350**; NO: (24h) **350**; AU: (1 day) **532**

Note: For daily air quality standards reference is made in parentheses to allowed exceedances expressed as number of days or percentiles. For a full year of measurements, 1% translates into the standard not to be exceeded on more than 3 days.

Note: where standards applicable in selected other OECD countries have been established as 'ppb (parts per billion)', this has been converted to μg/m³ for this table.

***AU (Australia):** Standards and Goal established under National Environment Protection (Ambient Air Quality) Measure, status of 25 February 2016, see https://www.legislation.gov.au/Details/F2016C00215*
***CA (Canada):** Canadian Ambient Air Quality Standards (CAAQS) established under the Canadian Environmental Protection Act, see http://airquality-qualitedelair.ccme.ca/en/*
***CH (Switzerland)**: ‚Luftreinhalte-Verordnung (vom 16 Dezember 1985, inklusive Änderung vom 11. April 2018)', see https://www.admin.ch/opc/de/classified-compilation/19850321/index.html*
***JP (Japan)**: Environmental Quality Standards in Japan – Air Quality. http://www.env.go.jp/en/air/aq/aq.html*
***NO (Norway):** 'Grenseverdier for tiltak', as established in 'forskrift om begrensning av forurensning' see https://lovdata.no/dokument/SF/forskrift/2004-06-01-931 (see Del 3)*
***NZ (New Zealand):** Ambient air quality standards for contaminants under Resource Management (National Environmental Standards for Air Quality) Regulations 2004 (SR 2004/309), see http://www.legislation.govt.nz/regulation/public/2004/0309/latest/DLM287036.html*
***US (United States of America):** National Ambient Air Quality Standards (NAAQS) set by the Environmental Protection Agency under the Clean Air Act, see https://www.epa.gov/criteria-air-pollutants/naaqs-table*

3. HEALTH IMPACTS OF AIR POLLUTANTS IN THE AMBIENT AIR QUALITY DIRECTIVES

This section provides an overview on the health effects of and WHO recommendations for the twelve pollutants covered by the Ambient Air Quality Directives. This is based on reviews of existing literature and meta-studies describing the health effects of the pollutants, focused on inhalative and outdoor air pollution exposure. Evidence from both toxicological and epidemiological studies is considered in developing health-based WHO recommendations.

As noted above, the WHO formulates Air Quality Guidelines, which are in form of a value and a corresponding qualitative description. These are recommendations, and not intended to be simply adopted as legally enforceable standards. Standards should include further factors such as the current exposure, the mixture of air pollutants, specific social, economic and cultural conditions, legal aspects, technological feasibility and the capability of air quality management. (WHO, 2021)

3.1 Fine Particulate Matter ($PM_{2.5}$) and Particulate Matter (PM_{10})

'Particulate matter in urban and non-urban environments is a complex mixture with components having diverse chemical and physical characteristics. Research on particulate matter and the interpretation of research findings on exposure and risk are complicated by this heterogeneity, and the possibility that the potential of particles to cause injury varies with size and other physical characteristics, chemical composition and source(s).

Different characteristics of particulate matter may be relevant to different health effects. Newer research findings continue to highlight this complexity and the dynamic nature of airborne particulate matter, as it is formed either primarily or secondarily and then continues to undergo chemical and physical transformation in the atmosphere.

Nonetheless, particles are still generally classified by their aerodynamic properties, because these determine transport and removal processes in the air and deposition sites and clearance pathways within the respiratory tract. The aerodynamic diameter is used as the summary indicator of particle size; the aerodynamic diameter corresponds to the size of a unit-density sphere with the same aerodynamic characteristics as the particle of interest. The differences in aerodynamic properties among particles are exploited by many particle sampling techniques.' (WHO, 2006)

World Health Organization recommendations for annual $PM_{2.5}$

The recommendation for an annual $PM_{2.5}$ in the 2021 edition of the WHO Air Quality Guidelines is 5 µg/m^3. The WHO also recommends maintaining the 2005 interim targets at 35 µg/m^3, 25 µg/m^3, and 15 µg/m^3, and introducing an interim target 4 at the level of 10 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

'If mortality in a population exposed to $PM_{2.5}$ at the WHO Air Quality Guidelines level is arbitrarily set to 100, then it will be 124, 116, 108 and 104, respectively, in populations exposed to $PM_{2.5}$ at interim target 1, 2, 3 and 4 levels. These projections are based on the linear hazard ratio of 1.08 per 10-µg/m³ increase in $PM_{2.5}$ for all non-accidental mortality reported in the systematic review. At higher concentrations, the CRF may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

World Health Organization recommendations for short-term (24-hour) $PM_{2.5}$

The recommendation for a short-term (24-hour) $PM_{2.5}$ WHO Air Quality Guidelines level is 15 µg/m^3, defined as the 99th percentile (equivalent to 3-4 exceedance days per year) of the annual distribution of 24-hour average concentrations. The WHO also recommends maintaining the 2005 interim targets at 75 µg/m^3, 50 µg/m^3, and 37.5 µg/m^3, and introducing an interim target 4 at the level of 15 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

World Health Organization recommendations for annual PM_{10}

The recommendation for an annual PM_{10} WHO Air Quality Guidelines level is 15 µg/m^3 (WHO, 2021). *'This is based on an evaluation of the studies on the long-term effects of PM_{10} on mortality only, without taking into consideration that a large proportion of PM_{10} is made up of $PM_{2.5}$. As in most situations $PM_{2.5}$ is about 50-80% of PM_{10} by weight, the annual PM_{10}* Air Quality Guidelines *level of 15 µg/m^3 is less protective than the annual AQG level for $PM_{2.5}$. In all situations where both $PM_{2.5}$ and PM_{10} measurements are available, preference should be given to the $PM_{2.5}$ Air Quality Guidelines level.'* (WHO, 2021). Furthermore, the WHO recommends maintaining the 2005 interim targets at 70 µg/m^3, 50 µg/m^3, and 30 µg/m^3, and introducing an interim target 4 at the level of 20 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

'*If mortality in a population exposed to PM_{10} at the Air Quality Guidelines level were arbitrarily set at 100, then it will be 122, 114, 106 and 102, respectively, in populations exposed to PM_{10} at the interim target 1, 2, 3 and 4 levels. These projections are based on the linear hazard ratio of 1.04 per 10-µg/m^3 increase in PM_{10} for all non-accidental mortality reported in the systematic review. At higher concentrations, the concentration-response functions may no longer be linear, which would change the numbers in this example.*' (WHO, 2021)

World Health Organization recommendations for short-term (24-hour) PM_{10}

The recommendation for a short-term (24-hour) PM_{10} WHO Air Quality Guidelines level is 45 µg/m3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. Furthermore, the WHO recommends maintaining the 2005 interim targets at 150 µg/m^3, 100 µg/m^3, and 75 µg/m^3, and introducing an interim target 4 at the level of 50 µg/m^3 (i.e., the air quality guideline level put forward in the 2005 edition). (WHO, 2021)

3.2 Nitrogen Dioxide (NO_2)

'Many chemical species of nitrogen oxides exist, but the air pollutant species of most interest from the point of view of human health is nitrogen dioxide. Nitrogen dioxide is a reddish brown gas with a characteristic pungent odour. Nitric oxide spontaneously produces the dioxide when exposed to air. Nitrogen dioxide gas is a strong oxidant, and reacts with water to produce nitric acid and nitric oxide.

Nitrogen dioxide is an important atmospheric trace gas not only because of its health effects but also because: (a) it absorbs visible solar radiation and contributes to impaired atmospheric visibility; (b) it absorbs visible radiation and has a potentially direct role in global climate change; (c) it is, along with nitric oxide, a chief regulator of the oxidizing capacity of the free troposphere by controlling the build-up and fate of radical species, including hydroxyl radicals; and (d) it plays a critical role in determining ozone concentrations in the troposphere because the photolysis of nitrogen dioxide is the only key initiator of the photochemical formation of ozone, whether in polluted or in non-polluted atmospheres.

Nitrogen dioxide is subject to extensive further atmospheric transformations that lead to the formation of strong oxidants that participate in the conversion of nitrogen dioxide to nitric *acid and sulphur dioxide to sulphuric acid and subsequent conversions to their ammonium neutralization salts. Thus, through the photochemical reaction sequence initiated by solar-radiation-induced activation of nitrogen dioxide, the newly generated pollutants are an important source of organic, nitrate and sulphate particles currently measured as PM_{10} or $PM_{2.5}$. For these reasons, nitrogen dioxide is a key precursor of a range of secondary pollutants whose effects on human health are well-documented.'* (WHO, 2006)

World Health Organization recommendations annual NO_2

The recommendation is an annual nitrogen dioxide *WHO Air Quality Guidelines level of 10 µg/m^3. An interim target 1 of 40 µg/m^3, an interim target 2 of 30 µg/m^3 and an interim target 3 of* 20µg/*m^3 are proposed.* (WHO, 2021).

If all-cause mortality in a population exposed to nitrogen dioxide at the WHO Air Quality Guidelines level is arbitrarily set at 100, then it will be 106, 104 and 102, respectively, in populations exposed to nitrogen dioxide at the interim target 1, 2 and 3 levels. For respiratory mortality, the numbers would be 109, 106 and 103, respectively, at the interim target 1, 2 and 3 levels. These projections are based on the linear hazard ratio of 1.02 and 1.03 per 10-µg/m^3 increase in nitrogen dioxide for all non-accidental and respiratory mortality, respectively, as reported in the systematic review. At higher concentrations, the concentration-response functions may no longer be linear, which would change the numbers in this example. (WHO, 2021)

World Health Organization recommendations short-term (24-hour / 1 hour) NO_2

The recommendation is a short-term (24-hour) nitrogen dioxide *WHO Air Quality Guidelines level of 25 µg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 120 µg/m^3 and an interim target 2 of 50 µg/m^3 are proposed. (WHO, 2021)*

Furthermore, the 2005 edition of the WHO Air Quality Guidelines included a recommendation for a 1-hour nitrogen dioxide concentration below 200 µg/m^3, which the 2021 edition confirms as being valid still.

3.3 Ozone (O_3)

Ozone (and other photochemical oxidants) are pollutants that are not directly emitted by primary sources, but are formed through a series of complex reactions in the atmosphere driven by the energy transferred to nitrogen dioxide (NO_2) molecules when they absorb light from solar radiation. Outside of polluted areas ozone is mainly formed by reactions of carbon monoxide and methane with nitrogen (US EPA, 2020a).

Such emissions result from anthropogenic sources (e.g., motor vehicles and power plants) and natural sources (e.g., vegetation and wildfires). In addition, ozone, which is created naturally in the stratosphere, mixes with tropospheric ozone near the tropopause, and, less frequently can mix nearer the earth's surface. Ozone is in a constant daily flux and because it is produced photochemically, levels are typically highest during sunny periods with reduced atmospheric dispersion (US EPA, 2020b). Ozone can be transported long distances by wind.

'The precursors that contribute most to the formation of oxidant species in polluted atmospheres are nitrogen dioxide and non-methane volatile organic compounds (VOCs),

especially unsaturated VOCs. Methane is much less reactive than the other VOCs but is present at much higher concentrations, having risen in concentration over the past 100 years owing to its increasing use as fuel, and is released from rice fields and farm animals. Photochemistry involving methane accounts for much of the rise in ozone over the oceans and remote land areas, from about 30 µg/m^3 to about 75 µg/m^3.' (WHO, 2006)

World Health Organization recommendations for peak season ozone

The recommendation for a peak season ozone '*WHO Air Quality Guidelines level is 60 µg/m^3 (the average of daily maximum 8-hour mean ozone concentrations). The peak season is defined as the six consecutive months of the year with the highest six-month running-average ozone concentration. In regions away from the equator, this period will typically be in the warm season within a single calendar year (northern hemisphere) or spanning two calendar years (southern hemisphere). Close to the equator, such clear seasonal patterns may not be obvious, but a running-average six-month peak season will usually be identifiable from existing monitoring or modelling data. An interim target 1 of 100 µg/m^3 and an interim target 2 of 70 µg/m^3 are proposed.'* (WHO, 2021)

'If mortality in a population exposed to ozone at the WHO Air Quality Guidelines level is arbitrarily set at 100, then it will be 104 and 101, respectively, in populations exposed to ozone at the interim target 1 and 2 levels. These projections are based on the linear HR of 1.01 per 10-µg/m³ increase in ozone of all non-accidental mortality reported in the systematic review. For respiratory mortality, the numbers will be 108 and 102, respectively, at the interim target 1 and 2 levels, based on the linear hazard ratio of 1.02 of respiratory mortality reported in the systematic review. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

World Health Organization recommendations for short-term (8-hour) ozone

The recommendation for a short-term daily maximum 8-hour ozone '*WHO Air Quality Guidelines level of 100 µg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of daily maximum 8-hour average concentrations. An interim target 1 of 160 µg/m^3 is retained from Global update 2005. An interim target 2 of 120 µg/ m^3 is also proposed*' (WHO, 2021)

3.4 Benzene (C_6H_6)

Benzene is highly volatile, and exposure occurs mostly through inhalation. The main sources of benzene in outdoor air are road transport and energy use in industry, and in indoor air smoking, and to a lesser extent building materials (WHO, 2010).

The most relevant health effects of benzene are haematotoxicity, genotoxicity and carcinogenicity. Based on sufficient evidence of its carcinogenicity in humans, sufficient evidence of its carcinogenicity in experimental animals, and strong mechanistic evidence benzene is classified by International Agency for Research on Cancer (IARC) as a human carcinogen (IARC, 2019).

World Health Organization recommendations for annual benzene

In the WHO Guidelines for Indoor Air Quality a unit risk of leukaemia per 1 µg/m³ air concentration of 6×10^{-6} is proposed. The concentrations of airborne benzene associated with an excess lifetime risk of 1/10 000, 1/100 000 and 1/1 000 000 are 17, 1.7 and 0.17 µg/m³, respectively (WHO, 2010). Which means, when exposed to 1.7 µg/m³ of benzene over a lifetime of 70 years, the risk of developing leukemia would be 1 in a 100 000.

In the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation noted that *"Ambient air exposure is widespread and relevant worldwide. Sources include biomass burning, the use of compressed petroleum gas and its presence in gasoline and high emissions in several countries including China, due to high concentrations of aromatic compounds in gasoline. (…) Experts agreed that all this body of new evidence should be re-evaluated."* (WHO, 2016).

3.5 Sulphur Dioxide (SO_2)

Sulphur dioxide is a colourless gas that is readily soluble in water. Sulphur dioxide has a strong odour. Anthropogenic sources are combustion of sulphur-containing fossil fuels for domestic heating, stationary power generation and motor vehicles (WHO, 2006). Natural sources are volcanoes.

In the air, it can be converted to sulphuric acid, sulphur trioxide and sulphates (ATSDR, 1999). Sulphur dioxide dissolves in water, where it forms sulphurous acid (WHO, 2006). However, inhalation is the only route of exposure to sulphur dioxide that is of interest with regards to its health effects (WHO, 2006).

Vulnerable groups are asthmatics, children and people exercising (heavy breathing leads sulphur dioxide to penetrate further into the respiratory tract).

World Health Organization recommendations short-term (24-hour) SO_2

The recommendation for a short-term (24-hour) sulphur dioxide *'WHO Air Quality Guideline level of 40 µg/m³, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 125 µg/ m³ and an interim target 2 of 50 µg/m³ are proposed.'* (WHO, 2021).

'If mortality in a population exposed to sulphur dioxide for a day at the 24-hour WHO Air Quality Guideline level of 40 µg/m³ is arbitrarily set at 100, then it will be 105 and 101, respectively, in populations exposed to sulphur dioxide at the interim target 1 and 2 levels. These projections are based on the linear hazard ratio of 1.0059 per 10-µg/ m³ increase in sulphur dioxide of all non-accidental mortality reported in the systematic review. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

Based on controlled studies of exercising asthmatics experiencing changes in pulmonary function and respiratory symptoms, a guideline value of 500 µg/m³ over an averaging period of ten minutes was set by the WHO in 2005 (WHO, 2006). The 24-hour guideline value is 20 µg/m³ to provide according to the precautionary principle greater protection than those provided in the previous guidelines.

3.6 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless and toxic gas, which is predominantly produced by incomplete combustion of carbon-containing materials (such as wood, petrol, coal, natural gas and kerosene). Examples are vehicle exhausts, fuel burning ovens, coal burning power plants, small gasoline engines, fires places, grills and gas heaters. (WHO, 2021).

Natural sources include volcanoes and forest fires. Further, vegetation can emit carbon monoxide directly in the atmosphere as a metabolic by-product. Carbon monoxide is also produced indirectly from the photochemical oxidation of methane and other volatile organic compounds in the atmosphere. Still, the biggest share of carbon monoxide emissions come from vehicle exhaust. (ATSDR, 2012a).

Carbon monoxide mixes freely with air in any proportion and moves with air via bulk transport (WHO, 2010). It is found indoors and outdoors. When it is released to the environment, it remains there for an average of about two months. Human exposure occurs through inhalation of outdoor and indoor air. Most vulnerable are people with ongoing cardiovascular and/or respiratory disease, as well as foetuses.

World Health Organization recommendations* short-*term (24-hour / 8-hour) CO

The recommendation is a short-term (24-hour) carbon monoxide *'WHO Air Quality Guideline level of 4 mg/m^3, defined as the 99th percentile (equivalent to three to four exceedance days per year) of the annual distribution of 24-hour average concentrations. An interim target 1 of 7 mg/m^3 is proposed, as a point of reference to the existing 24-hour indoor WHO air quality guideline.'* (WHO, 2021)

'If the number of myocardial infarctions in a population exposed to carbon monoxide for a day at the WHO Air Quality Guideline level of 4 mg/m^3 is arbitrarily set at 100, the number will be 106 in populations exposed to carbon monoxide at the interim target 1 level. This projection is based on the linear hazard ratio of 1.019 per 1 mg/m^3 increase in carbon monoxide for hospital admissions due to myocardial infarction. At higher concentrations, the concentration-response function may no longer be linear, which would change the numbers in this example.' (WHO, 2021)

Furthermore, the 2005 edition of the WHO Air Quality Guidelines included a recommendation for an 8-hour carbon monoxide concentration below 10 mg/m^3, a 1-hour carbon monoxide concentration below 35 mg/m^3, and ten min carbon monoxide concentration below 100 mg/m^3 which the 2021 edition confirms as being valid still.

3.7 Benzo(a)Pyrene (BaP)

Benzo[a]pyrene (BaP) is a five-ring polycyclic aromatic hydrocarbon (PAH) that results from incomplete combustion of organic matter at temperatures between 300°C and 600°C (e.g., coal, oil, fossil fuels, waste, tobacco smoke and wood). It is relatively insoluble in water and has low volatility. In air, BaP is predominantly adsorbed to particulates, but may also exist as a vapor at high temperatures (US EPA, 2017).

BaP can be found in coal tar, tobacco smoke and many foods, especially grilled meats. It is released to the environment via both natural sources (such as forest fires) and anthropogenic sources including stoves burning fossil fuels (especially wood and coal), motor vehicle exhaust, cigarettes and various industrial combustion processes (US EPA, 2017).

BaP is a suitable marker due to its stability and relatively constant contribution to the carcinogenic activity of particle-bound PAH (WHO, 2010b). BaP is measured as its total content and its compounds in the PM_{10} fraction (Directive 2004/107/EC). It is further specified: *"To assess the contribution of benzo(a)pyrene in ambient air, each Member State shall monitor other relevant polycyclic aromatic hydrocarbons at a limited number of measurement sites. These compounds shall include at least: benzo(a)anthracene, benzo(b)fluoranthene, benzo(j)fluoranthene, benzo(k)fluoranthene, indeno(1,2,3-cd)pyrene, and dibenz(a,h)anthracene. Monitoring sites for these polycyclic aromatic hydrocarbons shall be co-located with sampling sites for benzo(a)pyrene and shall be selected in such a way that geographical variation and long-term trends can be identified."*

The International Agency for Research on Cancer (IARC) concluded about the carcinogenicity of BaP in several assessments: "*There is sufficient evidence in experimental animals for the carcinogenicity of benzo[a]pyrene"* (IARC, 2010). *„Benzo[a]pyrene is carcinogenic to humans"* (IARC, 2012b).

World Health Organization recommendations for annual BaP

In the WHO Air Quality Guidelines from 2000 based on epidemiological data from studies in coke-oven workers, a unit risk for BaP as indicator air constituent for PAHs is estimated to be 8.7×10^{-5} per ng/m^3, which is the same as that established by WHO in 1987. The corresponding concentrations of BaP leading to an excess life time cancer risks of 1/10 000, 1/100 000 and 1/1 000 000 are 1.2, 0.12 and 0.012 ng/m^3, respectively (WHO, 2000). In some publications the unit risk of 8.7×10^{-5} per ng/m^3 is translated in a life time risk of 1/10 000, 1/100 000 and 1/1 000 000 for 1.0, 0.1 and 0.01 ng/m^3, respectively (WHO, 2013).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Even in the absence of new evidence, the acceptability of the level of risk associated with the current target value should be reviewed and discussed. The current lifetime cumulative risk for benzo[a]pyrene causing cancer ($1x10^{-4}$) that is associated with the current guideline (1 ng/m^3) is somewhat high."* (WHO, 2013).

In the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation, a re-evaluation of the evidence taking BaP as a reference compound was suggested, because "*on the basis of availability of new evidence since 2010 regarding non-cancer health endpoints (i.e. cardiovascular, neurodevelopment effects, lower birth weight etc.) and conclusions from ongoing health risk assessments that have included non-cancer health effects from benzo[a]pyrene and reference concentration values for inhaled PAHs* (….) *experts concluded that the new health evidence should be re-evaluated."* (WHO, 2016).

3.8 Lead (Pb)

Lead exists in different forms, elemental, inorganic and organic lead, each with own chemical and toxicological properties. Lead is a natural occurring metal, however anthropogenic activities lead to an accumulation due to its persistency. Key anthropogenic sources are energy use in industries, industrial processes and road transport. Smoking is another source, while natural sources include volcanic activities, geochemical weathering and sea spray emissions.

For non-smokers, the largest contribution to the daily intake of lead is from ingestion of food, drinking water, dirt and dust (WHO 2019c). Exposure by inhalation is mainly due to burning materials containing lead, e.g., smelting, recycling, stripping leaded paint, leaded petrol (HBM4EU, 2020). Dust and soil may contain high levels of lead concentrations and is thereby an important source of children´s exposure. Children are particular vulnerable to the neurotoxic effects of lead and even relatively low levels of exposure can cause serious and in some cases irreversible neurological damage (WHO 2019c). Furthermore, pregnant women and their unborn children are most susceptible to the adverse effects of lead. Blood lead level is the best available indicator of current and recent environmental exposure: most biological effects relate to blood lead levels (WHO, 2000).

The International Agency for Research on Cancer (IARC) concludes *"that inorganic lead compounds are probably carcinogenic to humans"* while *"organic lead compounds are not classified as to their carcinogenicity to humans"* (IARC, 2006).

World Health Organization recommendations for annual lead

The air lead guideline value from the WHO from 2000 is based on concentrations of lead in blood using a conversion factor from air lead (1 µg/m^3) to blood lead (50 µg/L) which includes a direct contribution of about 19 µg/L in children and 16 µg/L in adults. It was noted that cognitive impairment has been shown in children at blood lead levels of 100–150 µg/L and proposed a critical level of 100 µg/l. To assure that at least 98% of children have blood lead levels of less than 100 µg/l, the median should not exceed 54 µg/l. Further, a baseline value of the (dietary) contribution to lead in blood of 20 µg/l in uncontaminated areas was assumed. Aiming at a lead level in air that would not increase blood lead to a level above 50 µg/l, lead in air should contribute no more than 30 µg/l. The guideline value was therefore set at 0.5 µg/m^3 lead in ambient air (see WHO, 2000, and WHO, 2013).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Yes, there is definitely new evidence on the health effects of air emissions of lead that would have an impact on the current limit value. This evidence shows that effects on the central nervous system in children and on the cardiovascular system in adults occur at, or below, the present standards in the WHO air quality guidelines and EU"* (WHO, 2013).

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation *"There was a general expert consensus with the conclusions of the REVIHAAP Project in that the current WHO AQGs for lead need to be re-evaluated. (…) Experts pointed out the need to coordinate with other activities on lead that might be conducted by WHO."* (WHO, 2016).

3.9 Arsenic (As)

Arsenic has chemical and physical properties intermediate between a metal and a non-metal. It is emitted to the atmosphere from both natural and anthropogenic sources. Approximately one-third of the global atmospheric flux of arsenic is estimated to be from natural sources (IARC, 2012a), especially volcanic activity, followed by low-temperature volatilization, exudates from vegetation and windblown dusts. Anthropogenic emissions arise from mining and smelting of base metals, fuel combustion (e.g., waste and low-grade brown coal) and the use of arsenic-based pesticide (IARC, 2012a). Arsenic released from power plants and other combustion processes is usually attached to very small particles, and may stay in the air for many days and travel long distances. Ultimately, most arsenic ends up in the soil, sediment or water.

The primary route of arsenic exposure for the general population is via ingestion of contaminated food or water; inhalation of arsenic from ambient air is generally a minor exposure route for the general population. Arsenic compounds have long residence times in the atmosphere and are enriched in the fine particle mode about or below 1 µm and, consequently, can penetrate deeply into the respiratory system (EC, 2001).

From an epidemiological (population studies) perspective, the International Agency for Research on Cancer (IARC) concludes: "*There is sufficient evidence in humans for the carcinogenicity of mixed exposure to inorganic arsenic compounds (…). Inorganic arsenic compounds (…) cause cancer of the lung, urinary bladder, and skin. Also, a positive association has been observed between exposure to arsenic and inorganic arsenic compounds and cancer of the kidney, liver, and prostate. (…) Arsenic and inorganic arsenic compounds are carcinogenic to humans*" (IARC, 2012a).

Furthermore based on available toxicology (animal and cell-studies), IARC concludes: "*In view of the overall findings in animals, there is sufficient evidence in experimental animals for the carcinogenicity of inorganic arsenic compounds*" (IARC, 2012a).

World Health Organization recommendations for annual arsenic

In the WHO Air Quality Guidelines 2000 a unit risk for lung cancer per 1 $\mu g/m^3$ air concentration of 1.5×10^{-3} is proposed. The concentrations of airborne arsenic associated with an excess life time risk of 1/10 000, 1/100 000 and 1/1 000 000 are 66 ng/m^3, 6.6 ng/m^3 or 0.66 ng/m^3, respectively (WHO, 2000).

In 2013, a WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) concluded: "*Yes, there is some new evidence on the cancer risk of air emissions of arsenic, but it is contradictory in terms of the direction of risk. This new evidence is insufficient to have an impact on the current EU target value*" (WHO, 2013)

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation "*experts agreed with the conclusions of the REVIHAAP project, in that the new evidence available for arsenic might not lead to a substantial change to the unit risk currently recommended in the WHO AQGs. In addition, exposure through diet (food, water) is more relevant than air. However, non-carcinogenic effects should be looked at (…).*"(WHO, 2016).

3.10 Cadmium (Cd)

Cadmium is a silver-white solid metal. Particulate cadmium is emitted in the atmosphere from both natural and anthropogenic sources. The main anthropogenic sources are metal production and fossil fuel combustion, waste incineration and cement production. Cadmium particles in air can travel long distances before falling to the ground or water.

The main human exposure sources of cadmium are diet (higher uptake at low iron stores in the human body) and smoking (WHO, 2013). Inhalation is a minor part of total exposure (less than 10%), but ambient air levels are important for cadmium deposition in soil and, thereby, dietary intake. The average amount of cadmium ingested in European countries is 10-20 µg/day. The most well-known health effects of cadmium are kidney and lung damage and toxic effects on bone tissue (osteomalacia and osteoporosis) (WHO, 2013). Population groups at risk include elderly people, those suffering from diabetes and smokers. In addition, women may be at increased risk because, at the same level of exposure, they absorb more cadmium than men (WHO, 2007).

From an epidemiological (population studies) perspective, the International Agency for Research on Cancer (IARC) concludes: *"There is sufficient evidence in humans for the carcinogenicity of cadmium and cadmium compounds. Cadmium and cadmium compounds cause cancer of the lung. Also, positive associations have been observed between exposure to cadmium and cadmium compounds and cancer of the kidney and of the prostate. Cadmium and cadmium compounds are carcinogenic to humans."* (IARC, 2012a)

Furthermore based on available toxicology (animal and cell-studies), IARC concludes: *"There is sufficient evidence in experimental animals for the carcinogenicity of cadmium compounds. There is limited evidence in experimental animals for the carcinogenicity of cadmium metal"* (IARC, 2012a).

World Health Organization recommendations for annual cadmium

For the WHO Air Quality Guidelines 2000, the data behind the derivation of a unit risk of lung cancer was considered to be too complicated. The concomitant exposure with arsenic is seen as an important bias. It was noted that average kidney cadmium levels in Europe are very close to the critical level for renal effects. A further increase in dietary intake of cadmium, due to accumulation of cadmium in agricultural soils, must be prevented. Therefore, a guideline value of 5 ng/m3 was set for cadmium in air (WHO, 2000, 2013).

New evidence and new evaluations of data were published since the WHO Air Quality Guidelines 2000. A WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) noted that as the current EU air quality standard is already fully aligned with WHO recommendation, the latter do not point to a need for stricter levels. However, to prevent the increasing cadmium levels in agricultural soil by the air deposition and the thereby adverse health effects, more stringent standards would be needed (WHO, 2013).

Subsequently, in the summary of the expert pollutant advice of the WHO Air Quality Guidelines consultation *"experts agreed with the conclusions of the REVIHAAP project, in that present levels of cadmium in air are too high to obtain a cadmium balance in soils (suggesting that the cadmium dietary intake of the population will not decrease). In addition, strong evidence is available on new health effects due to cadmium exposure in the general population especially on bone, but also on hormone-related cancer, cardiovascular disease, and fetal growth."* (WHO, 2016).

3.11 Nickel (Ni)

Nickel is a hard silvery-white natural element, which is ubiquitous and naturally present in the environment, even if atmospheric nickel concentrations are higher in urban and industrial air than in rural areas. Anthropogenic sources of nickel and it species are industries that make or use nickel, nickel alloys, or nickel compounds. It is also released into the atmosphere by oil- and coal-burning power plants, and trash incinerators. In the air, nickel attaches to small particles of dust that settle to the ground or are taken out of the air in rain or snow; this usually takes many days.

The main routes of exposure are ingestion, dermal contact and to a lesser extend inhalation. Allergic skin reactions are the most common health effects of nickel, affecting about 2% of the male and 11% of the female population. Nickel content in consumer products and possibly in food and water are critical for the dermatological effect. The respiratory tract is also a target organ for allergic manifestations of occupational nickel exposure. There is no evidence that airborne nickel causes allergic reactions in the general population, although this reaction is well documented in the working environment. The key criterion for assessing the risk of airborne nickel exposure is its carcinogenic potential (WHO, 2000).

From an epidemiological (population studies) perspective, and on the basis of the underlying concept that all nickel compounds can generate nickel ions that are transported to critical sites in target cells, the International Agency for Research on Cancer (IARC) has classified nickel compounds as carcinogenic to humans, and metallic nickel as possibly carcinogenic to humans. Other than for lung cancer and nasal sinus cancer, there is currently no consistency in the epidemiological data to suggest that nickel compounds cause cancer at other sites (IARC, 2012a).

Furthermore based on available toxicology (animal and cell-studies), IARC concludes: "*There is sufficient evidence in experimental animals for the carcinogenicity of nickel monoxides, nickel hydroxides, nickel sulfides (including nickel subsulfide), nickel acetate, and nickel metal. There is limited evidence in experimental animals for the carcinogenicity of nickelocene, nickel carbonyl, nickel sulfate, nickel chloride, nickel arsenides, nickel antimonide, nickel selenides, nickel sulfarsenide, and nickel telluride. There is inadequate evidence in experimental animals for the carcinogenicity of nickel titanate, nickel trioxide, and amorphous nickel sulfide. In view of the overall findings in animals, there is sufficient evidence in experimental animals for the carcinogenicity of nickel compounds and nickel metal*." (IARC, 2012a)

World Health Organization recommendations for nickel

The WHO propose in the Air Quality Guidelines from 2000 on the basis of a risk estimated in industrial populations, an incremental risk of 3.8×10^{-4} per $\mu g/m^3$. The concentrations corresponding to an excess lifetime risk of 1/10 000, 1/100 000 and 1/1 000 000 are about 250, 25 and 2.5 ng/m^3, respectively (WHO, 2000). The carcinogenic effect of nickel is well researched, still different unit risks are recommended by different international organisations as well as limit values. Most of them are around the EU target value of 20 ng/m^3.

A WHO 'review of evidence on health aspects of air pollution' (REVIHAAP) noted *"there is some updated occupational epidemiology on nickel refinery workers since the review by the WHO Working Groupon Air Quality Guidelines for 2000. The impression is, however that this new data will not change the previous unit risk estimate substantially. Data on the effect of ambient nickel levels on cardiovascular risk are yet too limited to permit their use in WHO air quality guideline standards."* (WHO, 2013)

The expert pollutant advice of the WHO Air Quality Guidelines consultation noted: *"The levels in ambient air are generally low (except for some hot spots). […] More recently, potential associations of nickel exposure through air and cardiovascular disease and inflammation have been described, but experts agreed with the REVIHAAP project conclusion that more epidemiological and experimental studies are needed in this regard."* (WHO, 2016)

4. References

EC (European Commission), 2001. Ambient air pollution by AS, CD and NI compounds.Position Paper.

IARC (International Agency for Research on Cancer), 2006. organic and organic lead compounds. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol 87.

IARC, 2010. Some Non-heterocyclic Polycyclic Aromatic Hydrocarbons and Some Related Exposures. Vol 92.

IARC, 2012a. Arsenic, metals, fibres, and dusts. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol 100 C: A review of human carcinogens.

IARC, 2012b. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans Vol 100mF.

IARC, 2019 Benzene. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans.

US EPA, 2017, IRIS Toxicological Review of Benzo[A]Pyrene (Final Report).

US EPA, 2020a. Integrated Science Assessment for Ozone and Related Photochemical Oxidants.

US EPA, 2020b. Review of the Ozone National Ambient Air Quality Standards.

WHO (World Health Organization), 1987. Air quality guidelines for Europe.

WHO, 2000. Air quality guidelines for Europe, 2nd edition.

WHO, 2006. Air quality guidelines – global update 2005. Particulate matter, ozone, nitrogen dioxide and sulfur dioxide.

WHO, 2007. Health risks of heavy metals from long-range transboundary air pollution.

WHO, 2010. Preventing disease through healthy environments. Exposure to benzene: A major public health concern.

WHO, 2010b, WHO Guidelines for Indoor Air Quality: Selected Pollutants.

WHO, 2013. Review of evidence on health aspects of air pollution – REVIHAAP Project Technical Report.

WHO 2016. WHO Expert Consultation: Available evidence for the future update of the WHO Global Air Quality Guidelines (AQGs). Meeting report.

WHO, 2019a. Preventing disease through healthy environments. Exposure to arsenic: A major public health concern.

WHO, 2019b. Preventing disease through healthy environments. Exposure to cadmium: A major public health concern.

WHO, 2019c. Preventing disease through healthy environments. Exposure to lead: A major public health concern.

WHO, 2021. WHO global Air Quality Guidelines. Particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide. Geneva: World Health Organization.

Annex 11: Air Quality in Europe in 2020

1. Introduction

Air pollution is the single largest environmental health risk in Europe, causing cardiovascular and respiratory diseases that lead to the loss of healthy years of life and, in the most serious cases, to premature deaths. This annex presents the status of concentrations of pollutants in ambient air in 2020, in relation to both EU air quality standards and 2021 WHO Air Quality Guidelines. Exceedances of EU air quality standards are common across the EU, with concentrations well above the latest WHO recommendations. Nevertheless, in 2020, lockdown measures adopted to minimise the spread of COVID-19 had a temporary impact on emissions of air pollution from road transport and led to improved air quality.

Air pollution also damages vegetation and ecosystems. It leads to several important environmental impacts, which affect vegetation and fauna directly, as well as the quality of water and soil and the ecosystem services they support.

Sources and acknowledgement

This annex was prepared by the European Environment Agency (EEA). The EEA compiles information on air quality at station level reported by its member and cooperating countries, as well as Andorra. Hence, the analysis covers the 27 EU Member States, and third countries. The analysis of the air quality situation in Europe in 2020 is based on:

- European Environment Agency briefing "Europe's air quality status 2022" and
- Eionet Report 2022/2 "Status report of air quality in Europe for year 2020" produced by the European Topic Centre on Human Health and the Environment.

Information on population exposure to air pollution is based on the EEA indicator on the exceedance of air quality standards in Europe. Information on the health impacts of air pollution is based on the European Environment Agency briefing on the "Health impacts of air pollution in Europe, 2021" and refers to 2019. Data for 2020 calculations will be available later in 2022. Information on environmental impacts of ozone is based on European Environment Agency indicator on the exposure of Europe's ecosystems to ozone and the EMEP Status report 1/2021 and refers to 2019, since 2020 calculations will only be available later in 2022.

2. Overview of monitoring stations in the EU

Data included in this report was reported to the European Environment Agency by 24 March 2022. Air quality data is reported to the European Environment Agency for a total of 39 European countries, namely for all 27 EU Member States, as well as for Albania, Andorra, Bosnia and Herzegovina, Iceland, Kosovo, Liechtenstein, Montenegro, North Macedonia, Norway, Serbia, Switzerland and Turkey.

The number of stations that reported data for each pollutant by country for the 27 EU Member States is provided in Table A11.1.

Table A11.1 Number of stations reporting data for each air pollutant by country

Country	PM_{10}	$PM_{2.5}$	O_3	NO_2	BaP	SO_2	CO	C_6H_6	As	Cd	Pb	Ni
Belgium	65	70	40	121	23	25	20	20	22	22	23	22
Bulgaria	40	6	20	22	15	27	16	18	7	12	11	7
Czechia	148	91	64	96	53	57	21	31	58	59	59	59
Denmark	7	9	8	14	2	4	6	3	3	3	3	3
Germany	380	230	265	619	111	111	85	108	98	98	98	98
Estonia	7	7	9	9	5	9	7	4	5	5	5	5
Ireland	37	31	17	22	5	10	3	1	5	5	5	5
Greece	23	11	16	21	0	8	6	5	0	1	0	0
Spain	450	240	410	494	70	389	176	80	91	91	94	91
France	358	172	304	379	47	95	16	28	52	52	55	53
Croatia	11	10	12	12	3	7	4	3	2	2	2	2
Italy	540	293	339	603	161	223	204	226	140	140	135	133
Cyprus	3	4	3	3	1	3	3	1	2	2	2	2
Latvia	6	5	7	8	5	6	1	5	5	5	5	5
Lithuania	14	7	12	17	5	14	9	1	5	5	5	5
Luxembourg	6	4	5	8	2	3	3	1	2	2	2	2
Hungary	23	11	18	22	16	23	21	12	16	16	16	16
Malta	3	4	4	4	1	3	2	2	3	3	3	3
Netherlands	66	46	45	71	3	14	6	9	0	0	0	0
Austria	123	57	102	143	34	65	27	18	12	13	12	12
Poland	242	123	101	142	157	102	68	61	72	71	73	71
Portugal	40	16	39	44	0	17	13	2	0	0	0	0
Romania	23	5	28	32	3	19	21	49	23	34	32	34
Slovenia	18	4	5	8	5	4	2	2	5	5	5	5
Slovakia	34	33	16	26	15	16	14	12	5	5	5	5
Finland	38	18	17	36	6	15	0	2	5	5	2	5
Sweden	56	32	27	91	3	24	5	2	4	4	4	4
EU-27	**2.761**	**1.539**	**1.933**	**3.067**	**751**	**1.293**	**759**	**706**	**642**	**660**	**656**	**647**
Total [177]	3.102	1.711	2.128	3.334	767	1.574	903	718	661	680	675	666

For most of the pollutants, data is only included in this assessment from those sampling points stations that fulfil the criterion of reporting more than 75% of valid data for the full year. While the Ambient Air Quality Directives set the objective of a minimum data capture of 90% for monitoring stations for compliance purposes, for assessment purposes a coverage of 75% allows more stations to be included without a significant increase in uncertainty.

177 For all 39 countries that report air quality data to the European Environment Agency.

For random fixed measurements of particulate matter (PM), toxic metals (arsenic, cadmium, nickel and lead) and Benzo(a)pyrene (BaP), the required amount of valid data for the analysis is 14%, following the objectives for indicative measurements. For benzene, it is 50%. Stations not fulfilling the minimum data coverage are listed in the Annual Air Quality statistics table.[178]

3. CONCENTRATION LEVELS FOR KEY AIR POLLUTANTS IN THE EU

3.1 Fine particulate matter ($PM_{2.5}$) and particulate matter (PM_{10})

In terms of data coverage, $PM_{2.5}$ data with a general minimum coverage of 75%, and of 14% for fixed random stations, of valid data were received from 1 711 stations for the calculation of annual mean concentrations and from 1 711 stations in relation to the short-term WHO Air Quality Guidelines.

a) $PM_{2.5}$ annual mean concentration

The $PM_{2.5}$ concentrations were higher than the EU annual limit value (25 µg/m^3) in three EU Member States and three other reporting countries (Figure A11.1). These concentrations above the limit value were registered in 2% of all the reporting stations and occurred primarily (90% of cases) in urban (69%) or suburban (21%) areas.

The WHO Air Quality Guidelines for $PM_{2.5}$ annual mean (5 µg/m^3) was exceeded at 92% of the stations, located in 32 of the 33 countries reporting $PM_{2.5}$ data.

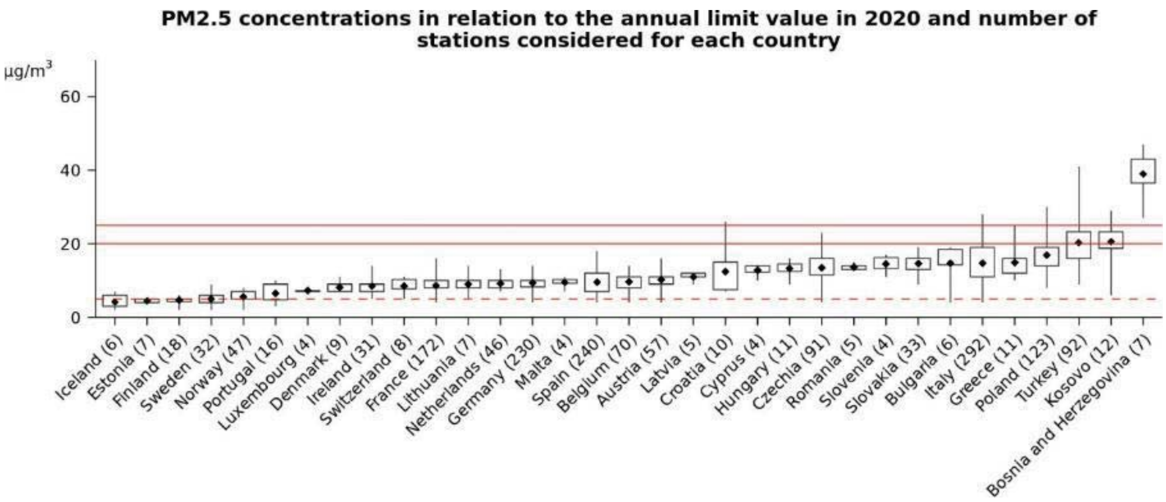


Figure A11.1 - $PM_{2.5}$ concentrations in relation to the annual limit value in 2020 by country. [179]

[178] EEA (2022), Annual AQ statistics portal (accessed: 09.06.2022)

[179] Note: The graph is based on annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The annual limit value and the indicative annual limit value set by EU legislation are marked by the upper continuous horizontal lines at 25 and 20, respectively. The WHO Air Quality Guidelines is marked by the lower dashed horizontal line.

Figure A11.2 shows the maps of measured $PM_{2.5}$ annual mean concentrations from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

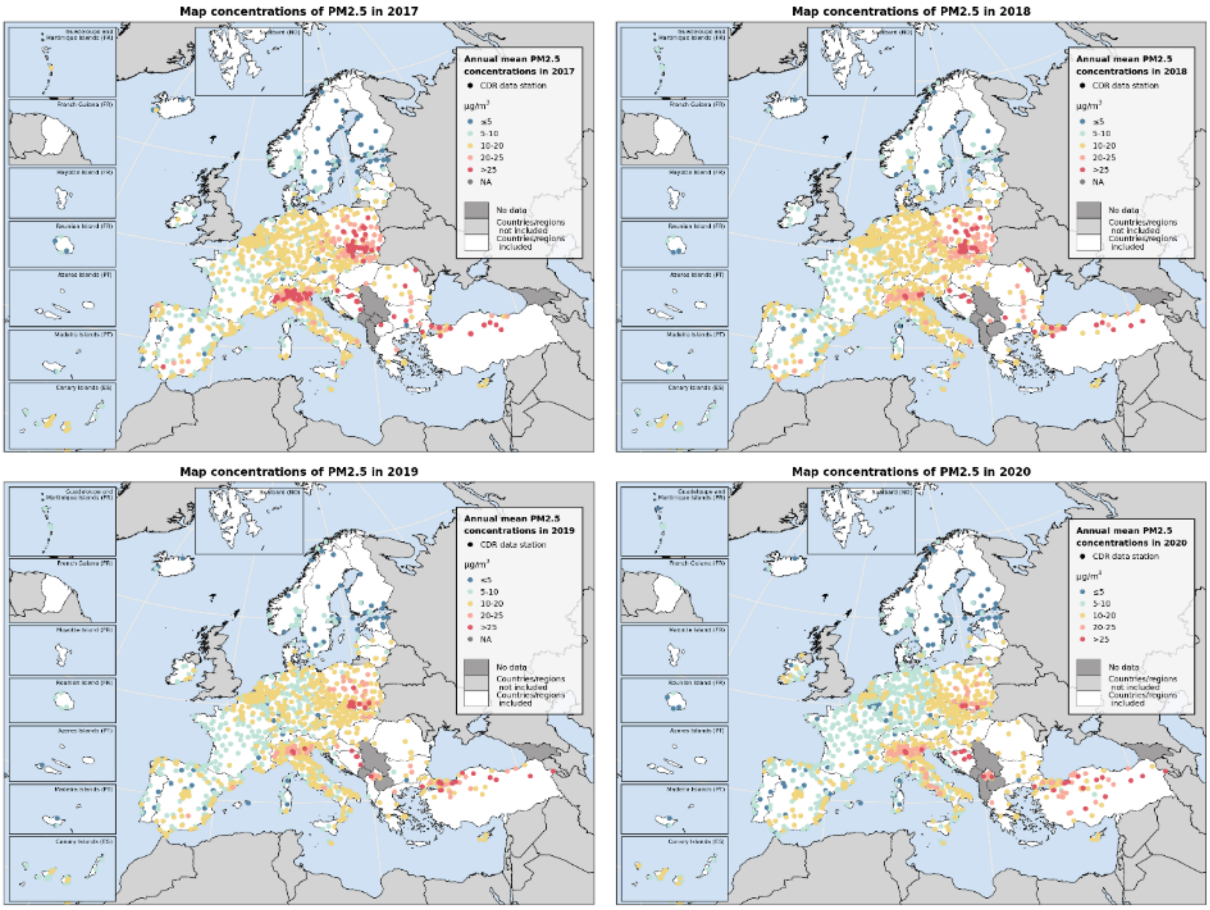


Figure A11.2 - $PM_{2.5}$ annual mean concentrations for 2017-2020

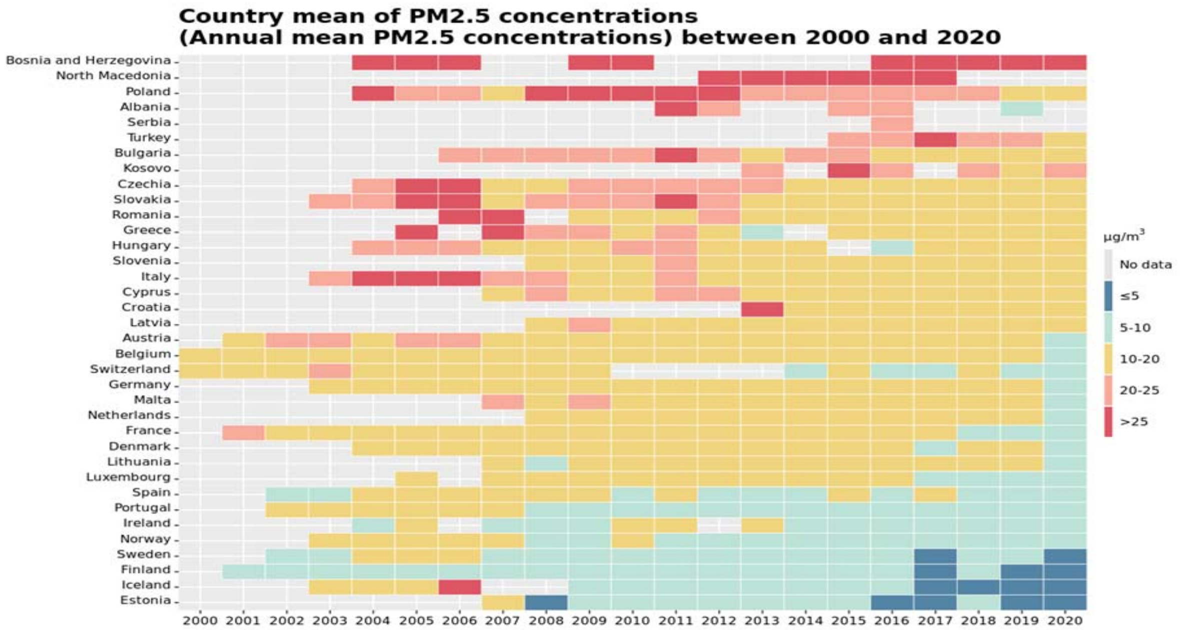
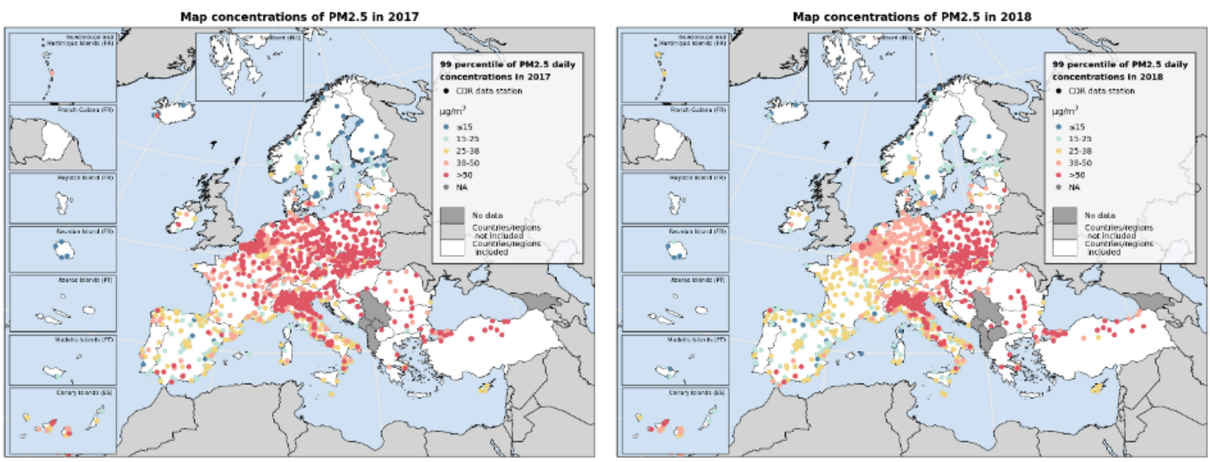


Figure A11.3 - Annual mean $PM_{2.5}$ concentrations between 2000 and 2020 by country

Heatmaps with the evolution from 2000 of the mean $PM_{2.5}$ annual mean concentrations at country level are shown in Figure A11.3. In this way, the evolution along years of the average measured concentration levels can be seen for each country. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

b) $PM_{2.5}$ daily mean concentration

Although the EU has not set any short-term standard for $PM_{2.5}$, the WHO defined in 2021 a daily air quality level of 15 µg/m³, expressed as 99th percentile. It was exceeded at 95% (1 616 stations) of all stations in the reporting countries. Figure A11.4 shows the maps of measured $PM_{2.5}$ annual mean concentrations from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.



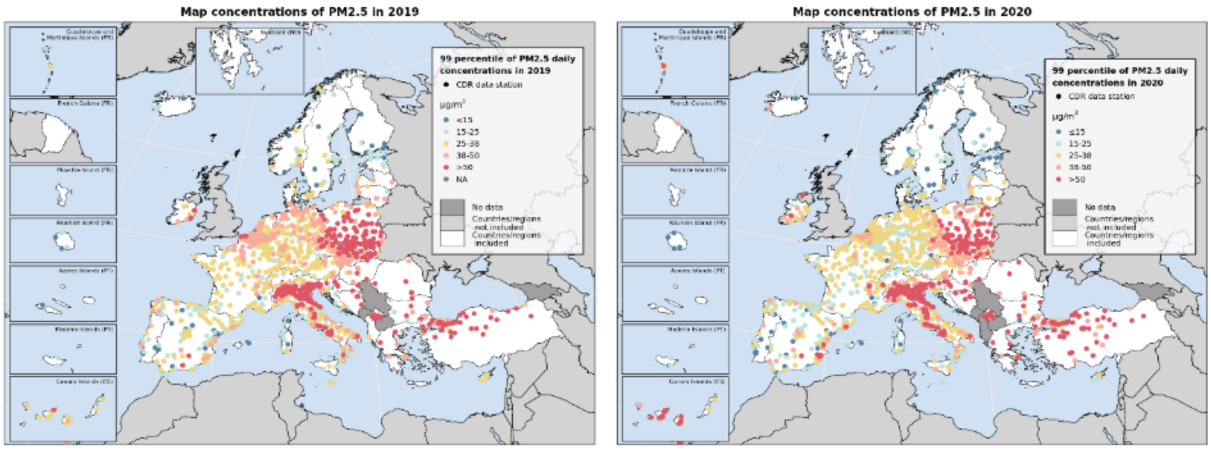


Figure A11.4 - $PM_{2.5}$ annual mean concentrations for 2017-2020

c) PM_{10} annual mean concentration

In terms of data coverage, the European Environment Agency received PM_{10} data for 2020, with sufficient valid measurements (a general minimum coverage of 75% and of 14% for fixed random measurements) from 3 101 stations for the calculation of annual mean concentrations and from 3 092 stations in relation to the daily limit value. Concentrations above the PM_{10} annual limit value (40 µg/m^3) were monitored in 5% (149 stations) of all the reporting stations, located in six countries in EU Member States, and four other reporting countries.

The stricter value of the WHO Air Quality Guidelines for PM_{10} annual mean (15 µg/m^3) was exceeded at 68% (2 118) of the stations in all the reporting countries, except in Iceland (Figure A11.5).

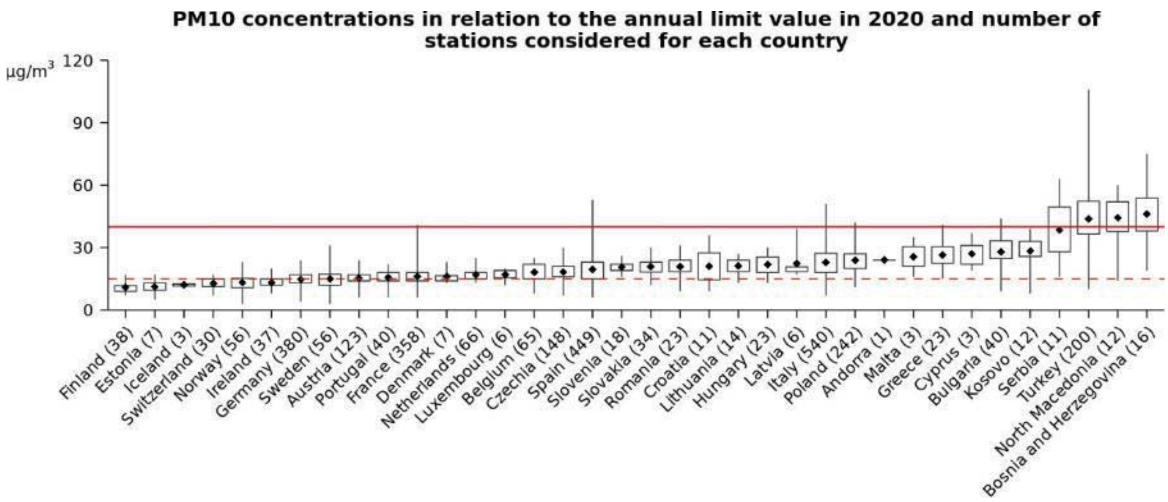


Figure A11.5 - PM_{10} concentrations in relation to the EU annual limit value[180]

[180] Note: The graph is based on annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the

Figure A11.6 shows the maps of PM_{10} annual mean concentrations at station level from 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

Figure A11.7 presents heatmaps of evolution of the mean annual mean PM_{10} concentrations from 2000 to 2020 at country level. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

lower percentile; at 25% of the stations, concentrations are above the upper percentile. The annual limit value set by EU legislation is marked by the upper continuous horizontal line. The WHO Air Quality Guidelines is marked by the lower dashed horizontal line.

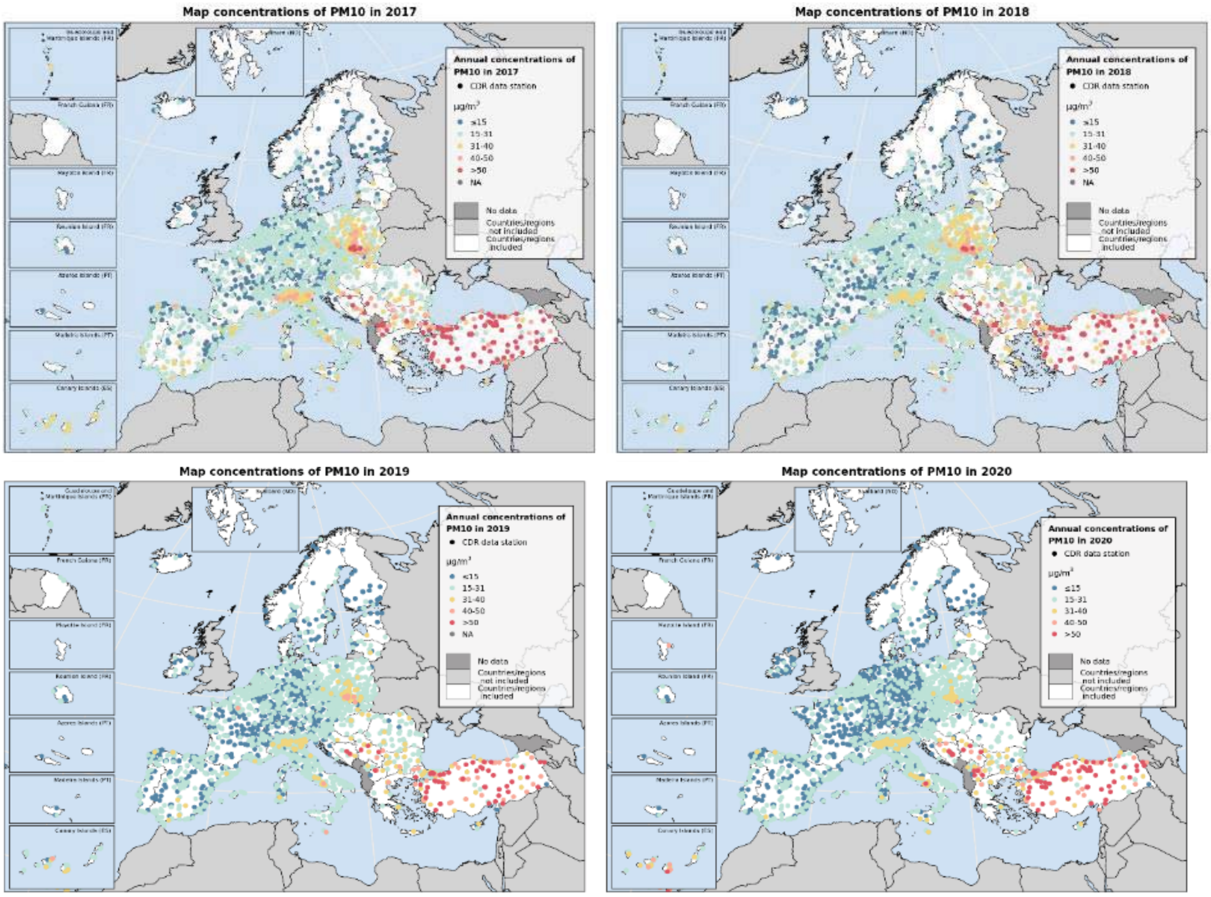


Figure A11.6 - PM_{10} annual mean concentrations for 2017 to 2020

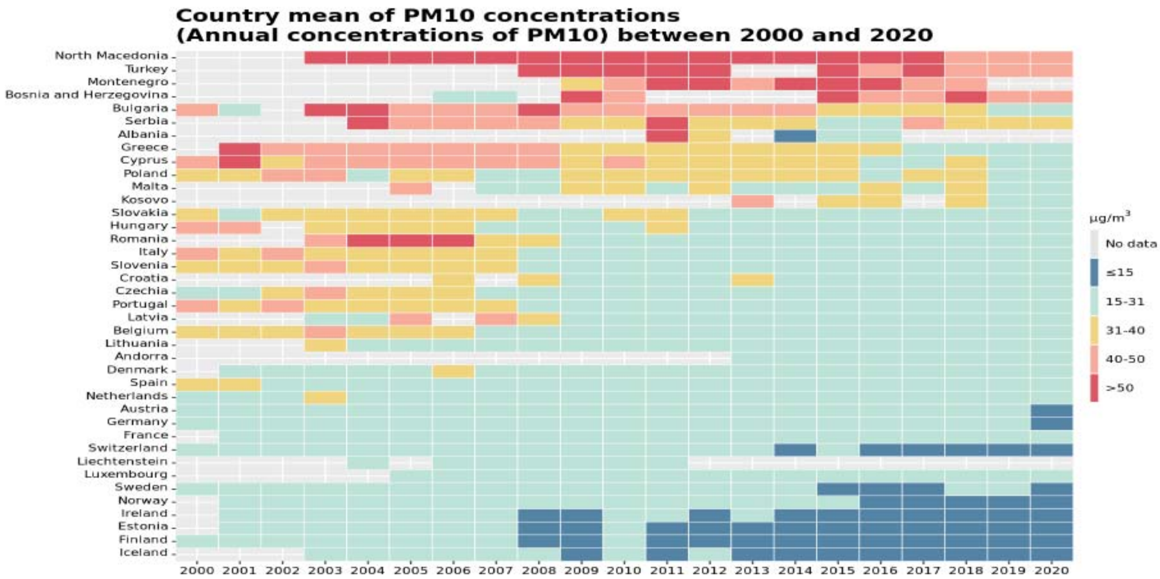


Figure A11.7 - Heatmaps presenting the evolution of the annual mean PM_{10} concentrations at country level from 2000 to 2020 *d) PM_{10} daily mean concentration*

15 EU Member States and five other reporting countries reported PM_{10} concentrations above the EU daily limit value of 50 µg/m^3 (Figure A11.8). This was the case for 16% (482) of reporting stations. In total, 95% of those stations were either urban (84%) or suburban (11%). The stricter WHO Air Quality Guidelines for PM_{10} daily mean (45 µg/m^3) was exceeded at 61% (1 894) of the stations in all the reporting countries.

Figure A11.8 shows the maps of the 90.4 percentile of PM_{10} daily mean concentrations (equivalent to the PM_{10} daily limit value) 2017 to 2020. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

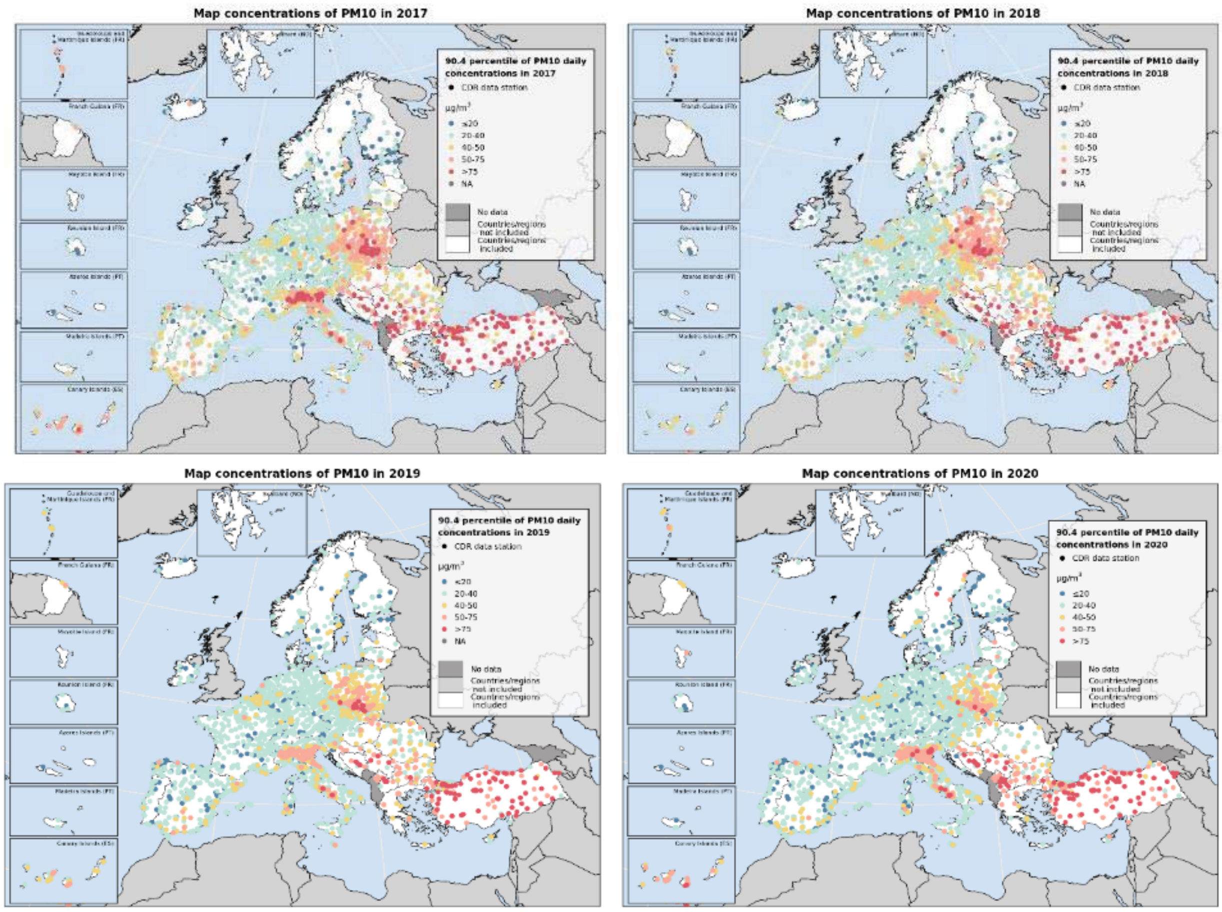


Figure A11.8 - PM_{10} daily mean concentrations for 2017 to 2020

3.2 Nitrogen dioxide (NO_2)

Reporting countries submitted NO_2 data from 3 333 stations for the annual limit value, 3 019 stations for the hourly limit value, and 3 329 stations for the daily WHO Air Quality Guidelines level.

a) NO_2 annual mean concentration

Seven EU Member States and one other reporting country recorded concentrations above the annual limit value (40 µg/m³), with exceedances reported by 2% of all the stations measuring NO_2. In contrast, 73% of stations, located in the EU Member States and nine other reporting countries reported concentrations above the WHO Air Quality Guidelines level of 10 µg/m³. Figure A11.9 presents the measured annual mean NO_2 concentrations at country level. 69% of all values above the annual limit value were observed at traffic stations. Furthermore, 100% of the stations with concentrations above the annual limit value were located in urban or suburban areas.

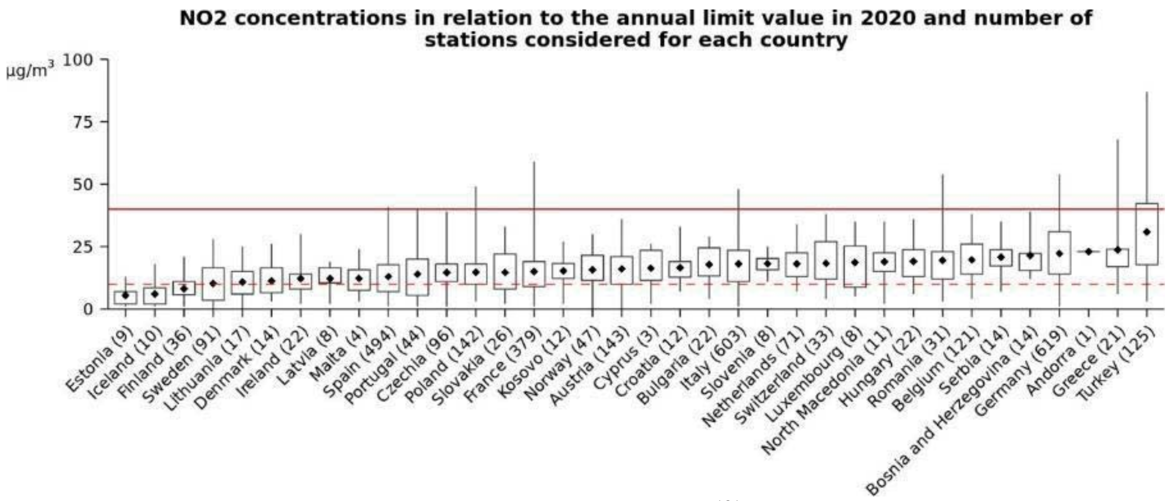


Figure A11.9 – 2020 annual mean NO_2 concentrations by country[181]

Figure A11.10 presents maps of NO_2 annual mean concentrations for the last four years.

Heatmaps resenting the evolution of NO_2 annual mean concentrations from 2000 to 2020 at country level are shown in Figure A11.11. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

[181] Note: The graph is based on the annual mean concentration values. For each country, the number of stations considered (in brackets) and the lowest, highest and average values (in µg/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The limit value set by EU legislation is marked by the horizontal line. The WHO Air Quality Guidelines level is marked by the lower dashed horizontal line.

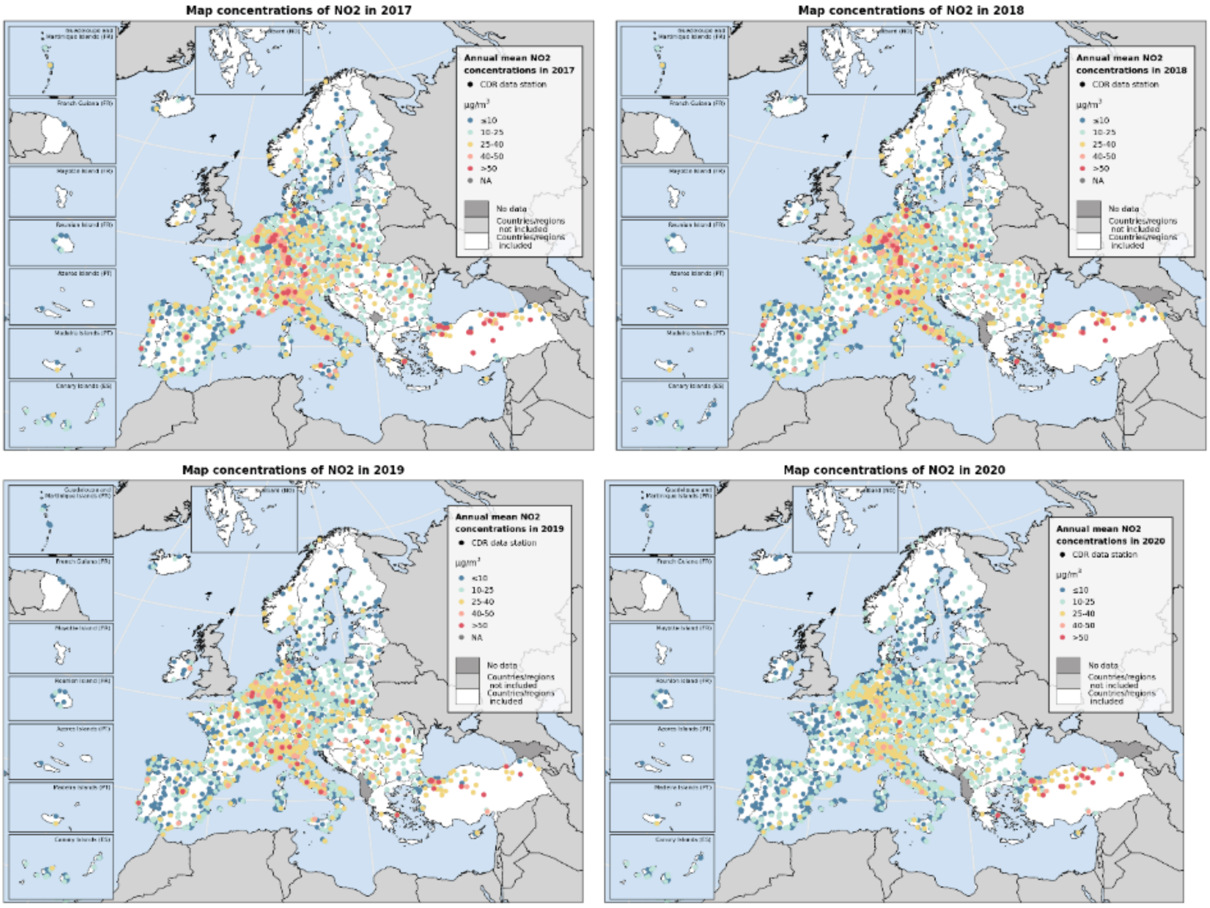


Figure A11.10 - NO_2 annual mean concentrations for 2017 to 2020

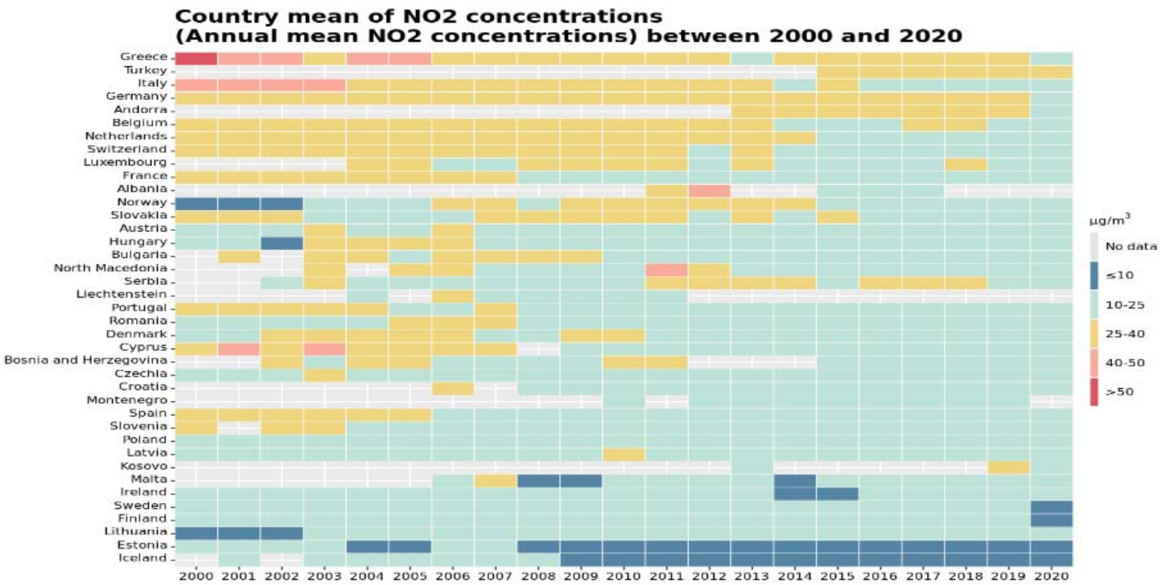


Figure A11.11 - Heatmaps showing the evolution of NO_2 annual mean concentrations from 2000 to 2020 at country level

b) *NO_2 daily and hourly mean concentration*

Concentrations above the daily NO_2 WHO Air Quality Guidelines level (25 µg/m^3) were registered in 78% (2 581 stations) of all the reporting stations in all EU Member States, as well as in nine other reporting countries (Figure A11.12).

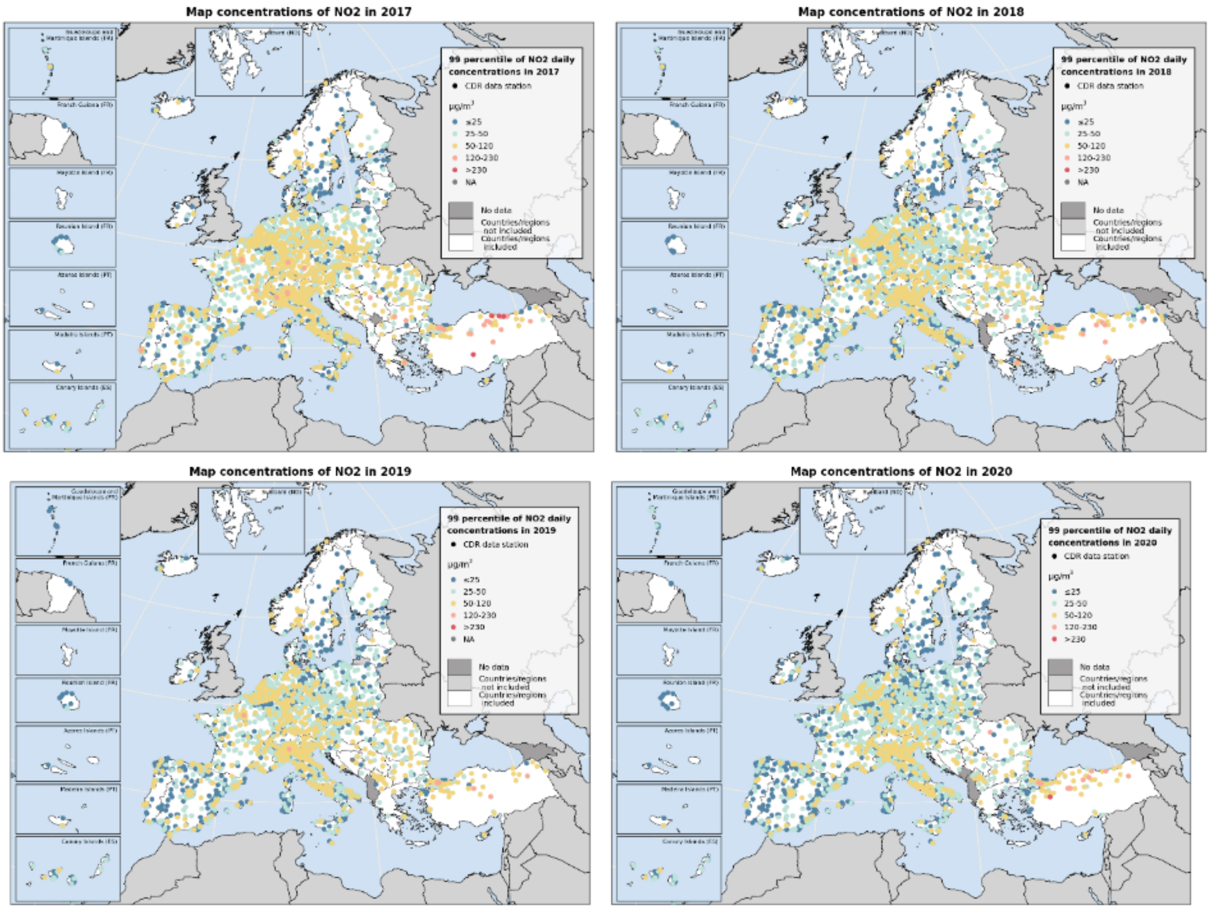


Figure A11.12 - NO_2 daily mean concentrations for 2017 to 2020

Concentrations above the hourly limit value (200 µg/m^3) were observed in only in Turkey, at 0.3% (ten stations) of all reporting stations, mostly at urban traffic stations.

3.3 Tropospheric ozone (O_3)

Data for O_3 were reported from 2 124 stations for the calculation of EU standards and from 2 008 stations for the long-term WHO Air Quality Guidelines.

a) O_3 peak season concentration

The long-term (peak season) WHO Air Quality Guidelines level (60 µg/m^3) was exceeded in 97% (1 950) of all stations located in 26 EU Member States and eight other reporting countries.

Figure A.1113 shows the maps of the peak season O_3 concentrations (equivalent to the long-term WHO Air Quality Guidelines level) from 2017 to 2020. In this way, significant changes in the spatial distribution of the values above the thresholds can be observed.

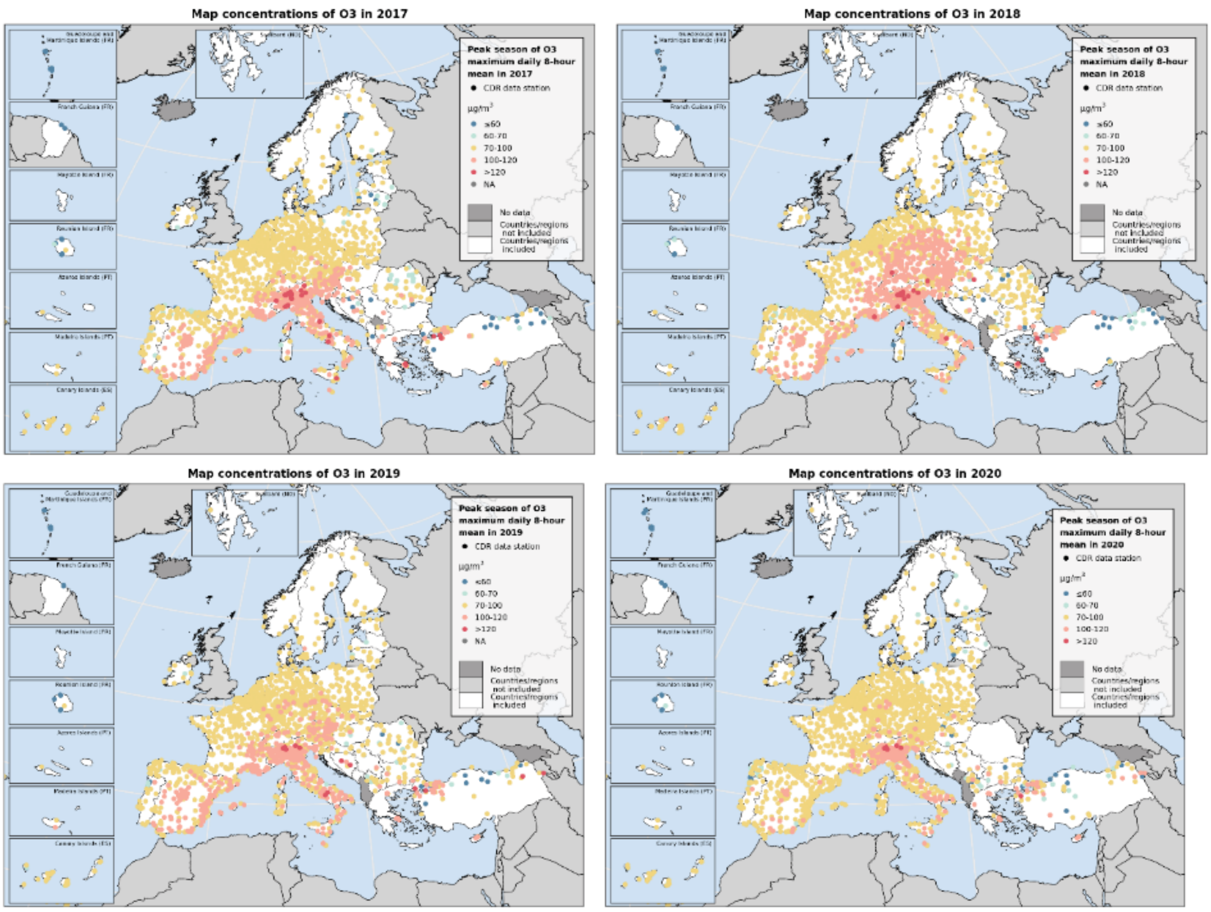


Figure A11.13 - peak season O_3 maximum daily 8-hour mean concentration for 2017 to 2020

Heatmaps presenting the evolution of the mean peak season O_3 concentrations from 2013 to 2020 at country level are shown in Figure A11.14. In this way, the evolution for year to year of the average measured concentration levels can be seen for each country. Note that meteorological variability has a considerable impact on year-to-year changes in ambient air concentrations of air pollutants.

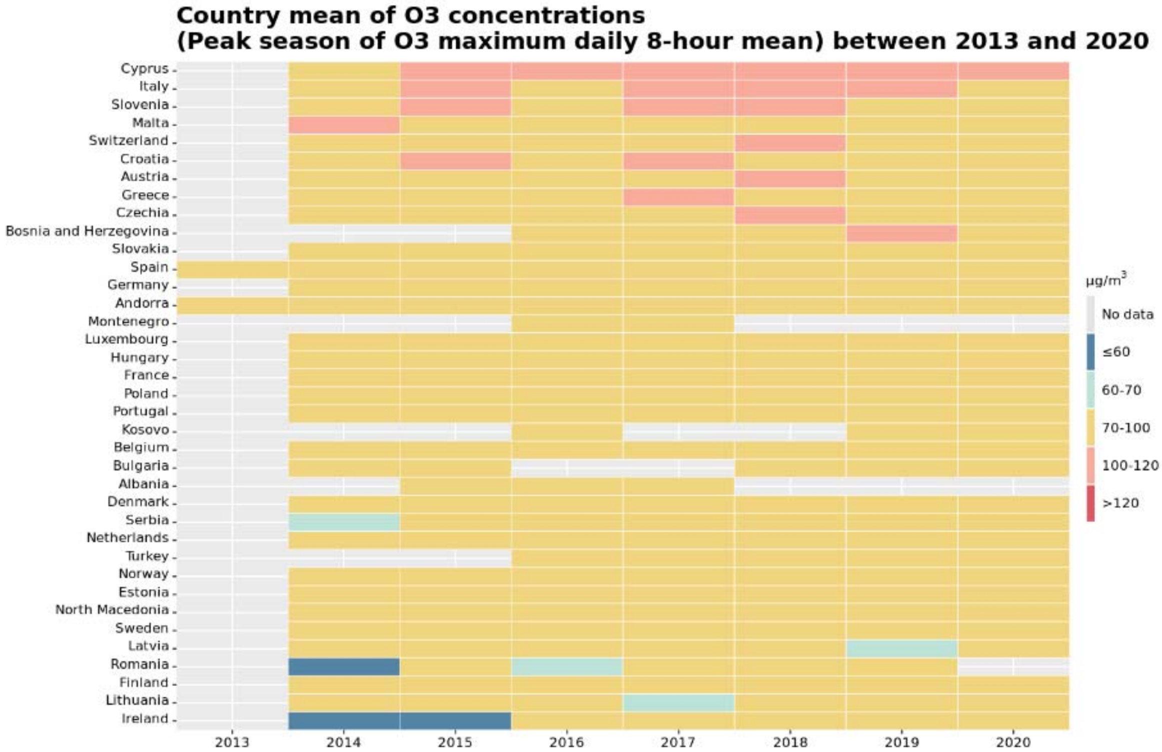


Figure 11.14 - Heatmaps presenting the evolution of the mean peak season O_3 concentrations from 2013 to 2020

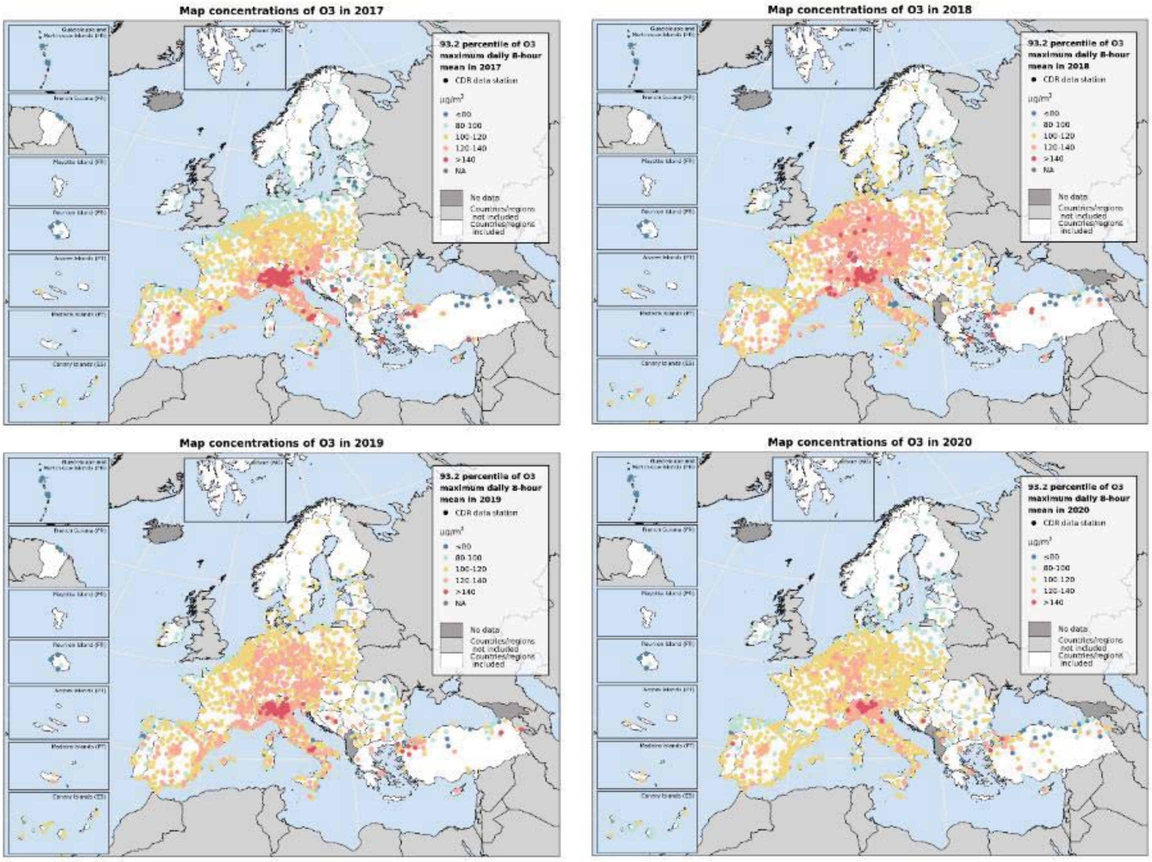
b) O_3 8-hour mean concentration

15 EU Member States and six other reporting countries registered concentrations above the O_3 target value (120 µg/m^3) more than 25 times. In total, 14% of all stations reporting O_3 showed concentrations above the target value for the protection of human health. In addition, only 19% (410) of all stations fulfilled the long-term objective (120 µg/m^3). 87% of the stations with values above the long-term objective were background stations.

Figure 11.15 shows the maps of the 93.2 percentile of the O_3 maximum daily 8-hour mean concentrations (O_3 target value) for the last four years. In this way, any significant change in the spatial distribution of values above thresholds can be observed.

200 (9%) of all stations measured values below the short-term WHO Air Quality Guidelines value for O_3 (100 µg/m^3). Only 27 of 539 rural background stations measured values below the short-term WHO Air Quality Guidelines value.

Figure 11.15 - O_3 maximum daily 8-hour mean concentrations by country for 2017 to 2020



3.4 Sulphur dioxide (SO_2)

The reporting countries reported measurements of SO_2 from 1 537 stations for the hourly limit value and 1 567 stations for the daily limit value.

a) SO_2 daily and hourly concentration

23 stations registered concentrations above the daily limit of 125 µg/m^3 for SO_2. In contrast, 7% (105) of all stations, located in 16 reporting countries, measured SO_2 concentrations above the WHO Air Quality Guidelines of 40 µg/m^3 for daily mean concentrations. Figure A11.16 shows the maps of the observed SO_2 daily mean concentrations from 2017 to 2020, allowing changes in the spatial distribution of values above the thresholds to be observed.

19 stations registered concentrations above the hourly limit value (350 µg/m^3).

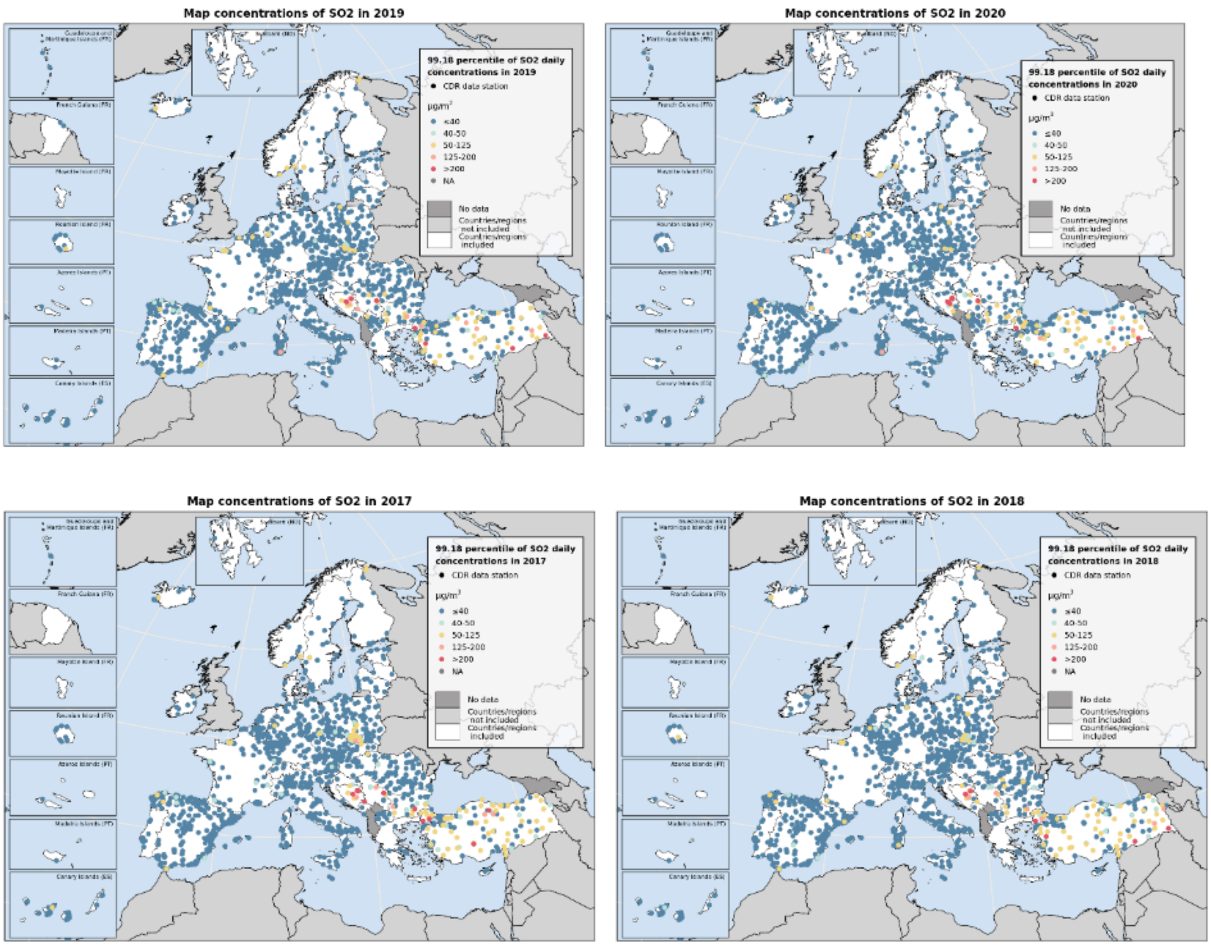


Figure A11.16 - SO_2 daily mean concentrations for 2017 to 2020

3.5 **Carbon monoxide (CO)**

Reporting countries measured CO data from 892 stations for the daily limit value and from 897 stations for the daily WHO Air Quality Guidelines.

a) CO 8-hour mean concentration

Only two stations (Figure A11.17) registered concentrations above the CO limit daily value (10 mg/m^3) and the WHO Air Quality Guidelines value for the maximum daily 8-hour mean, located outside EU Member States, in North Macedonia and Serbia.

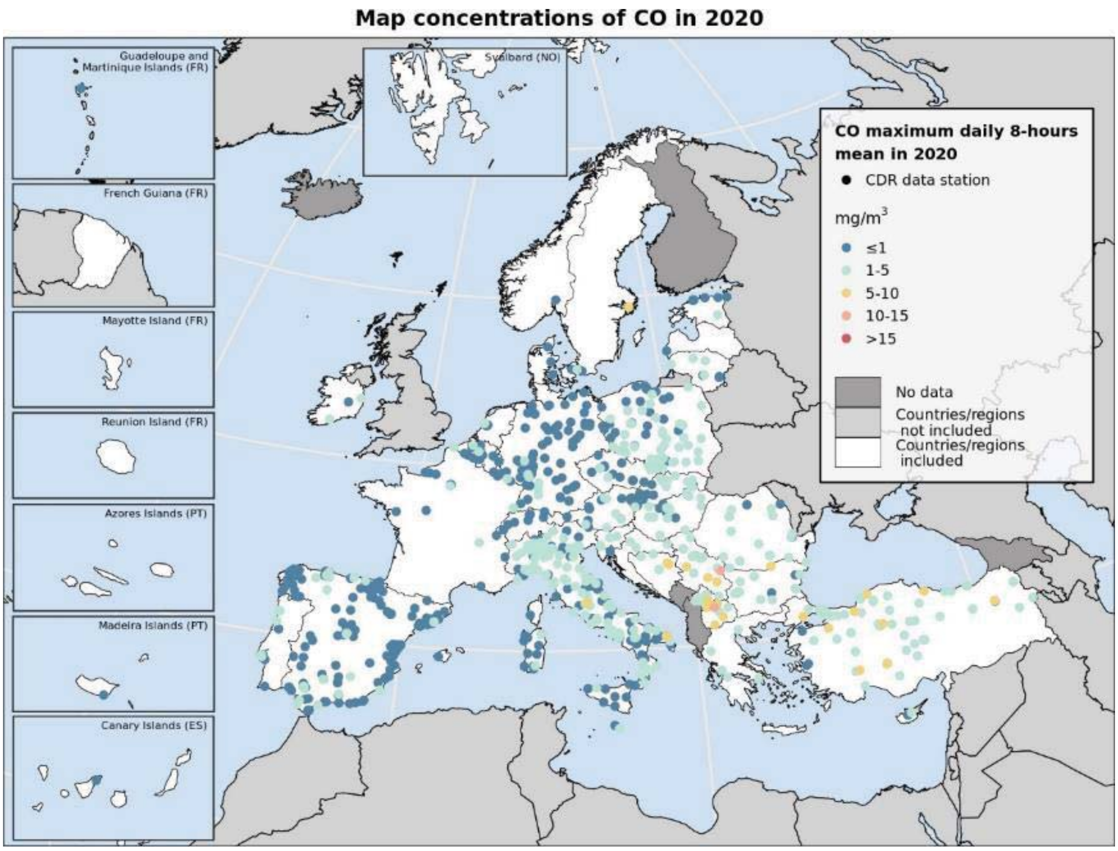


Figure A11.17 – CO maximum daily 8-hour mean in 2020

Concentrations above the daily WHO Air Quality Guidelines were measured at three stations, located in non EU Member States, namely: in Bosnia and Herzegovina (one), Kosovo (one) and North Macedonia (one).

Figure A11.18 shows the maps of the 99 percentile of CO daily mean concentrations (equivalent to the WHO Air Quality Guidelines for CO daily mean level) for the last four years. In this way, any significant change in the spatial distribution of the values above the set thresholds in the legends can be observed.

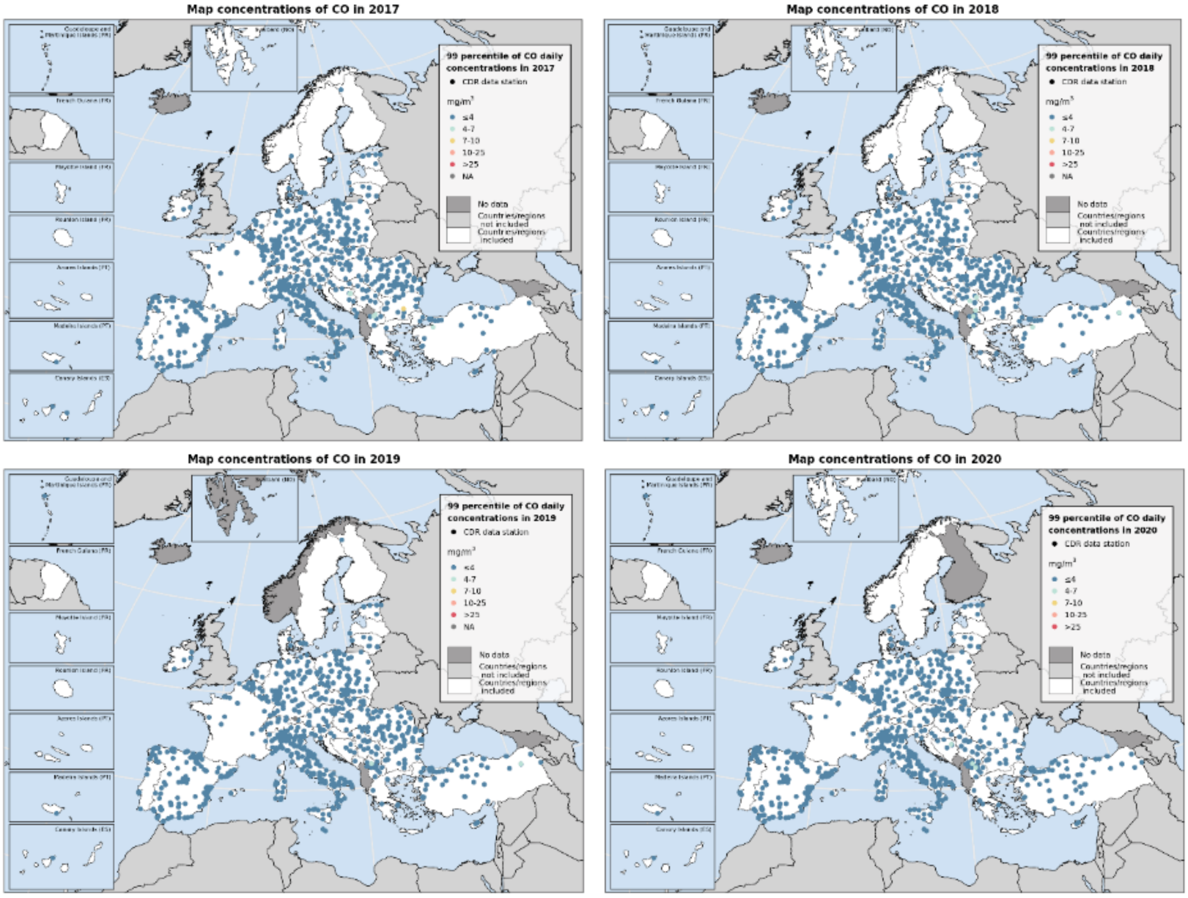


Figure A11.18 - CO daily mean concentrations for 2017 to 2020

3.6 Benzo(a)pyrene (BaP)

A total of 767 stations reported BaP data with sufficient data coverage.

a) BaP annual mean concentration

11 countries, all of which were EU Member States, registered values above 1.0 ng/m^3. Value above 1.0 ng/m^3 were measured at 27% of the reported BaP measurement stations, mainly at urban (79% of all stations with values above 1.0 ng/m^3) and suburban (15%) stations.

Regarding the WHO Air Quality Guidelines, all reporting countries, except for Cyprus, Malta and Sweden, had at least one station reporting concentrations above 0.12 ng/m^3. Only 20% of stations had annual concentrations below the reference level (Figure A11.19).

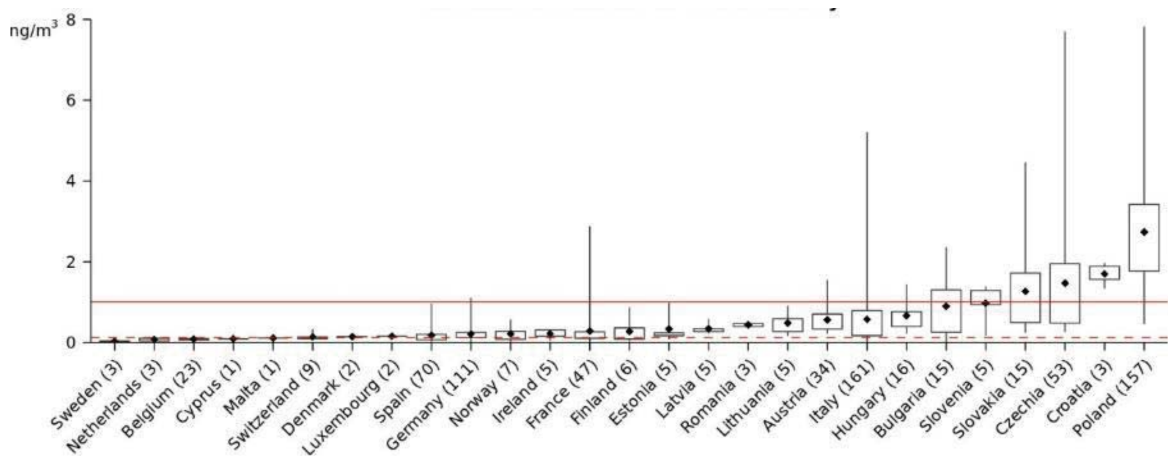


Figure A11.19 – 2020 BaP concentrations in relation to the annual limit value and WHO Air Quality Guidelines[182]

Figure A11.20 presents maps of the observed BaP annual mean concentrations from 2017 to 2020, allowing changes in the spatial distribution of the values above thresholds to be observed.

[182] Note: The graph is based on the annual mean concentration values. For each country, the number of stations considered (in brackets), and the lowest, highest and average values (in ng/m³) recorded at its stations are given. The rectangles mark the 25th and 75th percentiles. At 25% of the stations, levels are below the lower percentile; at 25% of the stations, concentrations are above the upper percentile. The upper horizontal line marks the concentration of 1.0 ng/m³. The lower horizontal line marks the estimated air quality RL. The highest value in the boxplot, Poland (18.4 ng/m³), has not been included in the graph for representation purposes.

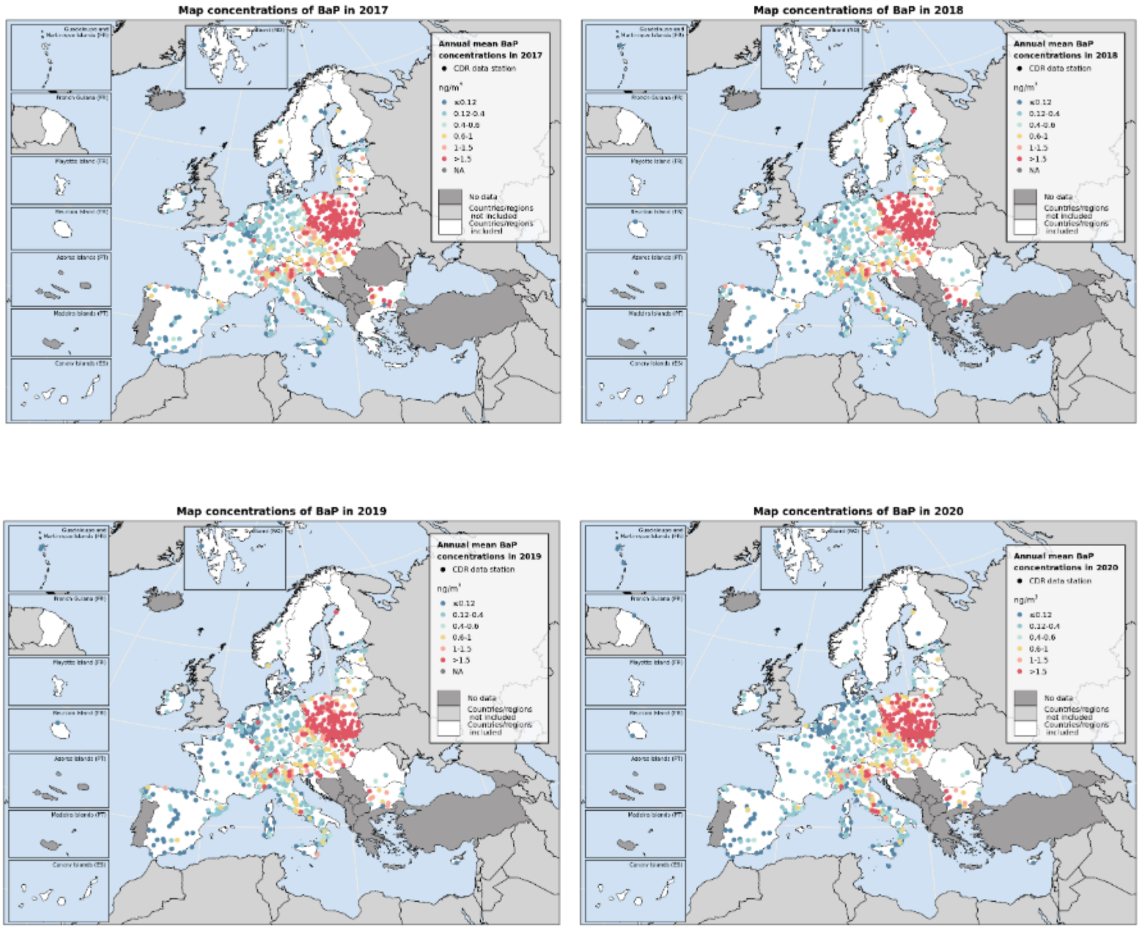


Figure A11.20 – Annual mean BaP concentrations for 2017 to 2020

3.7 Benzene (C_6H_6)

C_6H_6 measurements were reported from a total of 718 stations.

a) C_6H_6 annual mean concentration

As shown in Figure A11.21, concentrations above the limit value for C_6H_6 (5 µg/m^3) were not observed at any stations.

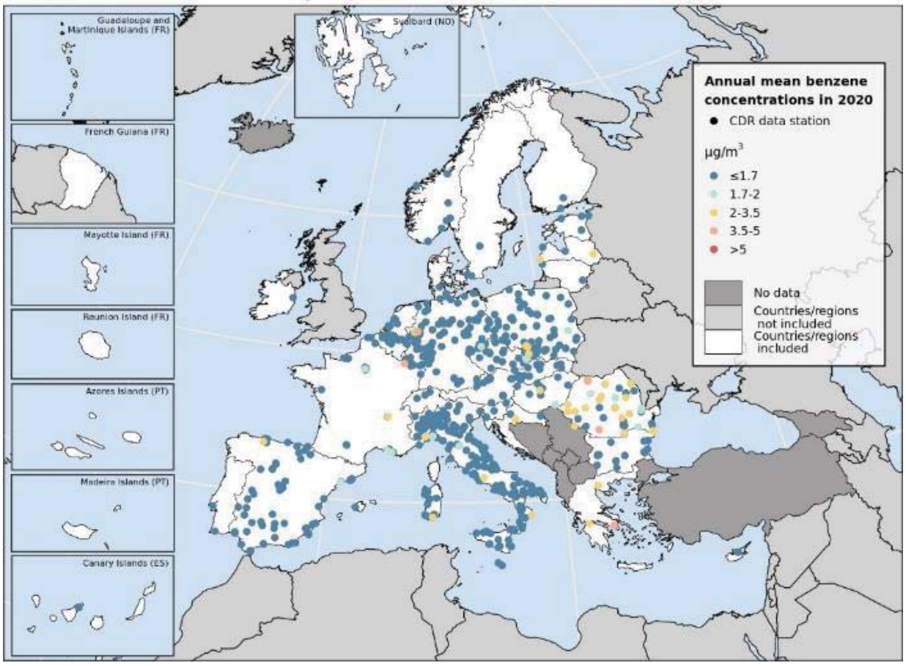


Figure A11.21 – Annual mean C_6H_6 concentrations in 2020

3.8 Lead (Pb)

Lead (Pb) data were reported from 675 stations.

a) Pb annual mean concentration

As shown in Figure A11.22, no stations reported Pb concentrations above the 0.5 µg/m^3 limit value.

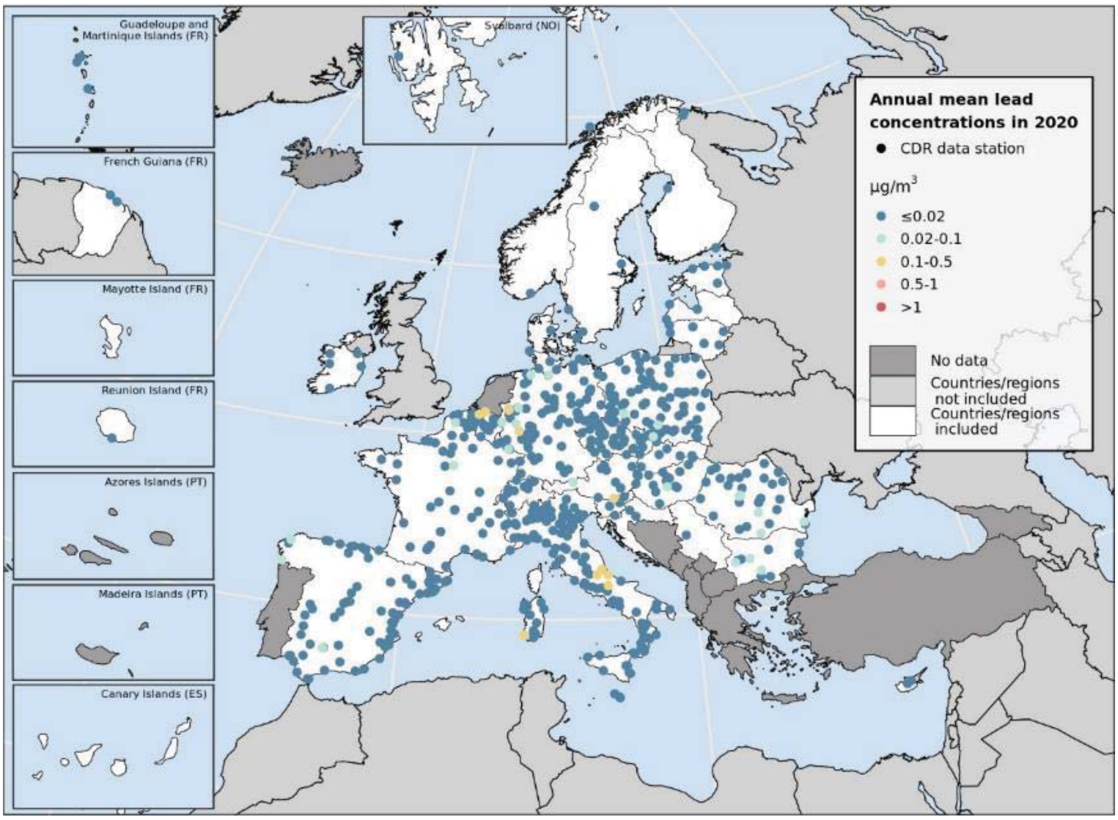


Figure A11.22 – Annual mean Pd concentrations in 2020

3.9 Arsenic (As)

Data for Arsenic (As) were reported from 661 stations.

a) *As annual mean concentration*

Seven stations measured concentrations above the target value of 6 ng/m^3. As shown in Figure A11.23, stations reporting concentrations above the target value were located in Belgium (three), Finland (two) and Poland (two). Four of these stations were industrial stations.

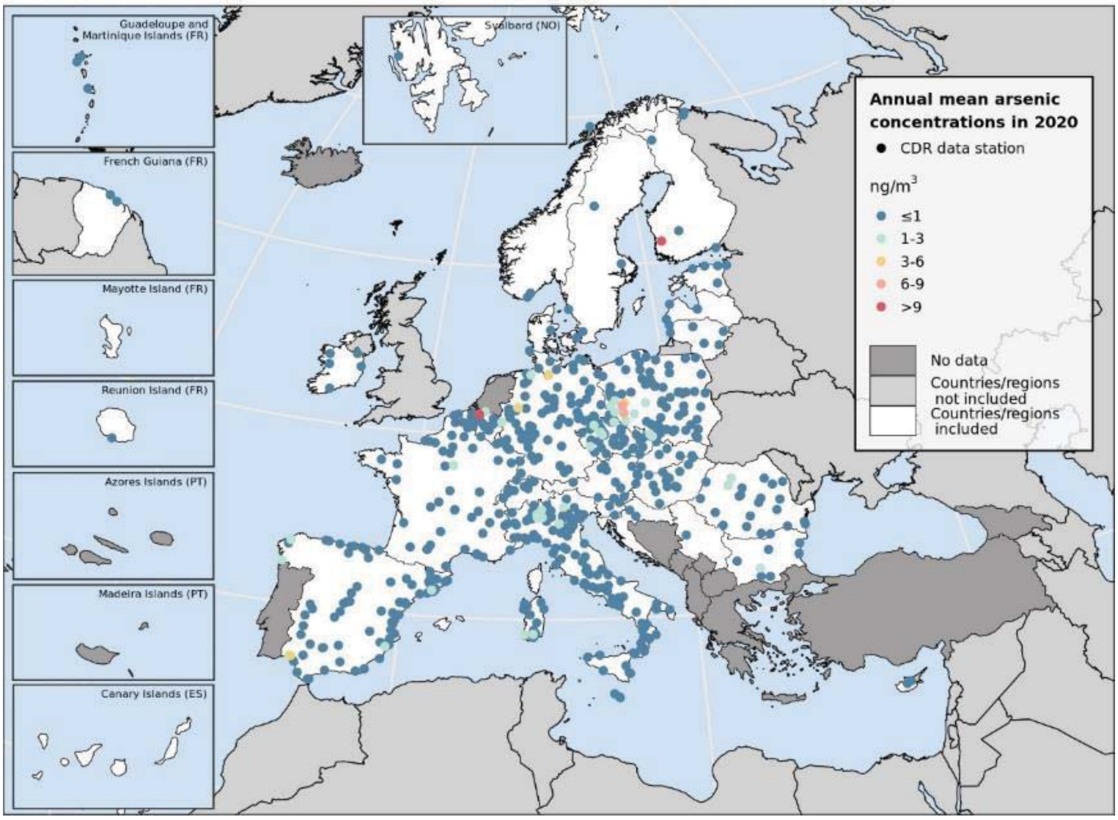


Figure A11.23 – Annual mean As concentrations in 2020

3.10 Cadmium (Cd)

Cadmium (Cd) data were reported from 680 stations.

b) Cd annual mean concentration

As shown in figure A11.24, concentrations above the target value of 5 ng/m^3 were measured at one station in Bulgaria.

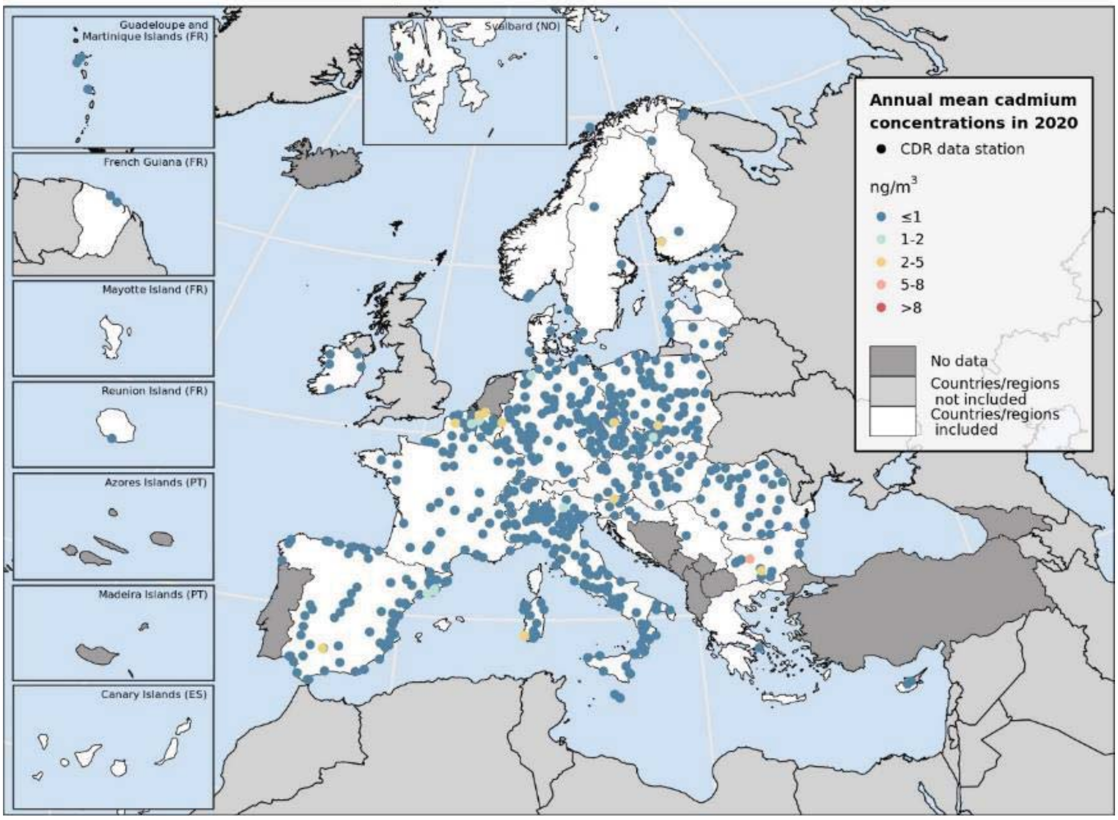


Figure A11.24 – annual mean Cd concentrations in 2020

3.11 Nickel (Ni)

Nickel (Ni) data were reported from 666 stations.

c) Ni annual mean concentration

As shown in Figure A11.25, concentrations were above the target value of 20 ng/m^3 were measured at two stations, one in Finland and one in France. Both of these stations were industrial stations.

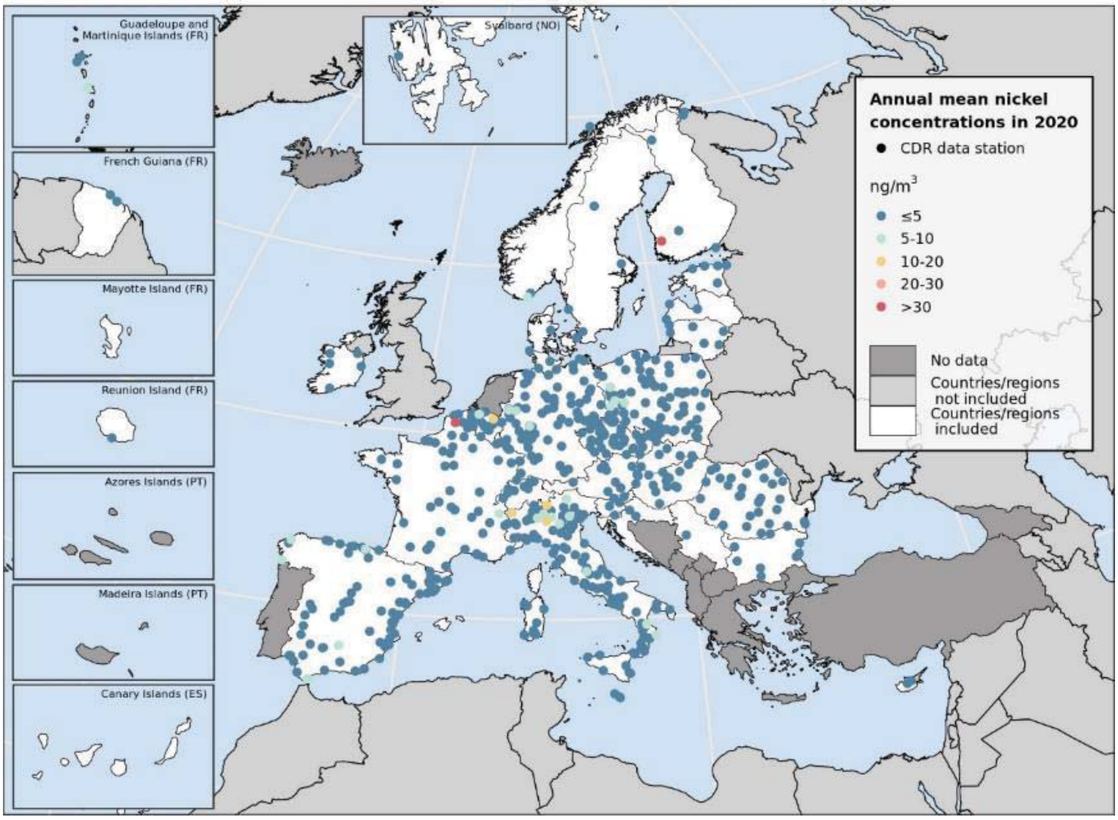


Figure A11.25 – Annual man concentrations of Ni in 2020

4. EXPOSURE TO AIR POLLUTION IN THE EU

In 2020, less than 1% of Europe's urban population was exposed to levels of $PM_{2.5}$ and NO_2 above EU legal standards in 2020, while 12% was exposed to O_3, and 11% to PM_{10}, levels above respective EU standards. Of note, 2020 concentrations of NO_2, PM_{10} and $PM_{2.5}$ fell as a direct result of reductions in road transport during COVID-19 lockdown measures, so reducing urban exposure to air pollution.

Nevertheless, poor air quality remains a problem, with 96% of the urban population in the EU exposed to levels of $PM_{2.5}$ above the latest health-based WHO Air Quality Guidelines. The figures for NO_2 and O_3 are 89% and 95%, respectively (see Figure A11.26).

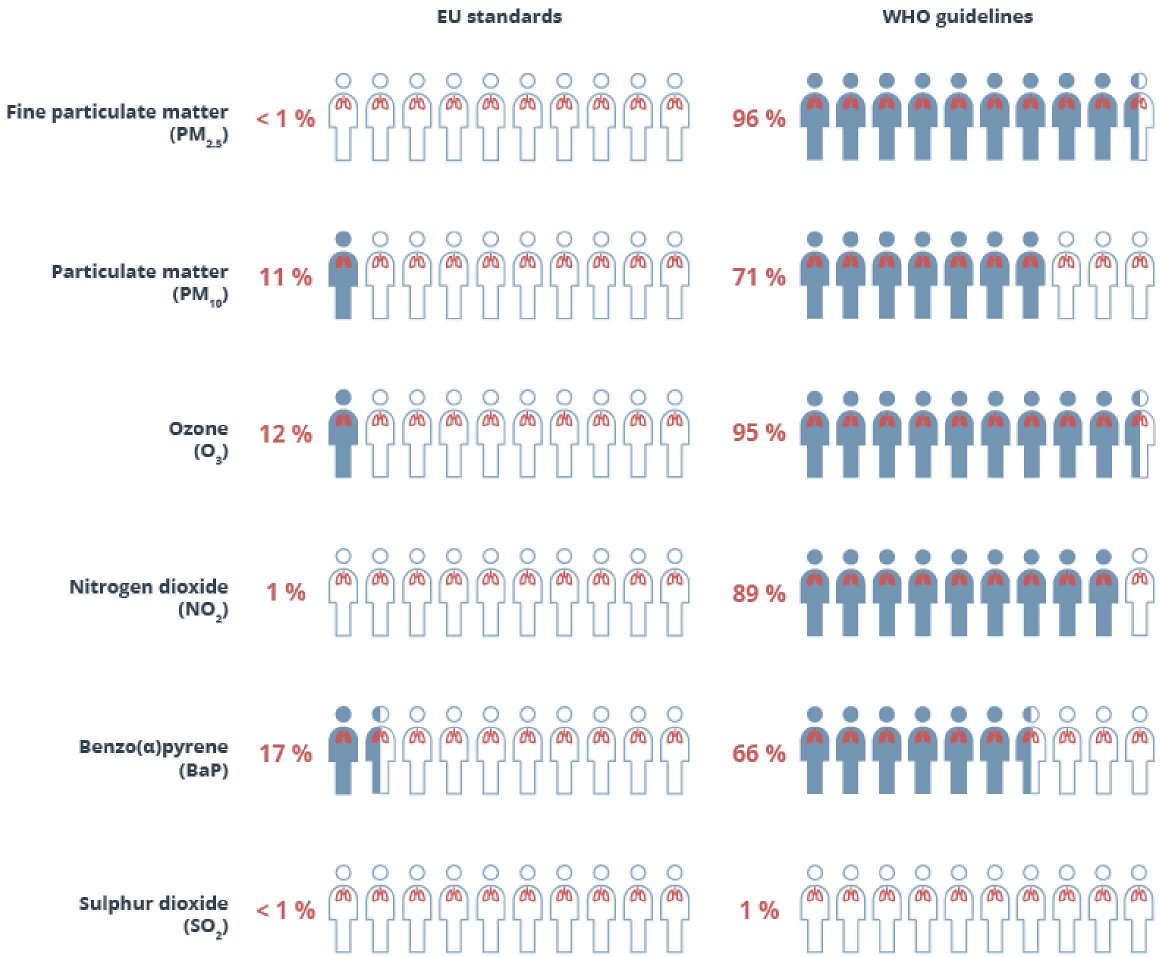


Figure A11.26 - Share of the EU urban population exposed to air pollutant concentrations above EU standards and WHO Air Quality Guidelines in 2020

ANNEX 12: INFRINGEMENT CASES AND LITIGATION UNDER THE AMBIENT AIR QUALITY DIRECTIVES

1. EU COURT PROCEEDINGS AGAINST MEMBER STATES FOR FAILURE TO FULFIL OBLIGATIONS UNDER AMBIENT AIR QUALITY LEGISLATION (2008 TO MAY 2022)

This section provides an overview of the cases referred to the Court of Justice of the EU based on the Ambient Air Quality Directives.

In a first wave of cases (2008 to 2012), the Commission initially decided to refer seven Member States to the Court of Justice of the EU on the basis of Article 258 TFEU due to exceedances of PM_{10} limit values: Italy, Portugal, Slovenia, and Sweden, as well as Cyprus, France and Spain.

The decision was executed only against the first four of the above Member States. Judgments delivered by the Court of Justice of the EU in these four cases (Table A12.1) confirmed the violations for a specific period in the past, but did not address the lack of appropriate measures to keep exceedance periods as short as possible.

The Commission saw a need to also address the absence or insufficiency of the measures dealing with the different sources of PM_{10} pollution. Accordingly, the earlier decisions regarding the other three Member States (Cyprus, Spain and France) were not confirmed at the time, as the Commission considered necessary to review its strategy.

Table A12.1 – Period 2008 to 2012: Focus on breaches of limit values over a given period, based on Directive 1999/30/EC (i.e. former First Daughter Directive)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Italy	C-68/11	2008/2194	PM_{10}	Infringement established (EU:C:2012:815)
Portugal	C-34/11	2008/2200	PM_{10}	Infringement established (EU:C:2012:712)
Slovenia	C-365/10	2008/2202	PM_{10}	Infringement established (EU:C:2011:183)
Sweden	C-479/10	2008/2204	PM_{10}	Infringement established (EU:C:2011:287)

A second wave of infringement procedures on the basis of Article 258 TFEU was initiated and resulted in a number of referrals to and judgments of the Court of Justice of the EU, in the period 2013 to 2022 (Table A12.2).

In 2020, the Commission also decided to refer a Member State to the Court of Justice of the EU on the basis of Article 260 TFEU, i.e. for failing to take the necessary measures to remedy a previously established infringement by the Court of Justice of the EU (Table A12.3).

Table A12.2 – Period 2013 to 2022: Focus on persistent breaches of limit values and the lack of adequacy of the measures aimed at attaining compliance (based on Directive 2008/50/EC, i.e. Ambient Air Quality Directive)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Bulgaria	C-488/15	2010/2109	PM_{10}	Infringement established (EU:C:2017:267)
Bulgaria	C-730/19	2009/2135	SO_2	Infringement established (EU:C:2022:382)
Germany	C-635/18	2015/2073	NO_2	Infringement established (EU:C:2021:437)
Greece	C-70/21	2008/2192	PM_{10}	*Pending case*
Greece	C-633/21	2018/2361	NO_2	*Pending case*
Spain	C-125/20	2015/2053	NO_2	*Pending case*
France	C-636/18	2015/2074	NO_2	Infringement established (EU:C:2019:900)
France	C-286/21	2008/2190	PM_{10}	Infringement established (EU:C:2022:319)
Italy	C-644/18	2014/2147	PM_{10}	Infringement established (EU:C:2020:895)
Italy	C-573/19	2015/2043	NO_2	Infringement established (EU:C:2022:380)
Hungary	C-637/18	2008/2193	PM_{10}	Infringement established (EU:C:2021:92)
Poland	C-336/16	2008/2199	PM_{10}	Infringement established (EU:C:2018:94)
Portugal	C-220/22	2015/2045	NO_2	*Pending case*
Romania	C-638/18	2009/2296	PM_{10}	Infringement established (EU:C:2020:334)
Slovakia	C-342/21	2008/2201	PM_{10}	*Pending case*
Other	**Case**	**Infringement Case no.**	**Pollutant**	**Judgment**
United Kingdom	C-664/18	2014/4000	NO_2	Infringement established (EU:C:2021:171)

Table A12.3 – Cases brought on the basis of Article 260 TFEU (failure to take the necessary measures to comply with a judgment of the Court of Justice of the EU)

Member State	Case	Infringement Case no.	Pollutant	Judgment
Bulgaria	C-174/21	2010/2109	PM_{10}	*Pending case*

2. Infringement cases initiated by the Commission for non-compliance with ambient air quality legislation (2008 to May 2022)

This section provides an overview of the infringement cases initiated on the basis of Article 258 TFEU and/or Article 260 TFEU during the assessment period, either for excessive NO_2 (Table A12.3), excessive PM_{10} and/or $PM_{2.5}$ (Table A12.4), excessive SO_2 (Table A12.5), or related to monitoring insufficencies (Table A12.6).

Table A12.4 – Infringement cases for excessive nitrogen dioxide (NO_2)

Member State	Case no.	Current status
Belgium	2016/2005	Reasoned Opinion (February 2021)
Czechia	2016/2062	Reasoned Opinion (February 2021)
Denmark	2016/2080	Closure (November 2019)
Germany	2015/2073	Judgment establishing infringement (June 2021) (see table A12.2)
Greece	2018/2361	Referral to Court (July 2021) (see table A12.2)
Spain	2015/2053	Referral to Court (July 2019) (see table A12.2)
France	2015/2074	Judgment establishing infringement (October 2019) (see table A12.2) Letter of formal notice (Art. 260 TFEU) (December 2020)
Italy	2015/2043	Judgment establishing infringement (May 2022) (see table A12.2)
Luxembourg	2017/2101	Letter of formal notice (October 2017)
Hungary	2016/2085	Letter of formal notice (July 2016)
Austria	2016/2006	Letter of formal notice (February 2016)
Poland	2016/2010	Reasoned Opinion (February 2021)
Portugal	2015/2045	Referral to Court (November 2021) (see table A12.2)
Romania	2020/2206	Letter of formal notice (May 2020)
Other	**Case no.**	**Current status**
United Kingdom	2014/4000	Judgment establishing infringement (March 2021) (see table A12.2)

Table A12.5 – Infringement cases for excessive particulate matter (PM_{10} and/or $PM_{2.5}$)

Member State	Case no.	Current status
Belgium	2008/2184	Closure (November 2018)
Bulgaria	2010/2109	Judgment establishing infringement (April 2017) (see table A12.2) Referral to Court (Art. 260 TFEU) (December 2020) (see table A12.3)
Czechia	2008/2186	Additional Reasoned Opinion (March 2015)
Denmark	2008/2187	Closure (June 2010)
Germany	2008/2191	Closure (April 2022)
Estonia	2008/2188	Closure (May 2011)
Greece	2008/2192	Referral to Court (December 2020) (see table A12.2)
Spain	2008/2203	Additional Reasoned Opinion (October 2014)
France	2008/2190	Judgment establishing infringement (April 2022) (see table A12.2)
Croatia	2020/2298	Reasoned Opinion (May 2022)

Italy	*2008/2194* 2014/2147	*Judgment establishing infringement based on Directive 1999/30/EC (December 2012) (see table A12.1) Closure (June 2013)*** Judgment establishing infringement (November 2020) (see table A12.2)
Italy	2020/2299	Letter of formal notice (October 2020)
Cyprus	2008/2185	Closure (February 2012)
Latvia	2008/2195	Closure (May 2020)
Hungary	2008/2193	Judgment establishing infringement (February 2021) (see table A12.2)
Malta	2008/2197	Closure (September 2010)
Austria	2008/2183	Closure (April 2015)
Poland	2008/2199	Judgment establishing infringement (February 2018) (see table A12.2) Letter of formal notice (Art. 260 TFEU) (July 2019)
Portugal	*2008/2200* 2013/2135	*Judgment establishing infringement based on Directive 1999/30/EC (November 2012) (see table A12.1) Closure (June 2013)*** Closure (July 2020)
Romania	2009/2296	Judgment establishing infringement (April 2020) (see table A12.2)
Slovenia	*2008/2202* 2012/2212	*Judgment establishing infringement based on Directive 1999/30/EC (March 2011) (see table A12.1) Closure (October 2011)*** Reasoned Opinion (May 2020)
Slovakia	2008/2201	Referral to Court (February 2021) (see table A12.2)
Sweden	*2008/2204* 2012/2216	*Judgment establishing infringement based on Directive 1999/30/EC (May 2011) (see table A12.1) Closure (October 2011)*** Reasoned opinion (June 2015)
Other	**Case no.**	**Current status**
United Kingdom	2008/2205	Closure (February 2013)

*** The case was closed due to a change of legal basis; a new case was initiated to accommodate for this.*

Table A12.6 – Infringement cases for excessive sulphur dioxide (SO_2)

Member State	Case no.	Current status
Bulgaria	2009/2135	Judgment establishing infringement (May 2022) (see table A12.2)
Czechia	2009/2136	Closure (January 2010)
Spain	2007/2180	Closure (June 2010)
France	2007/2181	Closure (November 2010)
Italy	2007/2182	Closure (May 2009)
Poland	2009/2137	Closure (January 2011)
Portugal	2009/2138	Closure (May 2011)
Romania	2009/2337	Closure (November 2013)

Slovenia	2007/2183	Closure (November 2008)
Other	**Case no.**	**Current status**
United Kingdom	2007/2184	Closure (May 2008)

Table A12.7 – Infringement cases related to the monitoring network

Member State	Case no.	Current status
Romania	2017/2024	Additional letter of formal notice (July 2019)
Slovakia	2017/2116	Closure (May 2022)

3. Selected case law of the Court of Justice of the EU related to the implementation of the Ambient Air Quality Directives

C-237/07, Janecek (EU:C:2008:447) - Entitlement of a third party, whose health has been impaired, to have an action plan drawn up

The case involved a dispute between Mr Dieter Janecek and Bavaria, over excessive PM_{10} pollution in the city of Munich. Mr Janecek filed a lawsuit, requesting an air quality plan to address the exceedances. The question was raised via a preliminary reference whether he would have such a right, based on the Air Quality Framework Directive (Directive 96/62/EC) applicable at the time.

The Court of Justice of the EU decided that where there is a risk that the emission limit values in respect of particulate matter PM_{10} or alert thresholds may be exceeded, persons directly concerned must be in a position to require the competent national authorities to draw up an action plan. This applies even in cases where, under national law, those persons may have other courses of action available to them for requiring those authorities to take measures to combat atmospheric pollution.

Furthermore, Member States are obliged, subject to judicial review by the national courts, to take measures – in the context of an action plan and in the short term – that are capable of reducing to a minimum the risk that the emission limit values in respect of particulate matter PM_{10} or alert thresholds may be exceeded.

C-404/13, ClientEarth (EU:C:2014:2382) - National courts' obligation to ensure an air quality plan is established in case of exceedances

Due to excessive nitrogen dioxide (NO_2) pollution in many zones in the UK, the environmental organisation 'ClientEarth' brought a claim in front of UK courts, seeking an order requiring the Secretary of State for the Environment, Food and Rural Affairs to revise the air quality plans to ensure that they demonstrate how conformity with the nitrogen dioxide limit values will be achieved as soon as possible. One of the questions raised via a preliminary reference was related to remedies that national courts must provide in cases like this one.

In its decision, building up on the *Janecek* judgment (see above), the Court of Justice of the EU decided that where a Member State has failed to comply with limit and target values under Directive 2008/50/EC, it is for the national court having jurisdiction, should a case be brought before it, to take, with regard to the national authority, any necessary measure, such as an order in the appropriate terms, so that the authority establishes the plan required by the directive in accordance with the conditions laid down by the latter.

As regards the content of the plan, while Member States have a degree of discretion in deciding which measures to adopt, those measures must, in any event, ensure that the period during which the limit values are exceeded is as short as possible.

C-723/17, Craeynest (EU:C:2019:533) - Locating sampling points and establishing exceedances

A number of residents of the Belgian Brussels-Capital Region and the environmental organisation 'ClientEarth' were in dispute with the Brussels competent authorities as to whether an adequate air quality plan had been established for the Brussels zone. In that regard, the court in Brussels deciding on the dispute asked the Court of Justice of the EU to give interpretation on the relevant provisions of Directive 2008/50/EC. It sought to clarify, first, the extent to which national courts may review the siting of sampling points and, second, whether the results from different sampling points may be averaged in order to assess compliance with the limit values.

Building up on the above case law, the Court of Justice of the EU decided that it is for a national court, hearing an application submitted for that purpose by individuals directly affected by the exceedance of the limit values from Directive 2008/50/EC, to verify whether the sampling points located in a particular zone have been established in accordance with the criteria laid down in that directive (i.e. that the sampling points are placed in areas where the highest concentrations occur) and, if they were not, to take all necessary measures in respect of the competent national authority, such as, if provided for by national law, an order, with a view to ensuring that those sampling points are sited in accordance with those criteria. Furthermore, in order to establish whether a limit value with an averaging period of one calendar year has been exceeded, it is sufficient that a pollution level higher than that value be measured at a single sampling point, and in that case the obligation to draw up an air quality plan is triggered.

C-752/18, Deutsche Umwelthilfe (EU:C:2019:1114) - Enforcement of obligations against competent authorities

The case involved a dispute between the NGO 'Deutsche Umwelthilfe' (a German non-governmental environmental protection organisation) and the Land of Bavaria concerning the latter's persistent refusal to adopt, in implementation of Directive 2008/50/EC, the measures necessary in order for the limit value set for nitrogen dioxide (NO_2) to be complied with in the city of Munich. Following several court orders (one in 2011, one in 2016 and one in 2017) requiring Bavaria to amend its air quality action plan applicable in Munich and imposing financial penalties, Bavaria nevertheless refused to observe those injunctions. Following which, Deutsche Umwelthilfe brought a new action seeking, *inter alia*, the coercive detention of the persons at the head of the Land of Bavaria (namely of the Minister for the Environment and Consumer Protection or, failing that, of the Minister-President). The Higher Administrative Court of Bavaria decided to request a preliminary ruling from the Court of Justice of the EU regarding whether EU law had to be interpreted as empowering, or even obliging, the national courts to order coercive detention.

The Court of Justice of the EU held that, in circumstances in which a national authority persistently refused to comply with a judicial decision enjoining it to perform a clear, precise and unconditional obligation flowing from EU law, in particular from Directive 2008/50/EC, it was incumbent upon the national court having jurisdiction to order the coercive detention of persons at the head of the Land of Bavaria provided that two conditions were met. First, domestic law must contain a legal basis for adopting such a measure which is sufficiently accessible, precise and foreseeable in its application in order to avoid all risk of arbitrariness. Second, the principle of proportionality must be observed. In this regard, the Court of Justice of the EU stated that, since the ordering of coercive detention entails a deprivation of liberty, recourse may be had to such an order only where there are no less restrictive measures (such as, in particular, high financial penalties that are repeated after a short time and the payment of which does not ultimately benefit the budget from which they are funded). It is for the national court to ascertain whether these two conditions are met. If those two conditions were to be met, EU law would not only authorise, but require, recourse to a measure such as coercive detention.

C-177/19, Germany - Ville de Paris and Others v Commission; C-178/19 P, Hungary - Ville de Paris and Others v Commission and C-179/19 P, Commission v Ville de Paris and Others (three appeals) (EU:C:2022:10) - Annulment of EU type approval provisions - Powers of a municipal authority in the field of air quality to limit the circulation of certain vehicles (discussed under admissibility)

The City of Paris, the City of Brussels and the Municipality of Madrid ('the respondents') each brought an action for annulment of Commission Regulation (EU) 2016/646 ('the contested regulation') which sets limit values for emissions of oxides of nitrogen which must not be exceeded during real driving emissions tests, in so far as it prevented them from imposing restrictions on the circulation of passenger vehicles in relation to their pollutant emissions. Those actions were partially upheld by the General Court, which held that the contested regulation was of direct concern to the applicant cities and that the action was therefore admissible.

Ruling on appeals brought by the Federal Republic of Germany (Case C-177/19 P), Hungary (Case C-178/19 P) and the Commission (Case C-179/19 P), the Court of Justice of the EU set aside the judgment of the General Court. The Court of Justice of the EU held that the interpretation given by the General Court of Directive 2007/46/EC (i.e. the Framework Directive on which the contested regulation is based) was too broad in scope by concluding that it precludes certain local restrictions on circulation which are intended, inter alia, to protect the environment. Such an interpretation is not consistent with the context, the objectives and the legislative history of Directive 2007/46/EC.

Consequently, the Court of Justice of the EU concluded that the General Court erred in law in holding that the contested regulation is of direct concern to the applicant cities. As regards the applicant cities' concerns with regard to the possibility of infringement proceedings being brought against one of the Member States to which they belong for infringement of the contested regulation, the Court of Justice of the EU pointed out that the adoption of legislation limiting the local circulation of certain vehicles for the purposes of protecting the environment is not liable to infringe the prohibition imposed by the contested regulation, with the result that it cannot have a direct effect on any action for failure to fulfil obligations. In the light of the foregoing, the Court of Justice of the EU sets aside the judgment under appeal and, considering that the state of the proceedings so permits, gives final judgment in the matter, dismissing the actions for annulment brought by the applicant cities as inadmissible.

C-61/21, JP / Ministre de la Transition écologique, Premier ministre - Right of individuals to compensation for damage to health from air pollution [183]

The underlying case concerns a proceeding in which a citizen requested the prefect of Val-d'Oise to take measures to resolve his health problems linked to environmental pollution (i.e. establishment of an air quality plan that ensures respecting air quality limit values) and the French state to pay compensation for damage to his health. The request for a preliminary ruling had been referred to the Court of Justice of the EU by the Cour administrative d'appel de Versailles (France) and regards the interpretation of Articles 13(1) and 23(1) of Directive 2008/50/EC, namely (1) whether these provisions entitle individuals, in case of a serious breach by a Member State, to claim compensation for health damage from that Member State; and (2) what the conditions would be for such an entitlement, in particular with regard to the date on which the existence of the failure attributable to the Member State concerned must be assessed.

In her Opinion of 5 May 2022, the Advocate General takes the view that an infringement of limit values set under Directive 2008/50/EC may give rise to entitlement to compensation from the State under the classic conditions for State liability. In particular, the first condition of state liability is satisfied since the limit values for pollutants in ambient air and the obligations to improve air quality laid down by EU directives were intended to confer rights on individual. The Advocate General's Opinion is not binding on the Court of Justice of the EU. The judgment will be delivered at a later date.

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[183] Note that this case is still pending at the time of drafting of this document.

C-375/21, Sdruzhenie "Za Zemyata – dostap do pravoadie" - Link between obligations under Directive 2008/50/EC and Directive 2010/75/EU [184]

The underlying case concerns proceedings before the Supreme Administrative Court of Bulgaria in which the association Sdruzhenie 'Za Zemiata – dostap do pravosadie' ('For the Earth – Access to Justice' Association) and other non-profit civil associations brought appeals in cassation against the judgment of the Administrative Court of Stara Zagora of 28 August 2020, by which the first association's action against the decision of the Executive Director of the Executive Agency for the Environment of 21 December updating Integrated Permit No 50/2005 issued to the Maritsa-iztok 2 EAD thermal power plant located in the village of Kovachevo, municipality of Radnevo, administrative district of Stara Zagora, was dismissed. The Supreme Administrative Court of Bulgaria referred three preliminary questions to the Court of Justice of the EU.

All the three questions ask the Court of Justice of the EU to clarify the link between Directive 2010/75/EU and Directive 2008/50/EC. More precisely, the referring Court is seeking confirmation whether, when considering a request for a BAT derogation under Article 15(4) of Directive 2010/75/EU, the competent national authorities should be guided by the purpose of achieving compliance with the limit values set by Directive 2008/50/EC and, in the event of exceedances – be limited by the measures included in the air quality plans, established pursuant to Article 23 of Directive 2008/50/EC, and whether it must refrain from granting a derogation if less stringent emission limit values for air pollutants from a the installation would contribute to the exceedance

4. ILLUSTRATIVE OVERVIEW OF CLEAN AIR CASES BEFORE NATIONAL COURTS

This illustrative overview gives an updated overview of clean air cases before national Courts similar as presented in Annex 6 of the Commission's Fitness Check of the Ambient Air Quality Directives (2019).[185] *This update is based on articles published on public websites of national judiciary and/or NGOs.*

Austria: The Austrian Administrative Court (Österreichischer Verwaltungsgerichtshof), ruled in February 2018 that based on the Aarhus Convention environmental NGOs can order a review of compliance with the legal provisions arising from EU environmental law. Moreover, the Austrian Administrative Court ruled in September 2019 that an individual has the right to apply for the establishment of sampling points in conformity with Directive 2008/50/EC to check compliance with limit values and, subsequently, ruled in October 2021 that such an application does not require the individual to demonstrate direct concern. [186]

Belgium: In December 2021, the Brussels Court of Appeal (Hof van beroep Brussel) ruled in favour of Greenpeace and condemned the Flemish government for its deficient policy against air pollution. The Court concluded that the Flemish government failed to set up an air quality

[184] Note that this case is still pending at the time of drafting of this document.
[185] Deutsche Umwelthilfe (2019), 'Legal Actions for Clean Air' (accessed: 10/06.2022)
[186] Austrian Administrative Court, Direct concern under the Air Quality Directive and application for the establishment of sampling points and EU Air Quality Directive: An application for the establishment of sampling points in conformity with the Directive does not require direct concern (accessed: 10/06.2022)

plan in accordance with Article 23 of Directive 2008/50/EC. It thereby confirmed the financial penalty that was imposed on the government by two prior judgments of the Brussels Court of First Instance (10/10/2018 and 08/07/2020) and that amounted to 850 000 EUR.[187]/[188]

Bulgaria: In June 2019, the Supreme Administrative Court of Bulgaria (Върховният административен съд) denied legal standing to residents and NGOs to appeal city air quality plans for the period 2015-2020.[189] Additionally, in January 2021, the Supreme Administrative Court of Bulgaria rejected the appeal of the Bulgarian NGO Za Zemiata (Friends of the Earth) against the city of Sofia's air quality plan for the period 2021-2026.[190] Both times, the Court held that air quality plans do not affect the rights, freedoms or legitimate interests of citizens or legal entities. This ruling is final, no national remedies against this ruling are available.

Czech Republic: In several cases in the Czech Republic, administrative courts have annulled air quality plans because of their lack of effectiveness. In December 2017, the Supreme Administrative Court (Nejvyšší správní soud České republiky) rejected the air quality plan for the agglomeration of Ostrava as not being appropriate. In February 2018, Prague's Municipal Court (Městský soud v Praze) revoked the city's air quality plan because it was deemed unfit to serve its purpose, i.e. swift achievement of binding air quality standards.[191] Additionally in February 2018, the Supreme Administrative Court revoked the air quality plan for the region of Usti referring to low effectiveness.[192] In May 2018, the Supreme Administrative Court revoked the air quality plan for the city of Brno for the same reasons.[193]

France: The NGO 'Les Amis de la Terre' with support of the NGO 'ClientEarth' brought a case against the French government. In its judgment of 11 July 2017, the Supreme Administrative Court (Conseil d'État) stated that Directive 2008/50/EC sets an obligation of results and ordered the adoption of new and more effective air quality plans by 31 March 2018. In July 2020, the Supreme Administrative Court concluded that the French government had still not taken the necessary measures to remedy the situation. It gave the state six more months to comply, failure of which would result in a lump sum payment of 10 million euro. In August 2021, the Supreme Administrative Court imposed the financial penalty of 10 million euro after establishing the continued failure of the French government to execute the judgment of 11 July 2017. Additionally, the Supreme Administrative Court held that it would re-evaluate the situation every six months and possibly impose a new lump sum of 10 million euro if the state had still not taken the necessary measures to comply.[194]

Germany: In February 2018, the Federal Administrative Court (Bundesverwaltungsgericht) ruled that health protection takes precedence over economic interest and thus cleared the way

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[187] Greenpeace (2021), press release (accessed: 10.06.2022)
[188] Greenpeace (2022), press release (accessed: 10.06.2022)
[189] UNECE (2020), Case Summary on ruling No. 9614, 13138, 16049 (accessed: 10.06.2022)
[190] Zazemiata.org (2022) Court decides citizens cannot appeal air program (accessed: 10.06.2022)
[191] Frank Bold.org (2018), A Major Win for Air Quality in Prague (accessed: 10.06.2022)
[192] Frank Bold.org (2018), A Major Win for Air Quality in Usti region of the Czech Republic (accessed: 10.06.2022)
[193] Frank Bold.org (2018)A Major Win for Air Quality in Brno, Czech Republic (accessed: 10.06.2022)
[194] Conseil D'État (2021), Pollution de l'air : le Conseil d'État condamne l'État à payer 10 millions d'euros (accessed: 10.06.2022)

for restrictions on the use of diesel vehicles. In February 2020, the Federal Administrative Court held in its ruling that traffic bans for diesel vehicles can be introduced as an appropriate measure to reduce NO_2 if they are the only means to keep the exceedance periods of the limit values as short as possible. However, it underlined the importance of the principle of proportionality and thereby partially overturned the judgment of the Higher Administrative Court.[195]

Hungary: In January 2021, the Budapest Supreme Court (Curia) rejected the claim of the NGO Clean Air Action Group for a reviewed air quality plan that reduces air pollution in a meaningful way. It held that such plans do not constitute administrative acts against which judicial action can be brought and thus they cannot be effectively challenged in court. Consequently, the NGO has brought a claim before the European Court on Human Rights in Strasbourg for breach of access to justice and public health rights (Article 6 of the European Convention on Human Rights).[196]

Italy: In 2018, a citizens' association in Milan promoting the need for cleaner air for the region of Lombardy (Associazione Cittadini per l'Aria), supported in its claims by ClientEarth, introduced legal proceedings against the region of Lombardy claiming that the latter had failed to draw up an air quality plan in accordance with Article 23 of Directive 2008/50/EC. In July 2019, the Lombardy Regional Administrative Court (Tribunale Amministrativo Regionale per la Lombardia) ruled that the association had legal standing to bring these claims and thus found the action to be admissible, contrary to the arguments put forward by the region of Lombardy. However, the Lombardy Regional Administrative Court rejected all the pleas made by the association on their substance.[197]

The Netherlands: Following a court ruling from September 2017 by the Court of The Hague (Gerechtshof Den Haag) in a case brought by the environmental protection organisation 'Milieudefensie', the Netherlands was ordered to take concrete measures to comply with all EU limit values in a 'foreseeable and demonstrable' manner. In a subsequent ruling on appeal in May 2019, the Court of The Hague did not recognize a breach of the fundamental rights to life and health by the state, when only aiming at complying with EU law and not targeting a higher goal, for instance WHO Air Quality Guidelines.[198]

Poland: In Poland, residents, supported by the NGO 'Frank Bold', went before the Constitutional Court (Trybunał Konstytucyjny) to claim their right to challenge air quality plans. The Polish residents put forward that the restrictive legal standing requirements established by Polish law, which prevented them from challenging air quality plans, were contrary to the Polish Constitution. In July 2021, the Constitutional Court rejected this claim but nevertheless pointed out that this did not change the fact that the underlying problem of the case (i.e. lack of standing of Polish citizens to challenge air quality plans) should be reconsidered by the legislator in light of the case law of the Court of Justice of the EU and the importance of protecting and improving the environment.[199] Moreover, in December 2021,

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[195] Bundesverwaltungsgericht (2020), Press release no. 13/2020 (accessed: 10.06.2022)

[196] Levego Munkacsoport (2021), Clean Air Action Group takes Budapest air quality plan to Strasbourg Court (accessed: 10.06.2022)

[197] Sentenze Italia - Cittadini per l'Aria (cittadiniperlaria.org)

[198] Rechtspraak (2019), https://uitspraken.rechtspraak.nl/inziendocument?id=ECLI:NL:GHDHA:2019:915 (accessed: 15.06.2022)

[199] Trybunal.gov (2021), Judgement Ref No. SK23/17 (accessed: 10.06.2022)

the District Court in Gliwice (Sąd Okręgowy w Gliwicach), confirmed that the state is liable for its failure to attain the EU air quality standards and awarded the claimant 30 000 PLN in compensation damages.[200]

Romania: In November 2020, the Municipal Court of Bucharest (Tribunalul Municipiului București) annulled the integrated air quality plan developed by the city's authorities, following an action initiated by a group of NGOs and residents claiming that the plan did not comply with the national legislation on ambient air quality transposing Directive 2008/50/EC (Law no. 104/2011). Two actions were joined; one challenging the substance of the air quality plan and one challenging the adoption process of the air quality plan and the lack of citizen's consultation during this process.[201]

Slovakia: In February 2017, a group of citizens from Bratislava and NGOs 'Cyklokoalicia' and 'ClientEarth', with the assistance of Via Iuris, took legal action against the Bratislava air quality plan. In November 2018, the Slovak Regional Court (Krajský súd v Bratislave) dismissed the air quality plan, stating it was vague and insufficient. A new plan must include effective measures to improve air quality in the city in the shortest possible time. The Municipality of Bratislava did not appeal the ruling.

Spain: The environmental NGO 'Ecologistas en Acción' filed a lawsuit against the lack of an air quality plan addressing illegally high levels of ozone in the region Castilla y León. In October 2018, the High Court of Castilla y León (Tribunal Superior de Justicia de Castilla y León) ordered the regional government to prepare within one year an air quality plan to tackle levels of ozone exceeding the EU air quality standards. This judgment was confirmed by the Spanish Supreme Court (Tribunal Supremo) in June 2020, which held that regional air quality plans are independent from the national plan, the non-existence of which cannot be an excuse for lack of action at regional level.[202] Moreover, in December 2021, the High Court of Navarre (Tribunal Superior de Justicia de Navarra) gave the regional government a year to prepare and approve the mandatory air quality plan for ozone in the Ribera Navarra area. By imposing a specific deadline by which the regional government has to comply, the Court goes beyond the ruling of the Spanish Supreme Court.[203]

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[200] Frank Bold.pl (2021), Breakthrough court ruling in Poland – state must pay for air pollution to citizen (accessed: 10.06.2022)

[201] Aerlive.ro, Victorie în instanță pentru cetățenii capitalei! » Aerlive Aerlive | Platformă pentru măsurarea calității aerului din București

[202] Ecologistas en acción.org (2020), El Tribunal Supremo obliga a las comunidades autónomas a aprobar planes de calidad del aire para reducir el ozono (accessed: 10.06.2022)

[203] Ecologistas en acción.org (2022), El Tribunal de Justicia de Navarra da un año al Gobierno Foral para adoptar un plan de calidad del aire que reduzca el ozono (accessed: 10.06.2022)