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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}

TABLE OF CONTENTS

TABLE OF CONTENTS – ANNEXES

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

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[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:

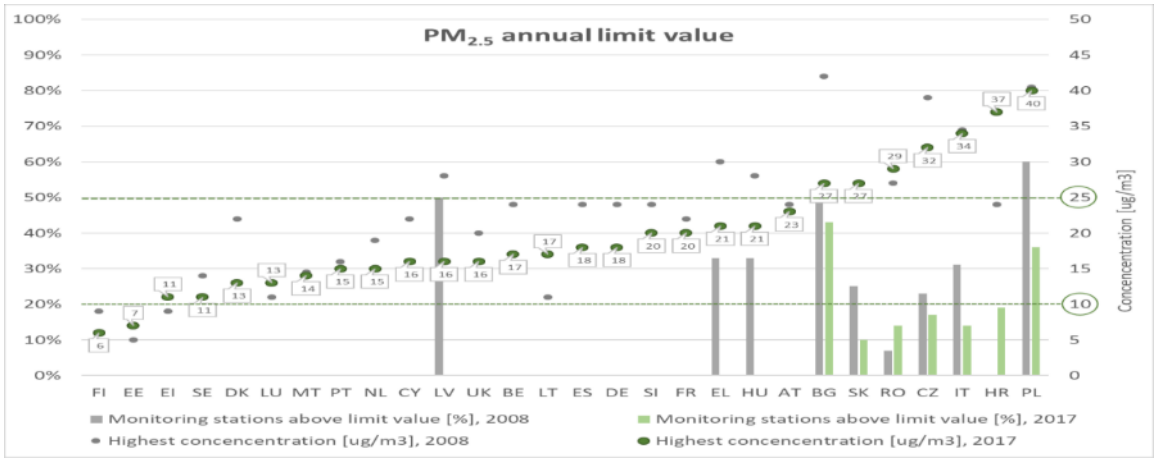
Problem I: Environment and health shortcomings

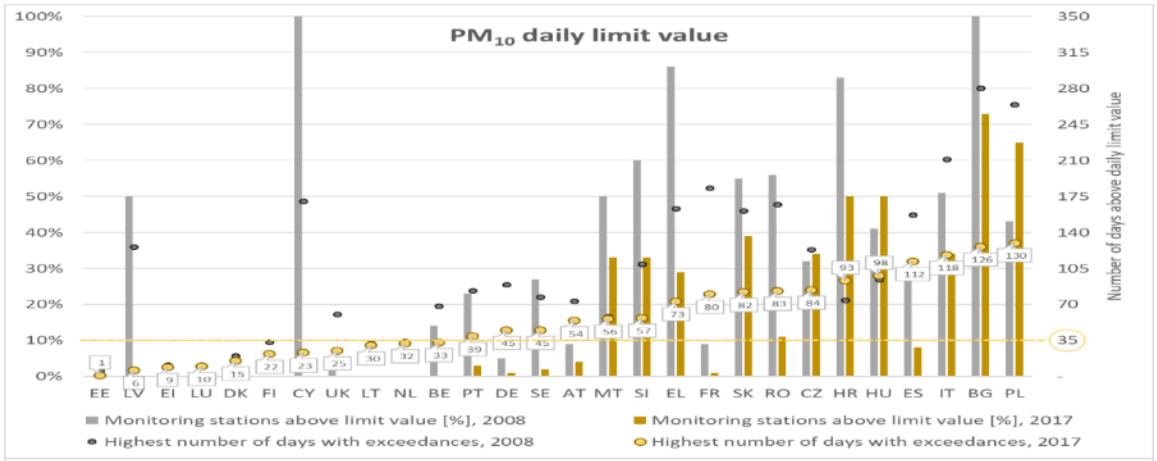
Over the past two decades, the overall health impacts due to air pollution have decreased by more than half.[11] Even so, significant mortality and morbidity continues to be associated with air pollution (estimates point to more than 300 000 attributable premature deaths related to air pollution).[12] 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.





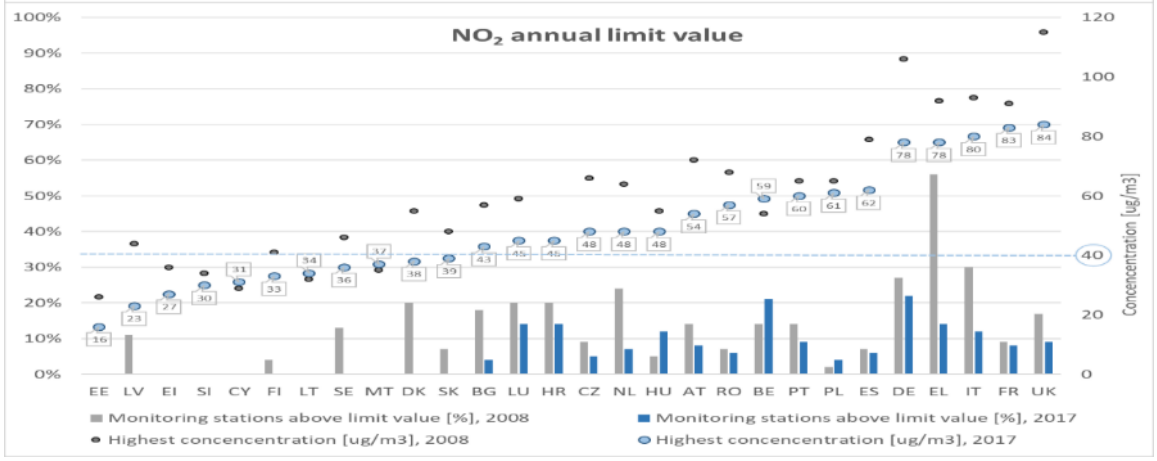


Figure 1 – Percentage of sampling points for fine particulate matter $PM_{2.5}$ (top) and PM_{10} (middle), and for nitrogen dioxide NO_2 (bottom), with exceedances above the annual limit value (columns, left axis), and highest concentration (points, right axis shows µg/m^3), as reported for each Member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

[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).

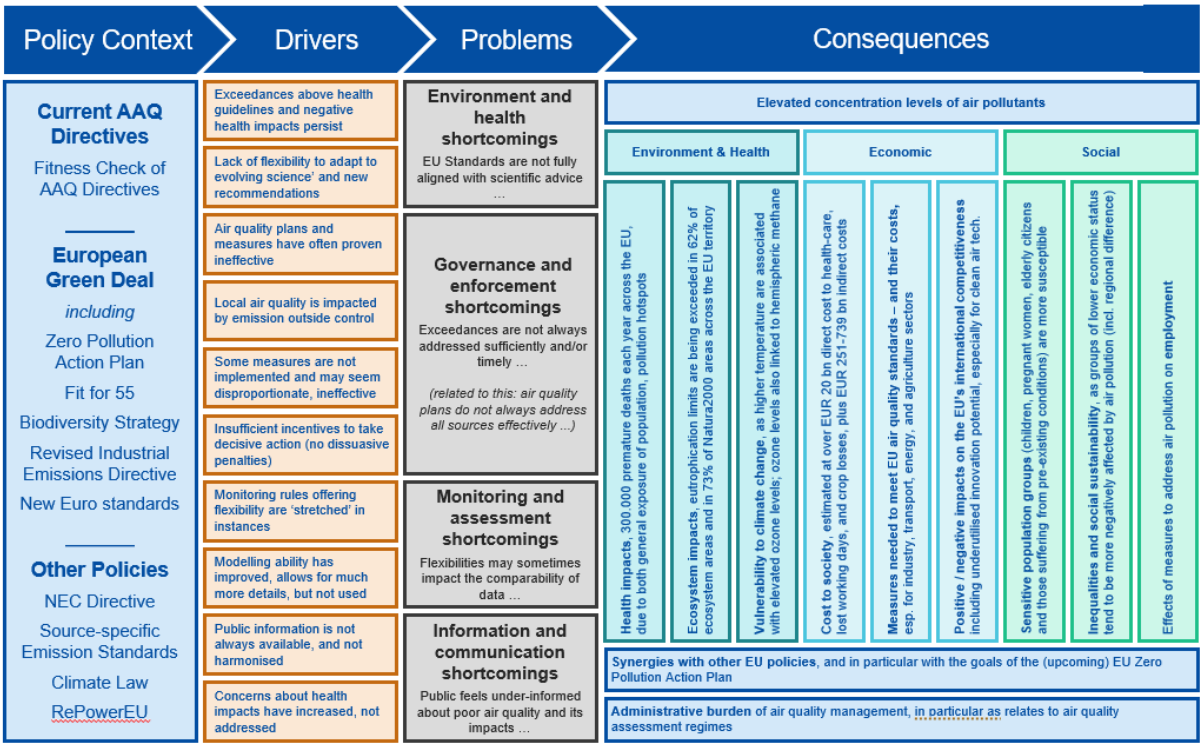

Figure 2 – Ambient Air Quality Directives: four problems, their drivers and consequences

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]

[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).

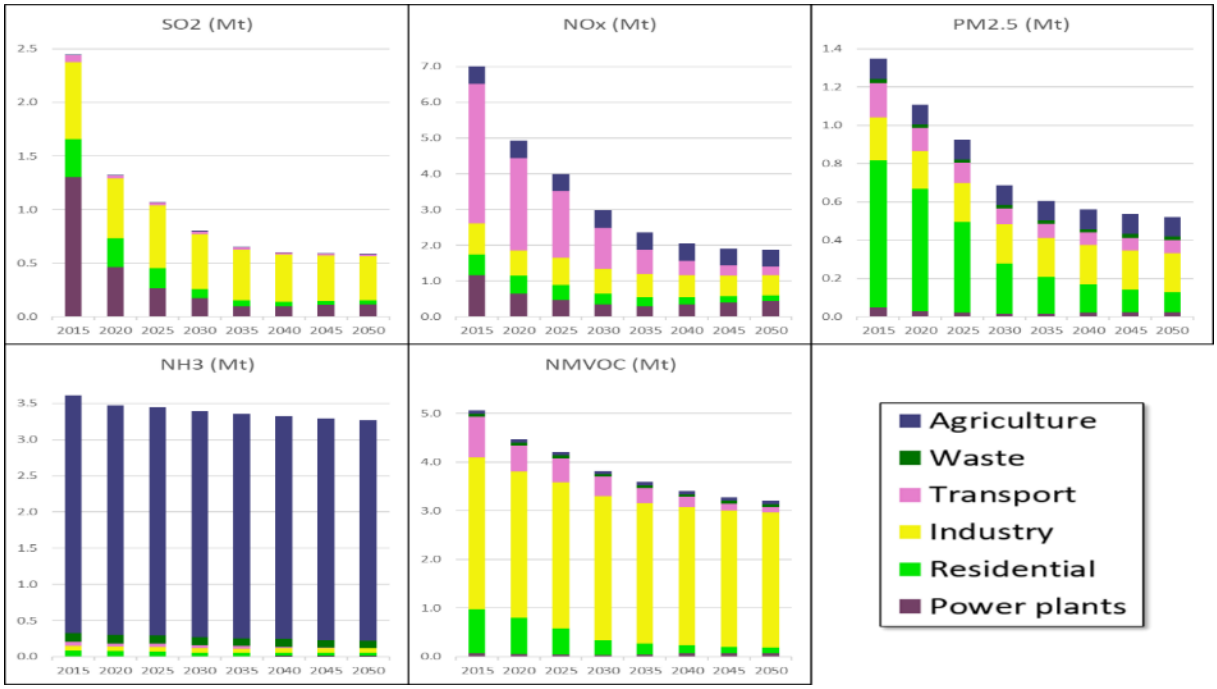

Figure 3 - Emissions of key air pollutants in the EU in the baseline scenario.[46]

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 µg/m^3 in 2030 (850 out of 994 sampling points) – with remaining areas even above the WHO Air Quality Guideline interim target of 10 µg/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 µg/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.

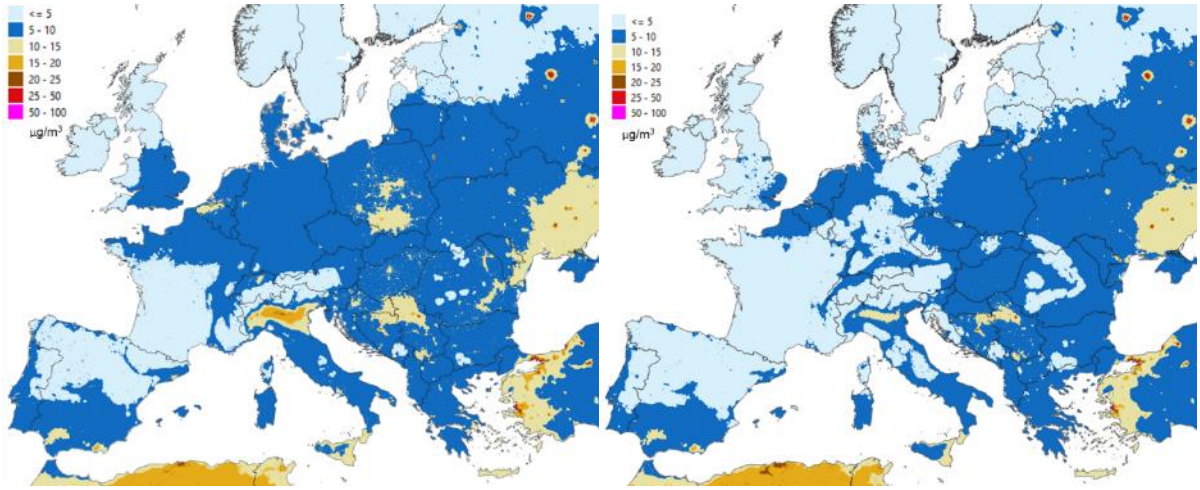

Figure 4 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under baseline scenario assumptions (for additional maps, including for other pollutants, please see Annex 5).[47]

Under baseline assumptions, by 2030 still around 25 million people are expected to continue to live in areas exceeding 10 µg/m^3, and more than 300 million in areas exceeding 5 µg/m^3.

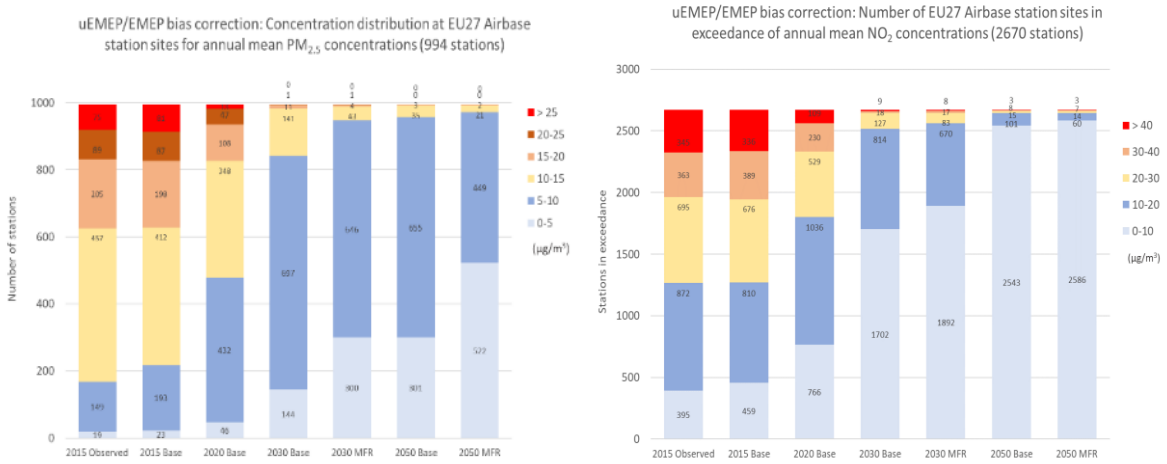

Figure 5 – $PM_{2.5}$ (left) and NO_2 (right) concentration modelling outputs for EU under baseline assumption.[48]

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.

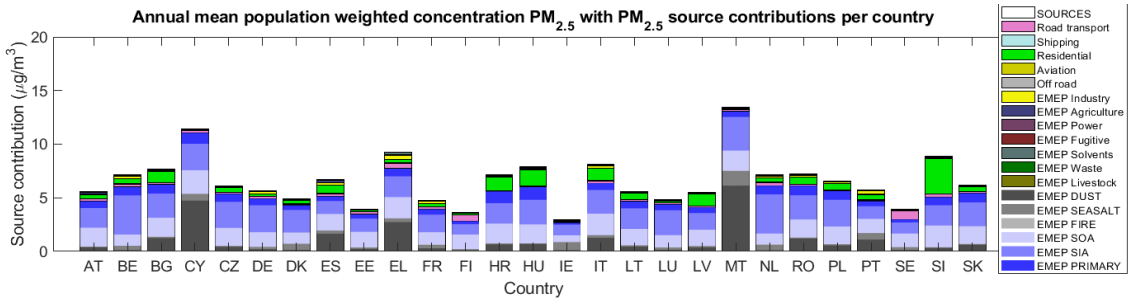

Figure 6 – $PM_{2.5}$ annual mean population weighted concentration under baseline assumption for 2030. [49]

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.

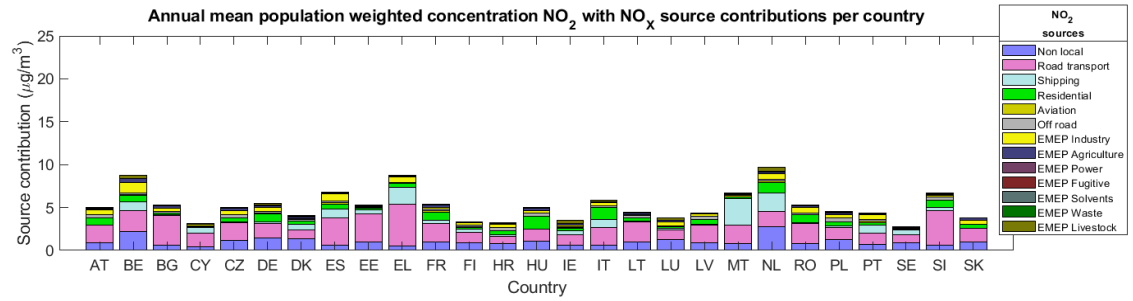

Figure 7 – NO_2 annual mean population weighted concentration under baseline assumption for 2030.[50]

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]

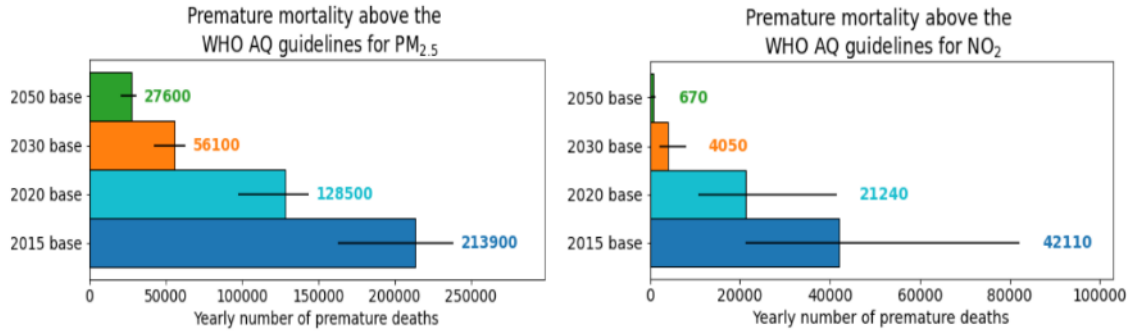

Figure 8 – Projection of premature mortality due to air pollutant concentrations above 2021 WHO Air Quality Guidelines levels for $PM_{2.5}$ (left) and NO_2 (right).[54]

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 µg/m^3 in Australia, 10 µg/m^3 both in Switzerland and in Canada, 12 µg/m^3 in the United States, and 15 µg/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.

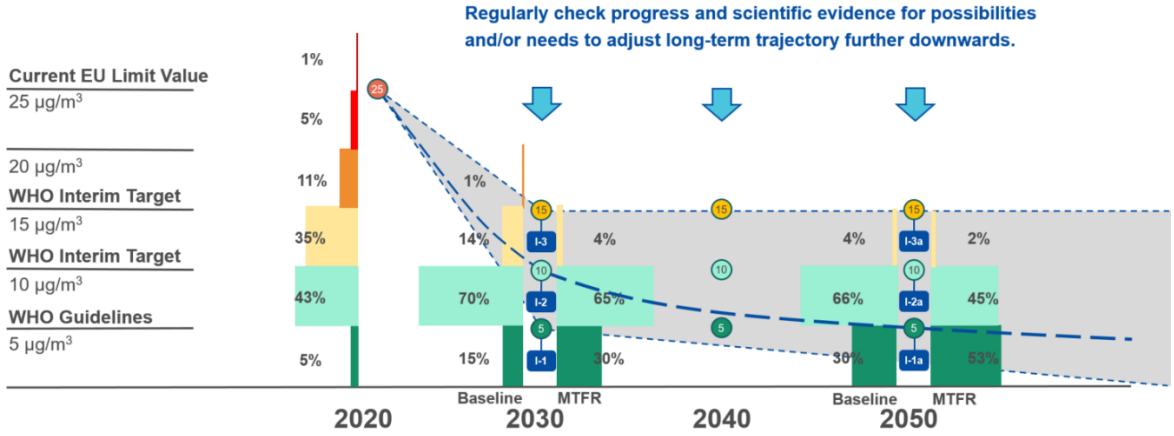

Figure 9 – INDICATIVE trajectories towards alignment with the 2021 WHO Air Quality Guidelines in 2030 / post-2030, based on the three policy options assessed (I-1, I-2, I-3). This figure also indicates for 2020, 2030 and 2050 the percentage of air quality sampling points that is projected to experience annual mean $PM_{2.5}$ concentration levels within the respective ranges (e.g. 5 to 10 µg/m^3 or 10 to 15 µg/m^3) 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/m^3

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 µg/m^3 and NO_2 at 10 µg/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/m^3

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 µg/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 µg/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/m^3

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 µg/m^3 objective to be met throughout

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[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/m³, 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

[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).

[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.

[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

[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

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[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 µg/m^3, 10 µg/m^3, or 15 µg/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 $PM_{2.5}$

[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).

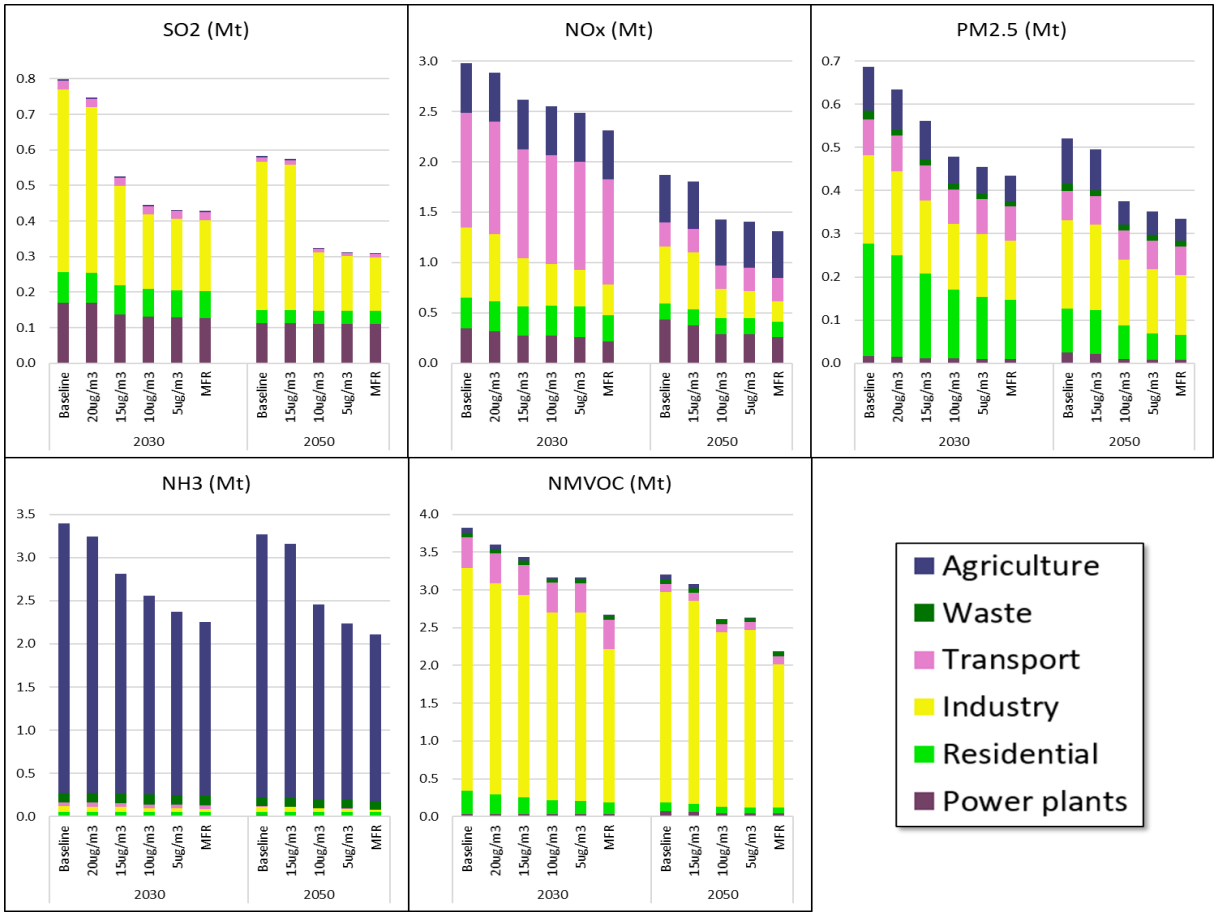

Figure 10 – EU emission in 2030 and 2050 for key air pollutants, and by key sector, under baseline assumption and for three policy options (I-1 at 5 µg/m^3, I-2 at 10 µg/m^3, I-3 at 15 µg/m^3), and MTFR scenarios.[91]

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.

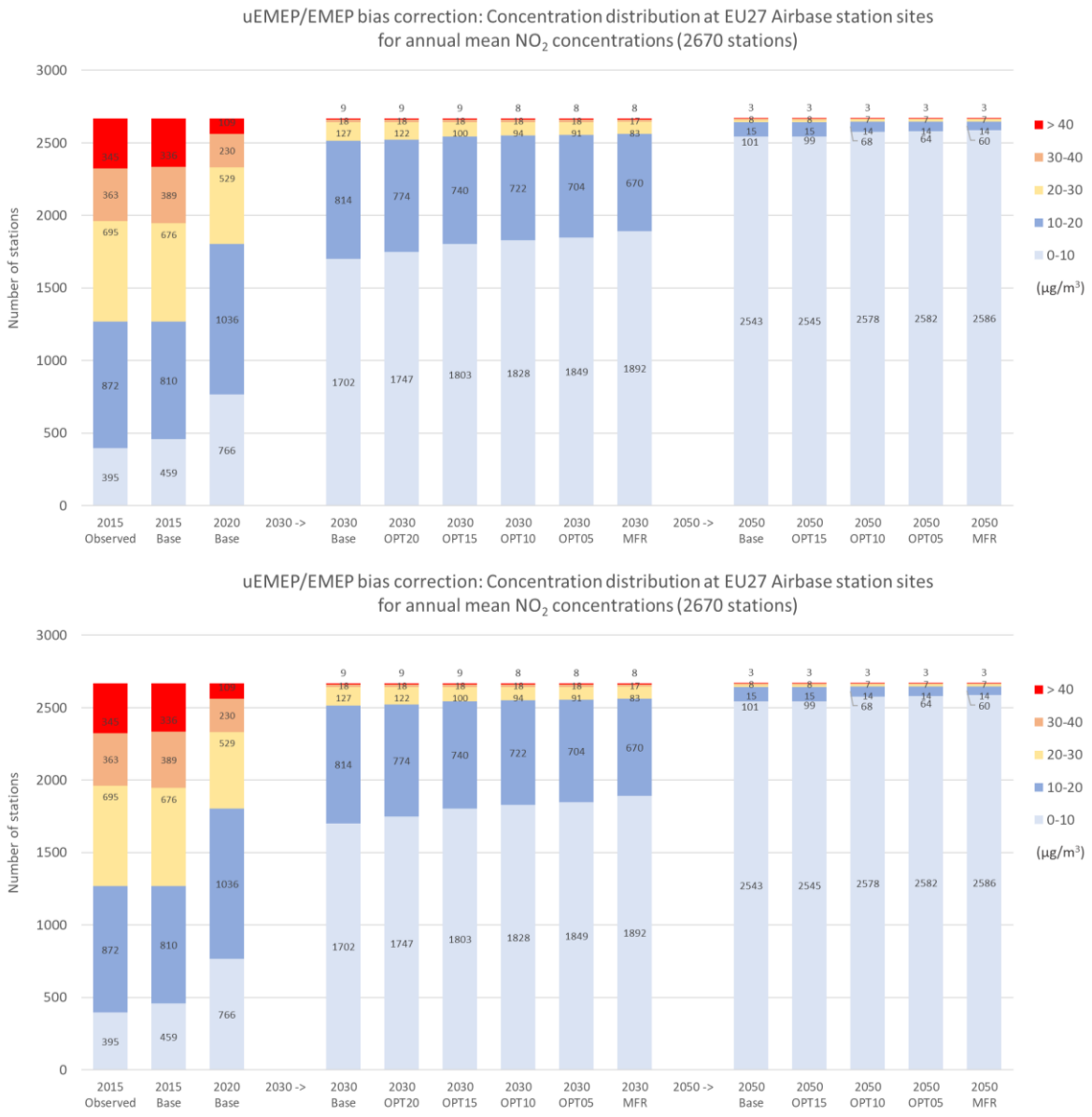

Figure 11 - Number of stations above selected annual mean concentrations in the EU for PM_2. and NO_2. Note that I-1 is labelled OPT05, I-2 is OPT10, and I-3 is OPT15 – also see Annex 5 for similar estimates for population exposed to different levels of air pollution under the different scenarios.

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/m³. 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/m³ 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)

			2030				2050		
Policy Option / Scenario			(PM2.5 at 20 µg/m³)	**I-3** (PM2.5 at 15 µg/m³)	**I-2** (PM2.5 at 10 µg/m³)	**I-1** (PM2.5 at 5 µg/m³)	**I-3a** (PM2.5 at 15 µg/m³)	**I-2a** (PM2.5 at 10 µg/m³)	**I-1a** (PM2.5 at 5 µg/m³)
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).

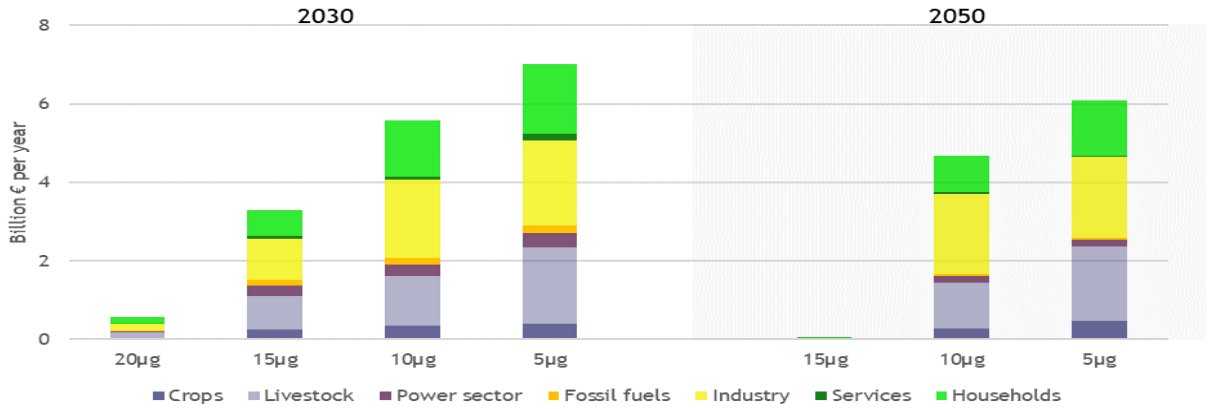

Figure 12 – Air pollution mitigation or adjustment costs (EU total) beyond the baseline, for different policy scenarios (I-1 at 5 µg/m^3, I-2 at 10 µg/m^3, I-3 at 15 µg/m^3).[100]

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/m^3 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/m^3 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/m^3 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.

[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		(PM2.5 at 20 µg/m3)	**I-3** (PM2.5 at 15 µg/m3)	**I-2** (PM2.5 at 10 µg/m3)	**I-1** (PM2.5 at 5 µg/m3)		**I-3a** (PM2.5 at 15 µg/m3)	**I-2a** (PM2.5 at 10 µg/m3)	**I-1a** (PM2.5 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 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) % 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 Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to 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.

[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** Env.	Soc.	Eco.	Cost	**Assessment and key considerations**	**Benefit to 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** Env.	Soc.	Eco.	Cost	**Assessment and key considerations**	**Benefit to 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

[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 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 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 Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to 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 <u>all</u> 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.

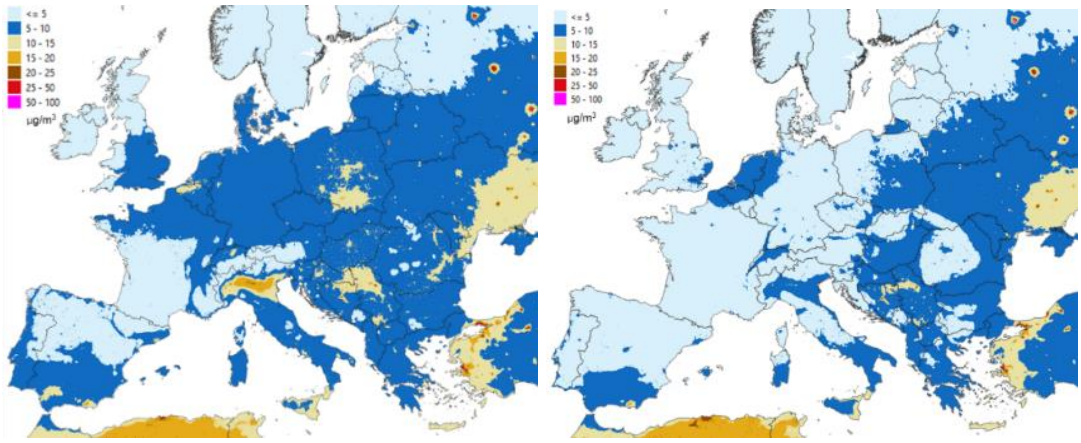

Figure 13 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, EU overview (for additional maps, including for other pollutants, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

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 µg/m^3 reduces significantly by 2030, some hotspots would be expected to remain, and may require additional time to reach this level.

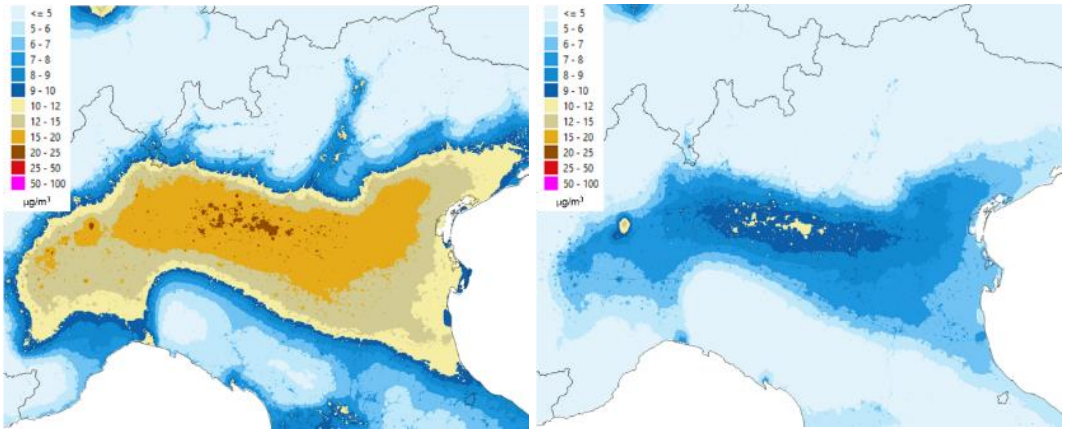

Figure 14 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, example Northern Italy (for additional maps, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

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.

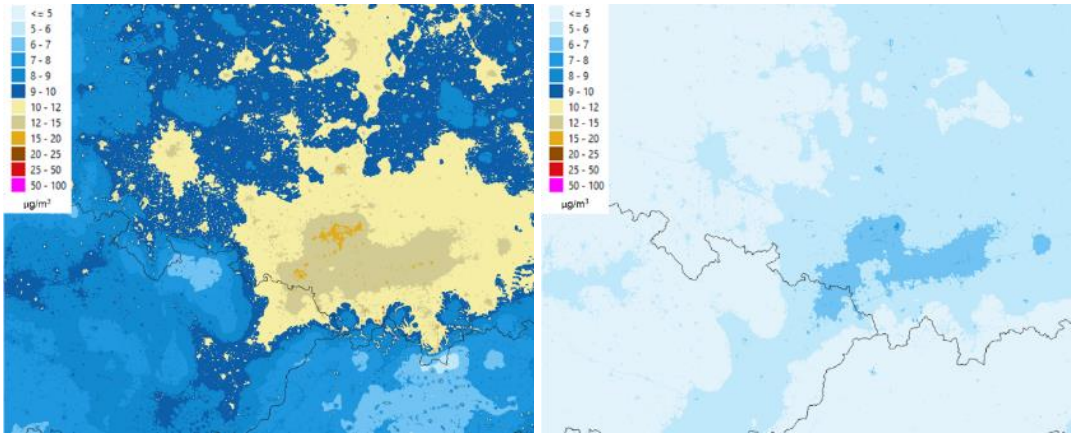

Figure 15 – Concentrations for $PM_{2.5}$ in 2020 (left), and for 2030 (right) under the preferred policy option I-2, example border region between Poland, Czechia and Slovakia (for additional maps, please see Annex 5). Also see the underpinning support study on the revision of the Ambient Air Quality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

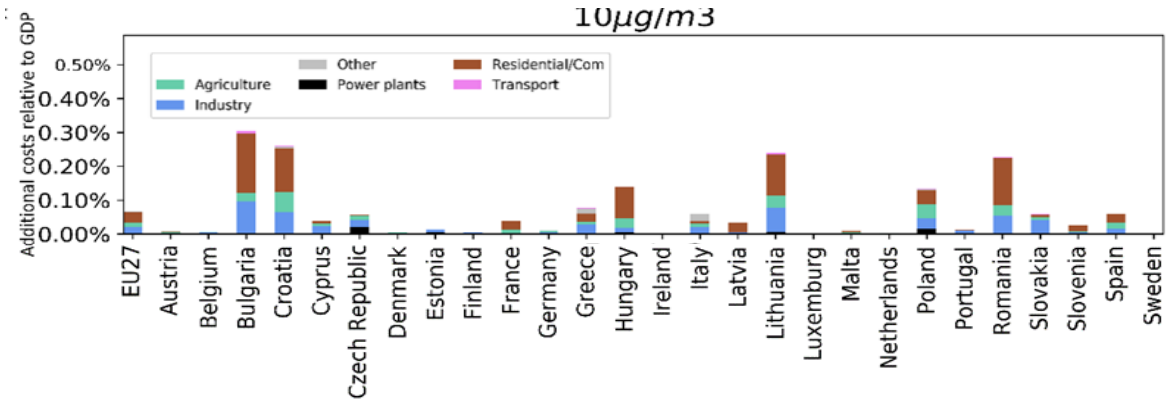

Figure 16 – Additional (compared to baseline) air pollution control costs in 2030 for the preferred policy option, shown as % of GDP. Also see the underpinning support study on the revision of the Ambient Air Quality Directives.

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).

[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 BUT 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.

[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.