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COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

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

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

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

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ANNEX 1: PROCEDURAL INFORMATION

1. LEAD DG, DECIDE PLANNING/CWP REFERENCES

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

This impact assessment started in December 2020.

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

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

Timeline

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

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

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

[2] COM (2022), Have your say - Air quality - revision of EU rules (accessed: 10.06.2022)

[3] Contract no. 09029901/2021/848269/SFRA/ENV.C.3, implementing Framework Contract no. ENV.F.l/FRA/2019/0001

[4] European Parliament (2021), resolution of 25 March 2021 on the implementation of the Ambient Air Quality Directives (accessed: 10.06.2022)

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

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

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

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

2. CONSULTATION OF THE REGULATORY SCRUTINY BOARD (RSB)

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

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

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

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

	review mechanism.	mechanism.	
(3) Justifying the chosen preferred option	Reflect better the feasibility concerns of the preferred option.	The presentation of policy options has been improved and enhanced, including by adding a summary comparison table presenting key figures on achievability of different WHO alignment choices,	Section 8.1
(4) Drivers of the identified problems	Clarify why the existing air quality plans are not effective, and whether this is due to a lack of enforcement, financing or monitoring.	A clarification on the reasons for ineffective air quality plans has been added.	Section 2.1
	Set out clearly the current set-up of monitoring stations and sampling points and be transparent about the extent to which existing air quality data is reliable and of comparable quality across the EU.	A clarification on the reliability and comparability of air quality data has been added.	Section 2.1

3. EVIDENCE, SOURCES AND QUALITY

Support study

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

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

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

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

Consultation strategy

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

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

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

Bespoke modelling

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

Evidence from air quality monitoring and reporting

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

- monitoring and assessment regimes, including assessment methods: http://aidec.apps.eea.europa.eu and http://aided.apps.eea.europa.eu
- attainment of environmental objectives, including information on exceedance situations: http://aideg.apps.eea.europa.eu
- air quality plans and programmes, as well as air quality measures: http://aideh.apps.eea.europa.eu and http://aidek.apps.eea.europa.eu

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

- information on source apportionment in zones and agglomerations: http://aidei.apps.eea.europa.eu
- information on air data and aggregated validated assessment data as summarised in the annual air quality reports published by the European Environment Agency
- online EEA indicators, such as:
  - Exceedance of air quality standards in urban areas: https://www.eea.europa.eu/ims/exceedance-of-air-quality-standards

Evidence from selected studies and policy documents

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

- European Commission (2019). Special Eurobarometer 497: 'Attitudes of Europeans towards Air Quality'
- European Court of Auditors Special Report 05/2018 on Renewable Energy
- European Court of Auditors Special Report 23/2018 on Air Pollution
- European Parliament (2017). 'Report on the inquiry into emission measurements in the automotive sector'
- European Parliament (2019). 'Sampling points for air quality: Representativeness and comparability of measurements in accordance with Directive 2008/50/EC on ambient air quality and cleaner air in Europe' (study requested by the ENVI Committee)
- EUROSAI (2019). 'Joint report on air quality by the European Organisation of Supreme Audit Institutions'
- IIASA (2014). 'Complementary Impact Assessment on interactions between EU air quality policy and climate and energy policy'
- IIASA (2017). 'Costs, benefits and economic impacts of the EU Clean Air Strategy and their implications on innovation and competitiveness'
- IIASA (2018). 'Progress towards the achievement of the EU's air quality and emissions objectives'
- JRC (2013). 'Assessment on siting criteria, classification and representativeness of air quality monitoring stations'
- JRC (2017). 'Urban $PM_{2.5}$ Atlas: Air Quality in European Cities'
- JRC (2017). 'Global Energy and Climate Outlook 2017: How climate policies improve air quality'
- JRC (2019). 'Urban NO_2 Atlas'
- JRC (2021). 'Urban $PM_{2.5}$ Atlas: Air Quality in European Cities'
- Nationale Akademie der Wissenschaften Leopoldina (2019). 'Saubere Luft. Stickstoffoxide und Feinstaub in der Atemluft: Grundlagen und Empfehlungen'
- OECD (2016). 'The Economic Consequences of Outdoor Air Pollution'
- OECD (2020). 'The economic cost of air pollution – Evidence from Europe'
- World Health Organization (2006). 'Air quality guidelines – global update 2005'
- World Health Organization (2013). 'Review of evidence on health aspects of air pollution'
- World Health Organization (2021). 'WHO global air quality guidelines: particulate matter ($PM_{2.5}$ and PM_{10}), ozone, nitrogen dioxide, sulfur dioxide and carbon monoxide.'

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

ANNEX 2: STAKEHOLDER CONSULTATION (SYNOPSIS REPORT)

1. AIM OF THE CONSULTATION

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

1.1 Consultation strategy[10]

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

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

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

- *Public authorities* – i.e. EU Member States and their public authorities, at different governance levels (national, regional, local) and other institutions;
- *Civil society & NGOs* – i.e. non-governmental organisations (NGOs) and civil society representatives;
- *Industry & businesses* – i.e. private economic sector operators such as business associations, organisations, trade unions, companies;
- *Academia & research* – i.e. research community, academia, medical professionals, and patient organisations;

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

- *EU citizens* – i.e. citizens not directly affiliated with the above stakeholder groups, but with a keen interest in the topic of air pollution.

1.2 Consultation activities

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

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

Table A2.1: Stakeholder groups

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

2 SUMMARY OF CONSULTATION ACTIVITIES

2.1 Open public consultation[11]

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

A total of 934 responses were received, and 116 position papers were submitted. In the general part of the questionnaire, respondents could choose whether they wished to respond

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

further to a targeted section. The targeted section received a total of 555 responses. On average, open questions received 124 individual responses, with a minimum of 11 and a maximum of 406 individual responses. 23 Member States were represented in the responses.

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

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

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

On policy area 2, the majority of *civil society & NGOs* and *EU citizens* were of the opinion that legislative changes in regards to air quality should include a provision ensuring access to justice for citizens as well as a provision ensuring compensation for health damage caused by air pollution. To expand requirements for action by national / regional / local authorities in case of exceedances as deemed as highly important by 65% (n=607) of respondents. Regarding the availability of information on air quality, *public authorities* and *industry &*

businesses felt the most informed while *civil society & NGOs* thought there was a room for improvement. In addition, this measure was thought to be highly feasible to implement by 58 % (n=541) of respondents. In general, regarding the feasibility and importance of new policy measures, there was quite a divide between the stakeholder groups, though there was a general agreement that making it easier for EU air quality standards to update to scientific progress would be an important measure.

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

2.2 Targeted stakeholder consultation

Targeted survey

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

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

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

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

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

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

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

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

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

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

from *public authorities* requested that this would be preferred as an additional index to the national index *(policy measure F4).*

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

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

measure N1 on refining the minimum information to be included in an air quality plan (43%, n=40) across all stakeholders groups.

Interviews

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

Table A2.1: Interviews

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

2.3 Stakeholder meetings

First stakeholder meeting

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

A total of 315 stakeholders from 27 Member States participated in the meeting, without considering the consultants contributing to the revision of the Ambient Air Quality Directives

and EU officials involved. The aim of the first stakeholder meeting was to confirm the shortcomings identified and gather initial views on the ambition level from all stakeholder groups.[13] All relevant stakeholder groups as set out in the consultation strategy were represented during the stakeholder meeting. The stakeholder groups and the country is indicated below in box A2.4.

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

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

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

On policy area 3, the use of models to supplement assessment methods was welcomed, though it was noted this should not be at the expense of a reduced monitoring network. The importance of clear meta-data to describe a site to enable cross-city comparison was noted. *Civil society & NGOs* and *public authorities* advocated an increase in the number of $PM_{2.5}$

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

monitoring stations, and more broadly set clearer requirements for the proportion between different types of monitoring stations, which would entail abandoning the $PM_{2.5}$ /PM_{10} ratio. Concerns were expressed by several public authorities (both national and regional level) with regards to stability and sensitivity issues, hence participants noted that single sensors should not be used for compliance purposes and that uncertainties must be communicated transparently if such data is used.

Second stakeholder meeting

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

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

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

On policy area 1, *public authorities* and *civil society & NGO* representatives expressed their preference for binding air pollutant standards. Several NGOs reiterated their preference for full alignment with the WHO Air Quality Guidelines levels by 2030 while one *public authorities* also expressed the same view. It was also raised by *civil society & NGO* representatives that they would be interested to see analysis of the percentiles for daily exceedances. Especially regarding NO_2, one NGO stressed the future focus should be on daily limit values. *Civil society & NGOs* also expressed opinions on the relative effectiveness of target or limit values. It was pointed out that in certain Member States target values do not

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

provide an effective incentive and as such the revised air quality rules should turn to limit values. Stakeholders from all stakeholder groups expressed their views regarding the definition of 'short' and 'long' term standards. Generally, *civil society & NGO* representatives were of the opinion that 2030 should already be considered as a 'long term' timeframe, while *public authorities* were more reserved and stated that 2040 might also be an appropriate long-term target. *Industry & business* pointed out that the transition in their sector would take time, and there is a need for the long-term targets to reflect that and align with sector plans and roadmaps. As such, *industry & business* expressed their preference for 2050 to be considered as the long-term target.

On policy area 2, representatives of *public authorities* stressed the importance of transboundary cooperation, which they proposed should be addressed by harmonisation of rules on air quality plans. This suggestion was also supported by certain *civil society & NGO* representatives. Furthermore on air quality plans it was suggested that their drafting starts with emission factors and should include absolute numbers. *Civil society & NGO* representatives also touched upon the topic of improvement of public information. They discussed that there is a need to harmonise the available information as well as to provide a link between the information provided and the health impacts of air pollution (e.g. by relying on colour coding of different health impacts). Linking health impacts with air quality will allow citizens to make more informed decisions. Making informed decisions can further be supported by providing citizens with real-life data, namely allowing citizens to limit their exposure levels. The list of pollutants on which real-life data are provided should be expanded and include pollen, for example. Furthermore, the topic of access to justice was also touched upon, namely that both the provisions on access to justice and on public information remain the largest gaps in the current Ambient Air Quality Directives. One attendee from *research & academia* stressed that penalties have to be more drastic in order to encourage Member States to take action. However, at the same it was highlighted that any legal action will be difficult if one relies on target values rather than limit values.

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

3 RESULTS OF THE STAKEHOLDER FEEDBACK

3.1 Feedback by stakeholder groups – Policy Area 1

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

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

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

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[15] ECO=Exposure concentration obligation

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

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

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

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

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

3.2 Feedback by stakeholder groups – Policy Area 2

Representatives of **public authorities** expressed largely positive feedback and a majority was in favour on policy measures regarding the periodically update of a list containing air pollutant of emerging concern, the establishment of additional short-term EU standards i.e. for $PM_{2.5}$, the expansion of exposure reduction targets, an agreed methodology for transboundary air pollution and the obligation for Member States to provide specific health

information to the public. Across all intervention areas[16] different levels of ambition and opinions were expressed by this stakeholder group, besides on topics that touch upon intervention area E, where only a minority from public authorities expressed their opinions *(incl. 29 out of 43 no replies to the survey)*. In addition, the feedback that was received on those topics was mostly negative. Other policy measures that found only little consent among the public authorities were the introduction of a mechanism to adjust air quality standards based on technical progress, the obligation to introduce short-term action plans for each pollutant and the requirement for Member States to harmonise air quality plans.

Representatives from **civil society & NGOs** were more in favour of policy measures in area M and E and lesser to measures in area A and B. Representatives in particular expressed stronger opinions for topics related to intervention area A, B and F and to a lesser extent on topics that touch upon the other intervention areas. The large majority of this stakeholder group favoured the introduction of a mechanism to adjust EU air quality standards based on scientific advice. In comparison, no representative expressed to be largely in favour to adjust the EU air quality standards based on technical progress. Other policy measures that found high support among the stakeholder representatives touch on the following interventions: establishing short–term EU air quality for example for $PM_{2.5}$, establish additional limit values for additional air pollutants, the introduction of an short-term action plan for each pollutant, the regular update of air quality plans, both policy measures regarding transboundary air pollution, the introduction of an explicit "access to justice" provision and the requirement to ensure more regular up-to-date data reporting. The policy measures that are included in intervention area A found in general the least support among the civil society & NGO representatives, i.e. the provision for Member States to adopt more stringent standards *(2 out of 12 replies to the survey being in favour)*.

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

Representatives from **academia & research** expressed in general higher support for policy measures that touch upon intervention areas C and M and didn't express strong support on policy measures that are included in intervention area E. Across all policy measures that were discussed, this stakeholder group expressed strong opinions for all policy measures except for those in area E *(incl. 18 out of 22 no replies to the survey).* A large majority of respondents are in favour to the periodically update of list for emerging air pollutants to ensure

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

monitoring of those *(13 out of 22 replies to the survey)*. Also policy measures regarding transboundary air pollution found among this stakeholder group large support *(incl. 13 for M1 and 14 for M2 out of 22 replies to the survey)*. Defining alert thresholds and information thresholds for all air pollutants to alert the public was the policy measure that found least support in this stakeholder group.

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

3.3 Feedback by stakeholder groups – Policy Area 3

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

Representatives of **civil society & NGOs** were largely in favour of the policy measure that foresees the expansion of list of required and/or recommended volatile organic compounds *(incl. 7 out of 12 replies to the survey)* and the requirement of a regular review of the assessment regime following clear criteria *(incl. 6 out of 12 replies to the survey).* In general, this stakeholder group was more supportive across all policy measures and the majority of policy measures received positive feedback and that support. However, policy measures related to policy area 3 were the least discussed or raised by this stakeholder group. Similarly, policy measures in relation to intervention area K were hardly discussed by representatives. The policy measure that allows to use of indicative measurement to substitute fixed

monitoring as part of the assessment was the measure that found the least support among the stakeholder group *(incl. 7 out of 12 replies not favouring this measure in the survey)*.

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

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

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

4 OTHER CONSULTATION ACTIVITIES

4.1 Ad-hoc contributions

In total 30 ad-hoc contributions (i.e. position papers, scientific studies and other documents) from 25 different stakeholders[17] were received throughout the duration of the revision period. Ad-hoc contributions were evaluated and analysed which policy area and policy option the

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

ad-hoc contribution was targeting and took the information into account for the Impact Assessment and legislative proposal. The following table A2.3 lists the organisation names and further details from the received ad-hoc contributions.

Table A2.3: Ad-hoc contributions

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

**Polish Smog Alert, Frank Bold Foundation, European Clean Air Centre, Electric Vehilces Promotion Foundation, Health and Environment Alliance, Client Earth, Towarzystwo na Rzecz Ziemi, Polski Klub Ekologiczny Okręg Pomorski, Stowarzyszenie Ekologiczne EKO-UNIA, Fundacja na rzecz Efektywnego Wykorzystania Energii, Stowarzyszenie Partnerstwo dla Bezpieczeństwa Ruchu Drogowego, Rodzice dla Klimatu, Polski Klub Ekologiczny Okręg Mazowiecki, Koalicja Klimatyczna*

4.2 Third EU Clean Air Forum

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

Stakeholder groups present at the event were mainly public authorities, environmental and non-governmental organisations, business associations and organisations, research and academia institutions and citizens. During the week of the event, the hashtag "*#CleanAirEU*"

[18] COM (2021), Third Clean Air Forum Events page (accessed: 04.08.2022)

reached close to 27 million accounts on the social networking applications *twitter.com* and *instagram.com* globally.

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

4.3 Inception Impact Assessment

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

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

Stakeholder per stakeholder group (descending):

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

Stakeholder per country (descending):

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

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

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

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

[19] COM (2021), Have your say portal (accessed: 04.08.2022)

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

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

- Review air quality standards to reflect latest scientific evidence and supplement limit values with regional exposure reduction targets (addressed in *problem area I*);
- Ensure coherence of action between different levels of governance to improvement the effectiveness of air quality measures and the implementation of the Ambient Air Quality Directives (*addressed in problem area II*);
- Improve monitoring networks to diminish discrepancies and enhance comparability across Member States; improve design of air quality plans and promote local/regional level action *(addressed in problem area III);*
- Monitoring of pollutants not currently covered by the Ambient Air Quality Directives such as Ultrafine Particles ($PM_{0.1}$), black carbon and other components of PM, metals, and ammonia *(addressed in problem area II);*
- Simplify the legislative framework by bringing together directives 2008/50/EC and 2004/107/EC in a single directive *(addressed as part of section 8.3 on administrative costs and REFIT);*
- Ensure coherence with EU legislation, including urban and road transport, renewable energy and agricultural policies *(addressed throughout this impact assessment, including modelling efforts and Annex 8)*;
- Address emission sources such as tyre and brake wear, non-exhaust traffic related particles, heavy goods vehicle refrigeration units, heating and power emissions, agriculture and wood burning *(not directly addressed in this impact assessment, as they are covered under relevant EU legislation.)*[21]

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

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

5 USE OF STAKEHOLDER FEEDBACK

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

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

ANNEX 3: WHO IS AFFECTED AND HOW?

1. PRACTICAL IMPLICATIONS OF THE INITIATIVE

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

Public authorities / Administrations

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

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

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

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

Businesses and the economy at large

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

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

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

Taking these two sides of the equation together, the **macroeconomic modelling** undertaken shows that the market **benefits** of improved air quality **outweigh the costs** of abatement measures and other investments needed to meet stricter EU air quality standards. The key insight is that all scenarios, including the preferred one, **improve aggregate economic outcomes** in the EU compared to a situation of unchanged policy, when productivity gains of clean air are accounted for (the positive impact on the gross domestic product, GDP, and private consumption increases with the stringency of the scenario). With the exception of

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

livestock-based agriculture, which sees a small percentage reduction, **all sectors raise output** compared to the baseline. Results further indicate **enhanced competitiveness** of the EU economy as indicated by an improved trade balanced and higher exports, again with productivity gains from clean air factored in.

Citizens and consumers

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

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

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

The **macroeconomic modelling** undertaken shows that on an aggregate level, private consumption increases compared to the baseline in 2030 across scenarios, including the preferred one, when productivity gains from clean air are factored in. When taking into

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

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

account further market and also non-market effects (avoided health care costs, years of life lost, loss of utility due to sicknesses etc.), which could not be taken into account in the macroeconomic modelling undertaken but is addressed separately, the overall benefit would become even larger.

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

Other

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

2. SUMMARY OF COSTS AND BENEFITS

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

[25] See previous section.

		possibly consumers if productivity gains are passed on through lower prices for wood-based products.
Reduced ecosystem impacts	Between **706** (*low estimate*) and **2 117** (*high estimate*) **million EUR** (2015 prices) in 2030	Benefits for biodiversity, benefits for those sectors relying on ecosystem services.
Indirect benefits / co-benefits for other policies		
This part of the table summarises the likely indirect benefits of more ambitious clean air policy including the co-benefits for other EU policy objectives. This is done in a qualitative way, as the quantification undertaken here has focused on estimating the direct benefits, indirect ones being much more uncertain.		
Climate	Generally, more action will be needed to clean energy supply and mobility to attain limit values. A move to clean, renewable energy sources and propulsion systems will reduce air pollutants and greenhouse gas emissions in parallel. Stricter air quality standards bring co-benefits in the form of reduction of black carbon (BC), a short-lived climate forcer (SLCF), mostly achieved in residential heating sector, introducing cleaner burning technology, and effective enforcement of ban of field burning of agricultural residues.	Society at large will benefit
Noise	As above, a move to cleaner modes of transport will trigger co-benefits for noise (electric power trains being significantly less noisy than internal combustion engines, and soft transport modes being less noisy than motorised ones).	Those currently most affected by noise pollution notably from road transport, i.e. those living along busy roads.
Indoor air quality	Indoor air quality depends to a large extent on the quality of ambient (outdoor) air and would therefore improve with stricter air quality standards.	*As for direct health impacts.*
Equality	Poor air quality disproportionally affects citizens of lower socio-economic status, as well as those with pre-existing conditions and children.[26] Consequently, introducing stricter air quality standards can be expected to have indirect redistributional effects in benefitting these groups most.	Groups of society of lower socio-economic status, vulnerable groups.
Quality of life	European citizens care strongly about air quality.[27]/[28] Besides the quantified health impacts of clean air, indirect benefits are likely to accrue from citizens awareness of breathing cleaner air and living in a more healthy environment.	*As for direct health impacts.*
Administrative cost savings related to the 'one in, one out' approach		

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

The Ambient Air Quality Directives **do not impose any direct administrative costs on consumers and businesses** (while these do bear important adjustment costs, i.e. due to measures needed to achieve EU air quality standards), therefore the one-in-one-out approach is not applicable (as explained in the main report section 8.4).

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

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

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

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

Administrative costs estimates include:

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

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

Costs for consumers and businesses are represented jointly as there are no direct regulatory requirements for businesses stemming from the Ambient Air Quality Directives. This also

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

means that there are **no direct administrative costs to be borne by business or citizens**. This means there is no need to look at potential off-setting measures as part of the Commission's commitment to the **'one-in-one-out'** scheme, and therefore the tables below do not contain the part of the template reserved for "costs related to the 'one in, one out' approach".

Hence, most costs for consumer and businesses are ***indirect costs*** that cannot always be broken down into who will bear what share. The costs most clearly attributable are ***direct administrative and enforcement costs*** falling on the competent authorities in Member States.

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

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

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

Table A3.2 – (II.1) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[30]						
		For public authorities (€)		For consumers & business (€)		Total administrative costs (€)
		One-off	Recurrent	One-off	Recurrent	
C1: Revise obligations triggered by exceedances	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
C2: Revise/clarify definition of 'as short as possible'	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
C3: Revise short-term action plans & air quality plans	Direct administrative and enforcement costs	30k	Low	-	-	**30 000**
C4: Introduce additional short-term action plans	Direct administrative and enforcement costs	50k	Low	-	-	**50 000**
C5: Introduce requirement to update air quality plans	Direct administrative and enforcement costs	Low	2400k	-	-	**2 400 000**
D1: Revise requirements to involve stakeholders	Direct administrative and enforcement costs	320k	Low	-	-	**320 000**
D2: Introduce a 'one zone, one plan' requirement	Direct administrative and enforcement costs	600k	Low	-	-	Not part of preferred option
E1: Introduce minimum levels for financial penalties	Direct administrative and enforcement costs	Low	Low	-	-	Low
E2: Introduce right to health damage compensation	Direct administrative and enforcement costs	Low	Low	-	-	Low
E3: Introduce a fund to be fed by penalties paid	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
E4: Introduce an explicit 'access to justice' clause	Direct administrative and enforcement costs	Low	Low	-	-	Low
F1: Revise provisions related to up-to-date data	Direct administrative and enforcement costs	140k	640k	-	-	**780 000**
F2: Introduce requirement to provide AQ health data	Direct administrative and enforcement costs	Low	Low	-	-	Low
F3: Introduce use of specific communication channels	Direct administrative and enforcement costs	60k	1280k	-	-	Not part of preferred option

Table A3.2 – (II.1) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[30]						
		For public authorities (€)		For consumers & business (€)		Total administrative costs (€)
		One-off	Recurrent	One-off	Recurrent	
F4: Introduce requirements for harmonised AQ index	Direct administrative and enforcement costs	10k	Low	-	-	**10 000**
	SUB-TOTAL					**4 790 000**

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

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

Table A3.3 – (II.2) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[31]						
I2: Introduce obligations to monitor long-term trends	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option
I3: Introduce a protocol for relocated sampling points	Direct administrative and enforcement costs	50k	Low	-	-	**50 000**
J1: Revise macro-scale siting of sampling points	Direct administrative and enforcement costs	150k	Low	-	-	**150 000**
J2: Revise micro-scale siting of sampling points	Direct administrative and enforcement costs	150k	Low	-	-	**150 000**
J3: Introduce obligation for spatial representativeness	Direct administrative and enforcement costs	370k	2 230k	-	-	**2 600 000**
K1: Revise AQ monitoring data quality objectives	Direct administrative and enforcement costs	100k	Low	-	-	**100 000**
K2: Introduce up-to-date data at all sampling points	Direct administrative and enforcement costs	140k	640k	-	-	**780 000**
K3: Introduce AQ modelling data quality objectives	Direct administrative and enforcement costs	20k	Low	-	-	**20 000**
K4: Revise approach to AQ assessment uncertainty	Direct administrative and enforcement costs	100k	Low	-	-	**100 000**
L1: Introduce concept of monitoring at 'super-sites'	Direct administrative and enforcement costs	1 080k	5 400k	-	-	**6 480 000**
L2: Introduce obligations to monitor more pollutants	Direct administrative and enforcement costs	4 390k	45 000k	-	-	**49 390 000**
L3: Revise list of VOC to monitor	Direct administrative and enforcement costs	1 690k	25 310k	-	-	Not part of preferred option
M1: Introduce methodology to assess transboundary	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
M2: Revise obligations for transboundary cooperation	Direct administrative and enforcement costs	Low	Low	-	-	Low
M3: Revise the information in air quality plans	Direct administrative and enforcement costs	600k	Low	-	-	**600 000**
	SUB-TOTAL					**70 290 000**

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

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

Table A3.4 – (II.3) Overview of costs – Assessment of administrative costs and burden for specific policy measures preferred policy options (note that one-off costs have been annualized assuming a period of 20 years and a discount rate of 3%)[32]								
R2: Revise standards for 8-hour O_3	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
R3: Introduce average exposure standards for O_3	Direct administrative and enforcement costs	240k	-	-	-	340k	**240k**	135k
S1: Revise standards for annual SO_2	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
S2: Revise standards for daily/hourly SO_2	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
T1: Revise standards for daily/8-hour CO	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
U1: Revise standards for annual benzene	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
V1: Revise standards for annual benzo(a)pyrene	Direct administrative and enforcement costs	1 210k	-	-	-	3 350k	**1 210k**	390k
W1: Revise standards for annual lead	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
X1: Revise standards for annual arsenic	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Y1: Revise standards for annual cadmium	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Z1: Revise standards for annual nickel	Direct administrative and enforcement costs	Low	-	-	-	Low	Low	Low
Ø 1: Introduce standards for additional air pollutants	Direct administrative and enforcement costs	Low	Low	-	-	Not part of preferred option		
	SUB-TOTAL					31 050k	**3 130k**	1 110k

3. RELEVANT SUSTAINABLE DEVELOPMENT GOALS

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

ANNEX 4: ANALYTICAL METHODS

1. OVERVIEW

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

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

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

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

[33] SWD(2021) 305 final

	pollution. Also considers synergies with climate action.	
Administrative burden	Administrative burden of air quality management, in particular as relates to air quality assessment regimes (including monitoring, modelling, and reporting of related data)	12

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

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

2. QUANTITATIVE MODELLING OF AIR POLLUTANT STANDARDS

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

2.1 Introduction of the modelling framework

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

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

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

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

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

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

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

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

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

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

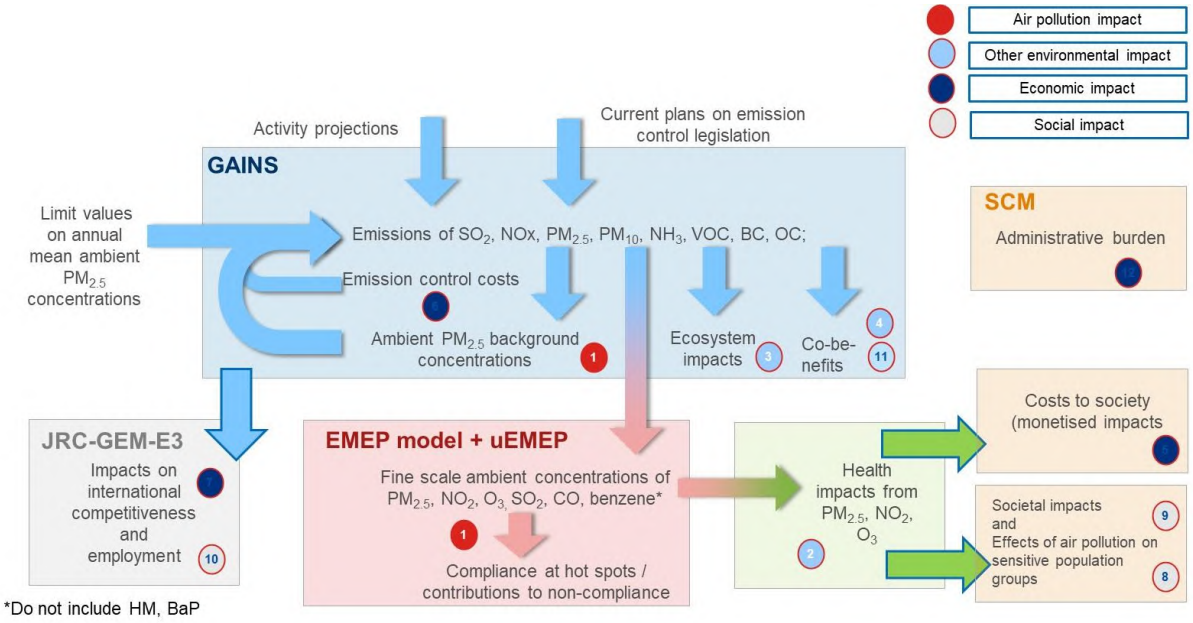

Figure A4.1 – Modelling framework applied to assess the twelve indicators

2.2 Application of GAINS

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

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

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

The emission scenarios have been developed with the optimisation module of the GAINS model, which has been applied to identify cost-optimal strategies to achieve ambient $PM_{2.5}$ concentrations in compliance with ambient air quality standards, where this is technically

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

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

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

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

2.3 Concentration modelling methodology

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

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

these sites, in relation to the currently observed concentrations. All scenario simulations were using meteorological conditions for 2018.[38]

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

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

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

2.4 Assessment of health impacts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.5 Monetisation of health and non-health impacts

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

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

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

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

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[42] EEA (2022), Europe's air quality status 2022 (accessed: 10.06.2022)

[43] Available in the annex to the support study for the Second Clean Air Outlook report, as well as in the annex of the support study underlying this impact assessment.

[44] Europa.eu (2015), Effects of Climate Change on Air Pollution Impacts- final. -nr. 282910 (accessed: 10.06.2022)

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

3. SHORTCOMINGS OF THE MODELLING APPROACH AND SOURCES OF UNCERTAINTY

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

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

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

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

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

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

- Only the morbidity related to exposure to particulate matter is considered. Other pollutants are not considered.
- Future projections for the baseline incidence are unavailable for most health outcomes. The analysis therefore relies on the morbidity rates for the most recent year for the future baseline morbidity. Impacts due to improvements in health care, more / less healthy lifestyle etc. are hence not considered.
- In general, the uncertainty on the morbidity estimates is larger than the uncertainty on the mortality estimates, mostly due to more pronounced uncertainty in the input datasets

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

(concentration response functions, baseline morbidity). When interpreting the results, the focus should therefore lie on relative differences between scenarios.

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

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

1. DESCRIPTION OF THE BASELINE SCENARIO

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

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

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

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[46] See Appendix 3 of the support study for a full list of policies included in the baseline.

[47] Extension of the EU Energy and Climate Modelling Capacity to include the Energy Community and its Nine Contracting Parties (ENER/2020/OP/0005)

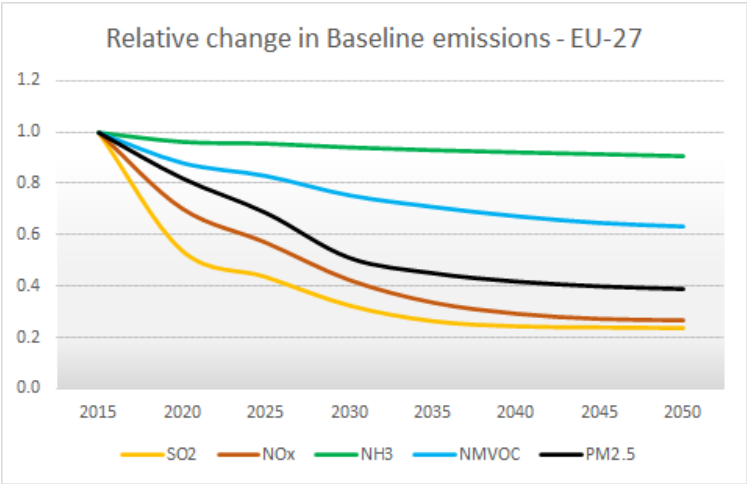
2. AIR POLLUTANT EMISSIONS: BASELINE DEVELOPMENT AND SCOPE FOR MTFR REDUCTIONS

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

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

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

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



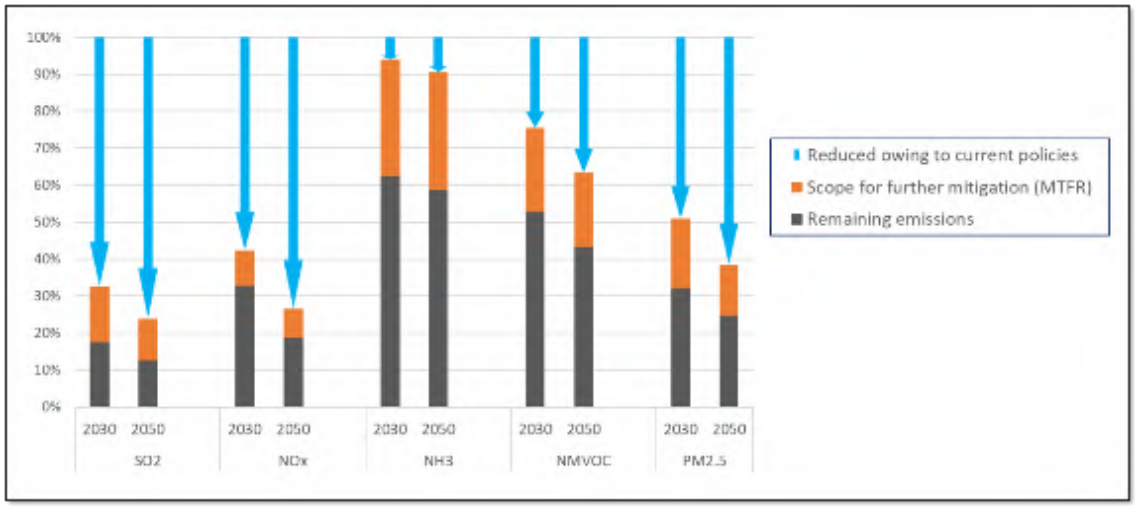
For NH_3, further emission reductions are expected from recently proposed revision of the IED, including cattle and reducing the farm size threshold for pigs and poultry.[48] While the modelling baseline used here does not include this proposal (implementation in the GAINS model is under way within the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

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

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

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

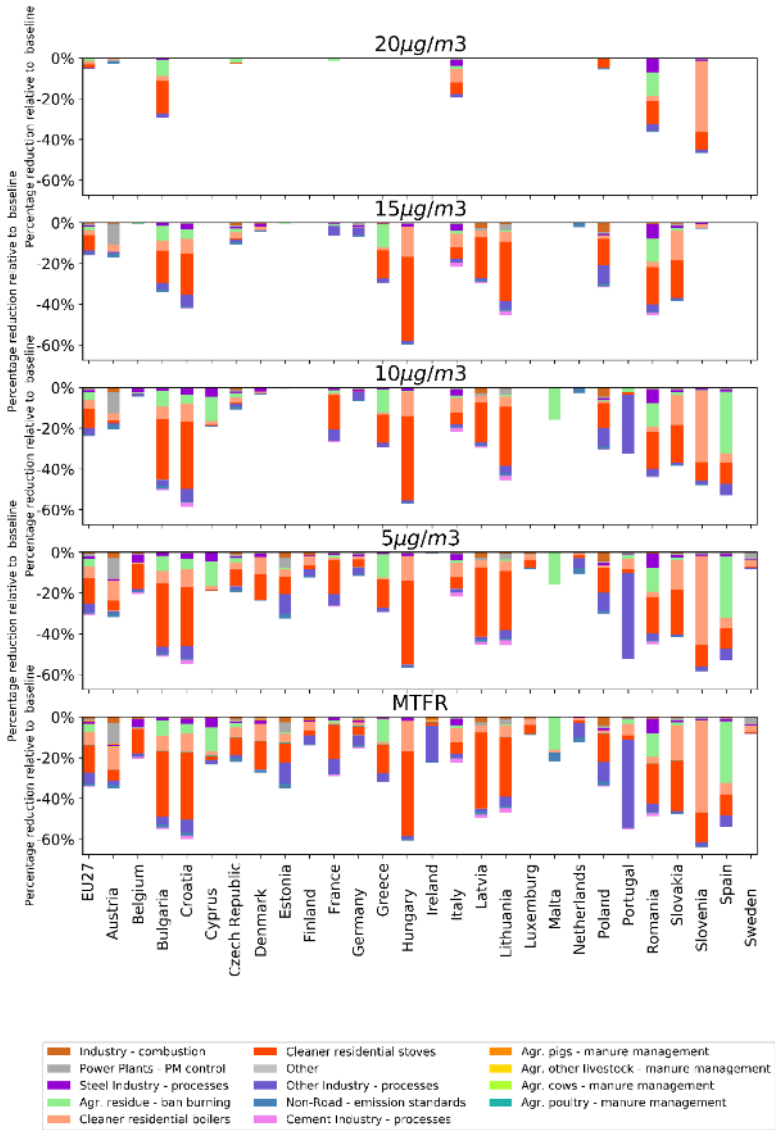
Figure A5.2 – Scope for further emission mitigation of air pollutant emissions in 2030 and 2050 in the EU-27. Changes shown relative to 2015 (GAINS model)



Since current legislation is expected to reduce emissions of **SO_2** and **NOx**, further potential is rather limited and even declines in the long-term owing to the reduced used of fossil fuels already in the baseline. Remaining limited potential has been identified for industrial process. For **$PM_{2.5}$**, key further mitigation can be achieved in the residential sector and also by enforcing bans on open burning of various agricultural residues that in spite of existing legislation are still burned, while there would remain very limited, if any, potential to further reduce emissions from power or industrial sectors. For **NMVOC**, apart from some potential in residential sector and agricultural burning, further reductions in solvent use applications were estimated. For **ammonia**, mitigation of emissions from mineral nitrogen fertilizer application and livestock offer significant reduction potential assuming that measures addressing housing, storage, and application of manures on land would be introduced in an integrated manner (as proposed in the revised IED), but for a much larger number of farms than is currently the case as per baseline assumptions, especially for cattle.

The mitigation potential shown above (as well as the results that include sectoral breakdown shown in chapter 6 of the main SWD) vary strongly between Member States depending on structure of emission sources and local constraints.[49] The following figures (A5.3 to A5.7) reflect this variation. They present the reduction of emissions of $PM_{2.5}$ and its precursors *compared to the baseline* as calculated in the GAINS model for policy and MTFR scenarios, showing a disaggregated sector/measure resolution and with results per Member State.

Figure A5.3 – Reduction of **$PM_{2.5}$** emissions, split by Member State (2030)



[49] See main report of the underlying support study for estimates per Member State.

Figure A5.4 – Reduction of **SO_2** emissions, split by Member State (2030)

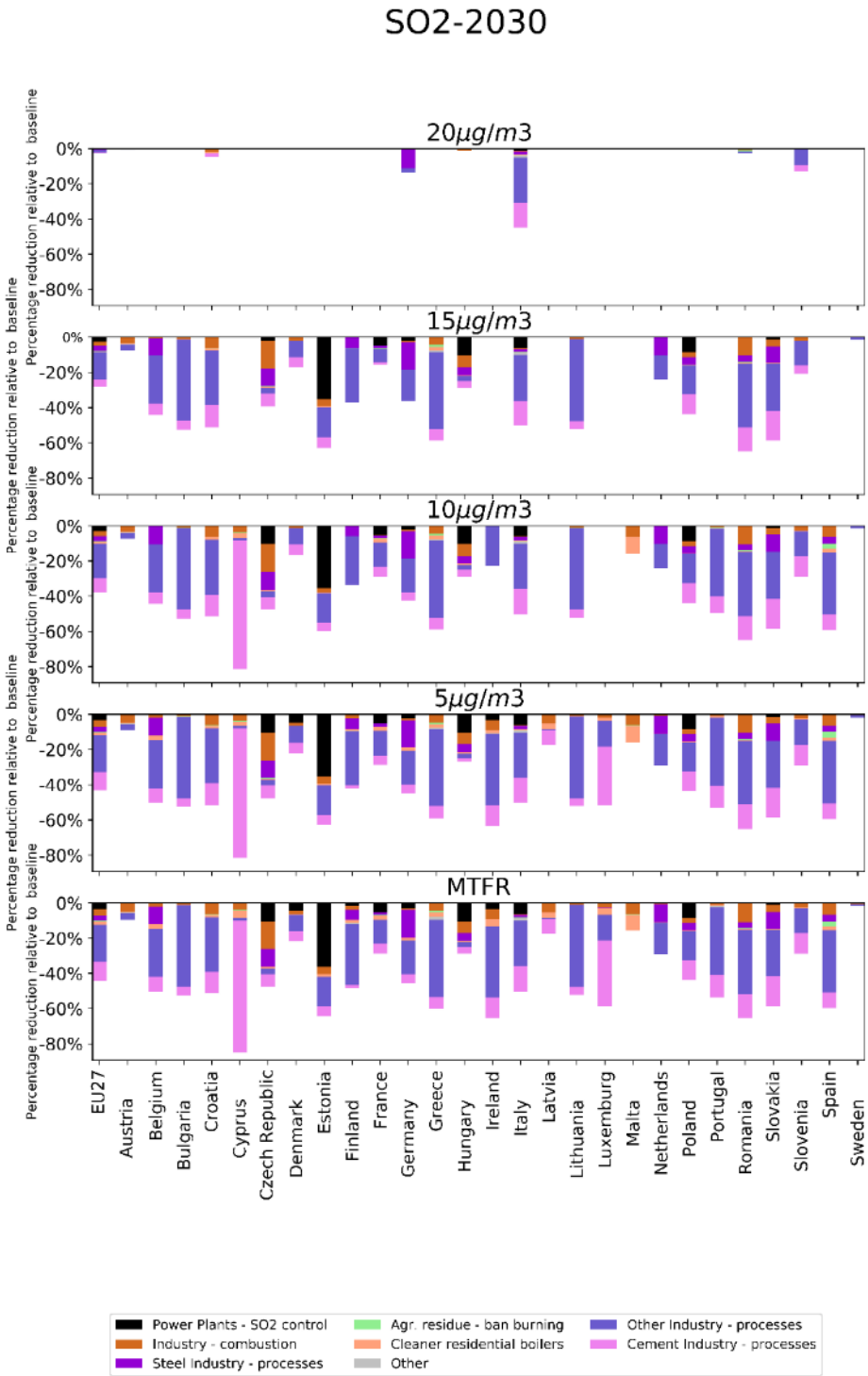


Figure A5.5 – Reduction of **NO_X** emissions, split by Member State (2030)

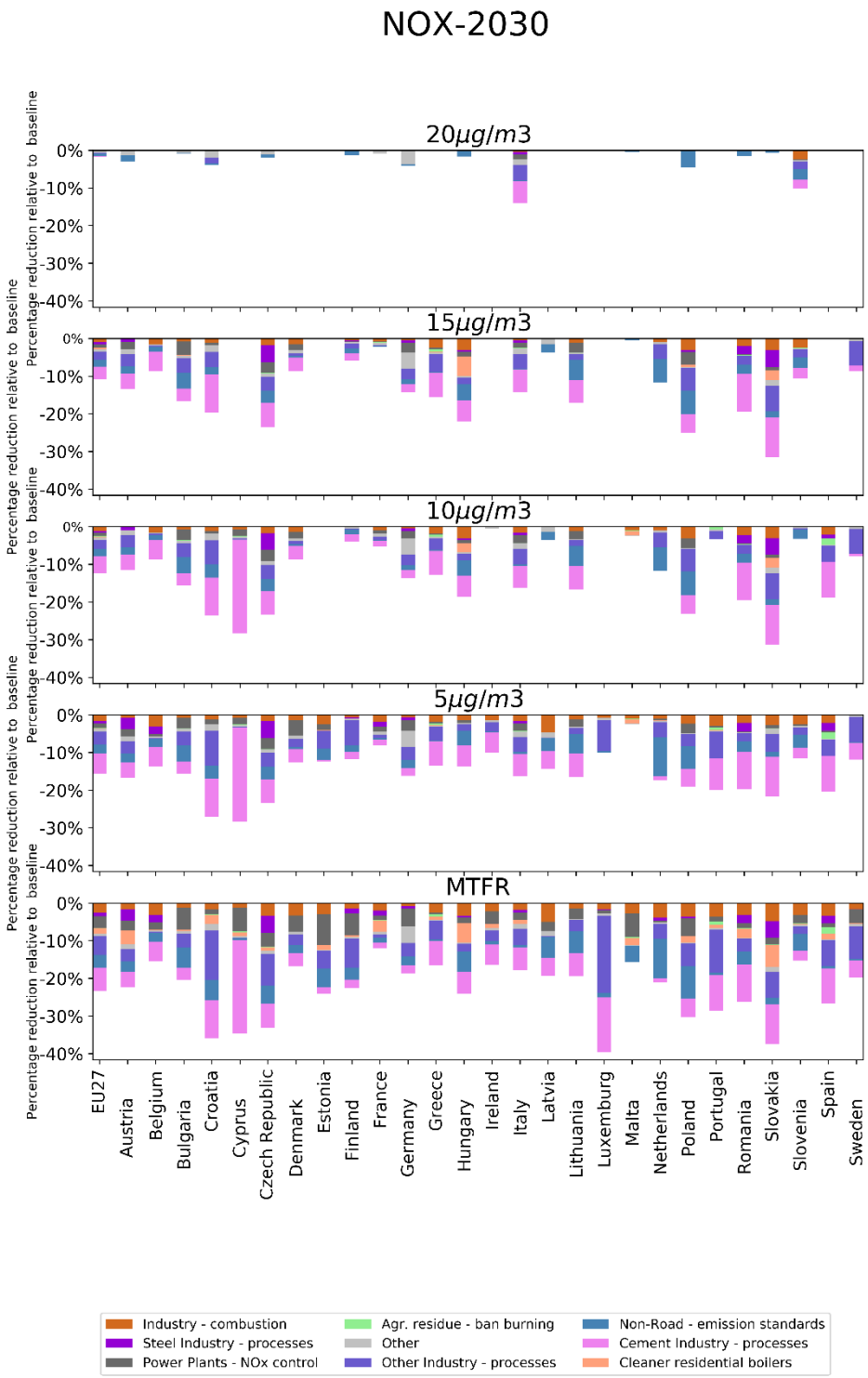


Figure A5.6 – Reduction of **NH_3** emissions, split by Member State (2030)

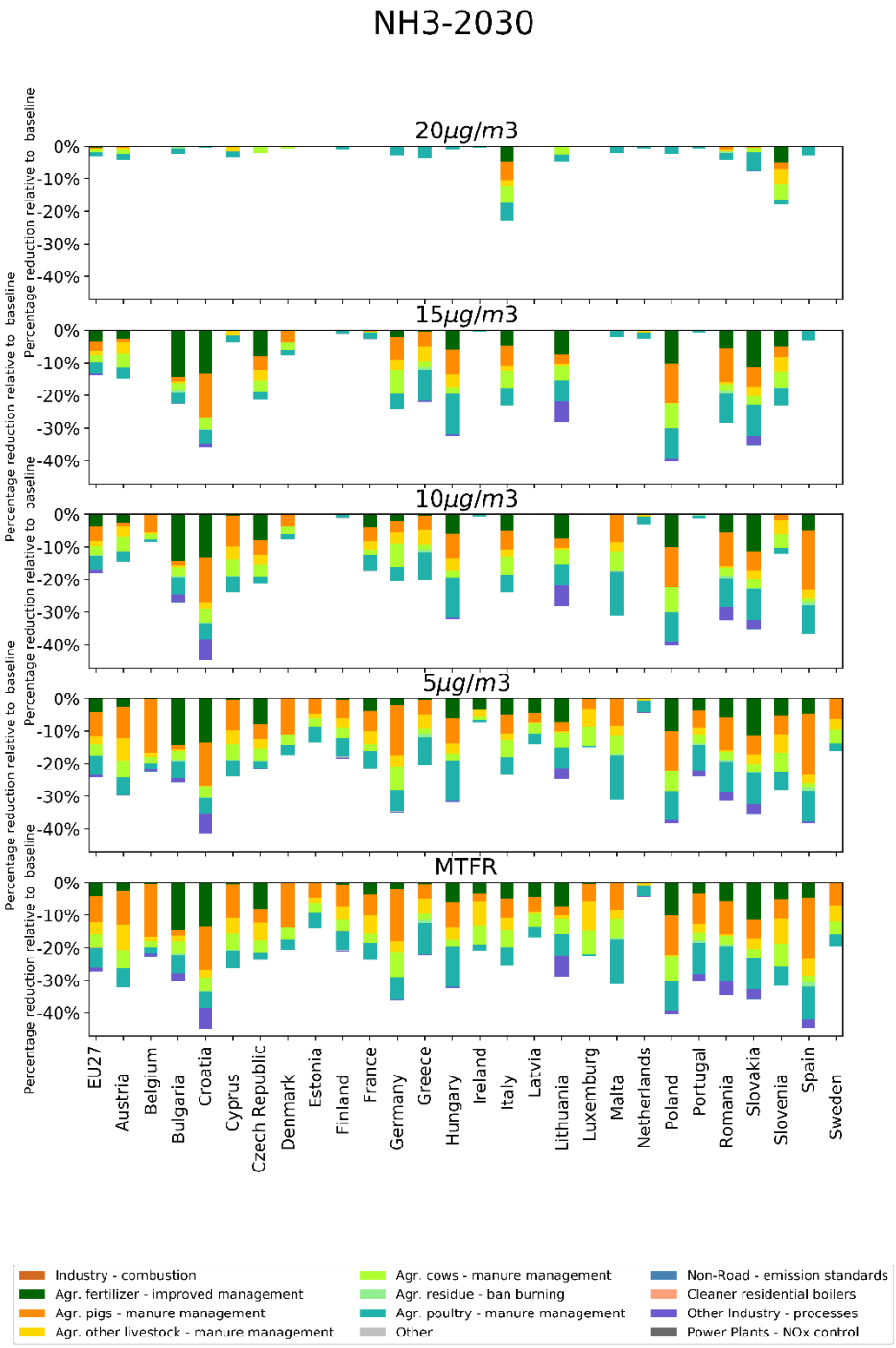
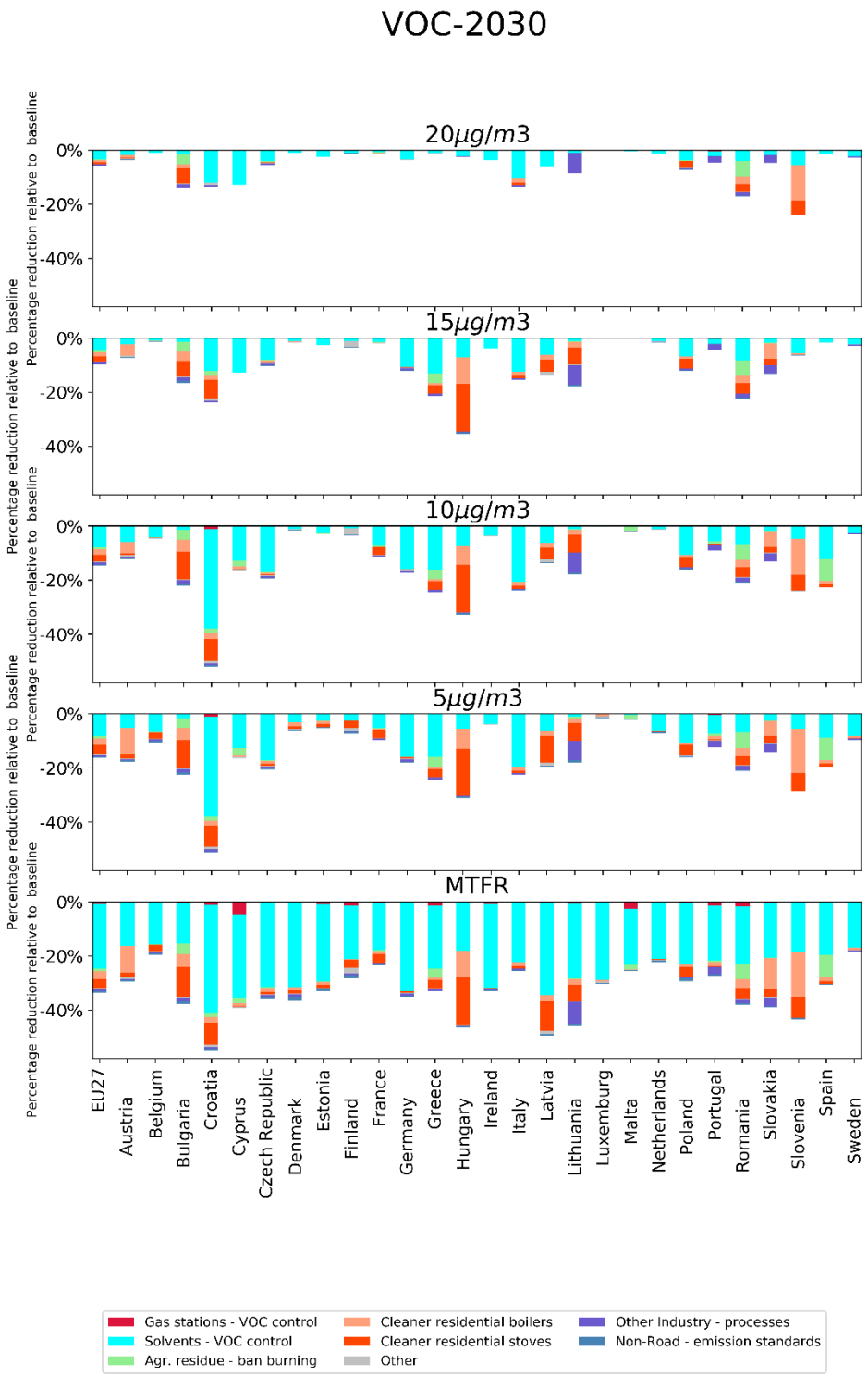


Figure A5.7 – Reduction of **VOC** emissions, split by Member State (2030)



3. AIR POLLUTANT CONCENTRATION PROJECTIONS

The main report includes detailed results for the baseline and policy scenarios showing the number of stations with remaining exceedances above different limit values. To complement these results, this section includes a number of maps that show the geographical distribution of air pollutant concentrations in the baseline, various optimisation and MTFR scenarios.

The below maps (Figures A5.8) show concentrations of **fine particulate matter ($PM_{2.5}$)** in 2030 indicate that already under baseline assumptions substantial improvements in air quality over the coming decades can be expected, with most of Europe reaching concentration levels below 10 µg/m^3. Areas including parts of Central Europe, the Baltics, Italy and Northern parts of France move even to concentration levels of below 5 µg/m^3.

The optimisation scenarios bring further improvements. Significant parts of Europe remain above 5 µg/m^3 in the OPT-5 scenario (which corresponds to policy option I-1), including Northern Italy (Figure A5.10), the border region of Czechia, Poland and Slovakia (see also Figure A5.11), as well as southern regions along the Mediterranean coast of the EU. This remains the case in the MTFR scenario, which would bring little additional improvements.

Going to 2050 (Figure A5.9), additional areas reach concentration levels below 5 µg/m^3, notably most remaining parts of Poland and Hungary, as well as of Belgium and the Netherlands. Elevated levels of fine particulate matter ($PM_{2.5}$) in Southern Europe are rather persistent, which is explained by the fact that much of the pollution is due to natural sources, and Sahara dust and sea spray in particular (which the current Ambient Air Quality Directives allow to be deducted from air pollution levels reported).

Figure A5.10 highlights the specific dynamics in the Po Valley region in Northern Italy, where specific meteorological and orographic circumstances lead to reduced dispersion, and elevated emission levels from residential heating (including biomass burning) as well as agricultural emissions represent particular challenges. While under the preferred policy option the area exposed to $PM_{2.5}$ concentration levels above 10 µg/m^3 reduces significantly by 2030, some hotspots would be expected to remain across optimisation scenarios (and significant parts remain are just below 10 µg/m^3).

Similarly, for much of Eastern Europe (see for example Figure A5.11), residential heating (often reliant on fossil fuel combustion) and industry production facilities today lead to elevated $PM_{2.5}$ concentration levels. Under the preferred policy option and based on the measures taken to address these emissions, the area exposed to $PM_{2.5}$ concentration levels above 10 µg/m^3 reduces almost to zero by 2030.

As regards the concentration levels of **particulate matter (PM_{10})** for the baseline and MTFR, most areas in the EU reach concentration levels of below 15 µg/m^3 in 2030 already in the baseline when looking at background concentration levels (Figure A5.12). The remaining areas above 15 µg/m^3 are along the Mediterranean cost and as such can be explained by pollution from natural sources.

Zooming in to a finer resolution, however, indicates that local peaks of concentration levels of particulate matter (PM_{10}) can be expected to remain under all scenarios analysed. These can be linked, for example to constant levels of non-exhaust emissions from transport: Figure A5.13

illustrate the particular case of Stockholm, where pollution peaks can be seen along the main road traffic axes.

The baseline assumptions related to improved vehicle emissions standards and increased electrification of road transport lead to reductions of **nitrogen dioxide (NO_2)** concentration levels in urban centres across the EU from 2020 to 2030, with further reductions in the MTFR and towards 2050 (Figure A5.14). A large area with noticeable improvements in NO_2 concentration levels is the area spanning parts of Belgium and the Netherlands as well as the Ruhr area in Germany. Zooming into this region (Figure A5.15) shows that areas with an annual mean concentration of over 20 µg/m^3 are markedly reduced in 2030, already in the baseline scenario, with remaining areas above 20 µg/m^3 being situated mainly around ports.

Moving from 2020 to 2030 in the baseline already brings marked improvements to **ozone (O_3)** (26th highest maximum 8-hour daily running mean) concentrations levels with large areas where concentrations levels are reduced to below 100 µg/m^3, and few remaining areas with levels above 120 µg/m^3 (in Northern Italy). Further reductions are observed in the MTFR in 2030 and even more pronounced in baseline and MTFR in 2050, when most parts of the EU have levels of 80 to 100 µg/m^3, with levels above 100 µg/m^3 remaining primarily in Romania, Northern Italy, in some parts around the Mediterranean cost as well as parts of North-Western Europe (Figure A5.16).

Figure A5.17 shows low levels of **sulphur dioxide (SO_2)** concentrations levels of below 40 µg/m^3 prevailing throughout the EU. This is explained by the strong reduction in coal use in power plants as well as in residential coal use in line with EU energy and climate policy that form part of the baseline assumptions.

Carbon monoxide (CO) concentration levels are below 1 mg/m^3 in most of the EU, with little changes between baseline and MTFR. Smaller patches are between 1 and 2 mg/m^3.

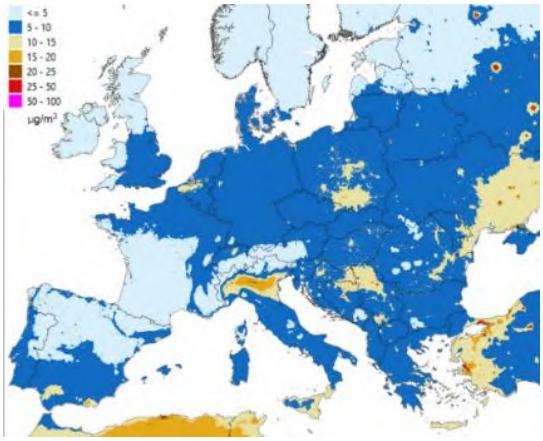
Most of the EU has concentration levels for **benzene (C_6H_6)** below 0.8 mg/m^3 already in the baseline in 2020. Parts of Northern Italy show more elevated levels between 0.8 and 3.4 mg/m^3. This area is reduced significantly already in the baseline in 2030.

Concentrations levels for **benzo(a)pyrene (BaP)** are above 1 ng/m^3 in significant parts of the EU in the baseline in 2020, notably in Poland, in Northern Italy and in more localised places in Southern, Central and Eastern Europe. Already the baseline assumptions reduce these areas in 2030 to a good extent, most notably in Poland. In the MTFR in 2030 and going towards 2050, there are very limited areas left with concentration levels exceeding (in Poland, Northern Italy and Greece) 1 ng/m^3.

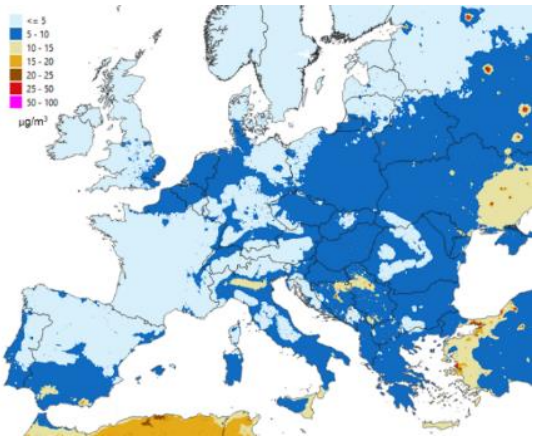
Maps for fine particulate matter - $PM_{2.5}$

Figure A5.8 - $PM_{2.5}$ concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for **2030**. Calculations are made on the EMEP 0.1° grid For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

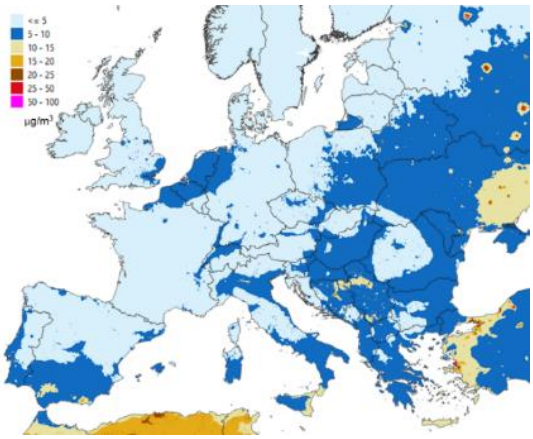
Base 2020



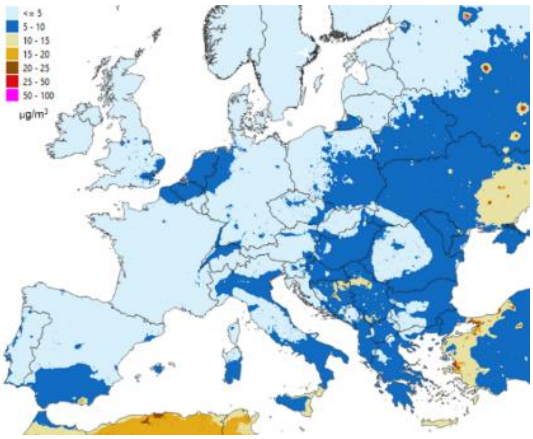
Base 2030



OPT-15 2030 (Policy Option I-3)



OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)

MTFR 2030

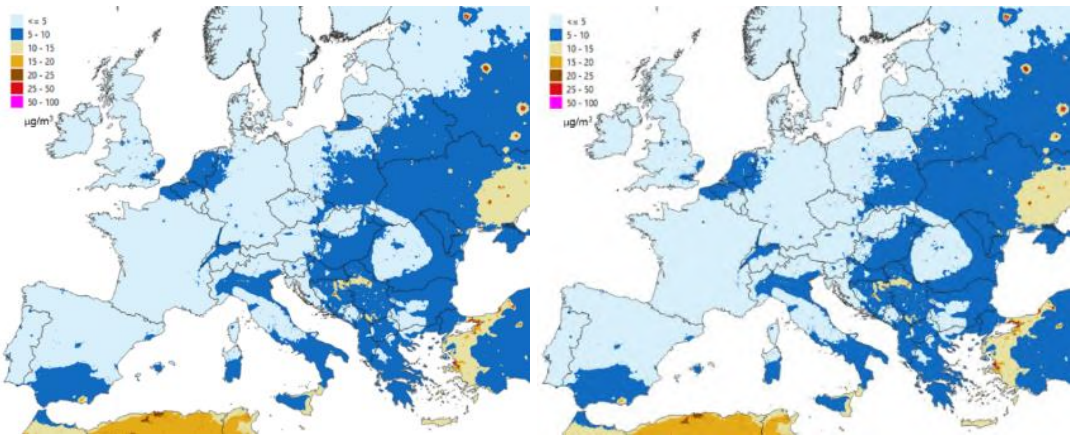
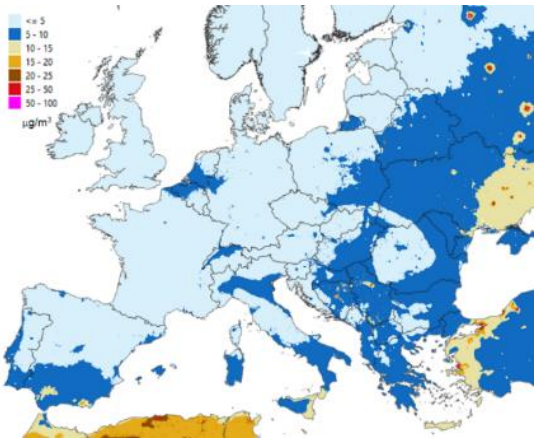
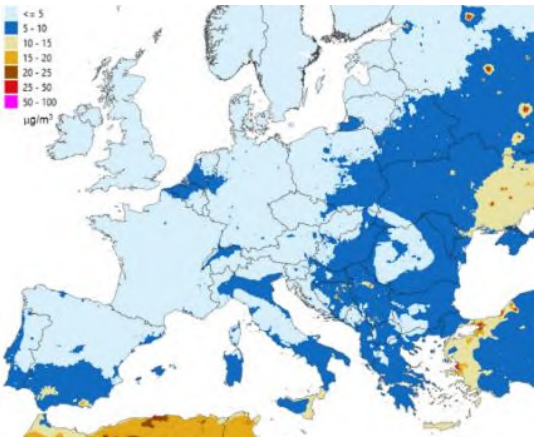

<= 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 50
50 - 100
µg/m³
<= 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 50
50 - 100
µg/m³

Figure A5.9 - $PM_{2.5}$ concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for **2050**. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

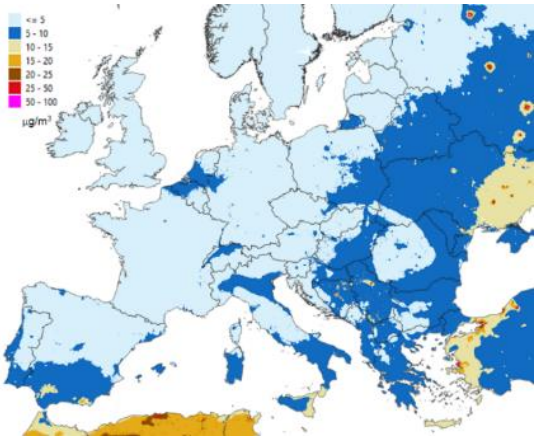
Base 2020



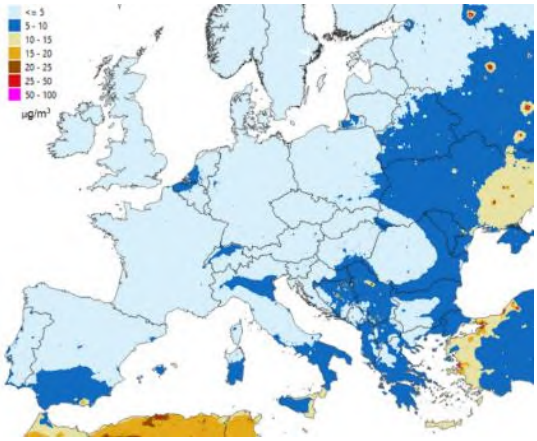
Base 2050



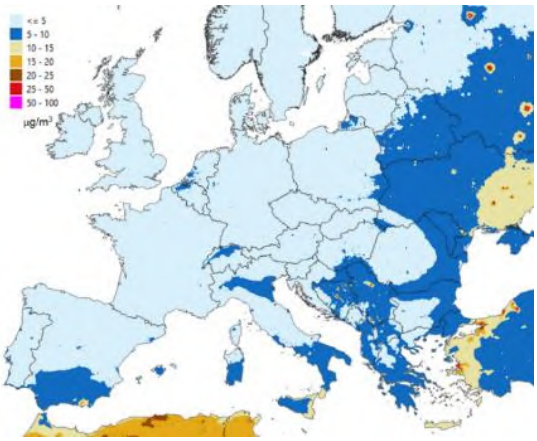
OPT-15 2050 (Policy Option I-3a)



OPT-10 2050 (Policy Option I-2a)



OPT-05 2050 (Policy Option I-1a)



MTFR 2050

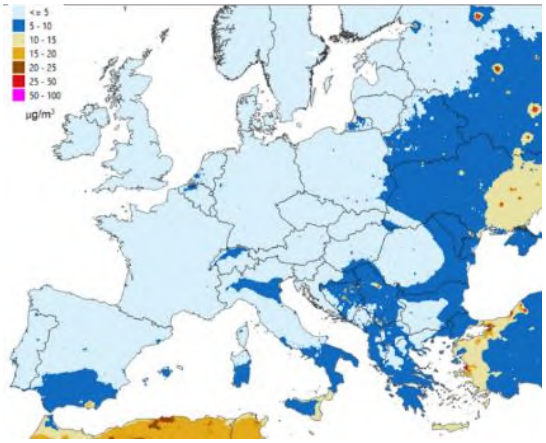
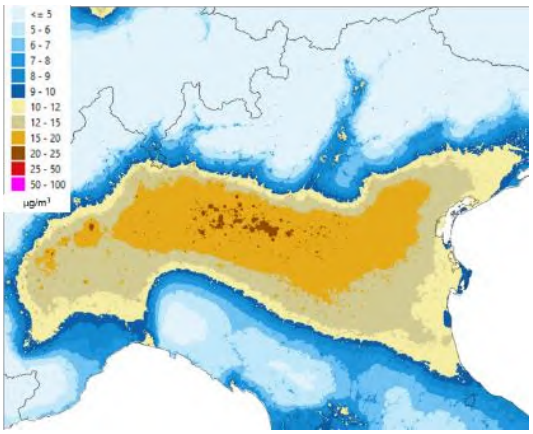
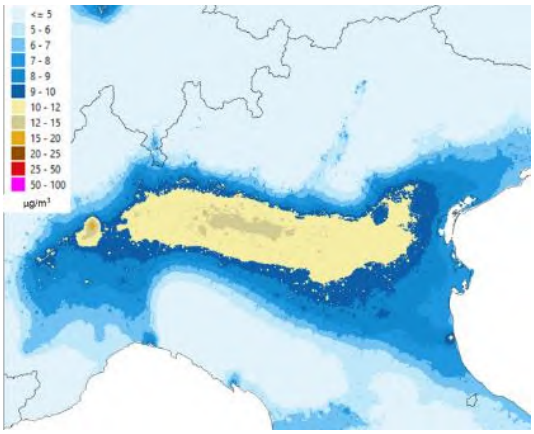


Figure A5.10 - Focus: Region in Northern Italy. $PM_{2.5}$ annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 5 and 12 µg/m^3. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

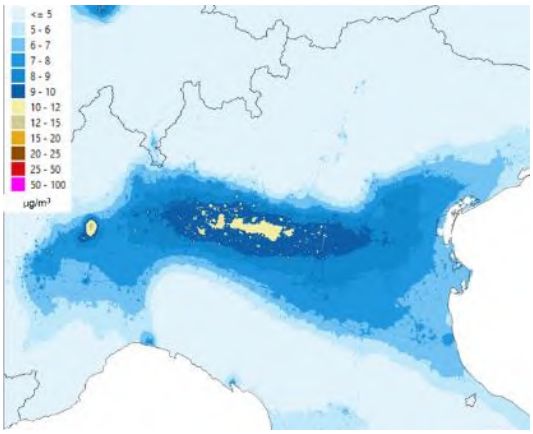
Base 2020



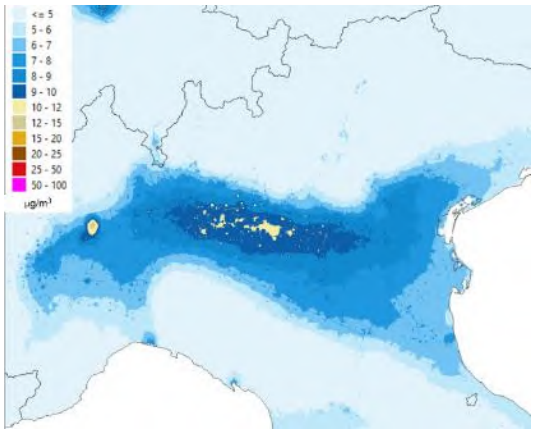
Base 2030



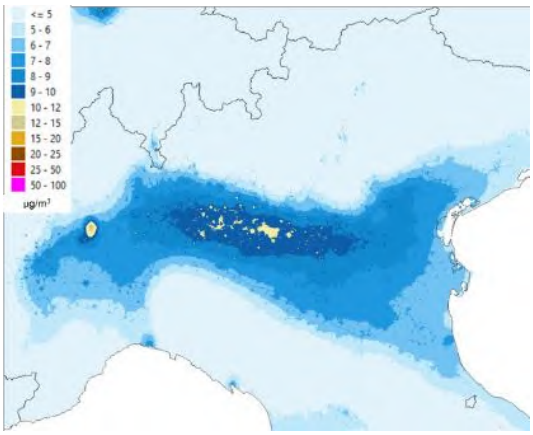
OPT-15 2030 (Policy Option I-3)



OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



MTFR 2030

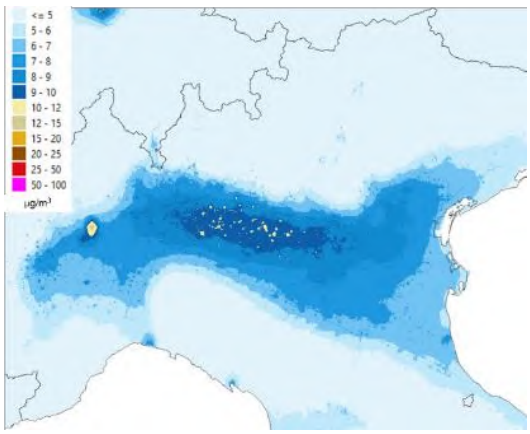
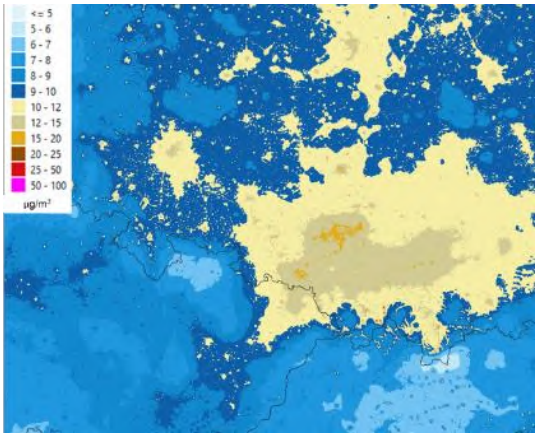
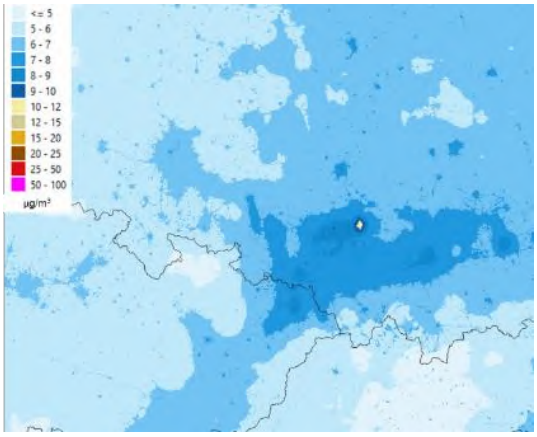


Figure A5.11 – Focus: Region in Central Europe. $PM_{2.5}$ annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 5 and 12 µg/m^3. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

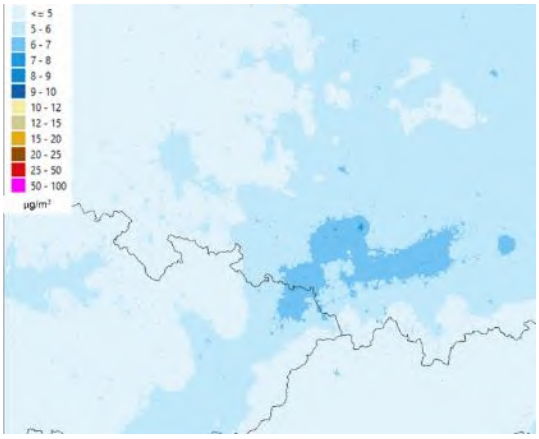
Base 2020



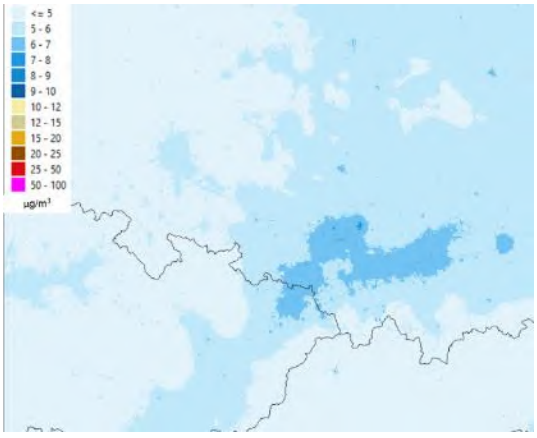
Base 2030



OPT-15 2030 (Policy Option I-3)

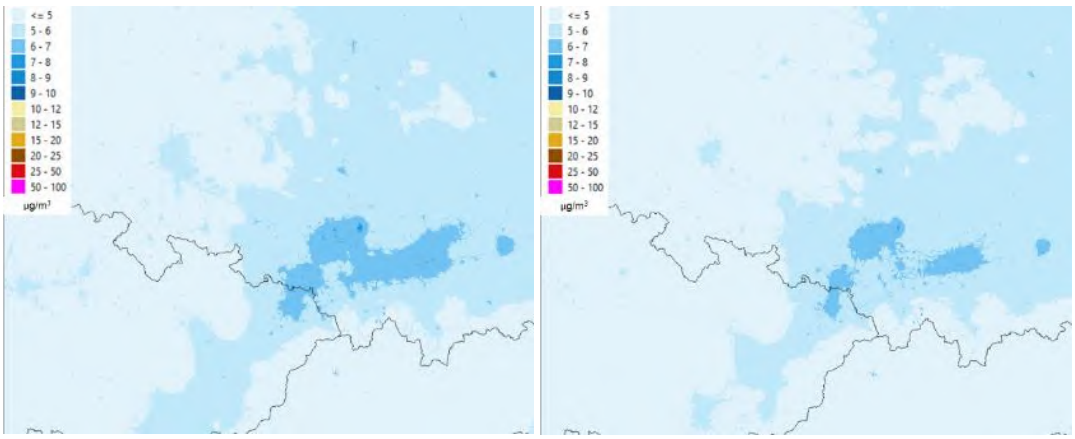


OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)

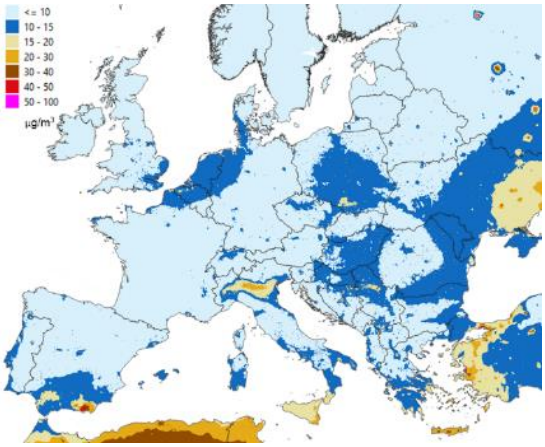
MTFR 2030



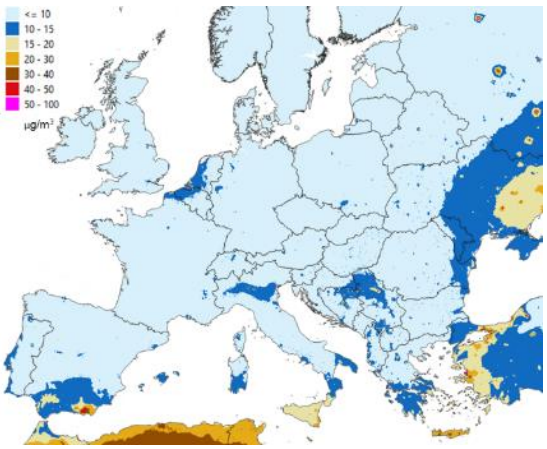
Maps for particulate matter - PM_{10}

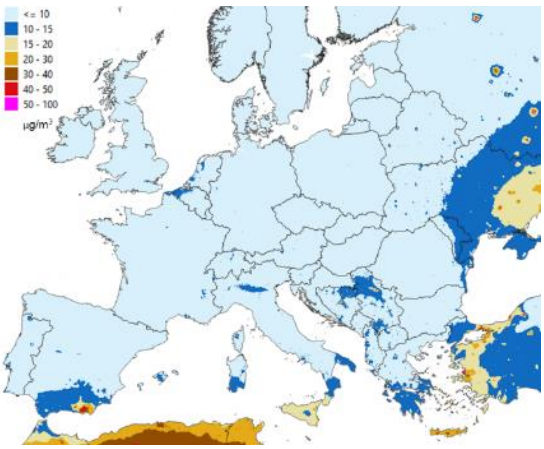
Figure A5.12 - PM_{10} annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

Base 2020



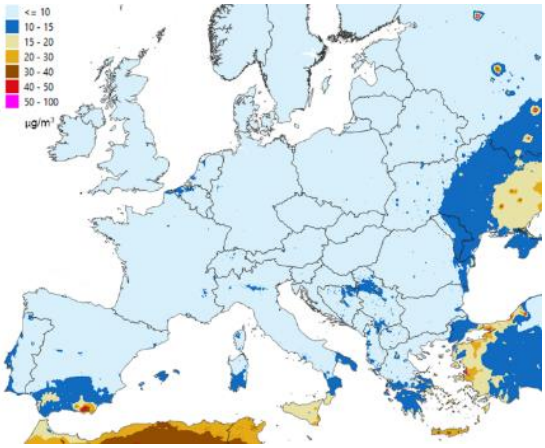
Base 2030 ***MTFR 2030***





Base 2050

MTFR 2050



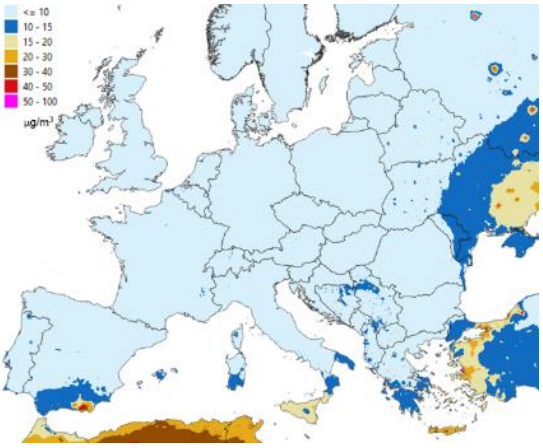
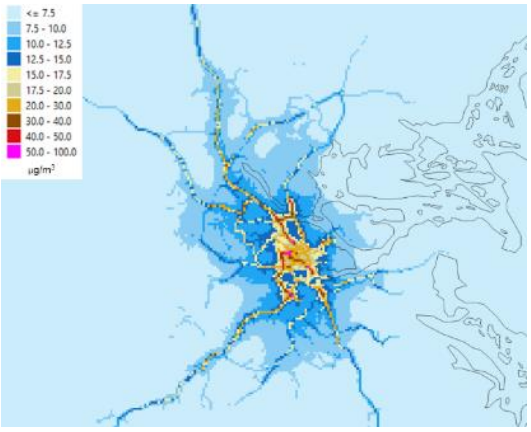
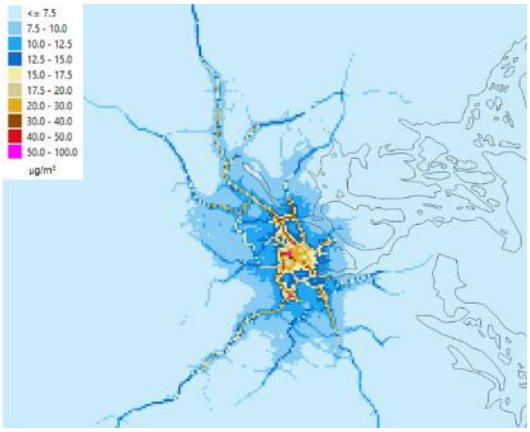


Figure A5.13 – Focus: Region in Scandinavia. PM_{10} annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Region shown is the city of Stockholm in Sweden. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 7.5 and 20 µg/m^3. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

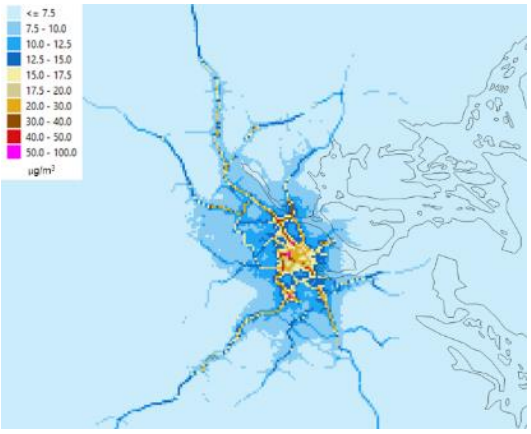
Base 2020



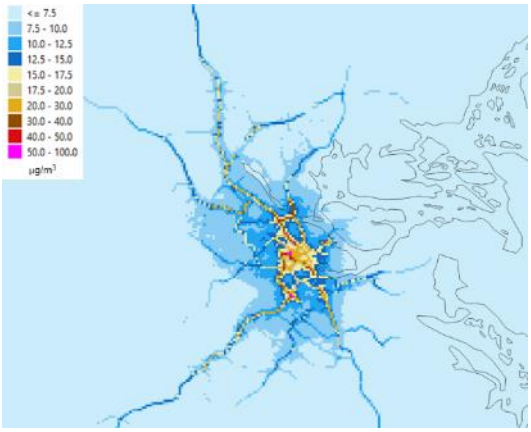
Base 2030



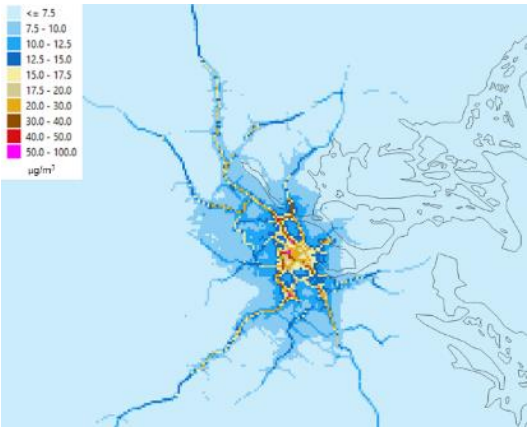
OPT-15 2030 (Policy Option I-3)



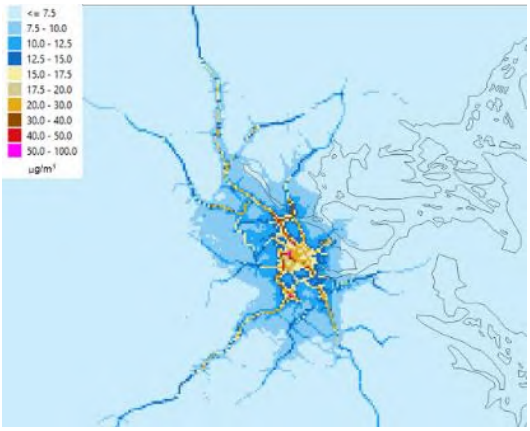
OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



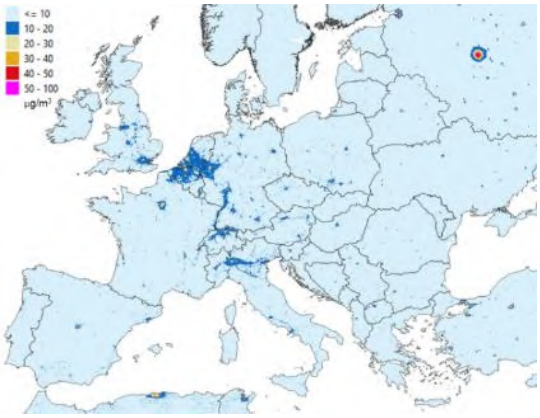
MTFR 2030



Maps for nitrogen dioxide - NO_2

Figure A5.14 - NO_2 concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the uEMEP 250 m grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

Base 2020

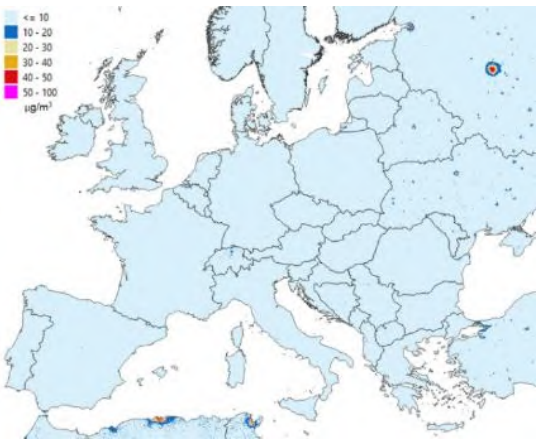


Base 2030

MTFR 2030

Base 2050

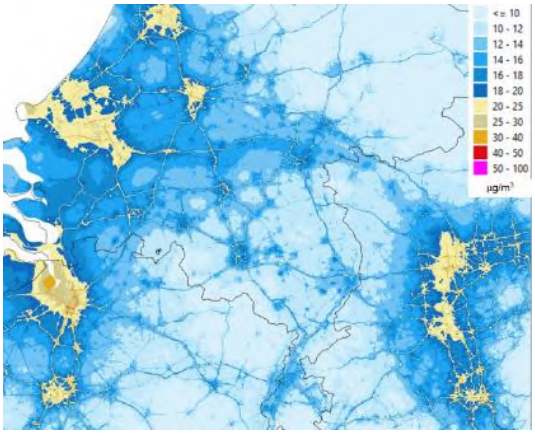
MTFR 2050


<= 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 100
µg/m³

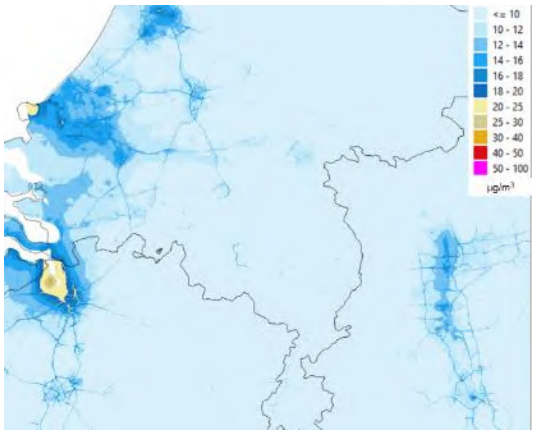
<= 10
10 - 20
20 - 30
30 - 40
40 - 50
50 - 100
µg/m³

Figure A5.15 – Focus: Region in North-Western Europe. NO_2 annual mean concentrations for baseline 2020 and a range of optimised (OPT) scenarios, including MTFR for 2030. Region in North-Western Europe including Belgium, Germany and The Netherlands. Calculations are made on the uEMEP 250 m grid. Note the change in colour scale to emphasize concentrations between 10 and 25 µg/m^3. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

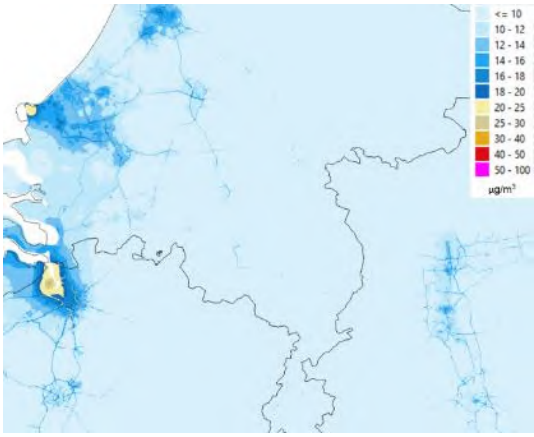
Base 2020



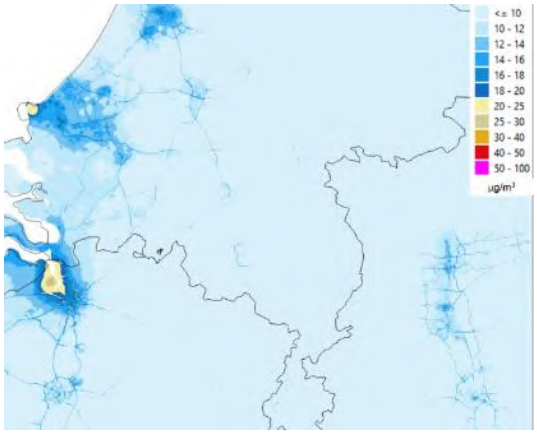
Base 2030



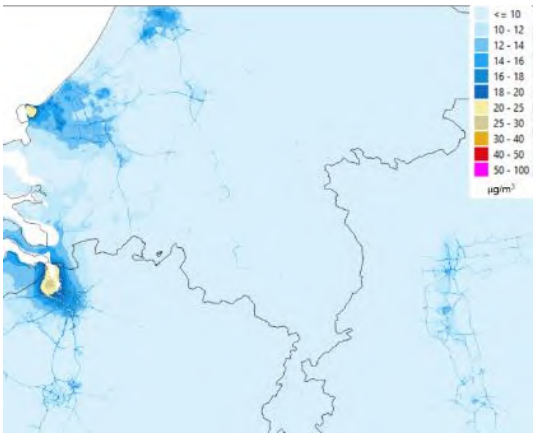
OPT-15 2030 (Policy Option I-3)



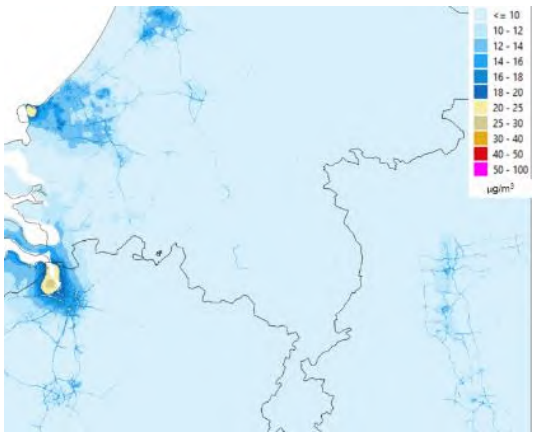
OPT-10 2030 (Policy Option I-2)



OPT-05 2030 (Policy Option I-1)



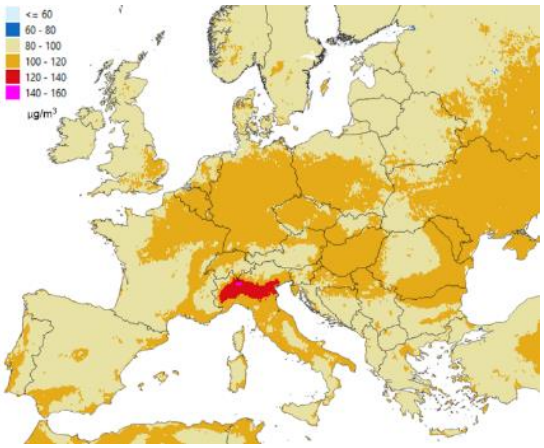
MTFR 2030



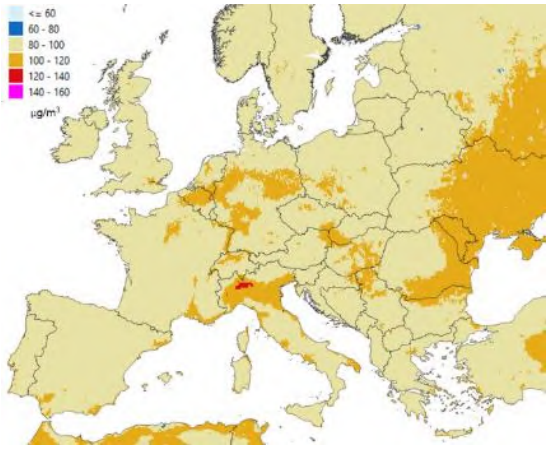
Maps for ozone – O_3

Figure A5.16 - O_3 (26th highest maximum 8 hour daily running mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

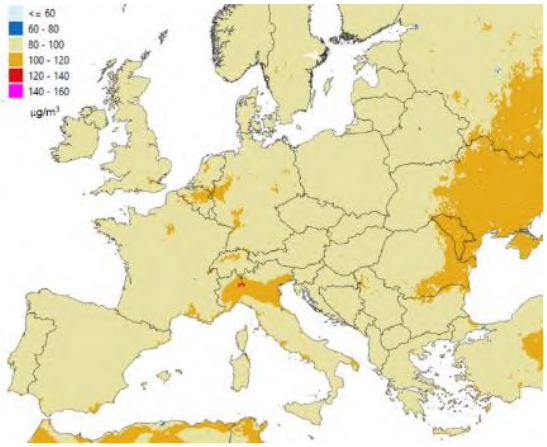
Base 2020



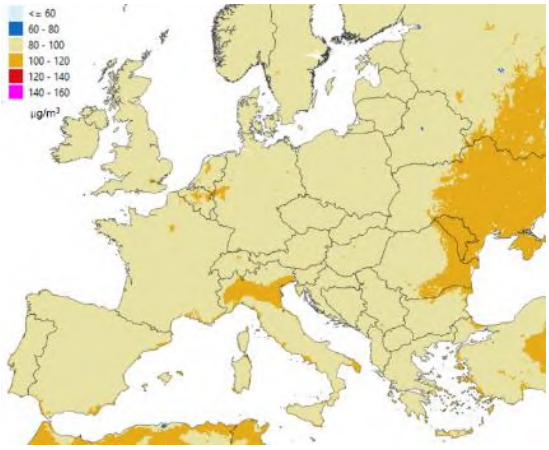
Base 2030



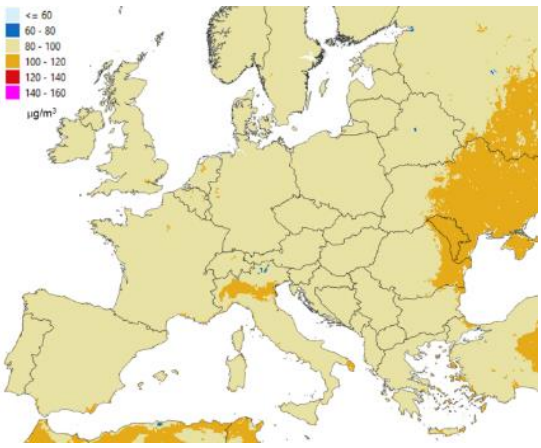
MTFR 2030



Base 2050



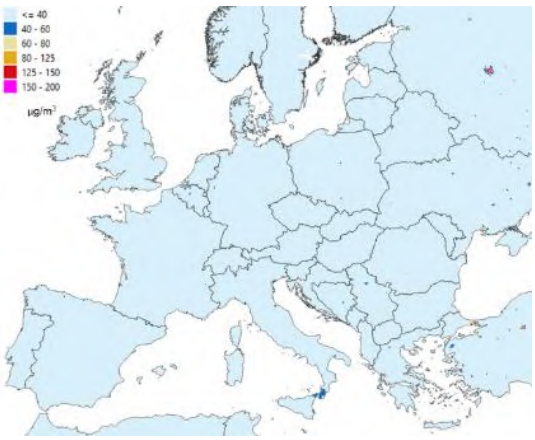
MTFR 2050



Maps for sulphur dioxide - SO_2

Figure A5.17 - SO_2 (99th percentile daily mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Annual means are calculated and converted to 99th percentiles. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

Base 2020

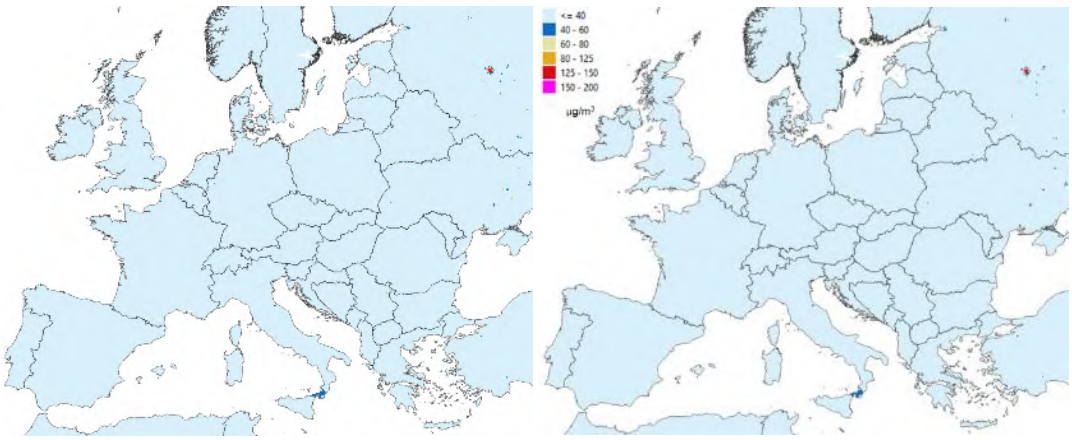


Base 2030

MTFR 2030

Base 2050

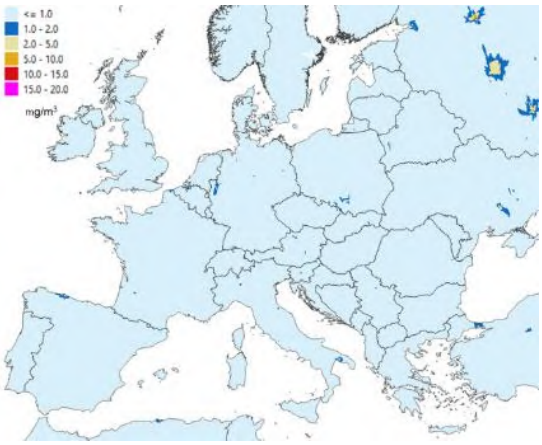
MTFR 2050



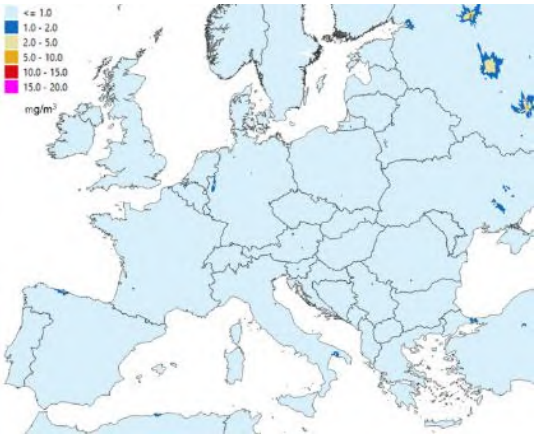
Maps for carbon monoxide - CO

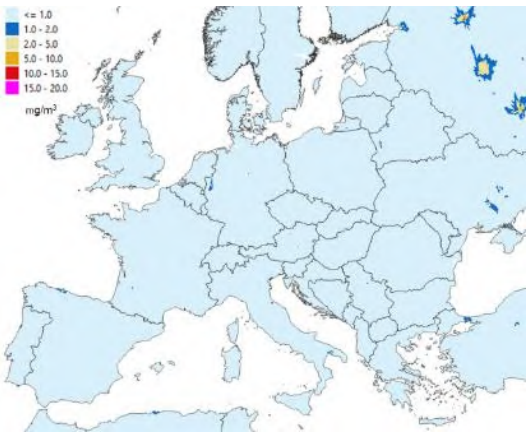
Figure A5.18 - CO (highest maximum 8 hour daily running mean) concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

Base 2020

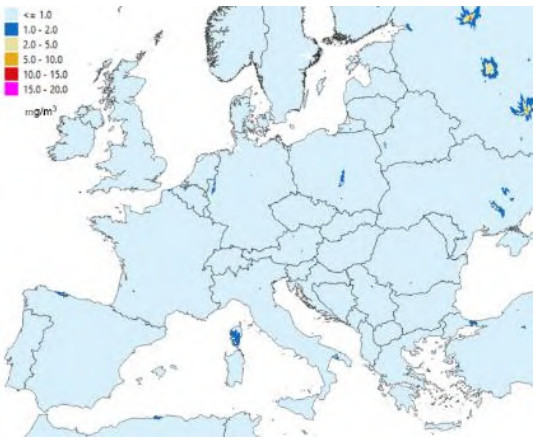


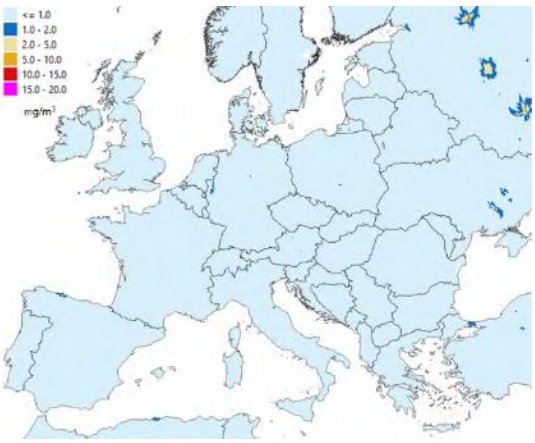
Base 2030 ***MTFR 2030***





Base 2050 ***MTFR 2050***


<= 1.0
1.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
mg/m3


<= 1.0
1.0 - 2.0
2.0 - 5.0
5.0 - 10.0
10.0 - 15.0
15.0 - 20.0
mg/m3