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EUROPEAN
COMMISSION

Brussels, 26.10.2022
SWD(2022) 545 final

PART 3/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT REPORT

Accompanying the document

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

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

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

TABLE OF CONTENTS

TABLE OF CONTENTS 148

4. POPULATION EXPOSURE 151

5. HEALTH IMPACTS 153

6. ECOSYSTEM AND OTHER NON-HEALTH IMPACTS 158

7. MACRO-ECONOMIC IMPACTS 163

ANNEX 6: POTENTIAL POLICY MEASURES (OR INTERVENTIONS) 167

1. POLICY MEASURES IN THE DIFFERENT POLICY OPTIONS 167

2. ASSESSMENT OF POTENTIAL POLICY MEASURES AND THEIR IMPACTS 168

2.1 Intervention area A: Regular review of EU air quality standards 170
2.2 Intervention area B: Type of EU air quality standards 175
2.3 Intervention area C: Actions when exceedances occur 180
2.4 Intervention area D: Air Quality Plan Involvement 186
2.6 Intervention area E: Enforcement tools 188
2.7 Intervention area F: Information to the public 193
2.8 Intervention area G: Assessment regimes 197
2.9 Intervention area H: Number and typology of sampling points 201
2.10 Intervention area I: Continuity of sampling points 205
2.11 Intervention area J: Siting of sampling points 208
2.12 Intervention area K: Data quality 212
2.13 Intervention area L: Additional pollutants 216
2.14 Intervention area M: Transboundary air pollution 220
2.15 Intervention area N: Information in air quality plans 222
2.16 Intervention area O: EU air quality standards for particulate matter ($PM_{2.5}$) 223
2.17 Intervention area P: EU air quality standards for particulate matter (PM_{10}) 228
2.18 Intervention area Q: EU air quality standards for nitrogen dioxide 232
2.19 Intervention area R: EU air quality standards for ozone 237
2.20 Intervention area S: EU air quality standards for sulphur dioxide 242
2.21 Intervention area T: EU air quality standards for carbon monoxide 245
2.22 Intervention area U: EU air quality standards for benzene 247
2.23 Intervention area V: EU air quality standards for benzo(a)pyrene 248
2.24 Intervention area W: EU air quality standards for lead 250
2.25 Intervention area X: EU air quality standards for arsenic 251
2.26 Intervention area Y: EU air quality standards for cadmium 252
2.27 Intervention area Z: EU air quality standards for nickel 253

2.28 Intervention area Ø: EU air quality standards for additional air pollutants 254

3. POLICY OPTIONS 255

3.1 Policy options to address environment / health shortcomings.....255

3.2 Policy options to address governance / enforcement shortcomings 256

3.3 Policy options to address air quality monitoring / assessment shortcomings 259

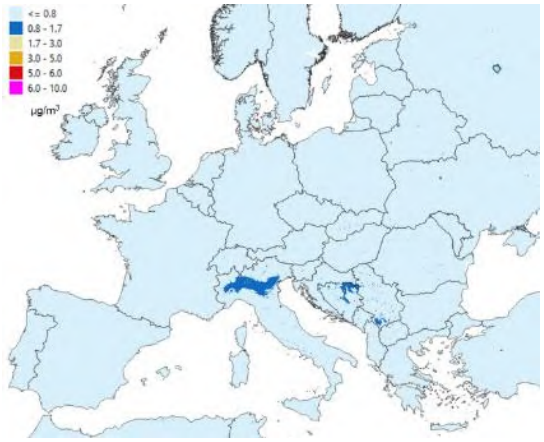
3.4 Policy options to address air quality information shortcomings 262

4. HOW DO THE OPTIONS COMPARE?.....263

Maps for benzene – C_6H_6

Figure A5.19 - Benzene annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

Base 2020



Base 2030

MTFR 2030

Base 2050

MTFR 2050

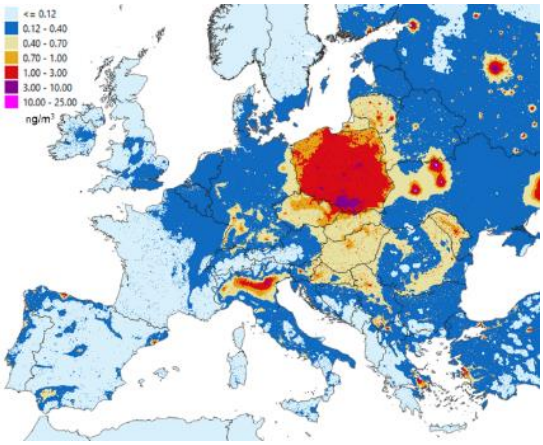
<= 0.8
0.8 - 1.7
1.7 - 3.0
3.0 - 5.0
5.0 - 6.0
6.0 - 10.0
µg/m³

<= 0.8
0.8 - 1.7
1.7 - 3.0
3.0 - 5.0
5.0 - 6.0
6.0 - 10.0
µg/m³

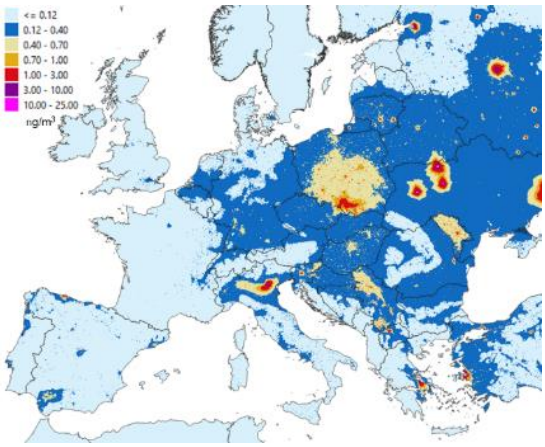
Maps for benzo(a)pyrene - BaP

Figure A5.20 - BaP annual mean concentrations for baseline (Base) and MTFR for 2020, 2030 and 2050. Calculations are made on the EMEP 0.1° grid. For details (including on bias correction), please see the underpinning support study on the revision of the Ambient Air Quality Directives.

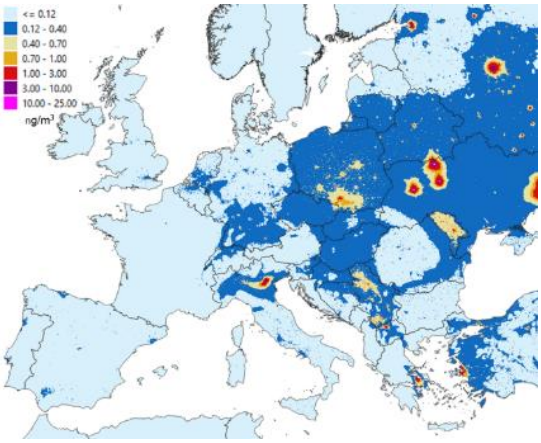
Base 2020



Base 2030

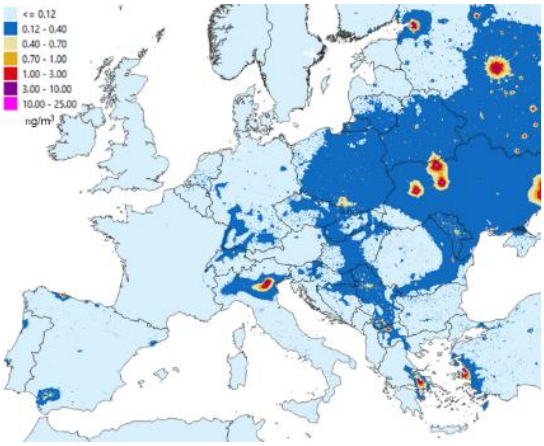


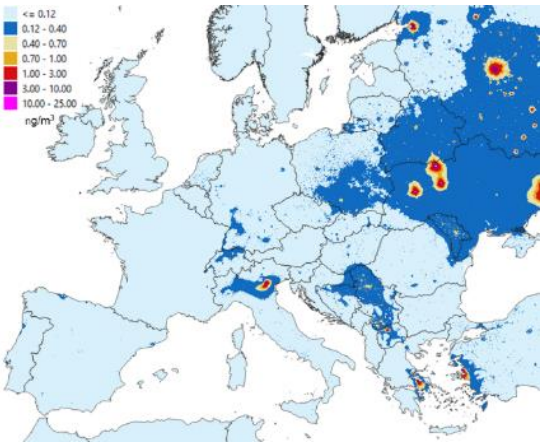
MTFR 2030



Base 2050

MTFR 2050

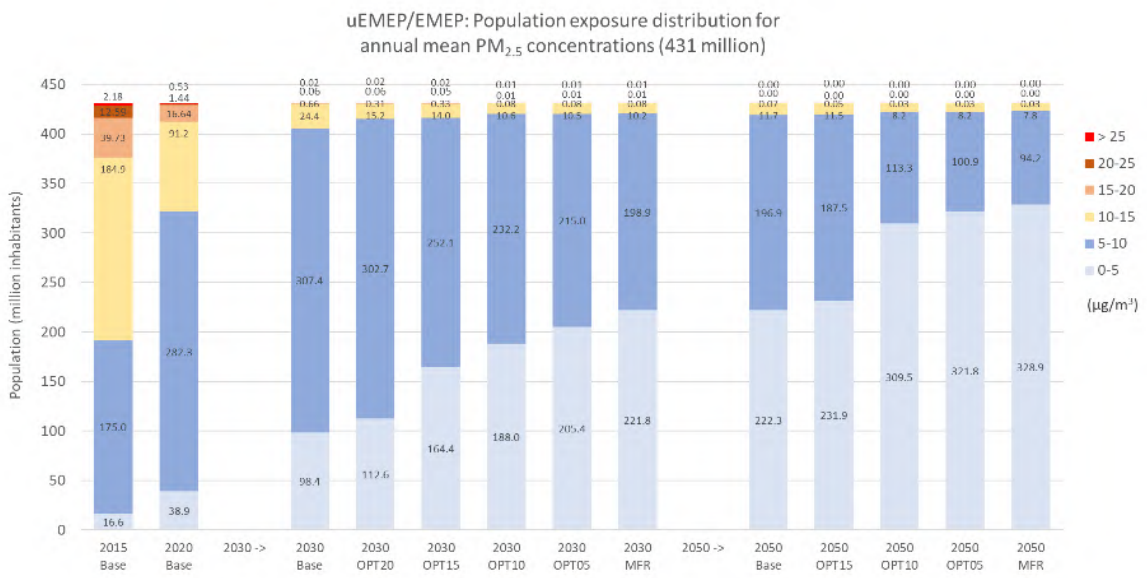

<= 0.12
0.12 - 0.40
0.40 - 0.70
0.70 - 1.00
1.00 - 3.00
3.00 - 10.00
10.00 - 25.00
ng/m³

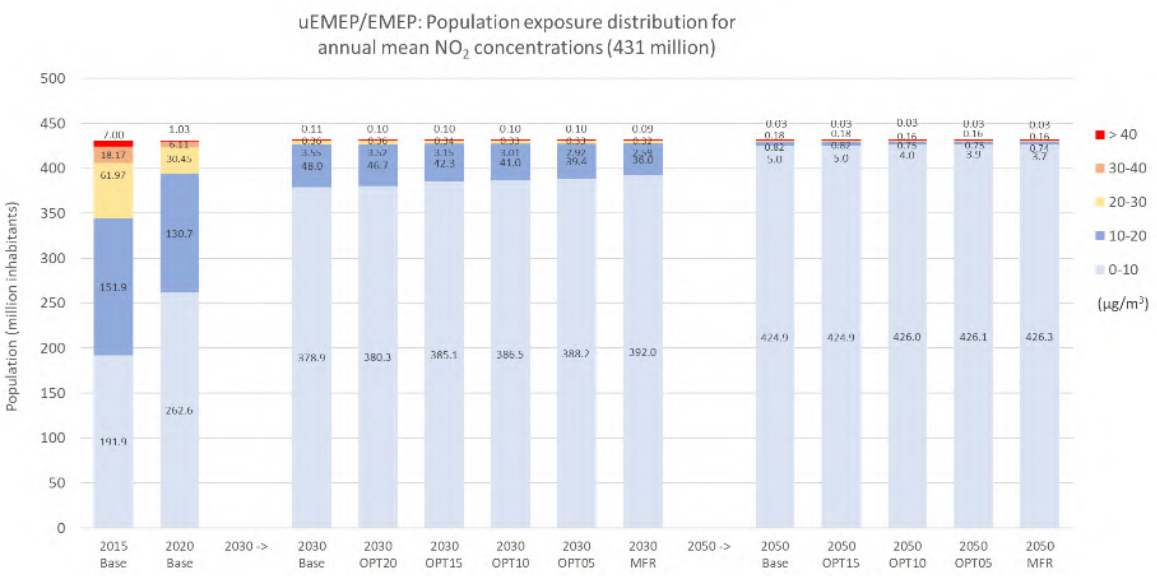

<= 0.12
0.12 - 0.40
0.40 - 0.70
0.70 - 1.00
1.00 - 3.00
3.00 - 10.00
10.00 - 25.00
ng/m³

4. POPULATION EXPOSURE

In the next step of the analysis, the air pollutant concentrations have been translated into estimates for population exposure. The number of people exposed in the EU-27 above selected annual mean concentration ranges is presented for the pollutants $PM_{2.5}$ and NO_2. All Baseline, MTFR (or MFR) and optimised (OPT) scenarios are presented. The exposure calculations follow the same trends as seen for the station site calculations (results of which are included in the main SWD).

Figure A5.21– Number of people exposed above selected annual mean concentrations in the EU-27 for $PM_{2.5}$ and NO_2





As in the station calculations, the optimised scenarios do not attain their goals, with the exception of the less ambitious optimisations of 20 and 15 µg/m^3 with less than 80 thousand inhabitants exposed above 15 µg/m^3. This is well within the uncertainty of the calculations. By 2050, all scenarios come close to attaining the WHO recommended NO_2 concentration level of 10 µg/m^3 but still with four to six million inhabitants exposed above this level.

Population exposure and source contributions

The results on population exposure are further broken down to show the split into the different sources of pollution at different levels of annual mean concentration.[1] The following points can be noted:

$PM_{2.5}$

- 530 000 inhabitants are exposed to $PM_{2.5}$ concentrations higher than 25 µg/m^3 in 2020 and this is chiefly attributable to residential emissions of primary $PM_{2.5}$;
- 16 000 inhabitants are exposed to $PM_{2.5}$ concentrations higher than 25 µg/m3 in 2030 but this number is well within the uncertainty of the methodology;
- In 2030, remaining high annual mean concentrations are mainly caused by residential emissions;
- Where low annual mean concentrations prevail, the relative importance of secondary sources as well as natural sources increases;
- In 2030, non-exhaust $PM_{2.5}$ emissions from road transport become a significant source contribution in some cities, notably Nordic countries. Non-exhaust emissions remain unchanged for all scenarios;
- Local primary $PM_{2.5}$ sources (i.e. all sources in lower case letters in figures below) that are emitted from within the ± 0.4^o window, account for 22% of the total $PM_{2.5}$ European exposure in 2020.

NO_2

- In 2020, the major source of NO_X contributing to NO_2 concentrations for all exposure levels is local road traffic, i.e. emitted from within the ± 0.4^o window;
- In 2030, road traffic contributes very little and the dominant source leading to exposures above 10 µg/m^3 is shipping. There is a large degree of uncertainty in these local emission sources at ports.

BaP

- In 2020, the dominant source for BaP is residential heating, followed by some individual industrial emissions;

[1] The underlying support study contains graphics showing the population exposed over a range of annual mean concentration, as well as the relative source contributions for the given exposure level.

- In 2020, around 80 million inhabitants were exposed above the current EU limit value of 1 ng/m^3. This was mostly in Poland and in Northern Italy. In 2030, this is reduced to 15 million;
- In 2030, residential heating remains the dominant source at concentration levels of up to 2 ng/m^3, with industrial sources dominating above 2 ng/m^3;
- With respect to industrial sources these exceedances are chiefly the result of one individual industrial plant in Northern Italy, Vicenza, and some lesser contributions in Spain and Poland. These emissions remain uncertain, both in present day and how they will evolve in the future.

The optimised calculations show similar results to the baseline scenario and MTFR scenarios but with a general reduction in concentrations from baseline scenario to MTFR.

5. HEALTH IMPACTS

Results for attributable mortality (Tier 1)

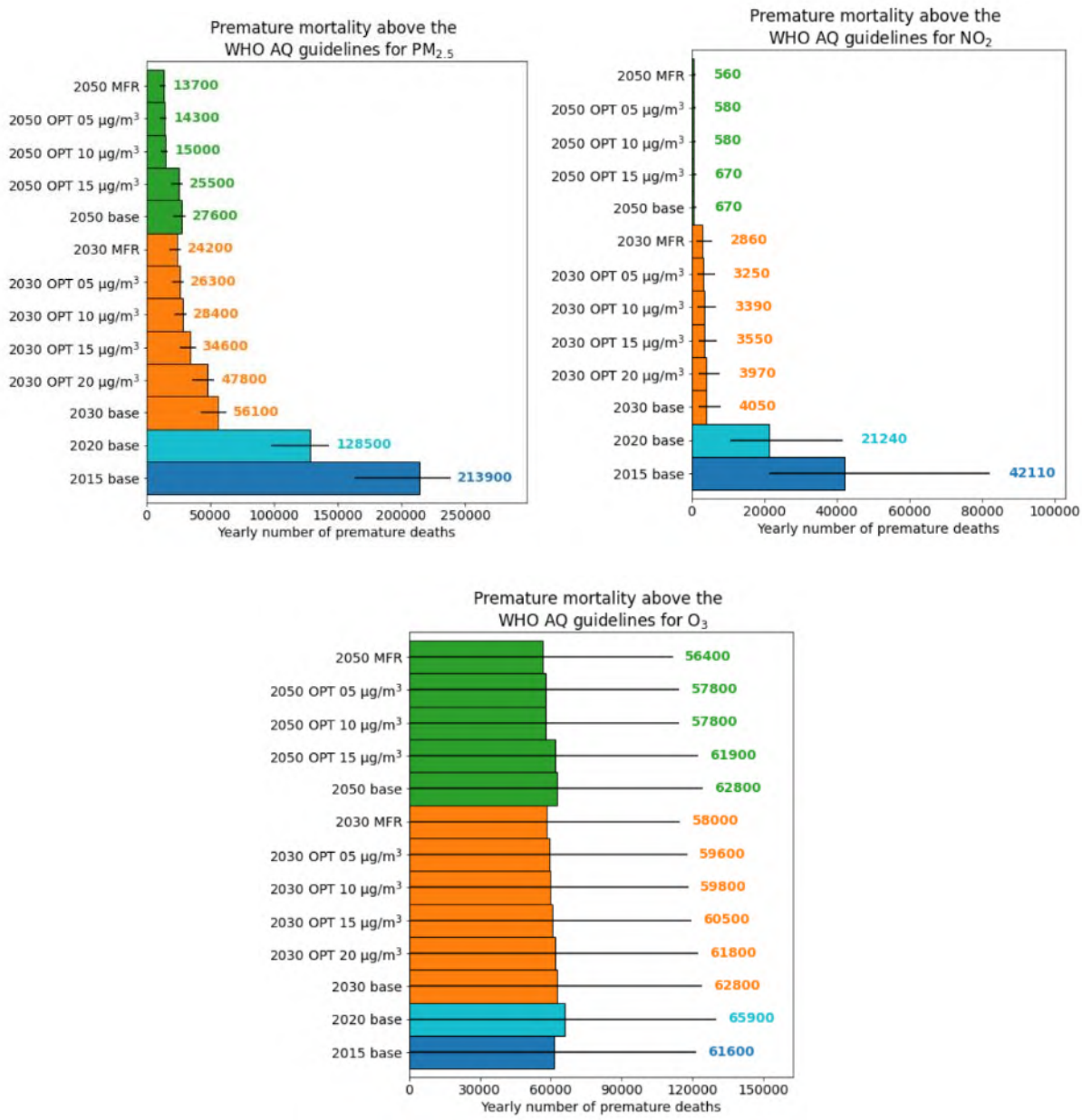
The impact of the various scenarios on the total number of yearly attributable deaths in the EU-27 for the three pollutants under consideration ($PM_{2.5}$, NO_2, O_3) is shown in the bar graphs in Figure A5.22 (total number of premature deaths) and Figure A5.23 (relative differences between the baseline and the scenarios). These charts and numbers refer to the health impact *above* the WHO air quality guideline concentration levels; all excess mortality caused by concentrations *below* these cut-offs is not taken into account.

For **particulate matter**, the relative impact of the policy scenarios depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios (as e.g. for the 20 µg/m^3 scenario in 2030 and the 15 µg/m^3 in 2050), the health impact of the scenarios is rather limited (15% for the 20 µg/m^3 scenario in 2030 and 8% for the 15 µg/m^3 scenario in 2050). For all other scenarios, the health impact for the OPT scenarios is significant (at least 38% in 2030 and at least 46% in 2050), and in many cases the difference between the health impact of the policy scenarios and the MTFR scenario is rather limited. As an example, the difference in health impact between the 10 µg/m^3 on the one hand, and the MTFR on the other hand is only 8% in 2030 and only 4% in 2050.

For **nitrogen dioxide**, the impact (relative to the baseline) for the policy scenarios depends on the year under consideration. For 2030, the 20 µg/m^3 has only a limited impact (2%), while the impact gradually increases for the more stringent scenarios (12%, 16%, and 20% respectively for 15 µg/m^3, 10 µg/m^3 and 5 µg/m^3). In 2050, the impact (relative to the baseline) of the 15 µg/m^3 scenario is small (1%), while the impact for the other policy scenarios is very similar to the impact of the MTFR scenario (14% reduction for both the 10 µg/m^3 and 5 µg/m^3, compared to 16% for MTFR). Finally, for ozone, the impact of the policy scenarios is small, with especially only marginal reductions for the 20 µg/m^3 and the 15 µg/m^3 scenario.

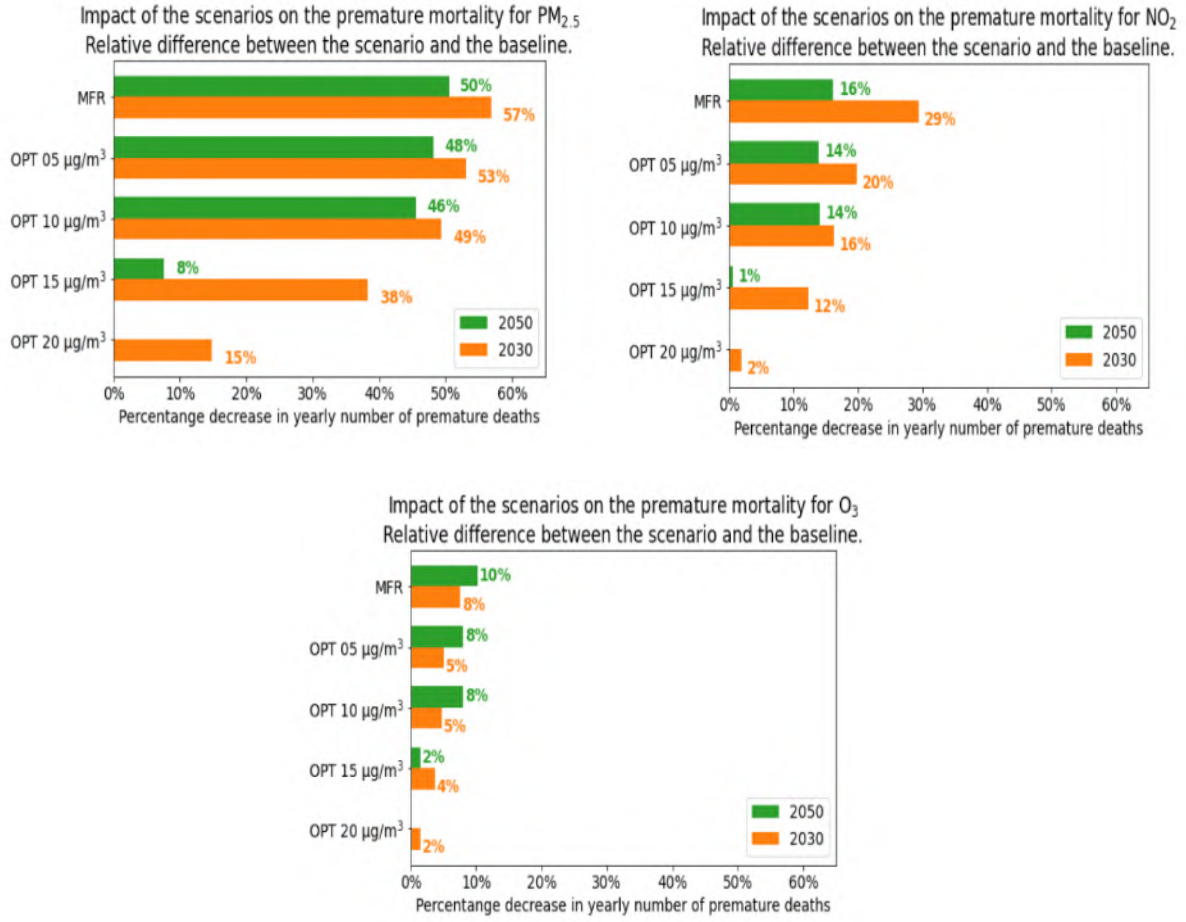
The support studies in its annexes provides further geographical breakdown of the results reported here at aggregate EU-27 level, indicating a rather stable spatial pattern across scenarios.

Figure A5.22 – Number of yearly premature deaths in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for all scenarios for three pollutants ($PM_{2.5}$, top-left, NO_2, top-right, O_3, bottom) based on the outcome of the modelling applied for this impact assessment[2]



[2] Notes: Impacts for the four reporting years considered in the study (2015 in blue, 2020 in cyan, 2030 in orange and 2050 in green) are included. The filled bars and the numbers refer to the central estimate (rounded to the nearest 100 for NO_2 and the nearest 1000 for $PM_{2.5}$, respectively), while the black lines provide the 95-percentage uncertainty estimate based on the uncertainty on the relative risks.

Figure A5.23 – Relative impact of the scenario on the number of yearly premature deaths in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for three pollutants ($PM_{2.5}$, top-left; NO_2, top-right; O_3, bottom) based on the outcome of the modelling applied for this impact assessment [3]



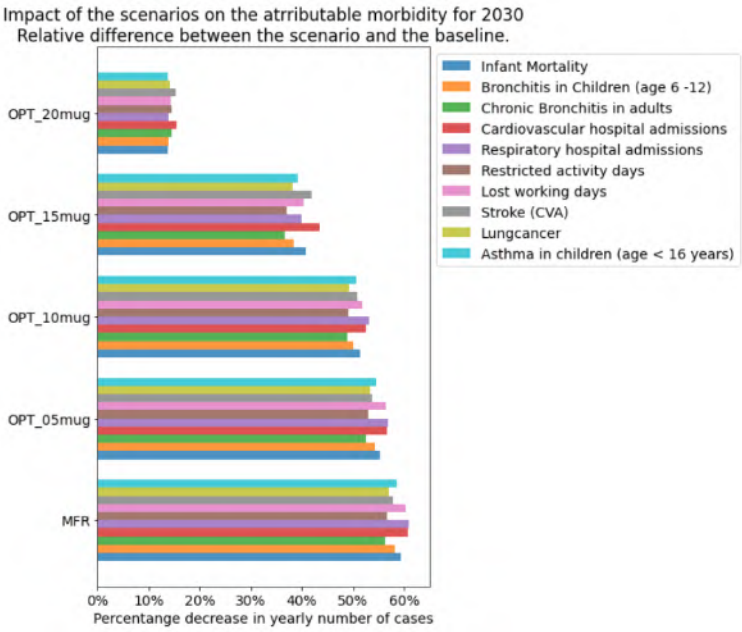
Results for attributable morbidity (Tier 2 and Tier 3)

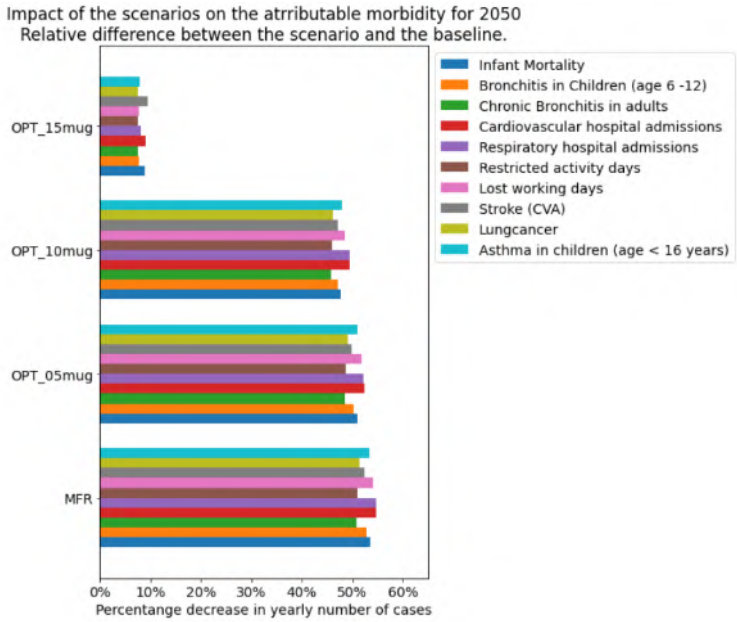
Figure A5.24 provides an overview of the relative impact of the scenarios on the morbidity from the second (morbidity according to HRAPIE) and third tiers (additional health outcomes beyond HRAPIE: stroke, lung cancer and asthma in children). For all health outcomes, the results correspond qualitatively and quantitatively with those for the chronic mortality caused by $PM_{2.5}$ exposure. The relative impact of the policy scenarios depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios, the health impact of the scenarios is rather limited, in line with the results for mortality. For all other scenarios, the health impact for the policy scenarios is significant, and

[3] Notes: Impacts for the two future reporting years considered in the study (2030 in orange and 2050 in green) are included.

in many cases the difference between the health impact of the policy scenarios and the MTFR scenario is rather limited.

Figure ***A5.24*** *– Relative impact of the scenarios on the morbidity in the EU-27 caused by the exposure to air pollution at levels above the WHO air quality guidelines for 2030 (top) and 2050 (bottom)*[4]





[4] Notes: The various bars correspond to the various morbidity outcomes considered in the main analysis of the study (Tier 2 and Tier3).

Health impacts - summary results

From this analysis, several conclusion can be drawn regarding the health impacts of the scenarios:

- Under the **baseline scenario**, the mortality caused by exposure to $PM_{2.5}$ and NO_2 decreases significantly from 2015 to 2030. However, there would still be a considerable number of premature deaths each year observed in 2030, with tens of thousands of attributable deaths per year caused by the exposure to $PM_{2.5}$ and thousands of deaths caused by the exposure to NO_2:
    - For **particulate matter**, the baseline attributable mortality is larger in Eastern and Southern European countries, in comparison with the impact in most Northern and Western European countries (which is in line with the spatial pattern of the baseline emissions and the natural contribution).
    - The results for **nitrogen dioxide** reflect the nature of the nitrogen dioxide pollution: because concentration hotspots are mostly linked to important local shipping and traffic emissions, also the highest baseline mortality is observed at these locations.
- The measures taken under the **MTFR scenario** have a significant impact on the health impact caused by the exposure to particulate matter (reductions with more than 55% in 2030, and with approximately 50% in 2050). Despite these strong reductions, a significant health impact remains under the application of the MTFR scenario, with more than 20 000 yearly attributable deaths in 2030 and more than 10 000 yearly attributable deaths in 2050. The impact of the MTFR scenario is somewhat more limited for the mortality caused by nitrogen dioxide pollution (relative reductions of 29% (2030) and 16% (2050) scenario).
- The relative impact of the different **policy scenarios** depends on the nature of the scenario. In case the baseline concentrations are already close to the target concentrations of the scenarios (e.g. 20 $\mu g/m^3$ scenario in 2030 and the 15 $\mu g/m^3$ in 2050), the health impact of the scenarios is rather limited. For all other scenarios, the difference in health impact for the policy scenarios is similar to the health impact of the MTFR scenario:
    - For **particulate matter**, a strong regional difference in the impacts of the MTFR scenario is observed, as smaller relative impacts are observed in Southern Europe in comparison with other regions (due to the impact of the natural contribution and the minor reductions in shipping emissions).
    - For **nitrogen dioxide**, the highest reduction in attributable mortality is observed at the hotspots for which the emissions are reduced by the greatest margin;
- Results for **morbidity** show similar pattern to the results for mortality.

Economic valuation – benefits from reduced health impacts

In line with the valuation methods described in Annex 4, the costs of air pollution arising from impacts on human health and ecosystems were monetised. Comparing the costs estimated for the policy scenarios to the baseline scenario, yields a monetised estimate of the benefits associated with the reduced impacts observed in the policy scenarios. These benefits are summarised in chapter 6 of the main document, whereas Table A5.1 below presents the underlying results per scenario for **health impacts**. The annexes to the support study contain further detailed breakdown of estimates per health outcome and pollutant.

As can be seen from the results, there is a marked difference in the monetised human health benefits depending on the approach taken and on the scenario. Monetised benefits are smaller under the VOLY than VSL approach. The benefits increase, as expected, with the ambition of the scenario. The benefits reduce over time as more progress is made in the baseline, which erodes the additional benefit of further action under the mitigation scenarios.

Across all scenarios, mortality effects contribute the vast majority of the overall valued effects: the share of morbidity effects in the total valuation of human health benefits ranges from 1-6% across scenarios and years under the VSL approach, to 5-19% under the VOLY approach.

Approach to valuing mortality	Scenario	2020	2030	2050
VSL	Baseline	739	444	332
VSL	($PM_{2.5}$ at 20 µg/m³)	-	408	-
VSL	**I-3** ($PM_{2.5}$ at 15 µg/m³)	-	352	320
VSL	**I-2** ($PM_{2.5}$ at 10 µg/m³)	-	325	266
VSL	**I-1** ($PM_{2.5}$ at 5 µg/m³)	-	317	263
VSL	MTFR	-	303	256
VOLY	Baseline	251	140	90
VOLY	($PM_{2.5}$ at 20 µg/m³)	-	128	-
VOLY	**I-3** ($PM_{2.5}$ at 15 µg/m³)	-	109	87
VOLY	**I-2** ($PM_{2.5}$ at 10 µg/m³)	-	100	71
VOLY	**I-1** ($PM_{2.5}$ at 5 µg/m³)	-	97	70
VOLY	MTFR	-	92	68
Net VSL	*($PM_{2.5}$ at 20 µg/m³)*	-	*36*	-
Net VSL	***I-3*** *($PM_{2.5}$ at 15 µg/m³)*	-	*92*	*12*
Net VSL	***I-2*** *($PM_{2.5}$ at 10 µg/m³)*	-	*119*	*66*
Net VSL	***I-1*** *($PM_{2.5}$ at 5 µg/m³)*	-	*127*	*69*
Net VSL	*MTFR*	-	*141*	*77*
Net VOLY	*($PM_{2.5}$ at 20 µg/m³)*	-	*12*	-
Net VOLY	***I-3*** *($PM_{2.5}$ at 15 µg/m³)*	-	*31*	*3*
Net VOLY	***I-2*** *($PM_{2.5}$ at 10 µg/m³)*	-	*40*	*19*
Net VOLY	***I-1*** *($PM_{2.5}$ at 5 µg/m³)*	-	*43*	*20*
Net VOLY	*MTFR*	-	*48*	*22*

Table A5.1 – Costs and benefits ("Net" values) to society (valuation of health impacts – both mortality and morbidity, with approach to valuing mortality indicated in the first column) per year – central estimate (all values €bn 2015 prices, EU-27)

6. ECOSYSTEM AND OTHER NON-HEALTH IMPACTS

Results for ecosystem areas exceeding critical loads for acidification and eutrophication

The following table presents the monetised impacts of air pollution on ecosystems (incl. productive ones) as well as material damage (mainly built environment) under the baseline, policy and MTFR scenarios. The size of the damage in the baseline and scenarios reduces over time alongside further emissions reductions delivered through current policy. The monetised benefits increase with the ambition under each scenario, as further reduction in air pollutant emissions are delivered. The scenarios and MTFR can deliver substantial benefits for ecosystems and from reduced material damage, however the aggregate size of these benefits is still smaller than the human health benefits.

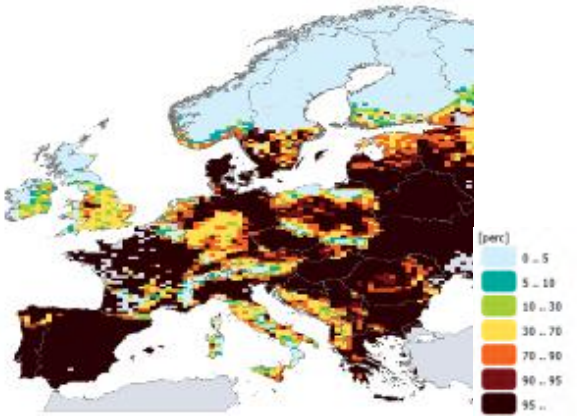
This section presents indicators on ecosystem impacts in terms of acidification and eutrophication from excess deposition of nitrogen (for acidification and eutrophication) and sulphur (for acidification). Results are calculated with the GAINS model using critical loads approved by the Air Convention in 2017.

Maps of ecosystem areas exceeding critical loads for acidification and eutrophication (percentages of area above critical load) from deposition of nitrogen and sulphur are shown in Figures A5.25 and A5.26 for the Baseline and MTFR scenarios and the years 2020, 2030 and 2050. Eutrophication is still a widespread problem in Europe, with an estimated 74% of all ecosystem areas exceeding critical loads. Despite improvements in 2030 and even further in 2050, still ~65% of ecosystem areas are expected to exceed critical loads for eutrophication in 2050 under the baseline scenario. Under the MTFR scenario, this is reduced to 48% in 2050. Acidification is much less of an issue, with 4.8% of ecosystem areas currently exceeding the critical loads, decreasing to 3.1% in 2030 and 2.4% in 2050 under the Baseline scenario (1.2% in 2050 under the MTFR scenario).

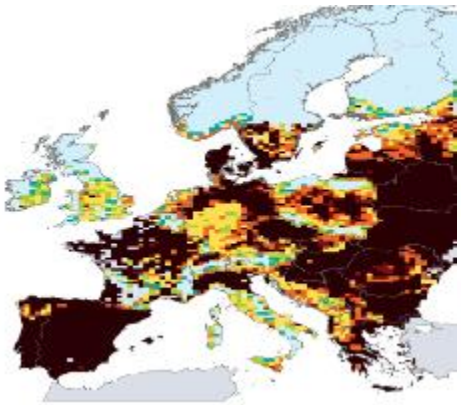
The support study includes tables that differentiate the impacts of the different scenarios in terms of area shares of different types of ecosystems where critical loads for eutrophication and acidification are exceeded by Member State.

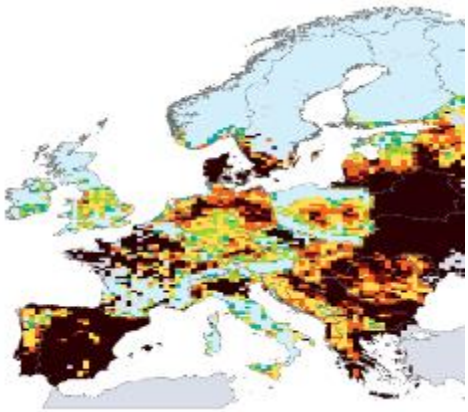
Figure A5.25 – Shares of ecosystem area exceeding critical loads for **eutrophication**

Baseline 2020

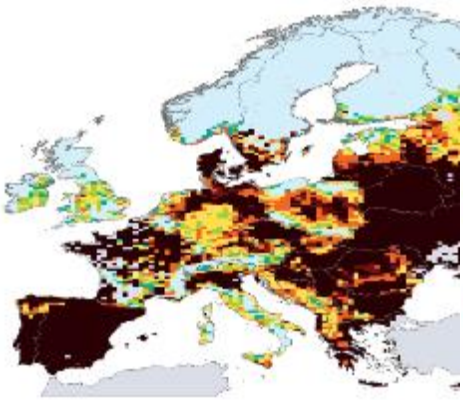


Baseline 2030 ***MTFR 2030***





Baseline 2050 ***MTFR 2050***



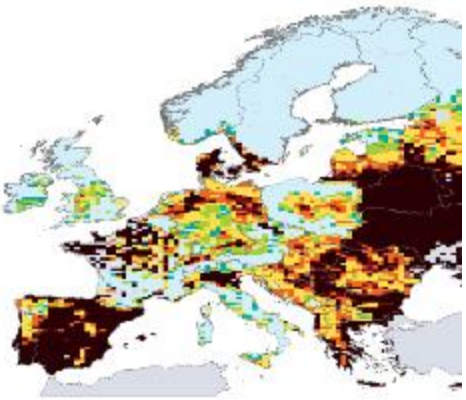
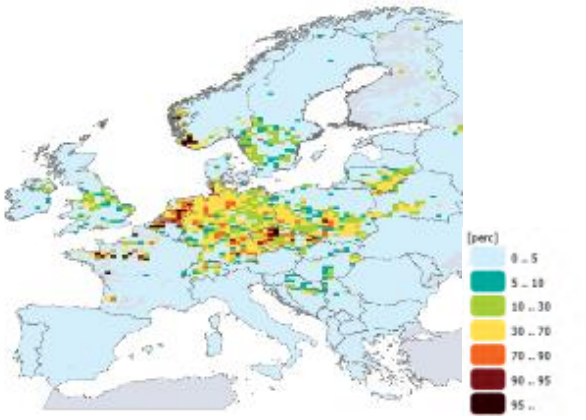
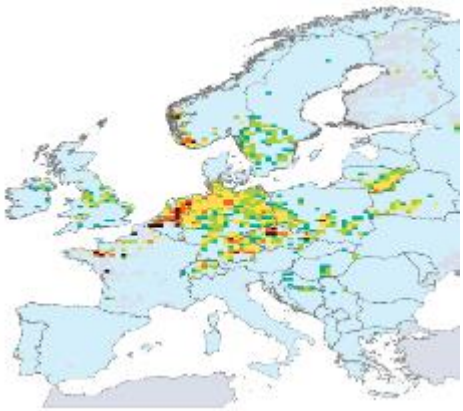


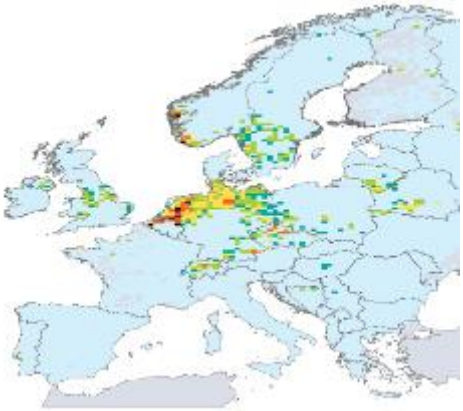
Figure A5.26 – Shares of ecosystem area exceeding critical loads for **acidification**

Baseline 2020

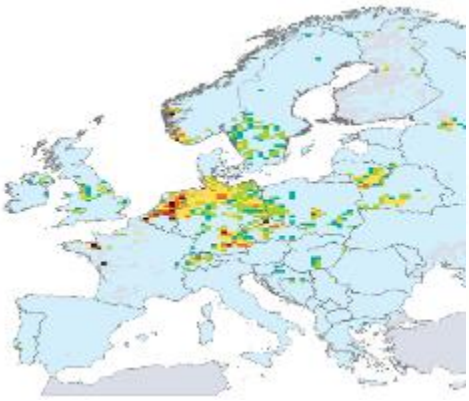


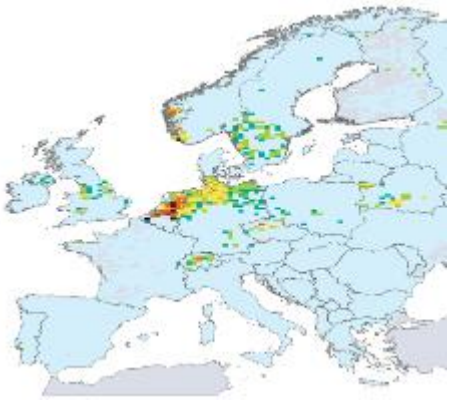
Baseline 2050 ***MTFR 2050***





Baseline 2050 ***MTFR 2050***





Economic valuation – benefits from reduced material damage and impacts on ecosystems

Table A5.2 presents the monetised impacts of air pollution on crops, productive forests and other ecosystems as well as material damage (mainly built environment) under the baseline, policy and MTFR scenarios. The size of the damage in the baseline and scenarios reduces over time alongside further emissions reductions delivered through current policy. The monetised benefits increase with the ambition under each scenario, as further reduction in air pollutant emissions are delivered. The scenarios and MTFR can deliver substantial benefits from reduced damage, however the absolute size of these benefits is several orders of magnitude smaller than the human health benefits.

Table A5.2 – Monetised material, crop and forest damage impacts per year. Gross values (upper part) and *benefit from reduced damage relative to baseline* (lower, NET part of table) – EUR million 2015 prices

	2020	2030	2050	2020	2030	2050	2020	2030	2050
	Material damage			*Crop damage*			*Forest damage (LOW)*		
Baseline	1,136	662	442	10,691	9,877	9,459	19,050	17,975	17,374
($PM_{2.5}$ at 20 µg/m³)		633			9,809			17,906	
I-3 ($PM_{2.5}$ at 15 µg/m³)		481	430		9,689	9,415		17,752	17,321
I-2 ($PM_{2.5}$ at 10 µg/m³		466	286		9,623	9,200		17,688	17,082
I-1 ($PM_{2.5}$ at 5 µg/m³)		458	281		9,600	9,201		17,659	17,080
MTFR		436	269		9,472	9,110		17,486	16,954
NET at 20 µg/m3)		*29*			*67*			*69*	
NET at 15 µg/m3)		*181*	*12*		*188*	*44*		*222*	*52*
NET at 10 µg/m3)		*196*	*156*		*254*	*259*		*287*	*292*
NET at 5 µg/m3)		*204*	*160*		*276*	*258*		*316*	*293*
NET MTFR		*226*	*172*		*404*	*348*		*488*	*420*
	Ecosystem damage (LOW)			*Ecosystem damage (HIGH)*			*Forest (HIGH)* [5]		
Baseline	3,901	3,588	3,375	11,702	10,765	10,124			42,217
($PM_{2.5}$ at 20 µg/m³)		3,488			10,463				
I-3 ($PM_{2.5}$ at 15 µg/m³)		3,140	3,291		9,420	9,874			42,090
I-2 ($PM_{2.5}$ at 10 µg/m³		2,883	2,585		8,648	7,754			41,505
I-1 ($PM_{2.5}$ at 5 µg/m³)		2,726	2,443		8,177	7,330			41,501
MTFR		2,588	2,328		7,765	6,984			41,194
NET at 20 µg/m3)		*101*			*302*				
NET at 15 µg/m3)		*448*	*83*		*1,345*	*250*			*127*
NET at 10 µg/m3)		*706*	*790*		*2,117*	*2,370*			*712*
NET at 5 µg/m3)		*863*	*931*		*2,588*	*2,794*			*716*
NET MTFR		*1,000*	*1,047*		*3,000*	*3,140*			*1,023*

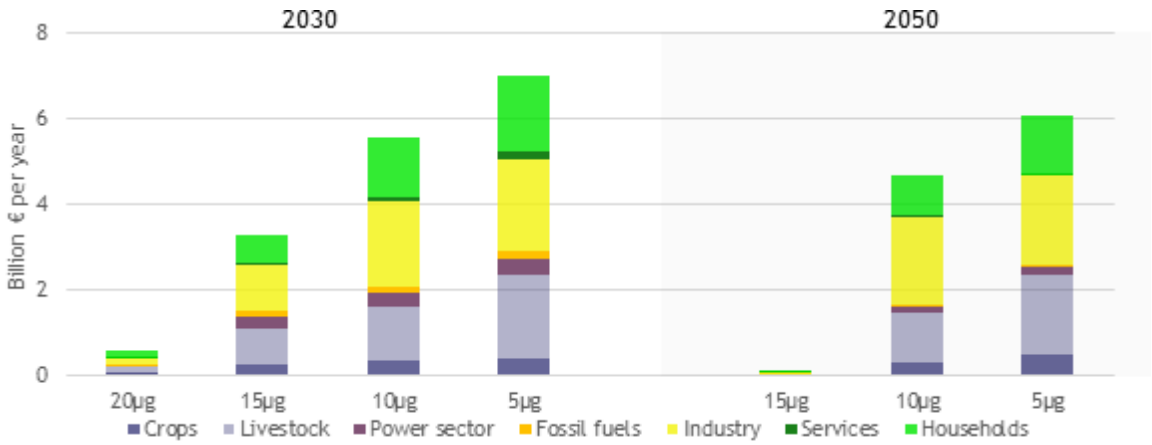
[5] Note that there is no difference between HIGH and LOW estimate for forest damage in 2020 and 2030 as only after 2030 different assumptions are used to monetise the reduced carbon sequestration potential due to forest damage.

7. MACRO-ECONOMIC IMPACTS

Air pollution has detrimental welfare impacts by affecting health outcomes. In addition, related healthcare expenditures, crop yield losses in particular due to ozone, absence from work due to illness (including of dependent children) and lower productivity at work (presenteeism) can imply a drag on the economy. Improving air quality can therefore bring economic gains. However, air pollution control comes at a gross cost, as it requires costly investments and purchases of abatement equipment. A priori, it is unclear whether air pollution control policies therefore lead to net economic gains or losses, and how these are distributed across stakeholders.

To shed some light on these trade-offs, a macro-economic benefit-cost analysis was conducted by linking the GAINS model with the JRC-GEM-E3 model. This has been done in previous work, such as the First and Second Clean Air Outlook, and both models feature in a broader modelling toolbox e.g. in the assessment of the EU long-term climate strategy[6]. The key information that flows from GAINS to JRC-GEM-E3 is the abatement cost associated to further air pollution controls induced by more ambitious policy measures and targets. These costs serve as inputs into the JRC-GEM-E3 analysis (Figure A5.13).

Figure A5.13 – Air pollution mitigation or adjustment costs (EU total) beyond the baseline, for different policy scenarios. Source: GAINS model, IIASA (support study).



The JRC-GEM-E3 model represents the whole economy and the interactions between key actors: firms, households and governments in the EU and in the rest of the world. End-of-pipe abatement costs from GAINS are treated as costly (intermediate) expenditures on abatement goods and services, and therefore generate additional demand for the sectors that deliver these goods and services. Furthermore, the model captures the potential loss in competitiveness of firms that need to incur abatement costs by reflecting price-driven

[6] Weitzel, M., et al. (2019). Model-based assessments for long-term climate strategies. Nature Climate Change, 9(5), 345-347.

international trade flows. For households, a loss of income or raised expenditure on abatement technologies implies that less means are available to purchase other goods. The economic modelling framework covers these interactions to provide an economy-wide picture of the implications of additional air pollution control costs.

On the benefit side, this analysis concentrates on productivity gains from clean air. The empirical basis stems from recent OECD work[7] that quantifies the causal impact of $PM_{2.5}$ pollution on productivity in the EU for the period 2000-2015. More specifically, labour productivity gains are derived by combining the point estimate on the impact of $PM_{2.5}$ on GDP per worker, with the changes (compared to the baseline) in population-weighted $PM_{2.5}$ concentrations from the GAINS model. The corresponding changes in labour productivity are fed into the JRC-GEM-E3 model, where labour constitutes an input the production process of the various economic sectors.

The results are displayed in Table A5.3. The key insight is that all scenarios improve aggregate economic outcomes in the EU compared to a situation of unchanged policy. The most ambitious 5 µg/m^3 scenarios imply larger gross costs, but these are more than compensated by productivity gains, as reflected by the positive impact on GDP and private consumption. With the exception of livestock-based agriculture, all sectors displayed raise output compared to the reference when productivity gains of clean air are accounted for.

Table A5.3 – Economic outcomes of clean air policy in the EU – expressed as percentage change relative to reference baseline. Note that the first number in a cell represents the effect of gross costs only. The second number (after the vertical line) represents the net effect, i.e. benefits minus costs.[8]

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

A few caveats are important to take into consideration when interpreting these results. Here, we focus exclusively on productivity benefits from clean air. This implies that other 'market' benefits are not included, such as reduced healthcare expenditures and increased crop yields. Furthermore, additional 'non-market' benefits, such as ecosystem impacts and reductions in premature mortality or life years lost due to air pollution, are not included in the results displayed in the table below. While these benefits are not included in the economy-wide assessment in this section, they are discussed in other sections of this report. The JRC-GEM-

[7] Dechezleprêtre, A., Rivers, N., & Stadler, B. (2019). The economic cost of air pollution: Evidence from Europe. OECD Economics Department Working Papers.

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

E3 modelling results furthermore include outcomes on employment changes by sector. In these simulations, it was assumed that wage setting is flexible such that it can fully accommodate labour market adjustments. This implies that aggregate, national unemployment levels are driven by fundamental factors that are unaffected by clean air policy. In other words, this assumption implies that the results will not pick up any potential aggregate net job creation associated with increased GDP and output levels as shown, and the results may therefore be interpreted as conservative estimates.

The results displayed in Table A5.4 indicate two consistent findings across all scenarios and years. First, we observe a creation of jobs in industry, which relates directly to the production of equipment required to abate emissions and the associated investments. While industry also faces increased abatement costs, in terms of net effect on jobs this is more than offset by increased demand for abatement goods from all sectors (including households). Second, the agricultural sector experiences job losses compared to the reference, which relates to output losses (livestock sector) or a transition of workers into industry (crops sector). Overall, the magnitude of the employment changes is limited in relative terms such that they may be largely absorbed by ongoing labour market dynamics (entry into and exit from the labour market). One caveat worthwhile mentioning here is that the productivity benefits are applied uniformly across all sectors. A stronger empirical evidence base would help refining (the sector-specific elements of) the analysis, e.g. by differentiating productivity impacts of air pollution for vulnerable workers.

Table A5.4 – Employment transition across sectors in the EU. Source: JRC-GEM-E3. Given the assumption of flexible wage setting, positive and negative employment effects balance out for a given year and scenario. Adding of numbers in a given column of this table does not yield zero in all cases due to rounding.

>>> Option analysed >>>	(PM$_{2.5}$ at 20 µg/m^3)	**Option I-1** (PM$_{2.5}$ at 5 µg/m^3)	**Option I-2** (PM$_{2.5}$ at 10 µg/m^3)	**Option I-3** (PM$_{2.5}$ at 15 µg/m^3)		**Sub-option I-1a**	**Sub-option I-2a**	**Sub-option I-3a**
Cost only | Net effect (benefit-cost) 1000 jobs, change rel. to reference	2030	2030	2030	2030		2050	2050	2050
Employment								
Crops	-1 | -2	-19 | -19	-18 | -18	-15 | -17		-17 | -16	-10 | -9	0 | 0
Livestock	-2 | -3	-25 | -31	-23 | -29	-20 | -24		-19 | -22	-17 | -20	0 | -1
Power sector	0 | -2	0 | -8	0 | -7	0 | -6		0 | -5	0 | -4	0 | -1
Fossil fuels	0 | 0	0 | -1	0 | 0	0 | 0		0 | 0	0 | 0	0 | 0
Industry	3 | 24	34 | 115	30 | 104	25 | 81		23 | 81	15 | 66	0 | 7
Services	1 | -17	10 | -57	11 | -49	10 | -33		13 | -38	12 | -33	0 | -6

8. SENSITIVITY ANALYSIS FOR IED IMPLEMENTATION

In order to quantify to the extent possible the impact of the proposal for a revised IED on air quality, a sensitivity analysis was conducted. Since it is not possible to precisely project the speed and scope of the IED implementation[9], as this depends on the development and uptake of BAT across economic sectors, a series of assumptions was taken:

[9] See explanations in the Impact Assessment accompanying the proposal for a revised Industrial Emission Directive (SWD COM(2022)111)

- For all non-agriculture sectors covered by the proposal for a revised IED, a 20% reduction in $PM_{2.5}$, SO_2, and NOx emissions in 2030 (additional to the reduction already foreseen in the baseline), reflecting the likely best-case scenario of the IED implementation and based on assumptions presented in the impact assessment underpinning the revision of the IED.
- For agriculture sectors covered by the proposal for a revised IED, country-specific and livestock category-specific NH_3 reduction rates estimated with the GAINS model for the third Clean Air Outlook, assuming an entry into force of the proposal in 2027. Typically, this results in about 1% to 4% reduction of national NH_3 emissions (about 2% for the EU27 as a whole) beyond the baseline used in this impact assessment.

The modelling approach followed the following steps:

- projection of the impact on country specific industrial emissions of $PM_{2.5}$, SO_2, NOx for the year 2030;
- projection of the impact on country specific NH_3 emissions from agriculture for the year 2030;
- these newly estimated emissions of all pollutants were used in the EMEP model simulations for 2030 to estimate $PM_{2.5}$ and NO_2 concentrations and station compliance and exposure.

The following table present the change in station concentrations from the 2030 Baseline to the 2030 IED sensitivity.

	Average change in mean concentration levels at sampling points		Number of sampling points that fall into / drop out of the respective concentration bands under IED sensitivity assumptions					
$PM_{2.5}$	Mean absolute change (µg/m³)	Mean relative change (%)	0 – 5 (µg/m³)	5 – 10 (µg/m³)	10 – 15 (µg/m³)	15 – 20 (µg/m³)	20 - 25 (µg/m³)	> 25 (µg/m³)
	-0.13	-1.6	35	-29	-6	0	0	0
NO_2	Mean absolute change (µg/m³)	Mean relative change (%)	0 – 10 (µg/m³)	10 – 20 (µg/m³)	20 – 30 (µg/m³)	30 – 40 (µg/m³)	> 40 (µg/m³)	
	-0.09	-0.89	17	-15	-2	0	0	

It should be noted that, due to the methodological limitations of any sensitivity analysis, these results cannot be used for drawing exact conclusion on impacts. They do however provide a useful indication of the impact of the revised IED implementation on pollution concentration, and show that these impacts are likely to be very small compared to the baseline used in the core of this impact. For more information, see the underpinning support study.

ANNEX 6: POTENTIAL POLICY MEASURES (OR INTERVENTIONS)

1. POLICY MEASURES IN THE DIFFERENT POLICY OPTIONS

This impact assessment considers a total of 69 potential specific policy measures - these measures are based on WHO recommendations (including as published in 2021), as well as stakeholder feedback to the Inception Impact Assessment and preliminary expert consultations (with those responsible for air quality monitoring, modelling and planning).

Table A6.1 – Overview of all 69 specific measures considered in this impact assessment

		Focus on AQ legislative framework	35	**J1**	Revise macro-scale siting of sampling points
1	**-**	Merge provision of Directives 2008/50 and 2004/107	36	**J2**	Revise micro-scale siting of sampling points
2	**A1**	Introduce review triggered by scientific progress	37	**J3**	Introduce obligation for spatial representativeness
3	**A2**	Introduce review triggered by technical progress	38	**K1**	Revise AQ monitoring data quality objectives
4	**A3**	Introduce option to notify stricter standards	39	**K2**	Introduce up-to-date data at all sampling points
5	**A4**	Introduce a list of priority pollutants	40	**K3**	Introduce AQ modelling data quality objectives
6	**B1**	Introduce additional short-term standards	41	**K4**	Revise approach to AQ assessment uncertainty
7	**B2**	Introduce additional alert/information thresholds	42	**L1**	Introduce concept of monitoring at 'super-sites'
8	**B3**	Revise definition of average exposure standards	43	**L2**	Introduce obligations to monitor more pollutants
9	**B4**	Introduce guidance on addressing exceedances	44	**L3**	Revise list of VOC to monitor
10	**B5**	Introduce limit values for additional air pollutants	45	**M1**	Introduce methodology to assess transboundary
11	**C1**	Revise obligations triggered by exceedances	46	**M2**	Revise obligations for transboundary cooperation
12	**C2**	Revise/clarify definition of 'as short as possible'	47	**N1**	Revise the information in air quality plans
13	**C3**	Revise short-term action plans & air quality plans			**Focus on EU air quality standards**
14	**C4**	Introduce additional short-term action plans	48	**O1**	Revise standards for annual $PM_{2.5}$
15	**C5**	Introduce requirement to update air quality plans	49	**O2**	Introduce standards for daily $PM_{2.5}$
16	**D1**	Revise requirements to involve stakeholders	50	**O3**	Revise average exposure standards for $PM_{2.5}$
17	**D2**	Introduce a 'one zone, one plan' requirement	51	**P1**	Revise standards for annual PM_{10}
18	**E1**	Introduce minimum levels for financial penalties	52	**P2**	Revise standards for daily PM_{10}
19	**E2**	Introduce right to health damage compensation	53	**P3**	Introduce average exposure standards for PM_{10}
20	**E3**	Introduce a fund to be fed by penalties paid	54	**Q1**	Revise standards for annual NO_2
21	**E4**	Introduce an explicit 'access to justice' clause	55	**Q2**	Revise/introduce standards for hourly/daily NO_2
22	**F1**	Revise provisions related to up-to-date data	56	**Q3**	Introduce average exposure standards for NO_2
23	**F2**	Introduce requirement to provide AQ health data	57	**R1**	Introduce standards for peak-season O_3
24	**F3**	Introduce use of specific communication channels	58	**R2**	Revise standards for 8-hour O_3
25	**F4**	Introduce requirements for harmonised AQ index	59	**R3**	Introduce average exposure standards for O_3
		Focus on AQ monitoring, modelling, plans	60	**S1**	Revise standards for annual SO_2
26	**G1**	Revise rules related to indicative sampling points	61	**S2**	Revise standards for daily/hourly SO_2
27	**G2**	Introduce requirements for AQ modelling	62	**T1**	Revise standards for daily/8-hour CO
28	**G3**	Revise rules for regular review of AQ assessment	63	**U1**	Revise standards for annual benzene
29	**H1**	Revise minimum number of sampling points	64	**V1**	Revise standards for annual benzo(a)pyrene
30	**H2**	Simplify combined PM_{10}/$PM_{2.5}$ monitoring	65	**W1**	Revise standards for annual lead

31	**H3**	Simplify the definitions of sampling points types	66	**X1**	Revise standards for annual arsenic
32	**I1**	Introduce obligations to maintain sampling points	67	**Y1**	Revise standards for annual cadmium
33	**I2**	Introduce obligations to monitor long-term trends	68	**Z1**	Revise standards for annual nickel
34	**I3**	Introduce a protocol for relocated sampling points	69	**Ø1**	Introduce standards for additional air pollutants

2. ASSESSMENT OF POTENTIAL POLICY MEASURES AND THEIR IMPACTS

Assessment criteria and indicators

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

Each of the above indicator is scored for each specific potential policy measure in a qualitative manner, taking into account the quantitative assessment provided in Annex 3 and Annex 5 where possible. Note that for several indicators no extensive quantification has been possible, due to the lack of available data per specific potential policy measure. In these cases the assessment is based on expert judgement provided via the underpinning support study.

Score	Description
+++	Very significant direct positive impact or benefit
++	Significant direct positive impact or benefit
+	Small direct positive impact or benefit
(+)	Indirect positive impact or benefit
+/-	Both direct positive and negative impacts, and balance depends on how implemented
0	No impact or only very indirect impacts
(-)	Indirect negative impact or cost

-	Small direct negative impact or cost
- -	Significant direct negative impact or cost
- - -	Very significant direct negative impact or cost
High	Benefits significantly outweigh costs of measure
Medium	Benefits on balance outweigh costs of measure
Low	Benefits close to or even below costs of measure
High (*)	Potential high benefits, but significant questions as to whether the measure can deliver outcome

For a summary overview the scoring of the twelve indicators for each specific potential policy measure is presented via an overview table, as per the following logic. Note that indicator #6 features twice, i.e. under economic impact and under cost.

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Code	Short-hand description of policy measure	**#1** #2 #3 #4	#8 #9 #10	#5 #6 #7	(#6) #12	#11	High Medium Low High (*)	Reference to which policy options and/or sub-options include this measure
		See above for indicator code, see legend below for scoring					*See legend*	

Note that indicator #12 on the administrative burden is based on the estimates presented in Annex 3. Combined additional annualised one-off and recurring administrative burden in the category of less than 10 000 Euro per year are marked '(-)', between 10 000 and 100 000 Euro as '-', between 100 000 and 1 000 000 Euro as '--', and above 1 000 000 Euro as '---'.

Stakeholder views

A targeted stakeholder survey asked for views on each potential specific policy intervention (see Annex 2 for details), and consulted with public authorities, civil society & NGOs, industry & businesses, and research & academia. The number of responses differed by policy are consulted upon.

For intervention areas A through N, in total 93 replies were received from:

- Public authorities (43);
- Civil society & NGOs (12);
- Industry & businesses (14);
- Research & academia (22).

For intervention areas O to Ø, in total 139 replies were received from:

- Public authorities (53);
- Civil society & NGOs (12);
- Industry & businesses (26);
- Research & academia (42).

Stakeholder views per potential specific policy intervention are summarised below.

2.1 Intervention area A: Regular review of EU air quality standards

A1 Introduce review of EU air quality standards triggered by scientific progress

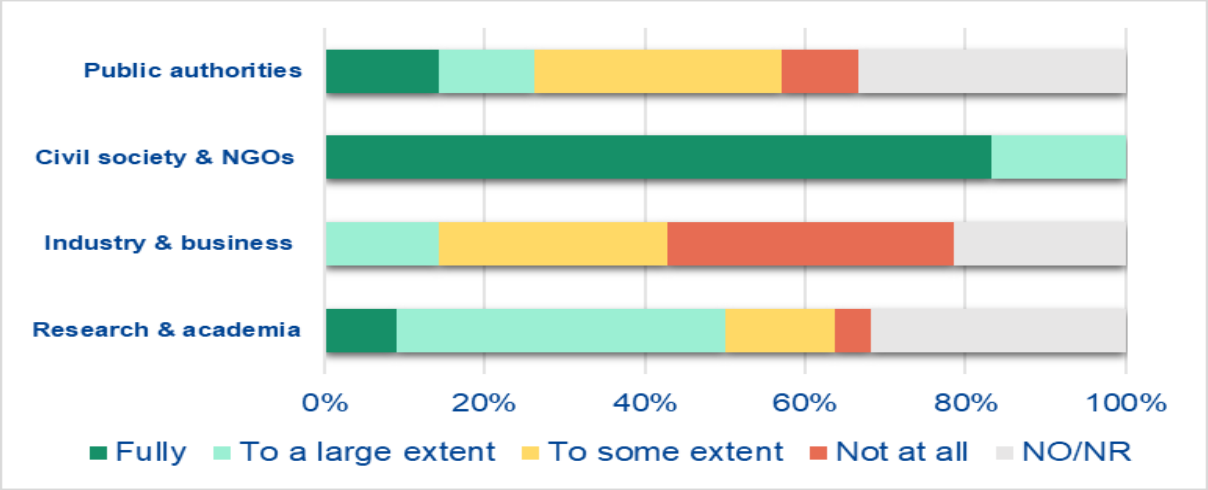
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A1	Introduce review triggered by scientific progress	++ (+) (+) +	(+) (+) 0	0 0 0	0 (-)	+	**High**	**Policy option I-6**

Focus of measure: Introduce a mechanism for adjusting EU air quality standards upon publication of new scientific advice (including, but not limited to, the publication of new WHO Air Quality Guidelines).

Description of measure: Appropriate mechanisms are needed to flexibly adapt to evolving science to protect human health. Article 32 of Directive 2008/50/EC and Article 8 of Directive 2004/107/EC provided grounds for once-off reviews on the basis of specific evidence (e.g. WHO Air Quality Guidelines or reduction potentials in Member States), but do not provide a mandate or obligation for regular reviews. Three possible intervention variants exist under this intervention to ensure that Ambient Air Quality Directives reflect latest scientific advice:

1. Introduce a binding schedule of reviews of scientific progress to be undertaken by the Commission - under this variant the Commission would undertake a periodic review of scientific progress related to air pollutants.
2. Introduce a mechanism for adjusting EU air quality standards upon publication of new WHO Air Quality Guidelines - under this variant the Commission would undertake a WHO Air Quality Guidelines related review of scientific progress related to air pollutants, with a view to presenting a proposal to amend the Directives to the European Parliament and the Council.
3. Introduce a mechanism for adjusting air quality standards based on (other) latest scientific advice - under this variant the Commission would undertake a review of new scientific knowledge of related to air pollutants, with a view to presenting a proposal to amend the Directives to the European Parliament and the Council.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Introduction of a mechanism that will provide a basis for the alignment of the Ambient Air Quality Directives with the latest scientific knowledge will directly contribute towards reductions in air quality concentrations. Meeting the direct objective of air quality reduction will subsequently indirectly protect EU population from harmful exposure to air pollution and indirectly benefit ecosystems. Direct costs estimated for this intervention are small administrative costs for the Commission.

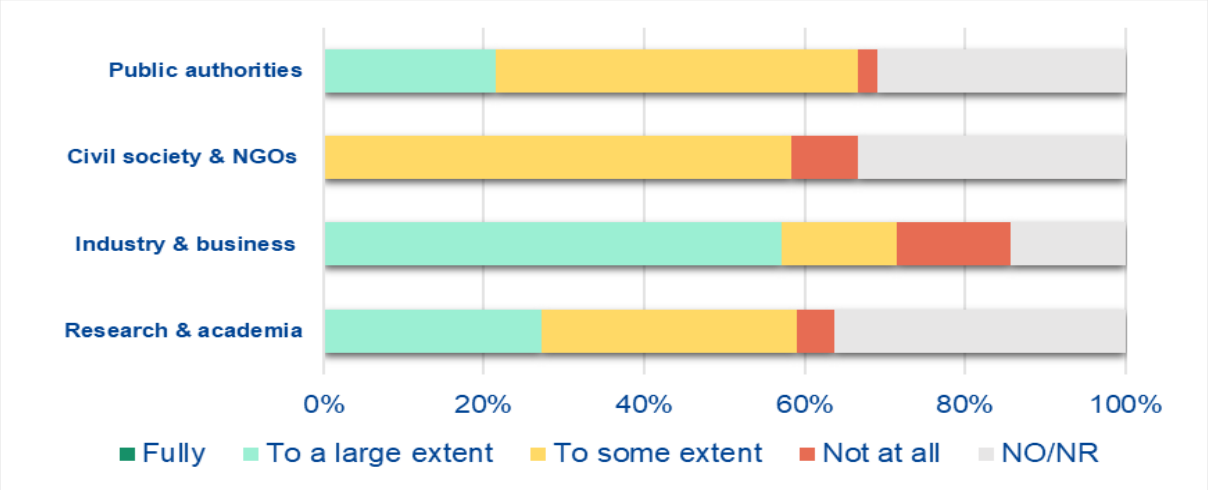
A2 Introduce review of EU air quality standards triggered by technical progress

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A2	Introduce review triggered by technical progress	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Low**	**Sub-option I-6a**

Focus of measure: Introduce a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction.

Description of measure: This intervention would introduce a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction. Accordingly, the Commission would undertake regular reviews of technical progress related to abatement techniques for air quality pollutants and the cost of implementing standards that are more stringent.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure introduces a mechanism for adjusting EU air quality standards based on technical progress in air pollution reduction. This intervention would formalise consideration of technological progress in the Ambient Air Quality Directive and could have a small positive indirect impact on improvements in air quality concentrations as advances in the technological knowledge might lead to revisions in the Ambient Air Quality Directive due to the enhanced technical feasibility of its implementation. However, the process would be driven by technology considerations, not health considerations, and therefore addresses the objective of protecting human health only to some extent. Direct costs estimated for this intervention are small administrative costs for the Commission.

A3 Introduce option to notify stricter standards by Member States

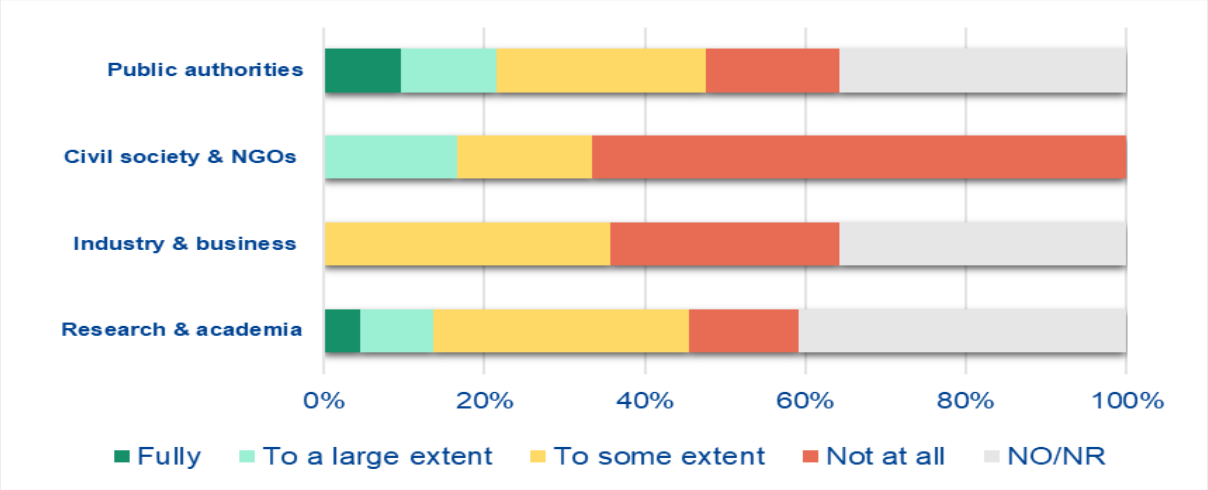
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A3	Introduce option to notify stricter standards	(+) (+) (+) (+)	(+) 0 0	0 0 0	0 (-)	0	**High**	**Policy option I-6**

Focus of measure: Introduce a provision in the Ambient Air Quality Directives to allow for EU Member States to adopt more stringent standards in light of the new technical and scientific progress coupled with an obligation to notify the Commission.

Description of measure: The European Commission would introduce a requirement to ensure that EU Member States notify the Commission if they adopt more stringent standards within their jurisdiction in light of the new technical and scientific progress. EU Member States already have the possibility to adopt more stringent protective measures in accordance with Article 193 TFEU which must be notified to the Commission. The intervention would explicitly enshrine this possibility with regard to stricter air quality standards in secondary

legislation and elaborate on the obligation to notify the European Commission with a view to collecting information on technical and scientific knowledge and national/local standards surpassing the EU standard and enabling information sharing across Member States.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure introduces a provision to allow EU Member States to adopt more stringent standards in light of the new technical and scientific progress coupled with an obligation to notify the Commission. This intervention has a potential to have a small indirect impact on reducing air pollution concentrations as it would contribute to sharing of information, including on scientific and technical data that can be used by the EU and other EU Member States. This intervention has been assessed under the assumption that it will enhance the Commission's evidence base regarding Member State policy action at EU level. Direct costs estimated for this intervention are small administrative costs for EU Member State competent authorities. The benefit cost ratio of this measure is considered high as low administrative burden would lead to an improved knowledge base.

A4 Introduce a list of priority air pollutants

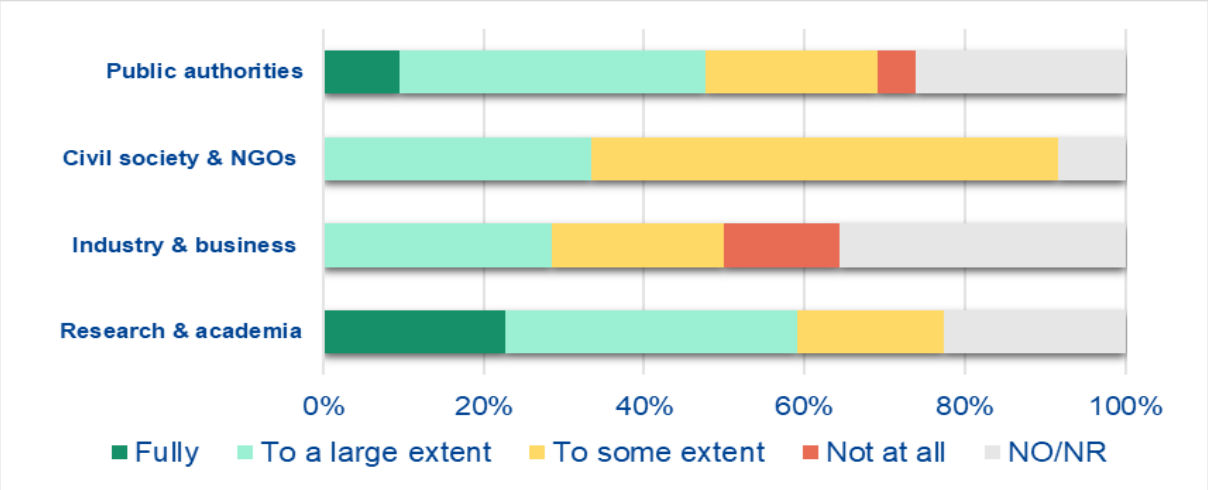
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A4	Introduce a list of priority pollutants	(+) (+) (+) (+)	0 0 0	0 0 0	0 -	0	**Low**	**Sub-option I-6b**

Focus of measure: Keep and periodically update a list of priority air pollutants with a view to monitoring air pollutants of emerging concern.

Description of measure: Directives 2004/107/EC and 2008/50/EC establish standards and objectives for a number of air pollutants, namely $PM_{2.5}$, PM_{10}, SO_2, NO_2, NO_x, Pb, CO, C_6H_6,

O_3, As, Cd, Ni and polycyclic aromatic hydrocarbons, to protect human health and the environment. This intervention would mandate the Commission to establish and periodically update a list of additional priority air pollutants with a view to monitoring air pollutants of emerging concern. Accordingly, the Commission would regularly update a "watch list" for emerging substances as part of the latest technical and scientific review and to demand their monitoring at Member State level. This measure would provide a first step for improving knowledge of and developing standards for air quality pollutants that are currently not covered in the Ambient Air Quality Directives. The Commission would be responsible for the watch list, but Member States would carry out the monitoring.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to keep and periodically update a list of priority air pollutants with a view to monitoring air pollutants of emerging concern. This intervention is likely to have a small indirect impact on air quality as the monitoring of identified priority pollutants could eventually lead to regulating them in the Ambient Air Quality Directive. Black carbon (BC), Ultrafine particles (UFP), ammonia (NH_3), PFAS (Per- and polyfluoroalkyl substances), dioxins and PCB (polychlorinated biphenyl) have been specifically highlighted as possible priority air pollutants. Direct costs estimated for this intervention are small administrative costs for the Commission. Additional burden would potentially be borne by the EU Member States if they were required (or voluntarily choose) to monitor priority emerging air pollutants, in particular if the content of the list changed frequently.

2.2 Intervention area B: Type of EU air quality standards

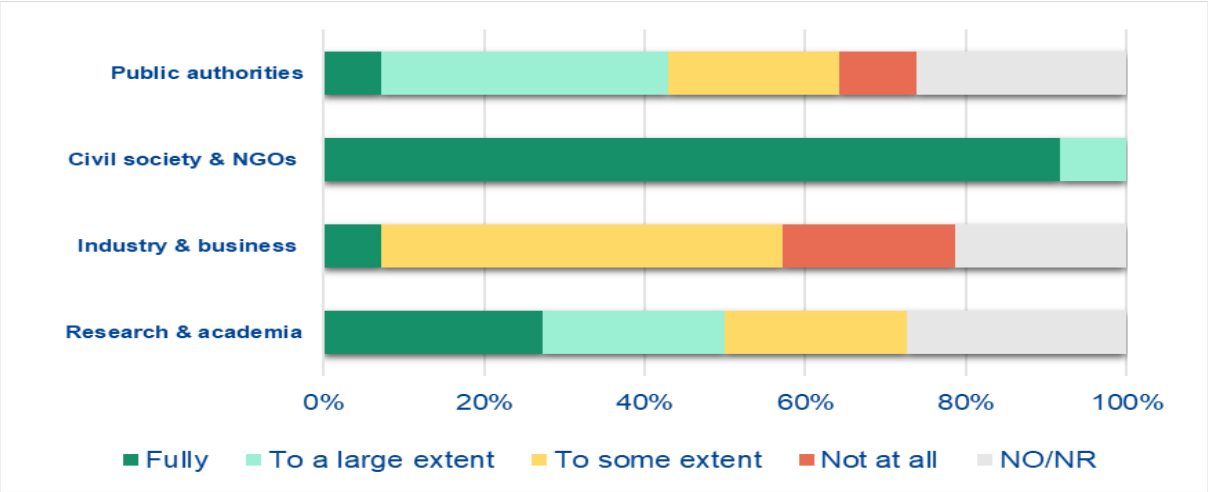
B1 Introduce additional short-term standards

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B1	Introduce additional short-term standards	+ 0 0 0	0 0 0	0 0 0	0 (-)	0	**High**	**Policy option II-2**

Focus of measure: Establish short-term EU air quality standards (daily or hourly) for additional air pollutants that currently only have annual or seasonal standards e.g. $PM_{2.5}$.

Description of measure: The Ambient Air Quality Directives sets short-term standards only for certain pollutants. There are cases where the WHO Air Quality Guidelines provide a recommendation for short-term exposure levels for additional pollutants. For example, for $PM_{2.5}$ there is an EU annual limit value, but no 24-hour standard; for SO_2 there are EU standards for 1-hour and 24-hour periods, but no 10-minute standard; for NO_2 there is an EU standard for 1-hour exposure, but no 24-hour standard. This intervention explores the regulatory change needed to underpin the formulation of additional short-term standards for various pollutants for which currently only long-term standards (annual-mean) exist, or alternative short-term averaging periods, to achieve greater alignment with the latest WHO Air Quality Guidelines.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This is a facilitating measure. It goes hand-in-hand with (and the true impacts are determined by) the ambition of the standards set under other interventions (O2, P2, Q2, R2, S2 and T1). This intervention provides the facilitating legal basis for such standards to be set, and hence is an important component of a wider solution that could be effective in improving air quality and thereby improving health protection. As such this measure has only low direct

costs, but the potential for high benefits. Stakeholders showed fairly strong support for this intervention, with 60% of respondents across all categories showing support at least to some extent.

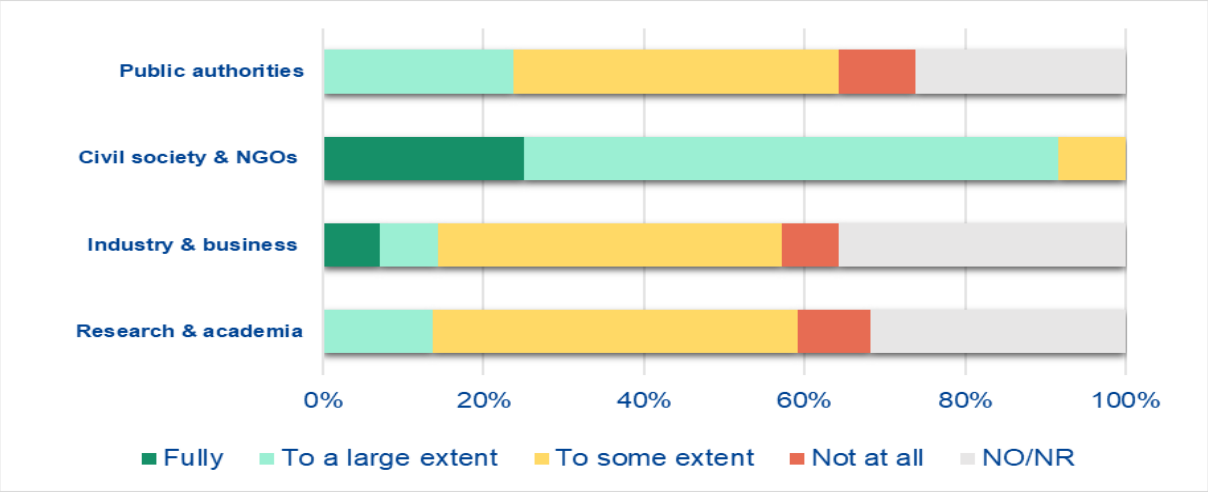
B2 Introduce additional alert/information thresholds

	Policy Measure	Env. impact	Soc. Impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B2	Introduce additional alert/information thresholds	+ + (+) (+)	+ 0 0	0 0 0	0 (-)	(+)	**Medium**	**Policy Option II-3**

Focus of measure: Define alert thresholds and information thresholds for all air pollutants as triggers for alerting the public and taking short-term action.

Description of measure: This intervention would establish alert thresholds and information thresholds for some or all air pollutants that currently do not have alert thresholds or information thresholds, as triggers for alerting the public and taking short-term action.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Alert and information thresholds provide a trigger for alerting the public and developing short term action. Short-term action is expected to benefit air quality indirectly to a small extent. Better information (on all relevant air pollutants) for the public would enable citizens, in particular vulnerable groups to take more targeted and effective personal measures to reduce their exposure to harmful air pollution, thereby having a direct small positive impact on human health. This intervention is expected to have small direct administrative costs for the Commission and competent authorities.

B3 Revise definition of average exposure standards

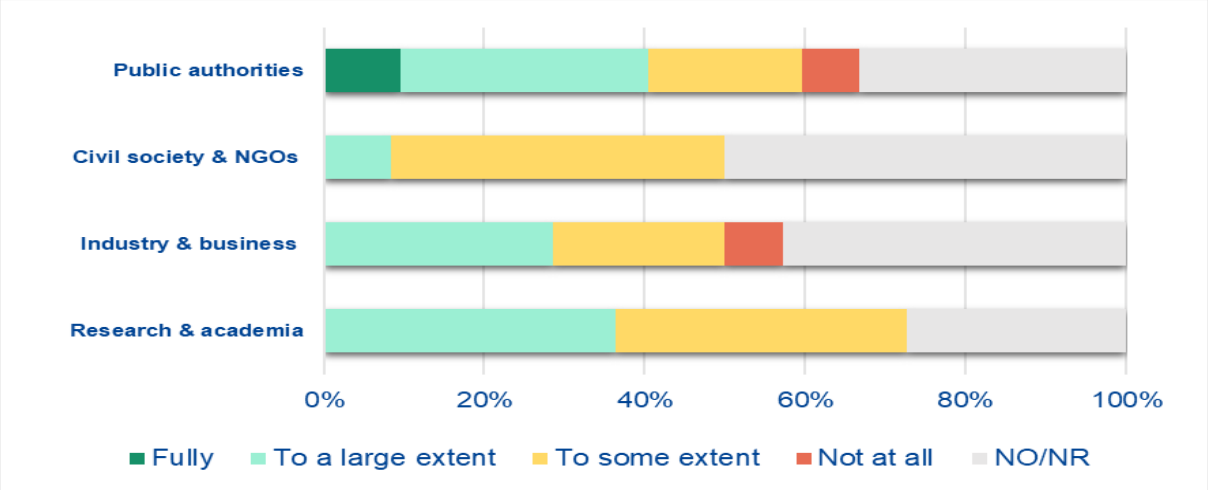
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B3	Revise definition of average exposure standards	(+) (+) (+) (+)	(+) 0 0	(+) 0 0	0 (-)	(+)	**High**	**Sub-option I-5**

Focus of measure: Expand the application of the exposure reduction targets (relative reduction in exposure).

Description of measure: The Ambient Air Quality Directives include average exposure obligations among the current provisions to regulate $PM_{2.5}$ concentrations. These complement the emission limit value for $PM_{2.5}$ by targeting average concentration values across larger areas. Accordingly, the Ambient Air Quality Directives set national $PM_{2.5}$ exposure reduction targets to protect human health (Article 15). The reduction target is a percentage reduction based on the initial concentration. To determine the initial concentration, an average exposure indicator is used (an average level determined on the basis of measurements at urban background locations throughout the territory of a Member State and which reflects population exposure). This intervention explores whether the formulation of the average exposure reduction targets and obligations should be changed. According to Article 15 of Directive 2008/50/EC, the distribution and the number of sampling points on which the average exposure indicator for $PM_{2.5}$ is based should reflect the general population exposure adequately. Annex XIV to Directive 2008/50/EC specifies Average Exposure Indicators (AEI) for $PM_{2.5}$. The AEI is currently measured at urban background stations, which might not always be reflective of the general population exposure. The following variants are explored:

1. Introduce an exposure reduction target at regional or local level (rather than at national level only).
2. Broaden the "average exposure indicator" metric to include locations other than urban background (e.g. rural background locations).
3. Establish requirements for Member States to adopt air quality plans to meet exposure concentration obligations.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention may improve the way that the average general population exposure reduction is monitored and addressed. The average exposure indicator is currently measured in urban background stations, which might not always be reflective of general population exposure. As a result, this measure is likely to provide better targeting of general air pollution exposure reduction measures, thereby contributing to further protection of public health from harmful air pollution and reducing the air quality cost to society. It could also improve the effectiveness of implementing mitigation measures. Direct costs estimated with this intervention are small administrative costs for the Commission and Member States.

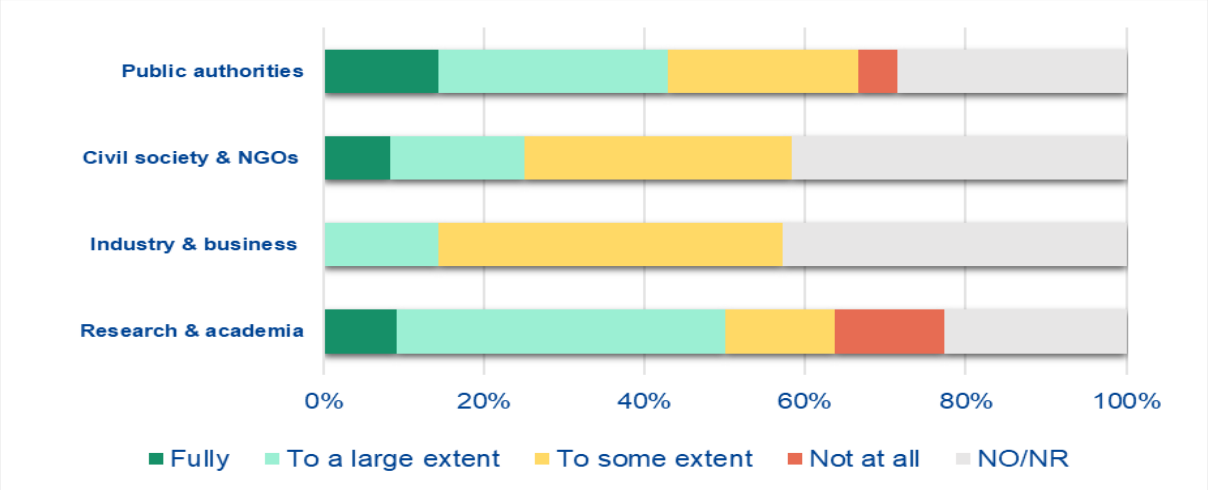
B4 Introduce guidance on addressing exceedances

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B4	Introduce guidance on addressing exceedances	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Medium**	**Policy option II-1**

Focus of measure: Provide guidance on the provisions concerning types of EU air quality standards and on the action to be taken in case of exceedance of different types of standards

Description of measure: This intervention would include guidance on how to respond to exceedances in terms of suitable air pollution response measures in case of exceedances, and on types of plans to be used. It would aim to enable clearer coordination with the development and implementation of short-term action plans under Article 24 of Directive 2008/50/EC and air quality plans under Article 23 Directive 2008/50/EC by clarifying the information to be provided in short-term action plans and ensure the requirements under short-term air quality plans do not overlap with the requirements for air quality plans set in Annex XV to the Directive 2008/50/EC.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: While varying circumstances across different EU member states are a challenge for developing effective guidelines, guidance could overall contribute towards better targeting of air pollution action, thereby contributing towards either more cost-effective response to exceedances or reducing the air quality cost on society by further protecting the general population from harmful air pollution. It is difficult to estimate indirect compliance and potential mitigation costs. Direct costs estimated with this intervention are small administrative costs for the Commission.

B5 Introduce limit values for additional air pollutants

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Synergies with other measures	Included in policy options
B5	Introduce limit values for additional air pollutants	++ + + +	+ 0 0	+ - 0	- (-)	0	**Medium**		**Policy option II-2**

Focus of measure: Establish limit values for additional air pollutants (i.e. for air pollutants currently subject to target values).

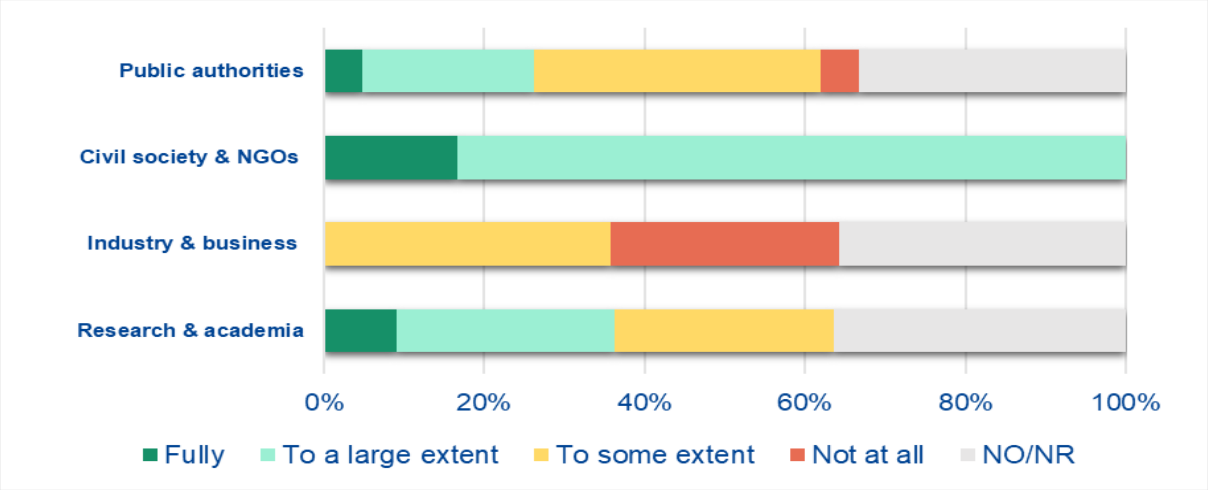
Description of measure: The Fitness Check of the Ambient Air Quality Directives found that limit values have been more effective in facilitating downward trends than other types of air quality standards, such as target values. This intervention explores the establishment of

limit values for additional air pollutants (i.e. for air pollutants currently subject to target values).

Intervention options for additional limit values include:

1. Establish limit values also for air pollutants that tend to depend on transboundary precursors and /or annual variations in meteorology (e.g. as is the case for ozone);
2. Establish limit values also for air pollutants that tend to correspond to specific point source emissions (e.g. as is the case for most heavy metals);
3. Establish limit values also for air pollutants that tend to correspond to emissions from specific widespread practices (e.g. as is the case for most poly-aromatic hydrocarbons).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Limit values have proved most effective in reducing air pollutant concentrations. Introduction of limit values for all pollutants, where these would prove feasible, would strengthen the Ambient Air Quality Directive. Direct costs estimated with this intervention are medium administrative costs for the Commission, associated with the review of the Ambient Air Quality Directive as well as additional monitoring needs (which would depend on the selection of pollutants for which limit values would be defined). One reason for setting target values rather than limit values is to take account of the specific formation mechanisms, for example in the case of ozone (also due to a strong role of transboundary sources and annual variations in meteorology for this air pollutant).

2.3 Intervention area C: Actions when exceedances occur

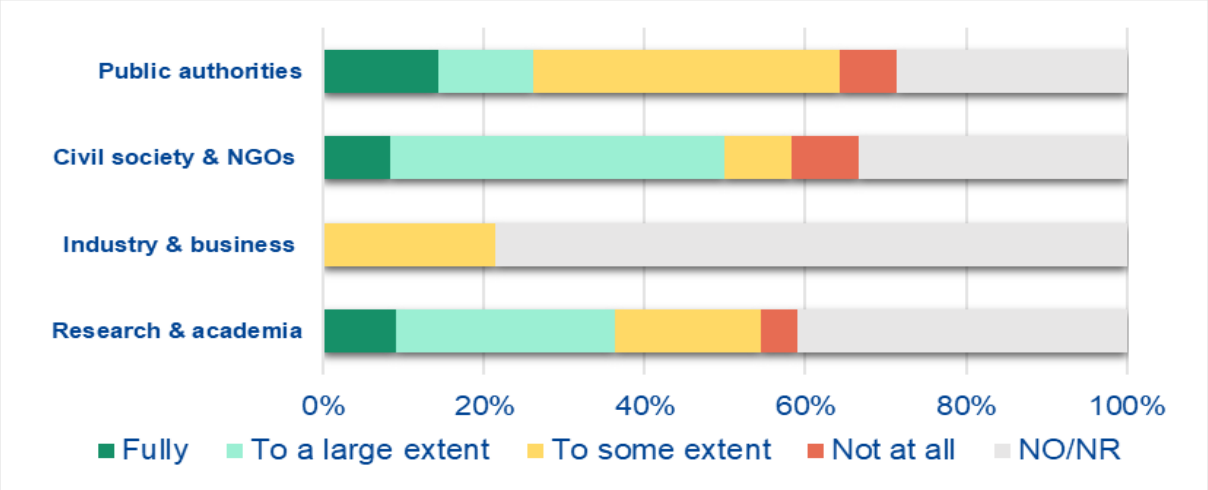
C1 Revise obligations for measures triggered by exceedances of air quality standards

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	**Medium**	**Policy option II-1** **Policy option II-4**

Focus of measure: Further specify the obligations to take measures to keep exceedance periods as short as possible.

Description of measure: This intervention would maintain the obligation to set out "appropriate measures, so that the exceedance period can be kept as short as possible" while further specifying the 'type of measures' that competent authorities must take to ensure that exceedance periods can be kept as short as possible. The type of measures to consider will depend on the type of pollutant, the source of pollution, and other factors. To this purpose the revised Ambient Air Quality Directives would contain a checklist of relevant abatement measures that competent authorities can consider and select from. The measures set out currently in section B of Annex XV could be updated and applied to air quality plans. Competent authorities would have to demonstrate that they have considered all relevant measures in the checklist of measures and if they decided not to implement a relevant measure, this should be justified (unlike currently, where air quality plans are not required to include reasoning behind the measures adopted). This means that this intervention would provide for a systematic assessment of measures and strengthen the information requirements that competent authorities need to make available in air quality plans. This intervention would build on requirements of Article 23(1) of Directive 2008/50/EC linked to exceedances of limit or target values. It could be extended to the Exposure Concentration Obligation (ECO) and Average Exposure Indicator (AEI), should the revision lead to establishing requirements in case of not complying with those standards. The rationale behind this intervention is that air quality plans have often proven ineffective due to inadequate or not sufficiently ambitious measures to reduce air pollution to achieve compliance.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure would specify the 'type of measures' that competent authorities must take to ensure that exceedance periods can be kept as short as possible. Since authorities would be provided with a long-list of measures to select from, this would lead to a systematic approach to developing an air quality plan and reduce time to explore potential measures. The intervention holds the potential to result in more effective measures which in turn can bring positive benefits in terms of air quality and related impacts, depends however also on funds for implementation of measures and properly trained staff on the side of competent authorities. The fact that the type of measures to be included in air quality plans is further defined does not guarantee these measures will be taken. The success of this intervention relies on the capability (knowledge, skills, competences) of competent authorities in charge of designing air quality plans to develop effective plans. This intervention will not result in any additional relevant direct costs for competent authorities as the obligation to develop air quality plans already exists.

C2 Revise/clarify the term 'as short as possible'

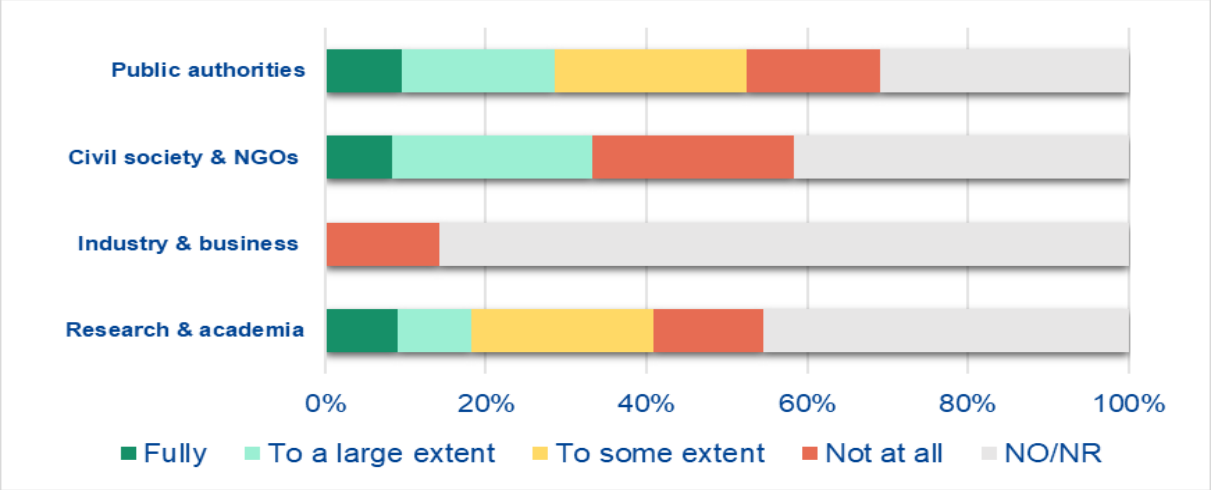
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C2	Revise/clarify definition of 'as short as possible'	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	**Medium**	**Policy option II-3**

Focus of measure: Reformulate the term "as short as possible" including a defined time period.

Description of measure: This measure would entail amending the text of Article 23 of Directive 2008/50/EC to define the specific time period within which competent authorities must bring emissions down below the exceedance threshold. This would replace the current

wording "as short as possible". This current provision is open to interpretation and therefore risks that exceedances remain systematic and persistent. In practice, since air quality plans must be prepared within two years from the exceedance at the latest, measures are often implemented only after three years at the earliest. Thus, the purpose of this intervention is to prompt competent authorities to take measures to reduce air pollution to a safe level in a timely manner. Where measures are implemented slowly, this intervention could contribute to ensuring that action is taken faster and that there is no room for different interpretations of what 'as soon as possible' means, as also voiced in the targeted stakeholder survey.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Specifying a clear time period within which air quality standards have to be respected holds the potential to result in faster action which in turn can bring indirect positive benefits in terms of air quality and related impacts. Introducing a fixed timeframe will provide a maximum time span within which results have to be achieved, improving the speed of response rates in many cases. However, as there is no one-size-fits-all timeframe, there is a risk that a fixed timeframe will slow down action in some cases where compliance could be achieved before the end of the fixed term. There may also be effective long-term measures that cannot be fully implemented within the given timeframe. A fixed timeframe may also weaken previous interpretations of the term 'as short as possible' by the courts.

C3 Revise short-term action plans and air quality plans

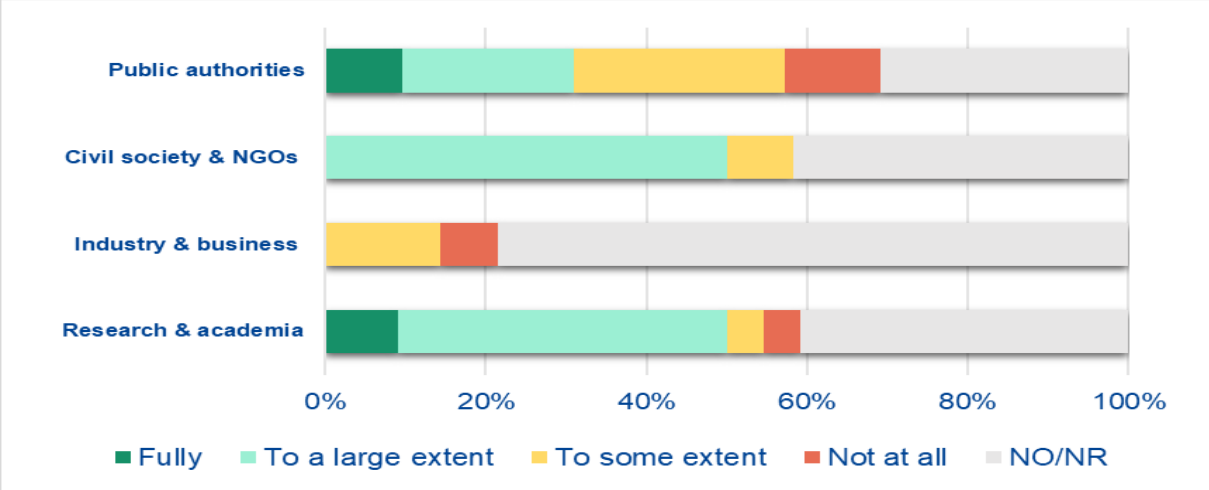
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C3	Revise short-term action plans & air quality plans	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 -	0	**Medium**	**Policy option II-1**

Focus of measure: Require a clearer coordination between short-term action plans and air quality plans.

Description of measure: This intervention consists of requiring clear coordination between the development and implementation of short-term action plans (under Article 24 of Directive 2008/50/EC) and air quality plans (under Article 23 and in Annex XV to Directive 2008/50/EC). It should be noted that this intervention is particularly relevant for Member States in which alert thresholds are exceeded but could apply to any Member State where there is a risk of exceeding limit or target values.

Coordination between short term action plans and air quality plans is not a requirement in the current Directive. As a result, not all Member States coordinate these. Since short term action plans and air quality plans may be under the responsibility of authorities at different levels (for example, the former may be under the responsibility of local authorities, while the latter of regional authorities), coordination may require additional efforts.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Coordination between short term action plans and air quality plans would lead to synergies among actions and avoid inefficiencies or inconsistencies. Small administrative costs may be incurred for Member State competent authorities related to coordination activities which are expected to be more than off-set by efficiency gains. According to several respondents to the targeted stakeholder survey, the revised Directive could require that short term action plans are included in air quality plans. Also, to facilitate this linkage between the two types of plans, the Ambient Air Quality Directives should include the minimum content that short-term action plans should contain.

C4 Introduce additional short-term action plans

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C4	Introduce additional short-term action plans	+ + +	+ (+) (-)	(+) 0/- (-)	0/- -	(+)	**Medium**	**Policy option II-3**

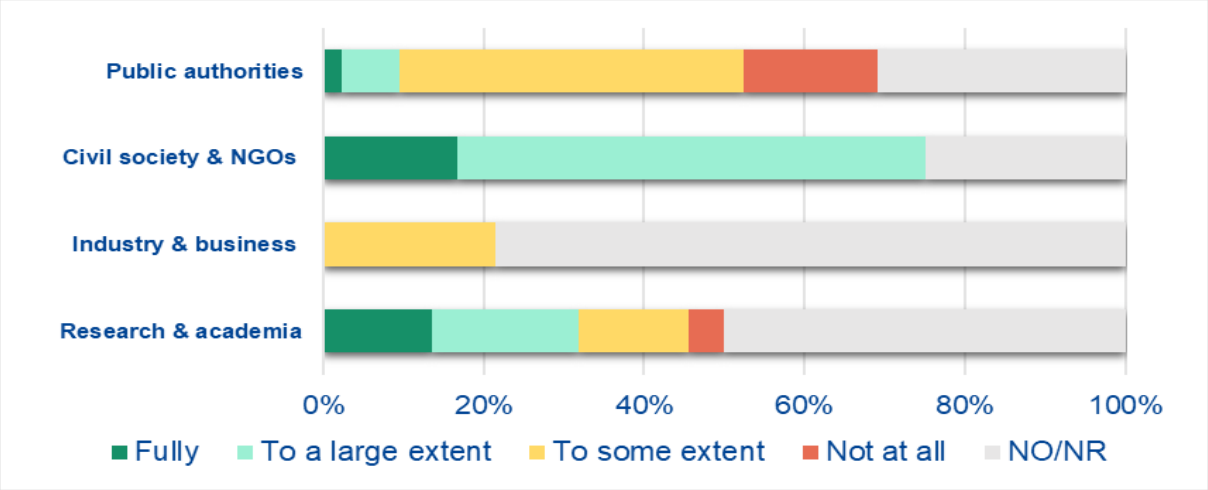
		(+)						

Focus of measure: Introduce an obligation for effective short-term action plans for each pollutant to prevent / tackle air pollution events.

Description of measure: This intervention consists of introducing in the revised Ambient Air Quality Directives the obligation to adopt effective short-term action plans for all pollutants to prevent and tackle pollution events.

Directive 2008/50/EC requires that action plans are drawn up indicating the measures to be taken in the short term "where there is a risk of an exceedance of one or more alert thresholds" (in order to reduce the risk of the duration of such an exceedance). However, alert thresholds as defined in Annex XII of Directive 2008/50/EC only exist for NO_2, SO_2 and O_3, and therefore short-term action plans are not required for other pollutants such as PM_{10}.[10]

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: An obligation for effective short-term action plans for each pollutant would prompt further action to bring emissions and concentrations down compared to the current situation, thus expected to benefit air quality and protect in particular sensitive groups from immediate health risks. Additional administrative burden is expected from this intervention as it imposes new requirements to Member State competent authorities. Risks linked to this intervention have to do with time-lag and separation of source from pollution. Short-term action plans may be effective only to a limited extent where pollution episodes cannot be influenced by local measures or in case of secondary pollutants for which it is not straight forward to identify immediate measures.

[10] COM (2019), Fitness Check of the Ambient Air Quality Directives- final

C5 Introduce a requirement to update air quality plans

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C5	Introduce requirement to update air quality plans	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- ---	(+)	**Medium**	**Policy option II-3**

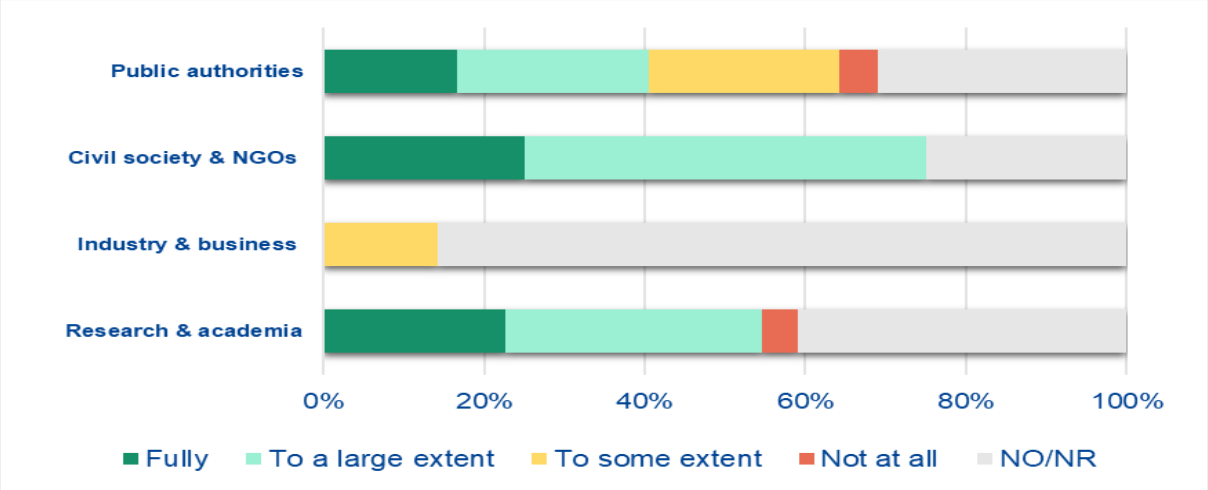
Focus of measure: Mandate regular updates of air quality plans.

Description of measure: This measure would introduce an obligation for competent authorities to update air quality plans at regular intervals to keep exceedance periods as short as possible. Specific frequency of the update would take into account the administrative burden such updates entail. Based on feedback received from the Targeted Stakeholder Survey, updating air quality plans every three years is seen as reasonable by stakeholders.[11] This measure is intended to enhance effectiveness of air quality plans by ensuring the relevance of air quality plans and associated measures in a changing air quality context for a specific location (i.e. to ensure that measures in air quality plans address new challenges for air quality). It would be important to define the scope of updates. Feedback from regional authorities received in response to the Targeted Stakeholder Survey note that:

- updates should not necessarily require an update of all underpinning data/studies on emissions/sources and of scenario model runs but evaluate the effectiveness of the implemented measures and consider whether more measures are needed;
- new measures to tackle emerging exceedances could be adopted within existing plans, without having to draft a new plan;
- updates should contain an evaluation of measures included in previous plans, and, if relevant, a motivation why these have not been taken or have not achieved the envisaged effects.

[11] Based on responses to Targeted Stakeholder Survey where replies ranges from requiring revisions yearly to every ten years, with a few stakeholders - including national and regional authorities - mentioning three years as adequate.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Requiring regular updates of air quality plans would increase the effectiveness of plans and thus have an 'indirect' positive effect on air quality. Mitigation costs and administrative burden are expected to directly impact Member State competent authorities responsible for the updating of air quality plans and implementation of measures. A risk identified for this measure relates to the fact that the process of drafting air quality plans tends to be long.

2.4 Intervention area D: Air Quality Plan Involvement

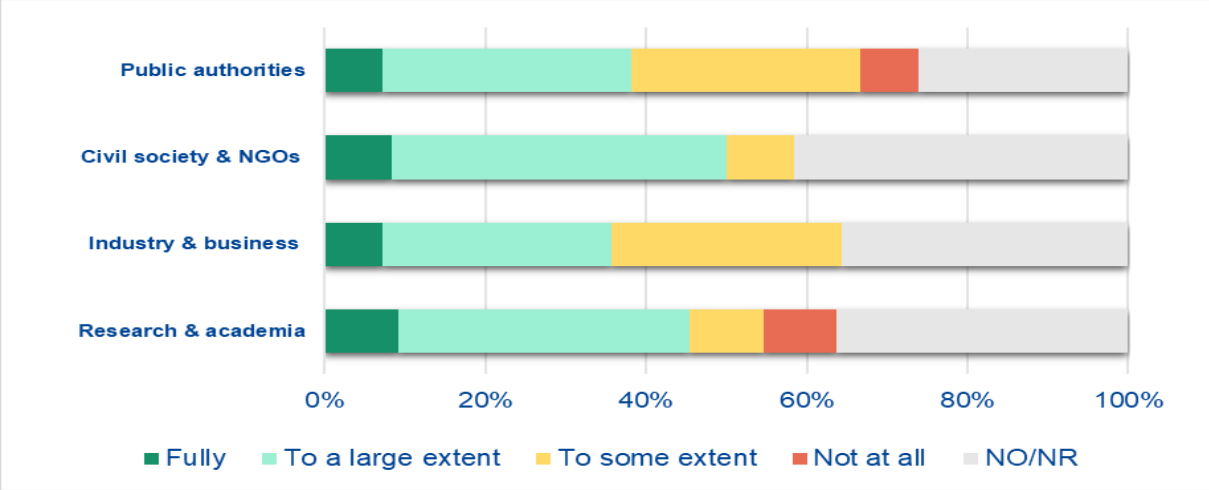
D1 Revise requirements to involve stakeholders

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D1	Revise requirements to involve stakeholders	(+) (+) (+) 0	0 0 0	0 0/- 0	0/- --	0	**High**	**Policy option II-1**

Focus of measure: Establish a requirement for Member States to involve specific actors in air quality plan development and to specify coordination arrangements for the development and implementation of air quality plans.

Description of measure: This measure would require Member States to involve all relevant actors in the drafting of air quality plans and coordinate better with these. Actors may include national/regional/local competent authorities, sectoral representatives from polluting industries, research institutes, civil society and local citizens. To this purpose, the revised Ambient Air Quality Directives should include the following concerning the preparation of air quality plans (1) a requirement for consulting and involving government authorities at various levels, and (2) a new 'public participation' clause for the development of air quality plans. The revised Directive should specify which aspects of the planning process should be open to public consultation and what this should involve. The problem that this measure is trying to address is that since there are no requirements on how to allocate roles and responsibilities in air quality plans, cooperation between government authorities at various levels is not a given. This can lead to insufficient action being taken by public authorities or to a mismatch of action, and therefore to air quality plans and measures being insufficient, inefficient and/or ineffective. In addition, while air quality remains a top environmental concern for EU citizens, citizens are not systematically consulted in the development of air quality plans.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure seeks to improve the involvement of all relevant actors in the design and implementation of air quality plans. This may be done by possibly adding a requirement for consulting and involving government authorities at various levels, and by introducing a new 'public participation' clause for the development of air quality plans.

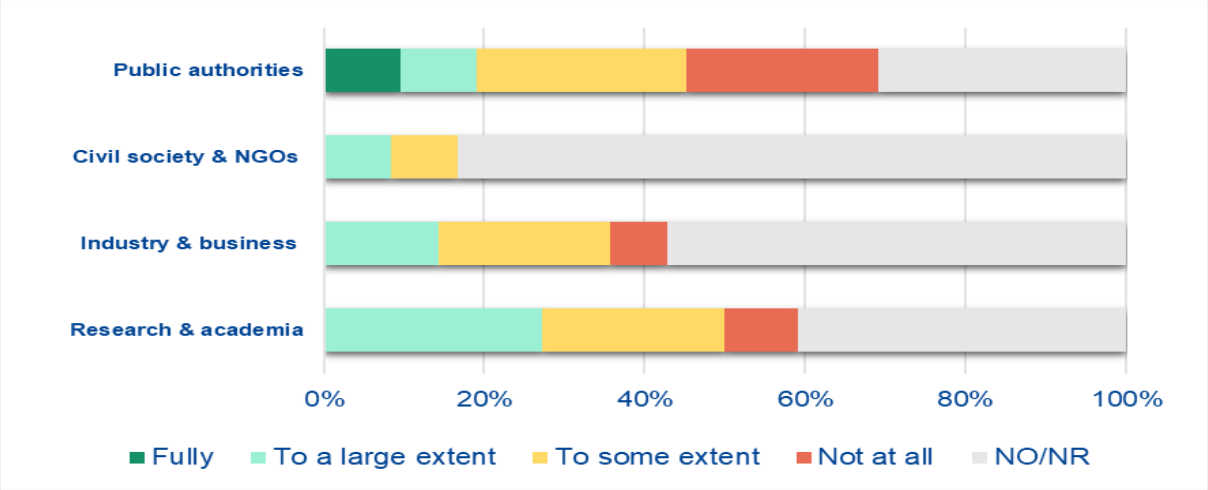
D2 Introduce a 'one zone, one plan' requirement

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D2	Introduce a 'one zone, one plan' requirement	0 0 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub-option II-1a**

Focus of measure: Introduce a requirement for Member States to harmonise air quality plans and air quality zones (and require a 'one zone, one plan' approach).

Description of measure: This measure would further define the requirements for drawing air quality plans in Article 23 of the Directive 2008/50/EC to require that one zone has to fully overlap with one plan (and hence avoiding zones with multiple plans and plans for multiple zones). This measure aims to increase the effectiveness of the Ambient Air Quality Directives by tackling the current mismatch between the zones of air quality monitoring and air quality plans.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to increase the effectiveness of the Ambient Air Quality Directives by tackling the current mismatch between the zones of air quality monitoring and air quality plans. However, the benefits and added value of this intervention are unclear while it would generate some costs (and considerable administrative burden). Overall it is unclear what the added value of this intervention would be and a global approach does not seem helpful as air quality plans and air quality zones are very specific to local conditions. Arguments against this intervention in the Targeted Stakeholder Survey revolve around changes that would be needed in terms of governance / responsibilities as well as around additional administrative burden that the intervention would lead to.

2.5

2.6 Intervention area E: Enforcement tools

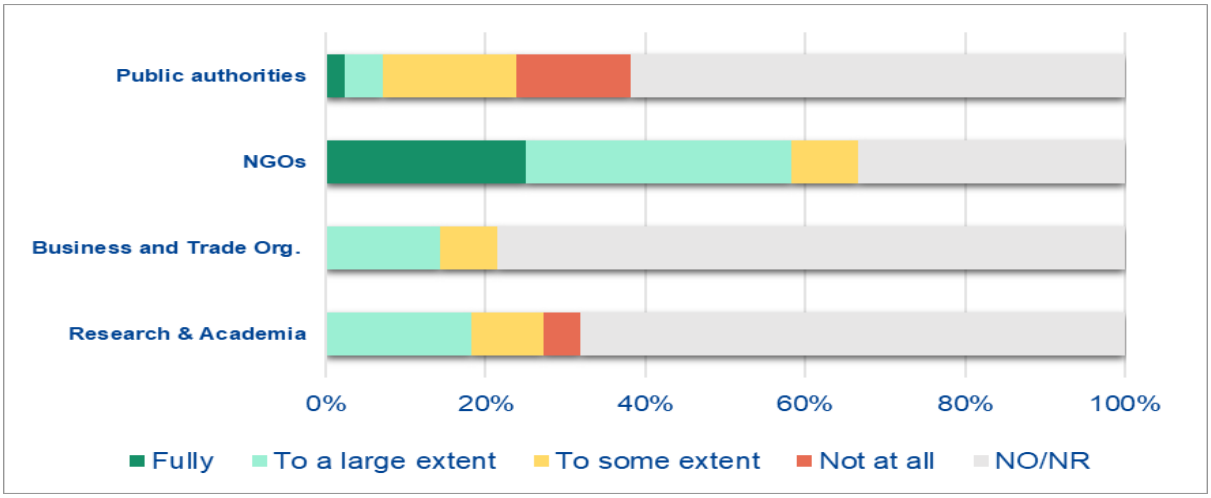
E1 Introduce minimum levels for financial penalties

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E1	Introduce minimum levels for financial penalties	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) (-)	(+)	**Medium / High**	**Policy option II-4**

Focus of measure: Introduce minimum levels for financial penalties decided at national level.

Description of measure: This measure aims to expand the current provisions on penalties in the Ambient Air Quality Directives (Article 30 of Directive 2008/50/EC and Article 9 of Directive 2004/107/EC) to specify the magnitude of the financial penalties to be paid. In cases of failure to comply with air quality standards by establishing a minimum level for such. These penalties would be directed to competent authorities as well as industry or other private entities and should lead to penalties or sanctions that are high enough to be effective and dissuasive. The number of continued exceedance situations can be seen as an indication that Member State penalties are not sufficiently effective, proportionate nor dissuasive, with the effect that the legislation has not been adequately implemented. Further, currently financial sanctions differ from Member State to Member State leading to leading to discrepancies in terms of level of penalties and their application across the EU. While penalties are to be laid down by Member States, there is potential for more clearly framing the use and scope of penalties in the Ambient Air Quality Directives following the examples of other EU legislation.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Effective minimum penalty levels should discourage competent authorities and industry or other private entities from breaching provisions of the Directives or measures adopted pursuant to the Directives, thus indirectly benefiting air quality, ecosystems and health. If effective, it would lead to competent authorities and industry implementing more measures to avoid breaches (and therefore avoid the high fines). This would indirectly generate additional costs for these actors, though related to achieving compliance. The additional administrative burden of clarifying levels of financial penalties is low and would facilitate their implementation. The risks for implementation have to do with determining penalty levels applicable across the EU and, more indirectly, with difficulties with enforcement of breaches.

E2 Introduce right to health damage compensation

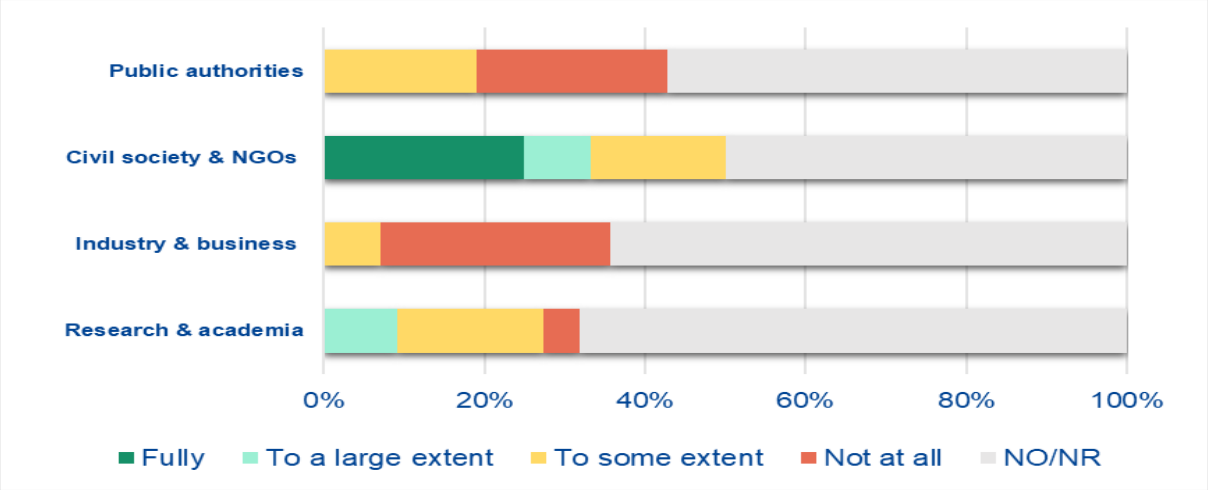
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E2	Introduce right to health damage compensation	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- 0	(+)	**Medium**	**Policy option II-4**

Focus of measure: Introduce an explicit provision that provides a right to compensation for damage to health caused by air pollution.

Description of measure: This measure would introduce an explicit provision within the Ambient Air Quality Directives on the right to compensation for damage to health caused by breaches of the Ambient Air Quality Directives. The principle of state liability allows for

individuals to seek compensation under certain conditions for harm suffered as a result of Member State non-compliance with EU law.[12] Such a provision would clarify and facilitate compensation for harm suffer to health from air pollution. The reason for this measure is that while there is overwhelming epidemiologic evidence on the negative health impacts of air pollution on the population, exceedances still take place (albeit the frequency, extent and magnitude of these have generaly improved since 2008) and damages linked to these are not always addressed sufficiently.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure would work as an incentive for competent authorities and industry/business to implement more effective measures, which in turn would benefit air quality, health and ecosystems. This measure, if implemented, would require competent authorities and/or industry (polluters) to pay compensation to those who have suffered damage to health from air pollution and would therefore carry mitigation costs for those who are held accountable for breaches of air quality standards. It would also carry administrative burden for competent authorities and/or industry (polluters) as they would need to put in place and manage the compensation scheme and deal with a potentially increasing number in lawsuits by citizens / civil society, though only in case of continued non-compliance. Implementation challenges include the difficulty to prove the causal link between pollution and long-term health effects and the question of accountability (who is held responsible).

[12] The application of this principle of state liability to breaches of Member States' obligations pursuant to Articles 13 and 23 under the Ambient Air Quality Directives is the subject of a preliminary reference currently before the Court of Justice of the EU in Case C-61/21, *Ministre de la Transition écologique and Premier ministre*. See Annex 12 for more detail on the case.

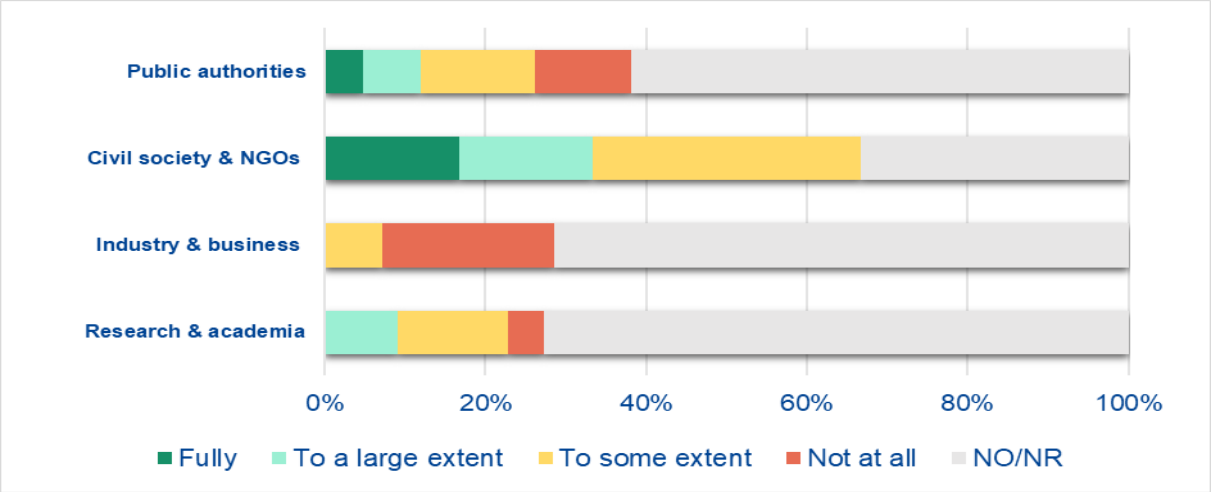
E3 Introduce a fund to be fed by penalties paid

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E3	Introduce a fund to be fed by penalties paid	0/(+) 0/(+) 0/(+) 0/(+)	0 (+) 0	0 0/(+) 0	0/+ (-)	0/(+)	**Low**	**Sub-option II-4a**

Focus of measure: Set up a fund to be fed by the payment of penalties which can be used to compensate material damage or finance air quality measures.

Description of measure: This measure consists of setting up a "clean air fund" to be fed by the payment of penalties when the rules established by the Ambient Air Quality Directives, or possibly other rules addressing air pollution, are infringed. It would be used to compensate victims of air pollution as well as to finance air quality measures. The fund could be established either at EU-level (an EU-wide fund) or at national level (with each Member State having their own fund).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: A dedicated fund would make available funding for compensation for health damage suffered and facilitate access to funding of the implementation of mitigation measures (leading to measures being more readily implemented). However, it could also lead to competent authorities using the fund to finance measures that they would implement in any case, without leading to 'more' (i.e. additional) measures being implemented, which is a risk the governance of the fund would have to address. Setting up and administering such a fund will generate additional burden. Risks for implementation include a potential conflict of interest in the case the authority that has to pay also administers the fund and alignment with national budgetary rules. The organisation of the fund could provide safeguards to avoid that the budget from which the penalty is paid into the fund is not the one benefiting from it.

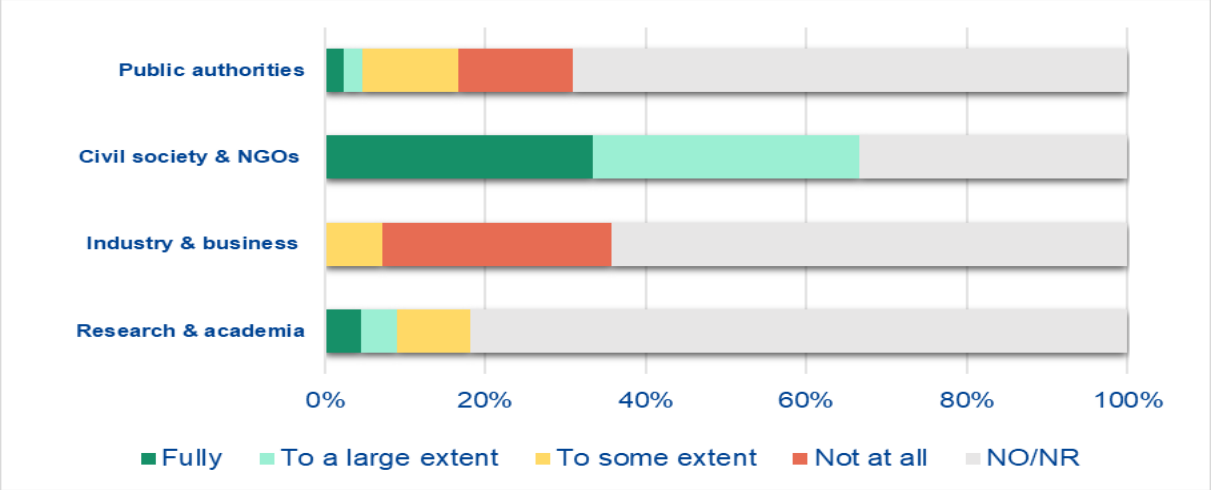
E4 Introduce an explicit 'access to justice' provision

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E4	Introduce access to justice provision	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) 0	0	**High**	**Policy option II-4**

Focus of measure: Introduce an explicit provision in the Ambient Air Quality Directives that grants the public concerned 'access to justice'.

Description of measure: This measure introduces a new explicit provision on 'access to justice' in the Ambient Air Quality Directives. The Fitness Check of the Ambient Air Quality Directives found that enforcement action by civil society actors in front of national courts has proven to be important to accelerate downward trends for air pollution. This has been confirmed by the Inception Impact Assessment, which notes that "the effectiveness of legal enforcement action by civil society is linked to the functioning of access to justice at national level".[13] However, studies have shown that rules on access to justice rules vary widely between Member States and that there exist still significant hurdles to effective access to justice at national level.[14]

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There is a gap in the Ambient Air Quality Directives with regard to 'access to justice' and including such a provision in the legislation would be a coherent step, in line with other environmental Directives,[15] Article 47 of the EU Charter of Fundamental Rights,

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[13] COM (2020), Inception impact assessment - Ares(2020)7689281 (accessed: 04.08.2022)

[14] For example: 2013 access to justice report on the Implementation of Articles 9.3 and 9.4 of the Aarhus Convention in the Member States of the European Union and 2019 Milieu Study on EU implementation of the Aarhus Convention in the area of access to justice in environmental matters. (accessed: 10.06.2022)

[15] For example: Article 6(2) of Directive 2003/4/EC, Article 13 of Directive 2004/35/EC, Article 11 of Directive 2011/92/EU, Article 25 of Directive 2010/75/EU and Article 23 of Directive 2012/18/EU.

the Aarhus Convention[16] and the case law of the Court of Justice of the EU.[17] Public judicial enforcement of the obligations under the Ambient Air Quality Directives has so far already lead to multiple national rulings (in several Member States) mandating national authorities to take action to improve air quality. Introducing an explicit provision would enable such action by citizens that are currently unable to do so because of strict national procedural requirements.[18] In turn, this would indirectly benefit air quality and human health as a whole. Additional administrative costs for Member States (probably central / national government) and industry may occur as an increase in lawsuits may be expected; this would largely depend on whether national authorities have already taken the necessary measures to comply with the Aarhus Convention and the relevant case law of the Court of Justice of the EU. The implementation of the intervention carries risks in terms of capacity for Member States to deal with additional legal claims.

[16] UNECE (1998), Convention on access to information, public participation in decision-making and access to justice in environmental matters (accessed: 10.06.2022)

[17] For an overview see: Commission Notice on Access to Justice in Environmental Matters (accessed: 10.06.2022)

[18] See Annex 12 for an illustrative overview of clean air cases before national courts.

2.7 Intervention area F: Information to the public

F1 Revise provisions related to up-to-date data

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F1	Revise provisions related to up-to-date data	0 (+) 0 0	(+) 0 0	0 0 0	0 --	0	**Medium / High**	**Policy option IV-1**

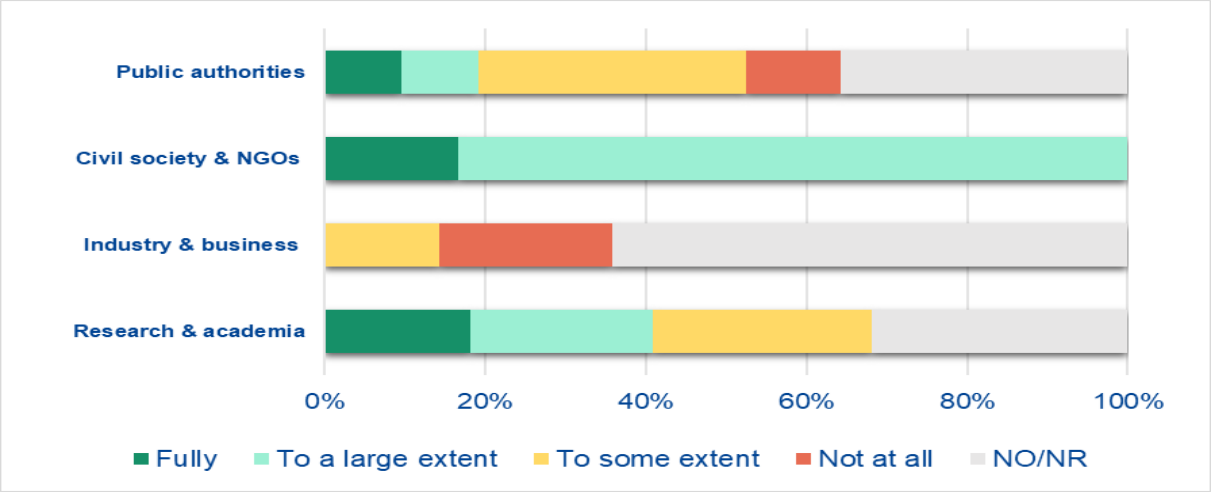
Focus of measure: Introduce more specific requirements to ensure regular reporting of up–to–date data / information (instead of allowing Member States to report data as available).

Description of measure: This intervention aims to tackle the problem that the general public is not always sufficiently informed regarding current air quality, and the problem that public information on air quality in Member States is not always timely. In addition, NGO stakeholders have consistently raised the issue that the current discretion given to Member States to determine when and how they provide information is sometimes leading to Member States reporting only on days on which air quality is good.

The intervention explores further specifying Article 27 of the Directive 2008/50 by **i**ntroducing regular reporting requirements to ensure up-to-date data and that information is made available to the public, specifying:

- the timeframe for reporting;
- the data/information to be reported;
- obligation to display such information / data on air quality on screens in key points of cities and towns.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Up-to-date data and information on air quality would allow citizens to make

decisions that may impact on their health, such as deciding not to participate in outdoor leisure activities or opting for a cleaner transport route. Hence there is a benefit in ensuring consistent access for citizens across Member States to real-time, appropriate information, which is publicly accessible. Having such information / data would be particularly important for vulnerable groups. The benefits of the intervention are indirect while its costs are negligible but administrative burden will increase slightly for Member States. There are risks around the accuracy of real-time information.

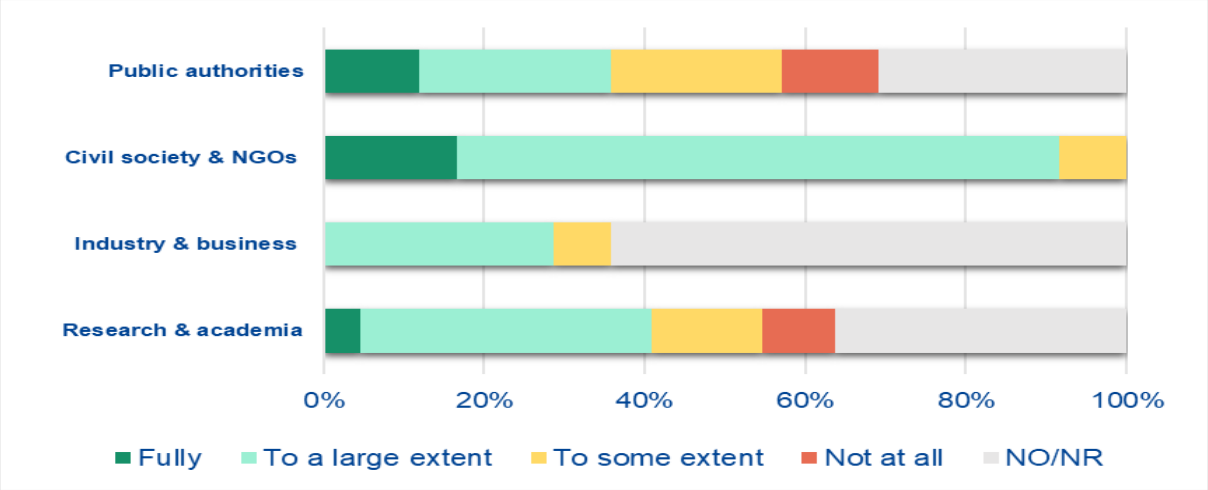
F2 Introduce requirement to provide air quality health data

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F2	Introduce requirement to provide air quality health data	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option IV-2**

Focus of measure: Require Member States to provide specific health / and health protection information to public as soon as exceedances occur.

Description of measure: This intervention would require Member States to provide information to the public as soon as exceedances of alert thresholds occur. The issue that this intervention is trying to solve is that currently when alerts are made public, it is often too late to protect the health of the population because pollution peaks often do not last long. A standardised approach to providing information about the negative health effects in a simple, understandable form may prove useful for considering under this intervention.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Information on health (protection) would allow citizens to make decisions that may impact on their health such as deciding not to exercise outdoors or opting for a cleaner transport route. Ensuring that information is provided to allow citizens to take timely action would increase the effectiveness of information provided, whilst the costs are considered negligible since relevant information and the systems to provide it are already in place.

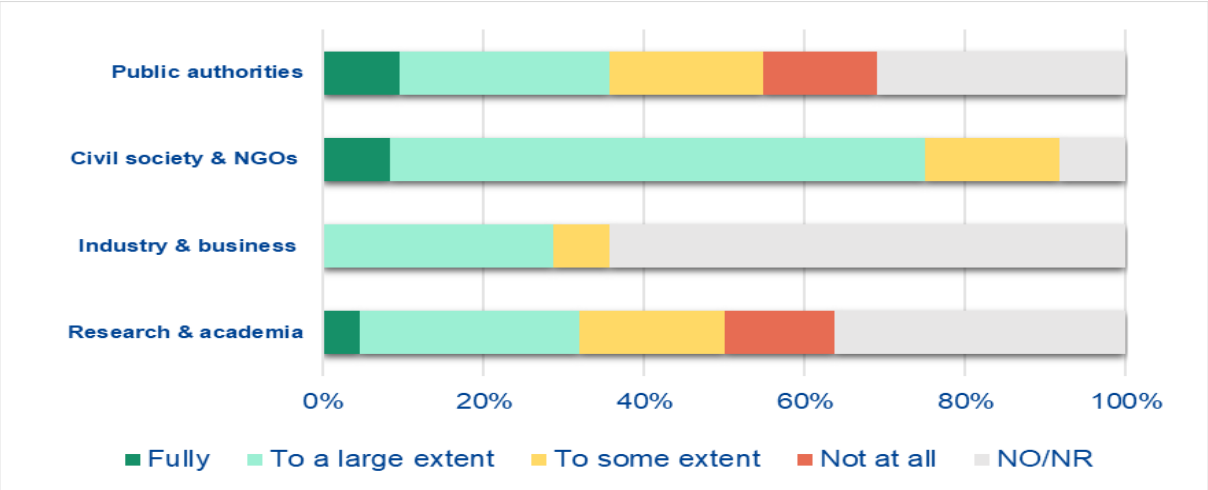
F3 Introduce use of specific communication channels

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F3	Introduce use of specific communication channels	0 0 0 0	(+/-) 0 0	0 0 0	0 ---	0	**Low**	**Sub-option IV-2a**

Focus of measure: Mandate specific communication channels with citizens, including user-friendly tools for public access to air quality and health risks information.

Description of measure: This intervention would mandate the use of specific user-friendly communication channels to reach out to citizens (for example, smartphone apps, social media, text messages, forecasts on television (similar to weather forecasts)) so that citizens have access to air quality data and information related to health risks. The issue this intervention is trying to solve is that citizens do not always know where to access (reliable) air quality information and that governments do not know how to best provide information. Tools and the quantity and quality of information provided to citizens varies between Member States.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Obliging competent authorities to use a set of information channels would lead to a better, and consistently informed public with indirect benefits on health, however given the case care has to be taken on which channels to define for use. The cost of developing (in particular where these are not currently in place) specific, high-tech channels may be more costly, which may divert resources from other, more productive, means.

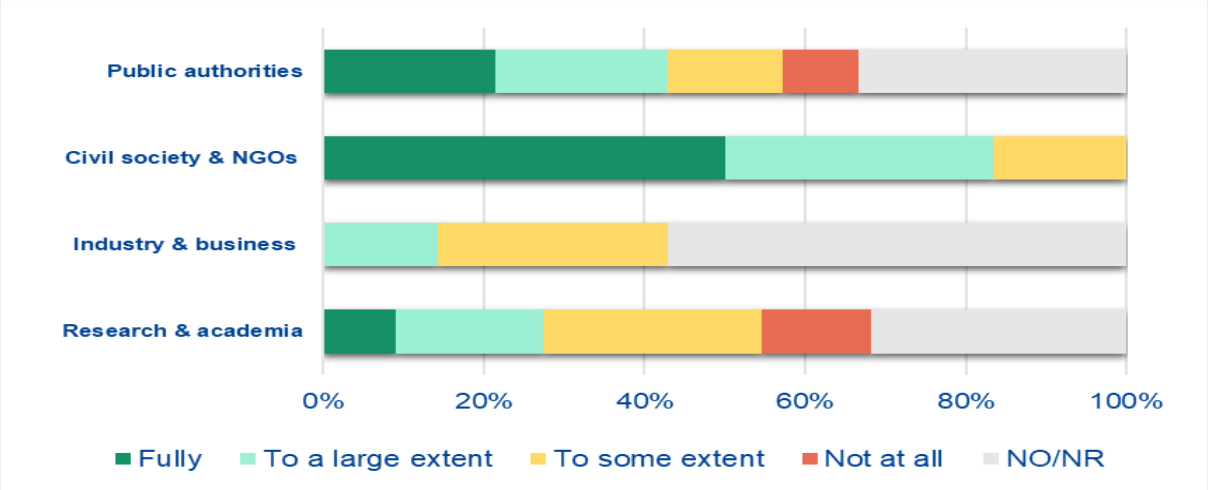
F4 Introduce requirements for harmonised air quality index

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F4	Introduce requirements for harmonised air quality index	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option IV-3**

Focus of measure: Require Member States to use harmonised air quality index bands.

Description of measure: This intervention consists of including a provision in the Directive 2008/50 to require Member States to use harmonised air quality index bands, namely those used in the European Air Quality Index. This way a one-size-fits-all where everyone adopts the same index is avoided, acknowledging that different countries and regions have their own characteristics which make different pollutants relevant. The problem that this intervention is aiming to solve is the current absence of a common metric used for publicised air quality indices. At the moment Member States (and even regions within in some cases) have different air quality indices whose bands and thresholds differ from the European Air Quality Index provided by the European Environmental Agency. This often means that the same data is presented in different ways in different locations. Although there is no consensus on whether and how air quality indices can be harmonised, what is known (from the study "*Strengthening of air quality monitoring, modelling and plans under the Ambient Air Quality Directives*") is that there is not much support for all Member States adopting the European Air Quality Index. As such adopting the bands alone seems the most feasible compromise which has obtained wide support in the stakeholder consultation activities.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Consistency in the information provided to citizens will aid clarity and uniformity in the opportunity provided to all EU citizens to take action to reduce their exposure with

indirect benefits for health. However, there are concerns that the European Air Quality Index is not effective (e.g. around its ability to represent multi-pollutant effects), and that complete harmonisation may restrict the ability of Member States to tailor advice and information to the specific situation in each Member State. The intervention will increase administrative burden for competent authorities (regional or national) as it will require these to adapt their index bands.

2.8 Intervention area G: Assessment regimes

G1 Revise rules related to indicative sampling points

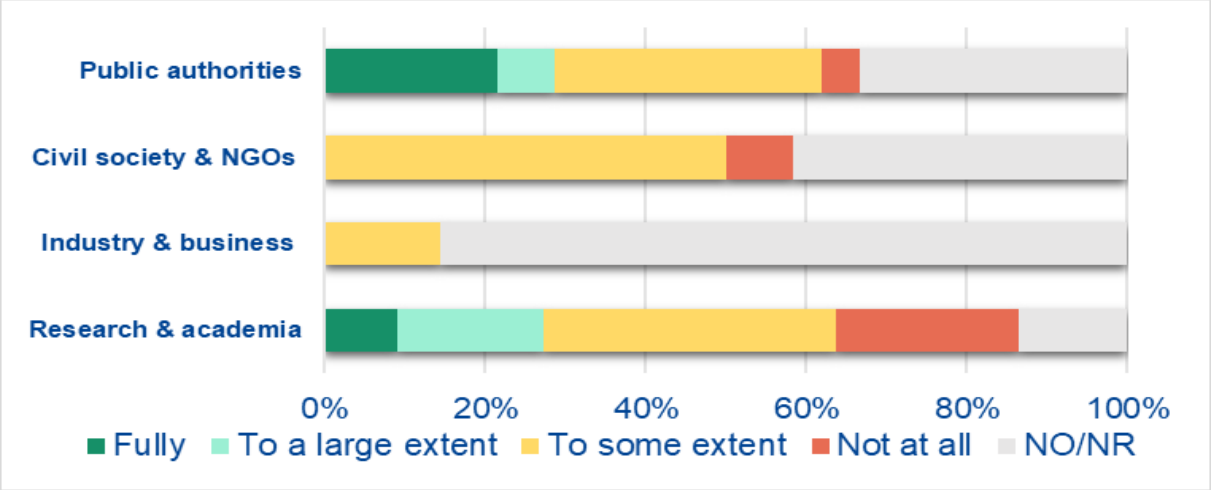
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G1	Revise rules related to indicative sampling points	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 ---	0	**High**	**Policy option III-1**

Focus of measure: Allow / continue to allow the use of indicative monitoring to substitute fixed monitoring as part of air quality assessment.

Description of measure: The use of indicative monitoring could substitute fixed monitoring stations in the air quality assessment process. However, the minimum number of fixed monitoring stations are still required to assess main temporal and spatial trends. Possibilities under which circumstances indicative measurements could substitute fixed monitoring include:

(1) Where there is a need to measure air quality but it is not possible to place a fixed monitoring station that meets the requirements of the Directive;
(2) Where the combination of different measurements (e.g. via data fusion) allows reaching data quality objectives

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: When used to supplement fixed monitoring (not substitute), such as in places where it is not possible to place a fixed monitoring station that meets the requirements of the Directive, additional indicative monitoring contributes to a better overall understanding of the air quality assessment process since additional sampling data is at hand. This contributes to an overall improved air quality assessment process with indirect benefits to air quality, health and ecosystems. However, the substitution of fixed monitoring stations by lower

quality indicative monitoring devices is seen by many stakeholders as a major risk to degrade an important pillar in air quality management. The network of National Air Quality Reference Laboratories (AQUILA), supports making the use of indicative measurements mandatory in areas where the upper assessment threshold is exceeded, supplementing fixed measurements. They should also be used for model validation.[19] Administrative burden is dependent on implementation: where used to supplement fixed monitoring, there would be an increase in costs and administrative burden, whereas substitution of fixed monitoring stations by indicative monitoring would result in cost savings.

G2 Introduce requirements for AQ modelling

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 ---	0	**Medium / High**	**Policy option III-1** and **Policy option III-5**

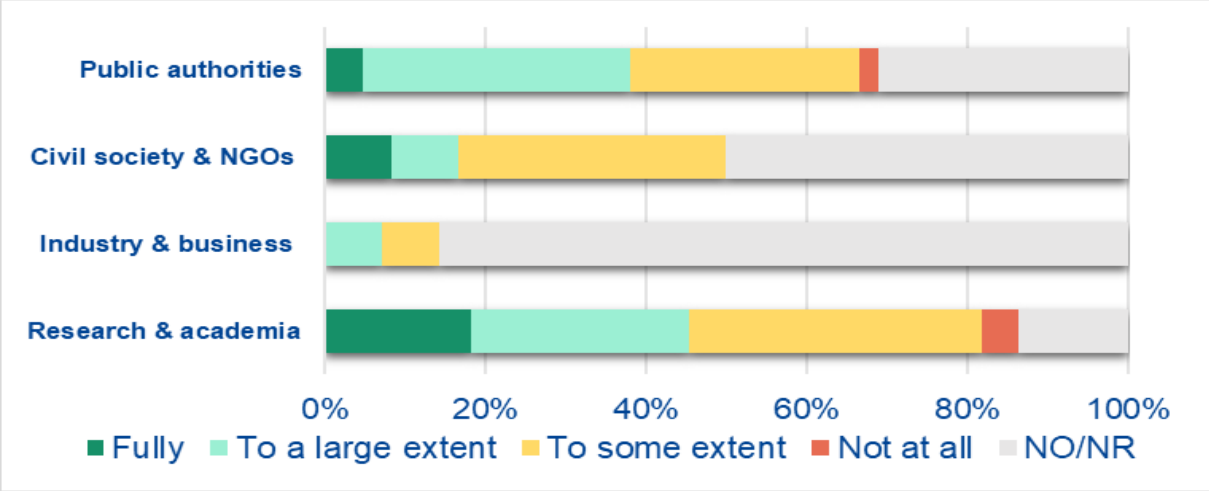
Focus of measure: Make the use of air quality modelling mandatory as part of air quality assessment (in some circumstances).

Description of measure: Modelling techniques can provide valuable information to supplement fixed measurements. Observations from fixed stations are limited to the sampling locations itself whereas modelling systems most often provide air quality maps with a full spatial coverage that can be used to derive specific indicators. Modelling can also help to disentangle the origin of the observed concentrations (source apportionment, long range transport) or extrapolate into the future (short term forecasts, future projections). Several variants exist for this intervention – related to the possible use of air quality modelling:

(1) For short term air quality forecasting (up to a few days ahead);
(2) For assessment of air quality for compliance checking purposes;
(3) For air quality near real time mapping and informing the public;
(4) For evaluation of monitoring network design;
(5) For estimation of population exposure and exceedance situation indicators;
(6) For source apportionment estimations;
(7) For assessment of long-range air pollutant transport;
(8) For future projections in support of air quality management and planning;
(9) As alternative to fixed monitoring (when placing such monitoring in line with the Directive is not possible).

[19] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Air quality modelling improves air quality monitoring and assessment, thus allowing for a better understanding of air quality concentrations, supporting a more effective and more targeted air quality management. The administrative burden may increase for competent authorities (to meet the reporting requirement). The increase is likely to depend on the current modelling capability and practices within each Member State. There are risks for implementation linked to technical capacity and potential lack of modelling guidance and/ or lack of resources for training and capacity building. There is also a risk that Member States may view the introduction of a mandatory requirement of modelling as a reason to reduce their monitoring network. There is strong support across all stakeholder types for the mandatory use of modelling for most of the nine use case variants in at least some instances. Some respondents, however, explained further that modelling should be (strongly) recommended in most of these use cases but only made mandatory for all Member States in one case, i.e. for future projections in support of air quality management and planning. The option of introducing requirements for the use of modelling for compliance checking purposes was the least favoured option among public authorities. The Forum for Air Quality Modelling (FAIRMODE) recommends the use of modelling for assessment purposes, forecasting and public information purposes, source apportionment and planning purposes, making it mandatory for air quality planning, exposure calculations, and short-term forecast.[20]

[20] Thunis P., Janssen S., Wesseling J.,Piersanti A., Pirovano G., Tarrason L., Martin F., S. Lopez-Aparicio, Bessagnet B., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerreiro C., González Ortiz A., Recommendations for the revision of the ambient air quality directives (AAQDs) regarding modelling applications.

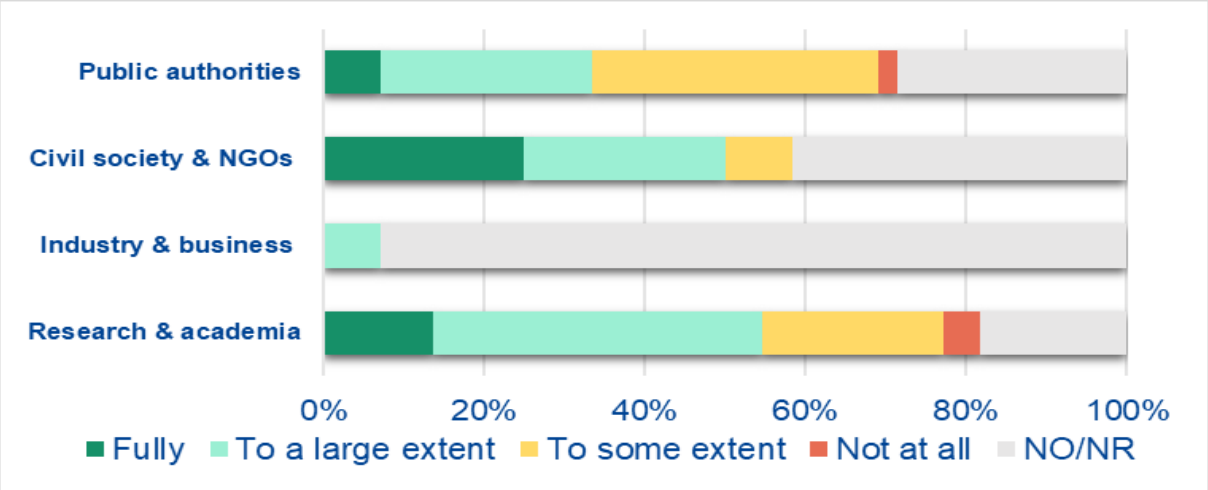
G3 Revise rules for regular review of AQ assessment

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G3	Revise rules for regular review of AQ assessment	0 0 0 0	0 0 0	0 0 0	0 (-)	0	Low	Sub option III-1a

Focus of measure: Require a regular review of the assessment regime following clear criteria defined in the Directive.

Description of measure: Regular review of the assessment regime is expected to ensure that the assessment techniques for air quality evolve with scientific advancements and knowledge. It also allows for improved and increased evidence on air quality including the use of models and more efficient monitoring networks. This would require the amendment of existing articles and Annex II point B to include set criteria. In addition, the interval at which a review should be done was queried with the options of every ten, five, three or one year(s).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention would require Member States to follow set criteria in their reviews of their assessment regime which rely on monitoring and/or modelling data. This would provide a more harmonised review of air quality assessment across Europe leading to a more transparent and coherent view of air quality status for wider public access. All Member States have ready access to fixed term monitoring, and most have modelling capability, so our expert view is that the costs for this intervention are insignificant. Administrative burden may be significant if the period for review is annual (stakeholder respondents favored the retention of five year reviews).

2.9 Intervention area H: Number and typology of sampling points

H1 Revise minimum number of sampling points

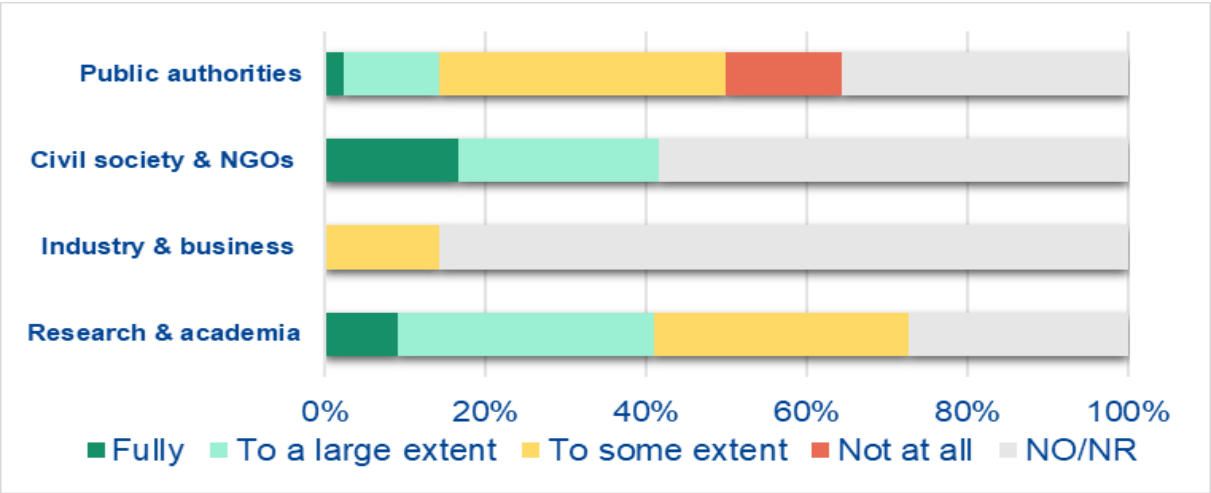
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H1	Revise minimum number of sampling points	+ + + 0	0 0 0	+/- 0 0	0 ---	0	**Medium**	**Policy option III-1**

Focus of measure: Change the minimum number of sampling points that are required per air quality zone.

Description of measure: The minimum number of sampling points per air quality zone for each pollutant should be revised with latest scientific knowledge. Possibilities to which extent would the below specific interventions address the above identified shortcomings include:

(1) Increase the minimum number of sampling points for all pollutants and all zones;
(2) Increase the minimum number of sampling points for some pollutants;
(3) Increase the minimum number of sampling points for some zones;
(4) Decrease the minimum number of sampling points for all pollutants and all zones;
(5) Decrease the minimum number of sampling points for some pollutants;
(6) Decrease the minimum number of sampling points for some zones;
(7) Require a minimum of 2 sampling points per zone per pollutant (i.e. to monitor both hotspots and background concentration levels);
(8) Establish a minimum number in the vicinity of point sources in view of emission densities;
(9) Establish a minimum number of sampling points for measuring pollution hotspots specifically;
(10) Establish a minimum number of sampling points for measuring population exposure.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Changing the minimum number of sampling points required has potential for an increase or decrease in monitoring for the assessment of air quality (a reduction in the minimum number of monitoring stations would be detrimental to air quality, public health, ecosystems and costs to society but lessen administrative burden, while an increase in the minimum number of stations would have a positive impact on air quality, health and ecosystem but increase administrative burden). Costs arising from an increased number of stations would be incurred from greater laboratory analysis, and the additional staff needed for servicing and maintenance and data management. There is little/no support from stakeholders for any decrease in the minimum number of sampling points, while an increase of monitoring stations was favored for at least some pollutants and with a minimum to measure population exposure. The network of National Air Quality Reference Laboratories also favors an increase of sampling points and suggests as well the removal of the possibility to reduce the number of sampling points if fixed measurements are supplemented with indicative measurements.[21] While additional monitoring is associated with high costs, many Member States report monitoring above the current required number of sampling locations, and therefore in practice, an increase in monitoring required is overall beneficial.

H2 Simplify combined $PM_{10}/PM_{2.5}$ monitoring

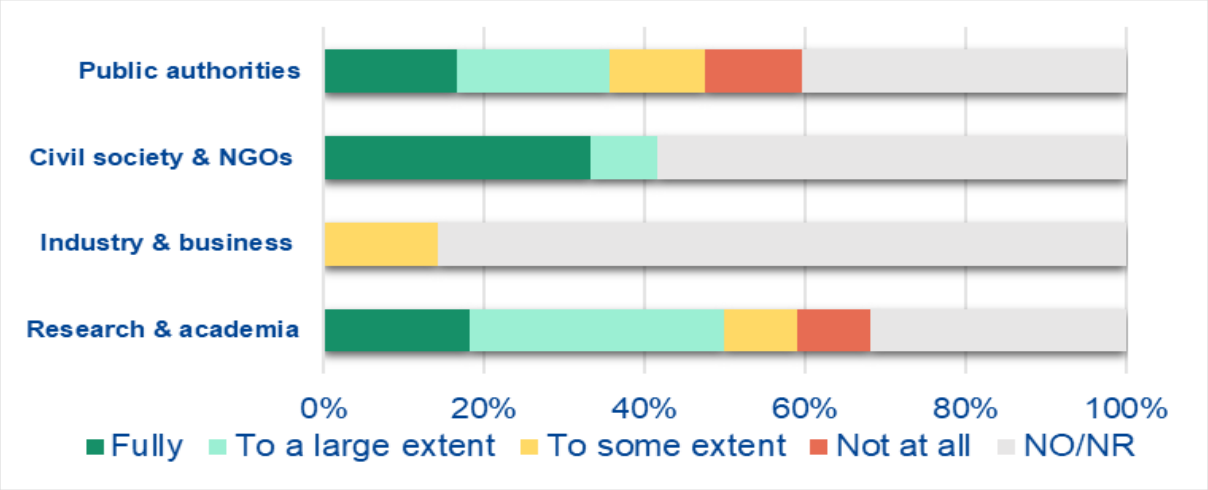
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H2	Simplify combined $PM_{10}/PM_{2.5}$ monitoring	(+) (+) 0 0	0 0 0	(+) 0 0	0 ---	0	**High**	**Policy option III-1**

Focus of measure: The minimum number of sampling points for measuring PM_{10} and $PM_{2.5}$ will be considered independently from each other.

Description of measure: This intervention de-couples of the current minimum number of sampling points for PM_{10} and $PM_{2.5}$, which should be set independently and cannot substitute one another.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.

[21] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.



Summary: This intervention de-couples the current minimum number of sampling points for PM_{10} and $PM_{2.5}$, which should be set independently and cannot substitute one another. $PM_{2.5}$ is a key pollutant for public health risk assessment. Given its important impacts on mortality and morbidity, it is essential for it to be considered and assessed independently from PM_{10}. Clarifying and giving more focus on the assessment of this pollutant in the revised Ambient Air Quality Directive would bring benefit to driving action in areas of exceedance to improve public health protection. Many Member States have already increased their sampling of $PM_{2.5}$ so in practice this intervention is unlikely to involve large costs, though for those Member States who monitor at minimum levels only, costs may be significant as those for new monitoring samplers are often high and comes with on-going maintenance costs. Public Authorities report no real increase in administrative burden to monitor PM_{10} and $PM_{2.5}$ separately. There is a time lag associated with this intervention (to establish the new sites) and this may risk air quality in the short term. Additional staff is needed to support sampler operation and data management.

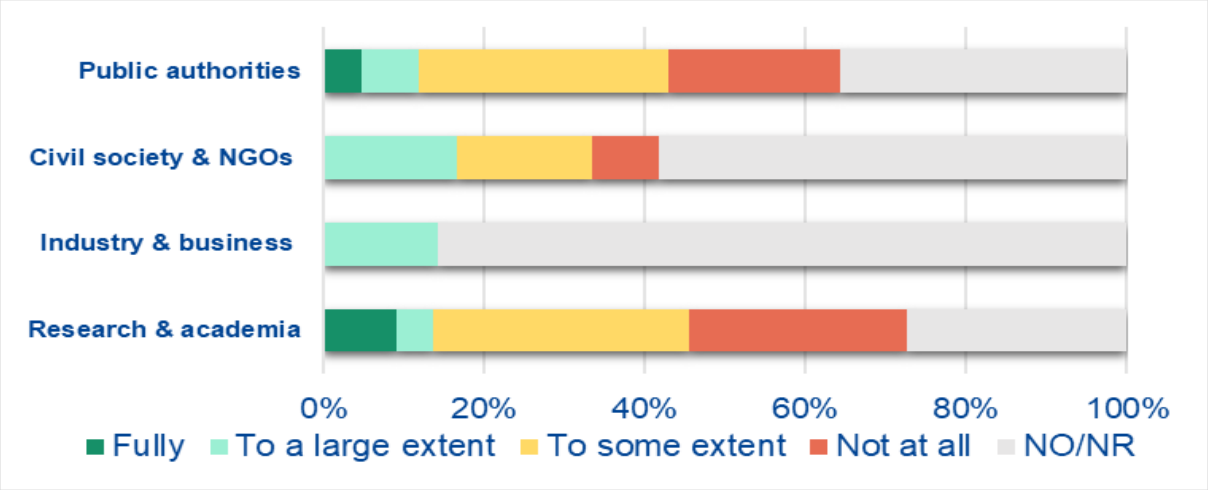
H3 Simplify the definitions of sampling points types

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H3	Simplify the definitions of sampling points types	0 0 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub option III-1b**

Focus of measure: Simplify the definitions of types of monitoring station and/or sampling point locations - and only differentiate for them to distinguish between hotspots or background concentrations.

Description of measure: Currently station classification includes a number of categories such as urban, suburban, rural, industrial, roadside etc. station classification could be simplified to identify sites as hotspots or background locations.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Currently station classification includes a number of categories such as urban, suburban, rural, industrial, traffic, background. Station classification could be simplified to identify sites only as hotspots or background locations. This may enable identifying a key source of pollution currently missing in the classification which is that due to residential combustion. As this intervention is a desk task to reclassify the current sites it is unlikely to have any real impact on administrative burden. To be effectively implemented, this intervention would require guidance. However, a more simplified classification risks loss of clarity and misunderstanding on the site differences and the main sources of pollution. The full reporting of site meta data under the IPR[22] and e-reporting by all Member States and clarification of terms further in the Ambient Air Quality Directive could greatly help to address this shortcoming.

[22] COM (2013), IPR Guidance part I and Part II (accessed 10.06.2022)

2.10 Intervention area I: Continuity of sampling points

I1 Introduce obligations to maintain sampling points

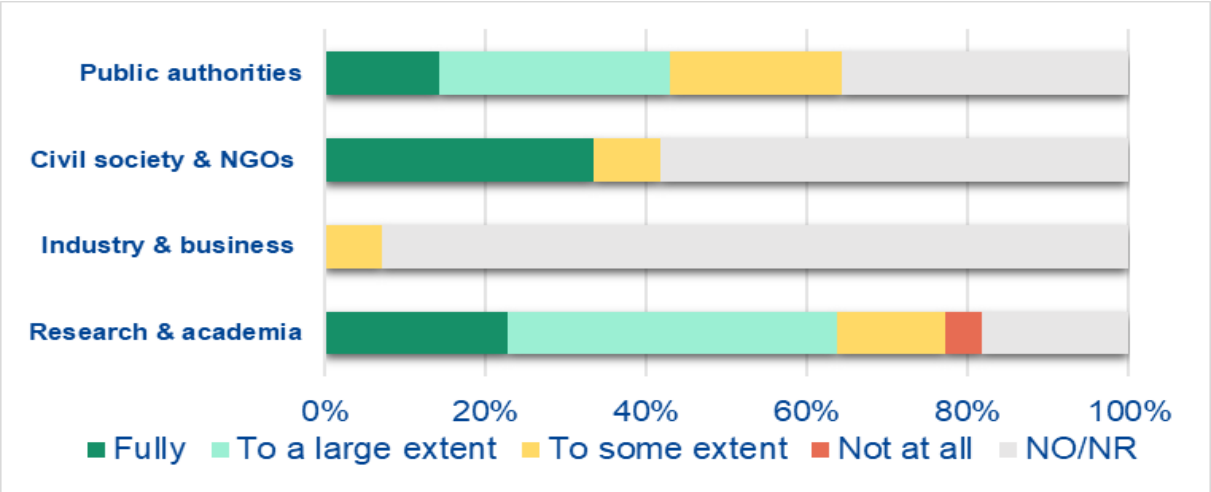
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I1	Introduce obligations to maintain sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 0	0	High	Policy option III-2

Focus: Specify that sampling points with exceedances of limit values for any of the pollutants measured under the Ambient Air Quality Directives should be maintained for a defined number of years.

Description of measure: Flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated (except for PM_{10} if exceeding limit values), but this disrupts trend analysis and causes uncertainty in areas of exceedance. This intervention would prevent sampling point closure within a defined number of years following site establishment. Possibilities under which circumstances can relocations of sampling points take place include:

(1) Due to requirements of local spatial development;
(2) If and when siting criteria are no longer met (macro-scale siting or micro-scale siting);
(3) If overlap between monitoring at 'old' and 'new' sampling point is guaranteed and reported (for a defined time period ensure monitoring at both locations to assure calibration)

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Providing clarity on the circumstances when sampling points may be relocated would reduce flexibility to close stations but allow for increased datasets for pollutant trend analysis. Requiring a set timeframe for the operation and maintenance of sampling points with exceedances of limit values for any of the pollutants under the Ambient Air Quality

Directives would result in better datasets for assessment and trend analysis. This would in most cases be a prerequisite for more effective and more targeted air quality management.

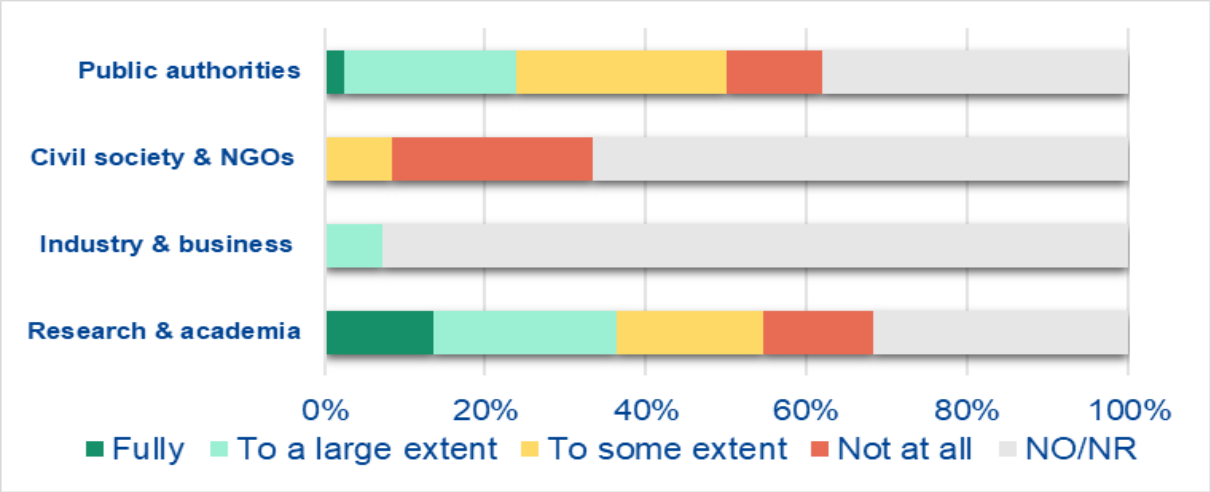
I2 Introduce obligations to monitor long-term trends

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I2	Introduce obligations to monitor long-term trends	(+) (+) (+) 0	0 0 0	0 0 0	0 (-)	0	**Low**	**Sub-option III-2a**

Focus of measure: Include the requirement to monitor long-term trends if fixed monitoring stations are discontinued (by assessing air quality via indicative measurements or air quality modelling), to not disrupt trend analysis.

Description of measure: Currently, flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated, but this disrupts trend analysis. Under the circumstances where stations are discontinued a requirement could be introduced to continue to monitor for long-term trends using indicative measurements or modelling.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Including a requirement to monitor long-term trend in the cases of relocation of fixed monitoring stations would allow for increased datasets for pollutant trend analysis. Assessing long-term trends in pollution data is important for the assessment and management of air quality. There is significant benefit to scientific understanding and policy development to protect health and the environment to have access to a long-established network of monitors. Costs for this intervention depend on the variant. Administrative burden and costs of monitoring could increase as the amount of fixed monitoring stations would remain the same, but it may be required to increase indicative measurements at all previous fixed measurement locations for long-term trend monitoring and analysis. However, where fixed monitoring stations could be replaced by indicative monitoring or modelling a cost saving is likely. For this intervention to be successful, it is important to align with those proposed interventions with the objective of improving quality of indicative monitoring and modelling.

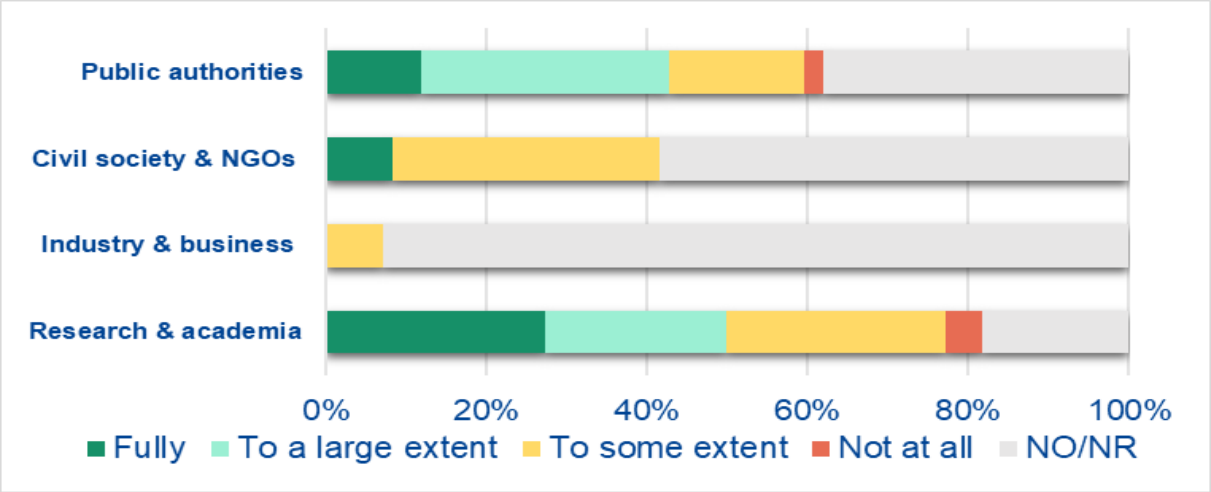
I3 Introduce a protocol for relocated sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I3	Introduce a protocol for relocated sampling points	(+) 0 0 0	(+) 0 0	0 0 0	0 -	0	**Medium**	**Policy option III-2**

Focus of measure: Establish a protocol to follow should a sampling point have to be re-located due to, for example, infrastructure development or changes in the assessment regimes.

Description of measure: Currently, flexibilities in the Ambient Air Quality Directives enable monitoring sites to close or be relocated, but this disrupts trend analysis. Whenever the circumstances of station discontinuation or sampling point relocation due to infrastructure development or changes in the assessment regime arise, a protocol establishing the requirements for such change should serve as guidance.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: A protocol could include an assessment of site representativeness, co-location of monitoring for a minimum time period, to assist in the assessment of data quality for trend analysis from the old and new sampling points and hence increase robustness and transparency especially when areas are in exceedance. This intervention, while helpful for greater assessment harmonisation is likely to have little impact on air quality and other indicators. The costs for this intervention are low. Although, reduced flexibility to relocate samplers when necessary, it may risk increased administration burden on Member States to find an alternative monitoring location.

2.11 Intervention area J: Siting of sampling points

J1 Revise macro-scale siting of sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J1	Revise macro-scale siting of sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 --	0	**Medium**	**Policy option III-4**

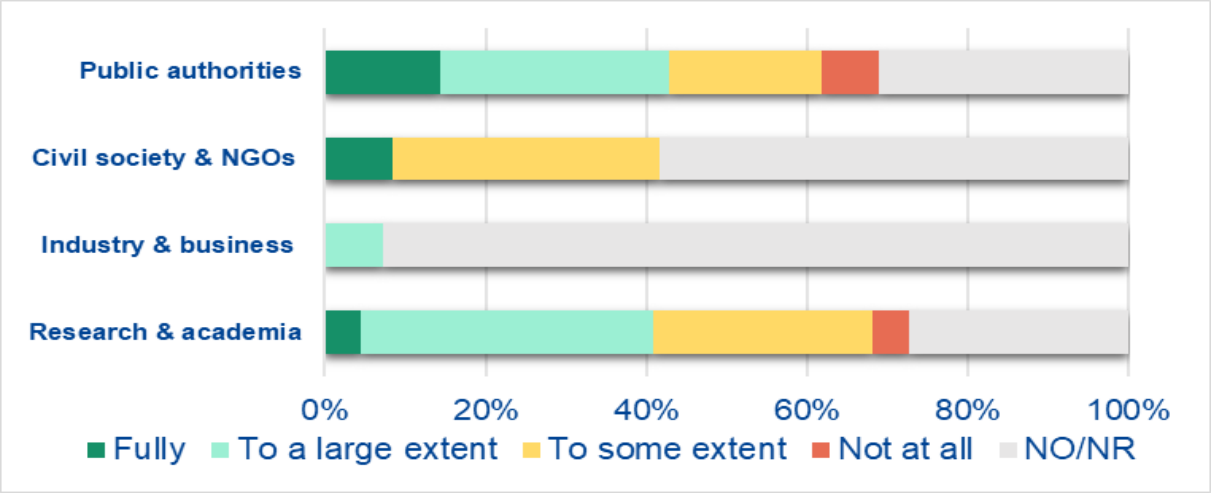
Focus of measure: Further clarify (and reduce flexibilities related to) the macro-siting criteria for sampling points.

Description of measure: The siting of sampling points can have a significant impact on the levels of air pollutants that are measured. In this intervention the macro-siting criteria for sampling points are clarified and flexibilities in the interpretation are further reduced.

This intervention has the following variants:

(1) Harmonise the macro-scale siting criteria laid down in Annex III and Annex VIII of Directive 2008/50/EC and Annex III of Directive 2004/107/EC – aligning with 2008/50/EC provisions;
(2) Clarify whether macro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements;
(3) Clarify whether specific locations should be explicitly excluded, even if there is public access to these (such as outdoor parking lots, train station platforms or street-facing café terraces).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The siting criteria are open for interpretation and not implementing the intervention could compromise the harmonisation and comparability of air quality measurement data within the EU. Inconsistencies can impact on the number of monitoring

stations, the number and extent of exceedances identified, the need for measures to improve air quality, and the costs associated with these activities. This could also lead to issues of inequality and fairness in the implementation of the requirements and affect the proportionality of any potential infringement action. This intervention would increase the administrative burden for competent authorities in terms of sampling point evaluation and reporting of the relevant indicators. Most stakeholders support the implementation of this intervention since it will increase the comparability and harmonisation of air quality data over Europe. However, the same stakeholders indicate that some flexibility is still required in order to deal with practical selection and installation of sampling points. The variant with more support across stakeholders was the one clarifying whether macro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements.

J2 Revise micro-scale siting of sampling points

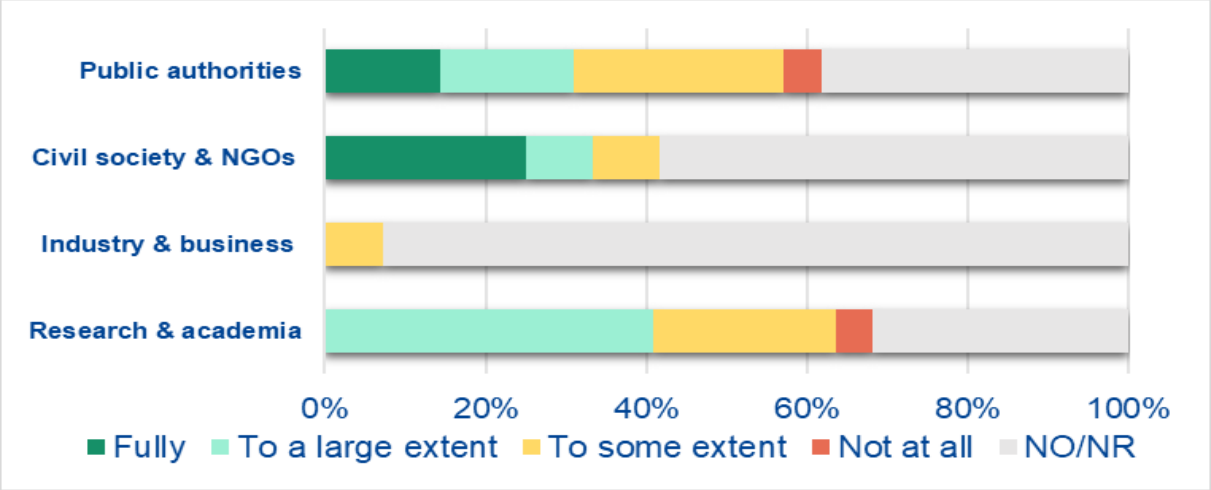
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J2	Revise micro-scale siting of sampling points	(+) 0 0 0	(+) 0 0	(+) 0 0	0 --	0	**Medium**	**Policy option III-4**

Focus of measure: Further clarify (and reduce flexibilities related to) the micro-siting criteria for sampling points.

Description of measure: This intervention has the following variants:

(1) Harmonise the micro-scale siting criteria laid down in Annex III and Annex VIII of Directive 2008/50/EC and Annex III of Directive 2004/107/EC – aligning with 2008/50/EC provisions;
(2) Clarify whether micro-scale siting criteria are applicable to sampling points for indicative measurements in addition to sampling points for fixed measurements;
(3) Clarify the flexibility related the unrestricted flow around the inlet of sampling points.
(4) Clarify the flexibility related to the height of the inlet of sampling points;
(5) Clarify the flexibility related to the distance to the kerbside (or other metrics) of traffic-oriented sampling points.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revisions to micro-siting criteria which also apply to indicative monitoring may have an indirect benefit to society costs due to an indirect improvement on public health. Where new indicative monitoring is being planned this intervention may give access to a higher quality monitoring dataset to assist air quality assessment, underpinning air quality action. There is a low administrative burden, unless the intervention leads to the disqualification of existing sites (in which case the administrative burden would be high). Costs are relatively low, particularly if this intervention does not result in the disqualification of established long-term sampling locations. The mostly favoured sub variant refers to the clarification regarding the flexibility related to the distance to the kerbside (or other metrics) of traffic-oriented sampling points. In this sense, the most concern raised by stakeholders was on the micro-siting criteria for sampling points is related to traffic sites, particularly in urban areas. However, these are complex environments with pollution concentrations varying in small micro-environments. Some level of flexibility is needed to local monitoring network managers to ensure monitoring effectiveness and efficiency.

J3 Introduce obligation for spatial representativeness

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J3	Introduce obligation for spatial representativeness	(+) (+) (+) 0	(+) 0 0	(+) 0 0	0 ---	0	**Medium**	**Sub option III-3d**

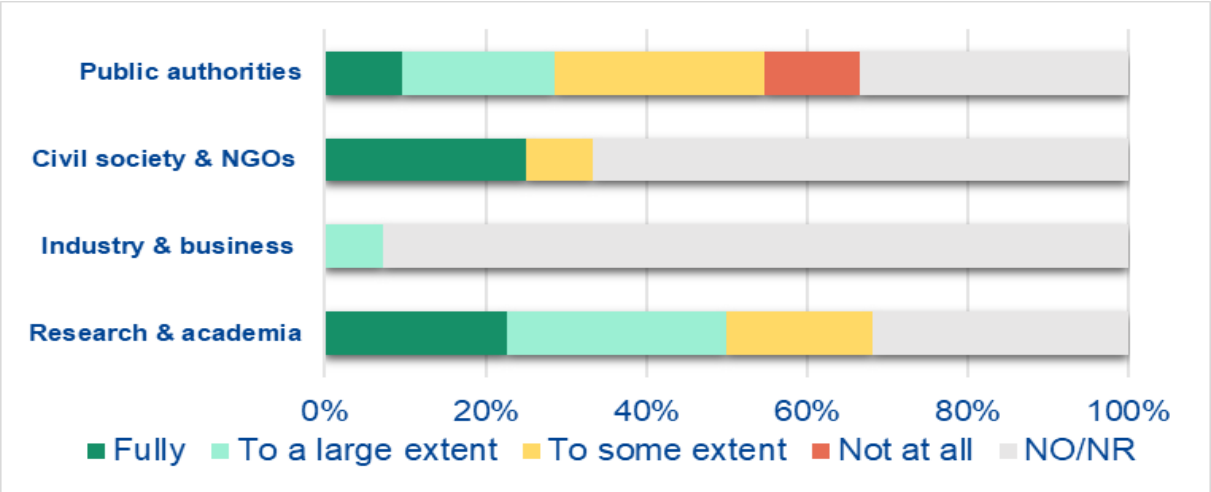
Focus of measure: Introduce the concept of a spatial representative area which should be estimated (and reported) for each sampling point (irrespective of exceedances being measured or not).

Description of measure: For every sampling location, a spatial representativeness (SR) area should be estimated and reported. This area of representativeness is an essential indicator of the sampling location. A Tiered approach is available to assess SR of monitoring sites:

- Tier 1: assessment based on expert judgement;
- Tier 2: assessment based on proxy data or indicative measurement campaigns;
- Tier 3: assessment based on fit-for-purpose modelling;

- Tier 4: assessment based on combination of modelling and indicative monitoring.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The concept of an SR area helps to clarify and harmonize air quality assessment based on monitoring data. It serves multiple purposes in this process: assessment of population exposure and exceedance situation indicators based on the monitoring data, monitoring network design and selection of stations for model validation and data assimilation. When modelling capacity is available higher Tier methods are rather straightforward to apply. Stakeholders indicate that there is a clear need for better definition for spatial representativeness and it would be useful to introduce this concept to the Ambient Air Quality Directives in order to ensure comparability between Member States.

2.12 Intervention area K: Data quality

K1 Revise AQ monitoring data quality objectives

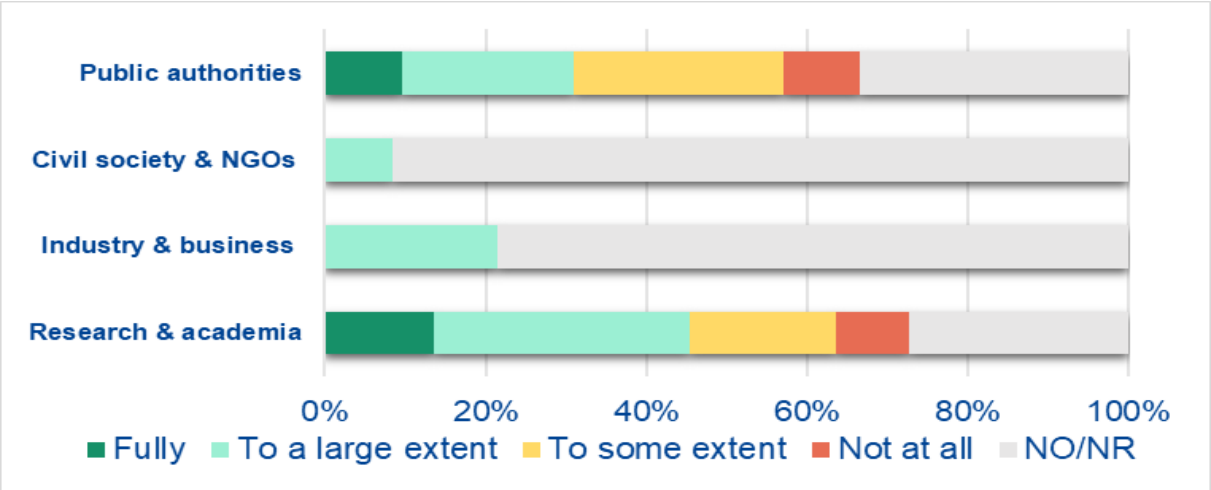
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K1	Revise AQ monitoring data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	**Medium**	**Policy option III-4**

Focus of measure: Further define the data quality requirements for sampling points / measurements used for air quality assessments.

Description of measure: To further define data quality including measurement uncertainty and data capture. Variants for this intervention include:

(1) Further align data aggregation requirements to be met for specific periods (e.g. hourly, daily, 8-hour or annual) or the whole year;
(2) Further align the data coverage (time coverage and data capture) requirements for all air pollutants;
(3) For ozone, align data coverage requirements for both for the full calendar year and for the period of April to September, as well as for the AOT40 indicator;
(4) For indicative measurements, set separate data coverage requirements for annual mean values and for short-term mean values;
(5) For calibration and validation of air quality modelling, introduce specific data quality requirements for sampling points / measurements (that are less strict than those used for air quality assessments).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: To make the full use of available data a protocol/guidance specifying appropriate methods for assessing compliance and estimating statistical parameters to account for low data coverage or significant data losses should be published. This intervention would improve data quality requirements for sampling points which is likely to increase robustness of data

and may supplement evidence for trend analysis and modelling. This may lead to indirect improvements in air quality, health and ecosystems which may indirectly reduce costs to society as clarity is provided over the use of data. The costs for this are low or may even be a cost saving as administrative burden may reduce as modelling is likely to cost less than additional fixed or indicative measurements. The most favoured sub variant across all stakeholders was that introducing specific data quality requirements for sampling points / measurements. The network of National Air Quality Reference Laboratories also strongly favours a revision of data quality objectives.[23]

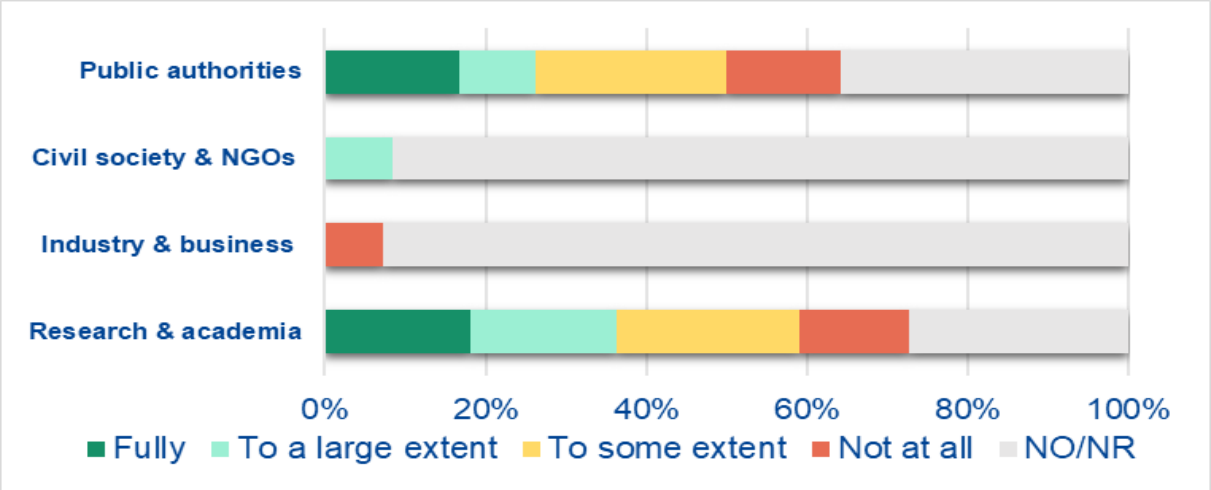
K2 Introduce up-to-date data at all sampling points

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 --	0	**Low**	**Sub option III-1c** and **Policy option IV-1**

Focus of measure: Make it mandatory to provide up-to-date information on the pollutant concentration for certain air pollutants for a minimum number of sampling points per air quality zone.

Description of measure: There exists some ambiguity around the provision of up-to-date information from air quality assessment. Access to up-to-date air quality information is important for public communication on air quality. However, it is not clear what `up-to-date' means nor is it is not possible to produce real time information with the reference method for particulate matter. In addition, technical guidance could be provided for how to produce this type of data when using the reference method for particulate matter.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



[23] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

Summary: This intervention would increase the harmonisation of the reporting of real-time air quality information, which during pollution episodic events, and for forecasters brings benefit to the public. Costs are low and those Member States already publishing real time data are unlikely to be impacted. There are risks to implementation in cases of monitoring sampler or IT system failure as this would inhibit publication of air quality data in real-time. Increased resources may be needed for some Member States to ensure immediate data quality.

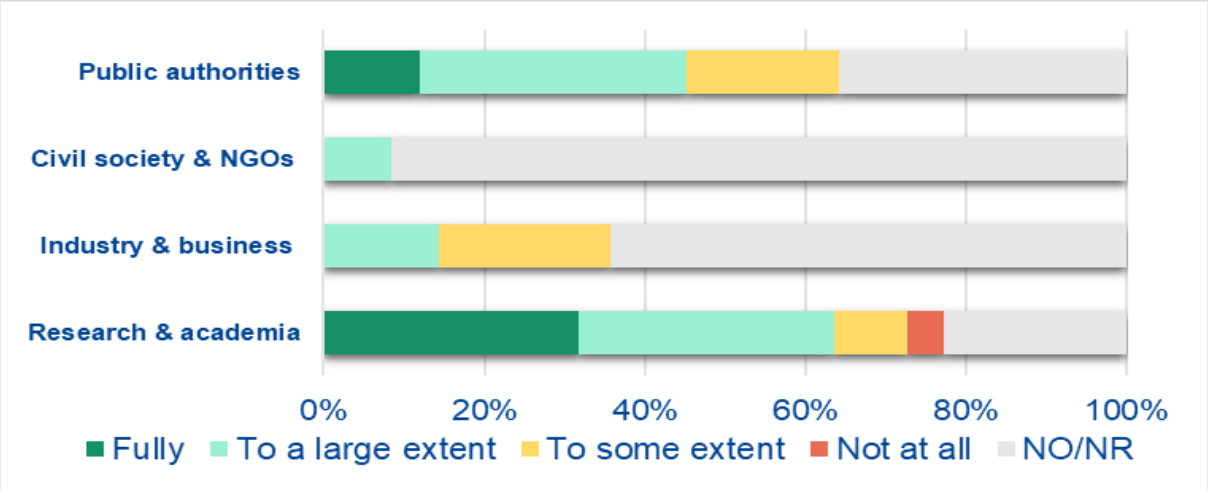
K3 Introduce AQ modelling data quality objectives

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K3	Introduce AQ modelling data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	**High**	**Policy option III-5**

Focus of measure: Introduce a standardized 'modelling quality objective' as a quality control mechanism to assess whether a modelling based assessment is fit-for-purpose.

Description of measure: Any modelling application used in support of the implementation of the Ambient Air Quality Directives should be of sufficient quality and be fit-for-purpose. This intervention is introducing a standardized Modelling Quality Objective (MQO) that should be met in the validation and QA/QC processes of modelling systems. FAIRMODE has proposed such a MQO which is currently under evaluation for becoming a CEN standard.[24]

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



[24] Thunis P., Janssen S., Wesseling J.,Piersanti A., Pirovano G., Tarrason L., Martin F., S. Lopez-Aparicio, Bessagnet B., Guevara M., Monteiro A., Clappier A., Pisoni E., Guerreiro C., González Ortiz A., Recommendations for the revision of the ambient air quality directives (AAQDs) regarding modelling applications.

Summary: Modelling Quality Objective (MQO) would need to be met in the validation and QA/QC processes of modelling systems. FAIRMODE has proposed such a MQO which is currently under evaluation for becoming a CEN standard. High quality modelling applications will contribute to better air quality assessment and planning process. This results in high quality information for the public at large, better source allocation and source identification and eventually better air quality planning. There would be a small administrative burden as some of the modelling systems would have to be upgraded to meet the quality standards.

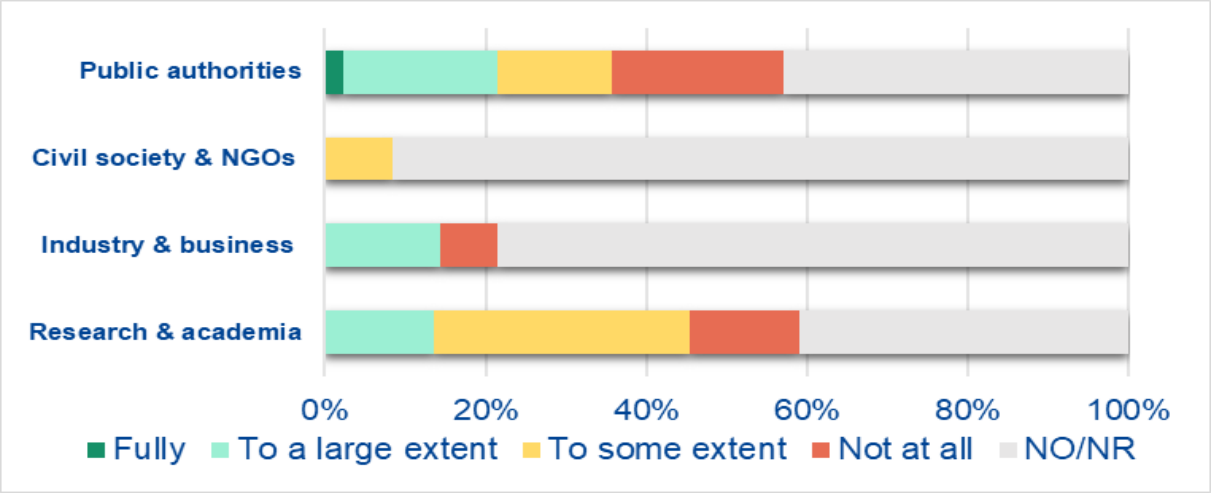
K4 Revise approach to AQ assessment uncertainty

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K4	Revise approach to AQ assessment uncertainty	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	**Medium**	**Sub option III-4a**

Focus of measure: Modify the definition of measurement uncertainty by defining it in absolute values and not in percentage values (or a combination of both).

Description of measure: Clarification in the definition of measurement uncertainty by establishing these both in absolute values and percentage values, and changes to threshold levels to be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revised monitoring uncertainty and how this is designed, particularly important particularly when air quality standards are low, could improve the quality of measurement data leading to overall improved air quality and reducing health and ecosystem impacts. While it is unlikely to bring significant benefits to air quality management it is an important aspect to clarify. Changes in the calculation for uncertainty may have a negative impact on

existing long-established monitoring datasets should it not comply with uncertainty standards. This would negatively impact data quality and overall assessment of pollutant levels for those in non-compliance. Overall, stakeholders saw benefit in combining uncertainty in both absolute and percentage terms.

2.13 Intervention area L: Additional pollutants

L1 Introduce concept of monitoring at 'super-sites'

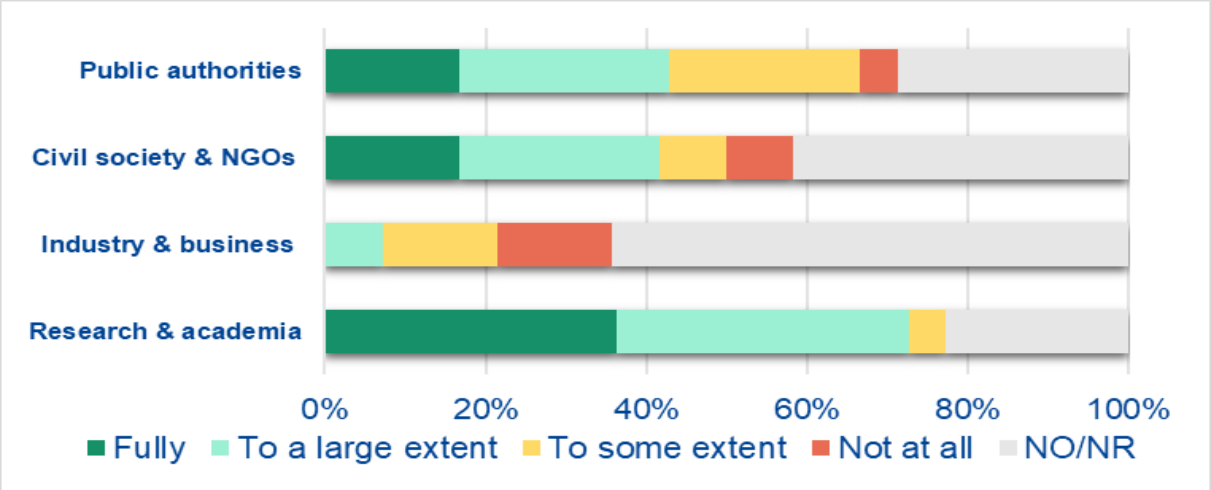
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 ---	0	**Medium**	**Policy option III-1** and **Policy option III-3**

Focus of measure: Require monitoring stations that measure continuously certain emerging air pollutants (e.g. called "supersites" across the Member States).[25]

Description of measure: Specify a minimum number of monitoring stations that should monitor emerging pollutants (supersites) together with site type. Possibilities for what specific considerations should guide the establishment of such "supersites" include:

(1) Establishment of the number of supersites should be guided by potential exposure;
(2) Supersites should be located at which locations, urban, rural etc.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Further establishment of supersites across Europe, particularly for observing emerging pollutant trends would bring large benefit for their future assessment and control.

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

Most benefit would be gained if these sites were established at both urban and rural locations. Monitoring is very costly and there is a significant administrative burden (for capital and maintenance costs as well as more staff and training needs), however some Member States already count with a supersite network in operation.

L2 Introduce obligations to monitor more pollutants

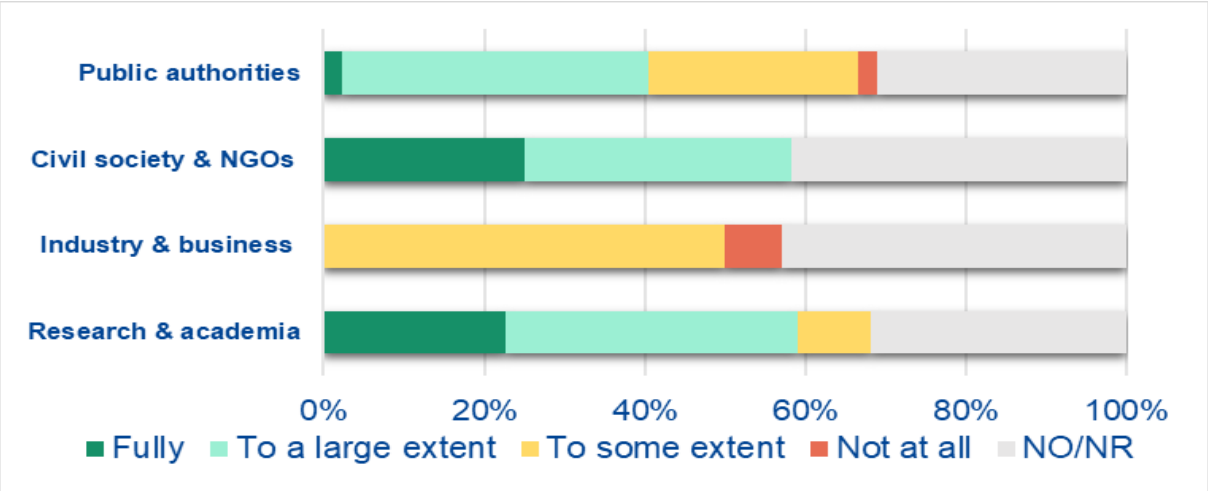
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L2	Introduce obligations to monitor more pollutants	(+) (+) (+) (+)	0 0 0	(+) 0 0	0 ---	0	**High**	**Policy option III-3**

Focus of measure: Require monitoring of additional air pollutants at a minimum number of sampling points and with relevant data quality requirements.

Description of measure: Requirements for the monitoring of additional pollutants, possibilities for which additional air pollutants should be monitored[26], and which include:

(1) Ultrafine particles;
(2) Ammonia;
(3) Fine combustion particles;
(4) Oxidative potential;
(5) Additional heavy metals;
(6) Hydrogen sulphide (H_2S) and other reduced sulphur compounds (TRS);
(7) Nitro-PAHs;
(8) Pesticides.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



[26] Suggested as such also by the network of National Air Quality Reference Laboratories under their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

Summary: Possibilities for additional air pollutants to be monitored include: ultrafine particles, ammonia, fine combustion particles, oxidative potential, additional heavy metals, hydrogen sulphide (H_2S) and other reduced sulphur compounds (TRS), nitro-pahs and pesticides. Monitoring of pollutants of emerging concern is essential to advance our understanding of current pollution loads, but also to assess source apportionment and underpin modelling to assess future projected levels. This intervention would facilitate research on these emerging pollutants and support epidemiological studies of pollutants of most concern to health. Monitoring of air pollution is costly, and even more so for pollutants which are not widely monitored. Administrative burden would be high, and likely to include capacity building to train site operators. For ammonia, monitoring would benefit from coordination with monitoring efforts under the National Emission reduction Commitments Directive[27], not least to minimise administrative burden, and a focus on locations where ammonia concentrations could particularly impact ecosystems. Monitoring of pollutants of emerging concern would be essential to setting standards for additional pollutants and the setting up of a priority watch list (links with Policy Area 1 and intervention Ø1 and Policy Area 2 and intervention A4).

L3 Revise list of VOC to monitor

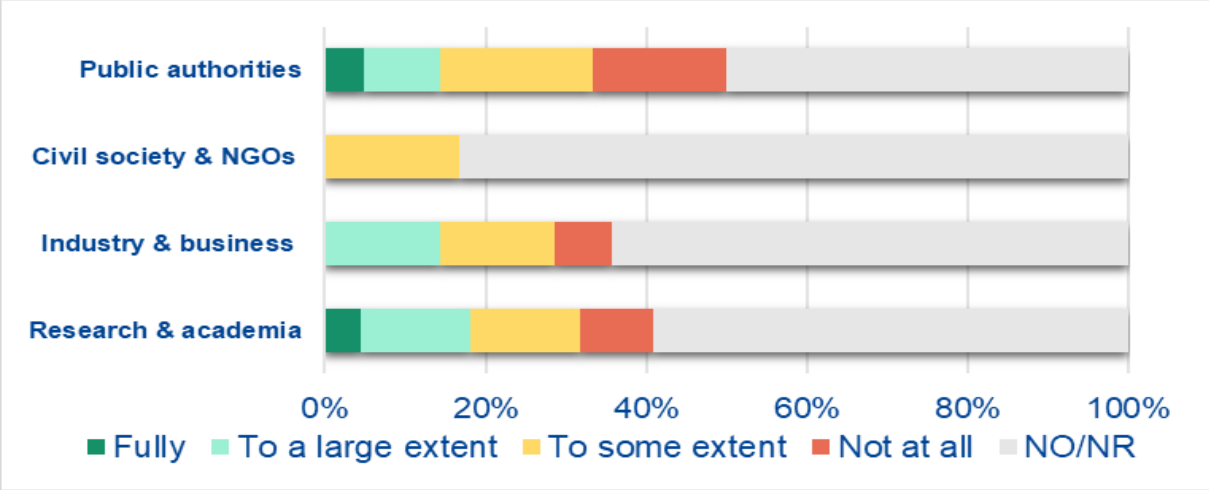
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L3	Revise list of VOC to monitor	(+) (+) (+) 0	0 0 0	0 0 0	0 ---	0	**Low**	**Policy option III-3a**

Focus of measure: Expand the list of required and/or recommended volatile organic compounds (VOCs) to measure.

Description of measure: Additional VOCs to be monitored should be specified together with monitoring methods, data quality objectives and minimum number and siting requirements and reporting of data.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.

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



Summary: Further elaboration of VOC monitoring is necessary to develop scientific knowledge to support emission control, though costs are high (for new analysers to measure more VOCs, and additional resources that may be needed to service and maintain sites, and manage and report data). The network of National Air Quality Reference Laboratories recommends the measurement of appropriate volatile organic compounds suggesting a list of 45 possible substances. Which specifically should be measured would depend on the objective sought.[28] However, the merit of monitoring more (or other) VOCs in addition to those regularly monitored is unclear. Further monitoring should be accompanied by data quality and siting specifications with appropriate guidance).

[28] As expressed in their internal Working Group document on suggestions for the Revision of the Ambient Air Quality Directives of December 2021.

2.14 Intervention area M: Transboundary air pollution

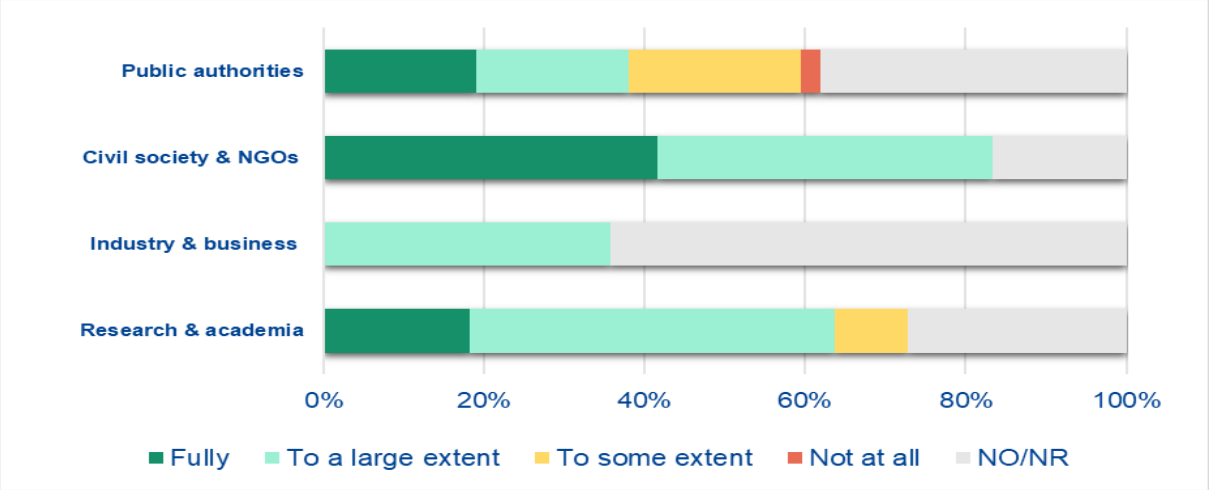
M1 Introduce methodology to assess transboundary

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M1	Introduce methodology to assess transboundary	(+) (+) (+) (+)	0 0 0	0 0/(+) 0	0/(+) -	(+)	**High**	**Policy option II-5**

Focus of measure: Require the use of an agreed methodology when assessing transboundary air pollution/contributions to local/regional air pollution.

Description of measure: Member States face intra-EU transboundary air pollution as well as air pollution from non-EU countries. Currently Article 25 of the 2008/50/EC Directive states that Member States concerned with transboundary air pollution 'shall' cooperate to mitigate air pollution (for instance through drawing joint or coordinated air quality plans). The Fitness Check findings highlight that the lack of coordination is likely to affect the understanding of which measures may prove most useful and effective. By offering a common methodology to assess transboundary air pollution, such coordination can be enhanced.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure aims to facilitate and harmonise the used methodology when assessing transboundary air pollution/contributions to local/regional air pollution. The effectiveness of this intervention to improve air quality is impacted by the willingness of Member States to implement mitigation measures within a joint air quality plan. Implementing this intervention would imply additional costs for Member States who must align their methodology to assess transboundary air pollution. A challenge for implementation is that it may be unclear where the responsibility lies for transboundary air

pollution assessment and action. In addition, assessment expertise is needed to conduct the modelling and there is a risk of limited expertise at local level.

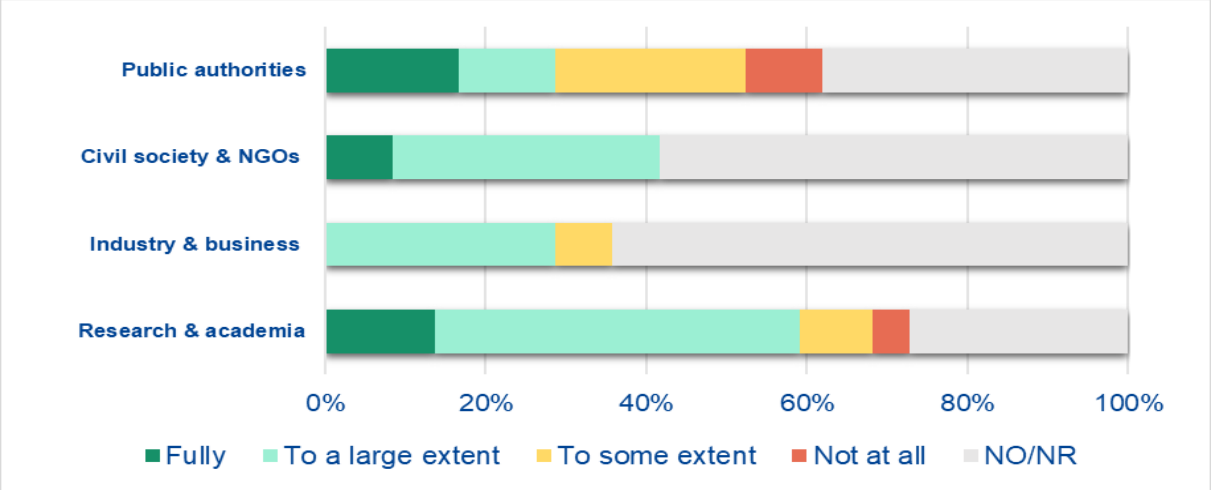
M2 Revise obligations for transboundary cooperation

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M2	Revise obligations for transboundary cooperation	(+) (+) (+) (+)	0 0 0	(+) - 0	- -	(+)	**Medium**	**Policy option II-5**

Focus of measure: Require transboundary cooperation and joint action on air quality if assessments of transboundary air pollution/contributions above certain thresholds (to be defined).

Description of measure: Under this policy measure, the Ambient Air Quality Directives would require EU Member States at bordering countries to engage in joint action on air quality with neighbouring non-EU countries in cases where air pollution reaches a certain threshold. Member States face intra-EU transboundary air pollution (as well as pollution coming from non-EU countries) which cannot be reduced by one country alone. Article 25 of the 2008/50/EC Directive states that Member States concerned with transboundary pollution 'shall' cooperate to mitigate air pollution for instance through drawing joint or coordinated air quality plans. However, such action is currently voluntary and the provision does not specify above which thresholds Member States should seek this cooperation which, in practice, results in lack of cooperation.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Requiring joint transboundary cooperation above a specific threshold would foster transboundary cooperation and in turn improve air quality in bordering regions, and benefit health and ecosystems in these areas. Implementing this intervention would imply additional costs for competent authorities especially in bordering countries were transboundary air pollution is an issue. Implementation challenges include enforcement (where one Member State cannot enforce action in another), lack of funds at local/regional

authority level and acceptability of authorities and industry to implement measures to bring air improvements elsewhere.

2.15 Intervention area N: Information in air quality plans

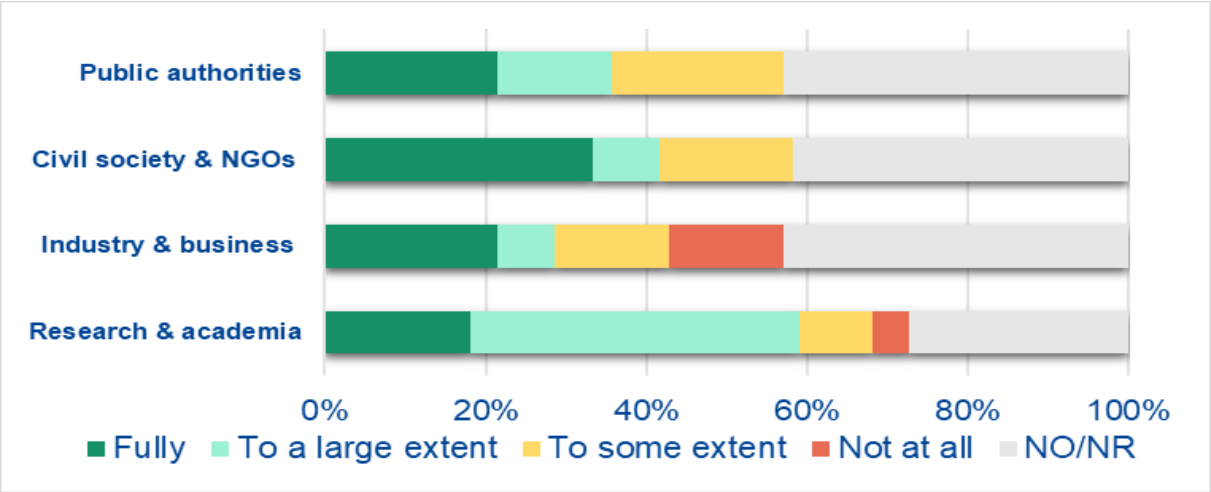
N1 Revise the information in air quality plans

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
N1	Revise the information in air quality plans	++ + + (+)	(+) 0 0	(+) - 0	- --	+	**High**	**Policy option II-1**

Focus of measure: Refine the minimum information to be included in an air quality plan.

Description of measure: This intervention refines the minimum information that is requested in an air quality plan. The current Ambient Air Quality Directive (2008/50/EC) includes in Annex XV a list of elements that need to be provided in an air quality plan. However, the current requirements lack information and is therefore not appropriate to evaluate the overall quality and eventual impact, effectiveness and efficiency of the air quality plan.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: It is expected that this intervention would provide an improved framework for air quality planning which gives rise to better air quality plans and eventually an improved air quality. Additional administrative burden expected to setup of a comprehensive and adequate air quality plan requires more resources for more in-depth analysis and more governance amongst various stakeholders involved in the planning process.

2.16 Intervention area O: EU air quality standards for particulate matter ($PM_{2.5}$)

O1 Revise standards for annual $PM_{2.5}$

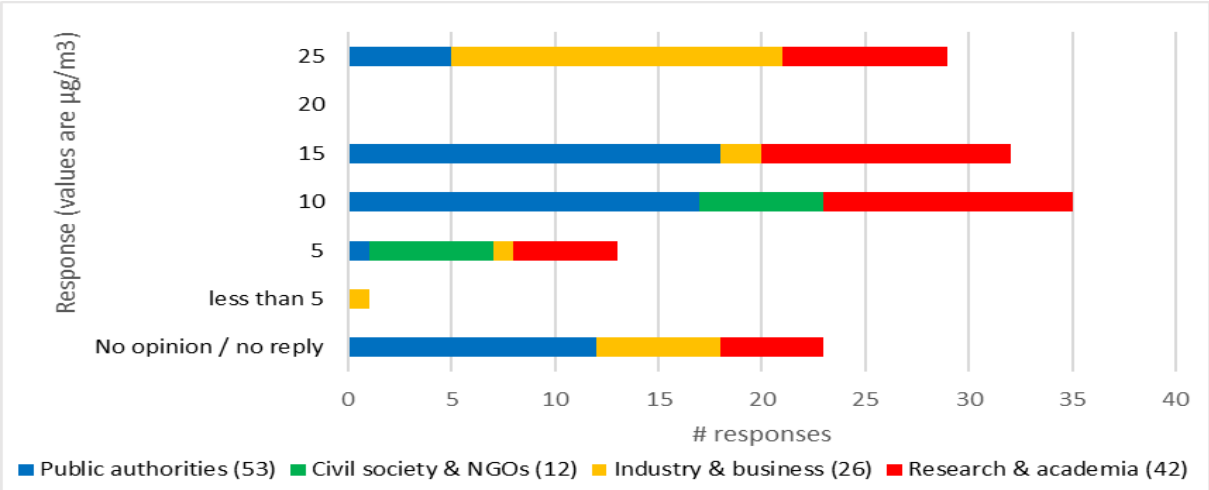
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O1	Revise standards for annual PM2.5 : **5 µg/m³**	+++ +++ +++ +++	+++ +/- +	+++ --- +	--- ---	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
O1	Revise standards for annual PM2.5 : **10 µg/m³**	++ ++ ++ ++	++ +/- +	++ -- +	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
O1	Revise standards for annual PM2.5 : **15 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of $PM_{2.5}$

Description of measure: The current Ambient Air Quality Directives standards for annual $PM_{2.5}$ set an annual average limit value of 25 µg/m³. The WHO Air Quality Guidelines are set at 5 µg/m³, alongside higher interim targets. This intervention explores the alignment of the EU long-term standard limit values for $PM_{2.5}$ with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. A sample of variants has been selected for the modelling in distinct 5 µg/m³ steps. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: A sample of variants has been selected for the modelling in distinct 5 µg steps: The modelling performed suggests that by 2030, there will be broad compliance with both a 20 and 15 µg/m^3 target, with around 400 000 people living in areas of exceedance for the 15 µg/m^3 target. More ambitious standards can achieve greater improvements in air quality, with corresponding benefits for health and ecosystems. Administrative burden will also scale with ambition (impacting Member State competent authorities) as the more ambitious the standard, the more new zones will be identified as requiring measures to avoid exceedances. Similarly, mitigation/adjustment costs increase with ambition. The costs of such action are uncertain and depend on the starting point for each one, but these could imply significant change in behaviour at local or national level. As the level of ambition increases, the cost of mitigation/adjustment measures will increase on a non-linear basis. Specific to $PM_{2.5}$ is the fact that this pollutant may be emitted directly by natural sources. It is also a transboundary pollutant. The extent to which standards can address these issues is uncertain. Stakeholders firmly recognise the value of an annual average standard for $PM_{2.5}$, which applies as a limit value to all territories in the EU, but opinions vary on what level of ambition is appropriate by when.

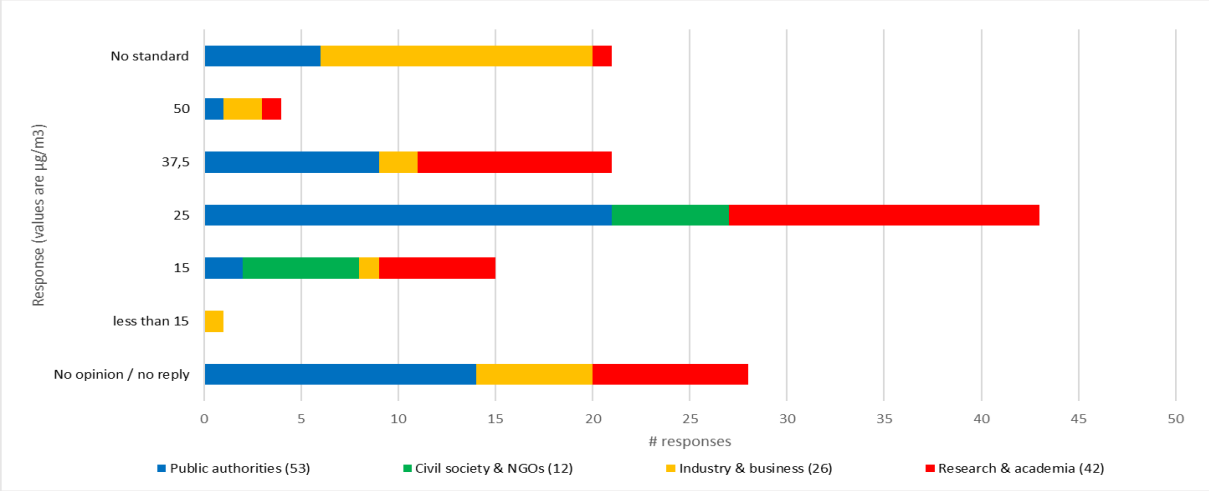
O2 Introduce standards for daily $PM_{2.5}$

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O2	Introduce standards for daily PM2.5 : **15 µg/m³** (on 99% days in a year)	+++ +++ +++ +++	++ +/- 0	+ --- +/-	--- --- ---	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
O2	Introduce standards for daily PM2.5 : **25 µg/m³** (on 95% days in a year)	++ ++ ++ ++	++ +/- 0	+/- -- +	-- -- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
O2	Introduce standards for daily PM2.5 : **37.5 µg/m³** (on 95% days in a year)	+ + + +	+ +/- 0	+ - +/-	- - -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards / thresholds for daily concentrations of $PM_{2.5}$

Description of measure: The current Ambient Air Quality Directives do not contain a short-term standard for $PM_{2.5}$. The WHO Air Quality Guidelines set a recommended limit of 15 µg/m^3 over a 24-hour period (99th percentile, three to four exceedance days per year), alongside higher interim targets. This intervention explores the value of introducing a new EU short-term limit values for $PM_{2.5}$ in line with the WHO Air Quality Guidelines. Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The intervention considers the introduction of a new standard. Variants take the same approach as described for O1. Short-term standards are not modelled explicitly, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure (in assessment), but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. Administrative burden will also scale with ambition (impacting Member State competent authorities). In addition, short-term compliance measures to tackle peak concentrations specifically may be more disruptive in nature (albeit for a short-time) and carry a higher cost. It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the advice of the WHO, who explore that even a small number of extreme peaks could have a significant impact.

O3 Revise average exposure standards for $PM_{2.5}$

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
O3	Revise standards for average exposure for PM2.5 : **5 µg/m³**	++ ++ ++ ++	+++ +/- +	++ -- +	-- --	++	**High** but uncertain	**Policy option I-5**

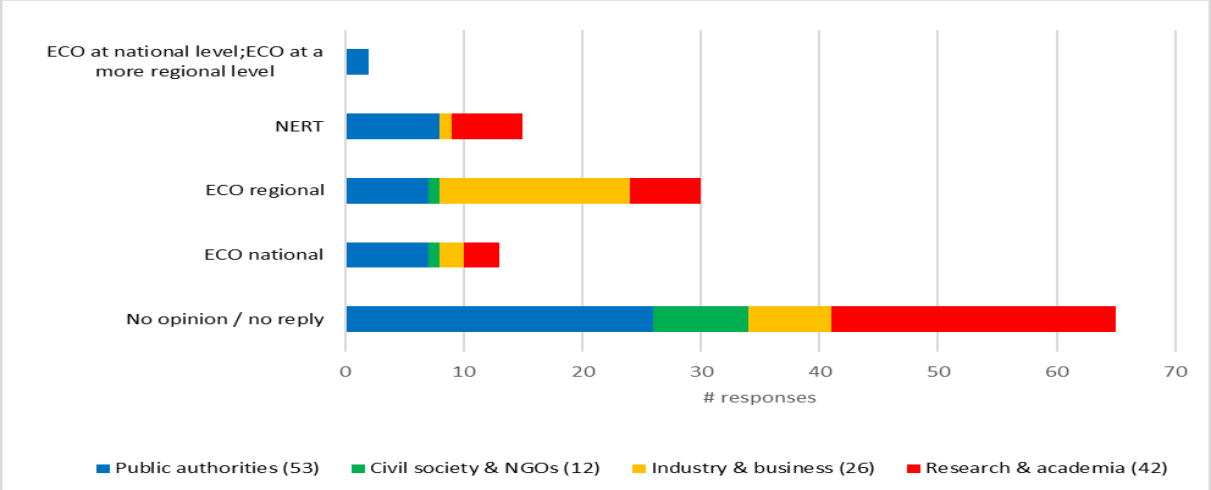
Focus of measure: Revise average exposure obligations and reduction targets for $PM_{2.5}$

Description of measure: This intervention would revise exposure reduction targets for $PM_{2.5}$ in terms of the initial concentration values and the percentage reduction target. Variants for this intervention are based on different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. The following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for $PM_{2.5}$ based on concentration values rather than exposure reduction targets. The Ambient Air Quality Directives include average exposure obligations among the current provisions to regulate $PM_{2.5}$ concentrations. This is to complement the limit value for $PM_{2.5}$ by targeting average concentration values across larger areas. Accordingly, the Ambient Air Quality Directives set a national $PM_{2.5}$ exposure reduction target to protect human health (Article 15 of Directive 2008/50/EC). The exposure reduction target is a percentage reduction based on the initial concentration. To determine the initial concentration, an average exposure indicator is used (an average level determined on the basis of measurements at urban background locations throughout the territory of a Member State and which reflects population exposure).

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for $PM_{2.5}$ is set at the WHO guideline level of 5 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of $PM_{2.5}$ and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising

primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action.

2.17 Intervention area P: EU air quality standards for particulate matter (PM_{10})

P1 Revise standards for annual PM_{10}

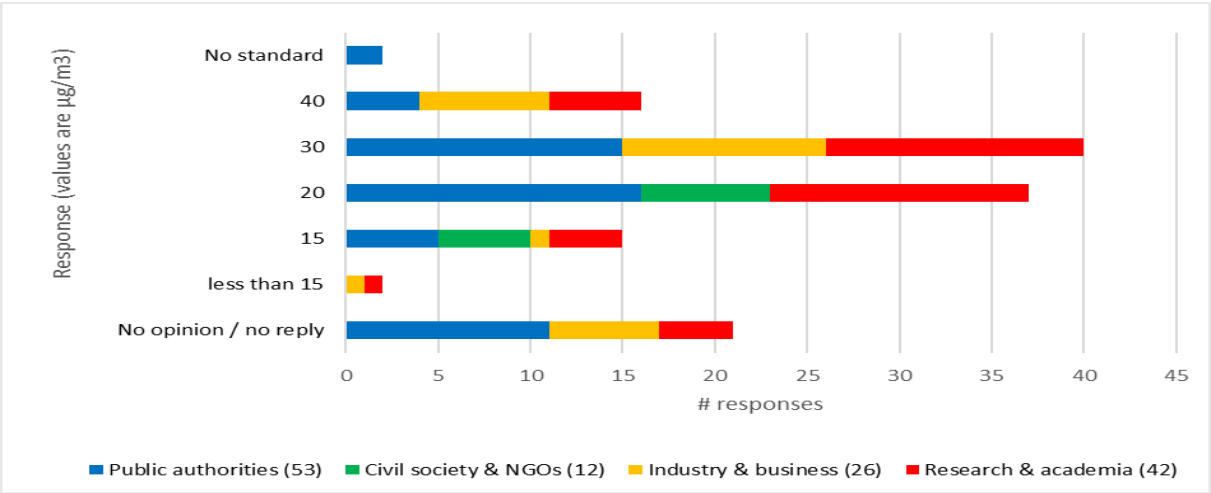
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P1	Revise standards for annual PM10: **15 µg/m³**	+++ +++ +++ +++	+++ +/- +	+ --- +	--- ---	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
P1	Revise standards for annual PM10: **20 µg/m³**	++ ++ ++ ++	++ +/- +	+ -- +	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
P1	Revise standards for annual PM10: **30 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of PM_{10}

Description of measure: The current air quality standards for annual PM_{10} under the AAQ Directives set an annual average limit value of 40 µg/m³. The WHO Air Quality Guidelines set an annual average of 15 µg/m³, alongside higher interim targets. This measure explores the alignment of the EU long-term standard limit values for PM_{10} with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Modelling shows that this intervention could have a significant positive impact on air quality. The health effects across the variants will scale with the level of ambition, even if

health effects are more closely associated with exposure to finer particulate matter ($PM_{2.5}$). For example the modelling performed suggests that by 2030, there will be broad compliance with a 30 µg/m^3 target, with only around 13 000 people living in areas of exceedance in OPT15. Under OPT10, around 2.7 million people remain living in areas exceeding 20 µg/m^3, implying a moderate level of effort would be needed at local level to meet this ambition. Under OPT5, 13.7 million remain in areas exceeding the WHO Air Quality Guidelines 15 µg/m^3. The mitigation costs of lower standards for PM_{10} have not been modelled. Many of the measures which mitigate $PM_{2.5}$ would also mitigate PM_{10} emissions, hence the measures and costs would be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities). Stakeholders firmly recognise the value of an annual average standard for PM_{10}, which applies as a limit value across all territories of the EU. Furthermore, stakeholders also affirm the additional value of a standard for PM_{10} alongside $PM_{2.5}$ and show a general interest for improvement. However, opinion varies on what level of ambition is appropriate and by when it should be achieved. .

P2 Revise standards for daily PM_{10}

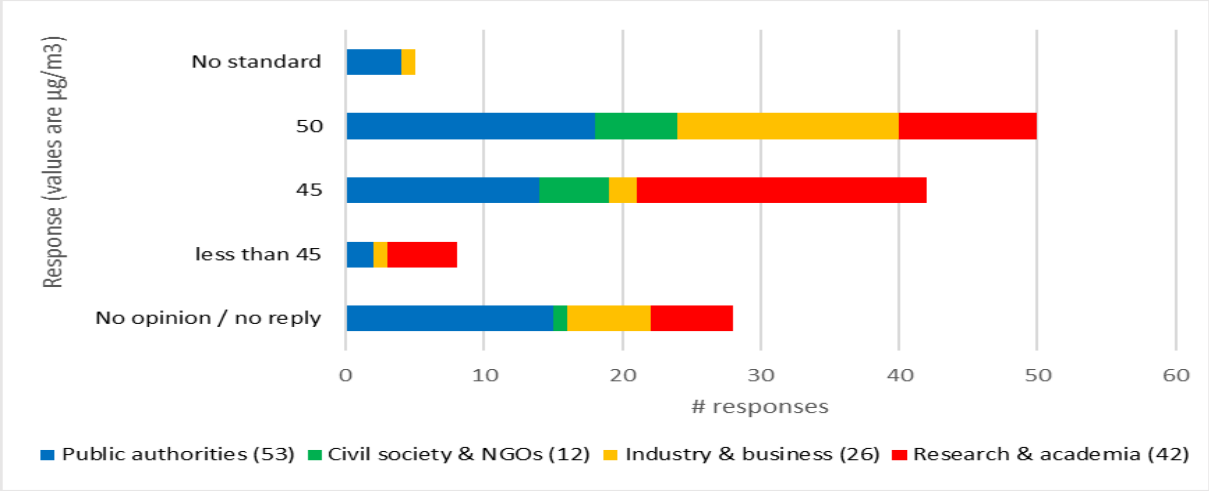
	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P2	Revise standards for daily PM10 : **45 µg/m³** (on 99% days in a year)	+++ +++ + +	++ +/- 0	+ --- +/-	--- --	+++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
P2	Revise standards for daily PM10 : **45 µg/m³** (on 95% days in a year)	++ ++ + +	+ +/- 0	+ -- +/-	-- --	++	**High**	**Policy option I-2** and **Sub option I-2a**
P2	Maintain standards for daily PM10 : **50 µg/m³** (on 90% days in a year)	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards / thresholds for daily concentrations of PM_{10}

Description of measure: The current Ambient Air Quality Directives standards for 24-hour PM_{10} set a limit value of 50 µg/m^3. The WHO Air Quality Guidelines set at limit of 45 µg/m^3, alongside higher interim targets. This measure explores the alignment of the EU 24-hour limit values for PM_{10} with the WHO Air Quality Guidelines updated limit values.

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Short-term standards are not modelled, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure, but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. The mitigation costs will increase with the level of ambition and will depend on the action taken. Short-term standards have not been modelled, as such the costs of mitigation actions are more uncertain. Expert judgement suggests many of the actions taken to mitigate peak concentrations will be the same as those to tackle annual average concentrations, which means the costs will be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities). It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the advice of the WHO, who explore that even a small number of extreme peaks could have a significant impact. Stakeholders voted positively that they see additional value in a standard to manage peak concentrations of PM_{10}. However, the additional value of a short-term PM_{10} standard may be limited if set alongside a corresponding standard for $PM_{2.5}$, since both are likely to share similar sources and hence, control strategies.

P3 Introduce average exposure standards for PM_{10}

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
P3	Introduce standards for average exposure for PM10 : **15 µg/m³**	++ ++ ++ ++	++ +/- +	+ -- +	-- --	++	**Low** but uncertain	**Policy option I-5**
P3	Revise standards for average exposure for PM10 : **20 µg/m³**	+ + + +	+ +/- +	+ - +	- --	+	**Low**	**Policy option I-5**

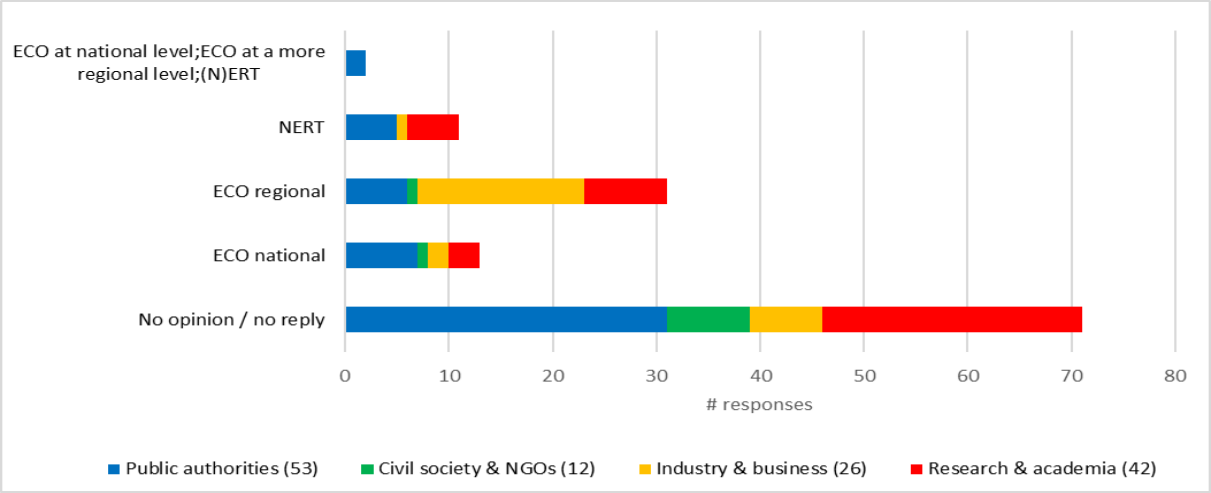
Focus of measure: Introduce average exposure obligations and reduction targets for PM_{10}.

Description of measure: This intervention would introduce average exposure concentration obligations and reduction targets for PM_{10}. Variants for this intervention are based on different initial concentrations (µg/m^3) and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for PM_{10} based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for PM_{10}.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for PM_{10} is set at the WHO guideline level of 15 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of PM_{10} and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised

action. An average exposure standard for PM_{10} may not offer significant additional value alongside the similar existing standard for $PM_{2.5}$, since both are likely to share similar sources and hence, control strategies.

2.18 Intervention area Q: EU air quality standards for nitrogen dioxide

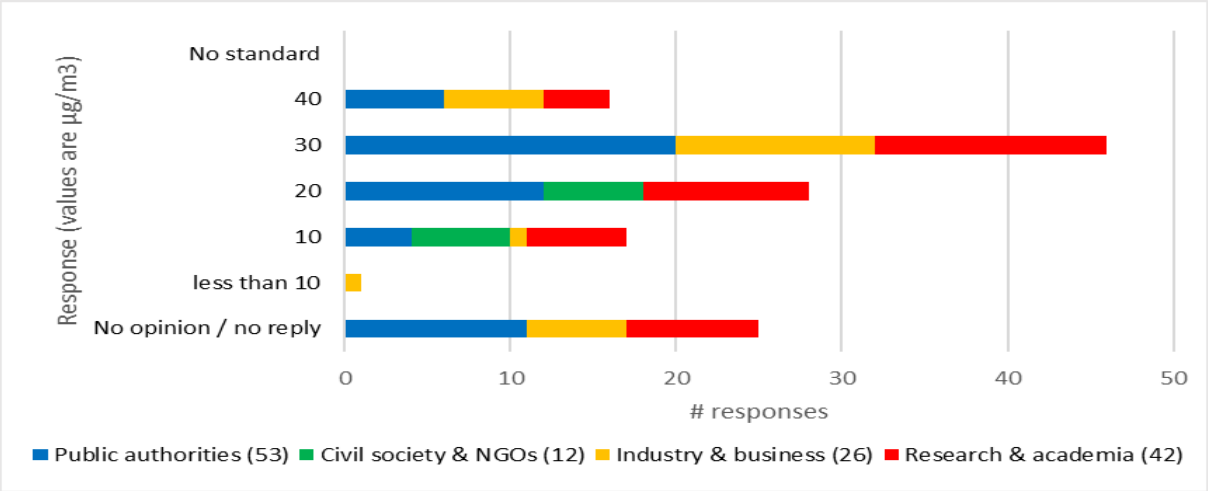
Q1 Revise standards for annual NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q1	Revise standards for annual NO2: **10 µg/m³**	+++ ++ +++ +	+ +/- +	++ -- +	-- ---	++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
Q1	Revise standards for annual NO2: **20 µg/m³**	++ + ++ +	+ +/- +	+ - +	- -	++	**High**	**Policy option I-2** and **Sub option I-2a**
Q1	Revise standards for annual NO2: **30 µg/m³**	+ + + +	+ +/- +	+ - +	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: EU air quality standards for annual concentrations of NO_2

Description of measure: The current Ambient Air Quality Directives standards for annual NO_2 set an annual average limit value of 40 µg/m^3. The WHO Air Quality Guidelines set the limit at 10 µg/m^3, alongside higher interim targets. This measure explores the alignment of the EU long-term standard limit values for NO_2 with the WHO Air Quality Guidelines updated limit values. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The health benefits of action targeting the revision of NO_2 concentrations may be smaller (assuming there are no co-benefits by way of particulate or GHG emission reductions). The mitigation costs of lower standards for NO_2 have not been modelled, as such contrasting benefits and costs is more uncertain. The modelling does show however a broad

alignment with a 20 µg/m^3 standard by 2030, and with the WHO Air Quality Guidelines by 2050, with only a small number of people which remain exposed to concentrations above these levels (around four to six million respectively). The additional costs and benefits of these options are both negligible (although in practice a reduction in the standard will help reinforce this delivery). Increasing ambition above the baseline will require the uptake of measures not captured in GAINS, and hence for which the costs are uncertain. However, expert judgement would suggest that costs of localised activity may be more disruptive and imply a higher cost (albeit at a local level). Several challenges for implementation have been identified.

Stakeholders firmly recognise the value of an annual-average standard for NO_2, applying as a limit value to all territory. Furthermore, stakeholders also show a general interest for improvement but opinion varies on what level of ambition is appropriate and by when it should be achieved. The majority of stakeholders feel alignment with the WHO Air Quality Guidelines would not be appropriate by 2030, but most feel a target in the range from 20-30 µg/m^3 would be achievable, with full alignment to 2050.

Q2 Revise/introduce standards for hourly/daily NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q2	Introduce standards for daily NO2:**25 µg/m³** (on 99% days in a year)	+++ + ++ +	+ +/- 0	+ --- +/-	-- ---	++	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
Q2	Introduce standards for daily NO2: **50 µg/m³** (on 95% days in a year)	++ + ++ +	+ +/- 0	+ -- +/-	- -	++	**High**	**Policy option I-2** and **Sub option I-2a**
Q2	Introduce standards for daily NO2: **50 µg/m³** (on 90% days in a year)	+ + + +	+ +/- 0	+ - +/-	- -	+	**High**	**Policy option I-3** and **Sub option I-3a**
Q2	Maintain standards for hourly NO2: **200 µg/m³** (on 99.99% hours in a year)	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

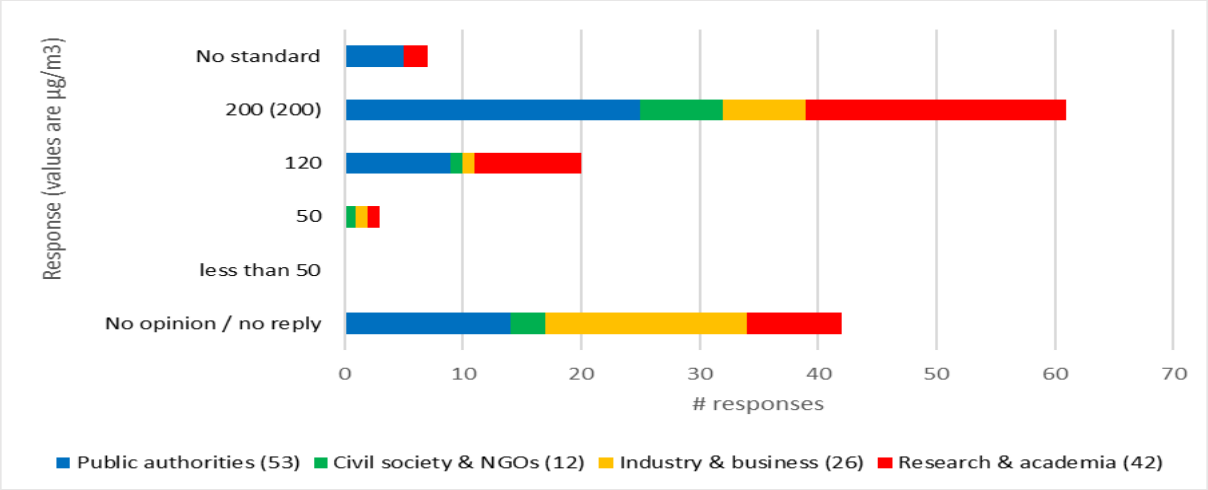
Focus of measure: EU air quality standards / thresholds for daily concentrations of NO_2

Description of measure: The Ambient Air Quality Directives sets a standard for 1-hour NO_2 at a limit value of 200 µg/m^3. The WHO Air Quality Guidelines does not include a 1-hour limit for NO_2, although its 2000 Guidelines[29] included a 1-hour limit which is consistent with the EU standard. The WHO Air Quality Guidelines set a standard for 24-hour NO_2 at a limit value of 25 µg/m^3, alongside higher interim targets. No current EU standard for the 24-hour period exists.

[29] WHO (2000), Summary of the WHO guidelines (accessed: 10.06.2022)

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The measure considers both the existing standard (1-hour) and the potential introduction of a new (24-hour) standard. In isolation, there is a strong case for a standard managing NO_2 peak concentrations. It appears that there is merit in having a standard to manage peak alongside annual average concentrations – this is underlined by stakeholders and the WHO Air Quality Guidelines, who explore that even a small number of extreme peaks could have a significant impact.[30] However, the effectiveness of a peak concentration as a safety net (and indeed its additional value over an annual standard) decreases with the number of allowed exceedance days per year.

Short-term standards are not modelled, and hence judgements regarding the balance of costs and benefits is more uncertain. Greater health benefits are typically associated with chronic exposure, but where the risk of peaks is quite high and considering this intervention in isolation, the benefits would be much more significant. The mitigation costs will increase with the level of ambition and will depend on the action taken. Short-term standards have not been modelled, as such the costs of mitigation actions are more uncertain. Expert judgement suggests many of the actions taken to mitigate peak concentrations will be the same as those to tackle annual average concentrations which means costs will be similar. Administrative burden will also scale with ambition (impacting Member State competent authorities).

Q3 Introduce average exposure standards for NO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Q3	Introduce standards for average exposure for	++ +	+ +/-	+ --	--	+	**Medium** but uncertain	**Policy option I-5**

[30] For more information on stakeholders views please see Annex 2.

	NO2: **10 µg/m³**	++ +	+	+	--			
Q3	Introduce standards for average exposure for NO2: **20 µg/m³**	+ + + +	+ +/- +	+ - +	- --	+	**Medium**	**Policy option I-5**

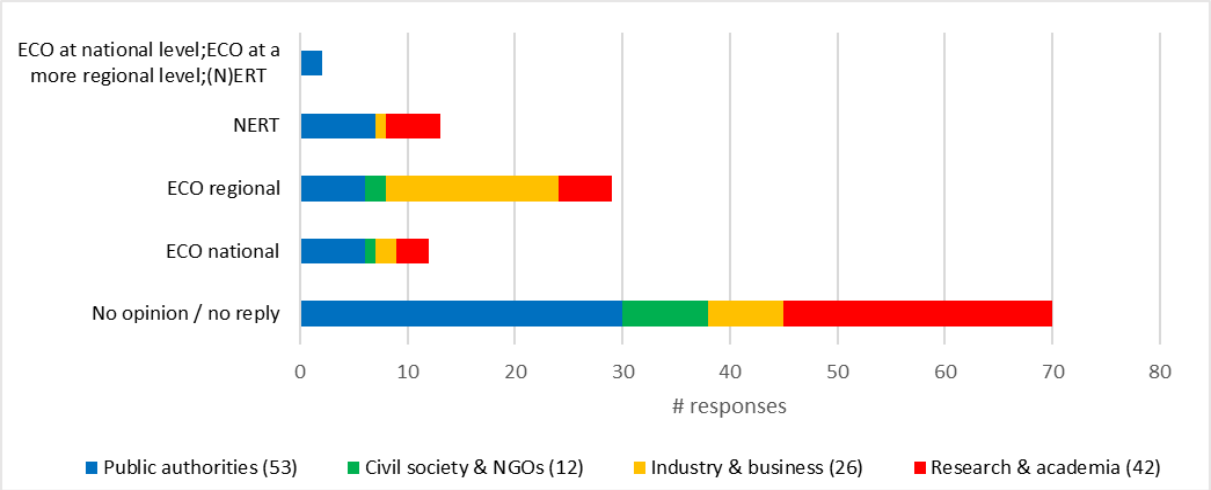
Focus of measure: Introduce average exposure obligations and reduction targets for NO_2

Description of measures: This intervention would introduce average exposure concentration obligations and reduction targets for NO_2. Variants for this measure are based on different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level. In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for NO_2 based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for NO_2.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for NO_2 is set at the WHO guideline level of 10 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality

improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of NO_2, rather than limiting focus on pollution hotspots, and therefore deliver health benefits. This is also important for NO_2 as a precursor, including to PM. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action.

2.19 Intervention area R: EU air quality standards for ozone

R1 Introduce standards for peak-season O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R1	Introduce standards for peak-season O3: **60 µg/m³**	+++ + +++ +	+ +/- 0	+ --- -	--- 0	+	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
R1	Introduce standards for peak-season O3: **70 µg/m³**	++ + ++ +	+ +/- 0	+ -- -	-- 0	+	**High** but uncertain	**Policy option I-2** and **Sub option I-2a**
R1	Introduce standards for peak-season O3: **100 µg/m³**	+ + + +	+ +/- 0	+ - -	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**

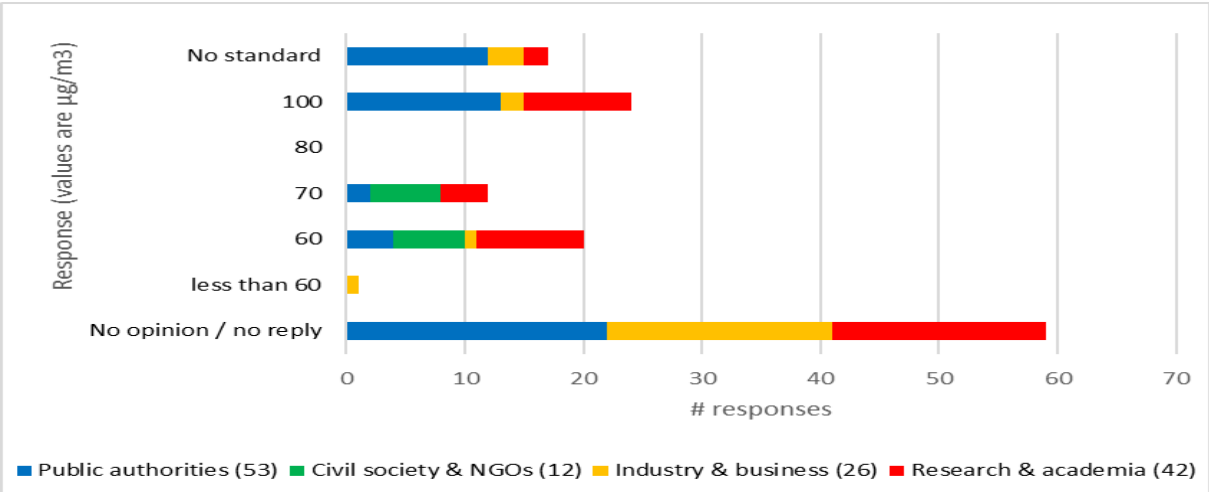
Focus of measure: EU air quality standards for peak-season concentrations of O_3

Description of measure: This measure explores the revision of the EU long-term standard for O_3.

The current Ambient Air Quality Directives have a long-term ozone standard aimed at the protection of vegetation. This target value is defined in terms of AOT40 (calculated from 1 hour values), over a May to July averaging period, at 18 000 µg/m^3 over five-year average. There is no current EU standard for long-term ozone targeting the protection of human health. The WHO Air Quality Guidelines set a peak season recommendation for average daily maximum 8-hour mean O_3 concentrations of 60 µg/m^3, in the six consecutive months with the highest six-month running-average O_3 concentration.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved, and the type of standard to be set.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The effectiveness of the intervention will vary with the level of ambition. However, given high levels of existing exceedance, the benefit to air quality is expected to be high. Human health benefits tend to be more linked with exposure to other pollutants and hence can be small. Likewise, ecosystem effects typically comprise a lower proportion of the overall benefit of air quality action, relative to human health effects (albeit this is based on an evidence base which has predominantly focused on the valuation of human health effects, for which by extension is more well explored and understood). The cost of achieving different standards for O_3 have not been modelled directly so costs are uncertain. Costs will increase with the level of ambition.

Controlling ozone concentrations is complex and challenging, and is driven in part by control of precursors but also by the meteorological conditions. As such it is questionable whether very ambitious standards for ozone would be feasible in all locations. This is perhaps underlined by the different of opinion amongst stakeholders as to whether limit or target values would be most appropriate. Furthermore, there is currently broad exceedances of both the existing EU target value and the WHO Air Quality Guidelines, as such substantial effort would be required to meet an even stricter target, whereas the benefits of such action (at least in economic impact assessment) often rank below action taken around other pollutants.

R2 Revise standards for 8-hour O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R2	Revise standards for 8-hour O3: **100 µg/m³** (on 99% days in a year)	+++ + ++ +	+ +/- 0	+ --- -	--- ---	+	**High** but uncertain	**Policy option I-1** and **Sub option I-1a**
R2	Revise standards for 8-hour O3: **120 µg/m³** (on 95% days in a year)	++ + + +	+ +/- 0	+ -- -	-- 0	+	**High**	**Policy option I-2** and **Sub option I-2a**
R2	Revise standards for 8-hour O3: **120 µg/m³** (on 90% days in a year)	+ + + +	+ +/- 0	+ - -	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**

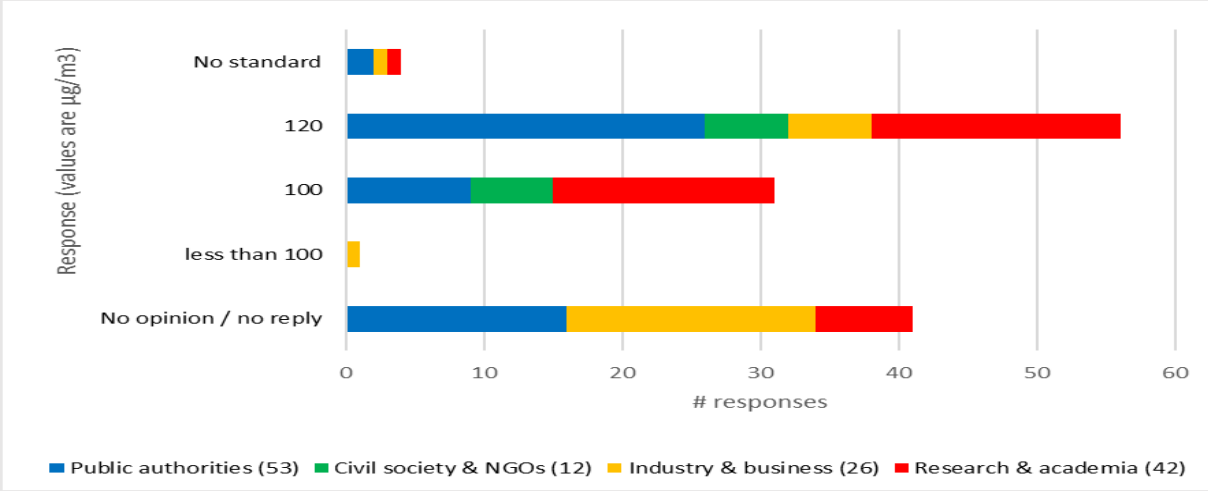
Focus of measure: EU air quality standards / thresholds for 8-hour concentrations of O_3

Description of measure: This measure explores the revision of the EU short-term standard for O_3.

The current AAQ Directives has a target value for the maximum 8-hour daily mean for ozone of 120 µg/m^3 (with 25 permitted exceedances allowed per annum averaged over 3 years). The WHO Air Quality Guidelines set a recommendation for average daily maximum 8-hour mean O_3 concentrations of 100 µg/m^3 (defined as the 99th percentile).

Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved, and the type of standard to be set.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There remains a clear need for a standard to regulate peak concentrations of ozone. However, controlling ozone concentrations is complex and challenging, and is driven in part by control of precursors but also by the meteorological conditions. The modelling data suggests that there will be broad compliance with the EU standard by 2030, but still substantial non-compliance with the WHO Air Quality Guidelines both under the baseline and the maximum feasible reduction scenario. As such it is questionable whether very ambitious standards for ozone would be feasible in all locations. This is perhaps underlined by the different of opinion amongst stakeholders as to whether limit or target values would be most appropriate. Given the size of existing levels of exceedance, and the challenges in controlling ozone concentrations, the costs of increasing ambition or switching to a limit value might be significant. Human health benefits tend to be more linked with exposure to other pollutants and hence can be small. Likewise, ecosystem effects typically comprise a lower proportion of the overall benefit of air quality action, relative to human health effects (albeit this is based on an evidence base which has predominantly focused on the valuation of human health effects, for which by extension is more well explored and understood).

R3 Introduce average exposure standards for O_3

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
R3	Introduce standards for average exposure for O3 : **60 µg/m³**	++ + ++ +	+ +/- 0	+ -- -	-- --	+	**Low**	**Policy option I-5**
R3	Introduce standards for average exposure for O3 : **70 µg/m³**	+ + + +	+ +/- 0	+ - -	- --	+	**Low**	**Policy option I-5**

Focus of measure: Introduce average exposure obligations and reduction targets for O_3

Description of measure: This intervention would introduce average exposure concentration obligations and reduction targets for ozone (O_3). Variants for this intervention are based on

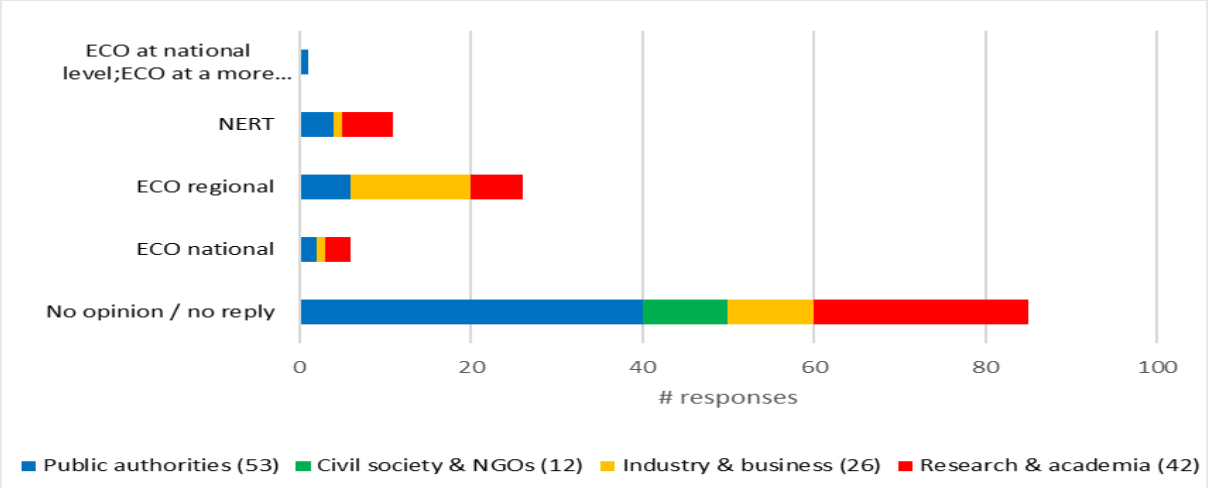
different initial concentrations and look at whether the reduction targets should be based on annual or daily exposure, and whether they should be set at a regional or national level.

In particular, the following mechanisms are under review:

- ECO: Exposure concentration obligation – i.e. 'based an average level determined on the basis of measurements at urban background locations, reflects population exposure – and to be attained over a given period';
- (N)ERT: (National) exposure reduction target – i.e. 'a percentage reduction of the average exposure to be attained where possible over a given period'.

The WHO Air Quality Guidelines include targets for ozone based on concentration values rather than exposure reduction targets. Current provisions in the Ambient Air Quality Directives do not set average exposure obligations or reduction targets for ozone.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The extent to which this intervention contributes to air quality improvements is partly dependent on the level of ambition. If the average exposure obligation for O_3 is set at the WHO guideline level of 60 µg/m^3, the level of ambition may be defined through the design of the exposure reduction target, i.e. the time allowed to reduce the gap between the initial average exposure and the average exposure obligation by a set percentage (e.g. reducing the gap by XX% over YY years). The exposure reduction target required may need to be adjusted in view of specific regional circumstances in some cases. A benefit of setting average exposure targets is that they can complement limit values by (a) targeting background concentrations more specifically and (b) steering further air quality improvements beyond attaining limit values where this is feasible. Benefits to ecosystems will occur as a co-benefit of the measures implemented to attain the reduction targets. Therefore, regardless of the level of ambition, revisions to average exposure targets can facilitate targeted reductions of background levels of O_3 and therefore deliver health benefits. Costs can be significant depending notably on the level of ambition, arising primarily from measures to attain the reduction targets and administrative burden. There is potential to reduce the administrative burden by taking more coordinated and centralised action. However, it is uncertain whether an average exposure standard would offer a useful complement and afford additional management options in the case of O_3, given the specific

chemical characteristics of ozone generation and its links with meteorological conditions (resulting in pronounced local and year-to-year variability).

2.20 Intervention area S: EU air quality standards for sulphur dioxide

S1 Revise standards for annual SO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
S1	Revise standards for annual SO2: **20 µg/m³**	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1, I-2, I-3** and **all sub-options**

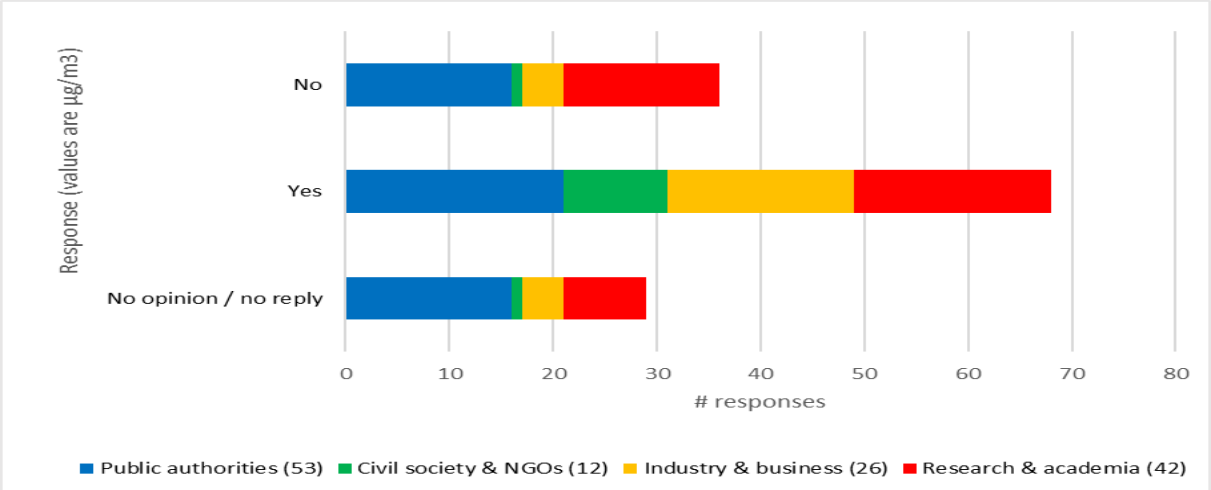
Focus of measure: EU air quality standards for annual concentrations of SO_2

Description of measure: This measure explores the revision of the EU long-term standard for SO_2.

The current Ambient Air Quality Directives set a critical level for the protection of vegetation over the calendar year and winter (1 October to 31 March) of 20 µg/m^3, with no margin of tolerance. There is no existing, long-term EU standard for SO_2 aimed at the protection of human health. Furthermore, the WHO Air Quality Guidelines do not include a recommendation for long-term exposure to SO_2.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Revisions to this standard were not modelled and therefore the balance of costs and benefits is more uncertain. There has been substantial progress around SO_2 emissions and concentrations historically. This may also suggest that a majority of the low-cost actions may have already been captured. Furthermore, the benefits per ton of pollutant abated are smaller

than for other pollutants (e.g. $PM_{2.5}$). The WHO did not include an Air Quality Guidelines recommendation around long-term exposure to SO_2 with which an EU standard targeting human health could align. In addition stakeholders provided limited input.

S2 Revise standards for daily/hourly SO_2

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
S2	Introduce standards for daily SO2: **40 µg/m³** (on 99% days in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1** and **Sub option I-1a**
S2	Introduce standards for daily SO2: **50 µg/m³** (on 95% days in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-2, I-3** and **Sub option I-2a, I-3a**
S2	Maintain standards for hourly SO2: **350 µg/m³** (on 99.98% hours in a year)	+ + + +	0 0 0	+ - 0	- 0	+	**Medium**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards / thresholds for daily concentrations of SO_2

Description of measure: This measure explores the alignment of the EU short-term limit values for SO_2 with the WHO Air Quality Guidelines updated limit values.

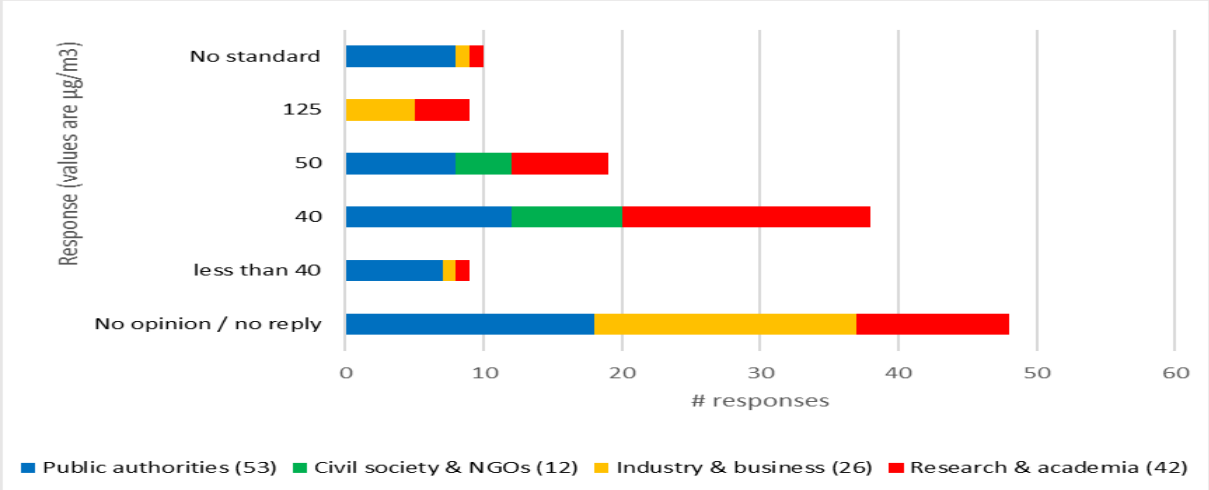
The current Ambient Air Quality Directives sets a two standards:

- A ***24-hour*** limit value of 125 µg/m^3 (can be exceeded up to three times per year), which is above the WHO Air Quality Guidelines of 40 µg/m^3 (based on 99th percentile);
- A ***1-hour*** limit value of 350 µg/m^3 (can be exceeded up to 24 times per year). The WHO does not make a recommendation of exposure over a 1-hour averaging period.

The measure also considers the revision of existing and/or the introduction of short-term standards, either alongside or instead of the existing standard.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure considers both: (a) changes to the existing EU limit values and (b) addition to or substitution of the existing EU standard with alternative short-term standards in the WHO Air Quality Guidelines. Revisions to this standard were not modelled and so the balance of costs and benefits is more uncertain. No monitoring data is available over a 10-minute period, which makes it challenging to draw conclusions around the impact of and merit to introducing a new 10-minute standard alongside, or instead of, other short-term standards for SO_2. As described for S1, historical progress for SO_2 may suggest that low-cost actions have already been captured. Stakeholders propose that the WHO standards could be met with limited additional effort.

2.21 Intervention area T: EU air quality standards for carbon monoxide

T1 Revise standards for daily/8-hour CO

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
T1	Introduce standards for daily CO: **4 mg/m³** (on 99% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-1** and **Sub option I-1a**
T1	Introduce standards for daily CO: **4 mg/m³** (on 95% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-2** and **Sub option I-2a**
T1	Introduce standards for daily CO: **7 mg/m³** (on 95% days in a year)	+ + 0 +	0 0 0	0 - 0	- 0	+	**High**	**Policy option I-3** and **Sub option I-3a**
T1	Maintain standards for 8-hour CO: **10 mg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for daily concentrations of CO

Description of measure: This measure explores the alignment of the EU short-term limit values for CO with the WHO Air Quality Guidelines updated limit values.

The current Ambient Air Quality Directives set a daily 8-hour mean limit value at 10 µg/m^3, which corresponds to the standard set by the WHO Air Quality Guidelines. This measure considers going beyond the WHO Air Quality Guidelines for this averaging period.

The WHO Air Quality Guidelines also set several other short-term standards, for which an EU standard does not exist:

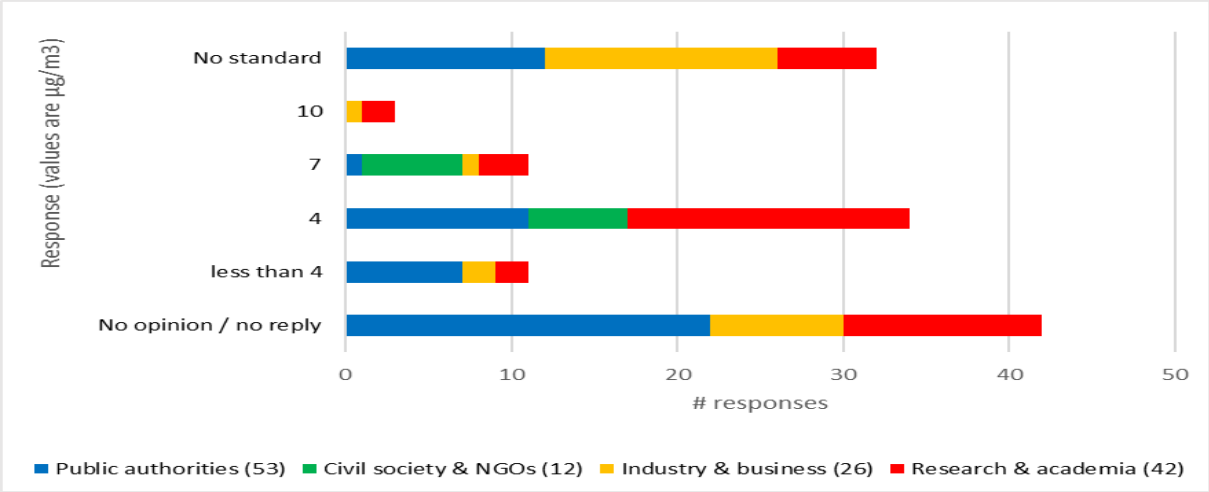
- The recommended 24-hour WHO standard is set at 4 µg/m^3 (measured on the 99th percentile)
- The recommended 1-hour WHO standard is set at 35 µg/m^3
- The recommended 15 minute WHO standard is set at 100 µg/m^3

The 24-hour target was introduced in the 2021 WHO Air Quality Guidelines, with the other three standards being confirmed as remaining valid.

The measure also considers the introduction of short-term standards over these averaging periods, either alongside or instead of the existing standard.

Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This measure considers both: (a) changes to the existing EU limit value and (b) addition to or substitution of the existing EU standard with alternative short-term standards in the WHO Air Quality Guidelines. From the modelling performed, a certain level of improvement can be made through abatement measures for moderate cost. However, achieving further improvements going beyond the WHO Air Quality Guidelines will require the take up of non-technical or local measures not captured by the modelling, thus the costs are uncertain. Health benefits are more commonly associated with $PM_{2.5}$, as such the benefits per ton of CO reduction are relatively lower. Stakeholders propose that the existing EU standards can be met with limited additional effort and propose to remain at the existing standard. For the introduction of an additional standard the response to the targeted stakeholder was uncertain.

2.22 Intervention area U: EU air quality standards for benzene

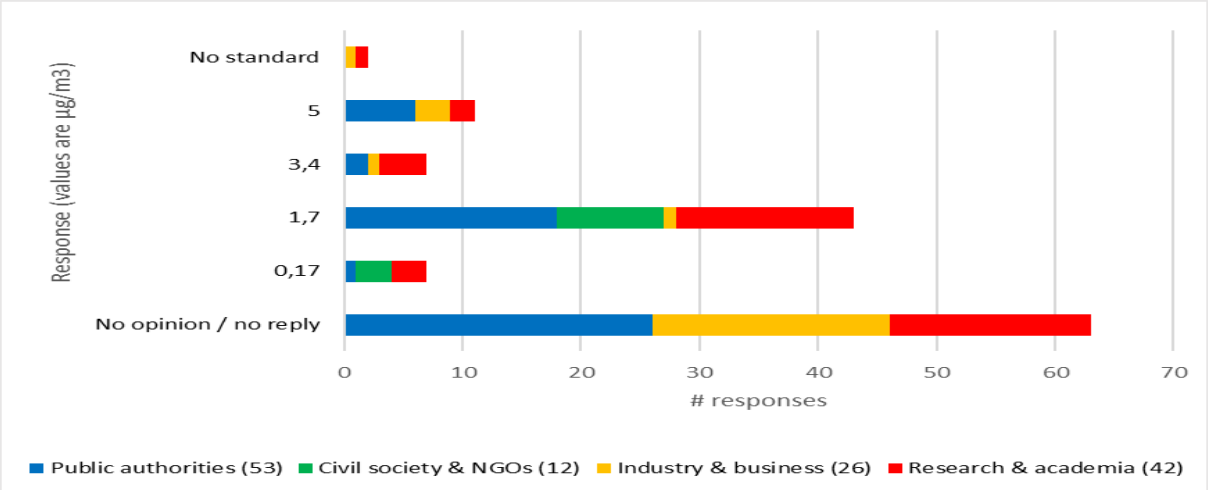
U1 Revise standards for annual benzene

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
U1	Revise standards for annual benzene: **1.7 µg/m³**	+ + 0 0	0 0 0	0 - 0	- 0	0	**Medium**	**Policy option I-1** and **Sub option I-1a**
U1	Revise standards for annual benzene: **3.4 µg/m³**	+ + 0 0	0 0 0	0 - 0	- 0	0	**Medium**	**Policy option I-2** and **Sub option I-2a**
U1	Maintain standards for annual benzene: **5 µg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: Revise EU air quality standards for annual concentrations of benzene

Description of measure: This intervention explores the alignment of the EU long-term standard limit values for benzene with the WHO Air Quality Guidelines, which for benzene were contained in the 2000 WHO Air Quality Guidelines. The current Ambient Air Quality Directives set an annual average limit value for benzene of 5 µg/m^3. The WHO standard is set at 1.7 µg/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: There is broad compliance with the existing standard in 2019 and low exceedances relative to the WHO Air Quality Guidelines, not accounting for further improvements in the baseline. The negative impact of benzene is however also lower in relation to other pollutants.

2.23 Intervention area V: EU air quality standards for benzo(a)pyrene

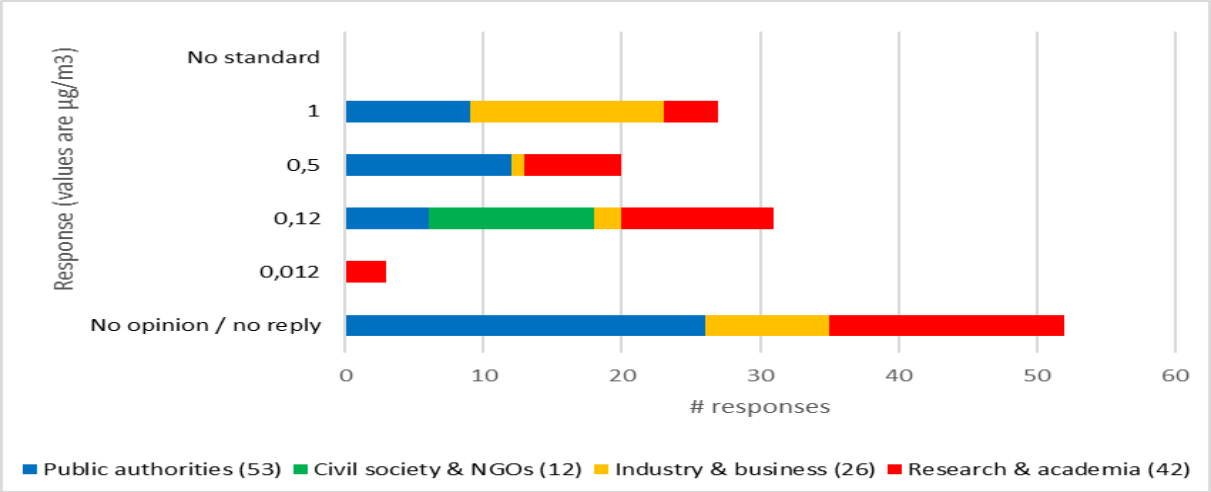
V1 Revise standards for annual benzo(a)pyrene

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
V1	Revise standards for annual benzo(a)pyrene: **0.12 ng/m³**	++ ++ 0 +	+ +/- +/-	+ - +/-	- ---	+	**Medium**	**Policy option I-1** and **Sub option I-1a**
V1	Revise standards for annual benzo(a)pyrene: **0.5 ng/m³**	+ + 0 +	+ +/- 0	+ - +/-	- ---	+	**Medium**	**Policy option I-2** and **Sub option I-2a**
V1	Maintain standards for annual benzo(a)pyrene: **1.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-3** and **Sub option I-3a**

Focus of measure: Revise EU air quality standards for annual mean concentrations of benzo(a)pyrene (Bap)

Description of measure: This intervention explores the possibility for the EU standard for benzo(a)pyrene to be aligned with the WHO Air Quality Guidelines, already contained in the 2000 Guidelines, and/or changing the type of standard. The current Ambient Air Quality Directives set an annual mean target value of 1 ng/m^3, relative to the WHO standard of 0.12 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: This intervention considers both: (a) changing from target to limit value and (b) aligning the standard with the WHO Guidelines. Emissions and concentrations of BaP have been modelled directly and reductions in the baseline are anticipated to be significant compared to the baseline but smaller compared to other pollutants. A moderate number will remain in exceedance in 2030 in the baseline, with high BaP concentrations primarily occurring in specific regions in three Member States. The number of sites exceeding could be

minimised through further measures. To 2050, there is broad compliance with the existing EU standard under the baseline already, and further action could achieve a lower one. BaP is mainly associated with detrimental health impacts. Likewise to comply with a lower standard would also require significant abatement action, both technical (as captured by GAINS) and non-technical or local measures (not captured by GAINS), the costs of which are uncertain.

2.24 Intervention area W: EU air quality standards for lead

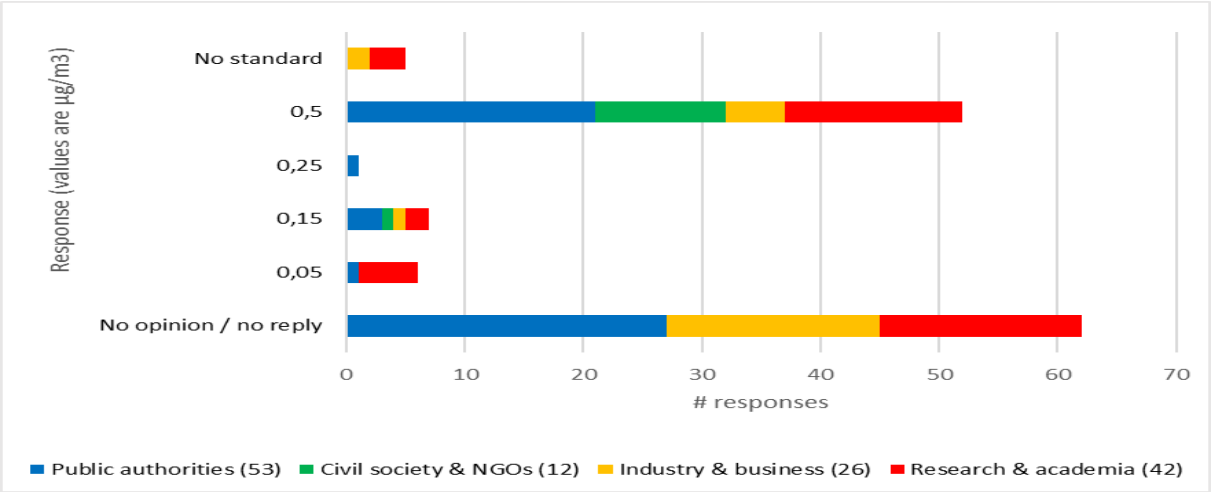
W1 Revise standards for annual lead

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
W1	Maintain standards for annual lead: **0.5 µg/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for annual mean concentrations of lead

Description of measure: The measure explores the possibility for the EU annual average limit value for lead to go beyond the WHO standard contained in the 2000 Guidelines. The current Ambient Air Quality Directives sets an annual average limit value of 0.5 µg/m^3, which is consistent with the WHO standard. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: The benefits of reducing concentrations would be significant on a per emission basis, but lower overall than for pollutants that are present more widely in concentrations above WHO air quality guideline levels. The costs of a stricter standard depend on the level of ambition. Compliance with the current target value is already very high, pointing to low costs also for a limit value. Costs of a stricter standard would strongly depend on the specific control measures deployed at an individual site to abate emissions. Given many sites will fall under the scope of a relevant IED BREF, many low-cost measures may already have been adopted. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.25 Intervention area X: EU air quality standards for arsenic

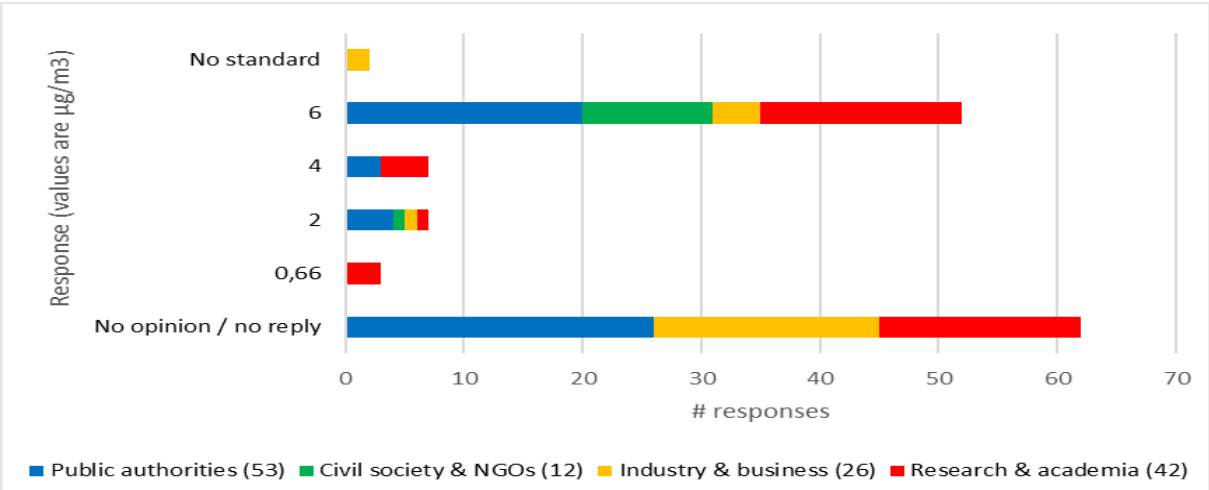
X1 Revise standards for annual arsenic

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
X1	Maintain standards for annual arsenic: **6.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: EU air quality standards for annual concentrations of arsenic

Description of measure: This intervention explores the possibility for the EU annual average target value for arsenic to be made stricter than the WHO recommendation contained in its 2000 Guidelines, and or changing the type of standard. The current Ambient Air Quality Directives set an annual average target value of 6 ng/m^3, which is already slightly below the WHO standard of 6.6 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Based on the monitoring data, only a very limited number of sites currently exceed the existing target value. As such the costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance of the few remaining sites (some of which have very high concentrations – max 21 ng/m^3 in 2019) and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission basis, but lower overall than for pollutants that are present

more widely in concentrations above WHO guideline levels. Costs would strongly depend on the specific control measures deployed at an individual site to abate emissions. Given many sites will fall under the scope of a relevant IED BREF, many low-cost measures may already have been adopted. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.26 Intervention area Y: EU air quality standards for cadmium

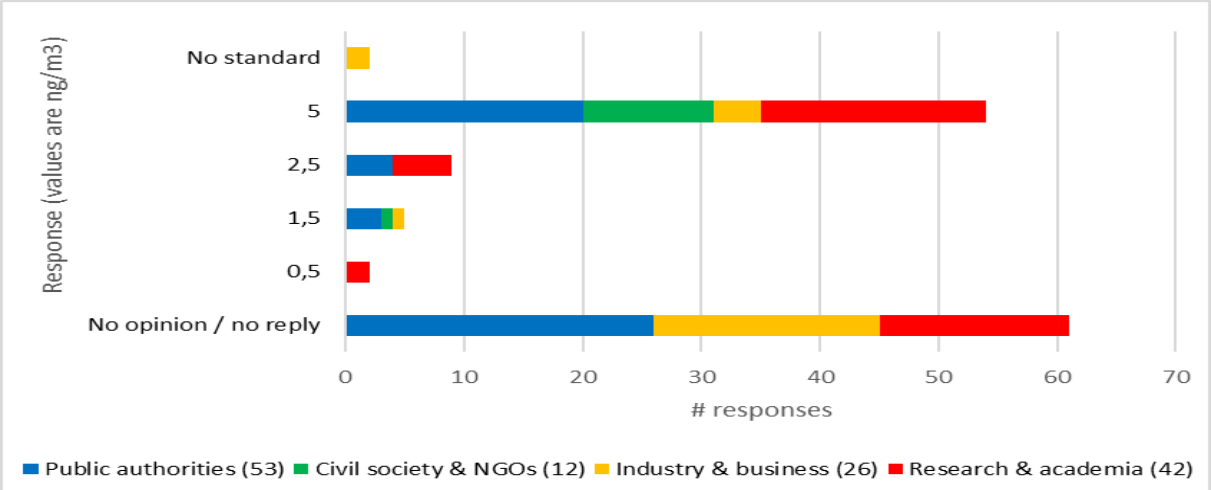
Y1 Revise standards for annual cadmium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Y1	Maintain standards for annual cadmium: **5.0 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: Revise EU air quality standards for annual concentrations of cadmium

Description of measure: This intervention explores the possibility for the EU annual average target value for cadmium to be made stricter than the WHO standard contained in its 2000 Guidelines, and/or to change the type of EU standard. The current Ambient Air Quality Directives set an annual average target value of 5 ng/m^3 which is equivalent to the WHO standard. Variants of the intervention consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance at the remaining sites and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission

basis. There is an important link to L3 regarding monitoring of additional heavy metals to improve evidence base.

2.27 Intervention area Z: EU air quality standards for nickel

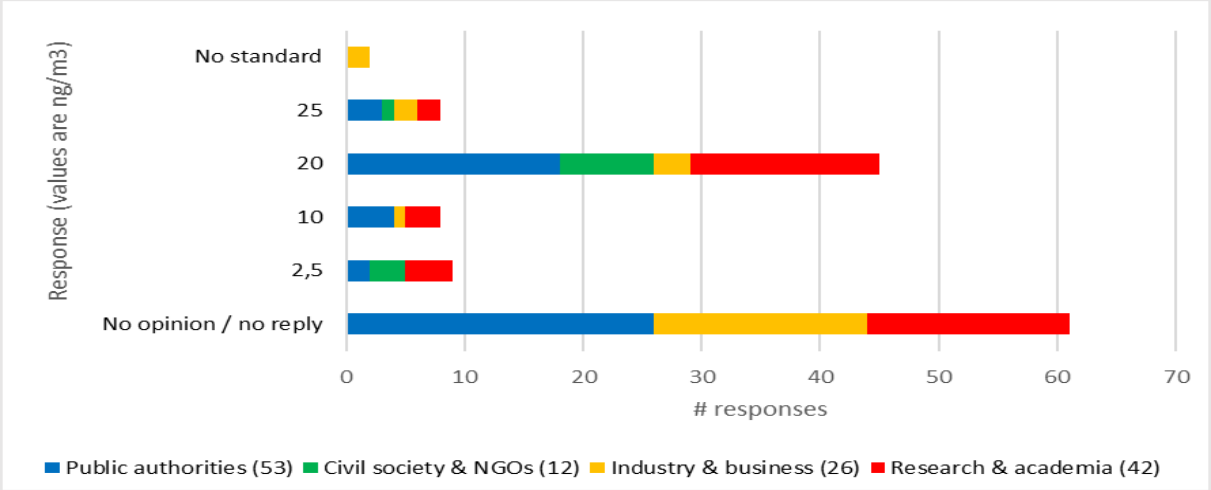
Z1 Revise standards for annual nickel

	Policy Measure	Env. impact	Soc. impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Z1	Maintain standards for annual nickel: **20 ng/m³**	0 0 0 0	0 0 0	0 0 0	0 0	0	**NA**	**Policy option I-1, I-2, I-3** and **all sub-options**

Focus of measure: Revise EU air quality standards for annual mean concentrations of nickel

Description of measure: This intervention explores the possibility for the EU annual average target value for nickel to be made stricter than the WHO standard contained in its 2000 Guidelines, and/or to change the type of EU standard. The **c**urrent Ambient Air Quality Directives set an annual average target value of 20 ng/m^3, which is already slightly below the WHO standard of 25 ng/m^3. Variants of the measure consider different levels at which the standard can be set below the existing EU standard. Variants can also change the timeframe over which a standard should be achieved.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Based on the monitoring data, only a very limited number of sites currently exceed the existing target value. As such the costs (and benefits) of implementing the standard as a limit value could be small, but this could help drive compliance of the few remaining sites and ensure continued performance at compliant sites. The benefits of reducing emissions would be significant on a per emission basis, but lower overall than for pollutants that are present more widely in concentrations above WHO air quality guideline levels. Costs would strongly depend on the specific control measures deployed at an

individual site to abate emissions. There is an important link to L3 regarding monitoring of additional heavy metals to improve the evidence base.

2.28 Intervention area Ø: EU air quality standards for additional air pollutants

Ø1 Introduce standards for additional air pollutants

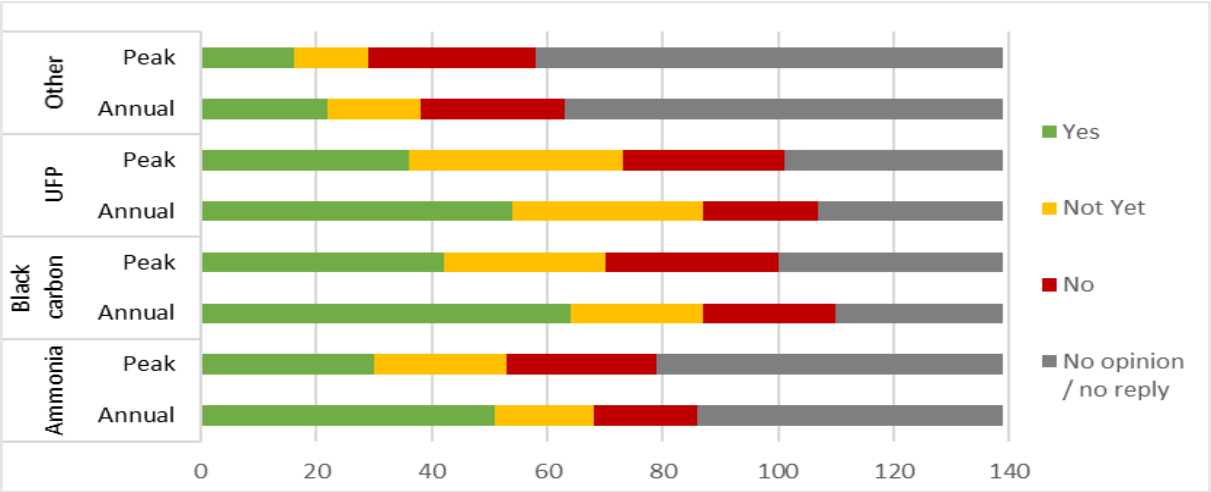
	Policy Measure	Env. impact	Soc. impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Ø1	Introduce standards for additional air pollutants	++ + + +	+ +/- +/-	+ -- +/-	-- ---	+	**Low** but uncertain	**Policy option** **I-1, I-2, I-3** and **all sub-options**

Focus of measure: Introduce EU air quality standards for additional pollutants

Description of measure: This intervention would introduce EU air quality standards for air pollutants for which there are no WHO Air Quality Guideline levels or reference levels (e.g. ammonia, black carbon, ultrafine particles (UFP), others). These could take the form of annual or short-term standards, and could be expressed as limit, target values or otherwise.

The WHO does not recommend introducing standards at this stage (except 'where appropriate for black carbon'). The focus of WHO recommendations is on action to enhance further research on risks and approaches for mitigation. The WHO concluded that as yet, available data is insufficient to provide recommendations and interim target levels for black carbon, ultrafine particles and ammonia.

Stakeholder views: A targeted survey provided feedback on *'to which extent would this specific intervention address the identified (related) shortcomings'*.



Summary: Setting standards would go beyond latest scientific advice and the extent to which they may reduce negative health impacts is therefore uncertain. A clear benefit of this intervention would be a requirement to monitor concentrations and this information could subsequently be used to gain more scientific evidence about health effects. Therefore, this

intervention is strongly linked to monitoring interventions (L1 and L2). Administrative burden and would vary with ambition (with more air quality plans required in cases of the high ambition variant to account for the greater number of exceedances). There would be costs associated with additional monitoring required.

3. POLICY OPTIONS

3.1 Policy options to address environment / health shortcomings

Policy option I-1 to I-3: Full / Closer / Partial alignment with WHO recommendations

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

Policy option I-4: Additional air pollutants

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

	Policy Measure	Env. impact	Soc. impact	Eco. Impact	Cost	Policy synergy	Benefit to cost	Included in policy options
Ø1	Introduce standards for additional air pollutants	++ + + +	+ +/- +/-	+ -- +/-	-- --	+	**Low** but uncertain	**Policy option I-1, I-2, I-3** and **all sub-options**

Policy option I-5: Average exposure reduction

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B3	Revise definition of average exposure standards	(+) (+) (+) (+)	(+) 0 0	(+) 0 0	0 (-)	(+)	**High**	**Policy option I-5**

Policy option I-6: Review air quality standards

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A1	Introduce review triggered by scientific progress	++ (+) (+) +	(+) (+) 0	0 0 0	0 (-)	+	**High**	**Policy option I-6**
A3	Introduce option to notify stricter standards	(+) (+) (+) (+)	(+) 0 0	0 0 0	0 (-)	0	**High**	**Policy option I-6**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A2	Introduce review triggered by technical progress	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Low**	**Sub-option I-6a**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
A4	Introduce a list of priority pollutants	(+) (+) (+) (+)	0 0 0	0 0 0	0 --	0	**Low**	**Sub-option I-6b**

3.2 Policy options to address governance / enforcement shortcomings

Policy option II-1: Responses to exceedances

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B4	Introduce guidance on addressing exceedances	(+) (+) (+) (+)	0 0 0	0 0 0	0 (-)	(+)	**Medium**	**Policy option II-1**

C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium / High	**Policy option II-1** **Policy option II-4**
C3	Revise short-term action plans & air quality plans	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 -	0	Medium	**Policy option II-1**
D1	Revise requirements to involve stakeholders	(+) (+) (+) 0	0 0 0	0 0/- 0	0/- --	0	High	**Policy option II-1**
N1	Revise the information in air quality plans	++ + + (+)	(+) 0 0	(+) - 0	- --	+	High	**Policy option II-1**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
D2	Introduce a 'one zone, one plan' requirement	0 0 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub-option II-1a**

Policy option II-2: Additional limit values

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B1	Introduce additional short-term standards	+ 0 0 0	0 0 0	0 0 0	0 (-)	0	High	**Policy option II-2**
B5	Introduce limit values for additional air pollutants	++ + + +	+ 0 0	+ - 0	- (-)	0	Medium	**Policy option II-2**

Policy option II-3: Implementation timelines

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
B2	Introduce additional alert/information thresholds	+ + (+) (+)	+ 0 0	0 0 0	0 (-)	(+)	Medium	**Policy option II-3**
C2	Revise/clarify definition of 'as short as possible'	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium	**Policy option II-3**
C4	Introduce additional short-term action plans	+ +	+ (+)	(+) 0/-	0/-	(+)	Medium	**Policy option II-3**

		+ (+)	(-)	(-)	-			
C5	Introduce requirement to update air quality plans	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- ---	(+)	Medium	**Policy option II-3**

Policy option II-4: Enforcement tools

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
C1	Revise obligations triggered by exceedances	(+) (+) (+) (+)	0 (+) 0	(+) 0 0	0 --	(+)	Medium / High	**Policy option II-1** **Policy option II-4**
E1	Introduce minimum levels for financial penalties	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) (-)	(+)	Medium / High	**Policy option II-4**
E2	Introduce right to health damage compensation	(+) (+) (+) (+)	0 (+) 0	(+) - 0	- 0	(+)	Medium	**Policy option II-4**
E4	Introduce access to justice provision	(+) (+) (+) (+)	0 (+) 0	(+) (-) 0	(-) 0	0	High	**Policy option II-4**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
E3	Introduce a fund to be fed by penalties paid	0/(+) 0/(+) 0/(+) 0/(+)	0 (+) 0	0 0/(+) 0	0/+ (-)	0/(+)	Low	**Sub-option II-4a**

Policy option II-5: Transboundary air pollution

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
M1	Introduce methodology to assess transboundary	(+) (+) (+) (+)	0 0 0	0 0/(+) 0	0/(+) --	(+)	High	**Policy option II-5**
M2	Revise obligations for transboundary cooperation	(+) (+) (+) (+)	0 0 0	(+) - 0	- -	(+)	Medium	**Policy option II-5**

3.3 Policy options to address air quality monitoring / assessment shortcomings

Policy option III-1: Air quality assessments

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G1	Revise rules related to indicative sampling points	(+) (+) (+) 0	0 (+) 0	(+) 0 0	0 --- ---	0	High	**Policy option III-1**
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 --- ---	0	Medium / High	**Policy option III-1** and **Policy option III-5**
H1	Revise minimum number of sampling points	+ + + 0	0 0 0	+/- 0 0	0 --- ---	0	Medium	**Policy option III-1**
H2	Simplify combined $PM_{10}/PM_{2.5}$ monitoring	(+) (+) 0 0	0 0 0	(+) 0 0	0 --- ---	0	High	**Policy option III-1**
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 --- ---	0	Medium	**Policy option III-1** and **Policy option III-3**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G3	Revise rules for regular review of AQ assessment	0 0 0 0	0 0 0	0 0 0	0 (-)	0	Low	**Sub option III-1a**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
H3	Simplify the definitions of sampling points types	0 0 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub option III-1b**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 --	0	Low	**Sub option III-1c** and **Policy option IV-1**

+

	Policy Measure	Env.	Soc.	Eco.	Cost	Policy	Benefit	Included in policy

		impact	impact	impact		synergy	to cost	options
J3	Introduce obligation for spatial representativeness	(+) (+) (+) 0	(+) 0 0	(+) 0 0	0 ---	0	Medium	**Sub option III-3d**

Policy option III-2: Monitoring continuity

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I1	Introduce obligations to maintain sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 0	0	High	**Policy option III-2**
I3	Introduce a protocol for relocated sampling points	(+) 0 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option III-2**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
I2	Introduce obligations to monitor long-term trends	(+) (+) (+) 0	0 0 0	0 0 0	0 (-)	0	Low	**Sub-option III-2a**

Policy option III-3: Additional sampling points

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option III-3 Additional sampling points *(Measures L1, L2)*	++	0	+	--/---	Clarifies current levels of these air pollutants, as a requisite for verifying health effects and need for taking action. Costs related to the expansion of the monitoring network and adding 'super-sites'.	Medium
+ **III-3a**: Measure L3	+	0	0	--/---	Can only be a gross list of VOC – needed in law?	Low

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L1	Introduce concept of monitoring at 'super-sites'	(+) (+) (+) 0	0 0 0	(+) 0 0	0 ---	0	Medium	**Policy option III-1** and **Policy option III-3**
L2	Introduce obligations to monitor more pollutants	(+) (+) (+) (+)	0 0 0	(+) 0 0	0 ---	0	High	**Policy option III-3**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
L3	Revise list of VOC to monitor	(+) (+) (+) 0	0 0 0	0 0 0	0 ---	0	Low	**Policy option III-3a**

Policy option III-4: Monitoring data quality

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
J1	Revise macro-scale siting of sampling points	(+) (+) (+) 0	(+) 0 0	0 0 0	0 --	0	Medium	**Policy option III-4**
J2	Revise micro-scale siting of sampling points	(+) 0 0 0	(+) 0 0	(+) 0 0	0 --	0	Medium	**Policy option III-4**
K1	Revise AQ monitoring data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	Medium	**Policy option III-4**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
K4	Revise approach to AQ assessment uncertainty	(+) (+) (+) 0	0 0 0	0 0 0	0 --	0	Medium	**Sub option III-4a**

Policy option III-5: Modelling data quality

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
G2	Introduce requirements for AQ modelling	(+) (+) (+) 0	(+) (+) 0	0 0 0	0 ---	0	Medium / High	**Policy option III-1** and **Policy option III-5**
K3	Introduce AQ modelling data quality objectives	(+) (+) (+) 0	0 0 0	0 0 0	0 -	0	High	**Policy option III-5**

3.4 Policy options to address air quality information shortcomings

Policy option IV-1: Up-to-date air quality data

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F1	Revise provisions related to up-to-date data	0 (+) 0 0	(+) 0 0	0 0 0	0 ---	0	Medium / High	**Policy option IV-1**
K2	Introduce up-to-date data at all sampling points	0 (+) 0 0	0 0 0	0 0 0	0 ---	0	Low	**Sub option III-1c** and **Policy option IV-1**

Policy option IV-2: Health related air quality data

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

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F2	Introduce requirement to provide AQ health data	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option IV-2**

+

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options
F3	Introduce use of specific communication channels	0 0 0 0	(+/-) 0 0	0 0 0	0 ---	0	Low	**Sub-option IV-2a**

Policy option IV-3: Harmonised air quality indices

Policy option	Consequences / Impacts Env.	Soc.	Eco.	Cost	Assessment and key considerations	Benefit to cost
Policy option IV-3 Harmonised air quality indices *(Measure F4)*	+	+	0	-	Harmonisation of air quality data saves costs for developing and updating separate indices. Provides clarity for citizens across the EU.	Medium

	Policy Measure	Env. impact	Soc. impact	Eco. impact	Cost	Policy synergy	Benefit to cost	Included in policy options

F4	Introduce requirements for harmonised AQ index	0 (+) 0 0	(+) 0 0	0 0 0	0 -	0	Medium	**Policy option IV-3**

4. HOW DO THE OPTIONS COMPARE?

Policy option	Consequences / Impacts				Benefit to cost	Synergies, complementarities and trade-offs with other options and/or sub-options
	Env.	Soc.	Eco.	Cost		
I-1 Full alignment with WHO recommendations	+++	+++	+++	---	High but uncertain	**Consider** a variant of sub-option I-1a (i.e. more ambitious objectives in a post -2030 perspective). **Not** the preferred option for 2030 compared to I-2.
I-2 Closer alignment with WHO recommendations	++	++	++	--	High	**Preferred** option for air quality objectives for 2030. **Effectiveness** depends on policy option II-2 - [Discard sub-option I-2a]
I-3 Partial alignment with WHO recommendations	+	+	+	-	High	**Not** the preferred option for 2030 compared to I-2. - [Discard sub-option I-3a]
I-4 Additional air pollutants	0/+	+/-	+/-	-	Low but uncertain	**Efficiency** is higher discarding this policy option, but retaining monitoring of additional air pollutants via policy option III-4.
I-5 Average exposure reduction	++	+	+	-	High	**Add** complementary sub-option I-5b (NO_2), and consider a variant of sub-option I-5c (O_3) - [Discard sub-option I-51]
I-6 Review air quality standards	++	+	0	-	High	- [Discard sub-options I-6a, I-6b]
II-1 Responses to exceedances	++	+	+/-	--	Medium	- [Discard sub-option II-1a]
II-2 Additional limit values	++	+	+/-	-	High	**Proportionality** of this option also depends on whether policy option I-1, I-2, or I-3 is preferred.
II-3 Implementation timelines & revised short-term action plans	+	+	+/-	--	Medium	
II-4 Enforcement tools	++	+	+/-	0/-	High	**Consider** also complementary sub-option II-4a.
II-5 Transboundary air pollution	+	0	+/-	-	Medium	**Effectiveness and efficiency** depend on refined approaches to policy options II-4 and III-1
III-1 Air quality assessments	+	+	+	--	Medium	**Add** complementary sub-option III-1d to enhance effectiveness of this option. - [Discard sub-options III-1a, III-1b, III-1c]
III-2 Monitoring continuity	+	+	0	-	Medium	- [Discard: Sub-option III-2a]
III-3 Additional sampling points	++	0	+	--/---	Medium	- [Discard: Sub-option III-3a]
III-4 Monitoring data quality	+	+	0	--	Medium	**Add** complementary sub-option III-4a to enhance effectiveness of this option. **Efficiency** of monitoring requirement for additional pollutants is higher than standards (option I-4).
III-5 Modelling data quality	+	+	0	-/--	Medium	**Complements** option III-1.
IV-1 Up-to-date air quality data	+	+	0	-/--	Medium	**Efficiency** of this option **depends on** whether and how options III-1 and III-4 are defined.
IV-2 Health related air quality data	+	+	0	-	Medium	- [Discard: Sub-option IV-2a]
IV-3 Harmonised air quality indices	+	+	0	-	Medium	**Effectiveness depends on** options IV-1 and IV-2 being implemented also.