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PART 1/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and he Committee of the Regions a Clean Air Programme for Europe

Proposal for a Directive of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants

Proposal for a Directive of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants and amending Directive 2003/35/EC

Proposal for a Council Decision on the acceptance of the Amendment to the 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone

{COM(2013) 917 final}
{COM(2013) 918 final}
{COM(2013) 919 final}
{COM(2013) 920 final}
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Executive Summary Sheet

Impact assessment accompanying a revised EU Strategy on Air Pollution, a proposal for amending Directive 2001/81 on national emission ceilings for certain atmospheric pollutants, and a proposal for a Directive regulating air emissions from Medium Combustion Plants

A. Need for action

Why? What is the problem being addressed? Maximum 11 lines

Air pollution causes substantial environment and health impacts: in 2010 annual premature mortalities amounted to over 400,000 and 62% of the EU area was exposed to eutrophication, including 71% of Natura 2000 ecosystems. Total health-related external costs are in the range of € 330-940bn per year, including direct economic damages of €15bn from lost workdays, €4bn healthcare costs, €3bn crop yield loss and €1bn damage to buildings. Significant non-compliance with existing air quality standards and the EU's new international obligations (under the Gothenburg Protocol) prevent better protection of EU citizens and its environment. The number of zones not in compliance with PM_{10} and NO_2 standards amount to 32% and 24%; 40m citizens are still exposed to PM_{10} levels above the EU limit values.

What is this initiative expected to achieve? Maximum 8 lines

The new strategy is set to update the pathway towards its long-term objective of reaching air quality levels that do not cause significant impacts on human health and the environment. To do so, it will set out action for promoting full compliance with the present air quality legislation by 2020 at the latest, based also on the outcome of an extensive ex-post analysis that is an integral part of this initiative. It will set new objectives for reducing health and environment impacts in the EU for the period up to 2030. It will set out the EU's priorities to enable achieving the new objectives for that period. It will include a proposal for amending the National Emission Ceilings Directive and measures for improving pollution at source. The new strategy will further promote enhanced coherence with other policies, notably climate, energy, transport, and agriculture.

What is the value added of action at the EU level? Maximum 7 lines

Because of the persistent transboundary nature of air pollution, effective reduction at national level needs co-ordinated EU action: limits to total emissions from each Member State must take into account how its pollution will affect other Member States. EU-level source controls not only reduce the Member States' burden of pollution reduction but also deliver a level playing field for economic operators. Among these EU source controls, product controls (e.g. of vehicle emission or domestic heaters) can only be established at EU level for single market reasons.

B. Solutions

What legislative and non-legislative policy options have been considered? Is there a preferred choice or not? Why? Maximum 14 lines

Sustained implementation of existing legislation will substantially improve compliance by 2020 , reducing the problem to a few localized but densely populated areas (6% of zones for PM_{10} and 8% for NO_2). Five additional options were considered: additional source controls; tighter ceilings under the NECD; supporting action for further MSs measures; further international action; and amending the AAQD. The preferred option for achieving full compliance with the air quality legislation by 2020 comprises a non-regulatory programme supporting MS action including implementation of already agreed EU legislation as well as enhanced, governance, monitoring, and evaluations provisions. In addition the NECD will be revised to incorporate the EU's international commitments for 2020 under the Gothenburg Protocol (GP) as amended in 2012.

To make progress towards the EU's long-term objective during the period up to 2030, four options for strategic impact reduction targets were examined in terms of a 25%, 50%, 75% or 100% closing of the gap between the current legislation "baseline" scenario and the maximum technically feasible reduction scenario. A further option to meet the WHO guideline values was assessed but considered not within reach before 2030. The preferred option sets the next strategic objectives at the level where marginal costs and benefits are optimized (i.e. at 75% of the maximum reduction). The objectives will be implemented by further tightening of emission ceilings under the NECD for the periods 2025 and 2030. The main options considered for additional EU source measures to reinforce emission reductions were Medium Combustion Plants (MCPs), agriculture and international shipping. Source control of Medium Combustion Plants is at present the preferred policy option. It would deliver 10-20% of the required reduction for SO2, NOx and PM under the NECD leaving full flexibility to MS for the remaining reductions.

Who supports which option? Maximum 7 lines

The main focus of most stakeholders for immediate action was on effective implementation of existing source controls for diesel emissions. Over 90% of the general public and over 80% of governments and NGOs supported strengthened emission controls going beyond current legislation. For the NECD, most NGOs supported the maximum reduction, a majority of government respondents called for substantial progress, and around 45% of business supported no reduction beyond what would be achieved by the climate and energy package. For source controls, a majority of NGOs and over 40% of government and individual experts supported EU source legislation on MCPs. For agriculture, NGOs and individual experts favoured control through NEC ceilings, Member States through source legislation, and business through support from the Regional Development Fund.

C. Impacts of the preferred option

What are the benefits of the preferred option (if any, otherwise main ones)? Maximum 12 lines

The preferred policy for **2020** will support Member States in resolving remaining non-compliance with current legislation and ensure coherence with international commitments. External costs associated with air pollution will be further reduced to €249-783bn. A fully implemented baseline will reduce impacts in 2020 by 36% for $PM_{2,5}$, 23% for ozone, 17% for eutrophication and 61% for acidification, compared with 2005. The preferred option for **2025-30** will reduce impacts by 50% for $PM_{2,5}$, 33% for ozone, 35% for eutrophication and 85% for acidification (relative to 2005) – i.e. an extra third of the reduction in health burden delivered by the baseline. Total external costs of air pollution will be reduced by a further €45bn (on the most conservative valuation) or ten times the compliance cost (see below). Eutrophication impacts will be reduced by 70% more than the baseline. Direct economic benefits include reduced labour productivity losses over the baseline of €2bn, reduced health care costs of €650m, reduced crop value losses of €270m, and reduced damage to the built environment of €140m. Once productivity improvements are taken into account, the policy would add around 110 thousand jobs.

What are the costs of the preferred option (if any, otherwise main ones)? Maximum 12 lines

The preferred option for **2020** entails no additional EU expenditure over the baseline except for the costs of supporting measures for national action (around €100m from LIFE). Complementary action at MS level could include low emission zones to tackle transport pollution, and for PM, accelerated replacement schemes for domestic heating appliances, restrictions on coal combustion and finance for fuel switching. Member States' costs will depend on local circumstances and can be covered in part by improved uptake of structural funds. Meeting the preferred policy objectives for **2025-30** implies annual compliance costs of €4,8bn (including investment, operating and maintenance costs for new abatement techniques as well as administrative costs also including MCP). The resulting overall GDP impact is neutral once increased productivity is taken into account, and turns to positive considering other direct benefits (reduced expenditure on healthcare and on compensating crop losses and damage to built environment).

How will businesses, SMEs and micro-enterprises be affected? Maximum 8 lines

The overall impact on the economy is fairly neutral although respective sectoral impacts can differ. Some sectors supplying pollution abatement equipment or benefitting from labour productivity will slightly gain during the period up to 2030 whilst agriculture and other sectors may be impacted more than others. Net impacts on agriculture and refineries amount to 0,21% and 0,09% once improved productivity is taken into account. Costs for the agricultural sector are further offset by reverting crop yield loss amounting to €270m, in the order of 0,1% of sectorial output. Most SME impacts would be expected in MCP and agriculture. Impacts are mostly mitigated in the preferred MCP control option (between 0.1 and 2% of gross operating surplus) by selecting a registration rather than a permitting requirement and emphasizing primary NOx control as the minimum standard.

Will there be significant impacts on national budgets and administrations? Maximum 4 lines

Administrative costs associated with amending the NECD include a one-off €6,9m and €2.5m annual cost. No significant impact is foreseen for controlling of MCPs.

Will there be other significant impacts? Max 6 lines

No; all principal impacts are covered above.

D. Follow up

When will the policy be reviewed? Maximum 4 lines
A five-year policy review cycle is considered appropriate with the first review taking place not later than 2020 at which time the scope for tightening the air quality standards under the Ambient Air Quality Directive will also be considered.

1. INTRODUCTION

This impact assessment comprises the outcome of the review of the EU Air Quality Policy Framework. It includes the outcome of a full ex-post analysis and offers the analytical basis for updating the EU's strategy on air pollution and the development of accompanying legal proposals and non-regulatory actions.

Chapter 2 sums up procedural issues and the consultation of interested parties. Details are provided in Annex 2. Chapter 3 and Annexes 3 and 4 set out the conclusions of the evaluation of existing policy on the policy's performance, the problem definition and the basic rationale for further action. The detailed analysis of the evolution of the problems for the period up to 2030 assuming no change in policy are provided in Annex 5. Chapter 4 describes the two general policy objectives derived from the problem analysis: 1) to deliver the full impact reductions envisaged by the existing air policy framework (by resolving the current non-compliance), and 2) to set out objectives and actions for further reducing impacts for the period up to 2030.

The remaining part of the impact assessment report is organised so as to facilitate the reading of a rather complex analysis. Thus, in a slight departure from the normal impact assessment structure, Chapter 5 presents the options, impact analysis, and comparison of options in pursuit of the first objective focusing mainly on the period up to 2020. Details are provided in Annex 6. Chapter 6 then considers the options, analysis, and comparison related to the second objective with a time horizon up to 2030, in line with the Commission's overall Europe 2020 strategy and related flagship initiatives. Analytical details, including sensitivity and competitiveness analysis are provided in Annexes 7, 8, 9, 10, and 11. Chapter 7 and annex 12 provide further details on the additional impact analysis carried out for the first additional source control measure identified, i.e. controlling emissions from medium combustion plants (MCP). Chapter 8 summarises the conclusions emerging from the analysis whilst monitoring and evaluation issues are considered in Chapter 9. A glossary is provided in Annex 1 and Annex 13 lists all references used in the analysis.

2. PROCEDURAL ISSUES, IMPACT ASSESSMENT BOARD, USE OF EXPERTISE AND CONSULTATION OF INTERESTED PARTIES

2.1. Procedural issues

Lead DG: DG ENV
Agenda planning /WP reference: 2013/ENV/001
Impact assessment steering group (IASG)
The impact assessment work was followed by a European Commission Inter-Service Steering Group (ISG) set up by DG ENV which met six times between June 2012 and May 2013. The following Directorates-General (DGs) of the European Commission participated in the work of the group: DG AGRI, DG CLIMA, DG ENER, DG ENTR, DG JRC, DG SANCO, Secretariat-General (SG), DG RTD, and the European Environment Agency (EEA).

2.2. Impact Assessment Board

The draft IA report was submitted to the Board on 5th June 2013 and discussed at the Board meeting 3rd July 2013. Following the ensuing IAB opinion a number of amendments were made in the final version of the IA report. In particular, the following main changes were made:

- the problem analysis and underlying evidence were more clearly brought out by annexing an extended report on the ex-post evaluation of the existing policy framework (Annex 4).
- The scope of the package was better explained by making the links with existing policy instruments clearer, and by including an additional separate chapter (Chapter 7) explaining the necessity and expected impacts of the MCP inititive.
- The costs and benefits of options for the period up to 2020 were set out in more concrete terms in Chapter 5, by including additional quantitative analysis and data in tabular form.
- Monitoring and evaluation arrangements were further detailed and clearly presented also in tabular form
- Procedure- and presentation-wise, stakeholder views were more extensively and precisely presented throughout the text, in particular in chapters 3 and 5. A literature list was annexed to the IA report.

The IA report was resubmitted to the Board on 7th August 2013; the Board issued a revised opinion on 7th September 2013, following which additional amendments were made to the IA report. The main ones are:

- The relationship between the Package and the upcoming Climate and Energy policy framework was clarified by strengthening the analysis of Annex 8 (sensitivity analyses) and updating and strengthening the analysis on methane emission reductions (Chapter 6.5.5 and Annex10). Additional sensitivity analysis on the feasibility of NECD ceilings in case of slower implementation of the renewables and energy efficiency targets was included;
- The link between the Package and ongoing and possible additional initiatives to reduce emissions from international maritime shipping was clarified and reinforced by strengthening the analysis of benefits of designating Emission Control Areas under Marpol Annex VI rules, and by examining possible voluntary offset schemes under the NECD;
- The link with the long-term air quality objectives was strengthened by presenting a feasible trajectory to bridge the interim targets in the medium term with the 2050 targets (Chapter 6.8 and Annex 7.4);
- A thorough update of all figures was made, taking into account the most recent PRIMES 2013 energy projections. Note that this resulted in only minor quantitative modifications and did not change the validity of the previous analysis and conclusions;
- Procedure- and presentation-wise, more precise references to specific sections of the Annexes have been introduced throughout the text.

2.3. Use of Expertise and Consultation of interested parties

The review process drew on expertise built up over several decades of air quality assessments, management and review activities in the EU and internationally. This impact assessment has been prepared on that basis and complemented with several targeted studies prepared by the EEA, JRC, WHO, IIASA, and other leading experts and scientists. Consulted parties included Member State authorities responsible for the implementation of the current policy framework at all administrative levels. Five stakeholder meetings were held between June 2011 and April 2013 to ensure transparency and offer opportunities for stakeholder comments and inputs. All meetings were web-streamed to enable the broadest possible participation. In parallel, two public consultations were organised: a first consultation of competent authorities and other stakeholders at the end of 2011 focused on the evaluation of the strengths and weaknesses of the existing air quality policy framework; the second (and mandatory) on-line public consultation of all stakeholders on the main policy options available to address the remaining air quality problems ran from 10 December 2012 until 4 March 2013 (12 weeks) on the 'Your voice in Europe' web page.[1] A Eurobarometer survey seeking the view of the general public on air pollution issues was conducted and reported in 2012.[2] The Commission and the EEA also conducted an Air Implementation Pilot project, bringing together 12 cities from across the EU to assess local experience with implementing the air policy framework.[3]

Annex 2 sets out in detail the expertise and analysis used to develop the impact assessment, the procedures for consultation of interested parties, and the feedback from the consultations by main theme. The main messages from the stakeholder consultation are integrated throughout the text.

3. REVIEW OF CURRENT POLICY, PROBLEM DEFINITION AND SUBSIDIARITY

3.1. The air pollution problem and the policy framework under review

3.1.1. The problem

Air pollution causes substantial environment and health impacts. In 2010, annual premature mortalities amounted to over 400000 and 62% of the EU area was exposed to eutrophication, including 71% of Natura 2000 ecosystems. Total external costs of the health impacts are in the range €330-940bn (depending on whether the low or high range of possible impact valuations is taken). Direct economic damage includes €15bn from lost workdays, €4bn healthcare costs, €3bn crop yield loss and €1bn damage to buildings. Annex 3 provides a summary of the main air pollution impacts, pathways, and sources.

3.1.2. The current policy framework

EU air policy developed from the 1980s[4], building on national and international efforts at pollution control, in particular the 1979 Convention on Long Range Transboundary Air Pollution (CLRTAP) which developed a multi-pollutant and multi-effect approach to tackle the range of air pollution problems. The policy has been substantially reinforced and consolidated since. The 6th Environment Action Programme (6EAP) adopted in 2002 by the Council and European Parliament established a common EU long-term objective for air quality: *to achieve 'levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment'*[5] (confirmed in the new General Union Environment Action Programme to 2020 a.k.a. the "7th EAP"[6]). It also called on the Commission to establish a Thematic Strategy on Air Pollution that would define the pathway towards achieving this objective through integrated actions in relevant policy areas. Since then, the current EU air policy framework comprises the following main elements:

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1 The consultation used two questionnaires: a total of 1934 individuals responded to a shorter questionnaire for the general public; for the longer questionnaire for experts and stakeholders, 371 responses were received. See http://ec.europa.eu/environment/consultations/air_pollution_en.htm

2 Results are available in Eurobarometer 2013.

3 For full results see EEA 2013B.

4 The first EU air quality directives and emission controls were established in 1980 for SO2 and suspended particles, in Directive 80/779/EC.

5 Article 7(1) of Decision N° 1600/2002/EC of the European Parliament and of the Council laying down the Sixth Community Environmental Action Programme. OJ L 242, 10.9.2002, p. 1.

6 Recital 13 of the Codecision on the General Union Action Programme (to be published).

(i) The 2005 Thematic Strategy on Air Pollution (TSAP) which sets out the overall policy direction that emerged from the 2000-2004 review of air policy, including interim objectives for 2020 towards the EU's long-term target and cost-effective actions to achieve those objectives while promotes overall policy coherence;

(ii) The Ambient Air Quality Directives (AAQDs) which set ambient concentrations for a range of parameters to be achieved everywhere in the EU and defines the minimum standards for assessing and managing air quality in the EU Member States;

(iii) The National Emission Ceilings Directive (NECD) which limits the total emissions from each Member State for a set of pollutants; and

(iv) A range of measures at EU, national and international level controlling pollution at the source to achieve the objectives set in the above mentioned instruments.

(v) International action under the CLRTAP and other international platforms, including the exchange of scientific and technical information that continue to provide an important backbone for the EU air policy framework.

These main elements of the framework have been subject to an extensive ex-post review. Annex 4 sets out in detail the procedural issues and the analysis of the relevance, effectiveness, efficiency and coherence of the principal instruments. The main conclusions and follow up options are set out in the next three sections and further taken up in the following chapters.

3.2. Review of the current policy framework

3.2.1. Past reduction of air pollutant emissions and impacts

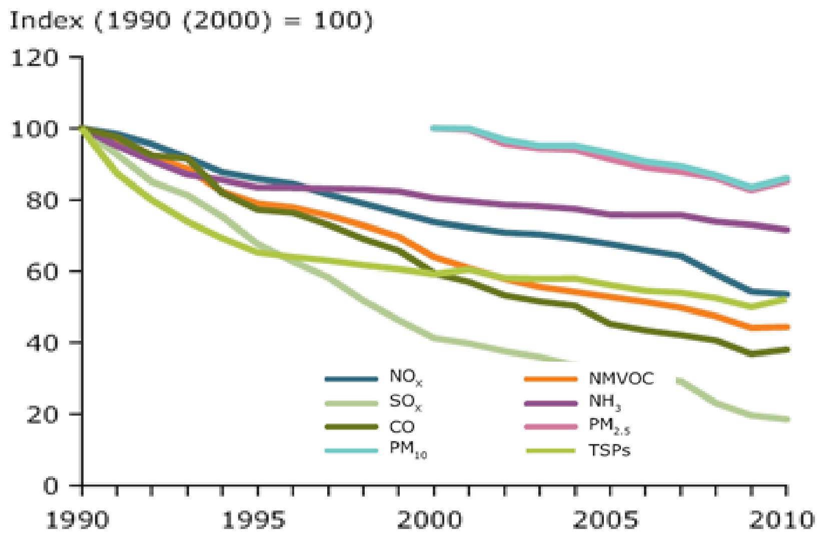
The current policy framework already allowed to significantly reduce air pollutant emissions and impacts. Figure 1 illustrates the substantial reduction in EU-wide emissions of the main pollutants delivered by policy between 1990 and 2010. In consequence the EU's huge acid rain (acidification) problem has been broadly solved[7], the impact of lead from vehicle fuels has been eliminated, and the ambient air health risk from other heavy metals and carbon monoxide has been greatly reduced. The health impacts of particulate matter, the main cause of death from air pollution, have been reduced by around 20% between 2000 and 2010 (see Annex 4 chapter 3 for details).

Action leading to these successes has been cost-effective, i.e. largely focusing on the most important sectors contributing to air pollution impacts in accordance with the polluter pays principle. It has stimulated innovation in pollution abatement techniques and radically improved the environmental performance of key production sectors, addressed the increase environmental concerns of consumers, and safeguarded markets without distorting competition or impairing economic growth. [8]

7 The emission reductions were triggered by EU legislation on sulphur emissions from large combustion plants (LCPs), and to the low sulphur road transport fuel requirements that also enabled the use of catalytic converters from Euro 4 onwards.

8 A fair proxy for the overall economic activity induced is the €60 billion annualised investment expenditure associated with air pollution management. Total air pollution control costs in 2010 as estimated in TSAP Report #10, March 2013.

Figure 1: EU air pollutant emissions 1990-2010 (EEA, 2012)



Despite the progress, however, the health and environmental impacts of air pollution in the EU remain large. The key outstanding health and environmental problems are set out in section 3.3.

3.2.2. Validity of objectives and scope, and overall coherence

The review has confirmed that the overall structure of air quality policy is logical and coherent. However, a better match must be ensured (in practical implementation) between source controls, ceilings and ambient air quality standards. This is required in particular to ensure that local achievement of ambient air quality standards is not compromised by (a) failure to limit pollution from significant point sources or from products,[9] or (b) high background concentrations resulting from the overall (Member State or transboundary) emission burden. The review examined for each individual policy instrument the extent to which its objectives and scope remain valid:

- For the Thematic Strategy, the underlying analytical framework remains valid for the current review, although some improvements are identified. The impacts identified in 2005 remain the priorities today (with the exception of acidification); an updated review should focus on the scope for further reducing these in the period up to 2030 (beyond which the uncertainties in the analysis become large). It should also focus on greater coherence across the range of policy instruments (including untapped synergies between the AAQD and the NECD).[10]
- For the Ambient Air Quality Directives, the health relevance of the pollutants and standards of the original policy has been reviewed by WHO, and confirmed, with the caveat that the level at which certain standards are currently set (mainly for PM) provides only incomplete protection for human health. As compared with 2005 there is additional evidence on the chronic impacts of ozone and NO2, which reinforces the rationale for the respective standards.[11]
- The scope and objectives of the NEC Directive are out of line with the latest scientific findings and international agreements. The NECD must be adapted to focus better on

9 For instance the issue of real-world emissions from light-duty diesel vehicles – see section 3.4.1.1 for details.

10 Annex 4 section 3.

11 Annex 4 section 4

health by introducing a ceiling for PM2.5, and on short-lived climate pollutants (black carbon and methane) in line with the 2012 amendment of the Gothenburg Protocol. Objectives must be extended to 2020 to fulfil the Gothenburg requirements, and strengthened for the period 2025-30 to deliver further reductions in background pollution to enable levels of air quality that are closer to those recommended by the WHO and CLRTAP .[12]

- For the EU source controls the scope and objectives also remain broadly valid. Updated emissions data and projections confirm that the sectors driving the relevant pollutant emissions were correctly identified. In the short term, the main priority is the full implementation of the existing legislation and in particular the resolution of the real world emissions issue for light duty diesel vehicles. In the longer term the main gaps relate to combustion from small and medium installations, and ammonia emissions from agriculture.[13]
- The scope, objectives, and coherence of international action under the CLRTAP remain relevant to co-ordinate action in the northern hemisphere on the key air quality drivers. The recently amended Gothenburg Protocol usefully extended the scope to include action on short-lived climate pollutants (notably black carbon), and flexibility has increased thereby also enabling a broader participation. Further action should focus on facilitating ratification by Eastern European and Central Asian Countries, action on short-lived climate pollutants (including also ozone) and extended exchange of scientific and technical co-operation with other regional groups notably in Asia and North America.[14]

80% of stakeholders considered that the current air policy framework is appropriate. The 6th EAP, TSAP and AAQDs are consistent and have substantially helped minimising health and environmental risks by air pollution, supporting policy makers in EU Member States. However, stakeholders commented that the coherence between air quality standards and emission ceilings and sectoral legislation should be improved.[15]

3.3. Key outstanding problems

Based on the above analysis, the following main outstanding problems have been identified.

3.3.1. Health and environmental impacts of air pollution in the EU remain large

Table 1 and Figure 2 summarize the state of play for certain headline air pollution impacts.

Air pollution is the number one environmental cause of death in the EU, responsible for 406,000 premature deaths, ten times more than from road traffic accidents.[16] In addition to premature mortality there are also substantial quality-of-life impacts (well-being and morbidity), ranging from asthma to exacerbation of cardiovascular symptoms. Health-related external costs range between €330 billion and €940 billion per year depending on the valuation methodology.[17] New evidence on the impacts of chronic ozone exposure would add around 5% to this total.[18]

12 Annex 4 section 5.
13 Annex 4 section 6.
14 Annex 4 section 8.
15 Report of the first public consultation, Part 1, p37. Available on: http://ec.europa.eu/environment/air/pdf/review/Survey%20AQD%20review%20-%20Part%20I%20Main%20results.pdf.
16 EUROSTAT statistics report the number of traffic fatalities in the range of 35,000 for EU 27 in 2010.
17 Annex 4 Section 3.5.
18 EMRC 2013

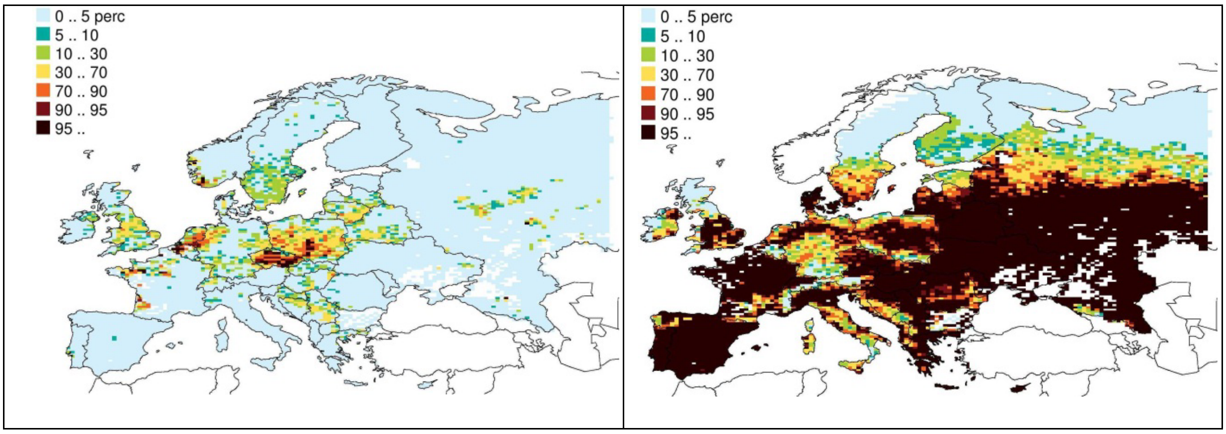
These costs include the impact of ill-health on those citizens who experience it, but also the direct cost to the economy. Air pollution causes more than 100 million workdays lost per year across Europe, with an economic damage in the range of €15 billion due to productivity losses. Although a full quantification remains challenging, it is estimated that increased healthcare costs of the order of €4 billion are incurred every year for the treatment of air-pollution-related chronic bronchitis alone, with total costs likely to be substantially higher.

Table 1: Health and ecosystem impacts of air pollution in 2010

Premature deaths due to PM and ozone	Restricted activity days due to PM[19]	Forest area exceeding acidification limits[20]	Lake area exceeding acidification limits	Ecosystem area exceeding eutrophication limits[21]	Natura 2000 areas exceeding eutrophication limits
406,000	569 Million	9%	25%	62%	71%

For ecosystems the contrast between the broadly solved problem of acid rain and the outstanding problem of eutrophication is clear from Figure 2.[22] This has substantial biodiversity and also economic impacts (e.g. from damaged fish populations). The eutrophication problem is very widespread but particularly acute in Natura 2000 protected areas, threatening more than three-quarters of sites and so jeopardising the €200-300bn annual benefits from the Natura 2000 network.[23] The tourism sector is affected by the resulting loss of amenity and recreational value of the natural landscape.

Figure 2: Percentage of ecosystems in each area at risk of acidification (left hand) and eutrophication (right hand)



Further direct economic damage includes damage to the built environment due to acid erosion and soot soiling is estimated at above €500 million annually. (This does not include damage to cultural heritage which is assumed to be substantially higher, but is hard to quantify in the absence of an accurate valuation of the existing stock.) Finally, ozone affects vegetation in addition to its significant

19 Including work loss days, asthma symptom days

20 Percentage of EU ecosystem area exceeding so-called critical loads for acidification (maximum sustainable annual deposition of acidifying pollutants).

21 Percentage of EU ecosystem area exceeding critical loads for eutrophication.

22 Eutrophication is the disturbance of an ecosystem's balance by nutrient pollution, which causes some species to multiply rapidly and choke out others.

23 http://ec.europa.eu/environment/nature/natura2000/financing/docs/Economic%20Benefits%20Factsheet.pdf

health impacts, and the resulting crop productivity loss in the EU is valued at €3 billion per year (source: EMRC 2013).

There are two specific problems related to these substantive impacts, as follows.

3.3.2. EU air quality standards are widely exceeded in densely-populated areas

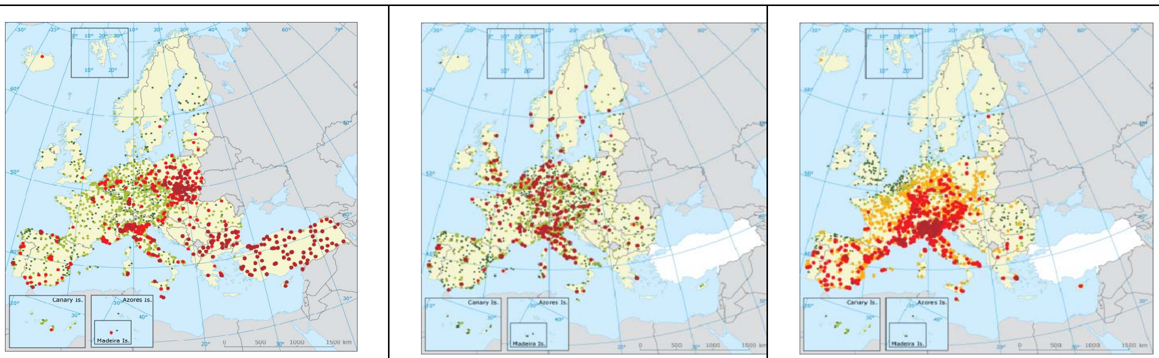
Part of the outstanding health and environment problem is due to the lack of compliance with existing EU legislation. Table 2 shows the situation for the AAQD[24]. For the NECD the current rate of compliance with the ceilings is 90%.[25]

Table 2: Compliance with AAQD obligations in 2010

PM10 compliance[26]	NO2 compliance[27]	O3 attainment	PM10 population exposed above the limit value[28]	NO2 population exposed above the limit value[29]	O3 population exposed above the target value
68%	76%	65%	40%	6-12%	35%

Whilst broad compliance has been reached for a number of key pollutants, standards for PM10, NO2, and ozone are widely exceeded throughout Europe (Figure 3). This leaves a substantial part of the EU population and environment exposed to harmful pollution levels.[30] Hence, 17 Member States are currently facing infringement procedures for failing to meet PM limit values, and further action on NO2 and NOx is likely to follow. More detail on the compliance situation with the main legal instruments is given in Section 3.5.2 and Annex 4.

Figure 3: Exceedance of EU air quality standards in 2010 for PM10 (left), NO2 (centre), and Ozone (right) in 2010 (EEA)



Dots represent monitoring stations; green indicates compliance with the standards, red exceedance.

[24] Note that 2010 was a meteorologically favourable year; preliminary indications are that population exposure will be higher (around 50%) in 2011.

[25] Percentage of the 108 ceilings under the National Emission Ceilings Directive which are complied with.

[26] Percentage of air quality management zones in compliance with the PM limit value.

[27] Percentage of air quality management zones in compliance with the NO2 limit value.

[28] Percentage of the population (source IIASA modelling) living in zones in exceedance.

[29] Percentage of urban population (source EEA, Air Quality in Europe Report). Note that NO2 exceedances are largely driven by traffic emissions, and therefore closely related to roadside impacts.

[30] A comprehensive overview of the state of air quality in the EU is found in the EEA's Annual Air Quality in Europe Report for 2012, available at http://www.eea.europa.eu/publications/air-quality-in-europe-2012.

Many stakeholders commented on the difficulty of attaining the standards, for reasons at times beyond the control of local/regional/national authorities. They highlighted a number of potential causes which are taken up in the next section, on problem drivers.[31]

In this context it should be noted that, following the 2012 amendment of the Gothenburg Protocol, the NECD is no longer compatible with the EU's international commitments, in particular the new emission reduction objectives established for 2020[32] and the new objective for primary PM emissions. While baseline projections show that the obligations should be met without further measures,[33] formal transposition into the NECD is necessary for ratification, to confirm the EU's commitment to the Gothenburg outcome and to encourage ratification and implementation by other parties.[34]

3.3.3. The EU is not on track to meet its long-term air quality objective

Compliance would bring significant health and environmental benefits, but it would not solve the substantial outstanding health and environmental problems beyond 2020, because the standards were set as interim objectives rather than at the low impact levels recommended by the WHO and other scientific bodies. Table 3 below shows current EU standards compared with the WHO 2005 guidelines.

Table 3: Comparison of selected EU Air Quality Standards with WHO 2005 guidelines

	PM10	PM2.5	NO2	O3
EU	40	25	40	120
WHO	20	10	40	100

Note: Figures are expressed as concentrations in µg/m^3 averaged over one year (with the exception of ozone which is averaged over 8 hours).

Similarly, on the emission side, while the additional reduction commitments agreed in the Gothenburg Protocol will make progress towards the interim objectives of the 2005 TSAP, they will not achieve them. Without further action there will be no further progress towards the EU's long-term objective of no significant adverse impacts on human health and the environment.[35]

Most stakeholders highlighted that the objectives of the 6th EAP, and the interim objectives of the TSAP, have not been attained, and that significant impacts remain for health, biodiversity, and eutrophication. Roughly equal proportions advocated on the one hand, further action to address this (including setting limits at the level of WHO guidelines), and on the other, caution in developing new policy and the need to minimise adverse economic impacts.[36]

31 Report of first consultation, p24. Op cit.

33 Annex 4 section 5.3.
34 Including Eastern European, Caucasus and Central Asian (EECCA) states.
35 Annex 4 section 3.4 shows that the baseline (which will achieve the Gothenburg reductions) will not achieve the TSAP 2005 objectives. Those objectives in turn were simply interim milestones towards the long-term objective.
36 Report of first public consultation, pp18-19. Op cit.

3.4. The main underlying drivers or causes of the outstanding problem

The main drivers are summarised below for each problem in turn.[37] They relate partly to the pollution sources themselves, and partly to the failure to manage air quality effectively and efficiently ("governance issues").

3.4.1. Exceedance of EU air quality standards

For the non-compliance issue a short-term perspective is appropriate, i.e. up to 2020, also considering that most existing standards had to be attained in 2010. Two main pollutant-related drivers have been identified.

3.4.1.1. Diesel emissions drive the NO2 and NOx compliance problems

Type-approval emission requirements for motor vehicles have been tightened significantly through the introduction and subsequent revision of Euro standards. While vehicles in general have delivered substantial emission reductions across the range of regulated pollutants, this is not true of NOx emissions from diesel engines (especially light-duty vehicles). While this has been observed for several years, many Member States continue to promote the sale and use of diesel vehicles compared to gasoline and other cleaner fuel vehicles. Sustained high levels of NOx emissions and NO2 concentrations are particularly related to these emissions and the associated AAQD and NECD compliance issues.

The problem is due in part to the poor representativeness of the standardised test cycle used for type approval in the EU[38] and weaknesses of in-service conformity testing.[39] Under the current regime an engine type has to meet the type-approval requirements when tested according to the test cycle, but under normal driving conditions the real emissions can be much higher.

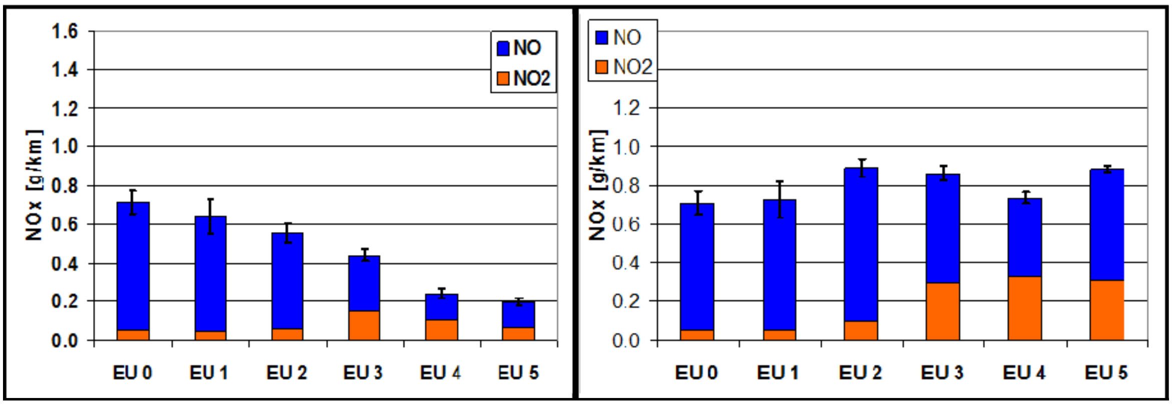
Figure 4 shows that while the NOx emission limit values for diesel passenger cars have been tightened by approximately a factor of 4 from 1993 to 2009 (Euro 1 to Euro 5), the estimated average NOx emissions in real driving conditions have slightly increased. As a side-effect of engine technology developments, the share of direct NO2 emissions in the NOx mixture has increased at the same time, posing additional challenges for the attainment of the NO2 air quality standards.

[37] Annex 3 presents the drivers and causes of air pollution in general. The detailed evaluation in Annex 4 identifies the specific causes and drivers set out here (see in particular the summary in Section 10.3 of Annex 4).

[38] The New European Driving Cycle (NEDC).

[39] In addition to the intrinsic weakness of the NEDC, some vehicles seem to be designed to respect the limits only when tested on this cycle. Moreover, there is increasing evidence of illegal practices by some end users that defeat the anti-pollution systems to improve driving performance or save on the replacement of costly components.

Figure 4: type approval (left) and real-world emissions (right) from diesel light duty vehicles across Euro standards (source: COPERT analysis and IIASA[40])



The consequences of the less than hoped for effects of the vehicle standards relating to diesel passenger cars and light-duty vehicles have been exacerbated by national taxation policies favouring diesels and increasing traffic volumes in urban areas (see also governance issues)[41].

Two-thirds of stakeholders identified the need to ensure consistency between real world emission reductions and the air quality limit values as a key issue. In particular, the implementation of Euro 6 should be managed so as to ensure proper control of real-world emissions from light-duty diesels.[42]

3.4.1.2. Small scale combustion and concentrated local pollution drive the worst PM compliance problems

The zones not in compliance with the PM10 standard fall into two categories. For the first category (around 39% of zones) the margin of exceedance over the limit value is limited,[43] and the exceedances are the compound effect of a wide range of sources, including traffic (notably older diesel engines, both heavy- and light-duty), industrial sources, power production and background concentrations including also secondary aerosols.

The problems in the remaining 6% of zones are more intractable and are driven by two issues in particular: (a) domestic solid fuel combustion, and (b) concentrated local pollution sources, sometimes combined with a particular topography. The domestic solid fuel problem is localised in particular geographical areas (the area at the border between Poland, the Czech and Slovak Republic, and Bulgaria). While EU action on the marketing and use of combustion appliances (under Ecodesign[44]) will have an impact over time, the replacement rate of those appliances is slow and open fireplaces will not be covered. Member States can tackle the problem directly by restricting solid fuel use, but the areas in question are relatively poor and the socio-economic impact of the restrictions is a deterrent.

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40 https://circabc.europa.eu/sd/d/2f169597-2413-44e2-a42c-35bbbde6c315/TSAP-TRANSPORT-v2-20121128.pdf

41 See also OECD, 2013

42 Report of first stakeholder consultation, p22. Op cit.

43 Of the order of around 10µg/m3.

44 Principally implementing regulations for solid fuel and biomass boilers (Lot 15).

Concentrated local pollution sources are a problem mainly in large urban centres which are usually densely-populated, making the resulting health impacts particularly significant.[45] Improved EU source controls will reduce the pollution per unit activity, but the effects of the concentration of activity must be managed by the Member State or region, also to ensure that the economic benefits are not compromised by adverse health impacts.

The role of domestic combustion in the outstanding PM compliance issues was stressed by national competent authorities in the PM workshop organised by the Commission on 18-19 June 2012.[46] The role of biomass combustion in particular, and the need to manage the interaction with climate policy on this topic, was raised by 50% of stakeholders in the first public consultation.[47]

3.4.1.3. Poor co-ordination between national and local action, and lack of capacity at regional and local level

In addition to the above pollutant-specific drivers, a set of governance-related issues have been identified. Evidence from the Time Extension Notification (TEN)[48] process shows that authorities often acted late in relation to the lead time necessary to bring air pollution down, with many plans and programmes developed only as the compliance deadlines approached and not fully implemented in practice. In many cases responsibility for meeting ambient air quality standards rests at regional and/or local level, but the financial and other tools to meet those responsibilities are often lacking. There have also been insufficient platforms to enable exchange of good practice and co-ordinated action across local areas. A further issue is lack of coordination between the national authorities mainly responsible for the NECD national programmes, and the regional and city authorities responsible for the AAQD action plans, to optimise joint compliance with the two instruments.

The Air Implementation Pilot (box below) confirmed the need to better support local authorities. It also confirmed that part of the reasons for delayed or insufficient action is lack of the assessment and management capacity to develop, implement and monitor plans. (For instance, local authorities have been unable to design effective air quality plans because no adequate inventories of the contributing local sources have ever been developed.[49] The lack of common guidelines for establishing local emission inventories and for undertaking local or regional integrated assessments has hampered comparison and exchange of good practice across local authorities.)

Twelve local and regional authorities participated in the joint Commission/EEA Air Implementation Pilot project which ran over 2012 and the first half of 2013. They identified the above as the key governance issues facing them,[50] reinforcing similar conclusions from the first public consultation.[51]

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45 Some of the main population centres in Europe remain in non-compliance, e.g. Milan, Madrid, Barcelona and London.

46 See report, 'PM workshop Brussels 18-19 June 2012', TNO 2012, p22.

47 Report of first public consultation, p23. Op cit.

48 The possibility under Directive 2008/50/EC (Article 22) for Member States to notify a postponement of the attainment deadlines for particulate matter (PM10), nitrogen dioxide and benzene, under certain conditions and subject to approval by the Commission.

49 In some cases, capacity has been further reduced in the wake of the economic crisis, including at the national level.

50 EEA Report No 7/2013, 'Air Implementation Pilot', pp6-7. Available on http://www.eea.europa.eu/publications/air-implementation-pilot-2013.

3.4.2. *The EU is not on track to meet its long-term air quality objective*

Even if compliance with current legislation is reached, major health and environment impacts will remain. Projections show that there will still be 340.000 premature deaths every year due to PM2.5 and ozone, and 55% of EU ecosystems will be affected by eutrophication. For these issues, three further pollution drivers and a further governance issue have been identified. These are particularly relevant for the period beyond 2020.

3.4.2.1. *The remaining health impacts from PM and ozone are driven by emissions from a range of sectors*

It is not possible to single out a particular sector as the driver of the remaining health impacts. All the main regulated pollutants are precursors of either particulate matter or ozone (or both); and every sector emits one or other of these pollutants. Thus a wide range of sectors must be addressed in order to resolve the problem. Additional effort may be required even of sectors which have been effectively regulated, such as power generation, transport, energy-intensive industries and waste management. But the potential for cost-effective reductions is greater from those sectors whose emissions have reduced less, and which now represent a larger relative share of the problem.

Among these, the emissions of combustion installations below 50MW, non-road mobile machinery[52] (including rail, inland waterway vessels and construction equipment), and the international shipping sector[53] are important. Increased biomass burning in small and medium combustion installations is already causing a worsening of PM (and carcinogenic PaH) emissions, and unless controls are put in place the trend could worsen if biomass uptake is promoted by climate and energy policies. SO2 emissions from maritime transport are set to reduce significantly following the revision of the Directive on sulphur content of marine fuels,[54] but engine-related PM and NOx emissions from vessels will continue to affect air quality levels in the EU unless further action is taken.

Agriculture now contributes substantially to PM concentrations, both through direct particle emissions and through emissions of ammonia which is an important PM precursor. Also, methane emissions from the agricultural sector contribute to ozone.

Around half of stakeholders singled out the need for reinforced source controls on a range of sectors, including (but not limited to) agriculture (NH3 limit value), emission standards for biomass burning in small (household) units, non-road mobile machinery, and (maritime) shipping.[55]

3.4.2.2. *Agricultural ammonia emissions drive the remaining environmental impacts*

Agriculture is responsible for 90% of the remaining ammonia emissions and is the primary driver of eutrophication in Europe; through the formation of secondary aerosols, ammonia emissions are also responsible for an increasing share of health impacts due to PM. There is a large untapped potential to achieve significant and cost-effective ammonia reductions (around 30% for 2025), and many of the

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51 See 'Air quality assessment', p28, 'Air Quality Management', p31, and 'Issues regarding governance', p33, in report of first public consultation. Op. cit.

52 Note that the ongoing revision of the Non-Road Mobile Machinery may already address the problem to a certain extent.

53 Emissions from maritime transport in EU seas were in 2005 equal to 25% of all EU land-based NOx emissions, and 21% for SO2.

54 1999/32/EC, amended by 2012/33/EU.

55 Report of first public consultation, p23.

measures could bring benefits to farmers.[56] Many actions in this area will also have climate co-benefits, by reducing nitrous oxide (N2O), a powerful greenhouse gas.

Until now, there has been little policy action stimulating reduction in ammonia emissions, because the provisions in the NECD have been too weak (most Member States are well below the ceilings, even without additional measures); and because there has been little support within the Common Agricultural Policy for ammonia reduction (as compared with reduction of pollution to water, for instance). The Integrated Pollution Prevention and Control Directive (now integrated in the Industrial Emissions Directive (IED)[57]) covers about 20% of pig production and 60% of poultry, but excludes cattle and other animals, which are substantial sources of ammonia (as well as PM and methane, see above). The Nitrates Directive[58] covers pollution to air only indirectly. The problem has been largely left to Member States to regulate, and there is large variation in MS controls, ranging from practically nothing to extensive national regulation, with the consequent potential for distortion of competition. Annex 4 section 6.4 provides further details.

Stakeholders consistently identified agriculture as a sector which is not currently well-controlled from an air quality perspective, and called for regulation of ammonia emissions.[59]

3.4.2.3. Sustained background pollution means that local action alone cannot effectively reduce impacts

For PM and ozone, and also for eutrophication, there is a substantial background[60] component to the problem, which is beyond the control of local competent authorities. Part of the background is national and should be addressed at that level. But the transboundary share has also remained high (more than 50% for PM2.5 and more than 60% for nitrogen deposition).[61]

There are several reasons for the persisting background problems. First, there has been limited interaction between authorities responsible for implementing the NECD (and focusing on country-wide measures to meet the ceilings) and local authorities made responsible for meeting AAQD standards. Second, controls on transboundary pollution at EU level are insufficient. There is no emission ceiling for primary PM under the NECD, and for PM precursors (which *are* regulated) the ceilings are not stringent enough. Moreover, there is limited co-operation between Member States to address transboundary air pollution, even though this is encouraged under the AAQD.[62] Third, air pollution is now understood to travel longer distances and faster than previously assumed.[63] The rise

56 Notably integrated management of the nitrogen cycle. There is now increased knowledge available on the nature of the nitrogen cycle and cost-effective solutions. See the European Nitrogen Assessment published by the CLRTAP Task Force on Integrated Nitrogen Management.

57 Directive 2010/75/EU.

58 Directive 91/676/EEC.

59 See, 'Report on the consultation of options for revision of the EU Thematic Strategy on Air Pollution and related policies', p61. Available on http://ec.europa.eu/environment/air/review_air_policy.htm.

60 Measured pollution levels are the sum of contributions originating from specific local sources (such as industrial sites or urban traffic) and background pollution, which in turn is composed both of regional sources and long-range sources.

61 Estimates from the European Monitoring and Evaluation Programme (EMEP).

62 The AAQD calls on the Member States concerned to organise cross-border meetings to deal with transboundary pollution, with the Commission to be notified and invited to take part. Few such discussions have taken place to date. The only meeting of which the Commission is aware took place between DE and PL.

63 See Air Pollution Studies No20: Policy-relevant science questions http://www.unece.org/index.php?id=25373 and UNEP Atmospheric Brown Cloud Regional Assessment www.unep.org/pdf/ABCSummaryFinal.pdf .

of the global economy, notably the major emerging economies in the northern hemisphere, could therefore be part of the explanation of the persisting high EU background concentrations (notably for ozone), among a range of other factors including climate change and meteorological variability.

Stakeholders consistently commented on the importance of action at EU or international level to deal with transboundary air pollution, which cannot be addressed locally but compromises achievement of local air quality standards.[64]There is also an increased understanding on the part of national authorities responsible for implementing air policy on the need to link more closely the implementation of the NECD and AAQD. [65]

3.4.2.4. There remain gaps in the information base for assessing and managing air pollution

In addition to the above pollution-related drivers, additional governance drivers were identified. The first concerns the quality and scope of the emission inventories used for assessing and managing air pollution. National emission inventories are often of limited use for local air quality assessment and management in particular where the relative importance of emission categories differs significantly from the national and local perspective. Historic (national) emission inventories are not always corrected when new and improved emission inventory methods have been applied thus limiting their usefulness for source attribution purposes done by linking measures air quality levels with emission inventories.

A key reason for these deficiencies is the limited inventory review process. There are no provisions under the NECD for a detailed annual inventory review, nor for following through adverse findings by the Commission (and EEA). Also, there is no automatic sanction for addressing incompleteness such as a provision authorising the Commission/EEA to complete any missing submissions for particular sectors or regions. Active engagement with Member States would be needed to develop solutions based also on better capacity building, and technical assistance programmes.

The second issue is the lack of systematic monitoring in the EU of the ecosystem impacts of air pollution. This is necessary for more effective assessment of the impacts of pollution reduction measures on the environment, and to fulfil the EU's international obligations under the CLRTAP.

The capacity to assess the local drivers of air quality and to closely monitor the air quality impacts also on ecosystems will become increasingly important as the most obvious problems are addressed, and greater precision becomes necessary to ensure further cost-effective policy design.

3.5. How will the problem evolve?

This section sets out the projected development of the main problems defined in section 3.2, including the impacts of air pollution on human health and on the environment and compliance with the current air quality legislation.[66] The projections are established by developing a baseline scenario based on the recent energy projections used as a reference for climate, energy, and transport policy analysis.[67]

64 Report of first public consultation, p31. Op. cit.

65 The views of national competent authorities became progressively more supportive over successive consultation meetings in the context of the Stakeholder Expert Group and the Expert Group on Air Quality.

66 Annex 5 reports the baseline emission projections as well as the underlying assumptions. The section focuses rather on impacts (substantive, and on compliance).

67 The "PRIMES" energy baseline projections show gross inland energy consumption declining by 12% in 2030 compared to 2005 (in 2020 9%); in 2020 CO2 emissions 22% lower than in 1990 (32% in 2030); share of Renewables increasing to 21% in 2020 and to 24 % in 2030; biomass use 80% higher in 2030 than in 2005. Details are presented in Annex 5.

(The data presented in this section is further referenced as the baseline or "no policy change" option in chapters 5 and 6.) The focus is on the pollutant-specific drivers identified above because the governance specific drivers are expected to remain unchanged unless further action is developed.

3.5.1. Future trends in air pollution impacts

Table 4 shows the headline human health and ecosystem damage indicators projected up to 2030 and with extrapolated estimates for the period up to 2050 (although the latter remains highly uncertain).

On business as usual the impacts of air pollution will continue to reduce until about 2020, but progress will slow substantially thereafter. Current human health impacts will reduce by only around a quarter towards 2030, and only minor improvements are expected for eutrophication (with more than half of the EU ecosystem area exceeding the critical load).

Estimated external costs associated with air pollution remain substantial as shown in Table 5. The range of €332-945 billion estimated for 2010 would reduce to €217-753 billion in 2030.

Table 4: Estimated reduction of headline human health and environmental impacts for the period up to 2050 assuming current legislation (EU28) [Source; IIASA 2013]

Headline Indicator	2010	2020	2025	2030	2050 baseline	*2050 MCE*[68]
Premature deaths from chronic PM2,5 and short-term ozone exposure	406.000	340.000	330.000	327.000	323.000	*152.000*
Reduction from 2005	13%	33%	37%	40%	44%	*71%*
Percentage forest area exceeding acidification critical load	9	4	4	4	3	*0*
Reduction from 2005	32%	66%	71%	74%	74%	*97%*
Percentage ecosystem area exceeding eutrophication critical load	62	55	53	52	52	*26*
Reduction from 2005	8%	18%	21%	22%	22%	*50%*

Table 5: External costs associated with air pollution in the EU28 for the period up to 2030 (EU28), € billion

Health related external costs	2010	2020	2025	2030	2050 baseline	*2050 MCE*
Low estimate	330	243	224	212	NC[69]	NC
High estimate	940	775	749	740	NC	NC

68 MCE stands for "Maximum Control Effort", and includes not only all technical measures, but also the further structural changes in the energy, transport and agriculture sectors that would be needed to meet the 2050 decarbonisation objectives of the low-carbon economy roadmap (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0288:FIN:EN:PDF Global Climate Action, effective technologies scenario).

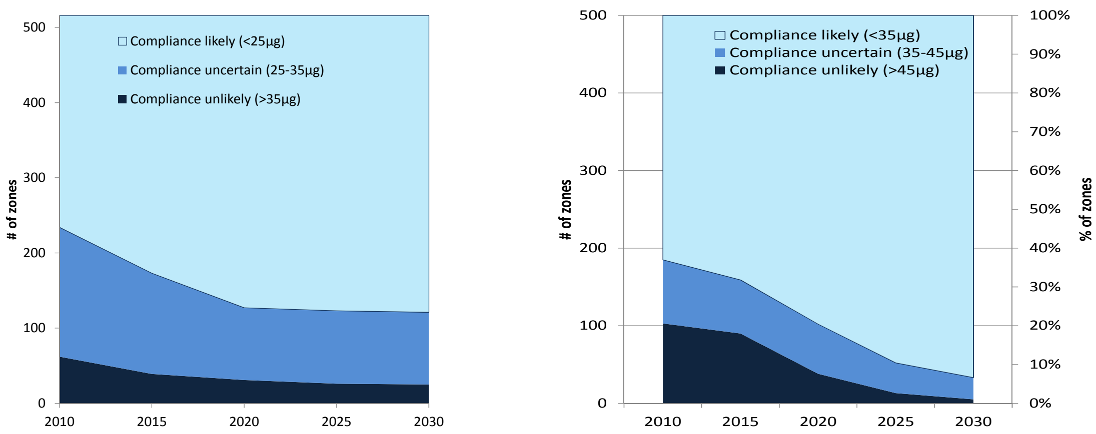
69 NC= Not Calculated: 2015 is not a target policy year, and estimates for 2050 are too uncertain.

The extrapolated figures for 2050 suggest that there is now some prospect for meeting the long-term objective in the 2050 timeframe. This could be realised by a combination of technical abatement stemming from air policy, and future structural changes that should be driven by the transition towards a low carbon economy.[70]This achievement will continue to require a trajectory for reducing impacts in successive stages in the period up to 2050 with a focus on the period up to 2030 (with important milestones in 2020 and 2025) because of the increasing uncertainty of analysis beyond that period. For that reason also, external costs have not been calculated for the period beyond 2030.

3.5.2. Compliance prospects under the current legislation scenario

As discussed in section 3.4.1, the main compliance problems of immediate concern relate to the legally binding limit values for PM10 and NO2 contained in the AAQD. The results for PM10 and NO2 are shown in Figure 5 below.

Figure 5: Statistical analysis of non-compliance situation in the EU for PM10 and NO2



For PM, the baseline would reduce the percentage of zones substantially above the PM10 limit value (LV) from 12% in 2010 to 6% in 2020, with a further 19% of zones in the vicinity of the LV (Figure 5). For $PM_{2,5}$ there is no compliance issue.[71]

The improved compliance prospects are the result of several factors. The first is the introduction of diesel particulate filters from 2009 onwards, driver by the Euro 5 requirements (Euro VI for heavy duty vehicles) on PM and particle numbers. The results are increasingly substantial as the fleet turns over towards 2020. The second is the development of robust pollution controls on industrial installations, notably in the power sector and some of the most polluting manufacturing industries.[72] Those and other controls will keep reducing PM emissions and concentrations substantially in the period up to 2020, and as a consequence, implementation of current legislation is expected to resolve most of the current compliance problems by then.

70 See, e.g., 'A Roadmap for moving to a low carbon economy by 2050', COM(2011)112 final.

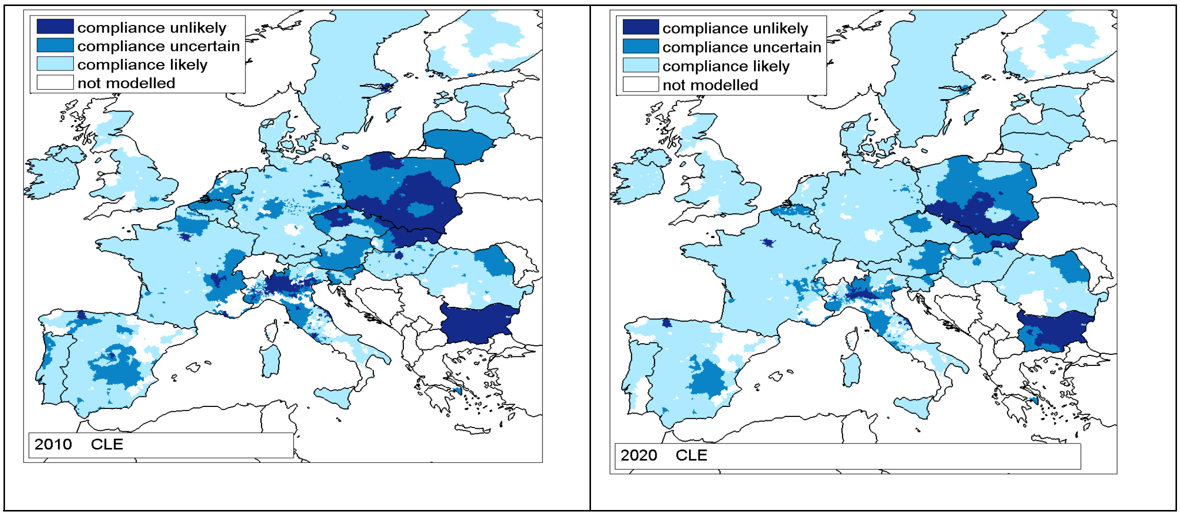
71 There is currently a target value ($25\mu g/m^3$) which in 2015 will become a binding limit value, but projections show that compliance will be very high, with around 96% of stations meeting the standard in 2015 and 99% in 2020. If the limit value were tightened in 2020 (to $20\mu g/m^3$ as the AAQD provides for subject to feasibility) there would still be 92% compliance. However, if the limit value were established at the level of the WHO guideline of $10\mu g/m^3$, only 35% of zones would comply in 2020.

72 See also recently adopted BAT conclusions for Iron and Steel (Decision2012/135/EU), and cement (2013/163/EU).

However, as highlighted in section 3.4.1.2, specific localised problems will remain for around 6% of the zones. These relate to (a) domestic solid fuel combustion, and (b) particularly concentrated local pollution sources, sometimes combined with a particular topography. The location of these residual problems (see Figure 6) nevertheless suggests substantial remaining population exposure.

Domestic (household) solid fuel combustion has historically been a major PM driver in many Member States, and most have restricted solid fuel use in response. For the areas where it remains the major pollution source (notably the border region of PL, SK, CZ, and BG) the required action has not been taken, but pioneering initiatives have been launched in a few locations, for instance Krakow.[73] The problem is not only continuing coal use, but also increase in biomass use, driven partly by renewables policy and (more recently) by the economic crisis.

Figure 6: Compliance with PM10 limit values in 2010 vs. 2020 projections (by zone)



Concentrated local pollution sources are a problem mainly in large urban centres. The problem is compounded in certain locations by a topography which limits effective dispersion of pollution, a factor which was explicitly recognised in Directive 2008/50, which allowed site specific dispersion characteristics as justification for delayed compliance. Reaching compliance in such 'difficult' locations requires further action on the relevant local pollution sources, to ensure that the economic benefits of the concentrated economic activity are not compromised by adverse health impacts.[74]

For NO2, the number of zones well above the standards would reduce from 21% in 2010 to about 8% in 2020, with a further 13% of zones registering levels in the vicinity of the LV. As shown in Figure 6, the timing of improved compliance prospects is somewhat delayed compared to the PM case but then improves much faster. That is because the NO2 compliance is mainly driven by the forthcoming

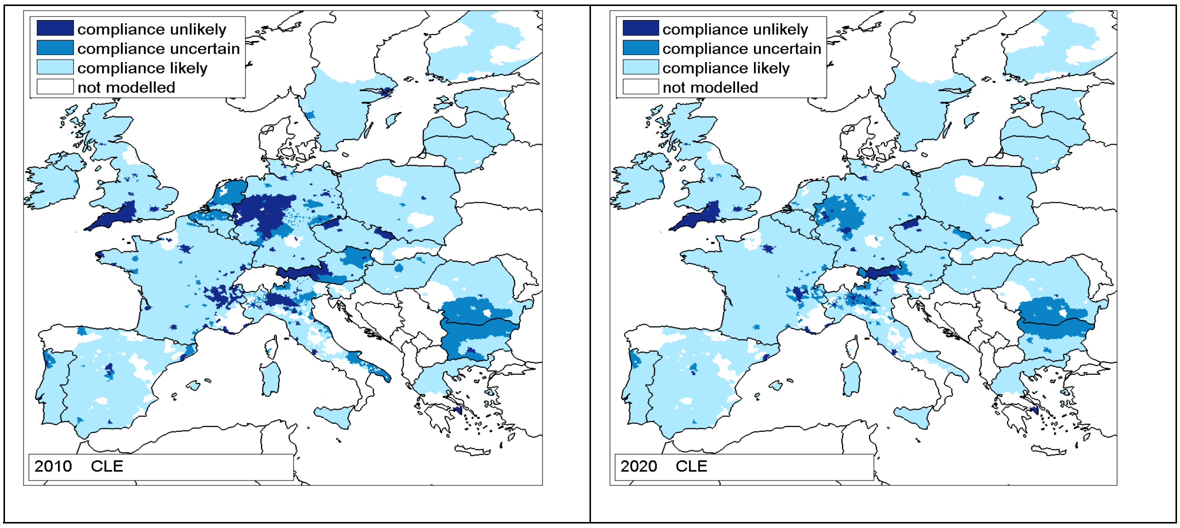
[73] See new Krakow air quality action plan: http://www.wrotamalopolski.pl/root_BIP/BIP_w_Malopolsce/root_UM/podmiotowe/Konsultacje+projektow/Programy+i+projekty/Konsultacje+spoleczne+Aktualizacja+Programu+ochrony+powietrza+dla+wojewodztwa+malopolskiego/

[74] From internal assessment of plans submitted fin support of time extension notifications for the PM10 and NO2 limit values.

introduction of the Euro 6 standard foreseen in 2014, and the correction of the "real world emission" problem seen for previous vintages of light-duty diesel vehicles by 2017 at the latest.[75]

As with PM, the remaining problem areas for NO2 (Figure 7 below) are often densely-populated, and the population exposure implications could be significant.

Figure 7: Compliance with the NO2 limit value in 2010 vs. 2020 (by zone)



For the NEC Directive, the main compliance problem concerns the NOx ceilings, where the environmental performance of diesel vehicles is again a major factor. All Member States currently in exceedance are projected to comply with the NOx ceilings under the baseline scenario by 2020, assuming the timely entry into force of the Euro-6 standard (Table 6).[76] The effect of a hypothetical failure of the Euro 6 standards is shown in section 3.5.3.[77]

Table 6 Projected Member States' compliance with the NECD ceiling for NOx assuming no change to current policy (kiloton/year; IIASA baseline projections, April 2013) (FU, fuels used emissions estimated from GAINS)

	NECD	2010	2015	compliance	2020	compliance
AT	103	133 (FU)	108 (FU)	✗	82 (FU)	✓
BE	176	234	215	✗	174	✓
DK	127	129	110	✓	87	✓
FI	170	172	147	✓	125	✓
FR	810	1053	847	✓	619	✓
DE	1051	1413	991	✓	751	✓
IE	65	91 (FU)	(91 FU)	✓[1]	(82 FU)	✓[1]
LU	11	16 (FU)	9 (FU)	✓	7 (FU)	✓
NL	260	276	243	✓	188	✓

75 The Commission is preparing implementing legislation for adoption by the relevant Member State Committee towards the end of 2013 so as to enable the timely introduction of Euro 6 and address the real world emissions.

76 There is some residual uncertainty over the prospects for compliance for LU.

77 A separate analysis based on official reports from the concerned Member States largely confirms the conclusions presented here of the macro-economic modelling approach.

ES	847	900	801	✓	579	✓
SE	148	161	129	✓	97	✓

Note: Member States already in compliance are not shown. Footnote 1: IE reported in 2012 its NOx emissions for 2011 to be 68 kt (i.e. 3 kton above its ceiling) and likely to comply before 2015.

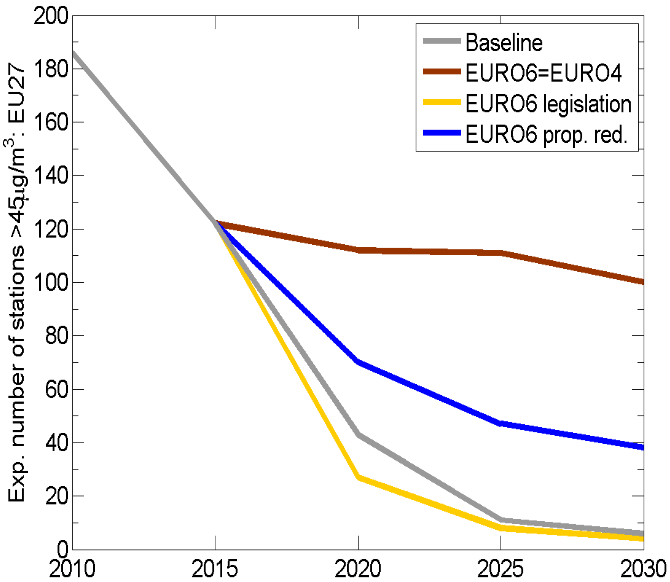
It is noted in this context that 6 Member States have so far failed to ratify the current Gothenburg Protocol despite several actions taken from the European Commission. Based on the compliance prospects shown above, this situation should be addressed at the earliest opportunity also to safeguard the EU's standing as a credible international partner.

3.5.3. Uncertainties and risks associated with baseline projections

As for any projection, the baseline contains a number of assumptions that are subject to uncertainties. Annex 5 describes the key assumption in further detail whilst sensitivity analysis is developed both in Annex 5 (for the baseline) and Annex 6 (for policy scenarios).

There is however a need to highlight a specific risk. The baseline assumes that introduction of Euro 6 standards for light duty (diesel) vehicles will be accompanied from 2017 onwards by a new test procedure and further enhanced in-use compliance provisions to ensure that real world emissions are aligned with the EURO limit values.[78] This will deliver a step change in the emissions of diesel light duty vehicles compared to the previous standards up until Euro 5. This is a key factor contributing to the significantly improved level of compliance with the NO2 limit values discussed in Section 3.5.2. Figure 8 shows that in case of poor implementation, , e.g. if Euro 6 diesel vehicles again performed equivalent to Euro 4 in terms of Real Driving Emissions (RDE), the projected non-compliance in 2020 would triple.[79] Possible options to mitigate this risk are discussed in Chapter 5.

Figure 8: Baseline projected compliance with NO2 standards in case Euro 6 would not correct the real world emission problems



[78] Euro 6 compliance is included in the baseline because the level of emission requirements is set in the adopted legislation; the implementing measure is a technical delivery mechanism.

[79] The projected percentage of stations substantially above the limit value would increase from 3% to 10%.

Analysis for the NECD shows that in case Euro 6 does not deliver, two Member States[80] will still be above their 2010 NECD ceilings in 2020. To manage this risk associated with the base case emissions from euro-6 diesel light-duty vehicles, additional monitoring provisions are needed, as described in Chapter 9.

3.6. Who is affected and how?

The remaining air pollution problem impacts many aspects of the EU. Impacts are summarized in section 3.3.1. Below is a summary of the main actors affected and in what way. Details are provided in Annexes 4 and 5.

EU citizens: Many citizens will remain exposed to damaging levels of air pollution in 2020 and beyond. In addition to the mortality impacts listed in section 3.3, there is a range of ill-health (morbidity) impacts which include asthma, lower respiratory symptoms (LRS), heart problems and chronic bronchitis. These are of particular concern to certain sensitive groups, notably the youngest and elderly citizens and those already suffering from weak health.

The healthcare sector: Poor health due to exposure to air pollution results in increased healthcare costs. Costs incurred every year in the EU for the treatment of air pollution related diseases are substantial and ultimately passed on to the citizens, to employers, and to the public sector.

Ecosystems: EU ecosystems will continue to endure substantial damage in 2020. Although acidification will be broadly resolved, more than 60% of EU ecosystems will remain at risk of biodiversity loss due to excess nitrogen deposition. Ozone pollution is adding to the pressure whilst also generating substantial material and economic losses as indicated below.

Economic operators: In addition to the high external costs borne by society at large, there are important costs directly impacting *Farmers* through significantly reduced crop yields, the *tourism sector* which affected by the loss of amenity and recreational value of the natural landscape, *public and private economic undertakings* that suffer from productivity losses due to air pollution induced workdays lost, and finally *property owners* that suffer damage to the built environment due to acid erosion and soot soiling.

Member States: Ultimately, Member States are bearing the consequences, not also because of having to incur a large part of the costs associated with air pollution referred to above, but also the possible consequences of the poor state of implementation. Seventeen Member States struggle to comply with AQ legislation, drawing substantial resources from competent authorities and facing the risk of financial penalties. The Member States are also affected by the lack of coherence between commitments under the Gothenburg Protocol and the NECD, as the ensuing regulatory uncertainty adds to the risks of not meeting environmental objectives.

3.7. Justification of EU action

The justification for legislative EU action on air pollution has long been established based on the transboundary nature of air pollution. The legal basis for action is Article 192(1) of the Treaty. The present EU air quality policy focuses mainly on the transboundary aspect of air pollution and related controls that facilitate Member States' actions to meet commonly agreed health and environment standards related to air quality. It incorporates the subsidiarity principle to a very large extent. Both the NECD and the AAQDs define commonly agreed targets, while leaving choice of the means to the

80 Belgium and Luxembourg.

Member States. EU enforcement is mainly focusing on whether the targets are reach rather than judging on the means to achieve them.

During the consultations there has been a broad plea for more EU measures to support implementation in Member States.[81]

3.7.1. Why can the objectives not be achieved sufficiently by the Member States?

Action at EU level continues to be necessary because:

- The transboundary component of air pollution continues to be significant. A Member State's emissions are not just its own problem but affect also its neighbours. To decide how far one Member State must reduce pollution so as to protect another, common environmental objectives must be agreed, and these can only be set at EU level.[82] To be operational in controlling transboundary pollution, the objectives must normally be translated into emission reduction obligations per Member State (i.e. caps on national emissions, as in the NECD and Gothenburg Protocol).
- Many of the sources which must be regulated to meet these emission reduction obligations are products that are subject to the rules on the functioning of the internal market. Some of the main examples are diesel vehicles, non-road mobile machinery, domestic solid fuel boilers, paints and varnishes, and fertilisers.

3.7.2. Can objectives be better achieved by action by the Community?

Action at EU level is not strictly necessary to regulate the remaining (non-product) sources, which can in principle be regulated at Member State level. Evaluation of the emission reductions achieved under the NECD showed, however, that best compliance was achieved where a substantial proportion of emissions was regulated by EU source legislation (e.g. for SO2 as described in Annex 4). Effective co-ordination between national and regional or local levels, and between measures to achieve the NEC ceilings and measures to achieve the AAQD limit values, is for the Member States to ensure. The EU can formulate the relevant provisions to maximise coherence, and support relevant capacity-building and information exchange.

To identify whether it is proportionate to adopt source legislation at EU level a detailed analysis of those sectors from which substantial emission reductions would be required. The key issue is what effect the adoption of harmonised standards on a given sector would have on meeting the overall objectives established for air policy. In broad terms, the higher the cost increase from EU harmonisation, the less proportionate the measure (because the same emission reduction can be achieved more cheaply by other means). If the cost increase is relatively small, the benefits of a level playing field, regulatory effectiveness and administrative efficiency would justify EU controls. This analysis is presented in detail in Annex 4 for the present policy and in Chapter 6 and Annex 8 for future policy options.

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[81] Many stakeholders, including 94% of government respondents to the stakeholder consultation, stressed the need for additional EU source controls to complement national emission reductions.

[82] e.g. as EU impact reduction targets (TSAP 2005), or as concentration limits for individual pollutants (AAQD).

4. OBJECTIVES

4.1. The long-term strategic objective

The long-term objective of the 6th and 7th EAP – to attain air quality levels that do not give rise to significant negative impacts, on or risks for, human health and the environment – remains valid also for the current strategic exercise.

It has been operationalized through the TSAP adopted in 2005 as called for by the 6th EAP. Although there is now an improved prospect of meeting the long-term objective for some headline indicators (see Chapter 3.5.1), the policy analysis focuses on the period up to 2030 (with important milestones in 2020 and 2025) whilst ensuring coherence with other relevant initiatives developed along the same time horizon, notably in the field of climate, energy, and transport.

4.2. General objectives relating to updating the present strategy

Two general objectives have been formulated based on the assessment of the present EU air quality policy framework and the outstanding problems and drivers identified during the ex-post evaluation described in Annex 4 and summarized in Chapter 3.

4.2.1. Ensure compliance with present air quality policies, and coherence with international commitments, by 2020 at the latest

The first general objective for the present review is to achieve compliance with the present air quality policy framework as soon as possible, thereby safeguarding at least a minimum level of protection for the EU citizens and the environment in the short term, i.e. 2020 at the latest. This objective includes the need to ensure coherence between the EU and international policy framework, notably the recently amended Gothenburg Protocol.

4.2.2. Achieve substantial further reduction in health and environmental impacts in the period up to 2030

The second priority is to make further progress in reducing air pollution impacts, i.e. to move EU air quality levels closer to the levels recommended by the WHO and other international bodies. The interim health and environmental impact reduction objectives set out in the 2005 TSAP should be updated in accordance with scientific and technical progress while extending the policy horizon to 2030.

4.3. Specific objectives

Measures to achieve the interim objectives should be identified, both at EU and national level, responding to the problem drivers identified in chapter 3. Pursuing the general objectives will require acting on the following specific objectives.

Specific objectives relating mainly to the period up to 2020:

- *Ensure full implementation of current legislation and ensure that "real world emissions" of light duty vehicles are brought in line with regulatory requirements (i.e. that limit values are met under normal driving conditions).* This is a matter of effective delivery of the baseline: the failure to effectively control NOx emissions from light-duty diesel vehicles has contributed substantially to current air quality compliance problems and should be rectified as a priority. In addition, options for action on existing vehicles should also be examined.

- *Facilitate action on residual local compliance problems:* Examine options to address the pollutant related drivers of outstanding non-compliance, principally transport and domestic combustion of solid fuels.

- *Promote enhanced policy co-ordination at Member State and regional/local level:* In the short term (2020) address deficiencies in capacity to assess and manage air quality, and weaknesses in co-ordinating the implementation of the AAQD and the NECD.

- *Incorporate Gothenburg Protocol obligations into EU legislation and ratify the protocol:* Ensure that the NECD is revised to as to ensure that the emission reduction obligations by 2020 are incorporated, and on that basis propose ratification of the Gothenburg amendment.

Specific objectives to achieve substantial further impact reduction in the period up to 2030:

- *Proportionately tap the pollution reduction potential of contributing sectors,* in particular those that in the past have not or insufficiently reduced their emissions, by identifying the most cost-effective policy options available for the main contributing sectors.

- *Address background pollution:* Achieve quantified reduction of national and transboundary background pollution within the EU, and reduce as far as possible transboundary pollution from outside the EU.

- *Improve the information base for assessing policy implementation and effectiveness:* At EU level, align reporting of emissions with international requirements and fill gaps in the monitoring framework, notably for ecosystem monitoring.

Quantified operational objectives are determined as part of the policy options in Chapter 6 and are therefore not predetermined at this stage.

4.4. **Coherence with other policies**

The objectives of this initiative are consistent with and reinforce the Europe 2020 objectives on smart, inclusive, and sustainable growth. They should stimulate innovation that will help support green growth and maintain the competitiveness of the European economy whilst assisting the transition to a low carbon economy, protecting Europe's natural capital and capitalising on Europe's leadership in developing new green technologies.[83] Simplification and clarification of existing policy to enable better implementation is pursued where possible in the spirit of smarter regulation.[84] Where measures are introduced, care is taken to safeguard the interests of SMEs along the "think small first" principle.[85]

The need to deliver coherence and optimise synergies with other policy areas applies notably to transport, industrial, agriculture and climate change policy; in particular, targets will be set so as to avoid regret investments *vis á vis* the new climate and energy policy framework for the 2030 time horizon that is part of the Commission work programme for 2013. This is especially important since

83 http://ec.europa.eu/europe2020/priorities/sustainable-growth/index_en.htm
84 http://ec.europa.eu/governance/better_regulation/key_docs_en.htm#_br
85 http://ec.europa.eu/enterprise/policies/sme/small-business-act/index_en.htm

air pollution and climate change mitigation policies often address the same pollutants and emission sources. A summary of how coherence has been addressed is provided in Chapter 8.

4.5. Organisation of the remainder of the impact assessment

The policy analysis has two time perspectives: the period up to 2020 for the first general objective, to ensure compliance with existing legislation and international obligations; and the period up to 2030 for the second general objective, to further reduce the remaining environment and health impacts. For simplicity these two issues are taken successively in the remainder of the document although the policy options are closely related. Chapter 5 sets out the options, impact analysis and comparison for the 2020 timeframe, and Chapter 6 does the same for the post-2020 period. Chapter 7 further details the impact analysis for the new source control instruments under consideration, on medium-scale combustion plants. Chapter 8 sets out the package of measures supported by the analysis and summarises the interactions with other policies.

5. ACHIEVING THE COMPLIANCE OBJECTIVE BY 2020 AT THE LATEST

Chapter 4 set out two general objectives for further developing the present air quality policy framework. This Chapter addresses the policy options identified for achieving the first objective, i.e. to achieve full compliance with the existing air quality policy framework not later than 2020 including with the EU's international obligations. The options were developed drawing from the ex-post review documented in Annex 4 and summarized in Chapters 3.2 and 3.3 as well as the compliance outlook summarized in Chapter 3.4 and Annex 5, and consulted on with stakeholders.[86]

It should be noted that the binding obligations contained in the AAQD and NECD were to be achieved already in 2010 or before.[87] The Commission has already undertaken infringement action to ensure that compliance is achieved as soon as possible.

5.1. Options to achieve compliance with the existing air policy framework

5.1.1. Option 1: No additional EU action

Under this "baseline" option, no new EU policies are envisaged. The baseline option is characterized in Table 7 and further summarised below.

	Option 6A	Option 6B	Option 6C	Option 6D	Option 6E
The 'Gap' closure					
	25% gap closure for PM 2.5 between baseline and MTFR	50% gap closure for PM 2.5 between baseline and MTFR	75% gap closure for PM 2.5 between baseline and MTFR	100% gap closure for PM 2.5 between baseline and MTFR	>100% gap closure for PM 2.5
possible cost-effective technical measures					
Power generation	Low sulphur coal	Low sulphur coal Stricter NOx control in medium-sized plants Stricter PM controls in biomass plants	Low sulphur coal Stricter NOx and SO2 control in medium-sized plants Stricter PM controls in biomass plants	All technically feasible measures irrespective of cost	All technically feasible measures irrespective of cost, as well as deeper phasing out of solid fuels
Domestic sector	Low sulphur coal Improved biomass stoves	Low sulphur coal Improved biomass stoves, boilers and fireplaces	Low sulphur coal Improved biomass stoves, boilers and fireplaces	All technically feasible measures irrespective of cost	All technically feasible measures irrespective of cost, as well as deeper phasing out of solid fuels;

86 The draft options were developed based on the problem identification endorsed by the 3rd Stakeholder Expert Group on 21 June 2012. They were consulted on informally with Member State authorities in an Air Quality Expert Group of 24 October 2012, and published in the second public consultation on 7 December 2012. The public consultation allowed free-text replies to highlight other options not listed.

87 In certain circumstances extensions are allowed for NO2 from 2010 to 2015.

		New coal boilers Dust filters for coal appliances	New coal boilers Dust filters for coal appliances Pellet boilers Improved coal stoves Low-sulphur fuel oil		Further energy efficiency improvements
Industrial combustion	Low sulphur fuel oil	Low sulphur fuel oil low sulphur coal stricter PM controls combustion modifications wet flue-gas desulphurisation	Low sulphur fuel oil low sulphur coal stricter PM controls combustion modifications wet flue-gas desulphurisation high-efficiency flue-gas desulphurisation in refinery stricter PM controls	All technically feasible measures irrespective of cost	All technically feasible measures irrespective of cost, as well as deeper phasing out of solid fuels
Industrial processes	stricter SO2 controls in steel industry	stricter SO2 controls in steel industry stricter SO2 controls in non-ferrous metal industry selective catalytic reduction for cement plants	stricter SO2 controls in steel industry stricter SO2 controls in non-ferrous metal industry selective catalytic reduction for cement plants stricter SO2 and PM controls in lime production and glass production	All technically feasible measures irrespective of cost	All technically feasible measures irrespective of cost
Road transport and Non-road machinery			Stage IV controls for inland waterway vessels, and railways Further alignment of NRMM emissions to heavy duty goods vehicle standards	Stage IV controls for inland waterway vessels, and railways Further alignment of NRMM emissions to heavy duty goods vehicle standards Further tightening of emission standards for light duty vehicles beyond Euro 6	Stage IV controls for inland waterway vessels, and railways Further alignment of NRMM emissions to heavy duty goods vehicle standards Further tightening of emission standards for light duty vehicles beyond Euro 6 Deeper electrification of urban transport
Agriculture	Reduced open burning of agricultural residues Low N feed (cattle and pigs) Covered storage of manure Low emission application of manure Low emission housing (pigs)	Reduced open burning of agricultural residues Low N feed (cattle and pigs) Covered storage of manure Low emission application of manure Low emission housing (pigs and poultry) Substitution of urea fertilizer	Reduced open burning of agricultural residues Low N feed (cattle and pigs) Covered storage of manure Low emission application of manure Low emission housing (pigs and poultry) Substitution of urea fertilizer NH3 scrubbers in pig and poultry housing	All technically feasible measures irrespective of cost	All technically feasible measures irrespective of cost

Table 13: Emission reductions by pollutant required by the options for post 2020 - Percentage changes vs 2005.

2025, EU28	2005	1	6A	6B	6C	6D	6E
SO2	8172	-70%	-73%	-77%	-79%	-81%	n/a
NOx	11538	-60%	-61%	-61%	-64%	-69%	n/a
PM2,5	1647	-23%	-36%	-42%	-49%	-58%	n/a
NH3	3928	-7%	-14%	-21%	-30%	-35%	n/a
VOC	9259	-39%	-43%	-44%	-50%	-64%	n/a
2030, EU28	2005	1	6A	6B	6C	6D	6E
SO2	8172	-73%	-76%	-79%	-82%	-83%	n/a
NOx	11538	-65%	-66%	-66%	-69%	-74%	n/a
PM2,5	1647	-27%	-40%	-45%	-51%	-63%	n/a

NH3	3928	-7%	-14%	-21%	-30%	-35%	n/a
VOC	9259	-41%	-44%	-46%	-51%	-66%	n/a

Option 6E, compliance with the WHO guideline values, is impractical at this time, as even the MTFR would fall short in the period 2025/2030. To achieve it further structural changes would be required which cannot be assumed here, and so this option is not further analysed for the 2030 timescale. For the same reason, emission reductions required to achieve Option 6E are also not presented in Table 13. In the long term, however, deep structural changes, innovation, technology learning and non-technical actions can set the EU on the path towards no significant air pollution impacts. This issue is taken up in section 6.8.

The other options are analysed for comparison against Option 1 (baseline, current policies). Section 3.4.2 showed that current policies will deliver substantial impact reductions in the period up to 2020, but will flat-line thereafter, with only marginal further reductions in impact.

Annex 9 provides an in-depth characterisation of the cost-effective measures presented in Table 12 and of how they may affect individual sectors for options 6A to 6C. In terms of emission reductions required by the various options, Options 6A and 6B achieve their target mainly by reducing primary PM SO2 and ammonia emissions, while the more ambitious targets of Options 6C and 6D drive deeper cuts in NOx and VOC emissions. The associated emission reductions per Member State are given in Annex 7.

5.2. **Impact of options**

5.2.1. ***Health and environmental impacts***

The baseline health and environmental improvements by 2025 and 2030 (Option 1), and the additional improvements delivered for those years by options 6A-D, are presented in Table 14. The table focuses on premature mortality from chronic PM and acute ozone effects; the full range of health impacts (mortality and morbidity, see section 3.6) is provided in Annex 7, Appendix 7.2, along with detailed impacts per Member State (Appendix 7.3).

Table 14: Impact indicators for 2025 and 2030 compared to 2005 (EU-28)

2025	**2005**	**1**	**6A**	**6B**	**6C**	**6D**
PM2,5-chronic-premature deaths	494 000	-38%	-42%	-46%	-50%	-54%
Ozone-acute- premature deaths	24 600	-28%	-29%	-30%	-33%	-39%
Eutrophication, unprotected '000 sq Km	1 125	-21%	-24%	-28%	-34%	-40%
Acidification, unprotected '000 sq Km	161	-71%	-77%	-81%	-85%	-87%
2030	**2005**	**1**	**6A**	**6B**	**6C**	**6D**
PM2,5-chronic-premature deaths	494 000	-39%	-43%	-47%	-51%	-56%
Ozone-acute- premature deaths	24 600	-30%	-31%	-32%	-35%	-41%
Eutrophication, unprotected '000 sq Km	1 125	-23%	-26%	-29%	-35%	-41%
Acidification, unprotected '000 sq Km	161	-74%	-79%	-83%	-87%	-89%

In the absence of additional measures (baseline Option 1) air pollution impacts will continue to go down by 2025 and (then slower) by 2030. The range of improvements delivered is very similar in 2025 and 2030. The maximum technical feasible reduction (Option 6D) could yield health impact reductions of around 40% while further reducing eutrophication and acidification by respectively about 80% and 20% compared to the baseline. Option 6C, however, could reduce health impacts from PM2,5 by an additional third over the baseline, from ozone by an additional fifth, while the reduction in eutrophication would be half as big again as on the baseline. Options 6A and 6B would result in impact reductions that are closer to the baseline.

5.2.2. *Economic impacts*

The economic analysis identifies the most efficient (least-cost) combination of technical measures to achieve the required gap closure. The more ambitious the objective, the more expensive each incremental reduction becomes (in economic terms, a standard marginal abatement cost curve). The broader economic impacts of the resulting compliance costs are then further analysed with the computable general equilibrium model GEM-E3.[88]

5.2.2.1. Direct expenditure to reach compliance

The direct cost of policy is the annualised investments required in different sectors to install pollution abatement equipment, as well as operation and maintenance (O&M) of that equipment. These are presented in Table 15 for the EU, and compared to the baseline costs deriving from implementation of current pollution control legislation (Option 1). [89] Details per Member State are provided in Annex 7.

[88] www.GEM-E3.net. Further details on the methodology and models used are provided in annex 7.

[89] It is important to note that the pollution control expenditure shown for Option 1 is not to be interpreted as the additional investment that on business as usual would be committed between the present day and 2025/2030;

Table 15: Incremental pollution control expenditure by option (€M/yr, % increase in 2025 and 2030 compared to baseline for EU-28)

	1	**6**A	%	**6**B	%	**6**C	%	**6**D	%
2025	87,171	221	0,25	1202	1,38	4,629	5,31	47,007	53,9
2030	92,103	212	0,23	1032	1,12	4,182	4,54	50,682	55,0

Incremental pollution control costs are modest for all but the full gap closure, i.e. maximum technical feasible reduction scenario (Option 6D), which would add over 50% to the baseline compliance costs. Costs increase from a quarter of a per cent over the baseline for a 25% gap closure (Option 6A), to around 5% over the baseline for the 75% gap closure scenario (Options 6C); the MTFR (option 6D) would add around 50% more to the total pollution control expenditure.

5.2.2.2. Affected industries and sectorial impacts

Table 16 and Table 17 show the distribution of additional pollution control expenditure by sector[90] in 2025 and 2030 for the different options and in comparison with the baseline (option 1). Detailed tables documenting how specific economic sectors are affected on the different options are presented in Annex 7 and Annex 9; a brief summary of the main conclusions is presented below.

Table 16: Effort required per SNAP sector in 2025 by option, expressed in M€ and in % increase compared to option 1 (baseline).

2025, EU28	*Option 1*	*Option 6A*		*Option 6B*		*Option 6C*		*Option 6D*	
Costs by SNAP sector (million €/yr, increase compared to baseline)									
Power generation	9561	44	*0,46%*	125	*1,31%*	470	*4,92%*	3519	*37%*
Domestic combustion	9405	74	*0,78%*	497	*5,29%*	1680	*18%*	17791	*189%*
Industrial combustion	2513	19	*0,75%*	156	*6,20%*	641	*25%*	1811	*71%*
Industrial Processes	5017	17	*0,34%*	125	*2,49%*	331	*6,61%*	3964	*79%*
Fuel extraction	695	0	*0,00%*	0	*0,00%*	6	*0,81%*	583	*84%*
Solvent use	1176	1	*0,08%*	2	*0,15%*	56	*4,76%*	12204	*1038%*
Road transport	48259	0	*0%*	0	*0%*	0	*0%*	0	*0%*
Non-road machinery	8760	1	*0,01%*	5	*0,06%*	145	*1,66%*	1451	*17%*
Waste	1	6	*786%*	7	*941%*	9	*1154%*	9	*1203%*
Agriculture	1783	59	*3,33%*	285	*16%*	1292	*72%*	5675	*318%*

on the contrary, it represents an estimate of the accumulated annualised cost of all pollution abatement equipment accumulated in the economy, compared to a hypothetical situation of no emission controls at all.. In this hypothetical situation, all power plants would burn the lowest grade of available fuels and would not have any end-of-pipe pollution abatement, motor vehicles would not have any exhaust gas after-treatment, domestic heating would still be in the conditions that led to the Great London Smog in 1953, etc. Pollution levels would be extreme.

90 Sectors are here defined by SNAP classification (Selected Nomenclature for Air Pollution). Note that the costs in in the tables are allocated by type of activity (combustion, solvent use, etc.) but these activities can take place in different economic sectors as defined in national accounts (chemicals, refineries, etc).

Total	87171	221	0,25%	1202	1,38%	4629	5,31%	47007	54%

Table 17: Effort required per SNAP sector in 2030 by option, expressed in M€ and in % increase compared to option 1 (baseline).

2030, EU28	Option 1	Option 6A		Option 6B		Option 6C		Option 6D	
Costs by SNAP sector (million €/yr, increase compared to baseline)									
Power generation	7122	36	0,50%	99	1,39%	436	6,12%	3658	51%
Domestic combustion	8928	52	0,59%	305	3,41%	1217	14%	19622	220%
Industrial combustion	2567	24	0,93%	175	6,81%	672	26%	1850	72%
Industrial Processes	5032	17	0,34%	125	2,49%	334	6,64%	4054	81%
Fuel extraction	619	0	0,00%	0	0,00%	5	0,82%	556	90%
Solvent use	1147	14	1,20%	15	1,28%	72	6,25%	12214	1065%
Road transport	52633	0	0%	0	0%	0	0%	0	0%
Non-road machinery	12271	1	0,01%	5	0,04%	146	1,19%	3007	25%
Waste	1	6	782%	7	938%	9	1148%	9	1196%
Agriculture	1784	61	3,44%	300	17%	1292	72%	5711	320%
Total	92103	212	0,23%	1032	1,12%	4182	4,54%	50682	55%

On the baseline, the transport sector bears the largest share (more than 50%), followed by the power sector, the domestic sector[91], non-road machinery (including non-road transport) and other industries. The varying distributions for options 6A-D reflects the limited further potential in sectors that have been stringently regulated in the past, and the larger potential in those that have not (e.g. agriculture, the domestic sector and solvent applications).[92]

For a 25% gap closure (option 6A), modest additional compliance cost are concentrated in the household sector, agriculture and (to a lesser extent) energy intensive industries; for all sectors the additional effort required is less than or of the order of 0,01% of total output. For the 50% and 75% gap closures (options 6B and 6C), households and agriculture remain prominent, but energy intensive industries progressively contribute more. Option 6C (which delivers 75% of the maximum health benefits) requires additional expenditure of 0,3% of the sectorial output in agriculture, 0,07% for refineries, 0,03% for the power sector and much less for all other industries. The effort required of households is 0,023% of their total consumption, on average ca. €3/year per EU citizen.

Option 6D (MTFR) shows a rather different picture, reflecting the fact that all commercially available technical measures are tapped, irrespective of their cost. Highest additional costs are

[91] The domestic sector includes residential, commercial and institutional activities. The pollution control measures attributed to this sector are improvements to heating appliances. The corresponding expenditure is calculated as the cost premium for the improved appliance compared to the basic type. Note that the pollution abatement costs for private cars (such as the cost of catalytic exhaust systems) are attributed not to the domestic but to the transport sector.

in the chemicals and consumer goods industries (food, clothing, furniture, etc.), related to relatively expensive VOC abatement measures.

5.2.2.3. Direct economic benefits due to reduced health and environmental impacts:

Reducing air pollution delivers substantial direct economic benefits which are summarised in Table 18 for 2025 and Table 19 for 2030. More detail is provided in Annex 7:

- *Labour productivity gains from reducing the lost working days:* Avoided economic loss from improved productivity alone ranges between €0,7bn and almost €3bn. These can offset by more than a factor 2 the direct emission control expenditure on option 6A, fully compensates it on option 6B, and cover about half those on option 6C.
- *Savings from reduced damage to the built environment:* Benefits due to reduced corrosion and soiling of infrastructure and buildings range between about €53-162M per year in options 6A-6D.
- *Savings from reduced crop losses:* Ground-level ozone damages plants, hampering the growth of trees as well as food crops. The damage to potato and wheat alone is currently estimated at about €2,6bn per year.[93] Emission reductions can reduce this damage by between €61 and 630M per year (options 6A-D). Timber losses are not included.
- *Savings from reduced healthcare costs:* These are evaluated where data are available. However, due to the lack of sufficient data for a number of symptoms (including lower respiratory symptoms, restricted activity days and child morbidity), the estimate is not a full account of overall healthcare costs from air pollution. Even so, the benefits delivered by options 6A-D are substantial, ranging between €219 and 886M per year.

Table 18: Direct economic benefits of policy options for 2025 vs baseline

2025, EU28	Option 6A	Option 6B	Option 6C	Option 6D
Lost working days, direct economic benefits vs baseline €M	726	1421	2137	2831
Damage to built environment, direct economic benefits vs baseline €M	53	106	145	162
Crop value losses, direct economic benefits vs baseline €M	61	101	278	630
Healthcare costs, direct economic benefits vs baseline (where data available)	219	437	657	886
Total direct benefits vs baseline	1,059	2,065	3,237	4,509

Table 19: Direct economic benefits of policy options for 2030 vs baseline

2030, EU28	Option 6A	Option 6B	Option 6C	Option 6D
Lost working days, direct economic benefits vs baseline €M	665	1307	1960	2805
Damage to built environment, direct economic benefits vs baseline €M	44	96	134	159
Crop value losses, direct economic benefits vs baseline €M	69	98	269	632
Healthcare costs, direct economic benefits vs baseline (where data available)	209	415	624	907

[93] EU27 + CH and NO

Total direct benefits vs baseline	988	1,916	2,987	4,503

5.2.2.4. Generalized economic benefits from reduced health-related external costs

The health benefits described in section 6.3.1 can be translated into economic gain figures based on a well-established literature of contingent valuation used to calculate health-related external costs and changes thereof. Table 20 provides the range of the total benefit estimates compared to the baseline (Option 1).[94] Annex 7 sets out the full detail. For comparison purposes the direct economic impacts benefits calculated in section 6.3.2.3 are also reported.

Table 20: Monetised Air Quality Benefits from reductions in health-related external costs of policy options for 2025 and 2030 vs baseline, in M€/year

2025, EU28	Opt. 6A	Opt. 6B	Opt. 6C	Opt. 6D
Total reduction in external costs of air pollution vs baseline (€M, low valuation)	**14 997**	**29 767**	**44 686**	**59 642**
Total reduction in external costs of air pollution vs baseline (€M, high valuation)	**50 317**	**100 937**	**150 853**	**200 074**
Of which, total direct economic benefits (table 18) €M	1 059	2 065	3 237	4 509
2030, EU28	Opt. 6A	Opt. 6B	Opt. 6C	Opt. 6D
Total reduction in external costs of air pollution vs baseline (€M, low valuation)	**13 870**	**27 619**	**41 309**	**59 506**
Total reduction in external costs of air pollution vs baseline (€M, high valuation)	**48 870**	**98 188**	**146 216**	**209 165**
Of which, total direct economic benefits (table 19) €M	988	1 916	2 987	4 503

Additional action yielding from the respective gap closure options could further reduce the external costs between €15-50 billion/year on Option 6A and €60-200 billion/year on Option 6D. Of these external cost savings, more than €4 billion could be direct economic savings due to improved productivity and reduced healthcare costs, reduced crop damage, and reduced damage to buildings and infrastructure.

5.2.2.5. Broader economic impacts

The direct costs (expenditure to reach compliance) presented in sections 6.3.2.1 and 6.3.2.2 are not to be interpreted as societal costs. This is on the one hand because the investment demand represents an economic opportunity for the manufacturers of (e.g.) abatement technology. But also, the costs of compliance affect production costs and can impact on the competitiveness of the affected sectors, including at the international level. Further analysis therefore assessed[95]:

- Which sectors benefit from expenditure in pollution control (by delivering the investment goods), and which other expenditure would be diminished to keep budget balances;
- Price effects and their consequences for international competitiveness and for consumers.

The effect of the improved labour productivity resulting from air quality improvements also has a macro-economic impact. This was assessed by proportionately adjusting the labour

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94 External costs of air pollution on the baseline were already shown in Table 5 and discussed in section 5.3.1.; These are projected to reduce by about 40% in 2025-2030 compared to 2005, but in absolute terms they would remain high (230-760 and 217-753 billion/year respectively in 2025 and 2030).

95 These aspects were analysed with the CGE model GEM-E3. The required investments and other direct costs per industry were introduced as additional expenditure in the corresponding sectors. Any possible measures with negative costs (i.e. no regret measures that would provide savings for operators at no extra compliance cost) were removed and excluded from the analysis.

supply for each option,[96] and is presented as the 'health' case below. Other direct economic benefits such as improved crop yields, reduced healthcare expenditure, and damage to utilitarian buildings are not included in the macroeconomic analysis, and are to be considered separately. Table 21 presents the results in terms of GDP impact and sectorial output[97].

Table 21: GDP and sectorial output change in options 6A-C, the effects of health benefits to labour productivity are presented separately as "health" case. Source: GEM-E3, JRC-IPTS

	6A		*6B*		*6C*	
Change in sectorial output in the EU28 (2025), and GDP change; % compared to option 1						
	base	*health*	base	*health*	base	*health*
Agriculture	-0,01%	0,00%	-0,06%	-0,04%	-0,22%	-0,20%
Chemical Products	0,00%	0,01%	0,01%	0,03%	0,03%	0,05%
Construction	0,00%	0,01%	0,02%	0,03%	0,07%	0,08%
Consumer Goods Industries	0,00%	0,00%	-0,01%	0,00%	-0,04%	-0,01%
Electric Goods	0,00%	0,02%	0,03%	0,05%	0,10%	0,13%
Electricity supply	0,01%	0,01%	0,02%	0,04%	0,10%	0,12%
Ferrous and non-ferrous metals	0,00%	0,01%	-0,01%	0,02%	0,00%	0,03%
Natural Gas	0,00%	0,00%	0,00%	0,00%	0,01%	0,02%
Market Services	0,00%	0,01%	0,00%	0,01%	0,00%	0,02%
Non Market Services	0,00%	0,00%	0,00%	0,01%	0,00%	0,01%
Petroleum Refining	-0,01%	0,00%	-0,03%	-0,02%	-0,10%	-0,08%
Other energy intensive	0,00%	0,01%	-0,01%	0,01%	-0,02%	0,01%
Other Equipment Goods	0,00%	0,01%	0,02%	0,05%	0,06%	0,11%
Transport	0,00%	0,00%	0,00%	0,01%	-0,01%	0,02%
Transport equipment	0,00%	0,01%	0,01%	0,04%	0,04%	0,09%
GDP	**-0,001%**	***0,007%***	**-0,007%**	***0,009%***	**-0,025%**	***-0,000%***
Direct benefits not included	***0.007%***	***0.002%***	***0.013%***	***0.004%***	***0.020%***	***0.007%***

indicators calculated as relative changes do not differ significantly for 2025 and 2030. Exact figures reported are for 2025.

Excluding health effects on labour productivity (which, together with the other direct benefits of table 18, would be equivalent to 0,020% of GDP), the estimated aggregate GDP impact is very small even on Option 6C, at 0,025%. Including those productivity gains turns the GDP impact positive for options 6A and 6B, and fully offsets the direct expenditure effect on GDP for option 6C. This is without considering other direct benefits (healthcare, crop yield, infrastructure impacts); as shown in Table 20, additional quantifiable direct benefits would amount in option 6C to 1080 M€, equal to 0,007% of GDP, and so option 6C would have an overall small positive effect on GDP.

Several of the sectors which bear additional abatements costs also benefit from increased demand for investment goods for pollution control. These sectors (ferrous and non-ferrous metals, chemicals and the power sector), see a net output increase. The sectors that bear a relatively larger share of the burden are agriculture and the refinery sector; however, impacts in agriculture are partly compensated by higher crop yields due to reduced ground-level ozone (Table 18, Table 19).

96 The supply was adjusted by +0,008 to +0,031% for options 6A to 2D; see table 18.

97 The estimate of macroeconomic impacts calculated with computable general equilibrium (CGE) models is less reliable when the divergence from the equilibrium benchmark is larger; for this reason, CGE modelling results are not shown for the MTFR option 2D, but can be assumed to be substantially more negative than in option 2D.

5.2.3. *Social impacts*

Table 22 summarises the employment impacts of options 6A to 6C by sector. In all cases the effect is essentially neutral (max 2000 jobs in option 6C, which is within the uncertainty range), even without taking labour productivity gains into consideration. When those are considered there is a net job creation (37-112 thousand jobs). The last row in table 22 reflects the impact on aggregate household consumption. The effect is small and in all cases turns from negative to positive when labour productivity is included.

Table 22: Sectorial employment change in options 6A-C, the effects of health benefits on labour productivity are presented separately as "health" case. Last row shows the net welfare effect. Source: GEM-E3, JRC-IPTS

	6A		*6B*		*6C*	
Change in Sector employment in EU28 (2025) in '000 jobs; and welfare change in % compared to option 1						
	base	*health*	base	*health*	base	*health*
Agriculture	-1,697	0,631	-6,051	-1,644	-24,574	-17,589
Chemical Products	0,055	0,886	0,294	1,912	1,264	3,711
Construction	0,826	3,825	4,209	10,148	16,237	25,043
Consumer Goods Industries	-0,095	1,668	-0,132	3,345	-0,878	4,398
Electric Goods	0,097	0,487	0,576	1,413	2,173	3,379
Electricity supply	0,127	0,355	0,428	0,855	2,387	3,066
Ferrous & non-ferrous metals	0,057	1,155	-0,883	1,234	0,697	3,947
Natural Gas	0,000	0,013	-0,031	-0,007	0,043	0,085
Market Services	0,008	10,299	-0,258	19,693	2,661	32,405
Non Market Services	0,102	6,268	0,427	12,165	3,283	21,101
Petroleum Refining	-0,013	-0,003	-0,044	-0,025	-0,111	-0,082
Other energy intensive	0,014	0,785	-0,578	0,922	-1,405	0,867
Other Equipment Goods	0,464	2,727	2,357	6,638	9,602	16,223
Transport	0,025	2,400	0,106	4,729	1,471	8,450
Transport equipment	0,107	1,004	0,634	2,329	2,857	5,424
TOTAL	-0,069	37,605	0,821	73,691	2,119	112,256
Impact on aggregate household consumption	**-0,002%**	**0,012%**	**-0,009%**	**0,017%**	**-0,030%**	**0,008%**

indicators do not differ significantly for 2025 and 2030. Exact figures reported are for 2025.

5.3. **Comparison of the options**

Table 23 summarises the costs (expenditure to reach compliance) and benefits delivered by options 6A to 6D compared to the baseline. Benefits are shown for the highest and lowest of the common valuations. Results are also shown for the quantified direct economic benefits alone (reduced workdays lost, healthcare costs, crop losses and damage to materials). Note however that due to methodological gaps the quantification of direct economic benefits is incomplete and should not be interpreted as an alternative valuation for total benefits.

Costs and benefits are presented as totals required and delivered by each option, and as difference vs the previous –see stringent- option. Such incremental values are useful to single out the consequences of the additional effort of moving from Option 6A to 6B, from 6B to 6C, etc.

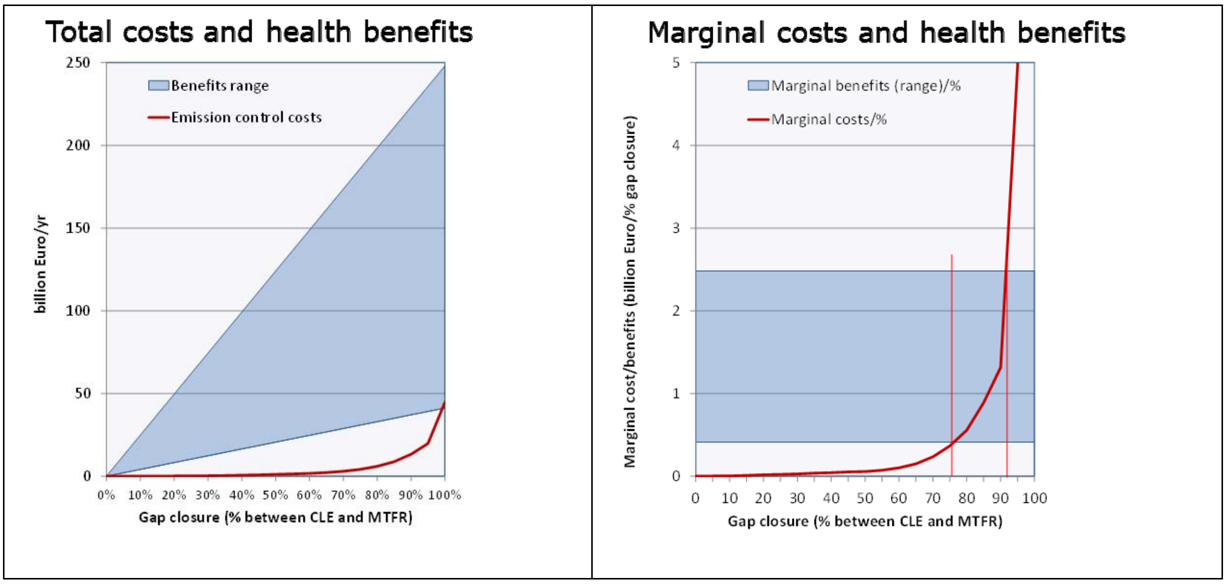
Total benefits are always larger than total costs and incremental benefits exceed incremental costs up to the level of option 6C. Even given the limitations of the quantified direct economic benefits, they alone exceed the compliance costs up to and including option 6B.

Table 23: Summary comparison of options for post-2020

2025, EU28	Opt. 6A	Opt. 6B	Opt. 6C	Opt. 6D
Costs relative to baseline €M	221	1202	4629	47007
Additional reduction in health impacts beyond baseline (2005 base year)	10%	21%	32%	43%
Additional reduction in eutrophication impacts beyond baseline (2005 base year)	16%	33%	62%	90%
GDP impact taking into account productivity gains	0,007%	0,009%	0,000%	-
Other direct benefits	333	644	1080	1678
Total reduction in external costs of air pollution vs baseline (low valuation)	**14 997**	**29 767**	**44 686**	**59 642**
Total reduction in external costs of air pollution vs baseline (high valuation)	**50 317**	**100 937**	**150 853**	**200 074**
2030, EU28	Opt. 6A	Opt. 6B	Opt. 6C	Opt. 6D
Costs relative to baseline €M	212	1032	4182	50682
Additional reduction in health impacts beyond baseline (2005 base year)	8%	18%	27%	40%
Additional reduction in eutrophication impacts beyond baseline (2005 base year)	13%	28%	54%	78%
GDP impact taking into account productivity gains	0,008%	0,012%	0,005%	-
Other direct benefits	322	609	1027	1698
Total reduction in external costs of air pollution vs baseline (low valuation)	**13 870**	**27 619**	**41 309**	**59 506**
Total reduction in external costs of air pollution vs baseline (high valuation)	**48 870**	**98 188**	**146 216**	**209 165**

The economically rational interim objectives for air pollution policy are those which maximise net benefits (i.e. where the marginal cost equals the marginal benefit). Beyond this point, the costs of additional measures are more than the monetised health benefits they deliver. The analysis suggests that this would happen at a gap closure in the range between 76% and 92%, depending on whether the low or high end of the valuation range is chosen; the additional emission control costs would be between 4,6 and 15 b€ per annum (Figure 9).

Figure 9: Total (left) and marginal (right) abatement cost and monetised health benefit curves for the year 2025, on low and high valuations



Conservative assumptions on benefits have been considered so as to avoid the risk of overestimating the benefits as compared to the costs thus securing a policy that ensure positive delivery of benefits.[98] If such conservative assumptions are used, the option which delivers the maximum net benefit is Option 6C.[99]

A majority of general public respondents to the stakeholder consultation stated that the additional progress to be pursued should be the "maximum achievable pollution reduction", and 37% called for "substantial progress" towards it. About 1/3 of expert/stakeholder respondents supported each of these two options.

The cost-benefit analysis presented here fulfils the requirements of the standard efficiency and effectiveness analysis. As the quantitative objectives are determined as part of the option analysis, efficiency can be considered to increase linearly with the stringency of targets. The positive marginal net benefits criterion indicates that Options 6A to 6C are economically efficient, whereas Option 6D is not.

Coherence with relevant other EU policies, especially as regards the forthcoming climate and energy policy framework, is ensured by (a) the essential climate neutrality of all options considered and (b) the very limited extent of potential regret measures. Section 6.7 elaborates on options to ensure that SMEs are not unduly affected.

5.4. Sensitivity analysis

A full account of the sensitivity analyses performed is given in Annex 8. The main conclusions are summarised here.

98 The most conservative (lowest) of the four valuations of health impacts was chosen. See Annex 7 for methodology.

99 To derive more accurate marginal figures, the analysis has been done with finer granularity, which results in MC=MB at 76.2% gap closure, to be precise.

5.4.1. *Changes in the target year*

In deciding whether to set targets for 2025 or for 2030, it must be borne in mind that maximisation of net benefit in 2030 will require application of the same pool of measures as for 2025. Thus the main effect of delaying application of the targets to 2030 is to sacrifice cost-effective impact reduction between 2025 and 2030.

The second aspect to the comparison between 2025 and 2030 is the question of regret measures: that the earlier date will force the application of abatement equipment that is retired before its normal lifetime. This may pose a risk in one particular country (the UK), and would be dealt with by appropriate flexibility if 2025 were chosen as the target date (for instance, by discounting emissions from installations which under binding national energy policy would be retired within a certain number of years).

5.4.2. *Interactions with climate policy*

The Commission work programme for 2013 foresees a new climate and energy framework for the 2030 time horizon which should deliver benefits in terms of air quality. The form of this policy is not clear at the time of writing, but the analysis presented in Annex 8 and summarised here has assumed a reduction in domestic GHG emissions below 1990 levels by 25% in 2020 and by 40% in 2030.[100] The analysis confirms that a more ambitious climate policy could make reaching the new air quality objectives cheaper by removing highly polluting sources such as coal plants or reducing fuel consumption. However, expanded biomass combustion can result in detrimental health impacts unless sufficiently stringent emission standards are put in place.

Based on a comparison of the available scenarios (see Annex 8.2), decarbonisation measures alone could reduce health impacts from PM2,5 by approximately 5% in 2030 and 10% in 2050 compared to the current legislation baseline. This compares with reductions from additional air pollution measures of around 30% in both years. Decarbonisation of the economy has a more substantial impact on acidification and ground-level ozone, delivering as much as two thirds of the MTFR reductions by 2050. The effect of decarbonisation on eutrophication impacts would be extremely small.

Thus while the impacts of decarbonisation are clearly positive for air, they would deliver only a sixth to a third of the health impact reduction from additional air policy, and only marginal reduction of ecosystem impacts.

This conclusion is also supported by the results of the stakeholder survey, with over 90% of general public and a strong majority of expert respondents (including 80% of government respondents) stating that the future EU air policy should set out additional measures beyond the maximisation of synergies with the forthcoming climate & energy policy.

Another important aspect to consider is the risk that climate change mitigation and air quality policies would deliver incoherent signals to investors, resulting in possible stranded costs similarly to the cases discussed in section 6.5.1 and Annex 8.1. Some sectors, such as the power and refinery sectors, may face in principle the risk that accelerated decarbonisation of electricity supply and of the transport sector could result in early retirement of large capacities and make redundant any additional pollution abatement investments on those

[100] Recent IIASA analysis (See Chapter 3.1, IIASA 2012B) based on the Global Climate Action/ effective technology scenario developed for the low carbon economy roadmap (SEC(2011) 288 final)

plants. However, the time horizon of the proposed air quality policy targets (2025-2030) will give sufficient time for plant operators to develop rational investment plans that give full value to the invested capital, also taking into account that the future low-carbon policy would be based on a cost-effective pathway minimising stranded cost risks.

There are further inter-linkages between climate and air policy. Firstly, some pollutants are also short-lived climate forcers; these include black carbon and ozone, and action to reduce their concentrations will be beneficial for both climate change mitigation and air quality. Secondly, atmospheric aerosols such as sulphates reflect incoming solar light, alleviating the global warming effect; this represents therefore a possible antagonism between climate and air quality measures, although the precise climate effect of aerosols is highly uncertain and any conclusions should be taken with due caution. Further, methane is both a potent GHG and an ozone precursor contributing to the raising hemispheric background concentration of ozone (which in turn is also a GHG). Reducing methane emissions is therefore a clear opportunity for synergy between climate and air quality policies, which is further discussed in section 6.5.5.

Taking all the above elements into consideration, the overall effect of achieving the air quality objectives for the 2025-2030 period compared to the baseline is an eventual small global cooling effect on climate. Calculated over a 100 year time horizon the cooling effect corresponds to - 0,0023 C (+/-0,0003 C) and over 20 year time horizon it is only slightly lower (-0,0021 C+/-0,0002 C). The regional cooling effects in Europe and the Arctic are likely to be stronger. The European contribution to depositions of black carbon in the Arctic is reduced by about 6 % as compared to the baseline.[101]

5.4.3. *Marginal deviations from the preferred option*

The main options (the baseline and 6A-D) are separated by rather large 'gap closure' steps (25%). Much finer-grained analysis has been done in order to compute marginal values as in Figure 9 above, and this analysis is instructive for assessing the implications of small changes in the preferred level of health and environmental impact reductions around Option 6C.

Table 24 below documents the additional expenditure by sector in the range +/- 10% around Option 6C's 75% gap closure. Options 6B (50%) and 6D (MTFR) are also reported for comparison. Impacts and expenditure by Member state are provided in Annex 7.

Table 24: Effort required per SNAP sector on sensitivity cases ranging between Option 6B (50% gap closure for PM2,5 health impacts) and Option 6D (MTFR), in M€/ year

2025	*Expenditure by SNAP sector, M€ increase compared to Option 1*						
Option	6B			6C			6D
PM2,5 gap closure	50%	*65%*	*70%*	75%	*80%*	*85%*	MTFR
Power generation	125	*195*	*249*	470	*827*	*1448*	3519
Domestic combustion	497	*1028*	*1439*	1680	*2853*	*4097*	17791
Industrial combustion	156	*395*	*457*	641	*853*	*1141*	1811
Industrial Processes	125	*233*	*277*	331	*407*	*488*	3964
Fuel extraction	0	*0*	*0*	6	*6*	*6*	583
Solvent use	2	*24*	*38*	56	*63*	*252*	12204
Road transport	0	*0*	*0*	0	*0*	*0*	0
Non-road machinery	5	*25*	*137*	145	*156*	*180*	1451

[101] Calculations made by JRC IES with the FASST tool

Waste	7	*8*	*9*	9	*9*	*9*	9
Agriculture	285	*586*	*745*	1292	*1459*	*2109*	5675
Total	1202	*2494*	*3352*	4629	*6633*	*9730*	47007

This sensitivity analysis shows that expenditure per sector in the vicinity of option 6C increases proportionately in most sectors. Costs for domestic combustion increase more rapidly beyond Option 6C, explaining the steeper slope of the marginal cost curve beyond this point. Below option 6C, less effort would be required especially of the agricultural and power generation sectors; however, each 5% less PM2,5 gap closure would mean renouncing €3-10 bn/y in health benefits alone, without taking into account the loss of substantial ecosystem benefits.

5.4.4. *Targets for ozone, acidification and eutrophication*

As explained above, the 75% gap closure on the PM2.5 health target (Option 6C) delivers also a certain reduction for ozone, eutrophication and acidification (because secondary PM precursors such as SOx and NOx affect those problems also). The outcomes are clearly valuable in themselves, however, and additional work was done to check for untapped potential for additional eutrophication and ozone reductions. (Acidification was not further pursued, since the ecosystem area left unprotected was already very small).[102]

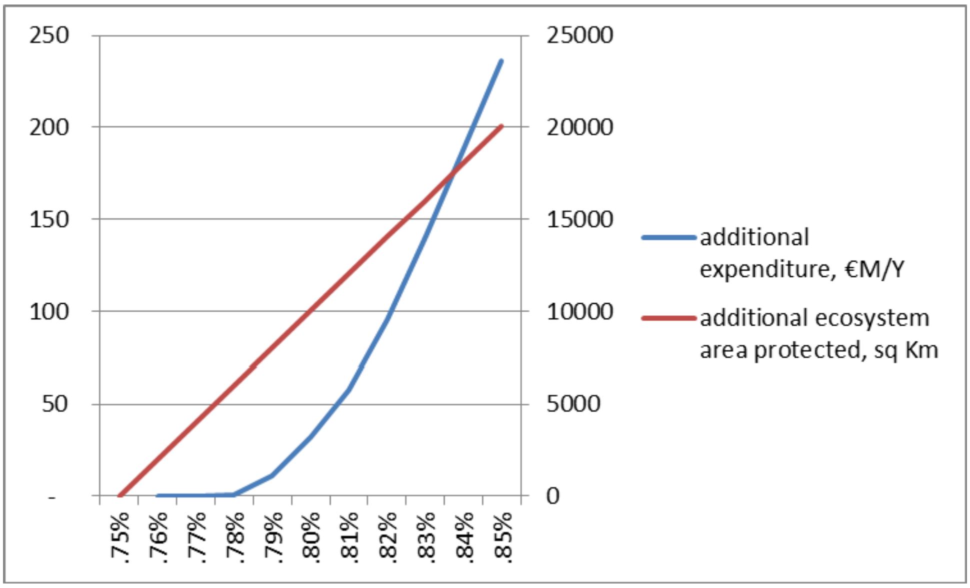
The majority of respondents to the public consultation stated that the EU air policy should give equal weight to human health and to the environment; almost 60% of government respondents, however, gave priority to human health.

Taking ozone first, the technical measures delivering 75% gap closure for PM2,5 also close 42% of the ozone impact gap. Each additional 1% ozone gap closure would deliver a health impact reduction of €15M.[103] Up to 46% gap closure this marginal benefit exceeds the additional expenditure (€13M per year to move from 45% to 46%), but the next 1% further closure would increase compliance costs by more than the benefits delivered. Thus 46% gap closure is optimal in economic terms. (The total cost to move from 42% to 46% ozone gap closure is €18M per year.)

For eutrophication, the benefits of reduction are hard to express in monetary terms and so the approach taken for ozone is not applicable. Rather, a range of variants were assessed going beyond the 75% gap closure delivered by Option 6C; the costs and emission reductions are summarised in Figure 10.

[102] For simplicity the sensitivity analysis is presented only for option 6C.
[103] From long-term ozone exposure.

Figure 10: Additional ecosystem area protection from eutrophication and related emission control costs (M€/yr) vs. baseline and vs. Option 6C (75% gap closure for eutrophication)



Moving from 75% to 80% gap closure would protect an additional 6,7% of ecosystem for an additional expenditure of €32M per year, around 0,7% additional expenditure; beyond this level of gap closure costs start increasing more steeply. Further analysis on the achievability of these objectives under different underlying hypotheses is presented in Annex 8.

For the subsequent sensitivity checks the central case is adjusted accordingly and is summarised in Table 25. (For the remainder of the IA it is referred to as Option 6C*.) Detailed information on impacts of Option 6C* including by MS and by sector are presented in Annex 7, Appendices 7.4, 7.5 and 7.6 .

Table 25: Summary of the central case 6C* gap closure vs Option 1 (baseline) and 6C

Gap closure objectives for main impacts, and required expenditure					
	PM Health	Ozone	Ecosystem Eutrophication	Expenditure in 2025	Expenditure in 2030
6C	75%	42%	75%	4629 M€/year	4182 M€/year
6C*	75%	46%	80%	4680 M€/year	4242 M€/year

5.4.5. *Addressing methane emissions*

Methane is an increasingly significant issue due to the impact of hemispheric emissions on background ozone concentrations and on climate change; several stakeholders have suggested that national methane ceilings should be included in the NECD. Annex 10 examines the reduction potential for methane in the EU. The baseline recently developed for the 2013

Climate & Energy policy framework[104] would cut emissions by 20% in 2025 compared to 2005, although the variation between individual Member States would be large. Beyond the baseline, a further 8% reduction (to around 26% overall) could be delivered by measures that are either cost neutral or pay for themselves through energy recovery. In 2030, the baseline would respectively deliver a24% methane emission reduction compared to 2005, while the further potential for cost-free measures is estimated at 9%) (33% overall).

Methane targets of up to a 30% reduction in 2025 and 33% in 2030 compared with 2005, suitably differentiated by Member State (see Annex 10), could thus be implemented by measures which, while requiring up-front investment, will have a positive return. Such targets would have a small but significant effect on ozone concentrations across the northern hemisphere, but more importantly could provide a negotiating platform to pursue comparable methane emission reductions internationally.

However, uncertainties in the projections are substantial (covering e.g. the impact of abolishing milk quotas), and may significantly change national methane emissions and the affordability of possible emission reduction targets. Moreover, methane is one of the greenhouse gases part of the international climate negotiations and of the Effort Sharing Decision (ESD) for reducing GHG emissions outside the ETS. Setting national ceilings for CH4 may limit the flexibility offered in the ESD to meet targets. These aspects would need to be taken into account in determining the level at which any ceilings would be set, and suitable flexibility should be allowed in their implementation.

Respondents to the stakeholder consultation from the agricultural sector expressed concerns about the possible inclusion of methane ceilings in the NECD, stating that this would not be cost-effective for their sector. Responses from governmental bodies were divided: some stated that existing international agreements are sufficient to control methane, some others argued that methane should be included in the NECD as an incentive for international action.

5.4.6. *Robustness to variations in the key analytical assumptions*

One of the key issues raised by stakeholders was how to handle uncertainties in the analytical assumptions. To test the impact of these uncertainties a range of analyses were run where key assumptions were varied (for details see Annex 8, section 4).

The first analysis assessed whether targets for 2025 could lead to regret investments – that is, to the deployment of abatement technology which would not be needed on a 2030 perspective (e.g. because other cheaper options would become available). These impacts are assessed to be around 0,5% of the total cost for the central case Option 6C*; they are concentrated in a particular Member State (the UK) and can be dealt with by suitable flexibility arrangements.

Of the respondents to the stakeholder consultation, just half supported 2025 as target year for the revised air policy, and almost 40% supported 2030. Among those, a majority of NGO and individual respondents chose 2025, while most government and business respondents chose 2030. However, more than 90% of the government respondents indicated that the 2030 targets should be reinforced by interim targets for 2025, with a clear preference for

104 See L. Höglund-Isaksson, W.Winiwarter and P. Purohit (2013) Non-CO_2 greenhouse gas emissions, mitigation potentials and costs in EU-28 from 2005 to 2050, Part I: GAINS model methodology, 30 September 2013, IIASA, Laxenburg

mandatory rather than indicative interim targets.

The second analysis assessed whether the 6C* targets would still be achievable if growth were higher than projected in the assumed baseline.[105] The conclusion is that the impact and emission reductions of Option 6C* would indeed still be achievable overall, and suitable flexibility arrangements could deal with any impacts at Member State level.

The third analysis assessed how much more expensive the objectives would be if the EU's renewable energy and energy efficiency targets were not fully met.[106] The conclusion is that the objectives would still be achievable, albeit at somewhat higher costs (additional 360 M€/year in Option 6C*). Even the national emission ceilings derived from Option 6C* (ie. those calculated as most cost-effective to deliver the reductions) would still be achievable, but would come at an additional cost of 1094 M€/yr (23% higher), almost entirely for pollution abatement in residential combustion,[107] This demonstrates the high synergetic potential of energy efficiency measures to curb energy demand and associated pollution from buildings.

5.4.7. *Burden sharing between Member States*

Option 6C* (Table 25) would require some 0,03% of the EU's GDP for expenditure in additional pollution abatement measures. However, the distribution of effort across Member States varies from 0,003% of GDP in Sweden to 0,168% of GDP in Bulgaria. This is a reflection both of different absolute GDP levels (the cost of the same piece of equipment would represent a higher share of GDP in a lower-income country); and of differences in past effort (a smaller reduction potential in countries with a longer pollution control tradition).

The effect of capping the direct additional expenditure as a percentage of GDP (while maintaining the environment and health benefits in each Member State) was assessed. The analysis is summarised in Annex 8 (section 5), and shows that any limitation substantially increases the costs for other Member States who are often in no better position to absorb the additional costs. This confirms that the effort required on option 6C* is well balanced across Member States.

5.4.8. *Summary of sensitivity analysis*

The following are the main points emerging from the above reported sensitivity analysis:

- while climate policy will be substantially beneficial for air quality, climate policy alone would not be sufficient to achieve the long-term air quality objective by 2050;
- option 6C could be improved (leading to option 6C*) for ecosystem and health impacts by complementary eutrophication and ozone targets of 80% and 46% gap closure, respectively, delivered at an increased compliance cost of 1%;
- there is potential to set an EU methane reduction target at low or zero cost;

105 The so-called PRIMES 2012-13 Reference Scenario is the basis for all the analysis presented. The PRIMES 2010 reference scenario was used as an alternative; it assumes higher growth than PRIMES 2012-13, but differs also in many other respects.

106 At the level of the policies currently enacted in the Member States; this is represented by the 2013 PRIMES Baseline scenario, which assumes that achievement of legally binding national targets on renewable energy, Effort Sharing Decision and energy efficiency depends on currently adopted national measures and policies. Total energy consumption in the EU in 2030 is thus 2,82% higher than in the Reference scenario, and the share of renewables 1,7% of total consumption lower.

107 €998M/year.

- the policy objectives are still achievable on alternative future scenarios, and while there could be some regret measures from application in 2025, these are concentrated in one sector and one Member State and would be dealt with by suitable flexibility arrangements.

5.5. **Policy instruments to achieve the targets**

5.5.1. ***National Emission Ceilings Directive***

The NECD will be the main implementing instrument for the policy, and the options and related impacts of setting ceilings for the period 2025-2030 have been analysed throughout chapter 6. However, in revising the Directive a number of more detailed issues arises which are examined in Annex 11. The measures analysed for the effectiveness and costs are already part of EU and MSs commitments under the LRTAP Convention, in particular for the air emission inventories and projections as well as air pollution monitoring of ecosystem impacts. The main conclusions are that the following further provisions can be included at very modest administrative cost (around €6.9m initial cost and €2.5m annual cost EU-wide):

- Comprehensive coherent national air pollution control programmes requiring that benefits for air quality be maximised
- Requirements to bring emission inventories and projections into line with CLRTAP requirements
- Ecosystem monitoring representative of sensitive ecosystems coordinated with the LRTAP Convention to assess the effectiveness of the NECD in protecting ecosystems
- Simplification and harmonisation measures designed in particular to ensure coherence in MSs reporting
- Measures to require that specific attention is paid to Black Carbon (BC) when designing measures to meet PM reductions, in line with CLRTAP and specifically the 2012 amendment of the Gothenburg Protocol.

In the public consultation, strong majorities (85-96%) of the expert stakeholders and of the general public gave their support to requiring coordination between national and local levels in respect of emission reduction measures and air quality management.

Strong majorities (80-95%) also support the pursuit of specific complementary action to curb emissions of SLCP, and specifically of BC; only 55% of expert respondents and 40% of government respondents, however, support the inclusion of separate BC ceilings in the NECD.

5.5.2. ***Source controls***

A number of stakeholders (including 94% of government respondents) stressed the importance of EU source controls in sharing the pollution reduction burden, and so the impacts of a range of source controls to complement the NECD have been assessed. EU-wide measures also secure single market objectives and a level playing field for economic operators being subject to the same conditions throughout the EU.

The analysis took several groups of measures and estimated the additional implementation cost if they were taken EU-wide.[108] Details are provided in Annex 8, section 7. The measures examined would entail only relatively minor cost-effectiveness compromises, and could be delivered with a combination of existing and new policy initiatives. For many sectors (including chemicals, cement and lime, refining), emission reductions could be delivered through the adoption of revised BAT conclusions under the Industrial Emissions Directive (IED) A first round of revisions is foreseen to be finalised by 2020 as mentioned in the 7EAP, while subsequent revisions of the documents will be starting around that time. Annex 8 provides a preliminary indication of the proportion of the reduction effort that could be delivered via IED implementation for the sectors considered. However, the outcome of the process of defining and establishing BAT conclusions gives a strong role to Member States through their vote on the relevant implementing Decisions in the IED Article 75 Committee.[109]

Ammonia emissions from agriculture have so far been hard to regulate at EU level, partly due to the structure of the sector, and partly because emissions and abatement options from the same activity can be different in different places.[110] A revised NECD will set new national emission ceilings for ammonia for 2020 and beyond, leaving it to Member States to identify and implement the appropriate measures to reach the ceilings. The measures required to achieve the ceilings are already implemented in a number of Member States, and the effect of the ceilings would be to bring other Member States up to a comparable level. Thus there is no barrier to implementing the required reductions at Member State level.

However, additional support at EU level will be further considered. Existing BAT conclusions for large farms under the IED are due to be revised in 2014 and 2020; although these will only cover the largest pig and poultry installations, their contribution to the overall emission reduction objectives can be significant, as in 2008 these holdings represented about 25% of all EU ammonia emissions.[111] A recent review under the IED[112] concluded that reducing emissions from manure spreading offers the highest benefit-to-cost ratio, and this option will be further explored as a matter of priority, with a view to determining if and how ammonia emissions should be controlled at EU level. Ways to address ammonia emissions from urea-based fertilisers will also be considered, including in the forthcoming review of the Fertilizers Regulation.[113] Any further measures on agriculture (beyond the ammonia ceilings in the NECD) will be subject to separate impact assessment.

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108 Note that measures related to product standards are always assumed to be taken at EU-wide scale due to single market provisions. These include: emission standards for road vehicles and non-road machinery; solvent content of consumer products; minimum standards under the Ecodesign directive.

109 Through this vote Member States will have the decisive role in determining the level of stringency of the BAT conclusions and so the share of emission reduction between EU and national measures.

110 Due to factors such as soil and climate conditions, the properties of various types of manure (linked to feed, species, age and weight), the timing and rate of application of manure to agricultural land, the type of housing facilities and manure storage systems, the proportion of time spent indoors or grazing, different local farm traditions and practices etc.

111 Source: SEC(2007) 1679.

112 Report from the Commission on the reviews undertaken under Article 30(9) and Article 73 of Directive 2010/75/EU on industrial emissions addressing emissions from intensive livestock rearing and combustion plants. COM(2013) 286.

113 Regulation 2003/2003/EC

SO2 emissions from international shipping will be significantly reduced[114] by the recently amended Sulphur Directive at a high cost-benefit ratio[115]. The cost-effectiveness of further emission reductions of SO2 is not evident on the basis of the current analysis, but further analysis is merited to investigate in more detail. Although any decisions on additional EU measures would need a separate, more specific analysis,[116] there is clear potential for shipping to cost-effectively deliver NOx emission reductions. Designating NECA in the EU sea areas could deliver substantial benefits,[117] and Member States that do so would need to take less action on land-based sources to meet the health and environmental objectives of the NECD. Although the emission reduction commitments of the NECD do not cover international maritime traffic emission,[118] a voluntary offset mechanism could be envisaged, which could deliver substantial emission control cost reductions for land-based sources while ensuring the achievement of the environmental objectives of option 6C* in all Member States, as detailed in Annex 8, section 6. [119]

An EU-level pollution levy was not considered a realistic instrument to deliver the EU-wide pollution reduction objectives. However, taxation at Member State level may well remain an effective policy instrument, also to stimulate growth and employment in a green tax reform context. Positive examples include Denmark's levy on sulphur content of fuels which has driven SO2 emissions sharply down, and its tax on NOx emitted from large and medium-sized point sources.

Combustion plants with a rated thermal input between 1 and 50 MW (hereafter Medium Combustion Plants or MCP) are generally not regulated at EU level, and have been identified as a notable gap in EU legislation. Annex 8 (section 6.2) provides an estimate of the emission reductions and associated emission control costs that would be required of the MCP sector on the central case policy option 6C*. These are estimated at 79 kiloton SO2, 108 kiloton NOx, and 13 kiloton PM2,5, for total additional emission control costs of 220 M€/year. A detailed assessment of options to achieve reductions in this order is provided in Chapter 7 and further background information in Annex 12. The analysis shows that extending the scope of such measures to an EU-wide instrument would result in emission reductions of 135 kiloton SO2, 107 kiloton NOx, and 23 kiloton PM2,5, for total additional emission control costs of 382 M€/year.

Combustion plants below 1 MW rated thermal input include millions of heating installations such as single-house boilers and room heaters. The cost-optimal policy options developed in this chapter include substantial measures for these sources (including 164 kt PM reductions in 2025 in the central case option 6C*). The sources are covered by Directive 2009/125/EC on ecodesign of energy-related products, and ecodesign requirements for solid fuel and biomass boilers (below 1 MW) and local space heaters (below 50-70 kW) are expected to be finalised at the end of 2013. As these installations are responsible for more than 40% of primary PM emissions, major air quality improvements are

[114] In SECA (in the EU: Baltic and North Sea) the sulphur content of marine fuels will be reduced from 1.50% to 0.10% as of 2015 and it other sea areas from 3,50% to 0,50% as of 2020.

[115] Benefits outweigh costs by a factor of 5 to 25. SEC(2011) 918 final

[116] Further studies would need to take into account a variety of factors including: low-sulphur fuel price premiums; the availability of cost-effective alternative technical solutions (scrubbers), and the exact definition of control areas.

[117] The findings show the cost-benefit ratio in the range of 1 to 3,2-11,1 in the Baltic Sea (source: own elaboration based on VITO, IIASA and EMRC) and 1 to 1,6-6,8 in the North Sea (source: Danish Ministry of the Environment, 2012); the North Sea assessment uses however less recent benefit estimates.

[118] This is the reason why emission reductions from international shipping are considered separately from the cost-effective emission reduction options 6A-6D.

[119] Annex 8 presents as an example the case of designating NECA in all EU sea areas, delivering €137M/yr NOx control cost reductions[119] for land-based sources in 2025.

expected as a consequence.; It must be kept in mind, however, that the general analysis of this chapter cannot fully capture the human exposure and health damage caused by household boilers, because it cannot differentiate between low-level sources (such as road vehicles and low chimneys) and high-stack sources such as power plants. Thus, this analysis should not guide in detail the decision on the exact level of stringency to be sought for ecodesign implementing regulations.

Directive 97/68/EC on non-road mobile machinery covers engines used in a variety of applications that include small handheld equipment, construction and forestry machinery, generators, railcars, locomotives and inland waterway vessels. The NRMM sector has become an increasingly important source of air pollution owing to a steep increase in the number of non-road machines put into service, and to the less stringent emission standards compared to the road sector. Directive 97/68/EC is currently under revision, with a Commission proposal expected before the end of 2013. The cost-optimal policy option 6C* includes 64 kt NOx reductions from the non-road sector, which would be delivered mainly by setting more stringent emission requirements for inland waterway vessels, for construction and industrial machinery, and for rail engines. The same considerations and caveats on low-level sources discussed for the Ecodesign Directive apply also to these measures, and the present analysis should not preempt the outcome of the revision of Directive 97/68/EC.

Based on existing legislation, initiatives in the pipeline and the new measure on MCP proposed here, more than 50% of the emission reductions required to meet the impact reduction objectives of the proposed revised Strategy can be delivered by source control measures at EU level. Detailed analysis on the emission reductions that could be delivered by existing instruments is provided in Annex 8.

Combined, the instruments discussed above could deliver a substantial share of the emission reductions required to achieve the objectives of the 6C* option. Table 26 summarises the total reductions necessary in 2025, the costs associated, and the share of reductions and economic effort that each instrument could deliver.

Table 26: Emission reductions and economic effort required to achieve the objectives of the 6C* policy option and potential contribution EU and MS instruments

		SO2, kt	NOx, kt	PM, kt	NH3, kt	VOC, kt	effort, M€
EU28 total		-753	-574	-420	-918	-975	4680
Ecodesign		0	-2	-164	0	-423	1475
NRMM		0	-64	-4	0	0	142
MCP		-135	-107	-23	0	0	382
IED		-326	-257	-29	-228	-134	1155
of which:	cement	-84	-247	-9	0	0	339
	glass	-11	0	-3	0	0	29
	refineries	-180	-10	-3	0	-33	289
	chemicals	-51	0	-14	0	-11	52
	solvents	0	0	0	0	-90	15
	Pigs and poultry				-228		430
National measures		-292	-144	-200	-690	-418	1526

% National			39%	25%	48%	75%	43%	33%

Product-based legislation, in this case relevant for Ecodesign requirements for domestic heating appliances and for emission standards for non-road machinery, would in any case need to be put forward at harmonised EU-level to ensure the functioning of the Single Market; this would leave around 2/3 of the effort under the responsibility of the Member States. If, additionally, the EU-level emission controls described above were introduced for medium combustion plants and for several sectors under the IED, EU-level measures would overall deliver more than half the required effort, leaving under Member States' responsibility one third of the costs and between 25 and 48% of the emission reductions, with the exception of ammonia emission reductions from agriculture, in which case the IED could cover around a quarter of the emission reductions and around 30% of the economic effort required of the sector.[120]

5.6. Competitiveness and SME impacts

A full analysis of competitiveness and SME impacts is provided in Annex 9. Potential impacts on competitiveness concentrate in sectors that – because they are more exposed to international competition – will have more difficulty passing through additional costs to their markets. Examples are refineries, chemicals, iron & steel and agriculture; it is likely that at least a subset of these users will have difficulty in passing costs through. The most significantly affected sectors would be agriculture and petroleum refining. In all cases, however, the additional resources committed under the policy options considered would be below or in the order of the 1% threshold of Gross Value Added, indicating headroom to absorb the additional costs.

Implementation of the NH3 ceiling for agriculture under the NECD remains under the responsibility of the Member States; however, the analysis indicates that the required reductions can be achieved by targeting measures on larger installations covering most of the sector capacity. Residual impacts on small farms can be dealt with by Member States by exempting the smaller farms (cattle and pig farms below the 15 Livestock Units threshold and larger thresholds for poultry), and by earmarking appropriate resources under the Rural Development Fund.

Considering the type of installations and abatement measures involved, impacts on SMEs are considered significant only for measures in medium combustion plants (MCP), addressed in chapter 7.

5.7. Trajectory to achieving the long-term objective by 2050

Option 6E of Table 12, aiming at achieving ambient air pollutant concentration below the WHO guideline values in 2025-2030, was not taken up in the analysis because there are no technical measures currently available that could achieve the WHO guidelines on that timescale. However, we have examined the possibility of reaching the WHO guidelines on a more extended timescale. A Maximum Control Effort (MCE) scenario was developed for the years 2030 and 2050, combining the effect of further phasing out of the most polluting sources (coal), increased electrification, energy efficiency gains and the application of available technical pollution control measures. The analysis shows that the MCE scenario in 2050 would achieve background PM2,5 concentrations below the 10 $\mu g/m^3$ limit recommended by the WHO virtually everywhere in the EU (99,5% of territory and 99% of population exposed). Even at the level of individual monitors, 90% of stations would meet the 10

[120] Possible further measures to restrict emissions from manure storage and application and from mineral fertilisers are not considered.

g/m^3 limit, while the residual 10% would be addressed by appropriate supplementary local action for hotspot management. A trajectory towards the 2050 MCE was developed, starting from the central case emissions for 2025, and is set out in Table 27 . Whilst these reductions would all be feasible under the MCE assumptions, their practical implementation would depend on structural and other changes which cannot currently be assumed. Thus the trajectory, and the implied pollution ceilings for 2030 which result, should be considered indicative. Details are in Annex 7, section 4.

Table 27: Emission reduction trajectory towards achieving the WHO guideline values in 2050; emissions in kilotons, reductions compared with 2005 emissions

EU28	2005	2025	2030	2040	2050
SO2	8172	-79%	-82%	-87%	-91%
NOx	11538	-65%	-70%	-78%	-83%
PM2,5	1647	-48%	-54%	-64%	-72%
NH3	3928	-30%	-38%	-42%	-48%
VOC	9259	-50%	-55%	-64%	-71%

5.8. Conclusions

The analysis indicates that the option which delivers the maximum net benefit (Option 6C, the 75% gap closure for PM2.5 health impacts) offers a robust and economically sound basis for further policy consideration.[121] Sensitivity analysis suggests that this option could be further improved by adding eutrophication and ozone targets of 80% and 46% gap closure respectively, delivered at an increased compliance cost of 1% (Option 6C*).

Setting air pollution reduction objectives for 2025 rather than only for 2030 would not cause economic inefficiency or incoherence with climate and energy policy, and would deliver additional cost-effective emission reductions in the period 2025-2030. The policy would be implemented by a revised NECD, supplemented by a legislative proposal controlling emissions from Medium Combustion Plants (see Chapter 7) and a Clean Air Programme summarising non-legislative initiatives to support implementation (see Chapter 5). Compared to the baseline, this option would entail in 2025 (figures for 2030 in parenthesis, if different):

- Health benefits of 62,000 (61 000) less premature deaths from long-term exposure to PM2,5 and 1,600 from acute exposure to ozone, as well as 84 (80) million less sick days.
- Environmental benefits of 146,000 (152,000) additional km^2 of ecosystems protected from eutrophication, 73,000 of which are in Natura 2000 areas; and 23,000 (21,000) additional km^2 of forest ecosystems protected from acidification.
- Additional compliance costs of €4,7 (4,2) billion per annum.
- Direct economic benefits of €3,2 (3,0) billion (reduced workdays lost, healthcare cost savings, improved crop yields and reduced damage to the built environment), compensating roughly two-thirds of the pollution control costs.
- No net GDP impact when labour productivity benefits accruing from improved health are included.

[121] To derive more accurate marginal figures, the analysis has been done with finer granularity, which results in MC=MB at 76.2% gap closure, to be precise.

- Overall benefits in the range of €45-150 (41-146) billion per annum, 10 to 35 times the compliance costs (without considering the ecosystem benefits).

The analysis remains subject to uncertainties and analytical constraints that upon further consideration may broaden the range within which sound policy decisions could be taken. However it offers a solid basis updating the TSAP also considering the need to ensure a maximum of synergies possible, not least with future climate and energy policy.

6. ANALYSIS OF OPTIONS TO REDUCE EMISSIONS FROM MEDIUM COMBUSTION PLANTS

6.1. Rationale for Action

The analysis described in the previous chapters has identified cost-effective emission reductions from combustion plants with a rated thermal input between 1 and 50 MW (hereafter medium combustion plants, MCPs) in a way that suggested a potential for cost-effective EU source legislation in this area.

This chapter presents a summary of the detailed impact assessment related to the options for delivering emission reductions from MCPs through an EU-wide legislative instrument as part of the revised EU Strategy on Air Pollution. The details are provided in Annex 12.A number of stakeholders stressed the importance of EU source controls in sharing the pollution reduction burden. However, the responses to the public consultation on this issue were rather diverse and did not allow conclusion on a clearly preferred option for all stakeholder groups. Several respondents referred to the need to limit administrative burden, stating it could become disproportionate in case of a "full" permitting regime both for operators and for competent authorities.

6.2. Characteristics of the sector

Currently, there is no EU legislation specifically addressing air emissions of polluting substances from MCPs. A number of Member States have legislation in place for all MCPs or for a part of the capacity range. Emission limits applied nationally (or regionally), however, differ significantly across Member States.

Combustion plants with a rated thermal input between 1 and 50 MW are used for a wide variety of applications, including electricity generation, domestic/residential heating and cooling, providing heat/steam for industrial processes, etc. For the purposes of this assessment, two groups have been distinguished, labelled as "boilers" and "engines and turbines" (or "others"). For Member States where no indication of the distribution between these two categories has been identified, the split has been assumed to be 80:20 boilers to others.

Taking into account the broad capacity range, the variety of applications, and that pollution abatement measures (and their costs) may differ depending on capacity, MCPs have been grouped in three capacity classes. The impacts related to each of those groups were assessed separately.

The table below (with data referring to 2010) illustrates that the three classes cover very different numbers of plants, but are comparable in term of current emissions for the three pollutants considered. In 2010, the dominant fuel for medium combustion plants was natural gas with 67% of the total fuel use (64% for plants 1-5 MW, 73% for 5-20 MW and 60% for 20-50 MW). Solid (biomass, coal) and liquid fuels each have a share of about 12%. In some countries the main fuel used differs significantly from the overall EU average.

Table 28: Overview of medium combustion plants (data for 2010)

Rated thermal input:	**1-5 MW**	**5-20 MW**	**20-50 MW**	***Total 1-50 MW***
Number of plants	113809	23868	5309	*142986*
Total rated thermal input (GW)	274	232	177	*683*
Annual fuel consumption (PJ/year):	1971	2325	1410	*5705*
SO_2 emissions (kt/year)	103	130	68	*301*
NO_x emissions (kt/year)	210	227	117	*554*
PM emissions (kt/year)	17	20	16	*53*

6.3. Methodology

Data on medium combustion plants was gathered from the Member States. From these Member State data and through extrapolation based on a number of assumptions, an EU wide dataset (number of plants, fuels used, emissions, legislation in place) was developed with which possible control options were assessed through a bottom-up approach. Member State data was gap-filled using literature data and expert judgement for applicable control measures and associated compliance costs.

Impacts were assessed for the years 2025 and 2030 but as the trends for both years are very similar, with emissions and costs in all but one case either the same or just a few per cent lower in 2030 as compared to 2025. For clarity reasons, analytical results presented in this chapter focus mainly 2025. The results for 2030 are presented in Annex 12.

6.4. Policy options

In designing the policy options two aspects were considered: the emission level and the approach by which plants would be regulated, in particular whether or not a permit would be required. A summary of the different emission level and regulatory options considered is provided in Table 29 and Table 30.

Table 29: Emission level options

Emission level	**Description**
Option 1	**"no EU action"** This option assumes continuation of current policy measures at Member State level and no further measures for controlling emissions of SO_2, NO_x or PM from combustion plants <50MW in the EU. It serves as a reference to calculate the impacts of the other policy options.
Option 7A	**“most stringent MS”** EU wide emission limit values for SO_2, NOx and PM are set for all combustion plants (new and existing) at the level of the most stringent legislation which is currently applicable in Member States for existing plants (for each of the fuel types and size classes considered).
Option 7B	**“LCP”** EU wide emission limit values for SO_2, NOx and PM are set for all combustion

	plants (new and existing) in line with the general applicable emission limit values in the IED for existing (large) combustion plants (LCP) with a rated thermal input between 50 and 100 MW (Part 1 of Annex V of the IED).
Option 7C	**"primary NOx"** A variant of option 7B, with the same ELVs for SO_2 and PM, but for NOx, the emission limit values would only require uptake of only combustion modifications (primary measures) and not of secondary (end-of-pipe) measures.
Option 7D	**"Gothenburg"** A variant of option 7C, differentiating between new and existing plants, ensuring alignment with the Gothenburg Protocol provisions, incorporating a number of cost mitigation measures.
Option 7E	**"SULES"** A variant of option 7D, where emission limit values for new plants are set at the level of the most stringent emission limit values applied by Member States.

Table 30: Regulatory options

Regulatory options	**Description**
Option R1	Integrated permit similar to the Industrial Emissions Directive (IED) regime (covering not only air, but also water, soil, waste, …)
Option R2	Permit, but only for emissions to air of SO2, NOx and PM
Option R3	Registration on the basis of notification (no permit)
Option R4	General Binding Rules without permit, notification or registration

6.5. Impact analysis

6.5.1. Environmental impacts

Table 31 provides an overview of the reduction of the annual emissions from applying the five policy options 7A-7E in comparison with a "no EU action" option. The highest emission reductions would be achieved for all the pollutants under option 7A, while slightly lower, but still very significant emission reductions result from option 7B. Little difference exists between the different options for SO_2 and PM.

For NOx however, only options 7A and 7B require very effective but costly secondary abatement measures. Option 7C would deliver fewer reductions while this is increasing again under option 7D and option 7E due to the introduction of secondary measures in a limited number of plants.

The NOx reductions foreseen in option 7D, where a bottom up-approach has been taken in the modelling, are the same as forecast in central case policy option 6C* (108 kilotons/year) which is based on the uptake of the most cost-effective pollution control measures in each Member State.

Table 31: Emission reduction compared with "no EU action" in 2025 (kt/y)

Option:	7A	7B	7C	7D	7E

Option:	7A	7B	7C	7D	7E
SO2	139	127	127	135	137
NOx	338	288	76	107	159
PM *	45	42	42	45	45

*for technical reasons this is expressed as total particulate matter; to be divided by a factor 2 for convert to PM2.5

6.5.2. Economic impacts

For assessing the economic impacts of the introduction of the EU wide emission limit values, a distinction was made between (i) compliance costs; (ii) emission monitoring costs and (iii) administrative costs.

Compliance costs reflect the cost of additional abatement measures needed to be implemented within the combustion plants concerned and include both capital and operational costs. When calculating total compliance costs per Member State, account has been taken of the extent to which emissions are already regulated under national legislation currently in place.

The introduction of emission limits also requires emission monitoring to allow verifying compliance. For the assessment, only periodic monitoring was assumed as the costs of continuous monitoring are considered prohibitively high.

The regulatory options R1 to R4 result in different administrative costs for both the operators and authorities involved. Depending on the option, administrative costs include elements such as the cost of bringing installations under the regulation, costs incurred in preparatory work for issuing permits, costs of reporting and checking compliance, etc. Several cost elements do not occur under options R3 and R4.

The total annualised costs for operators related to the different options considered are shown in Table 32 below. They range between from 385 and 3486 M€/year.

Table 32: Total annual costs for operators (1-50 MW) (M€/year, 2025)

Emission level option:	7A				7B				7C				7D				7E			
Regulatory option:	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
Administrative costs	165	90	9	5	165	90	9	5	165	90	9	5	165	90	9	5	165	90	9	5
Monitoring costs	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
Compliance costs	3296	3296	3296	3296	2226	2226	2226	2226	355	355	355	355	382	382	382	382	790	790	790	790
TOTAL	3486	3411	3330	3326	2416	2341	2260	2256	545	470	389	385	572	497	416	412	980	905	824	820

Compared to 'no EU action', option 7A would lead to an additional compliance cost in 2025 of nearly 3300 M€/year, which is about 1.5 times higher than option 7B. Under either of these options more than 80% of costs are associated with NOx abatement measures mainly due to the need to apply secondary measures in a high number of natural gas fired plants. Under option 7C, where only combustion modifications would be required to abate NOx, compliance costs are drastically lower (around 10% of costs under option 7A). The low costs are kept also under option 7D which foresees secondary abatement measures for NOx in new diesel engines and part of new boilers. In this case total compliance costs are only 2% higher than in option 7C and correspond to about 12% of the costs under option 7A.

Given its focus on very stringent standards for new facilities, the compliance costs for option 7E are higher than for option 7D. This is also the only option where costs in 2030 would be higher than in 2025 as the costs increase substantially as existing plants are replaced by new ones.

The administrative costs are strongly reduced under the "lighter" regulatory options (R3, R4).

SME considerations

About 75% of the medium scale combustion plants are assumed to be operated within SMEs. The direct economic impacts for SMEs were quantified by comparing the total costs per plant against the level of financial resources available to the operator for investment, expressed by using the gross operating surplus (GOS). This has shown that the impact on SMEs can vary between 0.1 to 21.7% of GOS depending on the option. Also under light regulatory options values of about 20% GOS could be reached for the most costly emission level options in cases of small enterprises operating a plant of the biggest category 20-50MW.

Therefore, in addition to the general approach of designing options with a limited administrative impact, a series of mitigation measures to further alleviate the economic burden on SMEs and to limit impacts on internal EU competition and competitiveness has been considered and assessed.

This includes in particular measures such as a later date of application of the emission limits for existing plants and exemptions for plants operating a limited number of hours and derogations for specific cases which have also been identified (e.g. in case of interruption of gas supply, in case of interruption of low-S fuel, when abatement equipment fails). Such mitigation measures would avoid requiring costly investments delivering only very limited environmental benefits and can thus be recommended. Elements of this have been reflected in options 7D and 7E which allow limiting the investment on existing plants with a limited remaining life time.

The impacts of a policy with light regulatory approach (R3, registration only), with emission level option 7D, where also some mitigation measures are already included, will amount to 0.1 – 2.4% of the GOS.

6.5.3. Comparison of options

The policy options are qualitatively compared against four key criteria (Table 33) using the following symbols: high +, low -, yes Y, no N, not applicable NA.

Table 33: Comparison of options

	7A	7B	7C	7D	7E	R1-R2	R3-R4
Pollutant abatement cost	+	+	-	-	+/-	NA	NA

	7A	7B	7C	7D	7E	R1-R2	R3-R4
Administrative costs	NA	NA	NA	NA	NA	+	-
EU compliance with international obligations	Y	N	N	Y	Y	NA	NA
Impacts on SMEs	+	+	-	-	+	+	-

For a quantitative comparison, the abatement cost is calculated as compliance cost divided by the associated emissions reduction. For all options, this compares very favourably with the damage costs (EMRC, 2013), except for NOx where this is only true for options 7C, 7D and 7E.

Table 34: Cost-effectiveness of options

Emission level option:	**Abatement cost per ton of pollutant reduced (€/t)**					**Damage costs (€/t)**
	7A	**7B**	**7C**	**7D**	**7E**	
SO2	2600	1400	1400	1400	1500	7600 – 21200
PM*	5200	2900	2900	2500	2800	14750-41650
NO_X	7600	6300	500	800	2900	5500-13900

* To allow comparison in this table, damage costs for PM2.5 (29500-83300€/t) have been reduced by half to account for the complex relationship between PM and PM2,5

While the abatement costs for option 7D remains in the same range as that for option 7C, option 7D allows further emission reductions and ensures compliance with the Gothenburg Protocol.

6.6. Conclusions and preferred option

The main conclusions from the detailed MCP analysis are as follows:

- Significant and cost-effective emission reductions can be achieved for all three pollutants (in 2025, addition reductions over the baseline of 135kT/y SO2, 107kT/y NOx and 45kT/y PM on option 7D);
- For all options, cost effectiveness compares very favourably with the damage costs for all pollutants and for all options(see Table 34), except for NOx where high cost-effectiveness is demonstrated only for options with less stringent emission limits;
- The total annualised costs for operators can be brought down to the range of 400 M€/year when secondary NOx control is applied only for part of the new plants (as required in the Gothenburg Protocol).
- Policy can be designed so as to minimise administrative costs, by requiring only registration of plants;
- Impacts on SMEs can be reduced to within 0.1 and 2.4% of GOS (option 7D);
- The following mitigation measures for SMEs have been considered: phased implementation with existing plants to comply later than new, temporary exemption for malfunctioning, exemptions for limiting operating hours and microenterprises, simplified reporting obligations (no permit) and limited monitoring for smaller capacity classes.

From the above it is concluded that the favoured policy option in terms of emission reduction is option 7D ("Gothenburg"), coupled with a registration (option R3) for all plants. This choice combines the emission reduction option delivering a high benefit-to-cost ratio, with low administrative costs, while ensuring implementation of the international obligations arising from the Gothenburg Protocol and taking into account comments and positions expressed from the different stakeholders.

In particular situations such as for instance air quality management zones in non-compliance with limit values of the AAQD, Members States might have to adopt stricter abatement measures, as reflected in the emission level option 7E (SULES).

Chapter 6.6.2 estimates the emission reductions that would be required in 2025 from MCPs under the central case policy option 6C* at 79 kT/y SO2, 108 kT/y NOx, and 13 kiloton PM2,5, for a compliance cost of 220 M€/year. An EU-wide instrument to control emissions from these plants would extend to all Member States the technical measures identified as cost-effective in the multi-sectorial analysis of Chapter 6. Designing such an instrument based on the preferred options would lead to a compliance cost of 382 M€/year and emission reductions of 135 kT/y SO2, 107 kT/y NOx, and 45 kT/y PM (corresponding to about 22.5 kT/y PM2,5). The increased emission reductions from the sector over option 6C* are commensurate with the increased cost.

7. SUMMARY

This Chapter summarizes the analysis of the policy options developed in Chapters 5 through 7 to address the outstanding problems defined in Chapter 3 in accordance with the objectives formulated in Chapter 4.

To ensure achieving full compliance with the air quality legislation by 2020 at the latest (the first general objective), six policy option were considered in Chapter 5: the baseline (Option 1); additional source controls (5A); tighter ceilings under the NECD (5B); supporting action for further Member States' measures (5C); further international action (5D); and amending the AAQD (5E). The preferred policy option comprises the non-regulatory programme supporting Member States' action including implementation of already agreed EU legislation as well as enhanced, governance, monitoring, and evaluation provisions. In addition the NECD will be revised to incorporate the EU's international commitments for 2020 under the Gothenburg Protocol (GP) as amended in 2012 (baseline option 1).

To achieve further health and environmental impact reductions during the period up to 2030 (second general objective) four options for strategic impact reduction targets beyond the baseline (i.e. the same scenario as considered in Chapter 5 but up to 2030) were examined in Chapter 6. These were defined in terms of the percentage closing of the gap between the baseline and the maximum technically feasible reduction scenario related to health impacts due to PM: 25% (Option 6A), 50% (Option 6B), 75% (Option 6C) or 100% (Option 6D). A further option to meet the WHO guideline values (Option 6E) was assessed but considered not within reach before 2030. The main options were further characterised in terms of the NECD reductions for 2025 and 2030 and the technical measures required to meet them. The preferred option for setting the next strategic level is at 75% of the maximum reduction feasible with respect to PM related health impacts, further optimized for additional reductions in eutrophication and ozone (Option 6C*). This option is to be implemented by further tightening of emission ceilings under the NECD for the periods 2025 and 2030.

The preferred policy will support Member States in resolving remaining non-compliance with current legislation (including by rectifying failures in current EU source controls) and ensure coherence with international commitments by 2020 at the latest. A fully implemented baseline will reduce impacts in 2020 by 36% for PM2,5, 23% for ozone, 17% for eutrophication and 61% for acidification, compared with 2005. By 2030, the reductions relative to 2005 will be 53% for PM2,5, 35% for ozone, 39% for eutrophication and 87% for acidification. External costs associated with the baseline will be further reduced to €212-740bn in 2030. The preferred policy for option 2025-30 will reduce the remaining health burden from air pollution by a third more than the baseline (relative to 2005). Eutrophication impacts will be reduced by 55% more than the baseline.

The preferred option for 2020 entails no additional EU expenditure over the baseline except for the costs of supporting measures for national action (around €100m from LIFE). Costs will depend sensitively on local circumstances and can be covered in part by improved uptake of structural funds. Local emitters affected by measures taken at national level to reduce diesel and domestic combustion emissions up to 2020 will inevitably include some SMEs as users of light duty diesel vehicles. The preferred policy for the period 2025-30 will reduce total external costs of air pollution by €45bn (on the most conservative valuation) compared to the €212bn in the baseline, including direct economic benefits amounting to more than €3 billion: €2bn from reduced labour productivity losses, reduced health care costs of €650m, reduced crop value losses of €270m, and reduced damage to the built environment of €140m. Meeting the policy objectives for 2025-30 implies annual compliance costs of €4,7bn (investment, operating and maintenance costs for new abatement techniques) or about one tenth of the external cost savings. Overall GDP impact is very low (-0,025%) and entirely offset once increased productivity is taken into account, without considering other direct benefits. Once productivity improvements are taken into account, the policy could add around 112 thousand jobs. A target year of 2030 rather than 2025 would result in loss of net benefits in the period 2025-30. Introducing harmonised EU controls for MCPs increases the total costs by about €160m. Administrative costs associated with amending the NECD include a one-off €8m and €3.5m annual cost).

The main affected sectors for the period 2025-30 are agriculture and refineries. Gross impacts amount respectively to 0,24% and 0,10% of sectoral outputs which are reduced to 0,21% and 0,09% once improved productivity is taken into account. Costs for the agricultural sector are further offset by reverting crop yield loss amounting to €270m, close to 0,1% of sectorial output. Two other industrial sub-sectors are affected (cement and sulphuric acid production) although in neither case impacting international competition. Most SME impacts are concentrated in MCP and agriculture. Impacts are mostly mitigated in the preferred MCP control option (registration rather than permitting and emphasizing primary NOx control as the minimum standard); less than 2% of gross operating surplus.

From the sensitivity analysis it was concluded that new NECD ceilings are required in addition to climate policy, and that the regret investment risk can be managed by appropriate policy design. Regarding the potential trade-off with biomass combustion, Ecodesign measures would help achieving the required reduction in emissions from solid fuel combustion (including biomass burning). For the remaining unregulated component of combustion (1-50MW) further action was required to manage the increased PM (and PaH) emissions resulting from climate and energy induced biomass uptake (see below). Regarding the control of methane (both a GHG and an ozone precursor), it was concluded that methane ceilings under the NECD could bring down emissions cost-effectively although flexibility would be needed in the ultimate design of the policy instrument to avoid undue interference with the implementation of the Effort Sharing Decision 406/2009/EC.

The main options considered for additional EU source measures to reinforce emission reductions were Medium Combustion Plants (MCPs), agriculture and international shipping.

With respect to MCP, five options were considered in Chapter 7 for delivering emission reductions in the range of 10 to 20% of the required reduction for SO2, NOx and PM under the NECD. The preferred policy option would set emission performance standards that are derived from the amended Gothenburg Protocol (option 7D) coupled with a registration requirement (option R3) for plants. In particular situations such as for instance air quality management zones in non-compliance with limit values of the AAQD, Members States may have to adopt stricter abatement measures (Option 7E). This will yield annual emission reductions of 135 kT SO2, 107 NOx, and 45 kT PM (corresponding to about 22.5 kT/y PM2,5) while increasing the costs of option 6C* with 382 M€/year. The preferred policy option avoids significant impact on administrative costs and SMEs.

Further (future) work will focus on detailed impact assessments related to possible additional source controls in agriculture (ammonia) and international shipping in EU waters (NOx). For agriculture emissions that focus has been particularly on ammonia but also of primary PM as these remain substantial contributors to health and environment problems. Measures relating to the agricultural sector already in the pipeline or an advanced stage of analysis include a requirement on Member States to implement specific "emission reduction measures" for ammonia in the context of implementing the NECD national programmes; the revision of the existing BREF under the IED for agriculture to deliver further reductions from large pig and poultry farms (noting that, the IED does not cover at present cattle farms which is a main emitting subsector.); and other ammonia abatement measures that could be facilitated through EU financial support to farmers for ammonia abatement such as adopting sustainable fertilization strategies (provided that MS gives priority to this in their national Rural Development Programmes). This work, including additional consultations with the sector, will be taken forward in dedicated fora established to ensure the objectives of the new strategy (and NECD) are reached. For emissions from international maritime traffic, previous studies and this review suggest that additional measures such as NOx Emission Control Areas are cost-effective. This option will also be pursued further together with Member States and stakeholders, possibly in combination with assessing appropriate incentive mechanisms such as NOx funds or linkages to flexibility mechanisms under the NECDs.

In conclusion, the package of proposals supported by this Impact Assessment supports the further development of the following package of proposals:

- A Communication on an updated EU Thematic Strategy on Air Pollution (TSAP) setting out a policy focus on effective implementation of the baseline so as to ensure compliance with the Ambient Air Quality Directive by 2020 at the latest and updated impact reduction objectives for the 2025 and 2030 accompanied by cost-effective implementation pathways for Member States' and sectorial action. The Communication will include An outline for strengthened non-regulatory EU action plan which the Commission will promote, using the funding opportunities provided under the LIFE Regulation to support active engagement of implementing authorities at all relevant levels (local, regional, national, EU, and international) and to promote early action on the implementation of the new strategy (presented as an updated European Clean Air Programme).
- A proposal for a revised National Emission Ceilings Directive incorporating the Gothenburg Protocol obligations for 2020, and setting ceilings for 2025 and 2030 to achieve the new TSAP impact reduction objectives; and
- A proposal for a legal instrument controlling air pollutant emissions from medium combustion plants (MCP).

8. MONITORING AND EVALUATION

The ex-post analysis confirmed that the overall monitoring and evaluation provisions for the TSAP was adequate. Certain gaps were nevertheless identified that required attention. The updated monitoring and evaluation provisions will be addressed as follows.

8.1. Monitoring and evaluation of the revised TSAP

Progress in achievement of the ambient air quality standards will be monitored by the Member States, the Commission, and the EEA as required by the AAQD and summarised annually in the EEA's air quality report. Member State action on localised exceedances will be monitored through the existing reporting provisions of the Ambient Air Quality Directive and through the strengthened network on implementation Uptake of available funds will be monitored in co-operation with DG REGIO and DG AGRI.

Resolution of the real-world emissions problem will be monitored against the procedural milestones outlined in the CARS 2020 Communication: adoption of a new test cycle by end 2014; monitoring of emissions according to the test cycle thereafter; and type-approval in accordance with the new test cycle by 2017 at the latest. The implementing provisions will include requirements to monitor and reporting of the "real world emissions" according to the new test cycle and in-use provisions in the period before it becomes mandatory for type approval (2014-17); this will be complemented by monitoring by the Commission's Joint Research Centre involving, where possible, independent test centres.

Progress towards the strategic impact reduction objectives will be monitored using the same indicators in which the targets are expressed (Table 35). The health impacts will be monitored by periodic health impact assessments conducted by the Commission with assistance of the EEA and other expert bodies using a methodology consistent with the analysis presented here and concentration data obtained from the monitoring network under the AAQD. For ecosystem impacts of air quality, there is currently no requirement to monitor these under EU legislation. As discussed in section 6.6.1, it is proposed that the revised NECD should only include a requirement for air pollution ecosystem monitoring in sensitive ecosystems representative for the Member States and coordinated with the effect-oriented monitoring of the LRTAP Convention. The monitoring will also use assessments from the GMES Atmosphere Service, Eye on Earth, air pollution modelling exercises and other available information sources.

Table 35: Selected indicators for monitoring progress towards the new strategic impact objectives

Objective	Indicator	Method	Responsible authority
50% reduction in premature deaths due to chronic PM2.5 exposure by 2025	Number of premature deaths due to PM health impacts per year in EU	Calculated from (a) monitored/modelled PM2.5 concentrations; (b) concentration-response relations; (c) population and (d) baseline health statistics.	Calculations by DG ENV using external contract or by the EEA.
33% reduction in premature deaths due to acute ozone	No of premature deaths due to acute ozone exposure	Calculated from (a) monitored/modelled ozone concentrations; (b) concentration-response relations; (c) population and (d) baseline health	As above

exposure by 2025		statistics.	
34% reduction in ecosystem area unprotected from eutrophication by 2025	Ecosystem area for which critical loads are exceeded.	(i) Assessment based on combined monitoring and modelling of nitrogen deposition to ecosystems (ii) Direct monitoring of sensitive ecosystem impacts under NECD (list parameters)	(i) EEA (ii) Member States under Article 7.5 of revised NECD
80% reduction in ecosystem area unprotected from acidification by 2025	Ecosystem area for which critical loads are exceeded.	(i) Assessment based on combined monitoring and modelling of nitrogen/ sulphur deposition (ii) Direct monitoring of sensitive ecosystem impacts under NECD (list parameters)	As above.

Progress in addressing third country emissions of air pollutants which affect EU air quality will be monitored procedurally (the number of ratifications of the revised Gothenburg Protocol) and regarding substantive pollution reduction in the context of the CLRTAP's monitoring and reporting mechanisms.

The implementation of the revised TSAP will be evaluated every five years by the Commission with reporting for the first time not later than 2020. On that occasion, the scope for tightening the air quality standards under the Ambient Air Quality Directive will also be considered.

8.2. Monitoring and evaluation of the revised NECD

Progress towards the EU and Member States emission reduction commitments for PM2,5, SOx, NOx, NMVOCs, NH3 and CH4, for 2020 and 2025/30 will be monitored and assessed based on (reinforced) provisions in NECD relating to emission inventories and projections. The effect of the ceiling reductions on background concentrations of air pollutants will be assessed through the monitoring under the AAQD, and the impact reduction achieved will be monitored through the TSAP monitoring as described above.

The implementation of the new NECD will be evaluated every five years (in combination with the TSAP review) and for the first time not later than 2020.

8.3. Monitoring and evaluation of the proposed legal instrument on MCP

Monitoring of the implementation and impact of measures on MCP will be based on streamlined and targeted reporting requirements on the Member States focusing on the key data which are necessary to assess the extent to which the objectives of the legislation are being achieved. The Commission will evaluate the results of this policy and report them at least every five years.

ANNEX 1 GLOSSARY

BAT	Best Available Techniques
CAFE	Clean Air For Europe Programme
CH_4	Methane
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO_2	Carbon dioxide
EC4MACS	European Consortium for Modelling Air Pollution and Climate Strategies
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Programme
GHG	Greenhouse gases
HDV	Heavy Duty Vehicles (heavy trucks and buses)
IED	Industrial Emissions Directive
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control (directive)
JRC	Joint Research Centre of the European Commission
kW	kiloWatt (1000 Watts, measure for power and power capacity)
LCP	Large Combustion Plants (directive)
LDV	Light Duty Vehicles (passenger cars and small trucks)
MARPOL	International Convention on the Prevention of Pollution from Ships
MCP	Medium Combustion Plants (between 1 and 50 MW thermal input)
MTFR	Maximum Technically Feasible Reduction: the lowest level of pollution achievable by deploying all commercially available technical solutions irrespective of cost
MW	MegaWatt (1 million Watts, measure for power and power capacity)
NEC	National Emission Ceilings (directive)
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NRMM	Non-Road Mobile Machinery (include diverse products ranging from hand-held power tools to large construction and agricultural machines)
NO_x	Nitrogen oxides (NO and NO_2)
O_3	Ozone
PM	Particulate Matter of any size
PM10	Particles with an aerodynamic diameter of less than 10 µm
PM2.5	Fine particles with an aerodynamic diameter of less than 2.5 µm
SO_2	Sulphur dioxide
SO_x	Sulphur oxides (including SO_2, SO_3)
TEN	Time Extension Notifications related to the Ambient Air Quality Directive
TSAP	Thematic Strategy on Air Pollution
VOC	Volatile organic compounds
WHO	World Health Organisation

ANNEX 2 USE OF EXPERTISE AND CONSULTATION OF INTERESTED PARTIES

1.1. External expertise

The review process draws on a long-standing knowledge base that is widely available as well as on expertise built up over several decades in air quality review and management activities[122]. The impact assessment has been prepared also with the support of several targeted studies prepared on behalf of the European Commission by consultants, the EEA, the JRC, the WHO and other leading scientists.

Specific information was collected through the following streams:

- Quantitative modelling of baseline emissions and associated impacts, of the scope for further emission reduction options, and of cost-effective emission reduction strategies was conducted with the GAINS Integrated Assessment Modelling suite.[123]
- Broader socio-economic and competitiveness impacts associated with different pollution reduction options and under different assumptions on the potential use of market-based and fiscal policy instruments were analysed by JRC-IPTS with the use of the GEM-E3 Computable General Equilibrium Model and of Environmentally Extended Input Output Models
- Additional insights on the extra-EU burden of pollution to EU air quality were provided by a specific study focusing on Hemispheric Transport of Air Pollutants[124]
- Specific review studies were conducted to supplement the information base for the most critical pollutants in terms of health risks:
    - Particulate Matter, Heavy Metals and PAH; the study was also complemented by a dedicated expert workshop on Particulate Matter
    - Ozone; with a focus on assessment of current situation, reasons for non-compliance and the relationship between ozone concentration and precursor emissions
- The WHO European Centre for Environment and Health provided an update of the knowledge base on the health burden of air pollution and of the Health Impact Assessment model used for the analysis underpinning this Impact Assessment[125]
- A study led by the Danish Centre for Environment and Energy supported the update of the EMEP EEA Emission Inventory Guidebook (the central reference manual used to support countries in estimating emissions under the NECD and the UNECE LRTAP Convention), in particular on methodologies for black carbon emissions
- The analysis of recommendations for the Air Quality assessment and management regimes provided by the AQUILA and FAIRMODE groups

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[122] See Annex 3 which summarises the air quality knowledge base

[123] Study conducted under external contract with the International Institute for Applied Systems Analysis (IIASA).

[124] Study conducted under external contract with the Norwegian Meteorological Institute using the EMEP Atmospheric Chemistry and Transport Model (Norwegian Meteorological Institute, 2012A).

[125] (REVIHAAP project (WHO, 2013B):: "Evidence on health aspects of air pollution to review EU policies". Among other specific objectives, this analysis assessed the evidence on the health effects of NO2 and of specific components and characteristics of particulate matter (aerodynamic diameter, chemical composition). The HRAPIE project further performed extensive meta-analysis of the available literature to update the key relative risk estimates according to latest scientific evidence (WHO, 2013A).

A DG RTD-funded initiative reviewed the latest scientific findings of EU RTD projects relevant to the EU Air Quality policy and gathered them into a single report aimed at the identification of key scientific messages relevant for the revision and implementation of EU Air Quality legislation. The report covered the following research review streams: Nitrogen; Particulate Matter; Ozone; Air Quality and Climate; Air Quality and Health; Integrated Assessment.

1.2. Consultation of interested parties

Stakeholders were widely consulted through a series of formal and informal stakeholder events: two online questionnaires, a Eurobarometer survey, and a continued dialogue with interested stakeholders through multi- and bilateral meetings. Input from stakeholders has been taken into account when refining the quantitative analysis, assessing the different possible options to curb air pollution where considered appropriate (particularly with regard to the design of the policy mix), possible unwanted effects and impacts on specific sectors and Member States, and implications on subsidiarity. Consultation with Member States on matters related to the IA also took place in the meetings of the Air Quality Expert Group, which is the expert preparatory group for implementing measures under the NEC Directive and the Directives on Ambient Air Quality.

1.1.1 Online consultations

A first scoping on-line public consultation was carried out at the end of 2011 with a view to broadening the information base for the initial development of the policy options to be carried forward in the following process.

The on-line public consultation on the main policy options analysed in the Impact Assessment *(Options for the revision of the EU Thematic* Strategy *on Air Pollution and related policies)* ran from 10 December 2012 until 4 March 2013 (12 weeks) on the European Commission's 'Your voice in Europe' web page.[126]. The consultation used two questionnaires: a total of 1934 individuals responded to a shorter questionnaire for the general public; for the longer questionnaire for experts and stakeholders, 371 responses were received.

The questionnaire for experts and stakeholders had 38 questions (not including sub-questions). Of these, 17 were open questions allowing written comments and the others were closed, multiple-choice questions. The questionnaire covered the following themes:

- Ensuring compliance with EU air quality requirements and coherence with international commitments
- Reducing exposure to damaging air pollution in the long term
- Revising the ambient air quality directive (AAQD)
- Revising the national emission ceilings directive (NECD); and
- Addressing major air pollution sources

The questionnaire for the general public had 13 questions covering all these themes except the last, air pollution sources. In order to provide comparability between the two questionnaires, 12 of the 13 questions were closed, multiple-choice questions also used on the questionnaire for experts and stakeholders. The last question was an open question allowing written comments.

[126] See EC, 2012A

Key strengths of the consultation responses include: the high number of responses from citizens and from experts and stakeholders; responses received from a broad range of economic sectors, government bodies and NGOs. However, limitations should be noted: for example, relatively few responses were received to either questionnaire from EU12 Member States. Key results from the consultation are here summarised per theme:

Theme 1: Ensuring compliance with EU air quality requirements and coherence with international commitments

Regarding options to ensure Member State compliance with current air quality legislation, just over 90% of respondents to the questionnaire for the general public, along with over 80% of government, NGO and individual expert respondents to the questionnaire for experts and stakeholders, support *strengthening emissions controls* (though few business respondents supported this option).

Theme 2: Reducing exposure to damaging air pollution in the long term

In terms of how future EU **air pollution policy should interact with EU climate and energy policy**, over 90% of respondents to the questionnaire for the general public, along with over 80% of government, NGO and individual expert respondents to the questionnaire for experts and stakeholders, support the option that EU air pollution undertakes *additional measures beyond synergies with climate and energy policy*. A majority of business respondents, however, feel that a new air pollution action should not go beyond synergies with climate and energy policy.

Regarding the **target year for a revised Thematic Strategy**, just over 80% of NGO respondents and just over 60% of individual experts indicate 2025. However, a majority of business and government respondents instead choose 2030.

In response to a question about the **extent of progress for a revised Thematic Strategy**, a majority of the respondents to the general public questionnaire (55%) chose '*maximum achievable pollution reduction*' as the level of additional progress to be pursued, and 37% called for '*substantial progress*' that is lower than the maximum reduction. On the expert/stakeholder questionnaire, a majority of NGO responses called for the maximum reduction; a majority of government responses called for substantial progress; and just over 45% of business responses called for the '*level delivered by the forthcoming climate and energy framework for 2030*'.

A further question asked whether priority should be given to **human health or the environment** in air pollution policy. Just over two-thirds of general public responses indicated that equal weight should be given to human health and environmental impacts. About 60% of NGO and individual expert responses chose this option; almost 60% of government respondents, however, indicated human health impacts as the priority. A large share of business responses, 25.4%, chose '*othe*r': in written comments, many of them referred to socio-economic factors.

Theme 3: Revising the Ambient Air Quality Directive (AAQD)

Over 80% of respondents to the general public questionnaire, similar shares of NGO and individual expert responses to the questionnaire for experts and stakeholders, and just over 55% of government respondents call for **the indicative limit for $PM_{2.5}$ to be mandatory**. However, 55% of business respondents are opposed to this proposal.

High shares of public, NGO and individual experts also call for AAQD limit values to be made more stringent to bring them **closer to WHO guidance values**. Almost 60% of government respondents, however, indicate that this should happen '*once the EU has made further emissions reductions*', and almost 50% of business responses call for '*no* change' on this topic.

Regarding monitoring and regulation for **black carbon**, a majority of public, NGO and expert responses favour both monitoring and a binding limit value; government respondents prefer either a non-binding target value plus monitoring, or only monitoring.

Regarding **ozone limit values**, a majority of NGO and expert responses indicated that current non-binding limit values for ozone should be replaced with binding limit values at more stringent levels. Just over 50% of business responses (50.9%) and over just 60% of government responses, however, prefer '*no change'* in this area.

There is strong support for the option that **zone-specific plans be consolidated into national plans**: this option is favoured by almost 80% of respondents to the questionnaire for the general public, similar shares of NGO and expert respondents to the questionnaire for experts and stakeholders, and almost 60% of government respondents.

Theme 4: Revising the National Emission Ceilings Directive (NECD)

In the general public questionnaire, 91.2% of respondents indicated that national emission ceilings should be adopted for **black carbon/elemental carbon**; among the expert/stakeholder responses, over 60% of NGO and individual expert responses agreed with the option; in contrast, about 60% of business and 45% of government responses were opposed.

Strong majorities of all respondents were in favour of **coordination between national and local levels** in respect to emissions reduction measures and local air quality management.
With regard to mechanisms for flexibility in the NECD management framework, a majority (63%) of respondents in governments indicated that compliance checking be made on multi-year average. This was supported also by business respondents (60 %) but not by the NGOs (7% support).

Further, the government respondents (60%) also supported the option to allow limited adjustment of the emission inventories after the approval by the Commission, but not (20%) of the ceilings. The option to allow adjustment of the inventories also had some support from NGOs (37 %) and business (44%)

Theme 5: Addressing major air pollution sources

Only the questionnaire for experts and stakeholders included questions on sources.

Respondents were asked to rank measures to address emissions from **road transport**. The highest-ranking option was to introduce with minimum delay the new test procedure to ensure that '*real world emissions of Euro 6 light duty diesel vehicles are as close as possible to the type approval limit values*'. The second-ranking option was to improve '*in-service compliance with emissions standards*'.

For non-road machinery, the highest-ranking option was for '*a more stringent Stage V standard*'. The second-highest was to '*ensure that approval emission tests reflect ... emissions in real world circumstances*'.

For measures to address emissions from the **agricultural sector**, NGO and individual expert responses gave the highest average ranking (i.e. lowest score) to the option, '*Set tighter emission ceilings for ammonia for 2020 and 2030 in the NEC Directive, leaving flexibility to Member States on how these ceilings can best be reached*'. Government responses gave the highest average ranking to the option: '*Where cost effective, introduce new or revise existing EU legislation to establish EU-wide specific rules for e.g. improved manure storage, management and spreading techniques*'. Business responses gave the highest average ranking to: '*Promote good practices in manure management and manure spreading in Member States through support from the Rural Development Fund*'. In written comments, representatives of the agricultural sector emphasised that new measures should mainly take through this fund.

A majority of NGO respondents and over 40% of government and individual expert respondents supported two options to address emissions from **small and medium combustion installations** (i.e. below 50 MW):

- *Develop a supplementary and more stringent standard for installations below the Ecodesign capacity threshold for use in national and local measures such as fiscal incentives to be applied in zones that are in non-compliance with air quality limits.*
- *Regulate combustion installations above the Ecodesign capacity threshold but below the 50MW threshold set in the Industrial Emissions Directive (IED).*

For business responses, however, the highest share of responses, about one-quarter, went to '*Don't know'*, followed by '*No additional* measures' (just under 20%).

Two options to address emissions from the **shipping sector** were chosen by at least 50% of government, NGO and individual expert responses:

- *Promote the extension of the Sulphur Emission Control Areas to additional EU sea areas such as the Irish Sea, the Gulf of Biscay, the Mediterranean and/or the Black Sea provided that such a measure is cost-effective.*
- *Promote the designation of NOx Emission Control Areas in EU regional seas where cost-effective (those listed above and/or the Baltic and the North Sea including the English Channel) provided that such a measure is cost-effective.*

None of the options regarding shipping received more than 24% of business responses. In written comments, respondents from the shipping industry as well as some other government sectors underlined that shipping should be regulated through the International Maritime Organisation.

1.1.2 Stakeholder meetings

The impact assessment process has been accompanied by a broad and extensive stakeholder consultation process.

A Stakeholder Expert Group (SEG) has been set up, including representatives of the Member States, of key concerned industry associations and of relevant NGOs. The SEG met 5 times between June 2011 and April 2013

Care was taken to ensure the minimum standards for consultation were fulfilled:

- Clear background documents were provided in all circumstances. For the public consultations, concise explanations were inserted before each section of the questionnaire, and a more detailed explanatory document was provided. At all stakeholder meeting, comprehensive consultant reports have been distributed ahead of the meeting, accompanied when necessary by guiding sheets containing lists of key questions on which the stakeholders were invited to reflect in advance.
- In order to make sure that all questions of the final on-line stakeholder survey were as clear and unambiguous as possible, the draft questionnaire was preliminarily consulted with the IASG and revised following the inputs of the IASG.
- All relevant target groups were consulted. Specific consultant reports were prepared and consulted with the stakeholders in specific sectors: mobile sources, international maritime shipping, small- and medium-scale combustion plants; agriculture.
- The consultation was publicised on Your Voice in Europe and a press release put out on RAPID: http://europa.eu/rapid/press-release_IP-12-1337_fr.htm
- The consultation was open for 12 weeks, and at least 20 days' notice was given to stakeholders ahead of each consultation meeting.

• ANNEX 3 AIR POLLUTION IMPACTS AND SOURCES

1. THE MAIN AIR POLLUTION IMPACTS

According to the EEA, more than 80 % of the EU's urban population is exposed to PM levels above the 2005 WHO Air Quality Guidelines, depriving citizens of more than eight months of life on average – with life expectancy reduced by up to two years in the most polluted places.

As well as health risks, air pollution causes significant damage to our environment and ecosystems. Ground-level ozone damages materials, as well as agricultural crops, forests and plants, reducing their growth rates. Nitrogen oxides (NO_x), sulphur dioxide (SO_2) and ammonia (NH_3) harm soil, lakes and rivers by acidifying them, causing loss of animal and plant life. Ammonia and NO_x also disrupt land and water ecosystems by introducing excessive amounts of nutrient nitrogen – a process known as 'eutrophication'. It is estimated that two-thirds of the protected sites in the EU Natura 2000 network are currently under severe threat from air pollution.

1.1. Health Effects

There is a large body of evidence on the health impacts of air pollution. Health effects related to air pollution are divided into short-term and long-term exposure effects. Effects caused by short-term exposure (in the order of days or hours) are described as acute effects. Those caused by long-term exposure (in the order of months or years) are identified as chronic effects. Impacts on mortality relate to people dying earlier than they would in the absence of exposure by air pollution. Morbidity relates instead to illness, ranging from minor effects such as coughing to life threatening conditions that require hospitalization.

The Table A3.1 below summarizes the key health effects for major air pollutants. Of particular concern are particulate matter (PM) – a type of fine dust – ground-level ozone (O_3) and nitrogen dioxide (NO_2).

The latest study from the World Health Organization (WHO)[127] links long-term exposure to very fine particles (PM2.5) with cardiovascular and respiratory deaths, as well as increased sickness, such as childhood respiratory diseases. There is also new evidence for the negative effects of long-term exposure to ozone on mortality and reproductive health.

Table A3.1: Overview of key health effects for major air pollutants (EEA)

Pollutant	Health effects
Particulate Matter (PM)	Can cause or aggravate cardiovascular and lung diseases, heart attacks and arrhythmias, affect the central nervous system, the reproductive system and cause cancer. The outcome can be premature death.
Ozone (O_3)	Can decrease lung function; aggravate asthma and other lung diseases. Can lead to premature mortality.
Nitrogen oxides (NO_x)	NO_2 can affect the liver, lung, spleen and blood. Can aggravate lung diseases leading to respiratory symptoms and increased susceptibility to respiratory

[127] WHO (2013) a

	infection.
Sulphur oxides (SO_2)	Aggravates asthma and can reduce lung function and inflame the respiratory tract. Can cause headache, general discomfort and anxiety.
Non-methane volatile organic compounds (NMVOC)	NMVOC, important O_3 precursors, are emitted from a large number of sources including paint application, road transport, dry-cleaning and other solvent uses. Certain NMVOC species, such as benzene (C_6H_6) and 1,3-butadiene, are directly hazardous to human health.
Carbon monoxide (CO)	Can lead to heart disease and damage to the nervous system and cause headaches, dizziness and fatigue.
Arsenic (As)	Inorganic As is a human carcinogen. It can lead to damage in the blood, heart, liver and kidney. May also damage the peripheral nervous system.
Cadmium (Cd)	Cadmium, especially cadmium oxide is likely to be a carcinogen. It may cause damage to the reproductive and respiratory systems.
Lead (Pb)	Can affect almost every organ and system, especially the nervous system. Can cause premature birth, impaired mental development and reduced growth.
Mercury (Hg)	Can damage the liver, the kidneys and the digestive and respiratory systems. It can also cause brain and neurological damage and impair growth.
Nickel (Ni)	Several Ni compounds are classified as human carcinogens. It may cause allergic skin reactions, affect the respiratory, immune and defence systems.

1.2. Acidification

Acidification damages plant and animal life in forests, lakes and rivers, as well as buildings and historical sites by corrosion.

Acidification of soil is related to the build-up of hydrogen cations (acid) thereby causing a reduction of the pH value. It is caused by the deposition of nitric acid and sulfuric acid (which are common components of acid rain). Acidification also occurs when cations such as calcium, magnesium, potassium and sodium are leached and lost from the soil through the action of acid rain. Soils and waters with poor buffering capacity are the most sensitive to acid rain. Plants take base cations (mainly potassium, magnesium and calcium) from the soil as they grow, donating a hydrogen cation (proton) in exchange for each base cation. Where plant material is removed, as when a forest is logged or crops are harvested, the base cations the plants have taken up in its biomass are permanently lost from the soil. Many nitrogen compounds, which are added as fertilizer, also acidify soil over the long term through the production of ammonium in the soil. Acidification therefore also occurs as a result nitrogen emissions into the air that end up deposited into the soil.

1.3. Eutrophication

Eutrophication refers to an excess of nutrients in water or soil. It threatens biodiversity through the excessive growth of "simple" plants which damage other plants and animals in soils, rivers and lakes. The two major causes of eutrophication are excess nutrient nitrogen (mainly nitrates and ammonium) and excess phosphates in ecosystems whereby the former source is most relevant from an air pollution perspective.[128]

Sources of these nutrients include animal wastes, agricultural runoff, sewage municipal water and nitrogen deposition from the air. The ecosystem quickly experiences an increase in algae and other simple plants, as these organisms thrive in the presence of the added nutrients. An algae bloom occurs as the algae accumulates into dense, visible patches near the surface of the water, prohibiting light from penetrating deeper areas of lake or stream. Other plants species are unable to survive without this light, and may become extinct. An even more serious problem arises when the algae begin to die and sediment to the floor of the rivers and lakes. At this point, oxygen-demanding bacteria take over the ecosystem, decomposing the organic material of the dead algae and using up dissolved oxygen in the process.[129] This lower concentration or in severe cases complete lack of oxygen causes many fish to suffocate, and as they die, the number of oxygen-demanding decomposers increases even more.

Several measures are known to control eutrophication. In addition to controlling air pollution induced pressures, mitigation methods can include measure to control runoffs from feedlots, planting vegetation along streambeds to slow erosion and absorb nutrients, controlling application amount and timing of fertilizer.

1.4. Ground-Level Ozone Pollution

Ozone (O_3) in the lower atmosphere (ground-level ozone) is an air pollutant with harmful effects on the respiratory systems of humans and animals as well causing significant environmental damage, including the "burning" (necrosis) of sensitive plants and the corrosion of materials and buildings. Ozone is not directly emitted into the atmosphere but formed from a chain of chemical reactions following emissions of precursor gases including NO_X, methane (CH_4) and non-methane volatile organic compounds (NMVOC), and carbon monoxide (CO). [130] The atmospheric lifetime of ozone is about 22 days in the atmosphere which means that it travels across continents and to be considered a global pollutant. Its main removal mechanism is deposition to the ground, and particular through the uptake by plants. There is also a global atmospheric background concentration of ozone (tropospheric ozone), partly resulting from photochemical ozone formation globally and partly from the downward transport of stratospheric ozone to the troposphere.

Ozone has a marked effect on human health. High levels cause breathing problems, trigger asthma, reduce lung function and cause lung diseases (WHO, 2008). Short-term exposure by current O_3 concentrations in Europe have adverse health effects, especially in the summer, on pulmonary function, lung inflammation, lung permeability, respiratory symptoms, increased medication usage, morbidity and mortality. Several European studies have reported that acute mortality rises with increases with ozone exposure (WHO, 2008). Epidemiological health evidence of chronic effects

[128] Unlike nitrates, phosphates (PO43-), are not water-soluble; they do not usually dissolve in water. However, they do adhere to soil particles, and as such often accumulate in soil and erode along with soil into aquatic environments.

[129] BOD is the amount of oxygen required for the decomposition of organic compounds by microorganisms in a given amount of water. It is usually measured in milligrams of oxygen consumed per liter of water. Biological oxygen demand is important because it affects the amount of dissolved oxygen available to all species in an aquatic ecosystem. A higher BOD indicates a lower level of dissolved oxygen.

[130] NO_x plays a complex role in ozone chemistry: close to its source it will actually deplete ozone due to the scavenging reaction between the freshly emitted nitrogen monoxide (NO) and ozone.

from exposure to ozone is now emerging indicating considerably larger mortality effects than from acute exposure alone (WHO, 2013).

High levels of O_3 also damage plants, impairing reproduction and growth, leading to reduced agricultural crop yields, decreased forest growth and reduced biodiversity. Ozone decreases photosynthesis, thereby reducing also plant uptake of carbon dioxide (EEA, 2010a). Ozone also increases the rate of degradation of buildings and physical cultural heritage. Even low concentrations of ozone in air are very destructive to organic materials such as latex, plastics, and lungs. Ozone is also a short-lived climate pollutant (see below).

1.5. Climate change

Atmospheric pollution and climate change are both distinct and linked in several ways. Contrary to greenhouse gases (GHG), air pollutants are toxic and create direct impacts on health and the environment. GHG generally have long lifetimes in the atmosphere, with about 12 years for CH_4 and about 100 years for CO_2. Classical air pollutant like SO_2, PM and NO_x have lifetimes of a few week to months As some of the classical air pollutants also have an effect on climate these are termed Short-Lived Climate Pollutants, i.e. substances that affect both air quality and the climate.[131]

Air pollution and greenhouse emissions often relate to the same sources, hence GHG reduction measures (e.g. on power generation and transport) can deliver substantial reductions also of air pollutants such as SO_2 and PM. This is furthermore an increasing shared interest in reducing emissions of the Short-Lived Climate Pollutants. But decarbonisation tends not always towards reducing emissions of PM, one of the air pollutants of highest concern. That is the case for example, where fossil fuel combustion is substituted for biomass burning, often considered climate neutral by convention, yet leads to increased emissions of PM and other carcinogenic substances such as PAHs.

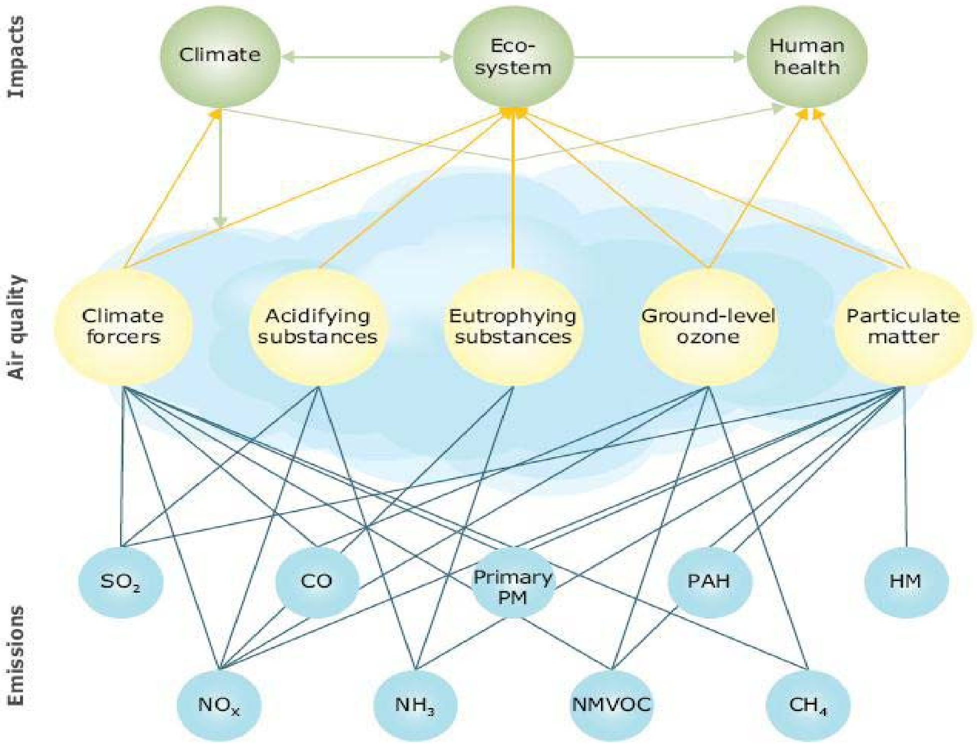
2. THE MAIN AIR POLLUTANTS AND THEIR ASSOCIATED IMPACT PATHWAYS

Over the past decades, a substantial scientific knowledge base on the causes and effects of air pollution has been established and validated.

Figure A3.1 presents a compact summary of the main air pollutant emissions considered and their associated impact pathways.

[131] The main ones are black carbon (BC, a sub-fraction of particulate matter), methane and ozone.

Figure A3.1: The problem of air pollution: Emissions and Impact Pathways (EEA)



3. THE MAIN SOURCES OF AIR POLLUTION

Emissions of air pollutants are closely linked to economic activity through combustion and/or other processes which sustain that activity.

Observed particulate matter (**PM**) concentrations in the atmosphere are the sum of a number of components which originate from different sources including primary and secondary sources. The most relevant sources are set out below.

Primary PM from combustion sources as well as some non-combustion and also natural processes; sectors and activities of particular importance are:

- Traffic, through the exhaust of diesel vehicles as well as new generation gasoline direct injection (GDI) vehicles. Non-exhaust particles from traffic (tyre and break wear, re-suspension) also contribute especially to the coarse PM fraction. Traffic emissions enter the atmosphere in or close to densely populated areas and thus contribute to population exposure in increased proportion.
- Off-road vehicles and machinery (which include ships and vessels, aircrafts, construction machinery, diesel trains, tractors, small hand-held engines, etc), which are currently regulated less stringently than road transport.
- Residential heating, especially related to biomass (wood and pellets), solid fuels (coal, coal briquettes), and certain liquid fuels; these installations and/or products are currently not covered by EU-wide regulation which would limit the emission of PM.
- Open burning of agricultural waste, which is banned in some of the Member States but continues to be widespread practice in others.

Secondary PM in the form of inorganic aerosols formed in the atmosphere by atmospheric reactions between SOx, NOx and NH3, and organic aerosols formed by reactions involving VOCs and oxidants.

Ozone is not directly emitted but is formed in the atmosphere through a number of reactions between ozone precursors. The most important ozone precursors are:

- VOCs, emitted by a large range of processes and applications such as energy use and supply systems, road and other transport systems (petrol vapour), industrial and domestic solvent use, agriculture and natural sources (trees and other plants).
- NO_x, emitted by traffic, especially diesel engines (also from off-road machinery); the power sector and industrial combustion sources, including small-scale combustion installations (SCI); boilers and heating appliances fired by liquid fuels and natural gas; and international transport (air and marine).
- CO, which is the product of incomplete combustion. CO emissions have decreased substantially over the years through the introduction of EURO standards for vehicles (oxidation catalyst) and improvements in residential heating devices.
- Methane (CH_4) Because of its long atmospheric lifetime, methane plays a much more significant role in the generation of hemispherically-transported O3 than in the locally-produced episodic O3 which has been the focus of control up until now.

Sulphur Dioxide (**SO_2**) is emitted by a number of energy intensive industrial processes and power generation. Over the last 20 years SO_2 emissions have substantially decreased thanks *inter alia* to effective implementation of emission controls at source of large combustion installations (regulation for Industrial Emissions) and improved fuel quality with low levels of suphur.

Another large source of SO_2 emissions is international shipping, which has traditionally relied on unabated high sulphur content residual fuel oil. Formerly, such emissions have been considered of lower significance because they occur at sea rather than on land, but with the reduction of land-based emissions following the progressive introduction of effective legislation on industrial emissions, maritime SO_2 emissions account for a progressively larger share of total emissions.

The vast majority of **ammonia NH_3** is produced by agricultural activities through emissions from fertiliser and manure application and storage, and animal housing facilities. For some activities, such as intensive pig rearing and chicken farming, the application of best available technology (BAT) is required through the Industrial Emissions Directive, but many large contributors, in particular cattle farms, are not subject to BAT requirements under EU legislation. Low-emission manure spreading techniques exist but are applied unevenly in different Member States. Overall, NH_3 emissions have remained stable in the last decade and are not projected to decrease in the future, in the absence of further measures.

ANNEX 4 REVIEW OF THE EXISTING EU AIR QUALITY POLICY FRAMEWORK

1. INTRODUCTION

The EU air policy framework was developed building on national policies developed in Member States at the time and international work in the 1979 Convention on Long Range Transboundary Air Pollution (CLRTAP) which developed a multi-pollutant and multi-effect approach to tackle the range of air pollution problems. The first EU air quality directives and emission controls were established in 1980 and the policy has been substantially reinforced and consolidated since.[132] The 6th Environment Action Programme (6EAP) adopted in 2002 by the Council and European Parliament established a common EU long-term objective for air quality: to achieve 'levels of air quality that do not give rise to significant negative impacts on and risks to human health and the environment'.[133] It also called on the Commission to establish a Thematic Strategy on Air Pollution that would define the pathway towards achieving this objective through integrated actions in relevant policy areas.[134]

2. THE SCOPE AND PROCEDURE FOR THE REVIEW

The present review incorporated a full evaluation of the functioning of the current EU framework for air quality policy in line with the Commission guidelines.[135] This section outlines what was evaluated, as well as the fact-finding and consultation processes. The outcome is presented in sections 3 through 9 as a critical review of the relevance, effectiveness, efficiency, and coherence of the respective components of the policy framework, including a comprehensive analysis of the present compliance problems and the underlying reasons. In detail: sections 3 to 5 focus on the main air policy instruments (the TSAP, the AAQDs and the NECD); sections 6 to 8 evaluates EU and national source controls and international air pollution policy, and section 9 addresses the overall coherence of the various policy elements. Section 10 summarizes the review of the policy framework as a whole and formulates the principal guidance for the review emerging from it. Those key conclusions are taken up in the main body of the Impact Assessment, principally from section 3 onwards.

2.1. What was reviewed?

The main elements of the air quality policy that were reviewed are:

132 For SO2 and suspended particles in Directive 80/779/EC.

133 Article 7(1) of Decision N° 1600/2002/EC of the European Parliament and of the Council laying down the Sixth Community Environment Action Programme. OJ L 242, 10.9.2002, p. 1.

134 Air policy has close links with many other policies but perhaps most so with climate change which also deals with atmospheric pollution and its impacts and covers many of the same sources. Measures reducing greenhouse gases (e.g. on power generation and transport) can deliver substantial reductions also of air pollutants such as sulphur oxides, and there is a shared interest in reducing emissions of so-called Short-Lived Climate Pollutants (substances that affect both air quality and the climate).[134] But decarbonisation tends to be not or less effective in reducing two of the main air pollutants: primary particles and ammonia (respectively impacting health and ecosystems). For example, while shifting away from coal use reduces the emission of primary particles, intensified biomass use increases it. Hence these and other "overlapping" areas must be carefully managed.

135 COM(2001)31 final.

- The **Thematic Strategy on Air Pollution** (TSAP) adopted in 2005[136]. Having established that the long-term objectives stated in the 6EAP were not achievable within its time horizon, the strategy set interim objectives for 2020 and outlined strategic priorities and actions to better co-ordinating the various strands of EU policy instruments to achieve them. (See section 3)

- The **Ambient Air Quality Directives** (AAQD). The original Air Quality Framework Directive 96/62/EC and its four daughter Directives setting ambient air quality standards for a range of pollutants: Directive 1999/30/EC covering SO_2, NO_2, PM_{10} and lead, Directive 2000/69/EC covering benzene and carbon monoxide, and Directive 2002/3/EC addressing ozone. These were consolidated into the Ambient Air Quality Directive 2008/50/EC as proposed in the 2005 TSAP, with the addition of a set of controls on $PM_{2.5}$ and the possibility for an extension of the original deadlines for compliance with the limit values for PM_{10}, NO_2 and benzene. It provided for the adoption of consolidated provisions on reporting (adopted as Commission Decision 2011/850/EU) and the consequent repeal of Decision 97/101/EC on Exchange of Information. The 4th Daughter Directive, 2004/107, covering heavy metals and poly-aromatic hydrocarbons (PAHs), was recently adopted at the time Directive 2008/50 was proposed, and thus remained as a separate instrument. (See Chapter 4)

- The **National Emission Ceilings Directive 2001/81/EC** (NECD). The NECD was adopted prior to the 2005 TSAP. As the name implies it caps the total amount of emissions of each of four pollutants (SO_2, NOx, non-methane VOCs and ammonia) for each Member State, with the caps designed to limit exceedances of acidification and eutrophication critical loads and to limit the formation of ozone so as to protect both health and ecosystems. The 2005 strategy indicated that the Directive should be revised so as to align the emissions ceilings for the relevant pollutants with the strategic health and environmental impact reduction objectives for 2020, but the revision planned for 2008 was not adopted. (See section 5)

- **Source legislation**. Whilst the AAQDs and the NECD comprise commonly agreed EU air quality and air emission standards, the Member States are generally considered to be best placed to determine the pollution reduction measures needed to achieve them. Hence, national and local source legislation and non-legislative policies are an essential component of the EU air quality policy framework (See section 7). However, EU source legislation has played an equally important role, e.g. where emissions from products contribute substantially to air pollution problems and such products must be regulated at EU level (e.g. light- and heavy-duty road transport, non-road mobile machinery, etc.). For a range of other pollution sources (typically large stationary sources) the co-legislators have determined also that control of emissions at source at EU level is appropriate (for instance the Directives recently consolidated into the Industrial Emissions Directive 2010/75/EU). EU Source Controls are discussed in section 6; National and local source controls are discussed in section 7.

- **International Action.** The CLRTAP and its Protocols form an important backbone for EU policy development and implementation. The TSAP pointed up the need to reinforce cooperation to tackle regional and global background pollution and to continue to support the Convention's scientific and monitoring activities (See section 8).

The most detailed review focused on the core elements of the current policy framework: the TSAP, the AAQDs and the NECD. In determining the extent to which these instruments met their objectives, their overall coherence also with other legislation, including the relevant EU source legislation is a key question and is addressed in section 6. However, an assessment of the fitness to its specific purpose, of each element of the source legislation individually, is beyond the scope of this

136 COM(2005)446 final.

exercise. The legislation in question often has policy objectives over and above the control of emissions to air, and has in many cases recently been subject to separate review of its effectiveness.[137] In other cases, an ex-post analysis is forthcoming for which the present review will serve as a useful benchmark.[138,139]

2.2. How was the review organised?

2.2.1. Design of the review

This initiative is part of DG ENV's annual evaluation plan for 2013. The evaluation unit of the DG has been involved and has actively overseen the process since the beginning of 2012.

An inter-service group was set up for the review on 4 February 2011. The overall framework for the review was presented at the first meeting of 23 February 2011 and formalised in Staff Working Document SEC(2011)342 of 14 March 2011, which announced the establishment of a Stakeholder Expert Group (SEG) and a public consultation evaluating the effectiveness of existing policy. The SEG (also including the relevant Commission services) was established on 6 June 2011 to advise, support, and ensure the quality of the review. The framework for review was presented and endorsed at the first meeting 6-7 June 2011.

2.2.2. Conduct of the review

The review was based on the series of questions set out in the first stakeholder consultation: These questions related to:

- The adequacy of the air quality legislation in relation to the objectives of the 6th EAP;
- The coherence and synergy of the EU air pollution policy tools, in particular the air quality directives, the national emission ceilings directive; and the sectoral directives;
- The coherence and synergy of the air quality standards with emission standards;
- The coherence and synergy of EU air pollution policies with other environmental policies (climate change, biodiversity, and noise), sectoral policies (in particular regarding transport, energy, and agriculture), and international policies.

The initial public consultation was a free-response questionnaire sent to the SEG on 17 June 2011 with a deadline of 15 September 2011 (later extended to 29 September 2011). The first results were presented to the SEG on 21-22 January 2012 and the final report was published on 29 May 2012.

In parallel a fact-finding process was conducted, comprising the launch of a series of additional studies for the review of each key policy instrument - the TSAP, the AAQD, the NECD and the source legislation covering key sectors. Specific questions were identified for each assessment. A list

[137] For instance the IED deals in an integrated way with emissions to air, water and land as well as resource efficiency. Industrial emissions policies were impact assessed as part of the of the proposal for an Industrial Emissions Directive SEC(2007) 1679; or in the forthcoming fitness check for EU vehicle emissions policy.

[138] See for example, the VOC Stage II legislation, i.e. Directive 2009/126/EC, which is yet to enter into force in full and which will be reviewed in detail in the future.

[139] Likewise, an assessment of the cumulative effect of EU policies on particular sectors, covering not only air policy but also other environmental and non-environmental policies, is beyond the scope of this exercise. A series of sector-specific fitness checks has been launched for this purpose and the progress has been followed closely from the perspective of the review.

of the questions addressed and the studies launched for each policy instrument is provided in Appendix 1.[140]

The national authorities responsible for implementation and enforcement of the TSAP have been involved extensively and at all levels (national, regional and local). For the initial evaluation questionnaire all Member States were consulted; 13 provided very detailed assessments which were a key input for the problem definition. Implementing authorities were also involved in the review through a workshop on particulate matter held on 18-19 June 2012,[141] through a pilot project on implementation of air legislation in urban areas co-organised with the EEA (involving 12 cities),[142] and as reviewers of all the evaluation material in the Stakeholder Expert Group. During the review process, there have also been interactions with regional groups including European city representatives, and the Committee of The Regions subsequently issued an own-initiative opinion setting out its views on the review. [143]

Member States were consulted on the draft evaluation conclusions and problem definition in October 2012, and the draft was presented to the 4th Stakeholder Expert Group in December 2012 and published as background to the second public consultation (on policy options). The minutes of the 4th Stakeholder Expert Group confirm the SEG's support for the review and problem identification presented. A follow-up Member State expert group in February 2013 was consulted on possible options for resolution of the governance issues identified, including options for better co-operation between authorities responsible for implementation. This meeting brought together for the first time representatives from the Member State Competent Authorities' responsible for the implementation of the AAQD and the NECD and was instrumental in encouraging the two communities to see the AAQD and NECD as complementary rather than separate instruments. Finally, the issue of air pollution was taken up by the Irish Presidency as the subject of the informal Environment Council discussion on 22 April 2013, including a preceding seminar.[144]

2.2.3. Dissemination and use

The SEG and Impact Assessment Steering Group (comprising concerned DGs) were consulted on the focus of the individual studies and the terms of reference. Reports (including interim drafts) were published on CIRCABC and final reports on the review website. A draft review of the existing policy framework, and draft problem identification, was presented to Member States on 24 October 2012. A revised draft was published as background to the second public consultation on 7 December 2012. The outcome of the fact-finding and consultation processes has been used as the basis for drafting this annex and the relevant parts of Chapter 3 and for each main conclusion a reference is provided to the relevant substantiating documentation.

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140 All reports are available at http://ec.europa.eu/environment/air/review_air_policy.htm unless otherwise specified.

141 See report 'PM Workshop Brussels 18-19 June 2012', TNO 2012.

142 Final report on http://www.eea.europa.eu/publications/air-implementation-pilot-2013.

143 Opinion of the Committee of the Regions on 'Review of EU air quality and emissions policy', 2012/C 225/03. Available on: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:225:0011:0019:EN:PDF.

144 REF forthcoming

EUROPEAN
COMMISSION

Brussels, 18.12.2013
SWD(2013) 531 final

PART 2/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the documents

Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and he Committee of the Regions a Clean Air Programme for Europe

Proposal for a Directive of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants

Proposal for a Directive of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants and amending Directive 2003/35/EC

Proposal for a Council Decision on the acceptance of the Amendment to the 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone

{COM(2013) 917 final}
{COM(2013) 918 final}
{COM(2013) 919 final}
{COM(2013) 920 final}
{SWD(2013) 532 final}

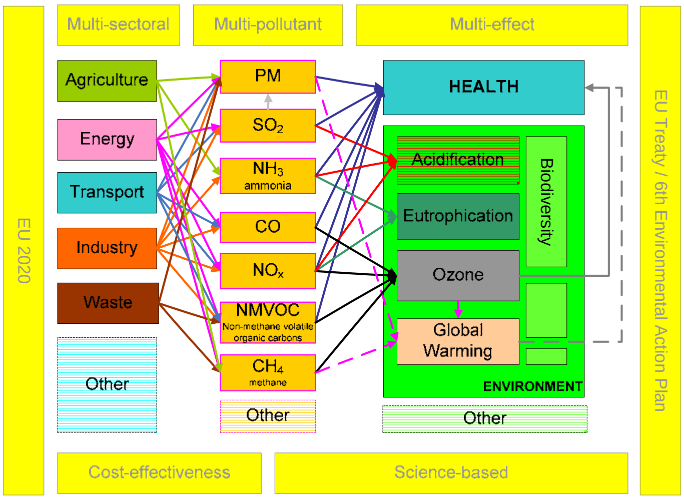
3. THE THEMATIC STRATEGY ON AIR POLLUTION

3.1. Objectives, scope and approach

The environmental and socio-economic scope of the TSAP 2005 is summarized in Box A.4.1.

It incorporates the above mentioned multi-effect, multi-pollutant and multi-sectoral methodology developed at the international level.

Box A.4.1: Summary of the environmental and socio-economic scope and context of the TSAP



The analysis underpinning the 2005 TSAP was based on a previous generation of the same suite of models used for the current assessment.[168] The objective of the analysis was to identify to what extent cost-effective progress could be made by 2020 towards the 6EAP objectives of no significant impact on human health or the environment from air pollution, focusing on five major impacts of air pollution: health impacts of particulate matter; health impacts of ground-level ozone; plant impacts of ozone; ecosystem impacts of acidification; and ecosystem impacts of eutrophication.

Impacts were calculated based on spatial modelling of pollution concentrations and depositions taking into account meteorological and topographic conditions that were characteristic for the respective regions in the EU. For ecosystem impacts, the depositions are compared with 'critical loads' calculated for each ecosystem type, which are deposition rates beyond which the ecosystem suffers damage, to determine the ecosystem area affected. For human health, the concentrations were combined with population data to determine exposure to those concentrations, and those were in turn combined with concentration-response functions established by the WHO based on a thorough scientific review, and baseline health impact data for the endpoints in question, to estimate the resulting years of life lost, or premature deaths.

Based on this assessment, the 2005 TSAP set out interim objectives for headline health and environmental indicators (Table 1) and accompanying pollutant emission reduction objectives (Table 2) for 2020 that would be required to meet those impact objectives.[169]

Table 1: TSAP Health & Environmental Targets (target year 2020)

168 See Annex 2 of SEC(2005)1133 for detail

169 One technical point is that the 2005 TSAP interim objectives for 2020 were formulated in terms of percentage reduction compared to 2000 as the base year, and for the EU25 rather than the current EU28. The present review is based on assessments for EU28 based on an updated energy baseline and with 2005 chosen as the base year (because emission inventory data are of better quality). Hence, the tables include a column with the equivalent TSAP objectives for 2020 presented on the revised basis.

Headline Health and Environmental Impacts	2020 "Interim Targets"	
	%Δ vs 2000	%Δ vs 2005
Loss of life expectancy due to PM exposure	47%	40%
Acute mortalities due to ozone exposure	10%	0%
Excess acid deposition in forest areas	74%	67%
Excess acid deposition in fresh surface water areas	39%	32%
Areas or ecosystems exposed to eutrophication [170]	31%	29%
Forest Area exceeded by ozone (M Km^2)[171]	15%	12%

Table 2: TSAP Emission Reduction Targets (indicative for target year 2020)

Headline Emission Reduction Targets	2020 "Interim Targets"	
	%Δ vs 2000	%Δ vs 2005
Primary Particulate Matter (PM2.5)	59%	52%
Nitrogen Oxides (NOx)	60%	56%
Sulphur Oxides (SOx)	82%	76%
Non-Methane Volatile Organic Compounds (NMVOC)	51%	38%
Ammonia (NH3)	27%	24%

The TSAP objectives were politically endorsed by Council and EP conclusions but have no formal legal status.[172]

3.2. Monitoring, Reporting and Evaluation

Progress towards the TSAP objectives is monitored through several indicators, most directly through trends in air pollutant emissions based on national emission inventories established by the Member States according to the requirements of the NECD (referring to the guidelines adopted by the CLRTAP-EMEP) and collated by the EEA.[173]

Impacts on health, acidification and eutrophication are calculated regularly and published on the occasion of comprehensive reviews conducted by the European Commission and the EEA or the CLRTAP.[174] The effectiveness of the TSAP has also been tracked through the EEA's annual report on Air Quality in Europe which collates monitored air quality data reported through EIONET in

170 The figure in the original strategy is 43%, but based on updated scientific methodology the 2005 emission reductions correspond to a reduction in impact of only 31%.
171 Rebased as percentage reduction in ozone flux, where the latter is defined as phytotoxic ozone dose (mmol/m2) over a threshold of 1 nmol/m2/s.
172 Council Conclusions on TSAP, 9 March 2006, available on: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:225:0011:0019:EN:PDF.
173 See http://www.eea.europa.eu/data-and-maps/indicators for air pollution related indicators and assesments.
174 See for example the CLRTAP co-ordination centre for effects annual status reports; 2012 report available on http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:C:2012:225:0011:0019:EN:PDF.

accordance with the implementing decisions adopted under the Ambient Air Quality Directives (See section 4).[175]

The TSAP was furthermore evaluated in the review of the 6EAP with regard to the breadth and quality of its analysis. [176] The review process builds on these monitoring and evaluation mechanisms and included extensive further consultation of stakeholders.

3.3. Relevance

The analysis under the current review of EU air policy has confirmed that the overall scope, objectives, parameters and sources identified in the TSAP remain relevant and appropriate to address the main air pollution challenges in the EU. The main impacts focused on in 2005 remain the key air quality impacts today. Successive reviews of the science underlying the problems have confirmed that the pollutants addressed are indeed the main problem drivers.[177] A review of evidence has confirmed that particulate matter and ozone are the two substances for which the evidence of health impacts in the EU is strongest.[178] For ecosystem impacts, while acidification has reduced dramatically, eutrophication remains substantial.[179] The modelling framework was further developed and updated in the period 2006-2013, with in-depth stakeholder consultation.[180] It was concluded that the approach to identify pollution reduction objectives, sources and legislative instruments remains valid.

Stakeholders have stressed the importance of maintaining, and where possible extending, the inter-relation between air quality and climate change policy analysis.[181] Likewise, the inter-relation between the AAQD and the NECD could be strengthened.[182]A number of tasks related to climate change and its effect on air pollution also require consideration on broader spatial scales whilst at the same time there is increasing need for more detailed information on pollution levels within Member States' territories that require assessments with finer spatial resolution. [183] It was noted that EU

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175 See most recent report, Air Quality in Europe – 2012 report, p34 for current emissions and historical trends; report available on http://www.eea.europa.eu/publications/air-quality-in-europe-2012. The EEA's annual report on implementation of the NECD provides more detail on four of the five main TSAP pollutants (the exception being PM2.5, which is not currently regulated under the NECD). Latest report available on http://www.eea.europa.eu/highlights/publications/evaluation-progress-nec-2012.

176 See 'Final report for the assessment of the 6th environment action programme, DG ENV.1/SER/2009/0044, chapter 3.3 and Annex A, in particular p80 ff. For stakeholder consultation, see Chapters 1-2 and Annexes E-G. Report available on: http://www.ecologic.eu/files/attachments/Projects/2010/ecologic_6eap_report.pdf.

177 For an in-depth assessment of eutrophication and its underlying causes see *the European Nitrogen Assessment: Sources, Effects and Policy Perspectives*, Sutton, M A et al, Cambridge University Press 2011; for an in-depth assessment of the health impacts of air pollution and their underlying causes see the *Review of Evidence on the Health Aspects of Air Pollution,* WHO/Europe 2013 (see above or Annex 1 for ref.)

178 WHO Review of Evidence on Health Aspects of Air Pollution, 2013. Available on http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report.

179 Report 'Factors determining recent changes of emissions of air pollutants in Europe, ENV.C.3/SER/2011/0009 TSAP report #2.

180 In the context of the EC4MACs project, a preparatory project under the LIFE programme. See http://www.ec4macs.eu/.

181 See 'Survey of view of stakeholders, experts and citizens on the review of EU Air Policy. Part II: Detailed results', pp17-19 points 2 to 4. Available on http://ec.europa.eu/environment/air/review_air_policy.htm.

182 See report from Member State Expert Group meeting on Air Quality review (2012)

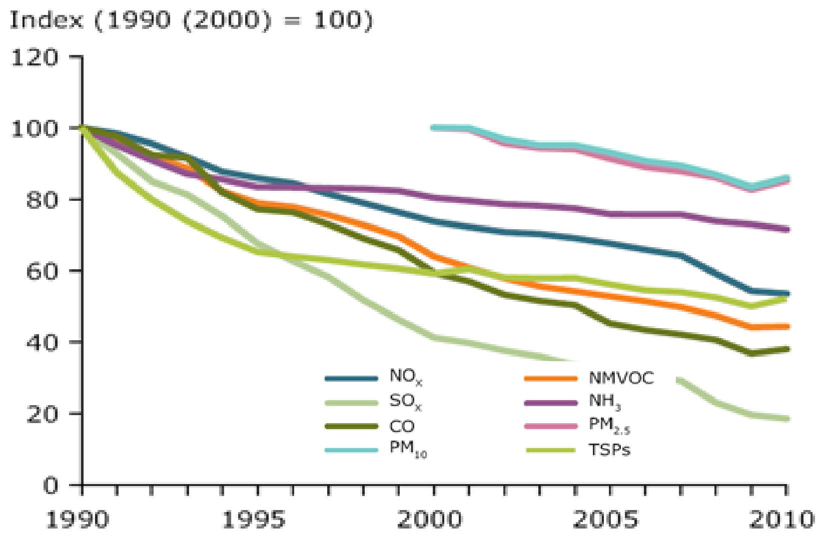
183 See reports from EMEP Steering Body and EMEP website.

provisions for monitoring ecosystems were lacking (See section 5 on NECD below. Finally, it has been suggested that in addition to the coverage of "traditional" sectors such as energy, industry, and transport, increasing attention should go to agriculture and maritime emissions as well as emissions from small and medium scale combustion.[184]

3.4. Effectiveness

As shown in Figure 1 below, substantial reductions have been achieved between 1990 and 2010 for the main air pollutants tracked by the TSAP.

Figure 1: EU air pollutant emissions 1990-2010 (EEA, 2012)



In consequence the EU's huge acid rain (acidification) problem is set to be broadly solved[185], the impact of lead from vehicle fuels has been eliminated, and the ambient air health risk from other heavy metals and carbon monoxide has been greatly reduced. The health impacts of particulate matter, the main cause of death from air pollution, have been reduced by around 20% between 2000 and 2010. Figure 2 shows the comparative success in eliminating acidification versus the large outstanding eutrophication problem.

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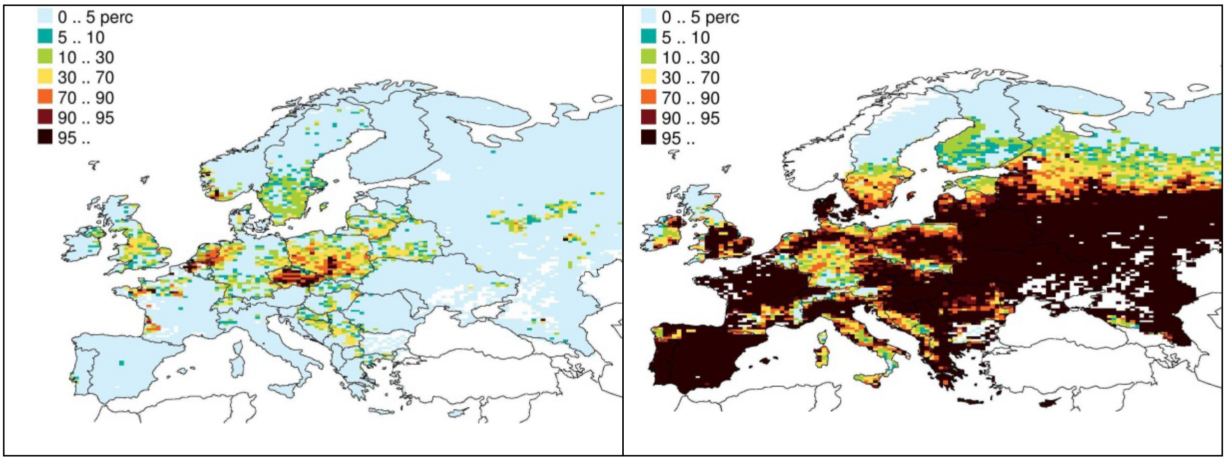
184 See 'Survey of view of stakeholders, experts and citizens on the review of EU Air Policy. Part II: Detailed results', pp19-20, point 5.

185 The emission reductions are due to EU legislation on sulphur emissions from large combustion plants (LCPs), and to the low sulphur road transport fuel requirements that also enabled the use of catalytic converters from Euro 4 onwards.

Figure 2: EU ecosystems at risk of acidification and eutrophication



The present review has also developed updated projections related to the air pollutant emissions and air quality impacts for the period up to 2030 assuming no changes to current policy (see Annex 5).

Despite the progress made in addressing air pollution, several of the 2005 TSAP objectives will not be met - the health and environmental impacts of air pollution in the EU remain large.

As shown in Table 3, projected emission reductions without further measures will fall short of the 2020 TSAP targets for all main pollutants, most importantly for PM2.5 and ammonia (NH_3) and to a lesser extent for NOx and NMVOC.[186] The reasons for this shortfall are further discussed in the section relating to the NECD and source controls.

Table 3: Distance to TSAP Emission Reduction Targets for 2020 (latest projections)

Headline Emission Reduction Targets for 2020	**%Δ vs 2005**	**%Δ vs 2005**
	TSAP 2005	**Projected[187]**
Primary Particulate Matter ($PM_{2.5}$)	52%	24%
Nitrogen Oxides (NOx)	56%	51%
Sulphur Oxides (SOx)	76%	65%
Non-Methane Volatile Organic Compounds (NMVOC)	38%	34%
Ammonia (NH3)	24%	15%

As a consequence of failing to achieve the emission reduction targets, there is also under-achievement of the TSAP's headline health and environmental targets for reduction of PM2.5 mortality, eutrophication and forest acidification (Table 4). [188] However, the target for fresh water acidification

186 Emission projections carried out in the context of this review are documented in Annex 5.

187 Projected emission reductions by 2020 compared to 2005 are calculated based on data presented in Annex 5.

188 The first column gives the scale of the impact in 2000, the second the projected impact in 2020 on a business as usual scenario (baseline), and the third, the projection for 2020 on the basis of the maximum technically feasible reduction of air pollution (MTFR). Note that the impacts reported in this table are smaller than in chapter 3 of this impact assessment. This is because advancements in atmospheric dispersion modelling and ecosystem impact assessment have led to the upward revision of the magnitude of impacts. In % reduction terms, however conclusions have not substantially changed.

will be met, as well as the ozone mortality target (the latter represented a 10% reduction compared to 2000).

Table 4: Distance to TSAP Health & Environmental Targets (latest projections)

Headline Health and Environmental Impacts for 2020	%Δ vs 2005	%Δ vs 2005
	TSAP 2005	Projected[189]
Loss of life expectancy due to PM exposure (M)	40%	26%
Acute mortalities due to ozone exposure (M)	0%	13%
Excess acid deposition in forest areas (M Km^2)	67%	64%
Excess acid deposition in fresh surface water areas (M Km^2)	32%	n.a.
Areas or ecosystems exposed to eutrophication (M Km^2)	29%	17%
Ozone flux (Forests (mmol/m^2 above effects threshold))	12%	13%

The updated human health impacts in the EU due to PM and ozone air pollution in 2010 are presented in Table 39.[190] The associated external costs and costs of implementation are discussed in the following section on efficiency. Air pollution remains the number one environmental cause of death in the EU, responsible for an estimated 406 000 premature deaths or ten times more than fatalities due to road traffic accidents.[191] In addition to premature mortality there are also substantial quality-of-life (well-being and morbidity) impacts, ranging from asthma to exacerbation of cardiovascular symptoms, which result in restricted activity days with associated productivity losses.

Table 5: Health Impacts in the EU Due to PM and Ozone Air Pollution in 2010 (EU28)

Acute Mortality (All ages)	Premature deaths	O3	26,525
Chronic Mortality (All ages) *	Life years lost	PM	4,030,653
Chronic Mortality (30yr +) *	Premature deaths	PM	379,420
Infant Mortality (0-1yr)	Premature deaths	PM	1,829
Chronic Bronchitis (27yr +)	Cases	PM	316,685
Bronchitis in children (6 to 12 years)	Cases	PM	6,231,812
Respiratory Hospital Admissions (All ages)	Cases	PM	142,243
Respiratory hospital admissions (>64)	Cases	O3	19,117
Cardiovascular Hospital Admissions (>18 years)	Cases	PM	108,989
Cardiovascular Hospital Admissions (>64)	Cases	O3	86,279
Restricted Activity Days (all ages)	Days	PM	436,351,761
Asthma symptom days (children 5-19yr)	Days	PM	11,290,673
Lost working days (15-64 years)	Days	PM	121,378,612
Minor Restricted Activity Days (MRADs all ages)	Days	O3	108,845,140

Notes: * These rows represent alternative measures of the same effect on mortality, and hence are not additive..

189 n.a. indicates that calculations are not available at this stage.
190 Source: EMRC 2013.
191 EUROSTAT statistics report the number of traffic fatalities in the range of 35,000 in the year 2010 across the EU 27.

3.5. Efficiency

Promoting cost-effective air pollution abatement actions

One of the principal aims of the TSAP was to promote cost-effective air pollution abatement actions in the EU and internalise externalities through the adherence to the polluter pays principal and optimal market based solutions.

As is set out in section 6 on EU source controls, the main focus of current air pollution policies has been on the major polluters. External costs associated with air pollution in the EU remains, however, very large. Table 40 below builds on table 39 above and shows the external costs associated with the main health impacts in the EU due to air pollution.

Table 6: External Costs Associated with Main Health Impacts in the EU Due to Air Pollution in 2010

Impact			€M/year
Acute Mortality (All ages)	Premature deaths	O3	1,531 – 3,679
Chronic Mortality (All ages) LYL median VOLY *	Life years lost	PM	232,569 – 559,052
Chronic Mortality (30yr +) deaths median VSL *	Premature deaths	PM	413,567 – 842,312
Infant Mortality (0-1yr) median VSL	Premature deaths	PM	2,990 – 6.090
Chronic Bronchitis (27yr +)	Cases	PM	19,001
Bronchitis in children (6 to 12 years)	Cases	PM	3,664
Respiratory Hospital Admissions (All ages)	Cases	PM	316
Respiratory hospital admissions (>64)	Cases	O3	42
Cardiac Hospital Admissions (>18 years)	Cases	PM	242
Cardiovascular hospital admissions (>64)	Cases	O3	192
Restricted Activity Days (all ages)	Days	PM	40,144
Asthma symptom days (children 5-19yr)	Days	PM	474
Lost working days (15-64 years)	Days	PM	15,779
Minor Restricted Activity Days (MRADs all ages)	Days	O3	4,571
Core median VOLY			**327,691**
Core mean VOLY			**657,913**
Core median VSL			**505,120**
Core mean VSL			**937,434**

Notes: * These rows represent alternative measures of the same effect on mortality, and hence are not additive.

The implementation costs of existing policy are given per sector in Table 41. Note that these are the costs for reducing pollution from a situation of no pollution mitigation at all, to the current pollution level. The pollution which would result from today's activity levels if there were no policy at all would be extremely high. The concentrations in such circumstances would be at least an order of magnitude higher than current concentrations, and although impacts are not linear over the whole concentration range, the impacts would also be several multiples of the current impacts.

Table 41: Pollution control costs for the baseline up to 2020 (EU28, M€)

	2010	2015	2020
Power generation	12700	12093	10711
Domestic sector	7476	9115	9629
Industrial combustion	2435	2468	2521
Industrial processes	4760	4983	5029
Fuel extraction	976	907	770
Solvent use	1638	1964	2140
Road transport	26022	34357	42023
Non-road mobile sources	1892	4320	6975
Waste treatment	0	1	1
Agriculture	1750	1775	1786
Total	59650	71983	81584

It can be seen that even on the most conservative valuation, the benefits of implementation of current policy hugely outweigh the costs. Despite the very substantial progress, the remaining impacts in 2010 still place a huge burden on society.

Enhancing the overall coherence of the principle TSAP instruments

Another principal efficiency related aim of the TSAP was to enhance the overall coherence of the main instruments put in place to achieve the TSAP objectives including the balance between Member State and EU action.

Whilst detailed comments are provided in the below sections relating to the respective instruments, the following areas for reinforcement of the strategy (and its underlying analysis) have been identified based on the public consultation for the TSAP review:

- A reinforced analysis of the impact of emission reductions (from source controls and national emission ceilings) on compliance with the AAQD air quality standards (it is now possible for the first time to model this at EU scale);[192]
- the interaction with other policies, in particular with the forthcoming climate and energy package;[193]
- the robustness of the proposed policy with respect to variations in the underlying analytical assumptions;[194]
- alternative instruments to those brought forward in 2005 (e.g. fiscal instruments); [195]

[192] See next section for rationale; See also TSAP report #9, 'Modelling compliance with NO2 and PM10 air quality limit values in the GAINS model', IIASA 2013. This and all other reports referred to here are available on http://ec.europa.eu/environment/air/review_air_policy.htm, unless otherwise specified.

[193] TSAP report #1, 'Future emissions of air pollutants in Europe – Current legislation baseline and the scope for further reductions', IIASA 2012, section on decarbonisation scenario impacts, pp43-48.

[194] For an ex post analysis of the robustness of the assumptions made in the 2005 TSAP, see TSAP report #2 'Factors determining recent changes of emissions of air pollutants in Europe', IIASA 2012. For an assessment of the achievability of prospective future targets on alternative assumptions, see TSAP report #10, 'Policy Scenarios for the revision of the Thematic Strategy on Air Pollution' IIASA 2013 section 4.2 pp16-19.

- how action at Member State level can be supported and reinforced at EU level;[196]
- additional flexibilities in instruments compared with those assessed in 2005.[197]

3.6. Relation of the TSAP analysis to emission ceilings and ambient air quality targets

The TSAP modelling delivered as one of its direct outputs emission reduction objectives for SO_2, NOx, NMVOCs, ammonia and $PM_{2.5}$ not only for the EU as a whole but for individual Member States. These reductions took account of the transboundary impacts of the pollution concerned by determining the optimum spatial and sectoral profile of pollution reductions across Europe, so as to meet the desired health and environmental objectives. Thus the outcome of the modelling translated naturally into national emission ceilings for the various pollutants. The NECD had been adopted in 2001, and while it addressed human health impacts from ozone exposure, its main focus was on ecosystem impacts. The level of the ceilings set did not correspond to those required to meeting the 2005 TSAP objectives, and importantly, the Directive did not include a ceiling for $PM_{2.5}$. The TSAP proposed that these points be rectified by a revision of the Directive.

However, the relation of the TSAP and its associated modelling to the ambient air quality standards adopted was less direct. Those standards had been adopted based on scientific advice from the WHO, and on an assessment of the current levels of concentration and achievability of reduced levels.[198] The TSAP analysis was not optimised to achieve compliance with the air quality limit values, but rather to maximise the reduction in air pollution impacts across Europe. Nor was it possible to determine in detail the impacts of achieving the impact reduction objectives on compliance with the air quality standards, as the resolution of the model grid was too coarse (at 50x50km). The TSAP thus did not propose any adjustment to the limit values already adopted under framework and daughter directives on air quality, but did allow an extension of the timescale for meeting these values based on evidence that Member States had taken all possible action and still certain limit values were unlikely to be reached by the required deadlines.

4. THE AMBIENT AIR QUALITY DIRECTIVES

4.1. Objectives, scope and approach

Legislation on ambient air quality stems principally from the Air Quality Framework Directive 1996/62/EC. That Directive set out a framework for the establishment of ambient air quality standards and for air quality assessment, public information, and management with the aim of establishing a uniform minimum level of protection for human health and the environment. It also listed a set of key pollutants which had been identified as posing the most significant threats to human health and the environment. Standards for these pollutants were initially set in four subsequent 'daughter' Directives that were governed by the Framework Directive.

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195 JRC-IPTS 2013. Market based instruments to reduce air emissions from household heating appliances: Analysis of scrappage policy scenarios. To be published.

196 Addressed in: EEA Air Implementation Pilot 'Lessons learned from the implementation of air quality legislation at urban level', EEA report No 7/2013, available on http://www.eea.europa.eu/publications/air-implementation-pilot-2013; 'Review of the Air Quality Directive and the 4th Daughter Directive, Service request no 6 under FW contract ENV.C.3/FRA/2009.0008. Final report 2012; 'Final report of the PM Workshop Brussels 18-19 June 2012' (service request 7 under FW contract ENV.C.3/FRA/2009/0008; 'Services to assess the reasons for non-compliance with the ozone target value set by Directive 2008/50, and potential for air quality improvements in relation to ozone pollution', Ecorys 2013.

197 The main two issues are offsetting for shipping NOx emissions and joint implementation for methane.

198 See Directive 1996/62/EC Annex 2, and Commission proposal for 1999/30 (COM(1997)500 final.

For SO_2, NO_2, PM_{10}, lead, benzene and carbon monoxide the standards were set as *limit* values, to be achieved everywhere; while standards for ozone were set as *target* values, in recognition of the difficulty in ensuring that the required concentration is met given the complex atmospheric chemistry involved in ozone production. The 4th Daughter Directive, 2004/107, covering heavy metals and polyaromatic hydrocarbons (PAHs), also established target values, on the basis that the desired concentrations of ambient air concentrations of arsenic, cadmium, nickel and polycyclic aromatic hydrocarbons (i.e. concentrations which would not pose a significant risk to human health) could not be achieved in a cost-effective manner in specific areas.[199] The implementation of target values does not require that measures entailing disproportionate costs be taken;[200] for an ambient air quality limit value, on the other hand, the obligation is binding as to the concentration to be achieved and Member States are obliged to put in place the necessary plans and programmes to reach compliance.

The 2005 TSAP was accompanied by a legislative proposal for amending the Ambient Air Quality Directives –eventually adopted as Directive 2008/50/EC. It significantly streamlined the legislation by merging the Air Quality Framework Directive and its first three daughter directives. It also included new flexibilities by introducing the possibility of time extensions for the PM_{10}, benzene, and NO_2 limit values originally established in 1999. New air quality standards were introduced for particulate matter ($PM_{2.5}$), based on the increasing evidence that health effects were dominated by long-term exposure to this pollutant. Finally, it called for further streamlining the existing implementing acts and further adapt them to reduce the administrative burden through making better use of electronic and automated data collection and processing technology. The latter consolidation was completed in 2011 through the adoption of the Commission Decision 2011/850/EU, consolidating and amending three implementing acts.

A particular innovation of Directive 2008/50/EC was to include a different kind of regulatory parameter for $PM_{2.5}$ in addition to the traditional ambient concentration: an average exposure indicator (AEI) designed to reflect the population exposure to $PM_{2.5}$ in an individual Member State, and with two related objectives.[201] The rationale was that there was no identifiable threshold below which $PM_{2,5}$ would not pose a risk, and so a mechanism was needed to prompt a general reduction of concentrations in the urban background to ensure that large sections of the population benefit from improved air quality. This would supplement the $PM_{2.5}$ limit value, the role of which is to ensure a minimum degree of health protection everywhere.[202]

Since the recent consolidation, ambient air quality standards are contained in the Directive 2008/50/EC and 2004/107/EC.

4.2. Monitoring, reporting and evaluation

The implementation of the ambient air quality standards is monitored according to specific provisions established in the relevant Directives and including provisions on zoning, the determination of the required assessment regime, criteria for location of sampling points (macro-scale and micro-scale

199 See Directive 2004/107/EC recital 3.

200 Ibid., recital 5.

201 A national exposure reduction target to be met by 2020 and an exposure concentration obligation to be met by 2015. See Annex IX of Directive 2008/50.

202 Directive 2008/50/EC recital 11.

siting), data quality objectives, reference methods for the assessment of concentration of pollutants, and the conditions under which modelling could be used in combination with fixed measurements.[203]

Data collection, quality assurance, and reporting of the resulting data is managed by the European Environment Agency (EEA). The EEA provides annually a consolidated report on implementation of the Directive.[204] Detailed data sets are maintained and publically available in the EEA's *Airbase*.[205]

It is noted that under the provisions of the new Decision 2011/850/EU a transition to electronic reporting compatible with the INSPIRE Directive will take place in 2014, allowing for further streamlined reporting and evaluation as well as enhanced public access to relevant air quality information.[206]

4.3. Relevance

The main issue of relevance for the Ambient Air Quality Directives is whether the pollutants regulated are indeed those of principal health concern, and whether the controls are set at the correct level. As part of the 2013 air policy review, the Commission asked WHO to carry out a review of the health effects of air pollution according to a series of questions identified in consultation with stakeholders.[207] Among the key questions were:

whether any developments in evidence would justify modifications to the emphasis on the main pollutants currently regulated (PM_{10} and $PM_{2.5}$, NO_2 and ozone), including:

  - o whether any fractions of particulate matter should be regulated in preference to particulate mass;
  - o whether new evidence affected the assumptions regarding a no-effect threshold for any pollutant;
  - o whether the health evidence related to NO_2 indicated that it impacted directly on human health, or was a marker for some other component of air pollution.
- whether any parameters could be consolidated or deleted from the regulatory framework, or whether any should be added;
- which metrics, health outcomes and concentration-response functions could be used to assess the health impacts of PM, ozone and NO_2.

These questions covered all the main issues raised by stakeholders in the first public consultation.[208] The question of the independent health impacts of NO_2 was particularly important given (a) the widespread non-compliance with the NO_2 limit value and (b) the fact that while vehicle related PM pollution has been decreasing (due e.g. to implementation of the diesel particle filter), NO_2 concentrations have been stable and often above the EU AQ limit value, and in several places increasing levels.

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203 See e.g. Directive 2008/50/EC annexes I-VI.
204 The most recent being report No 4/2012, 'Air Quality in Europe – 2012 report'; see above for availability.
205 See http://www.eea.europa.eu/themes/air/air-quality/map/airbase.
206 Directive 2007/2/EC establishing an infrastructure for spatial information in the European Community.
207 WHO, 'Review of the impacts on health of air pollution', 2013. http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report
208 See report 'Survey of views of stakeholders, experts and citizens on the review of the EU Air Policy Part II: Detailed results.' In particular pp35-40.

The main conclusions from the WHO analysis are as follows:

- While there is some evidence linking particular sub-components of $PM_{2.5}$ with specific health impacts (for instance the sub-components related to primary combustion), the balance of evidence favours retaining $PM_{2.5}$ mass as the target for policy measures;[209]
- Evidence still supports the absence of a threshold for $PM_{2.5}$.[210] For ozone the evidence is inconclusive, but any threshold, if it exists, is likely to lie below 90 µg/m3.[211] (The EU target value is 120µg/m3.) Since 2005 there is new evidence indicating potential severe health impacts (premature mortality) of chronic exposure to ozone.
- Evidence indicates that there are independent effects of NO_2 on short-term health outcomes; the evidence for independent long-term effects is less clear-cut but still suggestive of a causal relationship.
- There are independent rationales for each of the current PM limit values.[212] In addition there is a potential rationale for a limit value on short-term average concentrations (as well as the current annual average).[213]
- Specifications on the metrics and concentration-response functions appropriate for health impact assessment were provided in this and the follow-up project (HRAPIE), and used in the ex-ante impact assessment for the new Strategy.[214] The recommendation was that air pollution health impact assessments should focus on chronic $PM_{2.5}$ exposure and acute ozone exposure, as in 2005, but that sensitivity analysis on chronic ozone impacts and chronic NO_2 impacts would also be warranted.
- While the parameters of the current legislation are all separately justified based on the health evidence, there is evidence indicating the need to revise WHO guidelines for PM, ozone (long-term exposure), NO_2 and SO_2.[215]

With regard to the level at which the EU limit and target values are set, with the exception of the NO_2 annual limit value these are less strict than the current WHO guidelines, and no values have been tightened since they were originally established. The WHO advised in particular that the levels at which the PM limit values are set are not sufficient to adequately protect human health.[216] Thus, even full compliance with the existing Ambient Air Quality Directive would be insufficient to protect human health: very substantial health impacts would remain.

The review also examined the levels at which controls are set for the substances regulated in the AAQD in the EU's main trading partners and the WHO guidelines. Appendix 2 sets out the levels established in the EU as compared with the WHO guidelines and the limit values in the USA, Japan, Switzerland, China, Korea, and India. The limit values set are broadly comparable to those of the EU even in emerging economies. For the health problem of most concern ($PM_{2.5}$), the USA limit value is substantially tighter than the EU limit (at 12 $\mu g/m^3$, as compared with 25$\mu g/m^3$ in the EU). For the pollutants for which compliance in the EU is most difficult, the following observations are made:

- NO_2 annual average: the limit in the USA is substantially higher (100$\mu g/m^3$ as compared with EU's 40$\mu g/m^3$), but China and India are the same and Switzerland is tighter (30$\mu g/m^3$).
- PM_{10} daily average: this is difficult to compare given the crucial role of the number of allowed exceptions. USA looks less stringent (at 150µg/m3 as compared with the EU's 50µg/m3), but (a)

209 WHO REVIHAAP report pp10-12, 182-183.
210 Ibid., pp38, 182-183.
211 Ibid., p59.
212 Ibid., p35.
213 Ibid., p32.
214 Ibid., pp41, 62, 117.
215 Ibid., ppp182-186.
216 Ibid., p83.

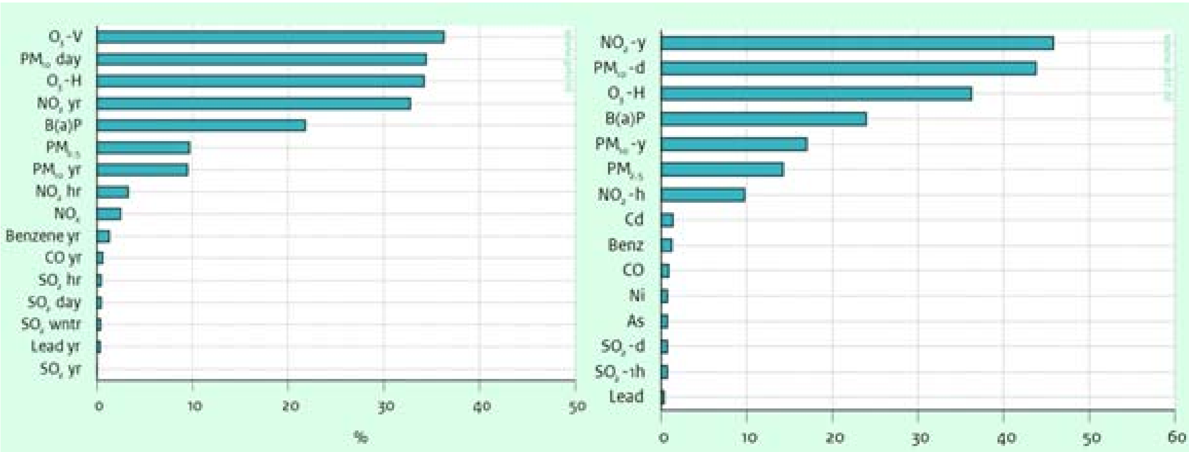
the USA strictly regulates the $PM_{2.5}$ sub-fraction of PM_{10} and (b) it allows only one day's exceedence a year as opposed to the EU's 35 days.

4.4. Effectiveness

The effectiveness of the AAQDs in achieving their objectives has been assessed in terms of the extent of compliance with the limit values set.

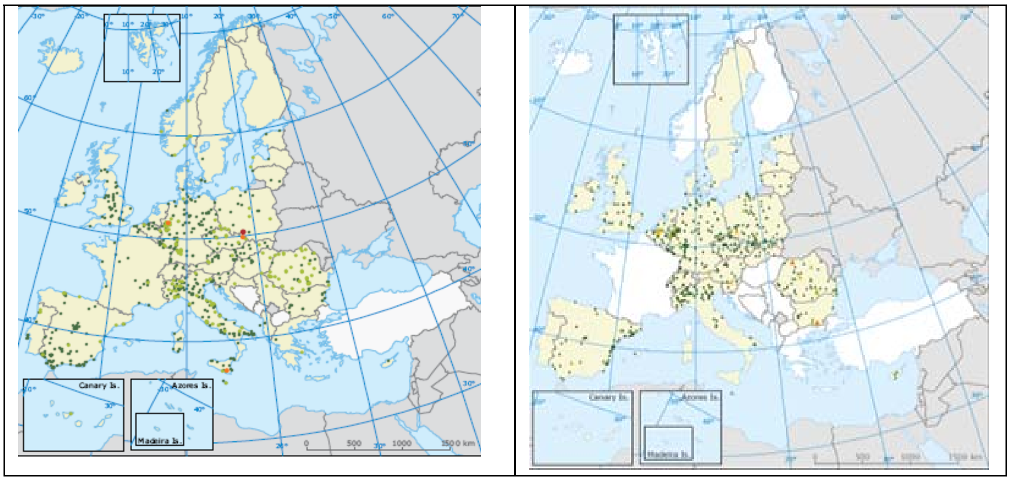
Figure 3 presents the summary compliance picture in graphical form. It shows the percentage of monitoring stations in exceedance of the limit or target values (left), and the percentage of the EU population potentially exposed to concentrations above those values (right).

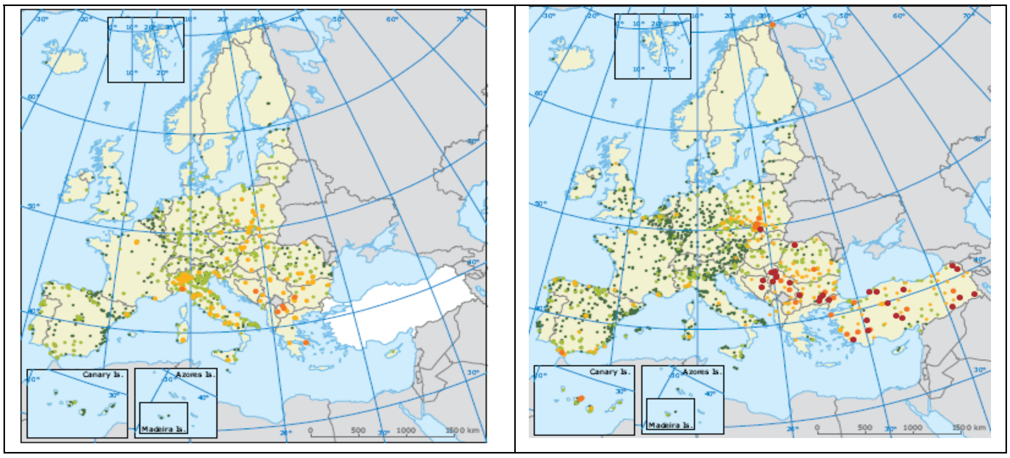
Figure 3: The 2010 AAQD Compliance and Population Exposure Picture (EEA)



Widespread compliance with the limit values for benzene, lead, CO, and SO_2 in the Directive has been achieved (Figure 4).

Figure 4: Status of compliance in 2010 with EU legally binding air quality standards for Benzene, Lead, CO, and SO_2 (clock wise from upper left onwards); EEA 2012





In addition, the non-binding target values for heavy metals (arsenic, cadmium, nickel) are also broadly complied with (Figure 5).

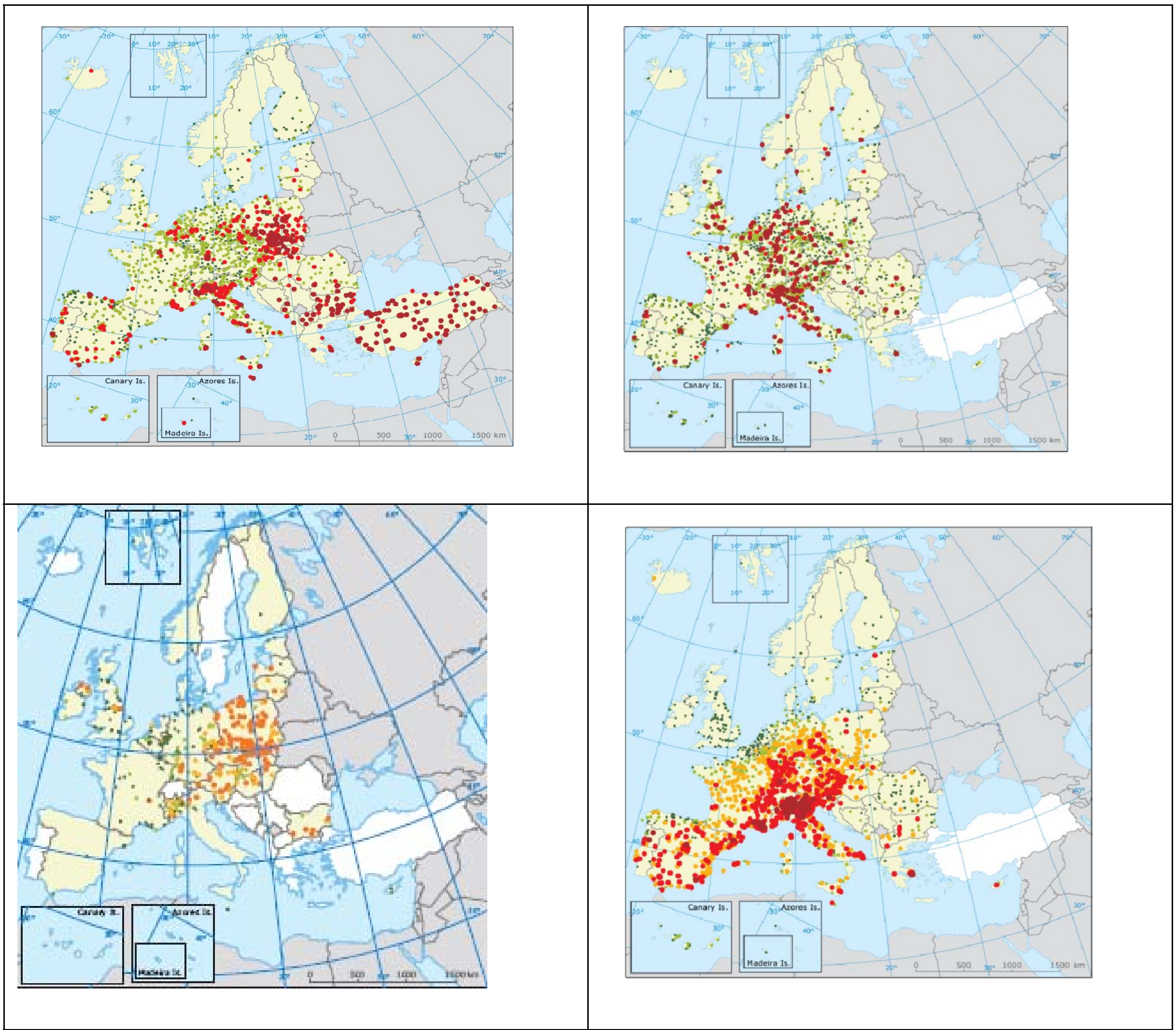
Figure 5: Level of compliance with non-binding target values for heavy metals (arsenic, cadmium, and nickel) in the EU

These successes have been mainly attributed to effective EU –level source controls including fuel quality measures (requiring the placing on the market of low-sulphur and unleaded fuels throughout the EU) and measures addressing large point sources such as the Large Combustion Plants Directive, the Waste Incineration Directive, and the Integrated Pollution Prevent and Control Directive, all now consolidated in the new Industrial Emissions Directive.

As shown in **Error! Reference source not found.**, there remains however widespread non-compliance with the PM_{10} and the NO_2 limit values despite the time extensions provided in the Directive 2008/50/EC.[217] There is also widespread exceedance of the target value for benzo(a)pyrene (BaP, the marker for polyaromatic hydrocarbons), and the target value for ozone.

[217] For PM_{10} the daily limit value is the most demanding to meet; for $PM_{2.5}$ the the annual average limit value is the most demanding to meet.

Figure 6: Exceedance of EU air quality standards in 2010 for PM_{10}, NO_2, Ozone, and BaP (clockwise from upper right) in 2010 (EEA)



Dots represent individual monitoring stations; green dots indicate compliance with the standards, red dots exceedance.

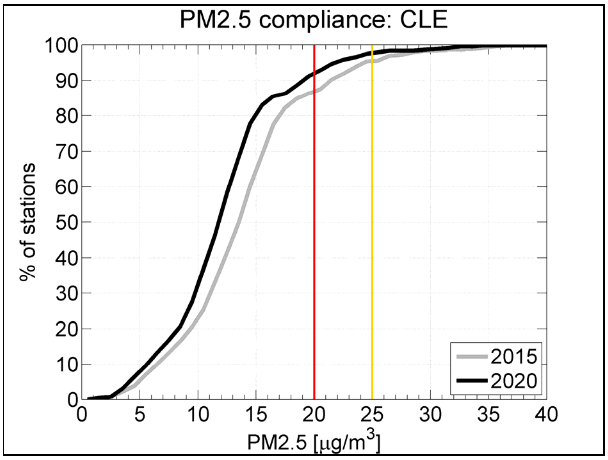
For PM_{10}, infringement procedures have currently been launched against 17 MS. For NO_2, 18 MSs have requested time extensions up to 2015 in accordance with the time extension provisions in the Directive; taking into account the Commission's decisions on these requests, 18 MSs are currently in non-compliance with the NO_2 limit values. The enforcement options related to BaP and ozone are currently limited.

With respect to the new $PM_{2.5}$ standards introduced in 2008, the limit value of $25\mu g/m_3$ for 2015 is likely to be broadly complied with.[218] That standard is, however, less stringent than the PM_{10} daily limit value. Projections show that the Directive's indicative limit value for $PM_{2.5}$ of $20\mu g/m^3$ by 2020 is also likely to be broadly complied with, except in specific circumstances.

[218] In 2011, 17 MSs are already in compliance with the limit value, with a further 4 within the so-called margin of tolerance (indicating a sound trajectory towards compliance).

With regard to the $PM_{2.5}$ average exposure reduction objectives introduced in 2008, the first legal milestone is achieving the exposure concentration obligation of 20µg/m^3 in 2015 at the latest. Member States were asked to share their experiences with implementing the exposure reduction obligations, but there is little practical experience at this stage given that the first substantive obligation is for 2015, and it is too early to assess the effectiveness of the concept in delivering health impact reductions.[219]

Figure 7: Projected compliance with PM 2.5 limit values (2015 and 2020) assuming no change to current policies



Pollutant specific causes of non-compliance and outlook for improvements

Particulate Matter

The causes of non-compliance vary significantly depending on the pollutant and the national or local circumstances. The following is an assessment by pollutant of the main reasons for non-compliance.

Concentrated local pollution sources for PM are a problem mainly in large urban centres which are often densely populated, making the resulting health impacts particularly significant.[220] In most locations currently in exceedance of the PM standards, high PM concentrations are the compound effect of different sources that include traffic (notably older diesel vehicles, both heavy- and light-duty), domestic heating, industrial sources, power production and background concentrations including also secondary aerosols, i.e. emissions of PM precursors including SO_2, NO_x, VOCs and NH_3.[221]

Projections of the compliance picture assuming no changes to the current policy framework developed in Annex 5 show that by 2020, reductions delivered by implementation of current legislation will bring most stations situated in these "*normal*" areas into compliance.[222] For instance, the continued penetration of Euro 5 light duty vehicles and Euro VI heavy duty vehicles into the fleet will progressively reduce (primary) particulate matter in line with the stricter emission introduced by those Euro standards. Further PM emission reductions can also be expected in the period up to 2020 from robust pollution controls on other relevant sources such as industrial installations and the energy sector that have been regulated the recently revised Industrial Emissions Directive, including the

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219 See report, 'Review of the Air Quality Directive and the 4th Daughter Directive', RICARDO-AEA 2012, section 4.4.3 p64.

220 E.g. some of the main population centres in Europe remain in non-compliance: Milan, Madrid, Barcelona, London and others.

221 See EMEP country reports, 'Transboundary air pollution by main pollutants (S, N, O3) and PM in 2010' showing the extent of transboundary contributions to concentrations of those pollutants in all CLRTAP parties (including all Member States). All reports are available on: http://www.emep.int/mscw/mscw_publications.html; see for instance p19 of the Belgium country report for 2010 for the transboundary contribution to PM2.5 in BE (around 80%). BE report available on http://www.emep.int/publ/reports/2012/Country_Reports/report_BE.pdf.

222 See Annex 5, section 5 for detail.

revision of the associated Best Available Technology Reference Documents and conclusions. As a consequence, implementation of current legislation will resolve most of the current compliance problems by 2020. (See also Annex 5).

However, this positive trend will not solve all non-compliance. Specific localised problems will remain related to special "*worst case*" circumstances that are particularly challenging to address at the local level. To identify the drivers responsible, the remaining areas of non-compliance were identified from the compliance modelling, and the reasons for non-compliance isolated, as follows.

Those are characterised by either (a) specific domestic solid fuel combustion issues, or (b) particularly concentrated local pollution sources, often combined with a particular topography.

- Domestic (household) solid fuel combustion has historically been a major driver of PM pollution in many Member States (for instance it caused the great London smog). Most Member States have restricted solid fuel use in response, but there are areas (notably the border region of PL, SK, CZ, and BG) where it remains the major pollution source. The required action has not been taken by the Member States in these regions mainly because the areas in question are often relatively poor, and the socio-economic impact of implementing the required restrictions is a deterrent. Pioneering initiatives have however been launched in a few locations, for instance Krakow.[223] The problem is not only continuing coal use, but also increase in biomass use, driven partly by renewables policy and (more recently) by the economic crisis which has caused some people to turn to wood burning and other forms of highly polluting and inefficient heating solutions. While action on the marketing and use of solid fuel combustion appliances will have an impact on the problem over time, the replacement rate of solid fuel installations is slow (and possibly even slower in low-income households), and open fireplaces will never be covered. Consequently, existing instruments such as the Ecodesign Directive,[224] which apply only to new products and do not affect existing installations, will not be sufficient; different approaches better adapted to specific local circumstances will be required.

- The problem is compounded in certain locations by a topography which limits effective dispersion of pollution, a factor that was explicitly recognised in Directive 2008/50/EC, which allowed time-bound flexibilities to deal with site specific dispersion characteristics. To reach compliance in such 'difficult' locations requires more comprehensive action than elsewhere on the relevant local pollution sources, to ensure that the economic benefits of the concentrated economic activity are not compromised by adverse health impacts.[225]

Further reductions in PM concentrations in the EU, beyond those required to achieve compliance with current air quality standards, will require reductions in background concentrations. This requires co-ordinated national and/or transboundary action on primary PM and on precursors. The lack of a primary $PM_{2.5}$ ceiling in the NECD, and of new stricter ceilings for PM precursors resulted in inadequate reductions in this regard. Also, the AAQD provisions on transboundary pollution problems (Art 25) are rarely used, and when used, ineffective.[226]

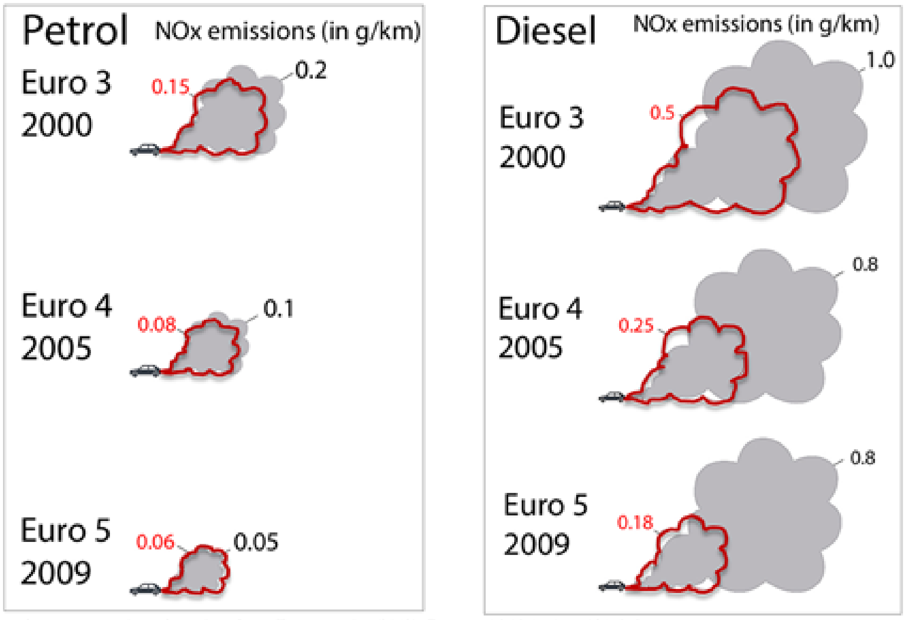
Nitrogen Dioxide (NO_2)

Type-approval emission requirements for motor vehicles have been tightened significantly through the introduction and subsequent revision of Euro standards. Figure 8 shows, however, that while

226 Few cases are known; DE made contacts with PL, and PL and CZ have had some contacts.

vehicles in general have delivered substantial emission reductions across the range of regulated pollutants, this is not true of NO_x emissions from diesel engines (especially light-duty vehicles).

Figure 8: Euro Emission standards and real world emissions for gasoline and diesel vehicles (ICCT, 2012)



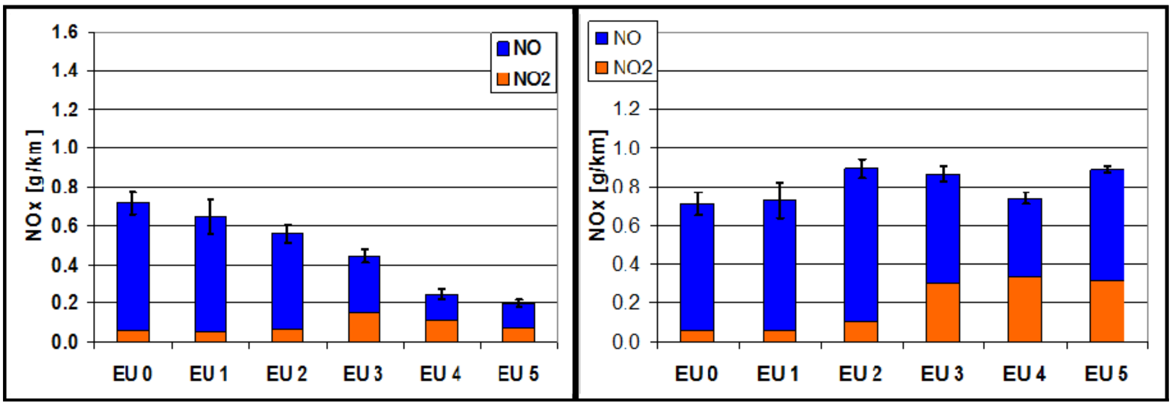
NO_x emissions of gasoline cars in the EU have decreased significantly since 2000, from about 0.2 grams per kilometer (g/km) to 0.05 g/km. This corresponds quite well with the Euro emission limits, which were adapted from 0.15 g/km to 0.06 g/km in the same time period. The Euro emission limits regulate how much specific pollutants, such as NO_x, may be emitted by a car when it is tested under laboratory conditions and using a specific driving cycle. In the case of gasoline vehicles, the NO_x emissions measured in the laboratory are fairly well in line with the level of emissions measured on-road, i.e., when driving the car under real-world conditions on a real road. This, however, is not the case for diesel cars. Diesel vehicles in the EU are allowed a much higher NOx emission level than gasoline cars. In 2000, when the Euro 3 standard was introduced, the allowed level was 0.5 g/km, more than twice as much as for gasoline vehicles. Yet, as vehicle tests show, even back then the real on-road emission levels were closer to 1.0 g/km, i.e., much more than actually allowed by the standard. Still, the vehicles received their type-approval and could be sold, as the Euro emission standards have to be met under laboratory conditions only. Over time, emission limits got stricter, and the current Euro 5 emission standard sets a limit of 0.18 g/km for NO_x diesel emissions. This is still more than three times as high as for gasoline vehicles, but of course much lower than back in 2000. However, research suggests that the on-road emissions did not really change at all during the last decade. The values measured are in the range of 0.8 g/km, only 20% lower than in 2000 and more than four times higher than allowed by the Euro 5 emission limit.[227]

[227] See for example the study carried out on on-road emission data from a by King's College London and the University of Leeds for the UK government. In total, emissions data from more than 80,000 vehicles were

The problem is due in part to the poor representativeness of the standardised test cycle used for type approval in the EU[228] and weaknesses of in-service conformity testing. Under the current regime an engine type has to meet the type-approval requirements when tested according to the test cycle, but under normal driving conditions the real emissions can be much higher.

Figure 9 shows that while the NOx emission limit values for diesel passenger cars have been tightened by approximately a factor of 4 from 1993 to 2009 (Euro 1 to Euro 5), the estimated average NOx emissions in real driving conditions have slightly increased. As a side-effect of engine technology developments, the share of direct NO_2 emissions in the NOx mixture has increased at the same time, posing additional challenges for the attainment of the NO_2 air quality standards.

Figure 9: type approval (left) and real-world emissions (right) from diesel light duty vehicles across Euro standards (source: COPERT analysis and IIASA[229])



While this has been observed for several years, many Member States continue to promote the sale and use of diesel vehicles compared to gasoline and other cleaner fuel vehicles. The consequences of the less than hoped for effects of the vehicle standards relating to diesel passenger cars and light-duty vehicles have been exacerbated by national taxation policies favouring diesels and increasing traffic volumes in urban areas (see also governance issues)[230].

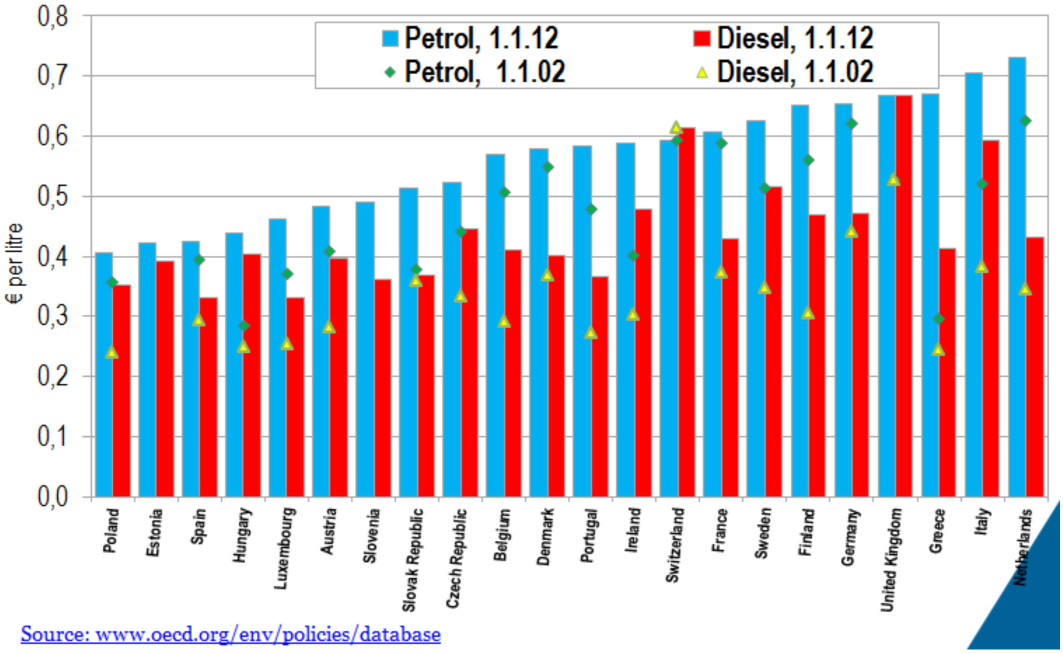
analyzed, and the authors conclude: "In the case of light duty diesel vehicles it is found that NO_x emissions have changed little over 20 years or so over a period when the proportion of directly emitted NO_2 has increased substantially".

228 The New European Driving Cycle (NEDC).

229 https://circabc.europa.eu/sd/d/2f169597-2413-44e2-a42c-35bbbde6c315/TSAP-TRANSPORT-v2-20121128.pdf

230 See also OECD, 2013

Figure 10: Fuel tax rate comparisons in the EU and CH in 2002 and 2012 (OECD, 2012)



Sustained high levels of NO_x emissions and NO_2 concentrations are particularly related to these emissions and the associated AAQD and NECD compliance issues.

Ground-level ozone

For ground-level ozone, there has been significant reduction in ozone precursor emissions since 1990, and this has been mirrored by a general trend towards lower peak values for severe ozone episodes.[231] However, there is no corresponding downward trend in background concentrations.[232] A significant part of this discrepancy is likely to be due to hemispheric transport of ozone which is substantially influenced by methane emissions across the northern hemisphere (methane has a long atmospheric lifetime and influences ozone concentrations at substantial distances from the point of emission).[233]

Poly-Aromatic Hydrocarbons and BaP

For BaP the exceedance is largely due to domestic biomass combustion and thus is linked to the drivers of PM exceedances.[234]

4.5. Efficiency

In addition to the above pollutant- specific drivers of non-compliance, several governance related problems that affected the efficiency of the AAQD emerged from the review.

231 See 'Services to assess the reasons for non-compliance with the ozone target values set by Directive 2008/50', Ecorys 2013, pp15-19. See also the EEA's annual ozone report on http://www.eea.europa.eu/publications/air-pollution-by-ozone-across-EU-2012.

232 Ibid.

233 EEA report 4/2012, 'Air Quality in Europe – 2012 report', p11.

234 Ibid p14 and Chapter 8.

The AAQD works through the development of action plans at local and regional level designed to achieve compliance with the concentration limits by the relevant deadlines.[235] This reflects the "subsidiarity" principle, i.e. that action should be left to the Member States where it is most cost-effective do so.

In practice, many Member States have relied substantially on EU source control measures whilst evidence from the time extension notification[236] process under the AAQD 2008/50/EC shows that authorities often acted late in relation to the lead time necessary to bring air pollution down in "local" hotspots, with many plans and programmes developed only as the compliance deadlines approached and not fully implemented in practice. [237] In many cases responsibility for meeting ambient air quality standards rests at regional and/or local level, but the financial and other tools to meet those responsibilities are often lacking.

Late or insufficient action often relates to the fact that local action was not sufficiently supported by action in surrounding zones or at the national level, or in some cases between Member States to address transboundary pollution.[238]

Part of the problem is also related to the lack of the assessment and management capacity to develop, implement and monitor plans. For instance, local authorities have been unable to design effective air quality plans because no adequate inventories of the contributing local sources have ever been developed. In some cases, capacity has been further reduced in the wake of the economic crisis, including at the national level.[239]

The efficiency of the Directive 2008/50/EC in driving local action has nevertheless improved over time, as effort on enforcement at EU level has intensified. As a result, good practices have been emerging (see also section 7).

5. THE NATIONAL EMISSION CEILINGS DIRECTIVE

5.1. Objectives, scope and approach

The National Emission Ceilings Directive 2001/81/EC aims at controlling transboundary fluxes of air pollution for the purpose of meeting in a cost-effective way, air pollution impact objectives for acidification, eutrophication and the health and environmental impacts of ozone. It does so by setting ceilings on total national emissions of four pollutants (SO_2, NO_x, non-methane VOCs and NH_3) which are to be complied with by 2010 and thereafter.

The NECD covers all emission sources on the territory that constitute the national totals. They include all land-based sources and inland waterway and national maritime navigation, but the large emissions

[235] For more detail see EEA report 7/2013, ‘Air Implementation Pilot’, p37.

[236] The possibility under Directive 2008/50/EC (Article 22) for Member States to notify a postponement of the attainment deadlines for particulate matter (PM10), nitrogen dioxide and benzene, under certain conditions and subject to approval by the Commission.

[237] Internal assessment based on analysis of Time Extension Notifications.

[239] From exchange of views with national and local competent authorities.

associated with international maritime traffic are excluded.[240] Aviation emissions are included only for the relatively minor shares associated with the take-off and landing phases, while the larger emissions occurring during cruise are excluded.

The 2005 TSAP announced a revision of the NECD to set new ceilings for 2020 in line with the objectives set in the Strategy for those pollutants already regulated, plus primary particulate matter ($PM_{2.5}$) which is not regulated in Directive 2001/81/EC. The proposal for revision was finalised by the Commission services in 2008, but not adopted by the College.

5.2. Monitoring and Evaluation

The Directive requires Member States to calculate and report emission inventories and projected emissions for 2010 according to the methodologies specified under the LRTAP Convention. Reports were to include emission projections for 2010 including information to enable a quantitative understanding of the key socioeconomic assumptions used in their preparation.

The EEA annually establishes compiled emission inventories and projections on the basis of information reported by Member States. The information is publicly disseminated on the EEA's website both as data files, core environmental indicators and in online data viewers.[241] In addition, the EEA annually publishes technical reports including its assessment of the progress being made towards the implementation of the NEC Directive. [242]

5.3. Relevance

A review of evidence has confirmed the continued importance of ozone impacts, and ecosystem impacts from eutrophication and acidification, among the problems caused by air pollution,[243] and as commented above for the TSAP, successive reviews of the science underlying those problems have confirmed that the pollutants addressed in the NECD are indeed main problem drivers.[244] The approach of the NECD, to cap transboundary flows of air pollution by setting national ceilings, remains relevant to address the continuing evidence that very substantial proportions of pollution concentrations in many Member States are due to transboundary pollution[245], and to bring down the background concentrations that affect the prospects of achieving the ambient air quality standards. [246]

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240 To be precise, they are excluded from the emission ceilings, although not from the obligation to establish inventories.

241 http://www.eea.europa.eu/data-and-maps/data/data-viewers/emissions-nec-directive-viewer and http://www.eea.europa.eu/data-and-maps/indicators/#c5=agriculture&c7=all&c0=10&b_start=0.

242 See 2012 report on http://www.eea.europa.eu/publications/nec-directive-status-report-2012/at_download/file.

243 WHO Review of Evidence on Health Aspects of Air Pollution, 2013. Available on http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/publications/2013/review-of-evidence-on-health-aspects-of-air-pollution-revihaap-project-final-technical-report.

244 For an in-depth assessment of eutrophication and its underlying causes see *the European Nitrogen Assessment: Sources, Effects and Policy Perspectives*, Sutton, M A et al, Cambridge University Press 2011; for an in-depth assessment of the health impacts of air pollution and their underlying causes see the *Review of Evidence on the Health Aspects of Air Pollution,* WHO/Europe 2013 (see above or Annex 1 for ref.)

245 See EMEP country reports, 'Transboundary air pollution by main pollutants (S, N, O3) and PM in 2010' showing the extent of transboundary contributions to concentrations of those pollutants in all CLRTAP parties (including all Member States). All reports are available on http://www.emep.int/mscw/mscw_publications.html; see for instance p19 of the Belgium country report for 2010 for the transboundary contribution to PM2.5 in BE (around 80%). BE report available on

However, the 2001 NECD does not explicitly address the health impacts of particulate matter, which was identified by the 2005 TSAP as the major health problem from air pollution in the EU (and confirmed as such by the current analysis).[247] While all pollutants regulated under the NECD are PM precursors, and so NECD reductions will influence PM concentration levels, the level of the ceilings in question was not determined on the basis of the required reductions in PM. Furthermore, the NECD includes no emission ceiling for primary particles. Such a ceiling was scheduled for introduction in the 2008 revision, along with tightening of the other ceilings for 2020.

A further issue is whether and how to regulate air pollutants which are also Short-Lived Climate Pollutants (black carbon and methane) under the NECD. For technical reasons[248] a separate ceiling for black carbon is currently not appropriate, but special attention to measures to limit black carbon emissions when designing national programmes for PM2.5 compliance, as agreed in the amended Gothenburg Protocol, would be sensible. Hemispheric methane emissions are a determining factor for background ozone concentrations, in addition to their climate forcing role.[249]

Thus there is a need to amend the NECD for the purpose of transposing the international obligations agreed under the Gothenburg Protocol of the LRTAP Convention, and also a case for considering an additional ceiling related to methane.

5.4. Effectiveness

The emissions ceilings have broadly been attained. Member States (EU27) reported for 2010 emissions breaches for in total 17 of the 108 ceilings, and the EU-wide emission ceilings (a combination of all Member States ceilings) were reached, except for a relatively limited exceedence of the NOx ceiling. Green bars and negative figures signify overachievement of the emission reduction objective; orange bars and positive figures signify exceedances.

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http://www.emep.int/publ/reports/2012/Country_Reports/report_BE.pdf.. For stakeholder comments on the importance of regulating transboundary pollution, see ‘Survey of views of stakeholders, experts and citizens on the review of the EU Air Policy: Part II’, p63.

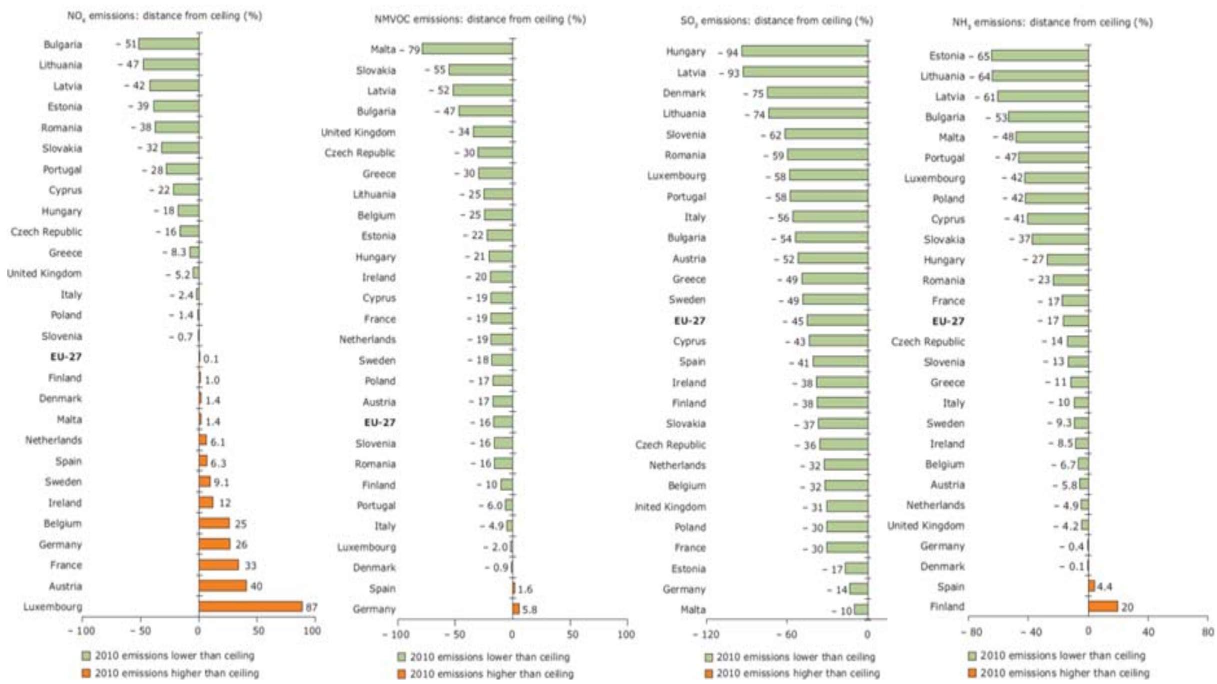
246 See for instance report on ‘PM Workshop Brussels 18-19 June 2012’, pp 5-6, 9,

247 See section 3.2.1 of the main Impact Assessment.

248 The need to introduce an inventory methodology. See report, 'Services to support the update of the EMEP EEA Emission Inventory Guidebook, in particular on methodologies for black carbon emissions', Ecorys 2013.[to appear on the EEA website within short]

249 For the impact of hemispheric methane emissions on ozone concentrations, see the Executive Summary of the LRTAP Task Force on Hemispheric Transport of Air Pollution (HTAP) 2010, p3 point 10 (report available on http://www.htap.org/). For the impact of methane on climate forcing, see the UNEP Synthesis Report, ‘Near-term climate protection and clean air benefits: actions for controlling short lived climate forcers’, UNEP 2011, Chapter 2 p3. Report available on http://www.unep.org/publications/ebooks/slcf/.

Figure 11: NECD Compliance Picture Related to 2010 Member State Obligations (EEA, 2012)



The extent to which action was driven specifically by the NECD varies by pollutant. This discussed in the section below dealing with source control measures.

The non-compliance issue is much smaller than for the AAQD. It relates mainly to the NOx ceilings, where nine Member States reported 2010 emissions that were above the ceilings.[250] In most cases, the less than expected emission reductions of the Euro standards for diesel vehicle NOx emissions have contributed to this situation.[251] The Commission launched a contract to identify the reasons for non-compliance with the ceilings. It concluded that for the vast majority of non-compliance cases, compliance could be achieved in a reasonable timescale with the appropriate effort from the Member States.[252]

The main message from the stakeholder consultation was that the NEC Directive is an effective instrument to bring down transboundary emissions, especially if the ceilings are supported by source legislation at European level, where cost-effective, and by identifying those national source controls which should contribute substantially towards achievement of the ceilings.[253]

As well as the NECD annual status report, the EEA produced a review of the overall achievements of the NECD in 2012 (the emissions data for the compliance year 2010 was available).[254] In performing an assessment of the progress made by the Directive in reducing harm caused by air pollution, the

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250 In 2011 only 8 MSs are in breach, and the number of ceilings breached is lower than in 2010 (down to 11, from 17). See EEA 2012 report, op. cit.

251 Ref to IIASA report indicating how compliance with NEC ceilings depends on Euro emissions.

252 Specific contract, 'Services to assess the reasons for non-compliance with the emissions ceilings set in the National Emissions Ceilings Directive'. Final report pending; will be published on the review website http://ec.europa.eu/environment/air/review_air_policy.htm.

253 See 'Survey of views of stakeholders, experts and citizens on the review of the EU air policy Part II', p80 point 3.

254 See EEA report No 14/2012, 'Evaluation of progress under the EU National Emission Ceilings Directive', available on http://www.eea.europa.eu/publications/evaluation-progress-nec-2012.

EEA took account of advances in scientific knowledge since the Directive's adoption in 2001, such as updates in emission inventories, improvements in dispersion modeling (including a finer resolution), and refinements of the critical load thresholds needed to protect ecosystems from harm.[255] It did so by employing two approaches in assessing the progress achieved toward meeting the interim environmental objectives: one assuming the science available at the time of adoption; the other using current science. The report concluded that in some cases the emission reductions achieved under the NECD have been insufficient to reach the Directive's environmental objectives, because the reductions estimated on the basis of the science of 1999 underestimated the reductions that were actually needed.[256] However, the NECD had been broadly successful in its own terms, in that the reductions and objectives agreed in 2001 had been broadly achieved in practice.

5.5. Efficiency

The NECD requires that Member States draw up and implement national programmes to meet the emission ceilings, which should be revised if projections show that the ceilings are unlikely to be met. An ex-post review of the efficiency of the national programmes[257] showed that:

- the programme design was often suboptimal and in some cases the national measures were inadequate to meet the ceilings.
- the structure and organisation for the preparation of programs varied across the Member States although the Commission services had prepared recommendations and guidance for that purpose[258] and did often not secure public participation in the process nor a commitment of the national governments to implement the proposed measures.
- the reporting from the Member States on their programs was incoherent and did not allow an effective review of the programs at the EU level to secure that the environmental and health objectives were met by the target year 2010. [259]

With regard to the assessment framework, the inventories used for assessing compliance were highlighted as an issue. Reporting obligations are inconsistent with international requirements, but also the quality of the inventories requires improvement.

Two key reasons for the quality issues are:

Limited inventory review process and resources allocated. The effort on inventory review for the NECD has been limited and depends on the reviews by the LRTAP Convention. Resources are limited also because there are no provisions in the NECD for a detailed in depth inventory review. Nor are there provisions for following through adverse findings by Commission (and EEA). Active engagement with Member States would be needed to develop solutions based on training, capacity building, technical assistance programmes etc. Finally, there is no possibility to sanction incompleteness such as a provision authorising the Commission/EEA to complete any missing submissions for particular sectors or regions. (Such a provision has proven in the context of greenhouse gas reporting to offer a strong incentive for Member States to provide their own data.)

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255 Ibid., pp5-6 and Chapter 2.

256 Ibid., pp7-10..

257 Report, 'National Emission Ceilings Directive Review Task 1: In-depth analysis of the NEC national programmes', Entec UK, 2005. Available at: http://ec.europa.eu/environment/air/pollutants/pdf/final_report.pdf.

258 See http://ec.europa.eu/environment/air/pdf/recs_national_programmes.pdf

259 See summary report of above Task 1 (and the other review tasks): 'National Emission Ceilings Directive Review: Project Summary and Conclusions', Entec 2005, pp6-7. Available at: http://ec.europa.eu/environment/air/pollutants/pdf/recs.pdf.

- *Limited guidance for developing local emission inventories.* The Air Implementation Pilot[260] demonstrated the need for guidance to address the present situation where local emission inventories are developed independently from national emission inventories. The lack of detailed local emission inventories has caused delays in developing appropriate air pollution management programmes (e.g. for measures reducing pollution from domestic heating) whilst hampering comparison and exchange of good practice across local authorities.

The second point on the assessment regime is that there is currently no legal basis requiring systematic monitoring in the EU of the ecosystem impacts of air pollution. Again this is inconsistent with international obligations, and it compromises the prospects for any review of the environmental effectiveness of EU and international policy.

6. EU SOURCE CONTROL MEASURES

6.1. Objectives, scope and approach

As stated above, the principle of the AAQDs and NECD is that while the EU should set the standards and ceilings, Member States are best placed to determine the pollution reduction measures needed to achieve them. However, source control measures at EU level are an essential reinforcement to the ceilings and standards in two respects. First, emissions from products placed on the common EU market contribute substantially to air pollution problems and these must be regulated at EU level (e.g. light- and heavy-duty road transport, non-road mobile machinery, etc). Second, for a range of other pollution sources the co-legislators have determined also that control of emissions at source at EU level is appropriate (for instance the Directives recently consolidated into the Industrial Emissions Directive 2010/75/EU). There is now a substantial *acquis* of source control legislation in the fields of transport, energy, industrial emissions and (to a much lesser extent) agriculture. A (non-exhaustive) list of relevant source controls is provided in Appendix 5.

The approach taken in this review was to assess the effectiveness of the source legislation in controlling emissions relevant to the achievement of the air policy objectives, and in particular to assess progress against the proposals of the 2005 TSAP regarding source legislation (see next section). A detailed review of the success of each instrument in its own terms is beyond the scope of this exercise: source policies normally have objectives which go beyond the reduction of air pollution and a comprehensive review would normally be carried out when the source policy itself was reviewed.[261]

Although we have assessed the financial impact by sector of implementation of the *acquis*, both historically and projected to 2030 (see Table 41 below), we have not assessed the cumulative impact on particular sectors of the air quality policy in combination with other environmental policies. That is also beyond the scope of this exercise, and would normally be taken up in 'fitness check' exercises for individual sectors.

With regard to source controls, the 2005 TSAP proposed:

- for industrial installations, to examine options to streamline existing legislation. This resulted in the Industrial Emissions Directive (IED) adopted in 2010 which consolidated seven Directives;

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260 Reference: http://www.eea.europa.eu/publications/air-implementation-pilot-2013

261 See for instance the Impact Assessment accompanying the proposal for an Industrial Emissions Directive, SEC(2007)1679.

- for smaller combustion plants, to examine a lower threshold (below 50 MW thermal input) for combustion installations under the IPPC directive, harmonisation of technical standards for domestic heating and fuels (Ecodesign Directive), and energy efficiency for buildings (Energy Performance of Buildings Directive and the Energy Efficiency Directive);
- for transport, additional pollution controls for car and truck emissions (Euro 5 and Euro VI), and a range of transport initiatives which were later reflected in the 2011 Transport White Paper (proposals on infrastructure charging, guidance on externalities charging, green procurement, etc.);
- for VOC management for petrol stations, so-called Stage II petrol vapour recovery controls (Directive 2009/126/EC);
- for international shipping, a request for a mandate to negotiate tighter shipping fuel and emission standards at the IMO / MARPOL level, which resulted in the recent revision of the Sulphur Content of Fuel Directive (Directive 2012/33/EU);
- for energy, no measures were proposed beyond already planned Commission initiatives (indicative Renewable Energy targets and minimum targets for the share of biofuels);
- for agriculture, an integrated approach to nitrogen management, which has so far not been adopted; the potential positive impacts from the 2003 CAP reform and the Rural Development Regulation 2007-13 were also highlighted;
- for EU funding, promotion of the available possibilities in the Cohesion Policy 2007-13, principally measures to support sustainable transport and energy; and
- international initiatives within the UNECE LRTAP Convention on hemispheric transport of air pollution which culminated in the revision of the Gothenburg Protocol in May 2012.

6.2. Monitoring, reporting and evaluation

Monitoring, reporting, and evaluation provisions for EU source controls are defined and carried out in accordance with the provisions applying to the individual instruments. In addition, however, periodic assessments are undertaken by the EEA which also maintains a set of sustainability indicators tracking the contribution of key sectors such as transport and energy to air pollution in the EU.

6.3. Relevance

As an indicator of the extent to which source legislation has contributed towards the total emission reductions required by air policy, Table 7 below summarizes the contribution of EU versus national source legislation towards compliance with the NECD ceilings for the four regulated pollutants. [262]

Table 7: EU versus National actions driving compliance with the NECD

Pollutant	Main drivers of action
SO_2	Action was driven mainly by emission control measures for large combustion plans, mainly in the Large Combustion Plants Directive 2001/80/EC (LCPD), the application of Best Available Techniques (BAT) in accordance with the IPPC Directive 2008/1/EC, the Sulphur Content of Liquid Fuels Directive 99/32/EC and the Fuel Quality Directive 98/70/EC.
NO_x	Action was driven in roughly equal proportions by: - the LCPD and the IPPC Directive

[262] Assessment by DG ENV based on the EEA SOER 2010 Air Thematic report pp31-37 (available on http://www.eea.europa.eu/soer/europe/air-pollution) and the EEA report 14/2012 on evaluation of progress under the NECD (http://www.eea.europa.eu/publications/evaluation-progress-nec-2012). See also the two reports 'Review and evaluation of national programmes 2002' (Entec UK 2005), and, 'Review and evaluation of national programmes 2006', AEA Energy and Environment, 2008). Available on http://ec.europa.eu/environment/air/pollutants/rev_nec_dir.htm.

	- the Euro vehicle standards - national and local action in NECD national programmes
NMVOCs	Action was driven largely by the Solvents Directive 1999/13/EC, the Paints Directive 2004/42/EC and the Petrol Vapour Recovery I (94/63/EC), and the IPPC Directive, and by EU and national labelling schemes to reduce VOC content in household products. At the national level, action on limiting use of solvents for in small and medium size enterprises was particularly important.
NH_3	The IPPC (for large scale pigs and poultry farms) and the Nitrates Directive (indirect effects e.g. due to thresholds for manure spreading) plus complementary national action going beyond the minimum requirement of the IED (scope and manure management), in particular aiming at meeting the NECD NH_3 ceilings.

The principal industrial, agro-industrial and power sector emissions contributing to air quality are regulated through the IPPC Directive 2008/1/EC[263] and the accompanying "sectoral" directives. From January 2014, these directives[264] will be replaced by the Industrial Emissions Directive 2010/75/EU (IED), which will tighten the requirements to apply Best Available Techniques (BAT) and set more stringent emission limits for large combustion plants.

Emissions from small (< 1 MW) and medium (1-50 MW) combustion plants have so far not been regulated at EU level. Plants under 1 MW capacity can only realistically be controlled through product legislation, which strongly motivates measures at EU level. The forthcoming Ecodesign measures on central heaters (up to 400 kW, including gas and oil boilers, the so-called Lot1), solid fuel central heaters (up to 1 MW, fueled by biomass or coal, Lot 15) and local room heaters (up to 50 kW, including appliances fired by gas, oil, biomass and coal, Lot 20) will partially cover this category. These Ecodesign measures do not address industrial or agricultural applications of such capacity, and it is not yet clear what a possible future Ecodesign measure for industrial ovens and furnaces (Lot 4) would cover. Moreover, Ecodesign requirements only apply to new installations placed on the market and do not cover existing installations so it will in general take about an average appliance lifetime of 15 years before more or less the whole stock complies through replacement. In any case there is a remaining gap in legislative coverage at EU level between 1 and 50 MW capacity, with significant potential for cost-effective emission reduction. An analysis was done on the potential contribution of Ecodesign measures to reduction of air pollution and the conclusions thereof are integrated into the main impact assessment.[265]

For road transport the main pollutant emissions relevant for air quality are in principle controlled by the EU legislation. [266] For Non-Road Mobile Machinery (NRMM) Directive the priority pollutants are addressed but there are gaps in the scope of the legislation which are being addressed in the

263 Codified version; originally 96/61/EC.

264 With the exception of the Large Combustion Plants Directive, which is repealed from January 2016.

265 TSAP report #5, 'Emissions from households and other small combustion sources and their reduction potential', IIASA 2012.

266 Regulation 715/2007/EC for light passenger and commercial vehicles; and Regulation 595/2009/EC for heavy duty vehicles.

current revision.[267] For inland waterway transport, the principal air emissions are not effectively taken into account by the NRMM Directive. The directive still allows for high PM and NO_x emissions, the impact of which is worsened by the long life span of the engines (up to 40 years). These ships are often navigating in near-urban areas and close to highly trafficked roads, adding to road pollution. The same reasoning holds for diesel trains, railcars and locomotives.

For international shipping, regulation proceeds through emission controls agreed at IMO which are then implemented at EU level. EU legislation to date has focused on implementing the internationally agreed provisions on sulphur content of liquid fuels; but IMO provisions on emissions of nitrogen oxides and particulate matter are also important and have not been addressed in the EU.[268]

Ammonia emissions decreased by less than 10% from 2000-2010 and are projected to remain at today's levels to 2020 and beyond. Agriculture is responsible for 90% of the burden and is the primary driver of eutrophication in Europe.[269] There is little EU source control of agricultural air emissions. The IED covers 20% of pig production, 60% of poultry and excludes cattle and other animals. The Nitrates Directive covers pollution to air only indirectly. Moreover, there is large variation in Member State controls, ranging from practically nothing to extensive national regulation. There is a large untapped potential to achieve significant and cost-effective emission reductions (around 30% for 2025), and many of the measures bring benefits to farmers, as they improve overall nitrogen efficiency and creates a playing level field for actors in agriculture. Many will also have climate co-benefits, by reducing nitrous oxide emissions (N_2O), a powerful greenhouse gas.[270]

6.4. Effectiveness

For large industrial installations, which still account for a considerable share of total emissions, the IPPC Directive and in particular the "sectoral" directives on large combustion plants, waste incineration and VOC emissions due to solvents use have successfully reduced emissions from the main polluting industries.[271] The implementation of the IED, in particular for large combustion plants, will contribute substantially to further reductions.

For road transport, Euro 5 (passenger cars and light duty vehicles) and Euro VI (heavy duty vehicles) emission requirements were implemented as scheduled in the type approval legislation for motor vehicles, with the European Parliament adding Euro 6 and VI in negotiations. The Euro standards have proved successful in reducing real-world emissions of particulate matter from road transport in line with the legislation. For petrol vehicles the same is true for NO_x emissions, but for diesel vehicles, real-world NO_x emissions are substantially higher than the limit values specified in the type

267 See website on review of Directive 97/68/EC on http://ec.europa.eu/enterprise/sectors/mechanical/non-road-mobile-machinery/publications-studies/index_en.htm

268 See report, 'Specific evaluation of emissions from shipping including assessment for the establishment of possible new emission control areas in European Seas', VITO 2013, pp5-7.

269 TSAP report #3, 'Emissions from agriculture and their control potentials', Chapter 5 pp31-34.

270 Ibid., pp24-26.

271 See impact assessment for proposal for an Industrial Emissions Directive, SEC(2007)1679 (op. cit.).

approval legislation.[272] As indicated in the previous sections, this is a major factor contributing to non-compliance with the NO_2 ambient air quality limit value and the NO_x national emission ceiling.

Directive 1999/32/EC on Sulphur Content of Fuels has reduced emissions of sulphur from shipping as expected. The recent modification by Directive 2012/33/EU fulfils a TSAP commitment and will substantially further reduce the levels of secondary PM in the EU. [273]

The existing EU source legislation on air pollution emissions from agriculture is very limited in scope. While the NECD ceiling on ammonia has been reached for most Member States, and work has been done to implement the IPPC and the Nitrates Directives, these instruments have been weak to provide significant emission reductions from agriculture as a whole. Emissions of ammonia from agriculture have decreased by about 30 % from 1990 (and by 11% from 1999 to 2009), but this is less an effect of environmental policy measures than of structural changes in the sector, in particular a reduction in livestock numbers (especially cattle). To some extent it is also an effect of changes in the management of organic manures and from the decreased use of nitrogen mineral fertilisers, but it is unclear to what extent these changes have been policy-driven.

The 2008 climate and energy package was brought forward and agreed after the TSAP, but contributes substantially to air pollution reduction. The exception is the use of biomass in small and medium combustion installations, where the potential negative impact on air quality may be substantial and careful management will be needed.

Other relevant source measures outlined in the TSAP were either not proposed (integrated nitrogen management), rejected by Council (reduction of the IED threshold to 20 MW for combustion plants) or are yet to be fully implemented (Stage II vapour recovery).

Reasons for failure

The main areas of failure that are relevant for the achievement of the air quality objectives are the failure to control real world emissions from passenger cars and light duty diesels; the lack of effective regulation of ammonia emissions from agriculture; and the failure to control combustion from installations below $50MW_{th}$ capacity .[274] The reasons for each of these failures are considered in turn below.

(i) Real world emissions from diesel vehicles

As discussed already above, the main reason for failure of the Euro standards to control real world emissions of NO_x from diesels is the test cycle for both type approval and in service compliance, which does not reflect emissions in normal driving conditions. [275] This problem has been addressed

https://circabc.europa.eu/sd/d/2f169597-2413-44e2-a42c-35bbbde6c315/TSAP-TRANSPORT-v2-20121128.pdf

. See the impact assessment for the review of Directive 1999/32/EC, SEC(2011)919, pp6-7.

274 IIASA 2013 demonstrates that these are the most significant impacts on outstanding air pollution problems.

275 https://circabc.europa.eu/sd/d/2f169597-2413-44e2-a42c-35bbbde6c315/TSAP-TRANSPORT-v2-20121128.pdf

for new heavy duty vehicles, but tackling it for diesel passenger cars and light duty vehicles in the implementation of Euro 6 is a major outstanding issue for the transport sector. Where feasible, retrofit of vehicles already placed on the market should be considered. (This is mainly applicable to municipal vehicles and transport vehicles, such as captive fleets, which make intra-urban trips. For all these vehicles, deployment of cleaner alternative fuels is also to be considered.)[276]

(ii) Lack of effective regulation of ammonia emissions from agriculture

The initiative on integrated nitrogen management proposed in the TSAP has not yet materialised, in particular due to uncertainties as to how such an initiative would impacts on the implementation of existing legislation such as the Nitrates Directive, and the time and effort needed to agree to a regulatory approach to integrated nitrogen management at EU level. As to the reasons for the lack of effective EU control of agriculture emissions to date, the main ones have been identified as follows:

- A relatively low priority has historically been given to NH_3 compared with other air pollutants. Policy has historically been driven mainly by health concerns and has focused on pollutants posing a more immediate threat (in particular SO_2 and NO_x). As these emissions have drastically reduced, the relative importance of ammonia emissions has increased both in terms of contributing to increased levels of PM2.5 and for eutrophication, the major outstanding ecosystem issue.

- The Gothenburg Protocol and the 2010 NECD ceilings are, therefore, not particularly challenging. Most MS are well below the ceilings, even without putting additional measures in place.

- More generally, ammonia emissions have been given low priority in the context of EU's general environmental legal framework, where the focus with regard to agriculture has been on water protection (e.g. through the Nitrates Directive and the Water Framework Directive), pesticide use, and biodiversity protection (land management). While these environmental problems remain very challenging, the ecosystem impacts of air pollution are increasingly significant.

- The CAP framework did not list ammonia among the core measures eligible for support, nor subject to cross-compliance requirements. Instead, priority was given to other agri-environmental issues, such as water protection or biodiversity. This has been mitigated recently by the addition of ammonia to the focus areas of the Rural Development Programme in the recent CAP agreement.

Thus until now, there has been very little interest in developing EU source legislation to address ammonia emissions, the problem being largely left to Member States to regulate, with the consequent implications for the conditions of competition in the sector. In the air policy review, calls have been made from many stakeholders to regulate ammonia emissions at EU level to support the achievement of the ammonia reduction commitments in the NECD. [277]

(iii) Failure to control combustion from installations below 50MW

The proposed extension of the IED scope by lowering the combustion threshold down to 20MW was rejected in co-decision, mainly because of concerns regarding the administrative burden of imposing the IED permitting regime in that capacity range.

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276 See, 'Review of the Air Quality Directive and the 4th Daughter Directive', op. cit. pp56-57.

277 See, 'Report on the consultation of options for revision of the EU Thematic Strategy on Air Pollution and related policies', op. cit., p61.

6.5. Efficiency

Table 8 below summarizes the estimated implementation costs related to current EU air pollution control measures. It shows the extent to which EU air pollution controls have focused primarily on large sources, notably road transport and industrial emissions including energy production in large combustion installation. It also shows that existing legislation is still set to yield further reductions (and therefore also costs).

Table 8: Estimated air pollution control costs associated with current legislation (EU28)

	2005	2010	2015	2020
Power generation	12496	12700	12093	10711
Domestic combustion	5957	7476	9115	9629
Industrial combustion	2180	2435	2468	2521
Industrial Processes	4471	4760	4983	5029
Fuel extraction	1096	976	907	770
Solvent use	756	1638	1964	2140
Road transport	18663	26022	34357	42023
Non-road machinery	980	1892	4320	6975
Waste	0	0	1	1
Agriculture	1094	1750	1775	1786
Sum	47694	59650	71983	81584

As indicated above, it is beyond the scope of this review to assess the efficiency with which each source control instrument achieves its objectives. However, the following comments can be made.

For industrial emissions, emissions from road transport and emissions from non-road mobile machinery, there is no obviously more efficient way than the chosen source controls to achieve the desired emission reductions. However, for combustion plants below 50MW, it may indeed be possible to regulate with a lighter permitting regime than that of the IED.

For agriculture, an integrated approach to nitrogen management would be the most efficient way to regulate emissions,[278] but for reasons explained above this option may not currently be practicable. However, the analysis shows that there is a strong case for more action at both EU and at national level to reduce ammonia and PM emissions from agriculture, advocated also by other emitting sectors on the grounds that the lack of reductions in agriculture is imposing unreasonable constraints on their emissions.[279]

A range of regulatory and non-regulatory policy options have been assessed and the following identified as promising in consultation with stakeholders:

- Implementing measures for the agriculture sector in the NECD;
- Controls on manure management at EU level;

[278] See 'The European Nitrogen Assessment', op. cit., Chapter 23 (pp541-550).

[279] See, 'Report on the consultation of options for revision of the EU Thematic Strategy on Air Pollution and related policies', op. cit., p62, comments from power and heating, cement and multi-sector business associations.

- Measures to reduce use of urea-based fertilisers (perhaps in the context of the on-going review of the EU Fertilisers Regulation);
- Support for national implementation through the EU Rural Development Programs.

For international shipping, other mechanisms than low-sulphur fuel are potentially more cost-effective to reduce SO_2 emissions, and these alternatives (e.g. scrubbers) are enabled in the recent revision (2012/33/EU). Given the IMO legal framework governing emissions from international shipping, there is no obvious alternative for regulation than implementation of agreed IMO positions. However, international shipping emissions could potentially be brought under national emission ceilings, thus making more explicit the choice between regulating land-based or (through IMO) sea-based sources.[280]

7. NATIONAL AND LOCAL SOURCE CONTROL MEASURES

7.1. Objectives, scope and approach

National and local source controls comprise a large set of measures applied with varying geographical scope ranging from legal instruments to voluntary programs, technical to economic instruments. In principle they cover all measures that Member States can take in areas not regulated at EU level. The range of actions that Member States can undertake is illustrated in the Appendices 4.3 through 4.5.

The terms national and local action are used interchangeably although in practice national measures have most often been related to the implementation of the NECD whilst local measures have been related to the implementation of the AAQD.

National measures triggered by the NECD have focused mostly on SO_2, NO_x, and VOCs (less so on NH_3 due to the relatively generous ceilings). Local action triggered by the AAQD focused on reaching compliance with the legally binding standards for PM and NO_2 in the AAQD.

7.2. Monitoring, Reporting and Evaluation

Several processes have led to enhanced insights on the relevance, effectiveness, efficiency, and coherence of national source controls. These include the monitoring and reporting processes required under the AAQD and NECD, the notifications of derogations/extensions under the AAQD, and the infringement processes.

There are also important lessons learned on the design, implementation, and evaluation of national and local actions from the Air Implementation Pilot, a dedicated urban air quality project conducted jointly by the EEA, the Commission, and 12 EU cities. [281]. (See appendix 4.6).

It is noted that the Commission does not typically assess the effectiveness of individual measures but rather assesses overall policy packages in terms of the ability to reach the binding standards.

7.3. Relevance

Both the NECD and the AAQD set commonly agreed and effect-based air pollution and ambient air quality standards requiring action at source from the Member States. Whilst a significant portfolio of EU source measures has been established over time (see above), national and local action continues to be required. Its relevance continues to be related to the principle of subsidiarity and cost-

[280] See discussion in report, 'Summary report for National Emission Ceilings Review', op. cit., p12.
[281] EEA Report No 7/2013, op. cit.

effectiveness, i.e. national and local action ensures that EU measures remain proportionate and do not lead to higher costs than required taking into account the different situations in the Member States (and urban areas) across the EU.

7.4. Effectiveness

The review yielded a mixed picture with respect to the effectiveness of national and local measures implemented by the Member States. Whilst Member States have revamped their national and local actions to reduce air pollution in the wake of enforcement procedures, their effectiveness is generally insufficient to enable reaching the EU air quality standards (See section 4).

Among the most successful local actions to address PM and NO_2 are: favouring public transport use whilst upgrading public transport fleets (through retrofitting old diesel vehicles with particulate and/or NO_x traps or alternative fuel purchase programmes, increasingly also electric vehicles); establishing access restrictions for the most polluting vehicles (e.g. low emission zones); road pricing and/or parking fee policies reducing traffic and improving traffic flows (thereby improving also the efficiency of catalytic equipment), speed limits on highways passing through high population density areas (also improving the traffic flow), greening taxi fleets, and facilitating cycling and walking. Impacts are increased where modal shifts can reduce short distance trips (representing up to 50% of vehicle use in urban areas), also because the 'light-off' time required for catalytic equipment to reach maximum efficiency is harder to achieve for shorter trips.

Actions have enabled the respective limit values to be met, or the number of zones in exceedance to be reduced, as well as reduction in population exposure. The low emission zone in Berlin, for example, gradually reduced the PM_{10} exceedance area from 27% to 7% between 2008 and 2012 whilst reducing the number of citizens exposed to levels exceeding the EU air quality standard from 21% to 5%. Limiting the maximum speed along the A13 beltway in Rotterdam reduced PM_{10} emissions in the area by between 25 and 35% leading to air quality improvements of 4 $\mu g/m^3$ at 50m from the roadside. The contribution of the highway to the city's overall PM_{10} pollution was reduced by 34%. NO_2 related emission benefits ranged between 15 and 25% leading to air quality improvements of 5µg/m3 at 50 m from the roadside. The contribution of the highway to the city's overall NO_2 air pollution was reduced by 25%. Other benefits yielded by the measure included a 15% CO_2 emission reduction and a 50% reduction in noise levels. In some cases of advanced air quality management, actions focused on reducing PM and NO_2 emissions from diesel equipment on construction sites and other small and medium scale combustion installations.

National actions influencing air quality both positive and negative include fuel and vehicle taxation and/or subsidies, scrappage schemes, public transport infrastructure projects.

National and local actions have been most successful where they were designed and implemented in a well-researched and integrated manner, i.e. based on robust emission inventories containing relevant information for the area under consideration as well as robust air quality models able to integrate the relevant local and regional dimension as well as the meteorological and topographic information in an appropriate manner.

Effective actions has often been hampered by a lack of political will to establish and/or maintain effective actions which in turn could be linked to the often poor capacity to conduct in-depth ex-ante analysis or timely ex-post assessments to help gathering public support. The effectiveness of low emission zones and/or differentiated road pricing systems has been vitiated by the real world emission issue (the lack of reduction in light-duty diesel emissions across successive Euro classes); and by the increasing share of diesel vehicles also promoted through favourable national tax structures. In other cases, traffic related air quality management cases were challenged on the grounds of limiting free movement of goods.

7.5. Main orientations for the future

In addition to the source categories that contribute to the present exceedance situation, a number of issues preventing better compliance have been identified relating to Member State Competent Authorities' technical capacity for assessing and managing air quality as well as general and specific governance issues.

Limited capacity to assess and manage air quality problems and impacts

In general, and with a few notable exceptions, the capacity of competent authorities to assess and manage air quality remains weak and has not been brought to the level required for dealing with the increasingly complex air quality challenges.

Whilst the analysis suggests that there is are no major compliance problems with the minimum criteria set for air quality monitoring and the establishment of national emission inventories as required by the AAQD and NECD, the capacity of competent authorities to use the available information for identifying the major sources contributing to the national and/or local air quality problems and for assessment the cost-effectiveness of abatement strategies and policies is limited, and this has often prevented the development, implementation, and monitoring of cost-effective strategies.

The ***lack of adequate emission inventories at local level*** is a particular problem where national emission inventories may not be representative for the local situation. Missing, under- or over-estimated emission categories may lead to ill-targeted air pollution policies or prevent the development of cost-effective measures all together. This has been a particular problem, for example, for taking timely action on certain important source categories such as domestic heating.

The ***lack of adequate air quality modelling*** (or expert modelling capacity) to assess national air quality and the effectiveness of national and local action is another problem that has been identified. Whilst various forms of air quality models are widely available, there analysis suggested that there is no systematic use made of them (compared for example to the practice in the US). Increased use of dispersion models could help assess the impacts of new sources in the area or the impact of large emission sources outside but upwind of the area. Atmospheric chemistry models can assist in predicting the impacts of air quality management measures taking into account meteorological and topographic conditions. Modelling is typically required also to ensure that trends in "background pollution" are duly taken into account. Many competent authorities have limited or no access to such important contextual information.

The EEA Pilot exercise also suggested that ***cost-effectiveness data and/or assessment tools are generally lacking*** at national and/or local level. Hence, local authorities are often forced to invest a considerable amount of time and resources to obtain such information or, where that is not possible, drive forward policies on a limited knowledge base.

Where competent authorities are well equipped, cost-effectiveness analysis often ignores the transboundary impacts of measures taken (or rejected) at national level.

Governance deficiencies preventing better coherence of air quality and other policies

The technical capacity problems that have contributed to the present state of poor compliance have in many cases been compounded by certain **governance deficiencies** and **poor public information**.

As a general principle, Member States' national governments are accountable for the implementation of EU legislation. In the case of the AAQD, national authorities have often delegated substantial responsibilities to regional and local authorities in line with the determination of air quality zones and agglomerations linked to the assessment and management of the respective air pollutants covered by the Directive. Whilst this is compatible with the air quality legislation, this sub-delegation has often taken place without foreseeing **adequate dialogue to reconcile air quality issues across zones and agglomerations and between the local and national governments**.

In a number of cases, local or competent authorities have been faced with problems that could not be solved adequately without the assistance of the national government. Typical problems have related to managing transport emissions, notably where exceedances were driven by diesel vehicles but national governments maintained tax incentives that promoted these vehicles. Other cases include where local air quality management needs required management of pollution sources outside the boundaries of the local authorities. Governance deficiencies ***also extended to the Member States' interventions at EU level,*** where certain authorities of a Member State argued for stricter EU measures whilst others from the same Member State argued the contrary. Better alignment of positions has proven possible after the Commission made Member States aware of the contradicting positions yet in a number of cases, the lack of detailed information referred to above, prevented Member States from taken fully informed positions.

Similar governance issues emerged with respect to the ***implementation of the NECD***. Contrary to the assessment and management of air quality standards, national emission inventories, projections, and plans and programmes related to the national emission ceilings have been (quite logically) managed at the national level. In doing so, however, little account has been taken of the needs at regional and local level, notably where a substantial part of the air quality exceedances are linked to background pollution. Recent initiatives to bring the NECD and AAQD experts closer together at the level of EU expert group meetings have started to enhance the prospect for more coherence between the management of these instruments.

Efforts from competent authorities and policy makers continue to be hampered by a relatively ***poor understanding of air pollution issues by the general public***. Whilst there is generally good access to air quality data and reports, it remains a challenge for citizens and consumers to take informed decisions considering the state of air pollution in their region and/or the environmental performance of products in relation to air pollution.

8. INTERNATIONAL ACTION TO REDUCE AIR POLLUTION

8.1. Objectives, scope and approach

Pollution sources external to the EU contribute substantially to EU air quality and impacts significantly on human health and the environment. For pollution formed in the atmosphere from precursor emissions (such as secondary particulate matter and ground-level ozone) the influence of long range transport becomes crucial. In particular for ozone, background concentrations in the EU are substantially influenced by ozone production and transport in the entire northern hemisphere.

Hemispheric methane emissions (an important ozone precursor) are a particular driver of the EU ozone background.

Historically, the principal international instrument is the UN Economic Commission for Europe (UNECE) LRTAP Convention, which covers Europe but also includes North America (the USA and Canada).

The Convention has 51 Parties within the region and it has generated a knowledge base on air pollution, its impacts and effective management which continues to provide a solid basis for air policy in the EU and beyond.

The 1999 'Gothenburg' Protocol to the CLRTAP is the most important instrument from the perspective of EU air quality policy, and has recently been revised (2012). It covers all the main pollutants, and sets the agenda for upcoming air quality issues (for instance on Short- Lived Climate Pollutants such as black carbon).

8.2. Monitoring, Evaluation, and Enforcement Provisions

The LRTAP Convention provides for extensive provisions for monitoring of air quality, emissions and policy implementation.

The European Monitoring and Evaluation Programme (EMEP) has the long term objective to provide the Parties with an objective assessment of air pollution emissions, transmission in the atmosphere and the air pollution concentration and deposition over the entire European part of the UNECE region (except North America). The Parties report their emissions and air quality data to the EMEP centres that annually evaluates and provides reports on emissions, air quality and transboundary fluxes of all pollutants covered by the Convention protocols.[282] It conducts method development for inventories and air quality assessment and provides guidance to Parties including the EU on better methods. EMEP thus provides the backbone for the application of EU legislation through methodologies and standards for inventories, projections and air quality assessments, as well as methods inter-comparisons and modelling.

EMEP also plays an increasingly important role in international cooperation beyond the Convention area, in particular in Asia. The EU has therefore jointly with the USA taken the co-lead for the Convention Task Force on Hemispheric Transport of Air Pollution to reinforce the monitoring and evaluation of hemispheric transport of air pollution, including also Short-Lived Climate Pollutants

Work under the Working Group on Effects collects information from the Parties on air pollution effects in order to establish the critical loads and levels for ecosystems, crops, materials and cultural heritage. The collected information under the International Cooperative Programmes is evaluated and annually reported to Parties including the EU[283]. Again the CLRTAP concepts of critical loads and levels are also central in EU legislation and a part of the NECD objectives and the 7th EAP objectives. The air pollution health effects are assessed by the joint CLRTAP/WHO Task Force on Health which systematically collects and reviews air pollution health impacts and provides scientific basis for CLRTAP and EU health impact assessments and cost-benefit analyses.

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282 EMEP main webpage http://www.emep.int/

283 WGE web page http://www.unece.org/env/lrtap/workinggroups/wge/welcome.html

Work under the Working Group on Strategies and Reviews systematically collects information on how Parties have implemented their obligations and the CLRTAP holds now a data basis on the various policies and measures implemented by the Parties to meet their obligations. The 2010 review of policies and measures is currently ongoing and not yet finalised. In addition to the general reviews of policies specific task forces have been reviewing the specific protocols on Heavy Metals and POPs for their effectiveness and sufficiency. The POPs Protocol was revised in 2009 and the Heavy Metals Protocol in 2012.

8.3. Relevance

While the geographical coverage of CLRTAP is appropriate for addressing some European problems (acidification and eutrophication), others such as methane, ozone and particulate matter have a wider geographical perspective, involving emissions from India and China in particular.

Also other international initiatives are worth mentioning in the latter context. The first is the Climate and Clean Air Coalition, which was set up to co-ordinate action of its members on the main Short-Lived Climate Pollutants (SLCPs, methane, ozone and black carbon). The second is the Global Methane Initiative[284] which stimulates international action for methane emission reduction. Finally, the Global Atmospheric Pollution Forum[285] under the auspices of the International Union of Air Pollution and Prevention Associations is raising awareness and advocating action in regions where air pollution management is still weak, such as in South East Asia and Africa.

8.4. Effectiveness

The Gothenburg Protocol

The Gothenburg Protocol presently has 26 Parties, of which 23 are EU or EU Member States. Six EU Member States have not yet ratified. Two more countries have deposited their ratification instrument but their accession needs approval by the current Parties (in December 2013 at the earliest.)

The Protocol played an important role in the pre-accession period for the EU 12, as the obligations in the Protocol largely reflected EU legislation at that time. Whilst the Protocol may have lost some of its added value following EU enlargement (when many CLRTAP Parties joined the EU), it remains an important forum for sharing experience with other Convention Parties, including the Eastern European, Caucasus and Central Asian Countries such as the Russian Federation, Ukraine and Belarus, as well as the US and Canada.

The Protocol was successfully amended in 2012 to strengthen the existing reductions commitments for SO_2, NO_x, NH_3 and VOC and introduce new reduction commitments for $PM_{2.5}$, to be attained from 2020 onwards. The amendment also updated the minimum performance standards for industrial emissions, which are now broadly in line with existing EU legislation. It is also the first Multilateral Environment Agreement to include binding obligations to monitor and abate SLCPs, such as black carbon.

Importantly, the 2012 amendment also allows a flexible approach for new Convention Parties to ratify the Protocol, which improves the prospect of ratification by Eastern European, Caucasus and Central Asian countries (including the Russian Federation). This was a main objective for the EU in the negotiations to amend the Protocol. A broadening of the ratification towards the east will not only

284 http://www.globalmethane.org/gmi/
285 http://www.sei-international.org/gapforum/

yield additional environmental benefits for the EU but also (potentially) a significant market extension for green products. [286]

The Climate and Clean Air Coalition

The Climate and Clean Air Coalition [287] (CCAC) was formed in 2012 to coordinate and extend action on reducing SLCPs such as black carbon, methane and hydrofluorocarbons (HFCs) largely based on the conclusion of the UNEP integrated assessment on black carbon and tropospheric ozone[288]. The CCAC thus aims at supporting fast action to simultaneously improve public health, food and energy security and climate. The focus of the work is to raise awareness of SLCP impacts and mitigation strategies, enhance and develop new national and regional actions, promote best practices and showcase successful efforts, and improve scientific understanding of SLCPs impacts and mitigation strategies. The Coalition has only recently been established, but a number of concrete projects have been initiated, such as action on improving domestic heating and cooking in developing countries, which are beneficial for both indoor and outdoor air quality and climate. The Coalition now comprises 70 countries and organisations, including the European Commission, and is increasing rapidly to become a major player in international action on SLCPs.

8.5. Efficiency

The CLRTAP and in particular the Gothenburg Protocol has been instrumental in the policy development of effective air pollution strategies across Europe. The effects-oriented policy of the Gothenburg Protocol, underpinned by scientific and technical knowledge has been endorsed by the EU and subsequently applied in EU legislation such as the NECD. In particular the scientific work under the European Monitoring and Evaluation Programme (EMEP), including its various science centres and task forces, the Working Group on Effects and the International Cooperative Programmes have provided important cornerstones for the EU in developing and applying a knowledge-based approach for air pollution policy.

The Convention has also provided an important platform to strengthen the wider international coordination on the scientific basis for air pollution and on the exchange of experience and information on best practices. Provided that more countries from Eastern Europe will ratify and implement the amended Protocol, it can potentially deliver significant direct benefits to EU air quality by reducing transboundary air pollution from the East.

9. COHERENCE OF THE OVERALL FRAMEWORK

The aim of the policy framework is to implement an optimized set of measures to reduce air pollution impacts in the EU. In broad terms, that entails (i) controlling the international impacts of our and our neighbouring states' pollution; (ii) bringing down background and transboundary pollution within the EU, and (iii) stimulating complementary action to deal with the regional and local contribution.

9.1. International pollution

The international framework in which EU air policy is embedded has the twin aims of reducing EU pollution impacts on air quality in neighbouring countries, and reducing their impact on EU air quality. The need for such co-ordination is still clear and the scale of the required co-ordination

286 I.e. products with lower environmental impact over the lifecycle compared with other similar products.
287 http://www.unep.org/ccac/
288 http://www.unep.org/publications/contents/pub_details_search.asp?ID=6201

depends on the transport scale for the relevant pollutants. For most pollutants, the effective scale is the EU and its neighbours to the east on the Eurasian landmass, which is covered by CLRTAP.

However for ground-level ozone and some aspects of particulate matter, such as black carbon, the relevant scale is the entire northern hemisphere. North America is included in CLRTAP (the USA and Canada) but effective control will involve extending international co-operation to include also China and India.[289]

In terms of the coherence between international action and EU action, there is a particular issue at the moment arising from the recent revision of the Gothenburg Protocol of the CLRTAP, which must be transposed into EU law.

9.2. Background and transboundary pollution within the EU

With regard to background and transboundary pollution within the EU, the main regulatory control mechanism is a ceiling on emissions of the relevant pollutants per Member State. The ceilings allow substantial discretion to Member States on how to achieve the relevant reductions. While this is legitimate on subsidiarity grounds, there are two caveats. The first is that the framework for meeting the required reductions (emission projections combined with national programmes) was not effectively implemented in practice.[290] If this control mechanism is to be used again, those aspects must be strengthened and and/or modified in order to ensure better effectiveness.

The second caveat is that effective implementation of emission ceilings has been facilitated by EU action on sources.[291] This is true not only of those source categories which can only be regulated at EU level (products), but also of action on other sources where efficient and cost-effective. An example is the support provided by the Large Combustion Plants Directive to the achievement of the sulphur dioxide emission ceilings.

The combination of EU source legislation with national emission ceilings is thus an effective framework to reduce background and transboundary pollution, so long as the individual pieces of legislation are effective.

9.3. Local pollution

The approach to regulating the local contribution to ambient air quality has been to set ambient air quality standards which apply everywhere in the EU, and to allow discretion to national, regional and local authorities to develop the complementary measures (building on background reductions) needed to meet them.

In principle this is a sensible approach, but problems arise where there is insufficient control of background and transboundary pollution. The obligation to meet the ambient standards remains but then local reductions need to carry more of the burden than anticipated.[292] There are also problems where the relevant pollution source is a product. For example, local diesel emissions are the main driver of local NO_2 concentrations; but regulation of emissions is an EU competence, and the taxation

[289] See Executive Summary of Assessment Report of CLRTAP Task Force on Hemispheric Transport of Air Pollution, op cit., p5.
[290] See evaluation of NECD above, section 'Efficiency'.
[291] See Table 14 above.
[292] See 'PM workshop Brussels, 18-19 June 2012', op cit, pp5-6, 9.

policies favouring diesel have often been national. Those tools that are available at the urban level are then strained to the limit.[293]

In addition to this, the compliance approach implemented at national level has often been deficient. As highlighted above for the emission ceilings, so for ambient air quality standards: action plans were often put in place late, without adequate supporting analysis or effective co-ordination.

One further question is whether local action is more effectively driven by ambient air quality standards or by an exposure reduction approach. Both have their merits: the ambient air quality standards ensure a minimum level of air quality for all, while the exposure reduction concept drives reduction even in those areas compliant with limit values, where substantial health problems remain.[294]

9.4. Analytical framework for the Thematic Strategy on Air Pollution

The TSAP was designed to set cost-effective objectives for reduction in air pollution impacts on health and the environment, and to marshal the appropriate combination of measures at local, national and regional, and international level to deliver those objectives. The analytical approach has assured substantial coherence between the various legislative instruments, but improvements are possible as outlined in section 3.5.

10. CONCLUSIONS AND ORIENTATIONS FOR THE REVIEW

10.1. Validity of objectives and scope, and overall coherence

The review has confirmed that the overall structure of air quality policy is logical and coherent. However, a better match must be ensured (in practical implementation) between source controls, ceilings and ambient air quality standards. This is required in particular to ensure that local achievement of ambient air quality standards is not compromised by (a) failure to limit pollution from significant point sources or from products,[295] or (b) high background concentrations resulting from the overall (Member State or transboundary) emission burden. The review examined for each individual policy instrument the extent to which its objectives and scope remain valid:

- For the Thematic Strategy, the underlying analytical framework remains valid for the current review, although some improvements are identified. The impacts identified in 2005 remain the priorities today (with the exception of acidification); an updated review should focus on the scope for further reducing these in the period up to 2030 (beyond which the uncertainties in the analysis become large). It should also focus on greater coherence across the range of policy instruments (including untapped synergies between the AAQD and the NECD).
- For the Ambient Air Quality Directives, the health relevance of the pollutants and standards of the original policy has been reviewed by WHO, and confirmed, with the caveat that the level at which certain standards are currently set (mainly for PM) provides only incomplete protection for human health. As compared with 2005 there is additional evidence on the chronic impacts of ozone and NO_2, which reinforces the rationale for the respective standards.
- The scope and objectives of the NEC Directive are out of line with the latest scientific findings and international agreements. The NECD must be adapted to focus better on health by

293 Ibid.

294 As indicated previously, no more robust conclusion is currently possible on the exposure reduction approach given that the first compliance deadline is 2015. See, 'Review of the Air Quality Directive and the 4th Daughter Directive', op cit, p64 section 4.4.3.

295 For instance the issue of real-world emissions from light-duty diesel vehicles – see section **Error! Reference source not found.** for details.

introducing a ceiling for $PM_{2.5}$, and on short-lived climate pollutants (black carbon and methane) in line with the 2012 amendment of the Gothenburg Protocol. Objectives must be extended to 2020 to fulfil the Gothenburg requirements, and strengthened for the period 2025-30 to deliver further reductions in background pollution to enable levels of air quality that are closer to those recommended by the WHO and CLRTAP .[296]

- For the EU source controls the scope and objectives also remain broadly valid. Updated emissions data and projections confirm that the sectors driving the relevant pollutant emissions were correctly identified. In the short term, the main priority is the full implementation of the existing legislation and in particular the resolution of the real world emissions issue for light duty diesel vehicles. In the longer term the main gaps relate to combustion from small and medium installations, and ammonia emissions from agriculture.
- The scope, objectives, and coherence of international action under the CLRTAP remain relevant to co-ordinate action in the northern hemisphere on the key air quality drivers. The recently amended Gothenburg Protocol usefully extended the scope to include action on short-lived climate pollutants (notably black carbon), and flexibility has increased thereby also enabling a broader participation. Further action should focus on facilitating ratification by Eastern European, Caucasus and Central Asian Countries, action on short-lived climate pollutants (including also methane, black carbon and ozone) and extended exchange of scientific and technical co-operation with other regional groups notably in Asia and North America.

10.2. Main outstanding problems

Based on the above analysis, the following main outstanding problem relates to the fact that the health and environmental impacts of air pollution in the EU remain large. This conclusion is set out further in Chapter 3.3.1 of the main impact assessment. Two specific problems related to these substantive impacts were identified as follows.

- EU air quality standards are widely exceeded in densely-populated areas
- The EU is not on track to meet its long-term air quality objective

The summary conclusions from the above review related to these specific problems are set out in Chapter 3.3.2 and 3.3.3 of the main impact assessment.

10.3. Main drivers of the outstanding problems

The review allowed further more to identify the main drivers for the aforementioned problems. They relate partly to the pollution sources themselves, and partly to the failure to manage air quality effectively and efficiently ("governance issues"). The main drivers are summarised in the main body of the impact assessment for each problem in turn as follows.

- Main drivers causing exceedance of EU air quality standards (See Chapter 3.4.1 of the main impact assessment report)
  - Diesel emissions drive the NO_2 and NO_x compliance problems (See Chapter 3.4.1.1 of the main impact assessment report)
  - Small scale combustion and concentrated local pollution drive the worst PM compliance problems (See Chapter 3.4.1.2 of the main impact assessment report
  - Poor co-ordination between national and local action, and lack of capacity at regional and local level (See Chapter 3.4.1.3) of the main impact assessment report

- The main drivers preventing the EU to stay on track towards meeting its long-term air quality objective (See Chapter 3.4.2 of the main impact assessment report)

[296] Annex 4 section 5.

- The remaining health impacts from PM and ozone are driven by emissions from a range of sectors (See Chapter 3.4.2.1 of the main impact assessment report)
- Agricultural ammonia emissions drive the remaining health impacts (See Chapter 3.4.2.2 of the main impact assessment report)
- Sustained background pollution means local action alone cannot effectively reduce impacts (See Chapter 3.4.2.3 of the main impact assessment report)
- There remain gaps in the information base for assessing and managing air pollution (See Chapter 3.4.2.4 of the main impact assessment report)

10.4. Orientations for the review

The conclusions from the review on the outstanding problems and drivers have formed a robust basis for further assessments and defining the policy objectives for the updated EU air quality policy framework (see section 4). As indicated during the review process documented in this annex, the problems identified in the review can be addressed by modification (rather than replacement) of the existing policy framework. The required modifications should take place in a stepwise manner as follows.

Based on experience with the existing policy framework, setting ambitious ambient standards in the absence of measures to control transboundary pollution, and emissions at source, generates large-scale non-compliance. It is thus proposed to move to a staged approach whereby transboundary and source controls are brought forward first, and then once they are implemented, ambient air quality standards (mainly for PM) are reduced building on the resultant reductions in background concentrations delivered.

On that basis, a sensible order for the further policy revision would be first of all i) a revision of the TSAP to set the future EU policy framework to 2030; and ii) a simultaneous revision of the NECD to control transboundary pollution and limit background pollution concentrations. Once these are in place and broad-based compliance with the current standards has been achieved, a revision of the AAQD could be envisaged to bring standards closer to the WHO guideline values and address outstanding issues (such as the appropriate balance between limit values and exposure reduction obligations).

These orientations have been taken into account when designing the policy options for further action as described in the main impact assessment report from Chapter 4 onwards.

APPENDIX 4.1 SPECIFIC EVALUATION STUDIES LAUNCHED FOR INDIVIDUAL POLICY INSTRUMENTS AND THE DETAILED QUESTIONS ADDRESSED

All reports are available at http://ec.europa.eu/environment/air/review_air_policy.htm unless otherwise specified.

1. THE THEMATIC STRATEGY ON AIR POLLUTION (TSAP)

Data sources:

- Quantitative review of experience with implementation of the 2005 TSAP (TSAP report 2 of Service Contract ENV.C.3/SER/2011/0009)

Questions addressed

- What underlying factors led to differences in emissions as compared with projections in 2005 TSAP?
- What were the substantive impacts on emissions?
- How did the implementation cost projections compare with actual experience?
- To what extent will the environmental objectives of the TSAP be achieved?

2. THE AMBIENT AIR QUALITY DIRECTIVES (AAQD)

Data sources:

- Review of the health evidence on the pollutants regulated by the Ambient Air Quality Directive (2 grant agreements with WHO).
- EEA report No 4/2012, 'Air Quality in Europe'.
- EEA report No 7/2013, Air Implementation Pilot, Final Report
- Specific contract on implementation of the Air Quality Directive and the 4th Daughter Directive (ENV.C.3/FRA/2009/0008 Service request 6, final report 10 December 2012)
- Workshop on PM (ENV.C.3/FRA/2009/0008 Service request 7, final report October 8 2012)
- Modelling compliance with NO2 and PM10 air quality limit values in the GAINS model (ENV.C.3/SER/2011/0009 Report #9)

Questions addressed:

- Are the pollutants addressed by the legislation the most relevant for health protection?
- Are the levels at which the standards are set appropriate for health protection?
- How effective is the management framework of the Directive?
- What are the health impacts of the pollutants?
- What is the status of air quality in Europe, the trends and the compliance picture?
- What are the underlying emission levels and their trends?
- What are the main reasons for non-compliance?

3. THE NATIONAL EMISSION CEILINGS DIRECTIVE (NECD)

Data sources:

- EEA report No 14/2012, 'Evaluation of progress under the EU National Emission Ceilings Directive' assessing

- Specific contract, 'Services to assess the reasons for non-compliance with the emissions ceilings set in the National Emission Ceilings Directive', (Specific Agreement 5 under Framework Contract ENV.C.3/FRA/2011/08)

Questions addressed:

- What are the evolution of emissions, state of compliance and the extent to which the NECD environmental objectives are achieved?
- What are the main reasons for non-compliance, (a) based on objective analysis and (b) as identified by the Member State?
- When is compliance likely to be achieved?
- Will the reasons for non-compliance of the NECD 2010 ceilings affect the ability of a Member State to meet its new 2020 emission reduction commitments under the Gothenburg Protocol?
- Recommendations for modification to the management framework of the Directive.

4. SECTOR POLLUTION CONTROL POLICIES

Data sources:

- Future emissions of air pollutants in Europe – current legislation baseline and the scope for further reductions (ENV.C.3/SER/2011/0009 Report #1)
- Emissions from agriculture and their control potentials (ENV.C.3/SER/2011/0009 Report #3)
- The potential for further controls of emissions from mobile sources in Europe (ENV.C.3/SER/2011/0009 Report #4)
- Emissions from households and other small combustion sources and their reduction potential (ENV.C.3/SER/2011/0009 Report #5)
- Specific review of emissions from shipping (Special report under ENV.C.3/SER/2011/0009)

Questions addressed:

- What are the main emissions from the sector, their sources, and abatement options?
- What existing policies and regulations impact on future emissions from the sector?
- What are the costs, emission reductions and compliance implications of implementation of current legislation for each sector?
- What is the further reduction potential in the sector?

APPENDIX 4.2 EU VERSUS INTERNATIONAL AIR QUALITY STANDARDS

International air quality standards for PM10 (µg/m^3 unless otherwise stated)

Statistics	EU	CH	US	JP	CN	KR	IN	WHO
Ann. av.	40	20	-	-	40 I 100 II 150 III	70	60	70 (IT-1) 50 (IT-2) 30 (IT-3) 20 (AQG)
	Ann. mean of min. 90% of yearly measurements	Ann. mean	50 Annual arithmetic mean, averaged over 3 years (Standard revoked in 2006) Sec. st.1 & Prim. st.2		Ann. mean Zone I: residential areas Zone II: commercial areas Zone III: industrial areas	Ann. mean	Ann. mean; min. 104 meas. p.a. at a particular site taken twice a week; 24 hourly at uniform interval.	Annual arithmetic mean
24 hr av.	50	50	150 Sec. st.[297] & Prim. st.[298]	100	50 I 150 II 25 III	150	100	150 (IT-1) 100 (IT-2) 75 (IT-3) 50 (AQG)
	35 d. p.a. admitted	1 d. p.a. admitted	1 d. p.a. admitted, on avg. over 3yrs	daily mean	daily mean Zone I: residential areas Zone II: commercial areas Zone III: industrial areas	daily mean	24 hrly values shall be complied with 98% of time in a year. 2% of values may exceed limit but not on 2 consecutive days.	3 d. p.a. (99th percentile)

[297] **Secondary standards** provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.
[298] **Primary standards** provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly.

International Air Quality Standards for PM2,5 (µg/m^3 unless otherwise stated)

Statistics	EU	CH	US	JP	CN	KR	IN	WHO
Annual av.	25	-	12 Secondary st.1 15 Primary st.2	15	40 I 100 II 150 III	-	40	35 (IT-1) 25 (IT-2) 15 (IT-3) 10 (AQG)
	Annual arithmetic mean of minimum 90% of measurements per year < 2015		Three year average of the weighted annual mean[299]		Annual arithmetic mean; Zone I: residential areas; II: commercial areas; III: industrial areas		Annual arithmetic mean of minimum 104 measurements p.a. at a particular site taken twice a week 24 hourly at uniform interval.	Annual arithmetic mean
24 hours av.	-	-	35 Secondary st.1 & Primary st.2	35	50 I 150 II 250 III	-	60	75 (IT-1) 50 (IT-2) 37,5 (IT-3) 25 (AQG)
			Three year average of the 98th percentile of daily means	Annual 98th percentile values at designated monitoring sites in an area	daily mean; Zone I: residential areas; II: commercial areas; III: industrial areas		24 hly values monitored shall be complied with 98% of the year; 2% may exceed the limit but not on two consecutive days.	3 days per year admitted (99th percentile)
Other	Exposure 20 3 calendar year running ann. mean of a set of urban background stations <2015							

[299] The EPA tightened the constraints on the spatial averaging criteria by further limiting the conditions under which some areas may average measurements from multiple community-oriented monitors to determine compliance (see 71 FR 61165-61167). [where "Federal register" "Vol. 71" 61164 - follow] *In this review, the Staff Paper concluded that it is appropriate to retain a concentration-based form that is defined in terms of a specific percentile of the distribution of 24-hour PM2.5 concentrations at each* ***population oriented monitor*** *within an area, averaged over 3 years.*

International Air Quality Standards for NO2 (µg/m³ unless otherwise stated)

Statistics	EU	CH	US	JP	CN	KR	IN	WHO
Annual av.	40	30	100 Secondary st.1 & Primary st.2	-	40 I 40 II 80 III	57 {0,03 ppm}	40	40 (AQG)
	Annual arithmetic mean of minimum 90% of measurements per year	Annual arithmetic mean	Annual arithmetic mean		Annual arithmetic mean Zone I: residential areas Zone II: commercial areas Zone III: industrial areas		Annual arithmetic mean of minimum 104 measurements per year at a particular site taken twice a week 24 hourly at uniform interval.	
hourly av. [or ½ h]	200	100	100 Primary st.2	-	120 I 120 II 240 III	188 {0,1 ppm}	80	200 (AQG)
	18 hours per year admitted	95o Percentile of ½ hourly values per year admitted			hourly mean Zone I: residential areas Zone II: commercial areas Zone III: industrial areas		1 hour means shall be complied with 98% of time in a year. 2% of the values may exceed the limit but not on two consecutive days.	
24 hours av.		80 Daily mean 1 day per year admitted		113 Daily mean {0,06 ppm} [within zone 0,04-0,06 ppm or below]	80 I 80 II 120 III daily mean	113 {0,06 ppm}		

International Air Quality Standards for Ozone (µg/m3 unless otherwise stated)

Statistics	EU	CH	US	JP	CN	KR	IN	WHO
1 hours av.	-	120	-	120 {0,06 ppm}	120 I 160 II 200 III	200 {0,1 ppm}	180	-
		1 hours per year admitted	238 (Standard revoked on 2005 in all US except 14 areas)	For all photochemical oxidants. That are oxidizing substances such as ozone and peroxiacetyl nitrate produced by photochemical reactions.	1 hour mean Zone I: residential areas Zone II: commercial areas Zone III: industrial areas		1 hour monitored values shall be complied with 98% of time in a year. 2% of the values may exceed the limit but not on two consecutive days.	
8 hours daily max	120 {Target Value}	-	160 {0,075 ppm} Secondary st.1 & Primary st.2	-	-	120 {0,06 ppm}	100	240 (Hi-L) 160 (IT-1) 100 (AQG)
	25 days per year admitted over 3 years		Three year average of the 4th highest daily maximum 8 hourly means (< 2007-2024)				8 hour monitored values shall be complied with 98% of time in a year. 2% of the values may exceed the limit but not on two consecutive days.	
Other	AOT40 18K May-Jul sum of values of difference between max 8h mean and 40 ppb	½ hourly av. 100 98o Percentile of ½ hourly values per month admitted						

Sources
CH: OIAt of 16/12/1985 (at 15/07/2010) 814.318.142.1;
<http://www.admin.ch/ch/i/rs/c814_318_142_1.html>
JP: Environmental Quality Standards in Japan <http://www.env.go.jp/en/air/aq/aq.html>
CN: National Ambient Air Quality Standards
<http://cleanairinitiative.org/portal/knowledgebase/countries/country_overview/China/Air%20Quality%20and%20Co-Benefits?page=4>
<http://transportpolicy.net/index.php?title=China:_Air_Quality_Standards>
KR: National Ambient Air Quality Standards
<http://www.airkorea.or.kr/airkorea/eng/information/main.jsp?action=standard>
IN: National Ambient Air Quality Standards
<http://cpcb.nic.in/National_Ambient_Air_Quality_Standards.php>
NZ: Resource Management (National Environmental Standards for Air Quality) Regulations
<http://www.mfe.govt.nz/laws/standards/air-quality/index.html>
WHO: Air Quality. Guidelines for Europe (World Health Organization)
<http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf>
US: National Ambient Air Quality Standards (NAAQS) <http://www.epa.gov/air/criteria.html>

APPENDIX 4.3 EXAMPLES OF NATIONAL AND LOCAL AIR QUALITY MANAGEMENT MEASURES

A set of broad categories of measures can be distinguished based on information obtained through the Time Extension Notifications for PM_{10} and NO_2, exchange of information in the context of on-going infringement cases, and various targeted workshops and projects. These categories are shown in Table 44 below. Further details illustrating practical implementation experience is provided in Appendix 4.4 for the case of Dresden. The potential of fiscal measures to promote emission reduction measures is provided in Appendix 4.5. Further information on experience with national and local measures is referred to in Appendix 4.6 summarizing the experience with the Air Implementation Pilot.

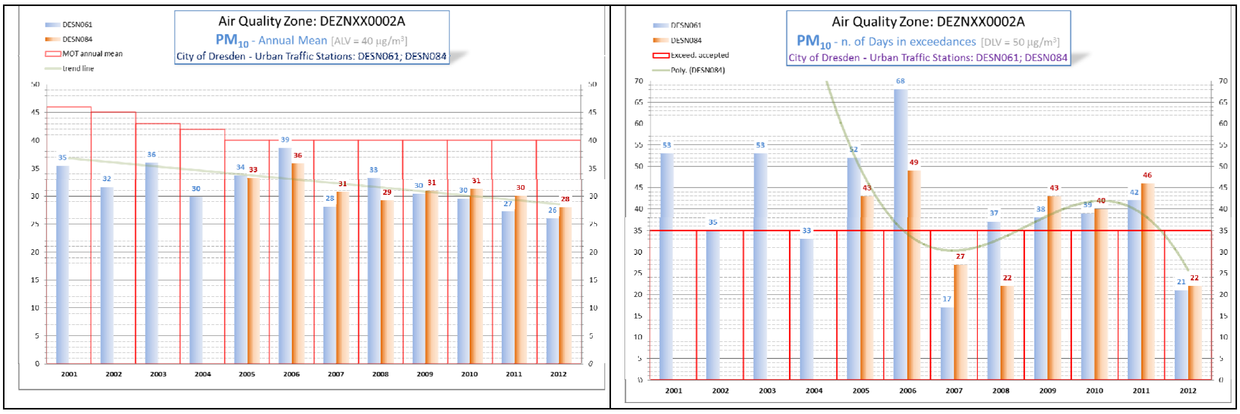
Table 44: Example of National and Local Measures by Source (Sub)Category

Emission source / sectors	**Subcategories**	**Measures / Examples**
Transport	Road Transport / traffic management	• Road pricing (e.g. London, Gothenburg) • Speed-limits (e.g. Rotterdam) • Low Emission Zones (e.g. Berlin) • Parking fees (e.g. Torino) • Car sharing (e.g. Cambio) • Bus or Heavy Occupancy Vehicles
	Road Transport / fleet management	• Green Public Procurement (Ultra Low emission or alternative fuelled vehicles) • Retrofitting standards (e.g. for buses, municipal service vehicles, trucks,…)
	Road Transport / inter-modality	• Kiss & Ride road and rail infrastructure • Pedestrian zones and dedicated bike lanes, …
	Road Transport / Promoting Public Transport	• Green taxis • Green buses (LPG, CNG cars and buses) • …
	Maritime Transport / Promoting clean Marine Ports	• Electricity at berth (Hamburg) • Differentiated fees • Remote sensing of emissions (JRC) • Retrofitting vessels • Discharge services • Alternative fuel infrastructure (Low sulphur fuels, LNG,…) • Clean intermodality
	Maritime Transport / Fleet management	• Retrofitting (inland, SSS) • LNG (SSS, inland) • Scrubbers …

	Air Transport / Clean Air Ports	• Public Transport Access • Differentiated fees
	Rail Transport / fleet management	• Retrofitting (diesel) railcars • Electrification • …
Energy	Large and medium sized combustions installations	• Permitting (upper range BAT/ beyond); • Promote energy efficiency • Promote RES, • District Heating and Cooling (Torino) • Fuel taxes (Denmark) • Carbon pricing (ETS)
	Small combustion installations	• Labels and/or standards for clean wood / biomass stoves (IT, DK) • Fuel switching (Dublin) • Permitting
Industry	Iron & Steel Cement …	• Permitting according to best Available Technologies or beyond (national / local competence!) • Joint clean air and climate change pilot projects
Agriculture		• Manure management conditions (BE, NL, DE) • Agriculture burning restrictions • Animal rearing criteria (CLRTAP) • Fertilizer Management • Food and feeding strategies
Economic incentives / general		• Greening vehicle taxation (differentiated registration tax, road tax, fuel tax) • NOx Funds (Norway) • Off-set systems (US) • Tradable permits (NL, California)
Public Information		• Promotion campaigns, on-site training and inspection for energy efficiency and RES • Awareness and actions at citizen level
Other		• Measures funded by the EU Cohesion Fund.

APPENDIX 4.4: ILLUSTRATING LOCAL ACTION TO REDUCE AIR POLLUTANT --THE DRESDEN CASE

This appendix offers further illustration of local measures implemented in the case of Dresden (Germany). Dresden is a town of about 517 000 inhabitants, situated in the river basin of the river Elbe in Eastern Germany. There is a wide mix of industries, but heavy industry is not dominant. It is an important traffic junction. Part of the city is densely built. This results in higher average temperature in these areas, resulting in less heating in winter, but also in less natural ventilation. Dresden has succeeded in reaching the limit values of PM10 and NO2 over the past years. There was no application for a Time Extension Notification (TEN) for PM10, but a TEN for NO2 was granted in 2011. The figure below shows the trends for PM10 and NO2 air quality levels from 2001.



The below paragrahs describe the measures taken in Dresden with respect to emissions from combustion installations, transport, and other sectors.[300]

Combustion installations

Already in the period from 1989 till 2000 Dresden already took many local measures related to emissions from combustion installations that resulted in a decrease of PM emissions from large and small combustion installations by about 99% and 97% respectively. These measures included:

- decommissioning of coal fired district heating plants
- fuel switch in district heating plants towards gas
- fuel switch in domestic heating installations
- modernising domestic heating installations

Whilst this reduction potential of PM emissions is no longer available for Dresden in future, they constitute good examples for other cities that have not yet taken such measures. It is noted that these reductions in Dresden were achieved without a significant increase in the use of renewable energy which could thus remain available options for going further (ground water heat pumps, solar).

Transport

[300] Source: Luftreinhalteplan für die Landeshauptstadt Dresden 2011.

The local emission inventories established by Dresden indicated a significant contribution from transport. For example trucks are responsible for about 74% of NOx and about 60% of PM10 emissions. On that basis, several measures have been implemented to address transport from the period starting from the 1999-2010 onwards. These measures include:

- urban planning measures –including the development of new residential areas close to existing road infrastructure; use of designated areas in the city to avoid residential expansion over a large area, and reconversion and upgrading of derelict areas and brownfields
- infrastructure development measures –such as changing the structure of the main roads from radial to tangential thereby avoiding that traffic first has to go to the city centre before leaving town again for the right direction; construction of bypasses for transit traffic; replacing top layers of roads; improving traffic signs taking into account local and regional traffic flows; improved intermodality (e.g.bus/metro, park and ride, bike and ride, construction of an intermodality logistics centre); expansion of public transport, especially metro and local train; construction of a railway link with the airport; electrification of railway tracks; purchase of cleaner buses; eliminate barriers (e.g. river and railway crossings); and promotion of non-motorised traffic (expansion and upgrading of pedestrian and cycling lanes, elimination of crossings and barriers, better traffic signs)
- traffic management –including improved use of existing infrastructure; preferential road access for public transport; intelligent traffic flow controls with real time information (e.g. green wave); speed limits (e.g. 30 km/h zones), traffic information with details on construction site related barriers , parking options for passenger cars as well as tourist buses, and intermodality options; promotion of car-sharing; traffic control and guidance for trucks; and speed limits on motorways close to town.
- mobility management including better or preferential access for cleaner vehicles; coordination with mobility plans for big employers (e.g. work-related traffic of staff); and combined tickets and e-tickets for public transport

Some results are remarkable: the city managed to increase the share of bicycle use in transport from 9.7% in 2003 to 12.3 % in 2009.

<u>Other measures</u>

Due to the specific nature of the city with its densely built city centre, special attention has been devoted to improve the heat balance and increase natural ventilation and the flow of fresh air from the surrounding area by constructing and expanding city parks and urban green. An analysis of the major fresh air flows from the area surrounding the city was done and based on the findings the following measures were taken:

- shifting the long term urban planning strategy towards a more compact city with concentration of energy efficient "city cells" in an ecological network; liberating environmental corridors; create a mix of functionalities (e.g. living, working, spending free time , sport, tourism); and ensuring ventilation and create/protect city zones with low concentrations of pollutants
- develop environmentally functional spaces and corridors such creating and linking woody areas; establishing green corridors that are wide enough and that integrate private and public green; making sure that corridors are nearby for all citizens; developing green "junctions" ; and making the corridors accessible for pedestrians and cyclists.

- developing criteria for the compact city's "city cells" to make them fit in the green urban structure by promoting active climatic elements such as vegetation, water works, solar energy, heat pumps, green roofs; promoting natural ventilation; replacing asphalt roads by other surfaces that retain less heat, linking green areas with public spaces such as schools, hospitals

It is furthermore noted that a part of these measures (e.g. speed limits) were coordinated with local noise plans or measures for urban green (parks, green corridors) and urban planning in general.

Although the measures mentioned above were mostly local, some required at least some cooperation or coordination with other levels of government or companies to get the best results.

APPENDIX 4.5 MARKET BASED INSTRUMENTS (MBIS) FOR PROMOTING CLEAN HOUSEHOLD HEATING APPLIANCES

This appendix contains the summary of a JRC-IPTS study conducted in support of this review to assess the potential for using market based instruments to contribute to reducing the emissions of particulate matter of less than 10 micrometres (PM10) from household heating appliances in the framework of the review of the Thematic Strategy on Air Pollution (TSAP).

The study focused on the assessment of the economic and environmental impacts of possible scrappage policies for promoting the accelerated replacement of existing heating appliances by cleaner ones. Under this policy programmes, households replacing an old appliance by a cleaner one would receive a subsidy from the government. This subsidy would compensate households for the residual value of the appliance scrapped and the opportunity costs of the early investment in a new one.

Two different scenarios have been analysed: 1) a "Scrappage All" scenario where all the different types of conventional appliances that do not incorporate any emission control technology ("non-controlled" appliances) are replaced, and 2) "Scrappage SHB" scenario where only "non-controlled" firewood and hard coal fired manual single house boilers (SHB) are replaced. It has been assumed that the scrappage programme would be in force for 3 years (between 2018 and 2020). For each of these scenarios, the study further focused on the effects of different levels of replacement of the "non-controlled" appliances and the size of subsidies relative to the investment costs.

Results for the EU-27 show that a scrappage programme designed to replace all types of "non-controlled" appliances and with subsidies limited to 20% of the investment costs, could contribute to the reduction of the emissions of PM10 from household heating appliances in 2020 by 18% (-79 kt), with an average annual reduction of 7.4% (-22 kt/year) for the period 2018-2030. This early replacement would increase average annual investment costs of the period 2018-2030 by 11% (+1.5 billion €/year). Total subsidies to compensate households for the early replacement would amount to 9.4 billion € during the period 2018-2020. Health benefits of this policy scenario would total between 0.9 and 2.7 billion €/year. This scheme would increase the Gross Value Added (GVA) by 2.3 billion €/year.

The scrappage mechanism which only targets SHB and with subsidies limited to 20% of the costs could achieve 9% of the reduction resulting from the previous "Scrappage All" scenario, while cutting the abatement costs and subsidies to 3.7% and 4.9% respectively. This mechanism would reduce PM10 emissions in 2020 by -3% (13.3 kt) and the average emissions of the period 2018-2030 by -0.7% (2.1 kt), the costs would increase by 0.5% (55.6 million €/year). Total subsidies during the period 2018-2020 would sum to 411 million €. Health benefits would range from 147 and 424 million €/year. Around 50% of the investment costs and subsidies, and 61% of the reduction in PM10 emissions would be generated by the accelerated replacement of SHB in Poland. This scrappage mechanism would increase the GVA by 106 million €/year; 42% of the total increase in the GVA would be in Poland, 11% in Germany, 8.5% in Slovenia and 7% in the United Kingdom.

APPENDIX 4.6 LESSONS LEARNED FROM THE "AIR IMPLEMENTATION PILOT"

The Air Implementation Pilot brought together 12 cities across the European Union and was jointly run by the cities themselves, the European Commission, and the European Environment Agency (EEA). It aimed at better understanding the challenges cities faced in implementing air quality policy, and also encouraged the cities to share their experiences, so they could learn from each other and see what has worked and what has not worked in other cities. The pilot also aimed to develop common proposals to help improve implementation of air policy. The pilot lasted for 15 months, starting in March 2012. It consisted of several workshops held with representatives of the European Commission's Directorate General of Environment; the EEA; the EEA's Topic Centre on Air Pollution and Climate Change Mitigation; and representatives of the cities participating in the pilot. Eight cities originally took part in the pilot: Berlin, Dublin, Madrid, Malmö, Milan, Ploiesti, Prague, and Vienna. Four more cities subsequently joined at the end of 2012: Antwerp, Paris, Plovdiv, and Vilnius. The cities were selected so as to ensure a representative sample of the diversity of Europe's urban areas. The selection aimed at including cities from different parts of Europe, of different population sizes, with different administrative traditions, and with a variety of sources of pollutants. The pilot focused on five 'work streams', where lessons for implementation could most usefully be drawn. The lessons learned and recommendations for further action are provided below.

Local emission inventories

Although 11 of the 12 cities have emission inventories[301], the pilot uncovered a great variety of methodologies used to compile these inventories. This variety means that the cities' emission inventories are often not comparable with one another, or with the emission inventories of the regions within which they are located. Cities have problems taking into account all sources of pollution, due to the difficulty in finding available data, or because of the difficulty in appropriately quantifying different sources.

The pilot project concluded that better input data and more guidance are needed on inventory methodology.

Modelling and the use of air quality models

For air quality modelling[302], there was also a great diversity of models used by the cities. Because air quality models make use of emission inventories, often the shortcomings of these inventories carry over to the modelling activities. Additional issues encountered by the cities related to the other input data used in models, such as meteorological information, and background concentrations of pollutants. Another difficulty when applying models at urban level was how to accurately reflect the specificities of urban topography, such as pollution hot spots on kerbsides. Finally, many city representatives said that the results of their models were often highly complex, and therefore difficult to interpret, consuming a lot of resources and computational time. This complexity also makes the subsequent validation of the results more difficult.

301 Emission inventories are sets of data that show what pollutants are emitted into the air, where, and from which sources.
302 Models are the computer-based tools that help to understand air pollution processes.

The pilot project concluded that greater training in modelling was needed, along with improved input data (including meteorological data, background concentrations, and the specificities of each city's topography).

Monitoring networks

On monitoring networks[303], the pilot project found that most of the cities had the necessary number of monitoring stations required by the relevant directives. However, the criterion for the macro-scale siting of ozone stations (their distribution between urban and suburban locations) has not always been met in the cities participating in the Air Implementation Pilot.

The cities' experts therefore recommended addressing this issue of the location of monitoring stations. Some experts also suggested that the air quality directives provide more detailed requirements for measuring stations. These requirements would stipulate the macro-siting (where the stations are located with respect to major pollution sources) and micro-siting (where the stations are sited with respect to their immediate surroundings, such as their height, proximity to the kerb, etc.), as well as the representativeness of the stations (the spatial area over which the value measured at the station can be accepted as meaningful).

Air quality management practices

The pilot project examined trends in concentrations of three air pollutants: nitrogen dioxide, particulate matter and ozone and the effect of measures taken to improve air quality for those pollutants. No clear trend in concentrations of these pollutants could be seen in the monitoring stations considered. Nevertheless, some commonalities did emerge in the management measures taken by the cities. In most of the cities, and in agreement with the main pollutant sources identified, more than the 50 % of the implemented measures are traffic related. Other measures focused on the domestic, commercial and industrial sectors. Another common theme emerged among all the cities: how to define and assess the effects of measures. The cities' experts also expressed a common uncertainty regarding how best to assess the costs and benefits of measures to abate pollution. Again, some of the deficiencies identified in previous work streams have implications that carry over: improvement of inventories and modelling tools, for instance, would better enable cities to assess which of their measures were most effective in improving air quality. Further support was also requested in the form of proposals for new EU legislation. Examples included: standard methodologies to measure emissions from boilers, regulations for domestic stoves, and improved vehicle emissions data to help ascertain the effect of traffic measures on air quality.

Public information.

This work stream focused on how the cities kept their citizens informed about air quality. The pilot project showed that, by and large, air quality information that is required by legislation to be made public is promptly provided by the cities to the public, mostly through dedicated air quality internet sites. In general, the cities underuse mass media, social media websites, and new technologies like smartphone applications. Most of the participating cities lacked feedback on the interest of their citizens in air quality issues. There is thus room for cities to increase the presence of air quality issues

303 These are the networks of sampling stations located across cities that take regular measurements of air quality.

in the media and for them to develop their smartphone and social media presences. The adoption of a common Europe-wide index for air quality, using the same colour codes to facilitate comprehension, would also help make air quality information comparable across Europe.

Next steps

The Air Implementation Pilot identified a number of challenges which cities face in implementing EU air quality policy that would have to be taken up in the present air quality policy review. This would include further consideration how EU action can best support local, regional and national authorities in addressing them. Options could include:

- financing of improved management and capacity-building through the forthcoming revision of the LIFE regulation (3);
- the development of a broader network of cooperation on the urban air quality challenge across the EU, with regular information exchange, capacity building, and a common database of measures;
- promoting and enabling increased use of other EU funding opportunities, such as the structural funds, particularly to address local drivers of persistent non-compliance with EU air-related legislation.

One possibility that has been discussed is to package all the European measures related to urban air quality in a single programme, which would then be one of the accompanying documents to a revised Thematic Strategy on Air Pollution. For its part, the EEA will continue to support its member countries and the European Commission in their aim to improve the implementation of environmental policy.

ANNEX 5 FUTURE AIR QUALITY PROJECTIONS ASSUMING NO CHANGE IN CURRENT POLICIES

1. METHODOLOGY FOR PROJECTING FUTURE EMISSIONS AND AIR QUALITY IMPACTS

Projections for future emission scenarios under alternative hypotheses have been prepared using the GAINS suite of models. This toolbox[304] brings together an ensemble of interlinked models with the objectives to simulate future emission scenarios and cost-effective emission reduction strategies; this is done following an upstream causal chain that includes standard Commission projections on economic development, energy, transport, agriculture and climate change mitigation policies to estimate emission levels for pollutants, which are subsequently used to determine concentration/ deposition patterns across Europe and finally impacts on human health, ecosystems, agricultural crops and the built environment.

2. MAIN ASSUMPTIONS AND RELATED UNCERTAINTIES

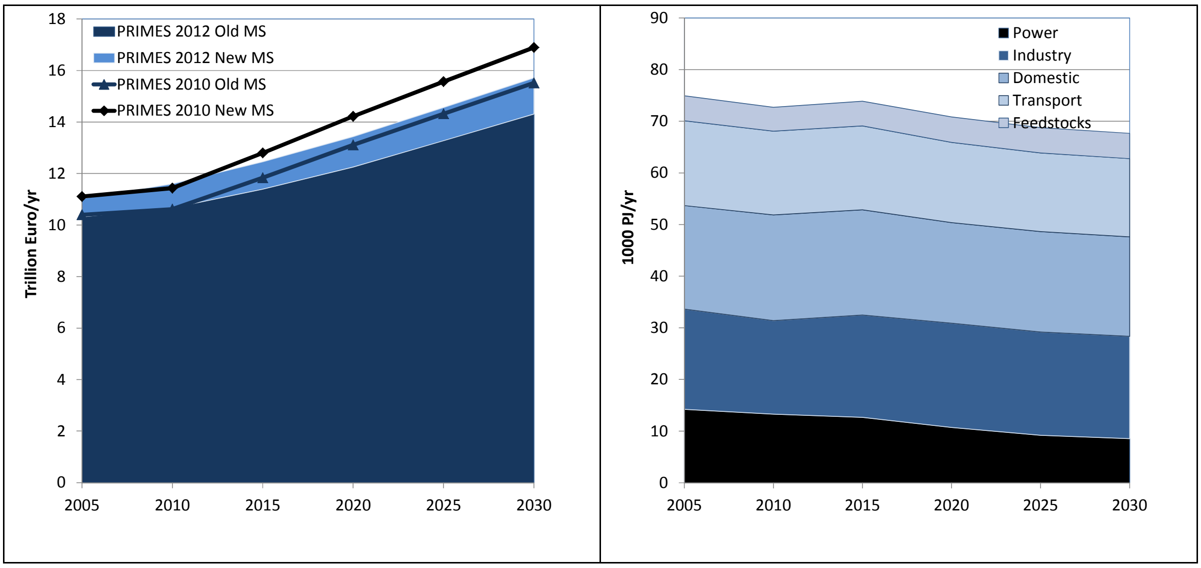
Baseline emissions are determined under standard Current Legislation assumptions described in chapter 2 below. Other important assumptions relate to economic growth, national energy balances, and agriculture.

[304] See description on the webpage of the EC4MACS Life+ project, which developed the latest update of the GAINS Integrated Assessment Modelling (IAM) toolbox

The baseline emission scenario has been developed based on and consistent with the draft 2012-3 EU Reference energy projection coordinated by Commission services ENER, CLIMA and MOVE. For the energy and CO2 reference scenario, the PRIMES energy system model operated by the National Technical University of Athens is used. Energy-related activity data and the evolution of fuel prices are taken from this scenario. It uses macroeconomic assumptions which are based on DG ECFIN/ Economic Policy Committee short and medium term growth projections and on the DG ECFIN/ EPC Ageing Report 2012 for long term GDP growth and population trends. Projections for agricultural activities are those developed with the CAPRI model in the context of the same EU Reference projection.

Despite a doubling in economic activity by 2050, the baseline scenario suggests a stabilisation of energy consumption, as energy efficiency policies will successfully reduce energy demand in households and industry. On a sectorial basis, the rapid penetration of energy efficiency measures maintains constant or slightly decreasing energy consumption despite the assumed sharp increases in production levels and economic wealth.

Figure A5.1: economic growth (left-hand side) and energy use by sector (right-hand side) in the E previosu PRIMES 2010 reference energy projections.



The adopted policies for renewable energy sources are expected to increase biomass use by more than a factor of two thirds in 2030 compared to 2005, and to triple energy from other renewable sources (e.g., wind, solar). In contrast, coal consumption is expected to decline by 40% by 2030, and oil and natural gas consumption is calculated to be 20% lower than in 2005, as shown in the following table.

Table A5.1: energy consumption by source up to 2030, EU 28.

PJ	2005	2010	2015	2020	2025	2030
Coal	13,3	11,8	11,1	9,9	9,0	7,3
Oil	28,6	26,0	24,7	23,1	22,2	21,8
Gas	18,8	18,6	18,2	17,0	17,0	16,6
Nuclear	10,8	9,9	9,6	8,1	7,6	8,4
Biomass	3,6	5,2	5,7	6,3	6,4	6,4
Other Renewables	1,6	2,5	3,8	5,3	6,2	7,0
Total	76,7	74,0	73,1	69,7	68,4	67,5

3. EU POLICIES INCLUDED IN THE CURRENT LEGISLATION (CLE) BASELINE

In addition to the energy, climate and agricultural policies that are assumed in the different energy and agricultural projections, the baseline projections consider a detailed inventory of national emission control legislation (including the transposition of EU-wide legislation).[305] They assume that these

305 For CO2, regulations are included in the PRIMES calculations as they affect the structure and volumes of energy consumption. For non-CO2 greenhouse gases and air pollutants, EU and Member States have

regulations will be fully complied with in all Member States according to the foreseen time schedule. For air pollutants, the baseline assumes the regulations described in the tables below.[306] The baseline assumes full implementation of this legislation according to the foreseen schedule.

Table A5.2: Legislation considered for SO2 emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs are considered according to the information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive.
- Directive on the sulphur content in liquid fuels
- Fuel Quality directive 2009/30/EC on the quality of petrol and diesel fuels, as well as the implications of the mandatory requirements for renewable fuels/energy in the transport sector
- MARPOL Annex VI revisions from MEPC57 regarding sulphur content of marine fuels
- National legislation and national practices (if stricter)

Derogations under the IPPC, LCP and IED directives granted by national authorities to individual plants are considered to the extent that these have been communicated by national experts to IIASA.

Table A5.3: Legislation considered for NOx emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs included according to information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive
- For light duty vehicles: All Euro standards, including adopted Euro-5 and Euro-6, becoming mandatory for all new registrations from 2011 and 2015 onwards, respectively (692/2008/EC), (see also comments below about the assumed implementation schedule of Euro-6).
- For heavy duty vehicles: All Euro standards, including adopted Euro-V and Euro-VI, becoming mandatory for all new registrations from 2009 and 2014 respectively (595/2009/EC).
- For motorcycles and mopeds: All Euro standards for motorcycles and mopeds up to Euro-3, mandatory for all new registrations from 2007 (DIR 2003/77/EC, DIR 2005/30/EC, DIR 2006/27/EC). Proposals for Euro-4/5/6 not yet legislated.
- For non-road mobile machinery: All EU emission controls up to Stages IIIA, IIIB and IV, with introduction dates by 2006, 2011, and 2014 (DIR 2004/26/EC). Stage IIIB or higher standards do not apply to inland vessels IIIB, and railcars and locomotives are not subject to Stage IV controls.

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issued a wide body of legislation that limits emissions from specific sources, or have indirect impacts on emissions through affecting activity rates.

306 The analysis does not consider the impacts of other legislation for which the actual impacts on future activity levels cannot yet be quantified. This includes compliance with the air quality limit values for PM, NO_2 and ozone established by the Air Quality directive, which could require, inter alia, traffic restrictions in urban areas and thereby modifications of the traffic volumes assumed in the baseline projection. For methodological reasons it is also difficult to reflect the impact of some other relevant directives such as the Nitrates Directive.

• MARPOL Annex VI revisions from MEPC57 regarding emission NOx limit values for ships • National legislation and national practices (if stricter)

For NO_x emissions from transport, all scenarios presented here assume from 2017 onwards real-life NO_x emissions to be 1.5 times higher than the NTE Euro-6 test cycle limit value. This results in about 120 mg NO_x/km for real-world driving conditions, compared to the limit value of 80 mg/km. As portable emissions measurement systems (PEMS) will only be introduced gradually, between 2014 and 2017 emission factors of new cars are assumed at 310 mg NO_x/km. Also, inland vessels are excluded from Stage IIIB or higher emission controls, and railcars and locomotives not subject to Stage IV controls.

Table A5.4: Legislation considered for PM10/PM2.5 emissions

• Directive on Industrial Emissions for large combustion plants (derogations and opt-outs included according to information provided by national experts) • BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive • For light and heavy duty vehicles: Euro standards as for NOx • For non-road mobile machinery: All EU emission controls up to Stages IIIA, IIIB and IV as for NOx. • National legislation and national practices (if stricter)

Table A5.5: Legislation considered for NH3 emissions

• IPPC directive for pigs and poultry production as interpreted in national legislation • National legislation including elements of EU law, i.e., Nitrates and Water Framework Directives • Current practice including the Code of Good Agricultural Practice • For heavy duty vehicles: Euro VI emission limits, becoming mandatory for all new registrations from 2014 (DIR 595/2009/EC).

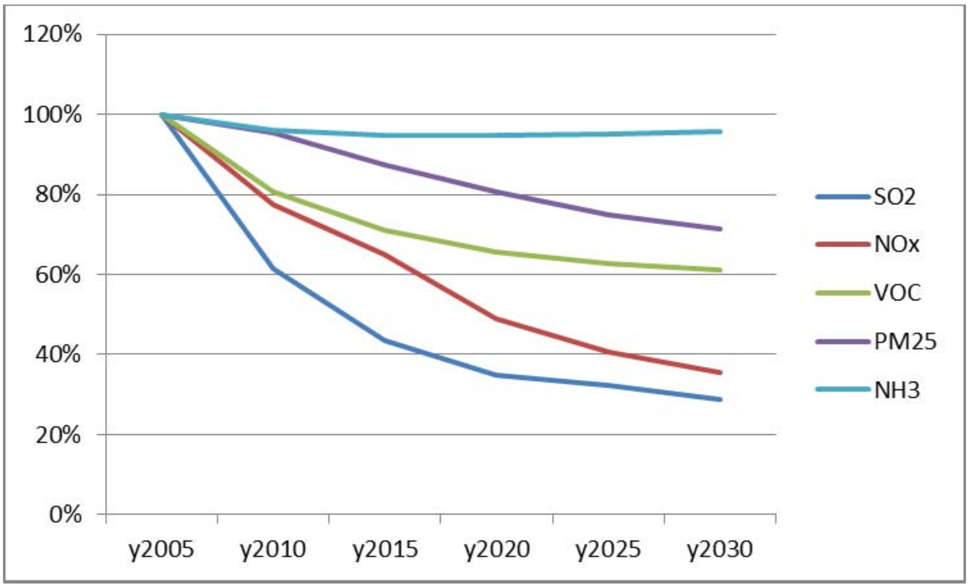
Table A5.6: Legislation considered for VOC emissions

• Stage I directive (liquid fuel storage and distribution) • Directive 96/69/EC (carbon canisters) • For mopeds, motorcycles, light and heavy duty vehicles: Euro standards as for NOx, including adopted Euro-5 and Euro-6 for light duty vehicles • EU emission standards for motorcycles and mopeds up to Euro-3 • On evaporative emissions: Euro standards up to Euro-4 (not changed for Euro-5/6) (DIR 692/2008/EC) • Fuels directive (RVP of fuels) (EN 228 and EN 590) • Solvents directive

- Products directive (paints)
- National legislation, e.g., Stage II (gasoline stations)

4. FUTURE AIR POLLUTANT EMISSIONS UNDER THE CURRENT POLICY SCENARIO

On the same time horizon, as a consequence of the structural changes in the energy and transport sectors and the progressing implementation of emission control legislation, SO2 emissions will fall drastically. The largest reductions are foreseen for the power sector, which is projected to cut its emissions by almost 90% in 2050 compared to 2005. NOx emissions may drop by more than 65% in the coming years provided that the EURO 6 emission standards are effectively implemented. Legislation directed at other pollutants reduces PM2,5 emissions by about 40%. In contrast to the other air pollutants, only minor changes are expected for NH3 emissions. VOC emissions will decline by 40% in the EU27, and converge on a per-capita basis across Member States.



More detail is provided below on a pollutant-by-pollutant basis

4.1. Sulphur dioxide

Progressing implementation of air quality legislation together with the structural changes in the energy system will lead to a sharp decline of SO_2 emissions in the EU; in 2025 total SO_2 emissions would be almost 70% below the 2005 level. Most of these reductions come from the power sector. Full implementation of the available technical emission control measures could bring down SO_2 emissions by up to 80% in 2025 vs 2005.

SO2 emissions	*2005*	*2010*	*2015*	*2020*	*2025*		*2030*	
EU28, kilotons					CLE	MTFR	CLE	MTFR
Power generation	5445	2739	1375	937	824	608	637	436
Domestic sector	623	624	520	467	399	250	336	213
Industrial combust.	1100	695	640	616	605	362	613	355

Industrial processes	743	626	578	577	570	344	575	345
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	36	7	6	5	5	5	5	5
Non-road mobile	215	137	109	71	37	29	37	29
Waste treatment	2	2	2	2	2	1	2	1
Agriculture	7	8	8	9	9	0	9	0
Sum	8172	4837	3238	2685	2451	1598	2214	1383

4.2. Nitrogen oxides

Also for NO_x emissions, implementation of current legislation will lead to significant declines, and for 2025 a 60% reduction is estimated. These changes emerge from measures in the power sector, and more importantly, from the implementation of the Euro-6 standards for road vehicles. Full implementation of additional measures for stationary sources could bring NO_x emissions in 2025 68% down compared to 2005. The sensitivity of these projections towards uncertainties about future real-life emissions from Euro-6 standards as well as the potential for further emission cuts from 'Super Ultra-Low Emission Vehicles' (SULEV) is explored in Chapter 5 of the main IA.

NOx emissons	*2005*	*2010*	*2015*	*2020*	*2025*		*2030*	
EU28, kilotons					CLE	MTFR	CLE	MTFR
Power generation	2879	1908	1513	1172	1055	636	906	517
Domestic sector	632	619	580	532	506	417	471	389
Industrial combust.	1253	913	898	884	901	492	929	503
Industrial processes	213	184	172	174	171	137	172	137
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	4905	3751	2994	1890	1210	1210	887	887
Non-road mobile	1630	1400	1156	914	748	632	661	513
Waste treatment	8	7	6	6	5	1	5	1
Agriculture	16	17	19	21	21	1	21	1
Sum	11538	8799	7338	5591	4617	3526	4051	2947

4.3. Fine particulate matter

Progressing introduction of diesel particle filters will reduce PM2.5 emissions from mobile sources by about two thirds up to 2025; the remaining emissions from this sector will mainly originate from non-exhaust sources. While this trend is relatively certain, total PM2.5 emissions in Europe will critically depend on the development for small stationary sources, i.e., solid fuel use for heating in the domestic sector. The anticipated decline in solid fuel use for heating together with the introduction of newer stoves would reduce emissions from this sector by ~17% in 2025. However, more stringent product standards could cut emissions by up to two thirds.

Overall, total PM2.5 emissions in the EU-28 are expected to decline by 25% in the CLE case, while additional technical measures could cut them by up to 60% compared to 2005.

PM2,5 emissions	*2005*	*2010*	*2015*	*2020*	*2025*		*2030*	
EU28, kilotons					CLE	MTFR	CLE	MTFR
Power generation	132	92	70	63	60	25	53	21
Domestic sector	573	695	653	597	523	230	465	156
Industrial combust.	85	72	73	75	73	38	76	37
Industrial processes	213	190	196	199	199	138	201	139
Fuel extraction	9	8	8	7	7	7	6	6
Solvent use	0	0	0	0	0	0	0	0
Road transport	270	217	149	115	104	104	102	102
Non-road mobile	123	99	74	53	41	33	35	27
Waste treatment	88	88	89	89	90	64	90	64
Agriculture	155	155	164	171	172	53	172	54
Sum	1647	1616	1477	1370	1269	692	1201	607

4.4. Ammonia

Although NH_3 emissions are subject to targeted controls in the agricultural sector and will be affected as a side impact of emission legislation for road transport (i.e. by improved catalytic converters), only slight changes in total emissions in the EU-28 are expected up to 2030.

Due to the absence of effective wide-spread legislation on the control of NH_3 emissions from the agricultural sector, the baseline shows only little change in NH_3 emissions over time. For 2025, a 5% decline in the EU-28 is estimated. However, EU-wide application of emission control measures that are already implemented in some countries could cut NH_3 by about one third.

Ammonia emissions	*2005*	*2010*	*2015*	*2020*	*2025*		*2030*	
EU28, kilotons					CLE	MTFR	CLE	MTFR
Power generation	14	22	22	25	24	22	23	20
Domestic sector	19	22	23	22	20	20	19	18
Industrial combust.	4	5	5	5	5	8	6	8
Industrial processes	78	73	74	75	75	28	75	28
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	128	88	67	54	48	48	46	46
Non-road mobile	2	2	2	2	2	1	2	1
Waste treatment	166	174	174	174	173	173	173	173
Agriculture	3518	3292	3336	3338	3311	2267	3319	2274
Sum	3928	3678	3702	3693	3658	2566	3663	2568

4.5. Volatile organic compounds

The future trend in VOC emissions is strongly determined by measures for mobile sources and by dedicated controls of solvents emissions.

Further implementation of the Euro-standards will eliminate almost all VOC emissions from road vehicles. Legislation on solvents is expected to cut VOC emissions from this sector by about 20% in 2025 relative to 2005. However, there remains significant potential for further reductions for VOC emissions from solvents. Together with additional measures in households, these could cut total VOC emissions in the EU-28 by two thirds, compared to the 37% reduction in the baseline case.

VOC emissions	*2005*	*2010*	*2015*	*2020*	*2025*		*2030*	
EU28, kilotons					*CLE*	*MTFR*	*CLE*	*MTFR*
Power generation	176	196	185	181	172	132	162	117
Domestic sector	987	1080	1026	911	813	195	736	156
Industrial combust.	53	56	60	69	77	77	85	85
Industrial processes	943	875	878	884	815	659	819	663
Fuel extraction	538	385	364	332	305	254	289	242
Solvent use	3600	3037	2882	2795	2584	1364	2603	1375
Road transport	2047	1100	593	392	293	293	257	257
Non-road mobile	657	538	414	355	314	259	281	223
Waste treatment	133	120	95	89	86	74	84	74
Agriculture	125	126	137	146	146	0	146	0
Sum	9259	7512	6635	6152	5604	3308	5460	3191

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PART 3/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and he Committee of the Regions a Clean Air Programme for Europe

Proposal for a Directive of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants

Proposal for a Directive of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants and amending Directive 2003/35/EC

Proposal for a Council Decision on the acceptance of the Amendment to the 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone

{COM(2013) 917 final}
{COM(2013) 918 final}
{COM(2013) 919 final}
{COM(2013) 920 final}
{SWD(2013) 532 final}

5. BASELINE

5.1 Compliance with NO2 limit values

The decline in NO_x emissions projected by the baseline should significantly improve future compliance with NO_2 air quality limit values.

A new methodology has been developed to estimate with the GAINS model future NO_2 concentrations at traffic stations (Kiesewetter et al. 2013). This enables the assessment of the impacts of the Europe-wide emission reduction scenarios on compliance with the air quality limit values for each of these stations.

However, due to data gaps, this approach could not be implemented for all monitoring sites in Europe, but is restricted for NO_2 to 2000 sites for which sufficient monitoring data have been provided to AIRBASE, and for PM10 for 1900 sites. Obviously, this sub-set of stations is not necessarily representative, and there are large differences in station numbers across Member States. To facilitate representative conclusions, stations have been allocated to their respective air quality management zones established under the Air Quality Daughter Directive. The analysis presented here determines the compliance status of each zone along the highest concentration modelled at any AIRBASE monitoring site located within the zone.

It has been shown for NO_2 that achievement of the annual limit value of 40 $\mu g/m^3$ is more demanding than compliance with the hourly limit value of 200 $\mu g/m^3$. Thus, modelling for NO_2 is restricted to the annual limit value.

To reflect unavoidable uncertainties in monitoring data, modelling techniques and future meteorological conditions, three compliance categories with the annual limit value are distinguished.

Computed annual mean concentrations of NO_2 below 35 $\mu g/m^3$ indicate likely compliance. If concentrations are computed in the range between 35 and 45 $\mu g/m^3$, compliance is possible but uncertain due to the factors mentioned above. This is also the range where additional local measures (e.g., traffic management) have a realistic chance to achieve safe compliance, even under unfavourable conditions. In contrast, compliance is unlikely if computed NO_2 concentrations exceed 45 $\mu g/m^{3.}$

On this basis, it is estimated that the number of air quality management zones in the EU-28 where compliance with the current limit values is unlikely will decline from about 100 zones (21%) in 2010 to 38 zones (8%) in 2020 under baseline conditions (for this, 500 zones have been considered). However, this estimate is conservative as it does not consider benefits from local measures (e.g., traffic management or low emission zones), which could be quite effective for reducing the large share of NO_2 from near-by emission sources.

Conversely, in 2020 safe compliance will be achieved in 80% of the zones, compared to 63% in 2010 (Table 3). Obviously, by 2020 Europe will not fully reach the ultimate target of bringing all Europe in compliance. However, as shown in Figure A5.2, Europe will be on track towards such a target, with non-compliances rapidly decreasing following fleet renewal. For the baseline projection, which does not consider additional local measures, the number of non-compliance zones is estimated to decline to 13 in 2025 and five in 2030 (Figure A5.3). The additional measures of the MTFR scenario could eliminate 99% of the robust non-compliance cases.

Figure A5.2: Compliance with air quality limit values for NO_2 in the air quality management zones

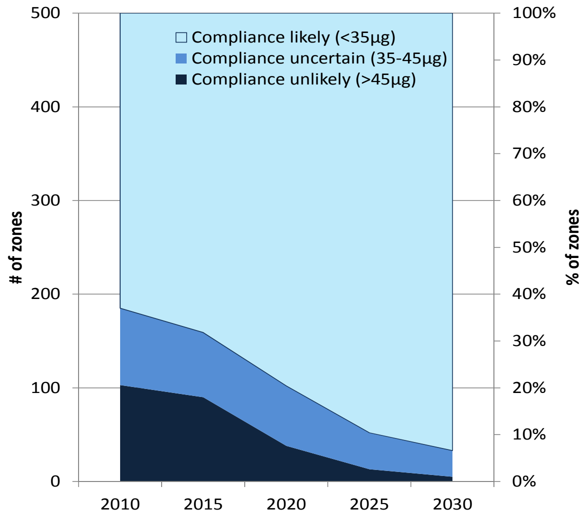


Figure A5.3: Compliance with air quality limit values for NO_2 in the air quality management zones

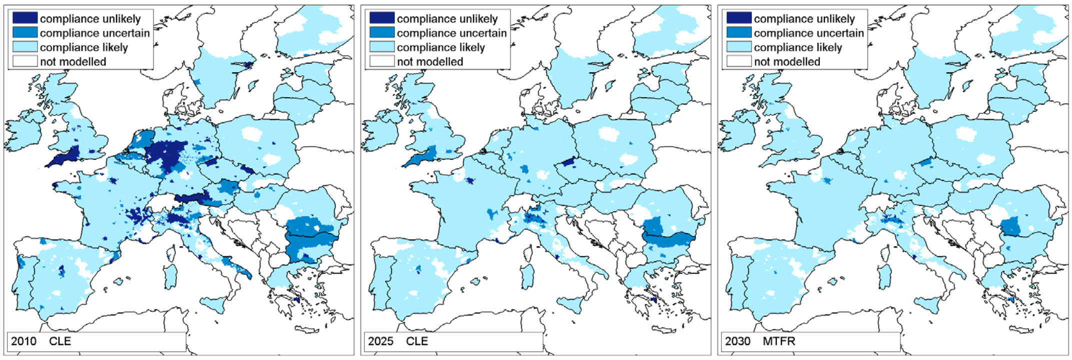


Table A5.7: Compliance with NO_2 limit values (number and % of zones). Note that this calculation does not include effects of additional local policies, such as low-emission zones.

	Compliance					
	unlikely	uncertain	likely	unlikely	uncertain	Likely
2010	103	82	315	*21%*	*16%*	*63%*
2020	38	64	398	*8%*	*13%*	*80%*
2025	13	39	448	*3%*	*8%*	*90%*
2030	5	28	467	*1%*	*6%*	*93%*
2030 MTFR	4	22	474	*1%*	*4%*	*95%*

Table A5.8: Population living in air quality management zones with different compliance with the NO_2 limit values (million people, % of European population)

	Compliance					
	unlikely	uncertain	likely	unlikely	uncertain	likely
2010	124.6	63.3	238.6	*29%*	*15%*	*56%*
2020	68.7	55.6	302.1	*16%*	*13%*	*71%*
2025	30.8	49.7	345.9	*7%*	*12%*	*81%*
2030	8.9	48.0	369.5	*2%*	*11%*	*87%*
2030 MTFR	8.1	33.5	384.7	*2%*	*8%*	*90%*

5.2 Compliance with PM10 limit values

For PM10, the limit on 35 allowed daily exceedances of 50 μg/m^3 is more difficult to attain than the annual mean limit value of 40 μg/m^3. However, there is a strong linear correlation between the 36th highest daily values and the annual mean concentrations, both in observations and model results. As an annual mean of 30 μg/m^3 corresponds well to the 36th highest daily concentration of 50 μg/m^3, this threshold is used as the criteria for the GAINS modelling, which is conducted on an annual mean basis. As for NO_2, uncertainty ranges of ±5 μg/m^3 are employed.

For the 516 zones for which sufficient monitoring data are available, it is calculated that in 2010 about 60 zones (12%) did not comply with the PM10 limit value. The decrease in precursor emissions of the TSAP-2013 Baseline should halve this number to about 30 by 2020 (Figure A5.4). As for NO_2, this estimate does not consider additional measures at the urban scale, which could achieve further improvements.

However, in contrast to NO_2, the TSAP-2012 baseline does not suggest additional reductions beyond 2020. Remaining problems will prevail in the new Member States where, due to continued reliance of solid fuels for domestic heating, only little further declines in the emissions from the domestic sector are anticipated.

Technical emission control measures, together with the switch to cleaner fuels and/or to centralized heating systems could bring down PM10 concentrations below the limit value also in urban areas in the new Member States. The third panel in Figure A5.5 illustrates the MTFR case that does not assume additional expansion of central heating systems.

Figure A5.4: Compliance of the air quality management zones with air quality limit values for PM10

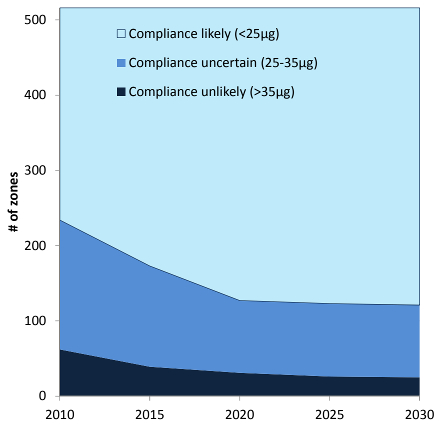


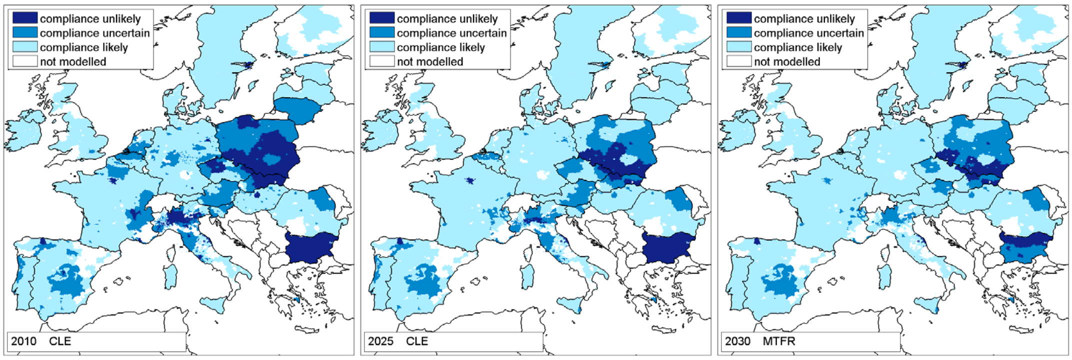
Table A5.9: Compliance with PM10 limit values in 2025 (number and % of zones)

	Compliance					
	unlikely	uncertain	likely	unlikely	uncertain	likely
2010	62	172	282	12%	33%	55%
2020	31	96	389	6%	19%	75%
2025	26	97	393	5%	19%	76%
2030	25	96	395	5%	19%	77%
2030 MTFR	17	56	443	3%	11%	86%

Table A5.10: Population living in air quality management zone with different compliance with PM10 limit values (million people, % of European population)

	Compliance					
	unlikely	uncertain	likely	unlikely	uncertain	likely
2010	81.3	132.0	213.5	19%	31%	50%
2020	48.8	85.3	292.7	11%	20%	69%
2025	39.5	92.6	294.6	9%	22%	69%
2030	40.3	86.8	299.7	9%	20%	70%
2030 MTFR	21.4	74.1	331.3	5%	17%	78%

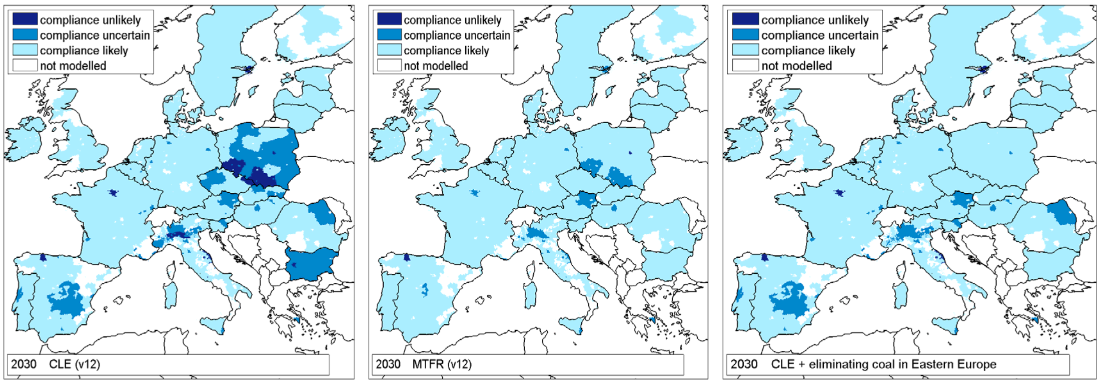
Figure A5.5: Compliance with the air quality limit values for PM10 in the air quality management zones



Alternatively to the MTFR, a hypothetical scenario assuming a complete switch of coal and biomass domestic heating to natural gas starting 2020 in four countries: Poland, Czech Republic, Slovakia and Bulgaria, which are the countries with largest projected compliance problems for PM10, where domestic solid fuel combustion plays a significant role.

Figure A5.6 compares the 2030 current legislation baseline (CLE) case with the MTFR and with the domestic solid fuel phase out case in the four countres mentioned. Furthermore, this simulation assumes that 75% of the unexplained PM2,5 component in the four countries is related to domestic solid fuel combustion[307].

Figure A5.6: Compliance with the air quality limit values for PM10 in the air quality management zones in 2030 for the CLE, MTFR and domestic coal phase-out scenarios. 75% of unexplained component linked to doemstic heating is assumed



The results confirm that eliminating the most polluting domestic sources would be able to resolve almost entirely the PM non-compliance problems even in the currently most affected areas. Once reasonable assumptions are made for the linkage between domestic heating and the fraction of PM concentrations that models cannot explain with existing emission inventories, it becomes apparent that -even without fuel switching- the application of state-of-

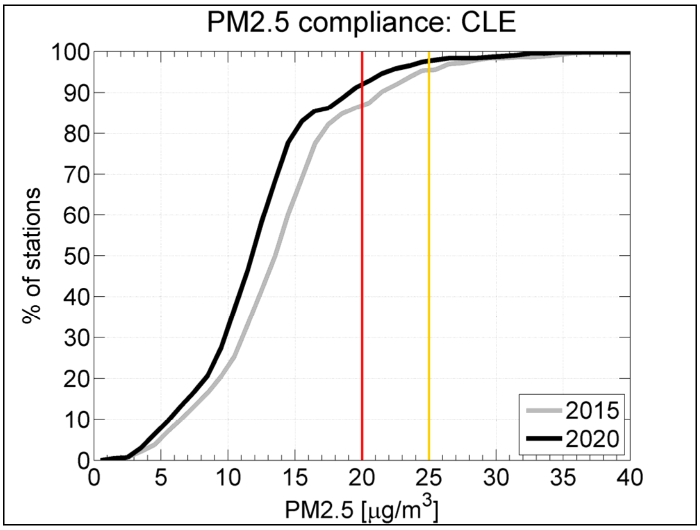
307 Explaining the high observed PM10 concentrations in regions such as Southern Poland poses a considerable challenge to CTM models even with the most recent gridded emission inventory. Concentrations of 50-60µg/m3 annual mean are measured at several background stations in this area, and state of the art models in many cases can only explain less than 50% of these concentrations. From the annual cycles of observed concentrations (closely following temperature-heating cycles) and from evidence provided by local experts to IIASA, it is highly likely that roughly 75% of the unexplained component be linked to combustion of solid fuels not reported in the inventories.

the-art solid fuel combustion techniques would be able to resolve the majority of non-compliance situations related to domestic solid fuel use.

5.3 Compliance with PM2,5 standards

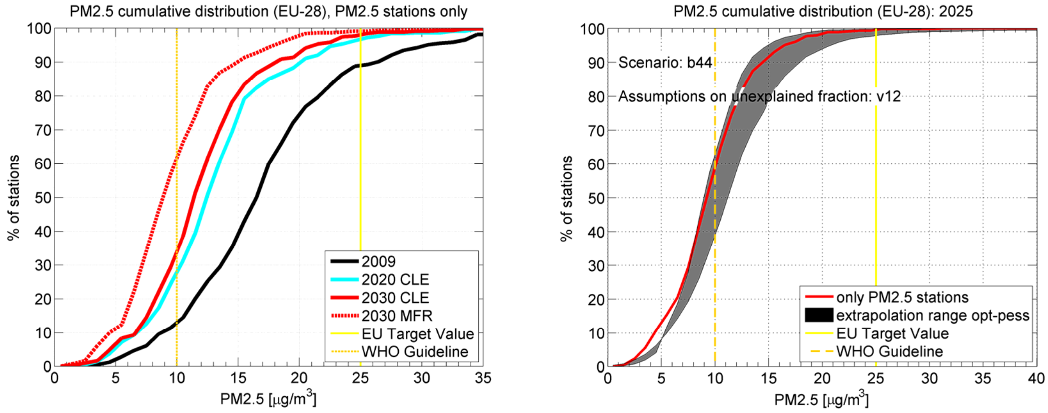
For PM2,5, the 25 µg/m^3 target value will become a binding limit value. For $PM_{2.5}$ the baseline projections show very high projected compliance in 2015 (Figure A5.7), with around 96% of stations meeting the standard. The AAQD provides for the tightening of the $PM_{2,5}$ LV from 25 to 20 µg/m^3 in 2020, subject to feasibility; 99% of stations would comply with the 25 µg standard but only 92% of them with the tighter 20 µg standard. Note that even the 20 µg standard is well above the WHO guideline value of 10µg/m^3.

Figure A5.7: Projected compliance with PM 2.5 limit values (2015 and 2020)



With a view to examining the range of PM2,5 limit values that could be set and ralistically enforced furhter in the future, Figure 0.11 shows the projected compliance picture further in the future; the left panel shows that in 2009 almost 90% of stationswere below 25 µg/m^3 and only 10% below the WHO guideline value of 10 µg/m^3. The situation is projected to gradually improve up to 2030, when 99% of stations would be below 25 µg/m^3 and 35% below the WHO guidance value. The MTFR would be able to bring 60% of stations below the WHO guidance value. The right panel shows the compliance situation projected for policy option 6C, taking into account also the uncertainty range due to possible different assumptions on the fraction of PM2,5 concentration that is not explained by CTM modelling. Under this case, the 25 µg/m^3 limit value would be safely met virtually by all stations. A tighter LV of 20 µg/m^3 would be complied with by 94-99% of stations. The uncertainty range progressively increases, with 80-96% of stations below 15 µg/m^3 and 40-65% below 10 µg/m^3.

Figure A5.8: Projected compliance with PM 2.5 limit values in: [LHS] 2009, 2020 (CLE), 2030 (CLE) and 2030 (MTFR); and [RHS] 2025 for option 6C. In the latter case, the uncertainty range is related to assumptions for the component unexplained by CTM modelling



6. FUTURE AIR POLLUTION IMPACTS UNDER THE BASELINE SCENARIO

6.1 Health impacts from PM2,5

The decrease in the precursor emissions of ambient PM2.5 of the TSAP-2013 Baseline projection suggests a decline of the loss of statistical life expectancy attributable to the exposure to fine particulate matter (PM2.5) from 8.5 months in 2005 to 5.3 months in 2025. However, in Belgium, Poland, the Czech Republic, Hungary and Romania people would still lose more than six months even in 2030 (See Annex 7 Appendix).

It is noteworthy that the PRIMES2012-3 baseline results in larger future health impacts compared to the PRIMES2010 baseline, mainly due to higher primary emissions of PM2.5 from expanded biomass combustion in small installations. Thereby, higher primary PM2.5 emissions compensate the benefits from lower precursor emissions of secondary PM2.5, i.e., SO_2, NO_x, NH_3 and VOC.

With the additional technical measures that could be implemented within the EU, life shortening could be further reduced by up to 1.4 months, or by 2030 down to about 3.6 months on average.

Overall, despite implementation of current emission control legislation, population in the EU-28 would still lose between 200 and 220 million years of life after 2020 (See Annex 7 Appendix). The additional measures could gain approximately 60-70 million life years.

Figure A5.9: Loss in statistical life expectancy from exposure to PM2.5 from anthropogenic sources; top: 2005, mid: 2025 CLE, bottom: MTFR 2030

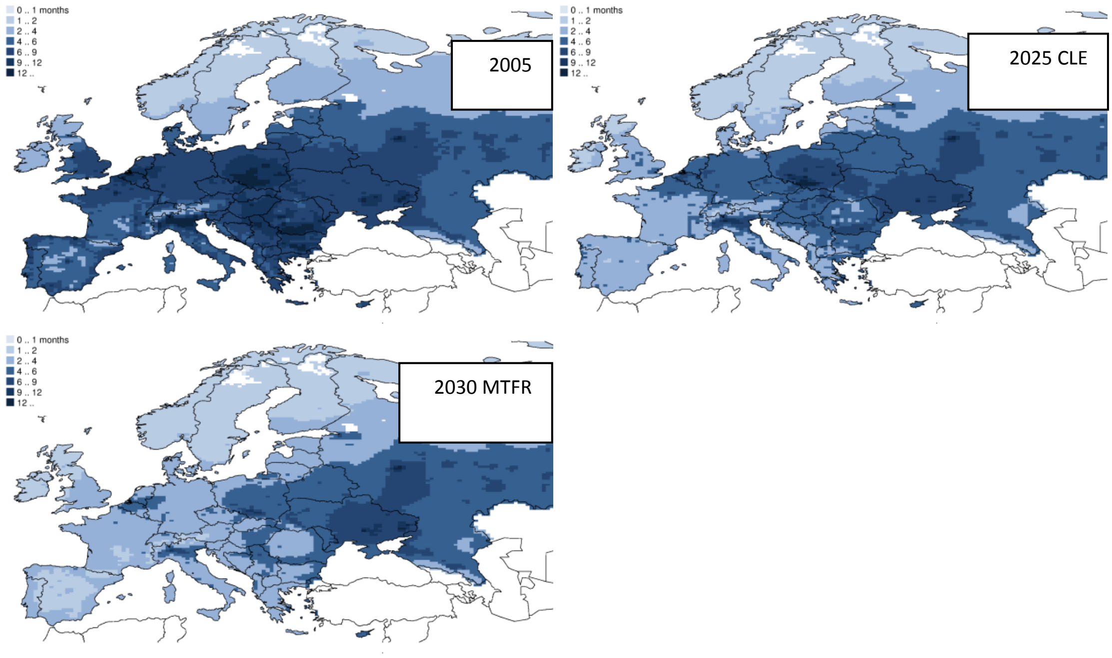
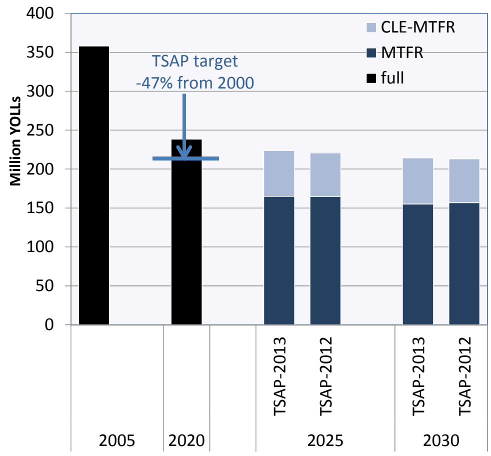


Figure A5.10: Years of life lost (YOLLs) due to exposure to fine particulate matter, EU-28



Despite progress, the TSAP-2013 Baseline would not meet the environmental target for health impacts from PM that has been established in the 2005 Thematic Strategy on Air Pollution for 2020. Instead of the 47% improvement in years of life lost (YOLL) relative to 2000, the current legislation case of the TSAP-2013 would reach only a 45% reduction.

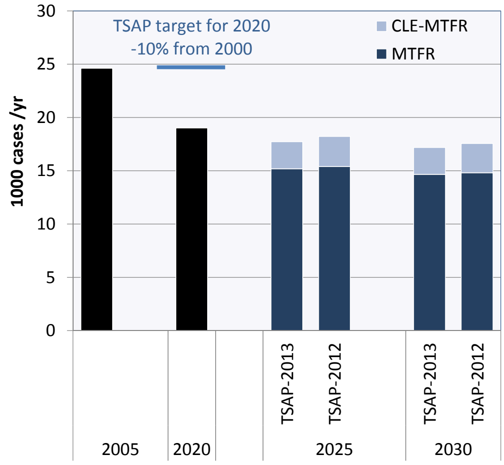
6.2 Health impacts from ground level ozone

The TSAP-2013 Baseline suggests for 2025 approximately 18,000 cases of premature deaths from exposure to ground-level ozone in the EU-28 (Figure A5.11). This is safely below the 10% reduction target (25,000 cases) that was established by the 2005 Thematic Strategy on

Air Pollution for 2020 relative to 2000, mainly due to more optimistic expectations on the development of hemispheric background ozone levels.

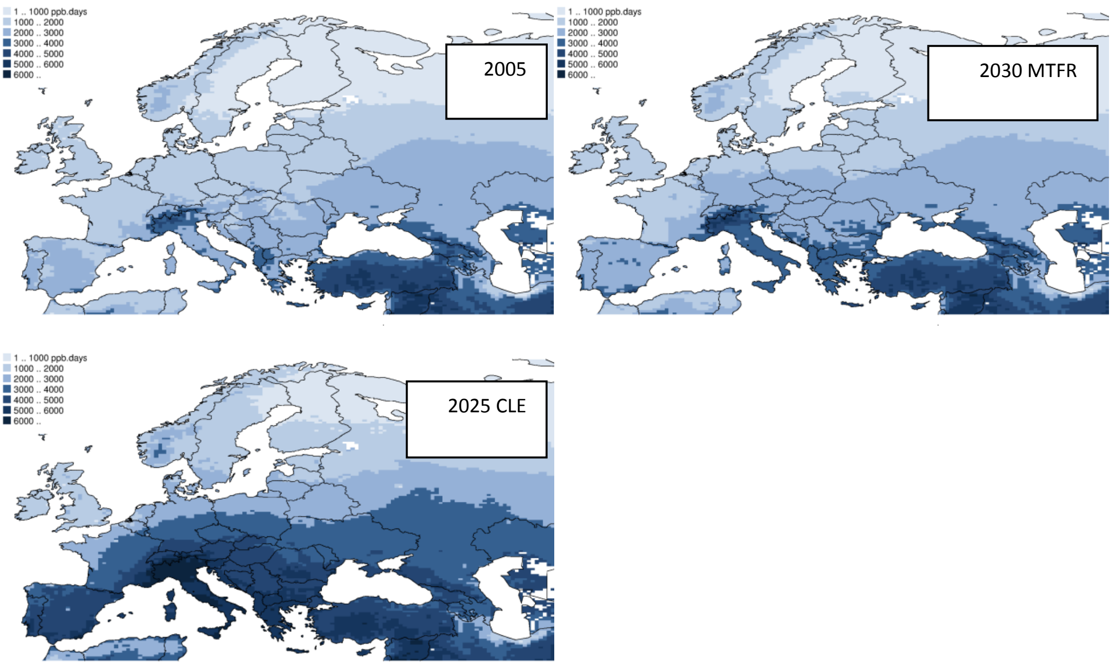
Additional emission reduction measures within the EU-28 could save another 2,500 cases of premature deaths.

Figure A5.11: Cases of premature deaths due to exposure to ground-level ozone, EU-28



The spatial pattern of the health-relevant SOMO35 indicator, and how this will be influenced by the different emission reduction scenarios, is presented in Figure A5.12

Figure A5.12: The SOMO35 indicator that is related to premature mortality from ground-level ozone

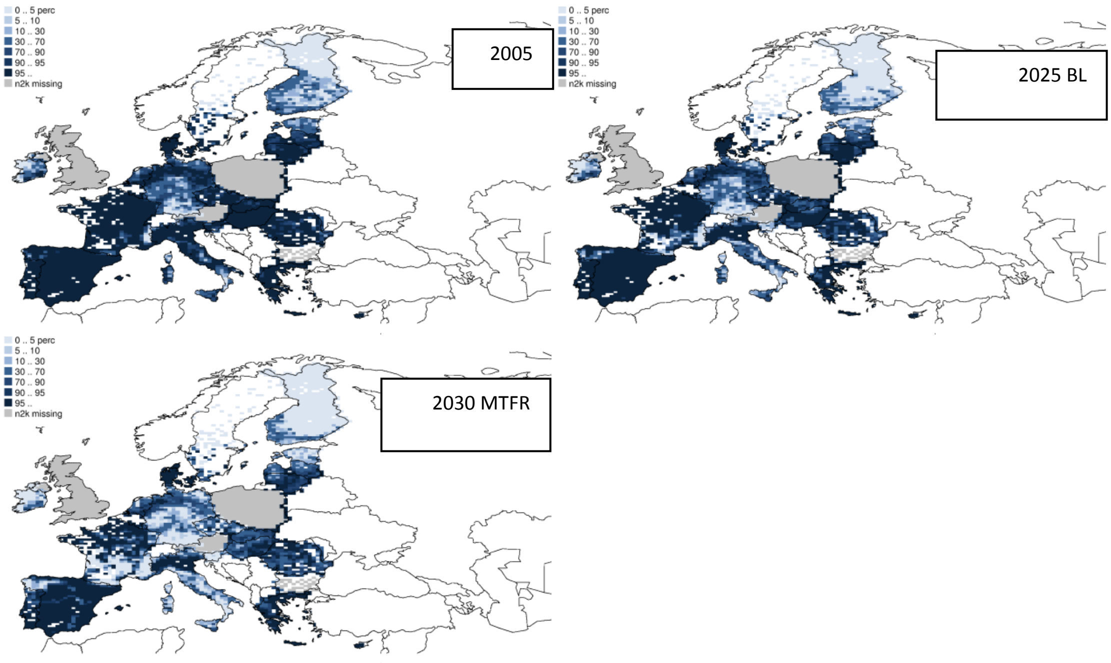


6.3 Eutrophication and biodiversity

Threat to biodiversity of Natura2000 areas

In addition to fragmentation and climate change, excess nitrogen deposition constitutes an important threat to biodiversity in areas that are protected under the Birds Directive and the Habitat Directive (i.e., Natura2000 areas).

Figure A5.13: Percentage of Natura2000 areas with nitrogen deposition above their critical loads for eutrophication. Top: 2005, mid: 2025 CLE, bottom: MTFR 2030



For 2005, it is calculated that biodiversity was under threat from excess nitrogen deposition in 77% (423,000 km^2) of the protected zones. By 2025, the expected declines in NO_x emissions would reduce the threatened area to 62%, leaving 343,000 km^2 unprotected. By 2030, full application of the available reduction measures, especially for ammonia emissions, could provide protection to another 95,000 km^2 of the nature protection areas in Europe (See Annex 7 Appendix).

Threat to biodiversity of all ecosystems

In 2005, more than 1.1 million km^2 (i.e., 66%) of the European ecosystems were exposed to nitrogen deposition that exceeded their critical loads for eutrophication. The future development will be mainly influenced by the fate of NH_3 emissions. In 2025, the TSAP2013 Baseline would reduce the area under threat to about 0.9 million km^2, while higher NH_3 emissions in the TSAP-2012 Baseline would leave about 0.94 million km^2 unprotected. The available additional emission reduction measures could safeguard another 180,000 to 200,000 km^2.

Due to less progress in the reduction of NH_3 emissions than anticipated, the TSAP-2013 Baseline would fail to meet the environmental targets for eutrophication that have been established in the 2005 Thematic Strategy on Air Pollution for 2020. Instead of the 31% improvement in ecosystems area with nitrogen deposition above critical loads for eutrophication relative to 2000, the current legislation case of the TSAP-2013 would achieve only a 24% reduction (Figure A5.14).

Figure A5.14: Ecosystems area with nitrogen deposition in excess of the critical loads for eutrophication, EU-28

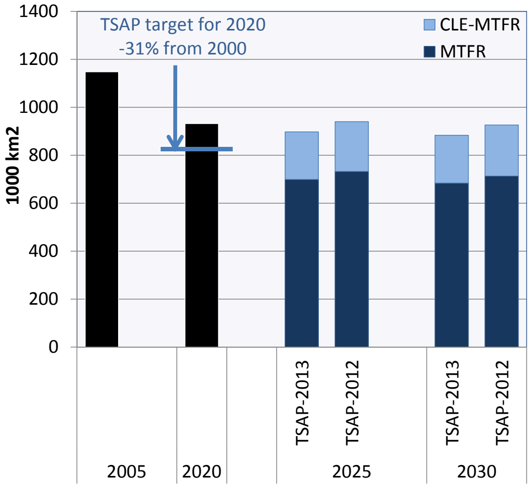
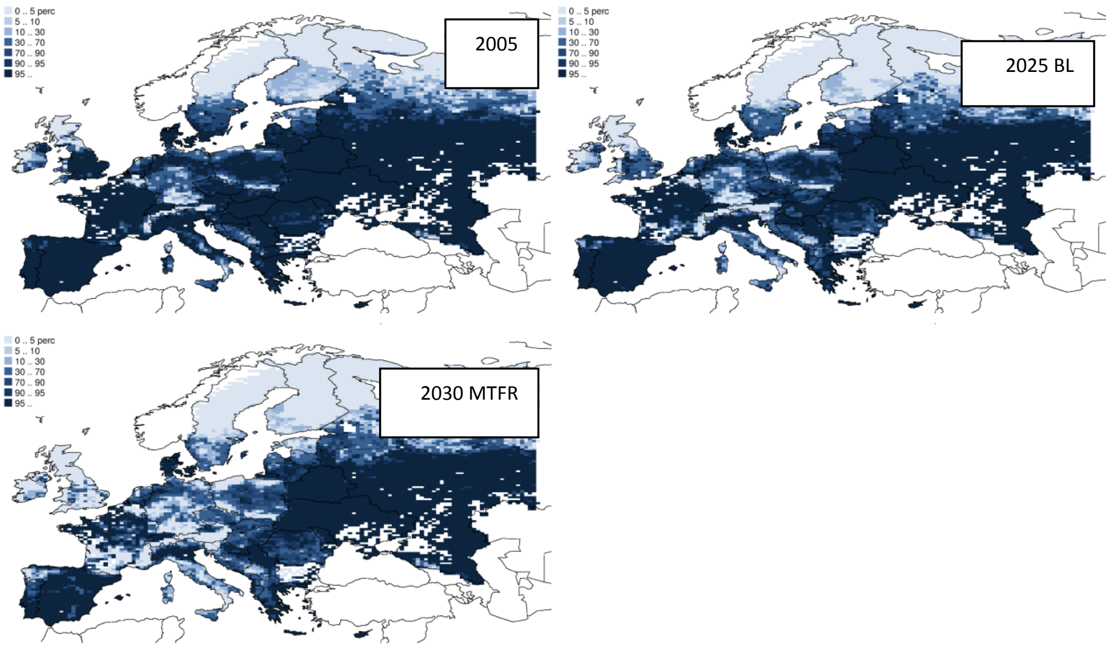


Figure A5.15: Percentage of ecosystems area with nitrogen deposition above their critical loads for eutrophication.

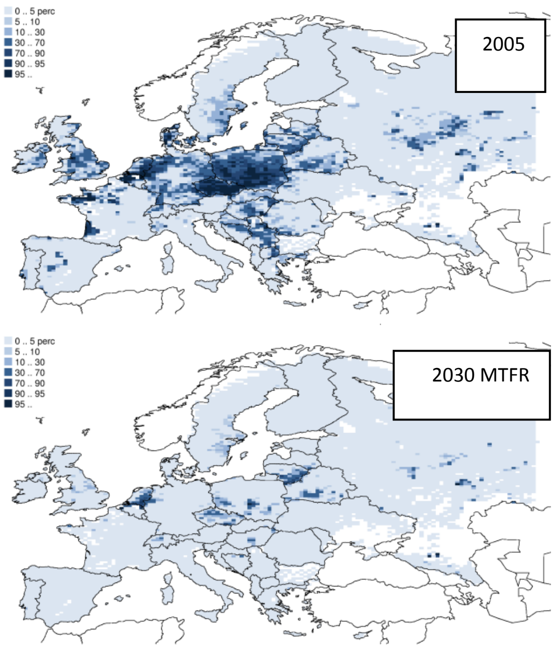


6.4 Acidification

Acidification of forest soils

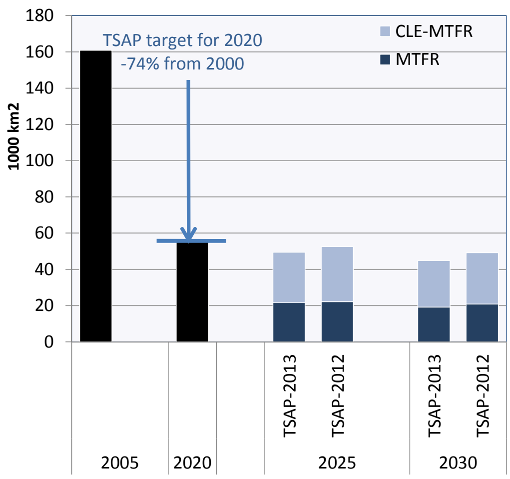
With the 2012 data set on critical loads (Posch et al. 2011), it is calculated that in 2005 critical loads for acidification have been exceeded in a forest area of 160,000 km^2, i.e., in about 12% of the forests within the EU-28 for which critical loads have been reported.

Figure A5.16: Percentage of forest area with acid deposition above the critical loads for acidification. Top: 2005, mid: 2025 CLE, bottom: MTFR 2030



Especially the anticipated further decline in SO_2 emissions will resolve the threat for another 110,000 km^2 up to 2025. Additional measures could provide sustainable conditions for another 30,000 km^2 up to 2030, and leave only 0.45% of European forests threatened by acidification (See Annex 7 Appendix). These measures would especially benefit the former ‘black triangle’ (i.e., in Poland, Czech Republic and the eastern parts of Germany), while residual problems would remain in the Netherlands due to high ammonia density. Thereby in 2020, the Baseline would achieve the 74% target for acidification of the TSAP 2005 (Figure A5.17).

Figure A5.17: Forest area with acid deposition in excess of the critical loads for acidification, EU-28



ANNEX 6 ELEMENTS OF A FUTURE EUROPEAN CLEAN AIR PROGRAMME TO SUPPORT MEMBER STATE ACTION ON REDUCING AIR POLLUTION

1. INTRODUCTION

The ex-post analysis of the present EU air quality policy framework assessed in detail the reasons for the outstanding compliance issues with respect to the AAQD and NECD. The analysis is documented in detail in Annex 4 with projections underpinning the compliance prospects further developed in Annex 5. The main conclusions are brought forward in Chapter 3 of the main impact assessment report.

In addition to a number of pollutant specific drivers of the problems, a number of drivers causing the outstanding were attributed to "governance" related issues, including the lack of capacity to effectively assess local air pollution problems and manage them efficiently and the scope for increasing synergies between national and local air pollution management efforts driven respectively by the NECD and the AAQD. The following key areas merited further attention (see in particular the description of options in Chapter 5.1):

- Enhanced capacity building for "local" air quality assessment and management to enable developing and implementing better targeted and cost-effective air pollution reduction strategies and policies for the purpose of reaching compliance and avoiding penalties resulting from ongoing infringement cases;
- Fostering enhanced synergies between local and/or national air quality management and other relevant plans developed and implemented at the national and/or local level (e.g. on climate change mitigation, sustainable energy, mobility, and urban development);
- Broadening the toolbox available to national and local authorities for assessing and managing air pollution and supporting best practice exchange nationally and across the EU (notably related to urban AQ management);
- Fostering enhanced public awareness, participation, and support for national and local action on air pollution, including the marketing and sales of "green" products;

It was suggested in Chapter 5 that the above actions could be usefully grouped into a future European Clean Air Programme also for the purpose of engaging all relevant bodies involved in implementing air quality measures. Considering the specific target groups, these actions are regrouped as follows:

- Action to improve the urban air quality
- Action to abate ammonia emissions
- Action at EU level to promote exchange of good practice and broaden the air quality management tool box
- Action at international level

It is furthermore noted that addressing the governance related issues hampering full compliance by 2020 will also benefit the proper implementation of the policy framework defined for the period beyond 2020 (as described in Chapter 6) inter alia by offering a platform for early action and dedicated stakeholder consultations.

2. ACTION TO IMPROVE THE URBAN AIR QUALITY

Many of the air quality-related problems are related to and concentrated in urban "hotspot areas", i.e. areas with a dense population, high levels of economic activity, and intense traffic. To address the challenges facing these areas, a combination of action is needed at all policy levels.

2.1. Action better identify and address key air pollution sources in urban areas

Based also on the outcome of the Air Implementation Pilot, and effective urban clean air action programme would include the exchange of good practice and, where appropriate, the development of common guidelines, for the following components:

- High quality and comparable local emission inventories, including enhanced synergies with the national emission inventories;
- High quality monitoring networks, including deriving the maximum information from existing networks;
- Source apportionment, i.e. the identification of key pollutant sources contributing to the air quality exceedances (based on matching emission inventories and monitoring data and using models to map the relative importance and abatement potential)
- Emission and air quality forecasting tools capable also ex-ante cost-effectiveness analysis;
- Air pollution abatement options applied across European (and possibly international) urban areas, including technical and non-technical costs and benefits;
- Integrated cost-benefit analysis integrating national and local conditions based on better understood trends in transboundary air pollution levels;
- Enhanced public information, including the development of harmonized and easy to understand air quality indexes to promote greater public awareness and guiding purchase decisions;

Enhanced capacity in these areas would serve to better integrate (and monitor) air quality consideration in other policy initiatives notably in the field of sustainable mobility and energy at national and local level. It could help assessing the air quality related benefits (or needs) related to upgrading (retrofitting) municipal transport fleets, plans for promoting alternative means of transport including cycling and walking as well as the roll out of e-mobility initiatives. It could furthermore help developing (more) effective low emission zones combined with road pricing schemes or access restrictions, optimized inter-modality plans, etc.

EU level support would be built around the new integrated projects foreseen under the new LIFE regulation which would also offer better access to other EU funds for more targeted action such as fuel switching programmes in certain particularly challenging areas in the EU.[308]

Project-based initiatives would be supported by horizontal services including the regular hosting of EU-wide platforms for reviewing progress, exchange of good practice, and identifying common challenges and solutions. Horizontal services could also deliver common

[308] The Partnership Agreements with Member States on priorities for the ‘big five’ EU funding instruments include a strong air quality component. Several Member States with particular air quality problems often have favourable access to structural funds (in terms of co-financing rate), and these funds can have an instrumental role in tackling urban air quality problems, e.g. by promoting fuel switching to reduce pollution from the domestic combustion sector.

guidelines in other fields than those mentioned above such as guidelines for air-quality-related retrofit programmes (possibly also including certification standards for practitioners); Voluntary programmes identifying and supporting the uptake of "Super Ultra Low Emission Standards" (SULES) to further limit emissions from industrial activities, vehicles, and heating appliances emission heaters, as a voluntary tool for national and local authorities to help achieve compliance with EU air quality legislation, and at the same time promote technical innovation, etc.

2.2. Action to improve the governance of air quality management at national and EU level

A major cause behind non-compliance has been attributed to poor or lacking co-ordination between the various levels of government whose actions affect air pollution. For example, national vehicle taxation policies have brought about the preponderance of diesels which – emphasized by the real world emissions problem for the Euro standards – has made it more challenging to reach the NO2 air quality standards. For particulates, more than half of concentrations in many locations can be due to pollution from outside the urban borders which makes it challenging to adequately address the situation without effective co-ordination of policies and measures at national level.

Eligibility for EU support of integrated programmes could be made subject to commitments made by the various national governance level in the Member States to tackle air pollution in a more integral and coherent way, including also appropriate arbitrage platforms to ensure that local air quality management needs are taking into account at regional and national level. Such provisions could also be made part of an amended NECD.

3. ACTION TO ABATE AGRICULTURAL AIR POLLUTION EMISSIONS

One of the main conclusions drawn from the ex-post evaluation of EU air quality policy is the need to give higher priority abating emissions from the agricultural sector, notably related to ammonia where there is a large untapped potential for cost-effective action.

Focal areas would include emission reductions from livestock manures during various stages of the animal production and manure management chains linked to animal feeding, manure management, manure storage systems and manure application to crop land, as well as inorganic fertilizer application (especially from urea-based nitrogen fertilizers).

Advanced ammonia abatement methodologies are available and have been tried and tested for many years, but have yet to be applied at a wider scale. Costs incurred are often offset by the combined benefits to the farmer, such as increased nitrogen use efficiency, whereby nutrients are taken up by the crops rather than emitted to the air, reduced need for costly mineral fertilizers, improved agronomic flexibility, reduced emissions of other environmental pollutants, a healthier working environment for the farmer, and limited odours. While some Member States have taken the lead by developing national standards and good practice, others have done little to address the issue as yet. At EU level, ammonia emissions are largely unregulated, and support measures through the Common Agricultural Policy have so far been limited. To further reduce ammonia emissions in future, the following elements for action will be instrumental.

- Formulation of national emission reduction potential and emission reduction options available (also for the purpose of assisting implementation of the ammonia ceilings contained in a revised NECD);

- Listing cost-effective source control measures to abate ammonia emissions from agriculture and assessing them in a national context, including their impacts on urban air quality challenges. Defaults options could include manure management options (storage, application techniques), feeding strategies, animal housing, fertilizer management (e.g. urea substitution), and balanced fertilization through national nitrogen budgets, extending nitrate vulnerable zones under the Nitrates Directive and/or applying the same rules outside designated nitrate vulnerable zones,

Horizontal support at EU level could entail the hosting of regular sector specific exchange platforms (e.g. a Agriculture Clean Air Forum) that could form the basis for discussing possible regulatory or quasi regulatory option including a review and update of the existing Best Available Techniques (BAT) Reference Document for pigs and poultry under the IED by 2014, including the adoption of new BAT Conclusions, consideration of appropriate labelling provisions as well as requirements for urease inhibitors in the context of the on-going revision of the Fertilizers Regulation, regulation of manure management on the basis of the conclusions and recommendations from a recent study on the collection and analysis of data for the control of emissions from the spreading of manure.

Initiatives would be linked to relevant initiatives and funding opportunities under the new Common Agricultural Policy, notably for those related to food production, sustainable management of natural resources and climate action, and balanced territorial development.

4. ACTION AT INTERNATIONAL LEVEL

EU air quality is largely influenced by emission sources outside the EU, and to achieve the long-term air quality objectives to protect human health and the environment, future international cooperation to reduce air pollution outside the EU and to and address short-lived climate pollutants (SLCP) is of crucial importance to limit background and hemispheric air pollution in the EU.

The regional cooperation in Europe and North America on air pollution has a long history, with the 1979 UNECE Convention on Long Range Transboundary Air Pollution (CLRTAP) providing the main framework. Early work was focussing on improving and coordinating air pollution research and monitoring, but over the last few decades a range of legally binding multilateral agreements and protocols have been agreed that set out reduction measures and cap national air pollution emissions. More recently, the CLRTAP has also reached out to other regional initiatives and frameworks, particularly in Asia.

In order to enhance international cooperation to reduce emissions from EU neighbouring countries and regions, future work should focus on the following elements for action.

- Broadening ratification of the (new) amended Gothenburg Protocol and supporting neighbouring countries with the implementation of the new Gothenburg Protocol by enabling targeted technical assistance by the CLRTAP secretariat, subsidiary groups, EMEP, and International Cooperate Programmes and promoting bilateral and multilateral development and cooperation programmes in the EECCA countries, in particular those under development and assistance programmes under EU neighbourhood policy, such as the EU Air Quality Governance Project (http://www.airgovernance.eu).
- Improve the global cooperation on air quality, incuding through information sharing platforms such as Global Atmospheric Pollution Forum (GPF) under the International Union of Air Pollution Associations, the UNEP Climate and Clean Air Coalition

(CCAC), the Global Methane Initiative (GMI), the Task Force on Hemispheric Transport of Air Pollution (TF HTAP) under the CLRTAP, and the World Health Organization (WHO)

- Promote further action on air quality within the IMO and the newly established the European Sustainable Shipping Forum focusing in particular on full and rapid implementation of the new sulphur standards in existing and possibly new Sulphur Control Areas, the creation of Nitrogen Emission Control Areas in the EU regional seas, Monitoring, Reporting and Verification of key air pollutants (SOx, NOx and PM), possibly also the establishment of an EU NOx Fund or maritime shipping to promote rapid uptake of abatement technologies.
- Further developing bilateral cooperation on air pollution with key EU trading partners including the United States' Environmental Protection Agency (EPA), Japan, and China.

ANNEX 7 ANALYSIS OF POLICY SCENARIOS RELATED TO TARGETS FOR THE PERIOD UP TO 2030

1. EMISSION REDUCTIONS DELIVERED BY THE RESPECTIVE OPTIONS

The measures listed in **Error! Reference source not found.** of chapter 6 would reduce pollutant emissions in different proportions in the various options.

Options 6A and 6B would mostly reduce primary PM emissions, SO2 and ammonia and rely only to a lesser extent on measures reducing NOx and VOCs; while deeper cuts in emissions of these two pollutants are delivered by options 6C and 6D.

These qualitative conclusions equally hold for emission reductions in 2025 and 2030.

Table A7.1: Emission reductions by pollutant delivered by the options for post 2020. Percentage changes vs year 2005 and Option 1.

2025			6A			6B			6C			6D		
	2005	Option1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1
SO2	8172	2446	2188	-73%	-11%	1903	-77%	-22%	1694	-79%	-31%	1593	-81%	-35%
NOx	11538	4616	4535	-61%	-2%	4484	-61%	-3%	4096	-64%	-11%	3525	-69%	-24%
PM2,5	1647	1266	1059	-36%	-16%	960	-42%	-24%	844	-49%	-33%	690	-58%	-46%
NH3	3928	3658	3390	-14%	-7%	3122	-21%	-15%	2767	-30%	-24%	2566	-35%	-30%
VOC	9259	5604	5322	-43%	-5%	5157	-44%	-8%	4648	-50%	-17%	3308	-64%	-41%
2030			6A			6B			6C			6D		
	2005	Option1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1	KT	vs 2005	vs opt1
SO2	8172	2211	1999	-76%	-10%	1720	-79%	-22%	1510	-82%	-32%	1383	-83%	-37%
NOx	11538	4051	3970	-66%	-2%	3921	-66%	-3%	3544	-69%	-13%	2947	-74%	-27%
PM2,5	1647	1200	994	-40%	-17%	904	-45%	-25%	802	-51%	-33%	607	-63%	-49%
NH3	3928	3663	3375	-14%	-8%	3099	-21%	-15%	2762	-30%	-25%	2568	-35%	-30%
VOC	9259	5460	5199	-44%	-5%	5043	-46%	-8%	4569	-51%	-16%	3191	-66%	-42%

For individual Member States, the associated emission reductions per pollutant in 2025 and 2030 are listed in Appendix 7.1. In the Appendix, % emission reductions are expressed against the 2005 benchmark, since this is the benchmark year for emission reduction commitments in the Gothenburg Protocol.

2. IMPACT REDUCTIONS DELIVERED BY THE RESPECTIVE OPTIONS FOR POST 2020 TARGETS

2.1. Health and environmental impacts

The impact indicators summarising the health and environmental improvements delivered by options 6A-D are presented in table A7.3. As described in chapter 3.5, health impacts due to exposure to particulate matter and to ground-level ozone include both mortality and morbidity effects. Table A7.3 is restricted to the headline effects on premature mortality due to chronic PM effects and to acute ozone effects, while the impact on the full range of health effects is provided in Appendix 7.2.

As well as the 2005 level, the health impacts in 2025 under option 1 are indicated. So, option 6A would lead to a reduction in premature deaths of 21,000 due PM2.5 compared to option 1 (308,000 less 287,000) etc.

Table A7.2: Impact indicators of the options for 2025 and 2030, and compared to 2005. [premature deaths, ozone: cases of premature deaths/yr, eutrophication and acidification: 1000 km2 of forests/ecosystems left unprotected]. Changes refer to year 2005 and to Option 1.

2025			6A			6B			6C			6D		
	2005	Option1		vs 2005	vs opt1		vs 2005	vs opt1		vs 2005	vs opt1		vs 2005	vs opt1
PM2,5-chronic-premature deaths	494000	307000	287000	-42%	-7%	266000	-46%	-14%	245000	-50%	-20%	225000	-54%	-27%
Ozone-acute-premature deaths	24600	17800	17500	-29%	-2%	17300	-30%	-3%	16500	-33%	-7%	15000	-39%	-16%
Eutrophication, unprotected '000 sq Km	1125	885	850	-24%	-4%	814	-28%	-8%	747	-34%	-16%	684	-39%	-23%
Acidification, unprotected '000 sq Km	161	47	37	-77%	-21%	31	-81%	-30%	24	-85%	-45%	20	-87%	-52%
2030			6A			6B			6C			6D		
	2005	Option1		vs 2005	vs opt1		vs 2005	vs opt1		vs 2005	vs opt1		vs 2005	vs opt1
PM2,5-chronic-premature deaths	494000	304000	284000	-43%	-7%	263000	-47%	-13%	243000	-51%	-20%	216000	-56%	-28%
Ozone-acute-premature deaths	24600	17200	17000	-31%	-1%	16800	-32%	-2%	16000	-35%	-7%	14400	-41%	-16%
Eutrophication, unprotected '000 sq Km	1125	870	832	-26%	-4%	794	-29%	-9%	726	-35%	-17%	665	-41%	-24%
Acidification, unprotected '000 sq Km	161	42	33	-79%	-21%	27	-83%	-36%	21	-87%	-50%	18	-89%	-57%

Detailed tables of impacts per MS are presented in Appendix 7.3.

2.2. Economic impacts

The economic analysis is undertaken by setting a constraint (a gap closure of 50%, say) and identifying the least-cost combination of available technical measures to achieve it. The modelling of the constraint also identifies the measures that meet it at least cost, which are then identified in Table A7.2.

At first, each percentage point of reduction is relatively cheap. However, the more ambitious the option is, the more expensive each percentage point reduction becomes (in economic terms, this is a standard marginal abatement cost curve).

Those factors are further analysed with the computable general equilibrium (CGE) model GEM-E3[309] taking into account the interaction between different sectors, the labour and capital markets and foreign trade. This is crucial to understand the full impacts of the direct compliance costs, which are investments as well as operation & maintenance costs, to all parts of the economy. Expenditure on pollution abatement is an economic opportunity for the sectors that produce the required capital goods; on the other hand, higher production costs in the complying sectors are reflected in price increases that reduce the domestic consumption and international competitiveness of the affected products.

[309] www.GEM-E3.net

2.2.1 Direct compliance costs

The direct cost of policy is the annualised investments required in different sectors to install pollution abatement equipment, as well as operation and maintenance (O&M) of that investment. These costs are presented in Tables A7.3 and A7.4 and are compared to the MTFR costs and to the baseline costs deriving from implementation of current pollution control legislation.

Table A7.3: compliance costs per Member state in 2025 by option, expressed in M€ and in % of GDP.

2025	Option 1	*GDP%*	Opt 6A	*GDP%*	Opt 6B	*GDP%*	Opt 6C	*GDP%*	Opt 6D	*GDP%*
Country				*additional*		*additional*		*additional*		*additional*
Austria	1908	*0,53%*	2	*0,00%*	7	*0,00%*	96	*0,03%*	1040	*0,29%*
Belgium	2333	*0,53%*	7	*0,00%*	22	*0,01%*	114	*0,03%*	759	*0,17%*
Bulgaria	1310	*2,73%*	1	*0,00%*	18	*0,04%*	76	*0,16%*	713	*1,49%*
Croatia	411	*0,66%*	1	*0,00%*	7	*0,01%*	34	*0,05%*	408	*0,66%*
Cyprus	140	*0,65%*	0	*0,00%*	0	*0,00%*	1	*0,00%*	48	*0,22%*
Czech Rep.	1912	*0,95%*	5	*0,00%*	18	*0,01%*	118	*0,06%*	1187	*0,59%*
Denmark	1105	*0,38%*	0	*0,00%*	0	*0,00%*	26	*0,01%*	774	*0,26%*
Estonia	298	*1,38%*	0	*0,00%*	0	*0,00%*	5	*0,02%*	323	*1,50%*
Finland	1373	*0,60%*	0	*0,00%*	0	*0,00%*	13	*0,01%*	1006	*0,44%*
France	11880	*0,48%*	15	*0,00%*	59	*0,00%*	375	*0,02%*	7675	*0,31%*
Germany	13741	*0,47%*	23	*0,00%*	169	*0,01%*	835	*0,03%*	5265	*0,18%*
Greece	2030	*0,84%*	1	*0,00%*	32	*0,01%*	81	*0,03%*	1163	*0,48%*
Hungary	999	*0,86%*	2	*0,00%*	19	*0,02%*	93	*0,08%*	652	*0,56%*
Ireland	1044	*0,46%*	0	*0,00%*	2	*0,00%*	22	*0,01%*	456	*0,20%*
Italy	10515	*0,58%*	30	*0,00%*	261	*0,01%*	655	*0,04%*	3841	*0,21%*
Latvia	373	*1,41%*	0	*0,00%*	0	*0,00%*	19	*0,07%*	592	*2,24%*
Lithuania	356	*0,93%*	0	*0,00%*	1	*0,00%*	23	*0,06%*	601	*1,58%*
Luxembourg	196	*0,37%*	0	*0,00%*	0	*0,00%*	3	*0,01%*	41	*0,08%*
Malta	97	*1,24%*	0	*0,00%*	0	*0,00%*	0	*0,00%*	18	*0,23%*
Netherlands	3855	*0,53%*	1	*0,00%*	9	*0,00%*	63	*0,01%*	913	*0,13%*
Poland	9864	*1,90%*	70	*0,01%*	236	*0,05%*	715	*0,14%*	5910	*1,14%*
Portugal	1353	*0,68%*	4	*0,00%*	29	*0,01%*	82	*0,04%*	832	*0,42%*
Romania	2457	*1,47%*	4	*0,00%*	41	*0,02%*	215	*0,13%*	2905	*1,73%*
Slovakia	760	*0,80%*	1	*0,00%*	15	*0,02%*	86	*0,09%*	777	*0,81%*
Slovenia	447	*0,99%*	0	*0,00%*	1	*0,00%*	48	*0,11%*	146	*0,32%*
Spain	7729	*0,55%*	9	*0,00%*	68	*0,00%*	306	*0,02%*	4747	*0,34%*
Sweden	1456	*0,31%*	0	*0,00%*	0	*0,00%*	14	*0,00%*	602	*0,13%*
Un. Kingdom	7229	*0,32%*	45	*0,00%*	187	*0,01%*	511	*0,02%*	3610	*0,16%*
EU-28	87171	*0,56%*	221	*0,00%*	1202	*0,01%*	4629	*0,03%*	47007	*0,30%*

Table A7.4: compliance costs per Member state in 2030 by option, expressed in M€ and in % of GDP.

2030	Option	*GDP%*	Opt 6A	*GDP%*	Opt 6B	*GDP%*	Opt 6C	*GDP%*	Opt 6D	*GDP%*
Country				*additional*		*additional*		*additional*		*additional*
Austria	1983	*0,51%*	2	*0,00%*	7	*0,00%*	88	*0,02%*	1099	*0,29%*
Belgium	2469	*0,52%*	7	*0,00%*	29	*0,01%*	113	*0,02%*	853	*0,18%*
Bulgaria	1212	*2,35%*	1	*0,00%*	18	*0,03%*	55	*0,11%*	752	*1,46%*
Croatia	423	*0,63%*	1	*0,00%*	7	*0,01%*	33	*0,05%*	440	*0,65%*
Cyprus	155	*0,64%*	0	*0,00%*	0	*0,00%*	1	*0,00%*	49	*0,20%*
Czech Rep.	1936	*0,88%*	4	*0,00%*	18	*0,01%*	108	*0,05%*	1269	*0,58%*
Denmark	1117	*0,35%*	1	*0,00%*	1	*0,00%*	12	*0,00%*	814	*0,26%*
Estonia	298	*1,24%*	0	*0,00%*	0	*0,00%*	5	*0,02%*	363	*1,51%*
Finland	1422	*0,58%*	0	*0,00%*	0	*0,00%*	13	*0,01%*	1035	*0,43%*
France	11905	*0,44%*	17	*0,00%*	58	*0,00%*	351	*0,01%*	7783	*0,29%*
Germany	13101	*0,44%*	34	*0,00%*	182	*0,01%*	829	*0,03%*	5576	*0,19%*
Greece	2051	*0,80%*	3	*0,00%*	18	*0,01%*	66	*0,03%*	1241	*0,48%*
Hungary	1061	*0,83%*	2	*0,00%*	19	*0,01%*	93	*0,07%*	695	*0,55%*
Ireland	1177	*0,45%*	0	*0,00%*	1	*0,00%*	19	*0,01%*	516	*0,20%*
Italy	11034	*0,56%*	26	*0,00%*	181	*0,01%*	572	*0,03%*	3950	*0,20%*
Latvia	408	*1,37%*	0	*0,00%*	0	*0,00%*	3	*0,01%*	621	*2,09%*
Lithuania	397	*0,95%*	0	*0,00%*	1	*0,00%*	13	*0,03%*	664	*1,59%*
Luxembourg	204	*0,35%*	0	*0,00%*	0	*0,00%*	3	*0,01%*	45	*0,08%*
Malta	103	*1,20%*	0	*0,00%*	0	*0,00%*	0	*0,00%*	17	*0,20%*
Netherlands	6977	*0,91%*	1	*0,00%*	9	*0,00%*	64	*0,01%*	1517	*0,20%*
Poland	9993	*1,77%*	55	*0,01%*	173	*0,03%*	625	*0,11%*	6849	*1,21%*
Portugal	1495	*0,68%*	4	*0,00%*	16	*0,01%*	69	*0,03%*	922	*0,42%*
Romania	2605	*1,46%*	4	*0,00%*	45	*0,03%*	117	*0,07%*	3010	*1,68%*
Slovakia	826	*0,78%*	1	*0,00%*	15	*0,01%*	86	*0,08%*	852	*0,81%*
Slovenia	467	*0,96%*	0	*0,00%*	1	*0,00%*	44	*0,09%*	147	*0,30%*
Spain	8628	*0,54%*	13	*0,00%*	71	*0,00%*	313	*0,02%*	5131	*0,32%*
Sweden	1484	*0,29%*	0	*0,00%*	0	*0,00%*	15	*0,00%*	635	*0,13%*
Un. Kingdom	7172	*0,29%*	36	*0,00%*	159	*0,01%*	473	*0,02%*	3836	*0,16%*
EU-28	92103	*0,55%*	212	*0,00%*	1032	*0,01%*	4182	*0,03%*	50682	*0,30%*

2.2.2. Affected industries and sectorial impacts

Tables A7.5 and A7.6 show the distribution of compliance costs in 2025 and 2030 for air pollution control in the baseline and in the different policy scenarios based on a technology-oriented classification of emission sources controlled[310].

[310] SNAP: Selected Nomenclature for Air Pollution

Table A7.5: effort required per SNAP sector in 2025 by option, expressed in M€ and in % increase compared to option 1.

2025, EU28	*Option 1*	*Option 6A*		*Option 6B*		*Option 6C*		*Option 6D*	
Costs by SNAP sector (million €/yr, increase compared to baseline)									
Power generation	9561	44	*0,46%*	125	*1,31%*	470	*4,92%*	3519	*37%*
Domestic combustion	9405	74	*0,78%*	497	*5,29%*	1680	*18%*	17791	*189%*
Industrial combustion	2513	19	*0,75%*	156	*6,20%*	641	*25%*	1796	*71%*
Industrial Processes	5017	17	*0,34%*	125	*2,49%*	331	*6,61%*	3964	*79%*
Fuel extraction	695	0	*0,00%*	0	*0,00%*	6	*0,81%*	583	*84%*
Solvent use	1176	1	*0,08%*	2	*0,15%*	56	*4,76%*	12204	*1038%*
Road transport	48259	0	*0%*	0	*0%*	0	*0%*	0	*0%*
Non-road machinery	8760	1	*0,01%*	5	*0,06%*	145	*1,66%*	1451	*17%*
Waste	1	6	*786%*	7	*941%*	9	*1154%*	9	*1203%*
Agriculture	1783	59	*3,33%*	285	*16%*	1292	*72%*	5675	*318%*
Total	87171	221	*0,25%*	1202	*1,38%*	4629	*5,31%*	46992	*54%*

Table A7.6: effort required per SNAP sector in 2030 by option, expressed in M€ and in % increase compared to option 1.

2030, EU28	*Option 1*	*Option 6A*		*Option 6B*		*Option 6C*		*Option 6D*	
Costs by SNAP sector (million €/yr, increase compared to baseline)									
Power generation	7122	36	*0,50%*	99	*1,39%*	436	*6,12%*	3658	*51%*
Domestic combustion	8928	52	*0,59%*	305	*3,41%*	1217	*14%*	19622	*220%*
Industrial combustion	2567	24	*0,93%*	175	*6,81%*	672	*26%*	1850	*72%*
Industrial Processes	5032	17	*0,34%*	125	*2,49%*	334	*6,64%*	4054	*81%*
Fuel extraction	619	0	*0,00%*	0	*0,00%*	5	*0,82%*	556	*90%*
Solvent use	1147	14	*1,20%*	15	*1,28%*	72	*6,25%*	12214	*1065%*
Road transport	52633	0	*0%*	0	*0%*	0	*0%*	0	*0%*
Non-road machinery	12271	1	*0,01%*	5	*0,04%*	146	*1,19%*	3007	*25%*
Waste	1	6	*782%*	7	*938%*	9	*1148%*	9	*1196%*
Agriculture	1784	61	*3,44%*	300	*17%*	1292	*72%*	5711	*320%*
Total	92103	212	*0,23%*	1032	*1,12%*	4182	*4,54%*	50682	*55%*

In option 1, the largest share of compliance costs implied by existing legislation is related to pollution control equipment in the transport sector (more than 50% of total costs), followed by the power sector, the domestic sector[311], non-road machinery and other industries. It is noteworthy that the distribution of additional cost-effective control measures in more stringent pollution control scenarios is very different from the baseline, reflecting the relatively lesser residual potential in sectors that have been more stringently regulated in the past (such as the power sector) and the large untapped potential in other sectors such as agriculture, the domestic sector and solvent applications.

The pollution control expenditure above is expressed in terms of type of activities (combustion, process, etc.) requiring additional investment to abate pollution through technical measures. Further detail on the nature and costs of the technical measures that would be required of individual economic sectors for each of options 6A-6C is provided in Annex 10 (Sectorial impacts and competitiveness proofing).

The costs in tables A7.5 and A7.6 are allocated by type of activity (combustion, solvent use, etc.) but these activities can take place in different economic sectors as defined in national accounts (chemicals, refineries, etc). Table A7.7 presents the costs per economic sector, and Annex 9 provides further analysis of sectorial impacts and their competitiveness implications for each option.

Table A7.7: Effort required per economic sector in 2025 by option, expressed in M€ and in % of sector output. Household expenditure expressed as % of total household consumption. Total cost as % increased compared to option 1 (baseline).

	6A		6B		6C		6D	
Costs by economic sector								
(million €/yr, % of sectorial output, % of total household consumption, or % of EU GDP)								
Agriculture	64	*0,01%*	338	*0,07%*	1425	*0,27%*	5841	*1,12%*
Chemical Products	12	*0,00%*	36	*0,00%*	174	*0,01%*	9111	*0,60%*
Coal extraction	0	*0,00%*	0	*0,00%*	0	*0,00%*	0	*0,00%*
Construction	0	*0,00%*	1	*0,00%*	25	*0,00%*	43	*0,00%*
Consumer Goods Industries	5	*0,00%*	15	*0,00%*	98	*0,00%*	5360	*0,22%*
Oil extraction	1	*0,00%*	1	*0,00%*	1	*0,00%*	6	*0,01%*
Electricity supply	16	*0,00%*	76	*0,02%*	264	*0,07%*	1572	*0,44%*
Ferrous and non-ferrous metals	11	*0,00%*	104	*0,01%*	231	*0,02%*	861	*0,08%*
Market Services	13	*0,00%*	24	*0,00%*	54	*0,00%*	669	*0,01%*
Non Market Services	2	*0,00%*	2	*0,00%*	3	*0,00%*	9	*0,00%*
Refineries	32	*0,01%*	103	*0,04%*	342	*0,13%*	1221	*0,48%*
Other energy intensive	14	*0,00%*	83	*0,01%*	389	*0,03%*	3854	*0,34%*
Transport	0	*0,00%*	3	*0,00%*	19	*0,00%*	60	*0,01%*
Transport equipment	0	*0,00%*	0	*0,00%*	1	*0,00%*	128	*0,01%*
Water Transport	1	*0,00%*	1	*0,00%*	102	*0,05%*	320	*0,15%*
Households	51	*0,00%*	416	*0,01%*	1501	*0,02%*	17937	*0,27%*
Sum	221	*0,00%*	1202	*0,01%*	4629	*0,03%*	46992	*0,31%*

311 The domestic sector includes residential, commercial and institutional activities. The pollution control measures attributed to this sector are improvements to heating appliances. The corresponding expenditure is calculated as the cost premium for the improved appliance compared to the basic type. Note that the pollution abatement costs for private cars (such as the cost of catalytic exhaust systems) are attributed not to the domestic but to the transport sector.

For a 25% gap closure (option 6A) the additional compliance cost is modest and concentrated in the household sector, agriculture and (to a lesser extent) energy intensive industries; for all sectors the additional effort required is less than or of the order of 0,01% of total output. For the 50% and 75% gap closures (options 6B and 6C), households and agriculture remain prominent, but energy intensive industries progressively contribute more. Option 6C (which delivers 75% of the maximum health benefits) requires additional expenditure of 0,27% of the sectorial output in agriculture, 0,13% for refineries, 0,07% for the power sector and much less for all other industries. The effort required of households is 0,023% of their total consumption, on average ca. €3/year per EU citizen.

Option 6D (MTFR) shows a rather different picture, reflecting the fact that all commercially available technical measures are tapped, irrespective of their cost. Highest additional costs are in the chemicals and consumer goods industries (food, clothing, furniture, etc.), related to relatively expensive VOC abatement measures.

2.2.3. Direct economic benefits due to reduced health and environmental impacts

Reducing air pollution delivers substantial direct economic benefits which are summarised in Tables A7.8 and A7.9.

- *Labour productivity gains from reducing the lost working days:* Avoided economic loss from improved productivity alone ranges between €0,7bn and almost €3bn. These can offset by more than a factor 2 the direct emission control expenditure on option 6A, fully compensates it on option 6B, and cover about half those on option 6C.
- *Savings from reduced damage to the built environment:* Benefits due to reduced corrosion and soiling of infrastructure and buildings range between about €53-162M per year in options 6A-6D.
- *Savings from reduced crop losses:* Ground-level ozone damages plants, hampering the growth of trees as well as food crops. The damage to potato and wheat alone is currently estimated at about €2,6bn per year.[312] Emission reductions can reduce this damage by between €61 and 630M per year (options 6A-D). Timber losses are not included.
- *Savings from reduced healthcare costs:* These are evaluated where data are available. However, due to the lack of sufficient data for a number of symptoms (including lower respiratory symptoms, restricted activity days and child morbidity), the estimate is not a full account of overall healthcare costs from air pollution. Even so, the benefits delivered by options 6A-D are substantial, ranging between €219 and 886M per year.

[312] EU27 + CH and NO

Table A7.8: reducing direct economic damage due to air pollution in 2025 options.

2025, EU28	2005	Option 1	Opt. 6A	Opt.6B	Opt. 6C	Opt. 6D
Lost working days, Million	136	82	76	71	65	60
Value of lost working days, M €	17,629	10,651	9,925	9,230	8,514	7,820
% of total labour days lost	0.30%	0.18%	0.17%	0.16%	0.15%	0.13%
Damage to built environment, M €	1,593	503	450	396	358	340
Crop value losses, M €	4,867	2,176	2,114	2,074	1,897	1,545
Respiratory and cardiac hospital admissions	850	641	609	580	542	494
Chronic bronchitis	3,782	2,762	2,574	2,386	2,204	2,023
Total healthcare where quantified	4,631	3,403	3,183	2,966	2,746	2,517

Table A7.9: reducing direct economic damage due to air pollution in 2030 options.

2030, EU28	2005	Option 1	Opt. 6A	Opt.6B	Opt. 6C	Opt. 6D
Lost working days, Million	136	76	71	66	61	55
Value of lost working days, M €	17,629	9,902	9,237	8,594	7,942	7,097
% of total labour days lost	0.30%	0.17%	0.16%	0.15%	0.14%	0.12%
Damage to built environment, M €	1,593	452	408	356	317	293
Crop value losses, M €	4,867	1,985	1,926	1,887	1,716	1,354
Respiratory and cardiac hospital admissions	850	635	605	577	540	483
Chronic bronchitis	3,782	2,668	2,490	2,311	2,139	1,913
Total healthcare where quantified	4,631	3,303	3,094	2,888	2,679	2,396

2.2.4. Broader economic impacts

Direct compliance costs as presented in tables A7.5 and A7.6 are calculated as additional annualised capital and O&M expenditure in the various sectors. Such compliance costs are not to be interpreted as societal costs. This is on the one hand because the investment demand generated represents an economic opportunity for the manufacturers of those investment goods, and on the other hand because the costs of compliance impact production costs and may affect the competitiveness of the affected sectors including at the international level. The analysis needs therefore to take into account:

- Which sectors benefit from expenditure in pollution control by delivering the investment goods, and which other expenditure would be crowded out
- Price effects, and the consequences of price changes for international competitiveness and for consumers.

These aspects were analysed with the CGE model GEM-E3. The required investments and other direct costs per industry were introduced as additional expenditure in the corresponding sectors[313]. Additional benefits in terms of reduced loss of working days are considered and presented separately by proportionately adjusting the labour supply (+0,012 to +0,048% in options 6A to 6D, see table A7.9) in the 'health' case in the table below. Other direct economic benefits such as improved crop yields, reduced healthcare expenditure, and damage to utilitarian buildings were not included in this analysis and are to be considered separately. The results in terms of GDP impact, sectorial output and exports by sector are presented in tables A7.10 and A7.11; the exact figures are for 2025 with the results, being calculated as percentage changes, are –considering also the error margin- not significantly different for 2030.

Table A7.10: GDP and sectorial output change in options, the effects of health benefits to labour productivity are presented seprately as "health"case

	6A		*6B*		*6C*	
Change in sectorial output in the EU28 (2025), and GDP change; % compared to option 1						
	base	*health*	base	*health*	base	*health*
Agriculture	-0,01%	0,00%	-0,06%	-0,04%	-0,22%	-0,20%
Chemical Products	0,00%	0,01%	0,01%	0,03%	0,03%	0,05%
Construction	0,00%	0,01%	0,02%	0,03%	0,07%	0,08%
Consumer Goods Industries	0,00%	0,00%	-0,01%	0,00%	-0,04%	-0,01%
Electric Goods	0,00%	0,02%	0,03%	0,05%	0,10%	0,13%
Electricity supply	0,01%	0,01%	0,02%	0,04%	0,10%	0,12%
Ferrous and non-ferrous metals	0,00%	0,01%	-0,01%	0,02%	0,00%	0,03%
Natural Gas	0,00%	0,00%	0,00%	0,00%	0,01%	0,02%
Market Services	0,00%	0,01%	0,00%	0,01%	0,00%	0,02%
Non Market Services	0,00%	0,00%	0,00%	0,01%	0,00%	0,01%
Petroleum Refining	-0,01%	0,00%	-0,03%	-0,02%	-0,10%	-0,08%
Other energy intensive	0,00%	0,01%	-0,01%	0,01%	-0,02%	0,01%
Other Equipment Goods	0,00%	0,01%	0,02%	0,05%	0,06%	0,11%
Transport	0,00%	0,00%	0,00%	0,01%	-0,01%	0,02%
Transport equipment	0,00%	0,01%	0,01%	0,04%	0,04%	0,09%
GDP	**-0,001%**	***0,007%***	**-0,007%**	***0,009%***	**-0,025%**	***-0,000%***
Direct benefits not included	***0.007%***	***0.002%***	***0.013%***	***0.004%***	***0.020%***	***0.007%***

indicators calculated as relative changes do not differ significantly for 2025 and 2030. Exact figures reported are for 2025.

Excluding health effects on labour productivity (which, together with the other direct benefits of table 18, would be equivalent to 0,020% of GDP), the estimated aggregate GDP impact is very small even on Option 6C, at 0,025%. Including those productivity gains overturn the direct expenditure effect for options 6A and 6B, and still fully offset the negative impact on GDP making it neutral on option 6C. This is without considering other direct benefits (healthcare, crop yield, infrastructure impacts); as shown in Table A7.8, additional quantifiable direct benefits would amount in option 6C to 1080 M€, equal to 0,007% of GDP, and so option 6C would have an overall small positive effect on GDP.

Several of the sectors that require additional efforts in terms of pollution abatement investment, such as ferrous and non-ferrous metals, chemicals and the power sector, also

313 Any possible measures with negative costs (i.e. no regret measures that would provide savings for operators at no extra compliance cost) were removed and excluded from the analysis.

benefit from additional demand for the delivery of the required investment goods throughout the economy and see a net output increase. The sectors that bear a comparatively larger share of the burden are agriculture and the refinery sector.

2.3. Social impacts of gap-closure options

Table A7.11 summarises the employment impacts of options 6A to 6C by sector. In all cases the effect is essentially neutral (max 2000 jobs in option 6C, which is within the uncertainty range), even without taking labour productivity gains into consideration. When those are considered there is a net employment increase (37-112 thousand jobs). This result is the sum of additional productivity of existing jobs (accounting for around two-thirds of the total) and net creation of new jobs due to increased competitiveness of EU industries.

Table A7.11: Sectorial employment change in options, the effects of health benefits to labour productivity are presented seprately as "health"case. Last row shows the net welfare effect.

	6A		*6B*		*6C*	
Change in Sector employment in EU28 (2025) in '000 jobs; and welfare change in % compared to option 1						
	base	*health*	base	*health*	base	*health*
Agriculture	-1,697	0,631	-6,051	-1,644	-24,574	-17,589
Chemical Products	0,055	0,886	0,294	1,912	1,264	3,711
Construction	0,826	3,825	4,209	10,148	16,237	25,043
Consumer Goods Industries	-0,095	1,668	-0,132	3,345	-0,878	4,398
Electric Goods	0,097	0,487	0,576	1,413	2,173	3,379
Electricity supply	0,127	0,355	0,428	0,855	2,387	3,066
Ferrous & non-ferrous metals	0,057	1,155	-0,883	1,234	0,697	3,947
Natural Gas	0,000	0,013	-0,031	-0,007	0,043	0,085
Market Services	0,008	10,299	-0,258	19,693	2,661	32,405
Non Market Services	0,102	6,268	0,427	12,165	3,283	21,101
Petroleum Refining	-0,013	-0,003	-0,044	-0,025	-0,111	-0,082
Other energy intensive	0,014	0,785	-0,578	0,922	-1,405	0,867
Other Equipment Goods	0,464	2,727	2,357	6,638	9,602	16,223
Transport	0,025	2,400	0,106	4,729	1,471	8,450
Transport equipment	0,107	1,004	0,634	2,329	2,857	5,424
TOTAL	-0,069	37,605	0,821	73,691	2,119	112,256
Impact on aggregate household consumption	**-0,002%**	**0,012%**	**-0,009%**	**0,017%**	**-0,030%**	**0,008%**

indicators do not differ significantly for 2025 and 2030. Exact figures reported are for 2025.

2.4. Monetised impacts of gap-closure options

Following the approach described in chapter 3, the health impacts described in table A7.3 can be translated into economic loss figures based on a well-established literature of contingent valuation studies (Tables A7.12 and A7.13 for 2025 and 2030). The direct health and non-health impact endpoints that are valued in the previous section are also reported.

Table A7.12: Monetised Air Quality impacts in 2005 and in options for the year 2025, in M€/year

	metric	2005	Option 1	Option 6A	Option 6B	Option 6C	Option 6D
Chronic mortality, low estimate	PM	268,792	160,066	149,167	138,448	127,643	117,023
Chronic mortality, high estimate	PM	916,190	685,035	638,815	592,247	546,445	501,559
Acute mortality	O3	16,121	11,774	11,057	10,247	9,460	8,732
Chronic Bronchitis	PM	42,571	30,405	28,339	26,264	24,268	22,258
Restricted Activity Days (RAD)	PM	9,341	6,656	6,391	6,143	5,793	5,279
Other morbidity	PM	268,792	160,066	149,167	138,448	127,643	117,023
Total, low estimate		**338,479**	**210,217**	**196,250**	**182,383**	**168,390**	**154,402**
Total, high estimate		**985,877**	**735,186**	**685,898**	**636,182**	**587,191**	**538,938**
Value of lost working days, M €		17,629	10,651	9,925	9,230	8,514	7,820
Healthcare cost (quantified)		4,631	3,403	3,183	2,966	2,746	2,517
Crop value losses, M €		4,867	2,176	2,114	2,074	1,897	1,545
Damage to built environment, M €		1,593	503	450	396	358	340

Note: to avoid any double counting, the value of lsot workind days has been subtracted from the total external cost of RADs; likewise, healthcare costs have been subtracted from the exteranl costs related to illnesses (morbidity)

Table A7.13: Monetised Air Quality impacts in 2005 and in options for the year 2030, in M€/year

	metric	2005	Option 1	Option 6A	Option 6B	Option 6C	Option 6D
Chronic mortality, low estimate	PM	268,792	149,724	139,727	129,817	119,996	107,110
Chronic mortality, high estimate	PM	916,190	678,255	633,258	587,778	543,620	485,982
Acute mortality	O3	1,654	1,322	1,302	1,288	1,232	1,109
Chronic Bronchitis	PM	16,121	11,375	10,615	9,852	9,121	8,153
Restricted Activity Days (RAD)	PM	42,571	29,508	27,540	25,562	23,674	21,157
Other morbidity	PM	9,341	6,456	6,206	5,971	5,638	5,062
Total, low estimate		**338,479**	**198,387**	**185,390**	**172,490**	**159,661**	**142,592**
Total, high estimate		**985,877**	**726,917**	**678,920**	**630,451**	**583,285**	**521,464**
Value of lost working days, M €		17,629	9,902	9,237	8,594	7,942	7,097
Healthcare cost (quantified)		4,631	3,303	3,094	2,888	2,679	2,396
Crop value losses, M €		4,867	1,985	1,926	1,887	1,716	1,354
Damage to built environment, M €		1,593	452	408	356	317	293

In 2025, external costs due to air pollution are projected to reduce about 37% compared to 2005, and 40% in 2030. However, in option 1 they would remain in the range between 225 and 760 billion €/year in 2025 and 215-740 in 2030. Additional action beyond option 1 could reduce up to 60-200 billion €/year. Of these, more than 4 billion € could be direct economic savings due to less work absenteeism, healthcare costs, crop damage and deterioration of buildings and infrastructure.

3. POLICY INSTRUMENTS TO ACHIEVE THE INTERIM TARGETS

The policy measures to deliver options 6A to 6E are set out in Table A7.1. While measures related to product standards (heating appliances in the domestic sector, emission limits for non-road machinery, inorganic fertilizers) are harmonised at EU level to meet the needs of the single market, other measures could in principle either be enacted either at national level or as EU-wide source controls. In practice, we will always look at a combination of both. A range of different sensitivity analysis has been undertaken for the central case Option 6C*, to investigate if and how different choices as regards the main policy instruments adopted may impact the costs of achieving the same overall environmental and health objectives. The analysis compared applying a maximum level of subsidiarity (i.e. NECD ceilings only) to applying various combinations of source controls and NECD ceilings, as well as including emission reductions from international marine shipping in the scope of the NECD.

As a general principle, constraining the range of policy instruments and technical measures that can be used will restrict access to cost-effective measures and so increase the costs of meeting a given set of environmental and health targets. Leaving full flexibility to Member States to decide on which emission sources to control and which technical measures to apply to achieve a national emission ceiling will normally always be the most cost effective option. However, EU source controls may be necessary and useful for levelling the playing field and improving administrative efficiency. In the public consultation, 94% of government respondents advocated more stringent source controls at EU level to support the achievement of emission ceilings.[314] Harmonised measures at EU level would to some extent result in lower cost-effectiveness, but this may be well justified in consideration of these benefits. Several different measures at EU level were analysed, and the additional implementation cost estimated.[315] The results are summarised as follows; details about the specific measures are provided in Annex 8:

Table A7.14: Additional pollution control costs entailed by taking EU-wide harmonised measures in specific sectors

Sector	*Control costs (vs base Option 6C*)*	*Policy instrument*
BASE case 6C*	4680 M€	NEC Directive only
Agriculture	51-67 M€ (+ 1,1-1,4%)	Possible specific EU initiative for e.g. integrated manure management, BREF revision, BAT conclusions
Medium combustion (1-50 MWth)	162 M€ (+3,4%)	Specific legislative initiative described in detail in Annex 12
Chemicals; Solvents	2 M€ (+0,05%)	BREF revision, BAT conclusions
Cement&Lime; Glass	63 M€ (+1,3%)	BREF revision, BAT conclusions
Petroleum Refining	24 M€ (+0,5%)	BREF revision, BAT conclusions

[314] Either alone (34%) or in combination with more stringent NEC ceilings (57%)

[315] Note that measures related to product standards are always assumed to be taken at EU-wide scale due to single market provisions. These include: emission standards for road vehicles and non-road machinery; solvent content of consumer products; minimum standards under the Ecodesign directive.

International marine shipping	Only NECA: 37 M€ (+0,7%) SECA+NECA: 433-1921 M€ (+9-40%)	Establishment of additional emission control areas for SO2 and NOx under IMO Marpol Annex VI rules

The conclusion is that taking further emission control measures at harmonised EU level in several industrial sectors as well as in agriculture and for medium-scale combustion plants would help the Member States to achieve the emission reductions required to meet their air quality targets in the post-2020 horizon by providing certainty on the emission controls covered by EU legislation and at the same time ensuring a level playfield for businesses across Europe; this would be achieved with relatively minor cost-effectiveness compromises. The EU could deliver the needed source controls with a combination of existing and new policy initiatives: emission limit values for many industrial activities are updated through the periodic revision of sectorial BREFs[316] under the Industrial Emissions Directive (IED) resulting in the adoption of BAT conclusions (as Commission implementing decisions). The Member States, through their vote on the draft Decisions in the IED Article 75 Committee, will eventually have a decisive voice in defining the stringency level of future BAT conclusions. This way Member States will determine the share of emission reductions to be delivered at EU-wide scale and the share to be left for them to deliver with national measures.

Combustion installations below the 50 MWth threshold set in the Large Combustion Plants directive (now merged in the IED) will be addressed by a specific proposal, for which Annex 12 provides details and supporting analysis. The bottom-up analysis shows that, depending on the emission level option chosen, this will reduce emissions of SO2, NOx and total PM (dust) by 127-139, 76-338 and 42-45 kilotons per year. Total annualised compliance costs for implementing the corresponding measures are in the range of 355 M€ - 3296 M€, with the upper end of the range being determined by expensive end-of-pipe measures for NOx abatement on all existing plants. When considering those particular techniques only for specific groups of plants, costs drop to the lower end of the range above, and the cost-effectiveness is in line with the ranges found under options 6A to 6C. In the central case Option 6C* (**Error! Reference source not found.**), pollution abatement expenditure attributed to MCP totals 220 M€ (see Annex 8 for detailed information). Additional costs for the MCP segment beyond those included in Option 6C* are thus 162 M€ in the preferred options (i.e. excluding end-of-pipe NOx controls) described in Annex 12. Administrative costs for regulating these plants may be limited by avoiding an integrated permitting regime.

Ammonia emissions from agriculture are challenging to regulate at EU level, partly because of the structure of the sector, covering a wide range of different farming activities and consisting of many small and medium-sized farms. In addition, ammonia emissions are influenced by several country-specific and local factors, such as soil and climate conditions, properties of different animal manure (linked to type of animal feed, species, age and weight), timing and rate of application of manure to agricultural land, type of housing facilities and manure storage systems, the proportion of time spent indoors or grazing by farm animals, as well as different local farm traditions and practices.

[316] Best Available Techniques (BAT) Reference documents

Some abatement measures for ammonia could be addressed in the NECD itself, through appropriate provisions and more detailed guidance for Member States on how to control agricultural activities in order to achieve the national ammonia ceilings. Such an approach would be complemented by strengthened IED BAT provisions at EU level for large pig and poultry installations, which are due for revision in 2014. Moreover, a recent review in accordance with Article 73 (2)(b) of the IED concluded that reducing emissions from the spreading of manure offer the highest benefit-to-cost ratio, and this option will be further explored as a matter of priority. There is also an opportunity to consider appropriate measures in the Fertilizers Regulation[317], which is to be reviewed in 2013. The regulation is a product regulation designed to harmonize the inorganic fertilizer market in the EU, provide adequate information to farmers about the nutrient content through labelling requirements, and ensure that fertilizers do not harm the environment or human health. Finally, a comprehensive non-legislative Action Plan for Ammonia Abatement will accompany the revised Thematic Strategy.

Further measures in international maritime shipping combining (further) emission control areas both for SO2 and for NOx would not be cost-effective to achieve the targets of the policy options 6A-6C or 6C*, as they would be more expensive than equivalent land-based emission reductions. This conclusion may however be reviewed in future as it depends on a variety of factors including: low-sulphur fuel price premiums; the availability of cost-effective alternative technical solutions (scrubbers, LNG); the fact that only impacts on EU land are considered; and the exact definition of control areas. The current analysis suggests that the designation of NECAs not combined with further SECAs would offer good cost-effectiveness even in the absence of further technical advancements.

Although an EU-level pollution levy has already been rejected as a possible instrument to deliver the EU-wide pollution reduction objectives, taxation at MS level may well remain an effective policy instrument to reduce pollution and at the same time stimulate growth and employment, as part of green tax reforms. As an example, Denmark has introduced several air pollution-related taxation levies; a 1997 2,7€/kg levy on sulphur content of fuels above 500 ppm led to a sharp decline of SO2 emissions, and in 2007 a levy of 3,2€/ per Kg NOx emitted from large and medium-sized point sources was introduced. The potential of fiscal instruments in this context is analysed with macroeconomic modelling.

4. TRAJECTORY TO ACHIEVING THE LONG-TERM OBJECTIVE BY 2050

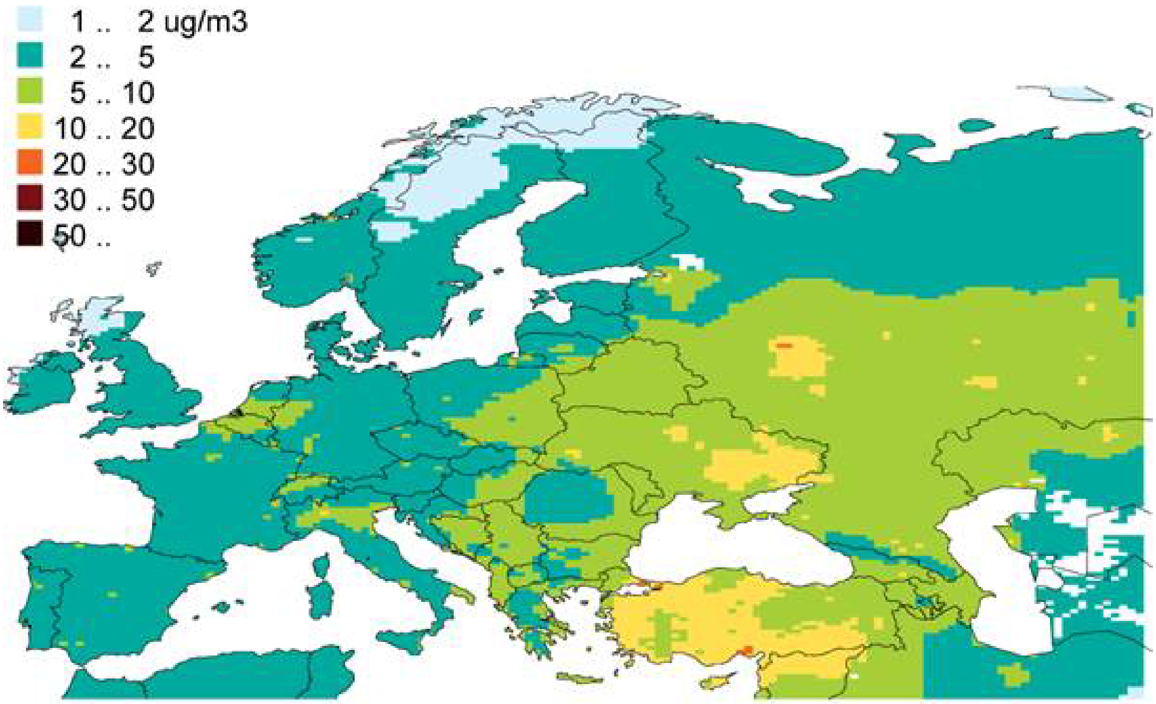
With a view to understanding whether or not the achievement of the long-term objective of no significant impact from air pollution could be within reach by 2050, a Maximum Control Effort (MCE) scenario was developed for the years 2030 and 2050, combining the effect of further phasing out of the most polluting sources (coal), increased electrification, energy efficiency gains as well as the application of available technical pollution control measures. Table A7.16 shows that the MCE scenario in 2050 would achieve virtually everywhere in the EU (99,5% of locations and 99% of population exposed) background PM2,5 concentrations below the 10 $\mu g/m^3$ limit recommended by the WHO. Fig. A7.1 shows the concentration map.

[317] Regulation 2003/2003/EC

Table A7.16: Percentage of EU territory and of EU population exposed to PM2,5 concetration ranges in 2050 in the MCE

PM2.5 range, µg m^{-3}	No. 28km grids	Population	% territory	% population
< 2	322	511328	5.5%	0.1%
2 - 3	1421	26628607	24.1%	5.5%
3 - 4	1657	112866725	28.1%	23.4%
4 - 5	1452	174130410	24.6%	36.1%
5 - 6	645	97956199	10.9%	20.3%
6 - 7	253	35728954	4.3%	7.4%
7 - 8	93	22420033	1.6%	4.7%
8 - 9	17	5712484	0.3%	1.2%
9 - 10	15	1189239	0.3%	0.2%
10 - 11	12	4556864	0.2%	0.9%
11 - 12	14	307425	0.2%	0.1%
12 - 13	3	6795	0.1%	0.0%
13 - 14	0	0	0.0%	0.0%
14 - 15	1	1422	0.0%	0.0%
15 - 16	1	264	0.0%	0.0%

Fig A7.1: Anthropogenic PM2,5 conentrations across Europe in the 2050 MCE scenario



Achieving this level starting in 2025 from the point delivered by the 6C* policy option would require reducing emissions of SO2 16,7% every 5 years; NOx 15%; PM2,5 12,4%; ammonia 6%; and VOC 10%. Table A7.17 reports the pathway to reaching this goal in 2050. Compared to 1990 levels, the 2050 emissions would be 97% lower for

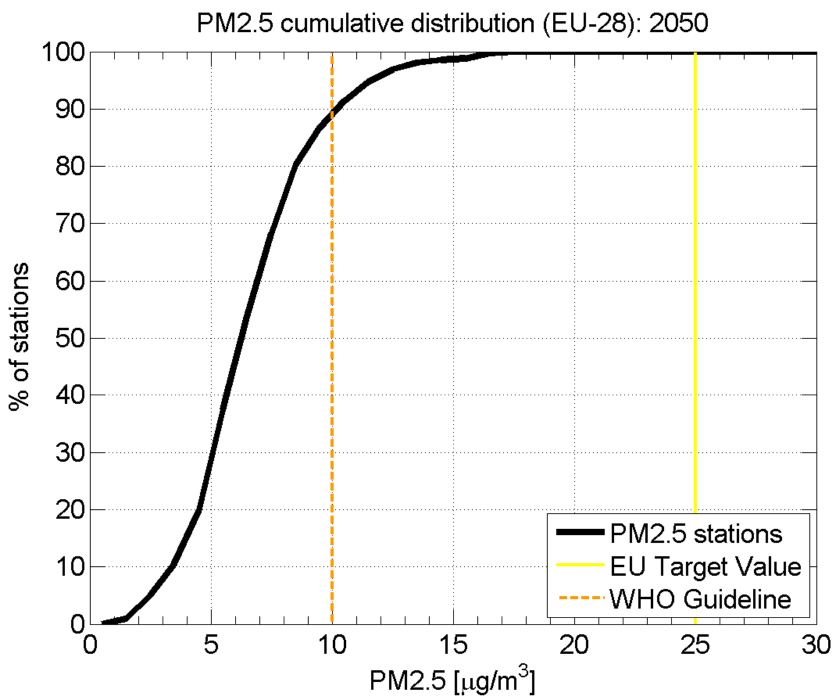
SOx, 89% lower for NOx, 84% for VOC, 74% for PM2,5 and 60% for ammonia, with average reduction percentage for the five pollutants of 80%. Whilst these reductions would all be feasible under the MCE assumptions, they could not be cost-effectively achieved by technical measures alone; the trajectory should be considered therefore indicative. Details by Member State are reported in Appendix 7.7.

Table A7.17: Emission reduction trajectory towards achieving the WHO guideline values in 2050; emissions in kilotons, reductions compared with 2005 emissions

EU28	2005	2025	2030	2040	2050
SO2	8172	-79%	-82%	-87%	-91%
NOx	11538	-65%	-70%	-78%	-83%
PM2,5	1647	-48%	-54%	-64%	-72%
NH3	3928	-30%	-34%	-42%	-48%
VOC	9259	-50%	-55%	-64%	-71%

Figure A7.2 shows compliance projections for the 2050 MCE scenario. Even at the level of individual monitors, 90% of stations would meet the 10 g/m3 limit. The residual 10% would be addressed by taking proportionate specific local measures to address particular hotspot situations.

Fig A7.2: Porjected distribution of concentrations at existing monitoring stations for PM2,5



APPENDIX 7.1 EMISSION REDUCTIONS PER MEMBER STATE AND PER OPTION IN 2025 AND 2030 (% VS 2005)

SO2 emissions in 2025, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	25	14	*-43%*	13	*-46%*	13	*-46%*	12	*-52%*	12	*-53%*
Belgium	140	59	*-58%*	54	*-62%*	51	*-63%*	46	*-67%*	46	*-67%*
Bulgaria	890	137	*-85%*	135	*-85%*	101	*-89%*	81	*-91%*	80	*-91%*
Croatia	68	21	*-70%*	20	*-71%*	11	*-84%*	9	*-86%*	7	*-89%*
Cyprus	38	2	*-95%*	2	*-95%*	2	*-95%*	1	*-97%*	1	*-98%*
Czech Rep.	208	81	*-61%*	74	*-64%*	68	*-67%*	65	*-68%*	62	*-70%*
Denmark	21	10	*-53%*	10	*-53%*	10	*-54%*	9	*-56%*	8	*-60%*
Estonia	66	23	*-66%*	23	*-66%*	23	*-66%*	20	*-70%*	18	*-73%*
Finland	90	64	*-29%*	63	*-29%*	63	*-29%*	63	*-30%*	59	*-34%*
France	444	124	*-72%*	117	*-74%*	108	*-76%*	103	*-77%*	100	*-78%*
Germany	549	333	*-39%*	317	*-42%*	308	*-44%*	295	*-46%*	291	*-47%*
Greece	505	66	*-87%*	65	*-87%*	65	*-87%*	52	*-90%*	39	*-92%*
Hungary	129	28	*-78%*	28	*-79%*	20	*-85%*	17	*-86%*	17	*-87%*
Ireland	71	18	*-75%*	17	*-76%*	16	*-77%*	13	*-81%*	13	*-82%*
Italy	382	142	*-63%*	119	*-69%*	106	*-72%*	93	*-76%*	75	*-80%*
Latvia	5	3	*-39%*	3	*-41%*	3	*-41%*	3	*-47%*	2	*-53%*
Lithuania	42	24	*-42%*	24	*-43%*	23	*-45%*	11	*-74%*	9	*-77%*
Luxembourg	2	2	*-20%*	2	*-20%*	1	*-25%*	1	*-44%*	1	*-56%*
Malta	11	0	*-96%*	0	*-96%*	0	*-96%*	0	*-98%*	0	*-99%*
Netherlands	70	34	*-52%*	33	*-52%*	31	*-56%*	30	*-57%*	28	*-60%*
Poland	1256	528	*-58%*	414	*-67%*	370	*-70%*	332	*-74%*	319	*-75%*
Portugal	111	49	*-56%*	45	*-60%*	33	*-71%*	23	*-79%*	19	*-83%*
Romania	706	101	*-86%*	97	*-86%*	63	*-91%*	55	*-92%*	50	*-93%*
Slovakia	92	45	*-51%*	44	*-51%*	29	*-68%*	20	*-78%*	19	*-79%*
Slovenia	40	6	*-85%*	6	*-85%*	5	*-86%*	5	*-88%*	5	*-88%*
Spain	1328	228	*-83%*	222	*-83%*	178	*-87%*	149	*-89%*	133	*-90%*
Sweden	38	32	*-15%*	32	*-15%*	32	*-15%*	32	*-16%*	31	*-19%*
Un. Kingdom	850	274	*-68%*	210	*-75%*	169	*-80%*	153	*-82%*	150	*-82%*
EU-28	8172	2446	*-70%*	2188	*-73%*	1903	*-77%*	1694	*-79%*	1593	*-81%*

SO2 emissions in 2030, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*
Austria	25	13	*-47%*	13	*-49%*	12	*-49%*	11	*-54%*	11	*-55%*
Belgium	140	58	*-59%*	52	*-63%*	49	*-65%*	44	*-68%*	44	*-68%*
Bulgaria	890	112	*-87%*	109	*-88%*	76	*-92%*	53	*-94%*	52	*-94%*
Croatia	68	20	*-70%*	19	*-71%*	11	*-84%*	9	*-87%*	6	*-91%*
Cyprus	38	2	*-95%*	2	*-95%*	2	*-95%*	1	*-97%*	1	*-98%*
Czech Rep.	208	74	*-64%*	67	*-68%*	61	*-70%*	59	*-72%*	56	*-73%*
Denmark	21	9	*-56%*	9	*-56%*	9	*-56%*	9	*-58%*	8	*-63%*
Estonia	66	22	*-67%*	22	*-67%*	22	*-67%*	19	*-71%*	15	*-78%*
Finland	90	64	*-29%*	63	*-29%*	63	*-29%*	63	*-30%*	59	*-35%*
France	444	117	*-74%*	111	*-75%*	103	*-77%*	98	*-78%*	92	*-79%*
Germany	549	295	*-46%*	278	*-49%*	269	*-51%*	258	*-53%*	246	*-55%*
Greece	505	50	*-90%*	51	*-90%*	50	*-90%*	38	*-92%*	26	*-95%*
Hungary	129	27	*-79%*	26	*-80%*	18	*-86%*	16	*-88%*	15	*-88%*
Ireland	71	14	*-80%*	14	*-80%*	13	*-81%*	11	*-84%*	11	*-85%*
Italy	382	142	*-63%*	119	*-69%*	105	*-72%*	92	*-76%*	73	*-81%*
Latvia	5	3	*-40%*	3	*-42%*	3	*-42%*	3	*-47%*	2	*-54%*
Lithuania	42	25	*-41%*	24	*-41%*	24	*-43%*	12	*-72%*	10	*-77%*
Luxembourg	2	2	*-21%*	2	*-21%*	1	*-25%*	1	*-44%*	1	*-56%*
Malta	11	0	*-97%*	0	*-97%*	0	*-97%*	0	*-98%*	0	*-99%*
Netherlands	70	32	*-54%*	32	*-54%*	30	*-58%*	28	*-59%*	26	*-63%*
Poland	1256	453	*-64%*	362	*-71%*	317	*-75%*	278	*-78%*	261	*-79%*
Portugal	111	49	*-56%*	44	*-60%*	33	*-71%*	23	*-79%*	17	*-84%*
Romania	706	99	*-86%*	95	*-87%*	60	*-92%*	51	*-93%*	45	*-94%*
Slovakia	92	46	*-50%*	45	*-50%*	29	*-68%*	20	*-79%*	19	*-80%*
Slovenia	40	6	*-85%*	5	*-86%*	5	*-87%*	5	*-89%*	4	*-89%*
Spain	1328	232	*-83%*	226	*-83%*	179	*-87%*	148	*-89%*	130	*-90%*
Sweden	38	32	*-16%*	32	*-16%*	32	*-16%*	32	*-16%*	31	*-19%*
Un. Kingdom	850	214	*-75%*	173	*-80%*	144	*-83%*	128	*-85%*	124	*-85%*
EU-28	8172	2211	*-73%*	1999	*-76%*	1720	*-79%*	1510	*-82%*	1383	*-83%*

NOx emissions in 2025, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	230	77	*-67%*	77	*-67%*	77	*-67%*	71	*-69%*	65	*-72%*
Belgium	295	146	*-50%*	142	*-52%*	141	*-52%*	123	*-58%*	111	*-62%*
Bulgaria	167	68	*-59%*	68	*-59%*	68	*-59%*	65	*-61%*	52	*-69%*
Croatia	76	36	*-52%*	36	*-53%*	35	*-53%*	27	*-64%*	17	*-78%*
Cyprus	21	7	*-67%*	7	*-67%*	7	*-67%*	7	*-67%*	5	*-78%*
Czech Rep.	296	130	*-56%*	129	*-56%*	127	*-57%*	114	*-61%*	98	*-67%*
Denmark	182	70	*-62%*	69	*-62%*	69	*-62%*	63	*-65%*	55	*-70%*
Estonia	40	18	*-55%*	18	*-55%*	18	*-55%*	18	*-55%*	13	*-69%*
Finland	201	110	*-45%*	110	*-45%*	110	*-45%*	110	*-45%*	92	*-54%*
France	1351	502	*-63%*	501	*-63%*	486	*-64%*	453	*-66%*	393	*-71%*
Germany	1397	608	*-56%*	575	*-59%*	572	*-59%*	522	*-63%*	460	*-67%*
Greece	407	150	*-63%*	134	*-67%*	133	*-67%*	133	*-67%*	108	*-74%*
Hungary	155	59	*-62%*	59	*-62%*	58	*-62%*	53	*-66%*	42	*-73%*
Ireland	150	63	*-58%*	63	*-58%*	63	*-58%*	55	*-64%*	49	*-68%*
Italy	1306	514	*-61%*	506	*-61%*	489	*-63%*	447	*-66%*	418	*-68%*
Latvia	36	24	*-34%*	23	*-35%*	23	*-35%*	23	*-36%*	19	*-49%*
Lithuania	62	31	*-50%*	30	*-51%*	30	*-51%*	30	*-52%*	25	*-60%*
Luxembourg	47	13	*-73%*	13	*-73%*	13	*-73%*	13	*-73%*	12	*-75%*
Malta	10	1	*-86%*	1	*-86%*	1	*-86%*	1	*-86%*	1	*-89%*
Netherlands	380	158	*-58%*	158	*-58%*	155	*-59%*	134	*-65%*	119	*-69%*
Poland	797	438	*-45%*	437	*-45%*	435	*-45%*	404	*-49%*	343	*-57%*
Portugal	268	103	*-62%*	101	*-62%*	100	*-63%*	85	*-68%*	68	*-75%*
Romania	311	140	*-55%*	139	*-55%*	137	*-56%*	112	*-64%*	95	*-69%*
Slovakia	95	50	*-47%*	50	*-48%*	48	*-49%*	42	*-55%*	35	*-63%*
Slovenia	50	18	*-63%*	18	*-63%*	18	*-63%*	17	*-66%*	15	*-69%*
Spain	1513	496	*-67%*	485	*-68%*	485	*-68%*	441	*-71%*	365	*-76%*
Sweden	216	82	*-62%*	82	*-62%*	82	*-62%*	82	*-62%*	72	*-67%*
Un. Kingdom	1480	504	*-66%*	503	*-66%*	502	*-66%*	450	*-70%*	380	*-74%*
EU-28	11538	4616	*-60%*	4535	*-61%*	4484	*-61%*	4096	*-64%*	3525	*-69%*

NOx emissions in 2030, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*
Austria	230	65	*-72%*	65	*-72%*	65	*-72%*	60	*-74%*	54	*-76%*
Belgium	295	134	*-55%*	131	*-56%*	130	*-56%*	112	*-62%*	95	*-68%*
Bulgaria	167	60	*-64%*	60	*-64%*	60	*-64%*	57	*-66%*	41	*-75%*
Croatia	76	33	*-56%*	33	*-56%*	33	*-57%*	25	*-68%*	14	*-81%*
Cyprus	21	6	*-70%*	6	*-70%*	6	*-70%*	6	*-70%*	4	*-81%*
Czech Rep.	296	112	*-62%*	111	*-62%*	110	*-63%*	99	*-67%*	83	*-72%*
Denmark	182	61	*-66%*	60	*-67%*	60	*-67%*	56	*-70%*	46	*-75%*
Estonia	40	16	*-61%*	16	*-61%*	16	*-61%*	16	*-61%*	10	*-74%*
Finland	201	99	*-51%*	99	*-51%*	99	*-51%*	99	*-51%*	82	*-59%*
France	1351	441	*-67%*	440	*-67%*	424	*-69%*	395	*-71%*	332	*-75%*
Germany	1397	530	*-62%*	495	*-65%*	491	*-65%*	442	*-68%*	380	*-73%*
Greece	407	126	*-69%*	113	*-72%*	112	*-72%*	112	*-72%*	91	*-78%*
Hungary	155	52	*-66%*	52	*-67%*	52	*-67%*	46	*-70%*	35	*-77%*
Ireland	150	43	*-71%*	43	*-71%*	43	*-71%*	35	*-76%*	28	*-82%*
Italy	1306	456	*-65%*	449	*-66%*	432	*-67%*	391	*-70%*	360	*-72%*
Latvia	36	20	*-44%*	20	*-44%*	20	*-44%*	20	*-44%*	15	*-58%*
Lithuania	62	28	*-54%*	28	*-55%*	28	*-55%*	27	*-56%*	22	*-65%*
Luxembourg	47	10	*-79%*	10	*-79%*	10	*-79%*	10	*-79%*	9	*-80%*
Malta	10	1	*-89%*	1	*-89%*	1	*-89%*	1	*-89%*	1	*-92%*
Netherlands	380	143	*-62%*	143	*-62%*	141	*-63%*	121	*-68%*	105	*-72%*
Poland	797	379	*-52%*	378	*-53%*	376	*-53%*	343	*-57%*	280	*-65%*
Portugal	268	92	*-65%*	91	*-66%*	90	*-67%*	75	*-72%*	57	*-79%*
Romania	311	127	*-59%*	127	*-59%*	124	*-60%*	100	*-68%*	81	*-74%*
Slovakia	95	47	*-51%*	46	*-51%*	45	*-52%*	39	*-59%*	31	*-67%*
Slovenia	50	16	*-69%*	16	*-69%*	15	*-69%*	14	*-72%*	12	*-75%*
Spain	1513	434	*-71%*	422	*-72%*	422	*-72%*	378	*-75%*	300	*-80%*
Sweden	216	76	*-65%*	76	*-65%*	76	*-65%*	75	*-65%*	64	*-70%*
Un. Kingdom	1480	441	*-70%*	440	*-70%*	439	*-70%*	391	*-74%*	316	*-79%*
EU-28	11538	4051	*-65%*	3970	*-66%*	3921	*-66%*	3544	*-69%*	2947	*-74%*

NH3 emissions in 2025, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	63	67	*7%*	59	*-6%*	56	*-11%*	51	*-19%*	46	*-26%*
Belgium	74	74	*0%*	69	*-8%*	66	*-10%*	62	*-16%*	60	*-19%*
Bulgaria	65	64	*-2%*	62	*-5%*	61	*-6%*	58	*-11%*	57	*-13%*
Croatia	29	29	*0%*	28	*-5%*	26	*-12%*	21	*-27%*	18	*-38%*
Cyprus	6	6	*-6%*	6	*-7%*	5	*-12%*	5	*-21%*	4	*-33%*
Czech Rep.	80	63	*-21%*	60	*-25%*	55	*-31%*	52	*-35%*	52	*-35%*
Denmark	73	51	*-31%*	49	*-33%*	49	*-34%*	46	*-37%*	39	*-46%*
Estonia	12	13	*7%*	12	*6%*	12	*-1%*	11	*-10%*	8	*-30%*
Finland	34	31	*-8%*	30	*-11%*	30	*-11%*	28	*-17%*	24	*-29%*
France	675	638	*-5%*	580	*-14%*	534	*-21%*	463	*-31%*	425	*-37%*
Germany	593	570	*-4%*	485	*-18%*	392	*-34%*	318	*-46%*	299	*-50%*
Greece	57	47	*-16%*	46	*-19%*	43	*-25%*	41	*-28%*	38	*-32%*
Hungary	78	67	*-13%*	62	*-20%*	54	*-31%*	48	*-38%*	48	*-38%*
Ireland	104	101	*-4%*	101	*-4%*	98	*-6%*	92	*-11%*	85	*-18%*
Italy	422	386	*-9%*	364	*-14%*	330	*-22%*	299	*-29%*	296	*-30%*
Latvia	13	15	*16%*	15	*14%*	15	*13%*	13	*3%*	12	*-5%*
Lithuania	44	49	*12%*	49	*11%*	48	*8%*	46	*4%*	32	*-28%*
Luxembourg	6	6	*-10%*	5	*-18%*	5	*-22%*	5	*-25%*	5	*-27%*
Malta	2	2	*-7%*	2	*-7%*	1	*-21%*	1	*-25%*	1	*-34%*
Netherlands	146	112	*-23%*	112	*-24%*	111	*-24%*	111	*-24%*	110	*-25%*
Poland	344	331	*-4%*	300	*-13%*	294	*-14%*	245	*-29%*	227	*-34%*
Portugal	71	71	*0%*	65	*-8%*	62	*-13%*	55	*-22%*	49	*-30%*
Romania	161	142	*-12%*	136	*-16%*	134	*-17%*	122	*-24%*	112	*-31%*
Slovakia	28	24	*-16%*	21	*-25%*	18	*-35%*	17	*-41%*	17	*-42%*
Slovenia	19	17	*-12%*	15	*-18%*	15	*-20%*	14	*-25%*	14	*-28%*
Spain	366	352	*-4%*	334	*-9%*	303	*-17%*	258	*-29%*	211	*-42%*
Sweden	54	48	*-10%*	48	*-10%*	47	*-13%*	44	*-19%*	39	*-27%*
Un. Kingdom	308	282	*-8%*	275	*-11%*	257	*-17%*	240	*-22%*	236	*-23%*
EU-28	3928	3658	*-7%*	3390	*-14%*	3122	*-21%*	2767	*-30%*	2566	*-35%*

NH3 emissions in 2030, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*
Austria	63	68	*8%*	60	*-5%*	56	*-11%*	51	*-19%*	47	*-26%*
Belgium	74	73	*-1%*	68	*-9%*	66	*-11%*	62	*-16%*	60	*-19%*
Bulgaria	65	64	*-1%*	62	*-4%*	61	*-6%*	59	*-10%*	57	*-12%*
Croatia	29	30	*2%*	28	*-4%*	26	*-12%*	22	*-26%*	19	*-36%*
Cyprus	6	6	*-4%*	6	*-5%*	6	*-10%*	5	*-20%*	4	*-31%*
Czech Rep.	80	62	*-22%*	59	*-26%*	55	*-32%*	51	*-36%*	51	*-36%*
Denmark	73	51	*-31%*	49	*-33%*	48	*-34%*	46	*-38%*	39	*-47%*
Estonia	12	13	*9%*	13	*7%*	12	*1%*	11	*-9%*	8	*-29%*
Finland	34	31	*-8%*	30	*-11%*	30	*-11%*	28	*-17%*	24	*-29%*
France	675	639	*-5%*	574	*-15%*	527	*-22%*	458	*-32%*	424	*-37%*
Germany	593	565	*-5%*	472	*-20%*	379	*-36%*	312	*-47%*	294	*-50%*
Greece	57	48	*-16%*	46	*-18%*	43	*-25%*	41	*-28%*	39	*-32%*
Hungary	78	67	*-13%*	62	*-20%*	54	*-31%*	49	*-37%*	48	*-38%*
Ireland	104	101	*-3%*	101	*-3%*	98	*-5%*	93	*-11%*	86	*-18%*
Italy	422	389	*-8%*	367	*-13%*	329	*-22%*	302	*-28%*	299	*-29%*
Latvia	13	15	*19%*	15	*17%*	15	*15%*	14	*6%*	13	*-3%*
Lithuania	44	51	*15%*	50	*13%*	49	*11%*	47	*6%*	33	*-26%*
Luxembourg	6	6	*-11%*	5	*-19%*	5	*-24%*	5	*-25%*	5	*-27%*
Malta	2	2	*-8%*	2	*-8%*	1	*-22%*	1	*-26%*	1	*-35%*
Netherlands	146	111	*-24%*	110	*-24%*	110	*-25%*	109	*-25%*	109	*-25%*
Poland	344	332	*-3%*	300	*-13%*	294	*-14%*	245	*-29%*	228	*-33%*
Portugal	71	73	*3%*	66	*-7%*	63	*-11%*	57	*-20%*	50	*-29%*
Romania	161	141	*-12%*	136	*-16%*	133	*-18%*	121	*-25%*	112	*-31%*
Slovakia	28	24	*-16%*	21	*-25%*	18	*-35%*	17	*-41%*	17	*-42%*
Slovenia	19	17	*-12%*	15	*-18%*	15	*-20%*	14	*-25%*	14	*-28%*
Spain	366	349	*-5%*	330	*-10%*	300	*-18%*	258	*-30%*	209	*-43%*
Sweden	54	49	*-9%*	49	*-9%*	47	*-12%*	44	*-18%*	39	*-27%*
Un. Kingdom	308	287	*-7%*	279	*-10%*	260	*-16%*	244	*-21%*	239	*-22%*
EU-28	3928	3663	*-7%*	3375	*-14%*	3099	*-21%*	2762	*-30%*	2568	*-35%*

VOC emissions in 2025, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	171	107	*-38%*	105	*-39%*	104	*-39%*	90	*-47%*	54	*-68%*
Belgium	158	99	*-37%*	97	*-39%*	97	*-39%*	89	*-44%*	68	*-57%*
Bulgaria	139	73	*-47%*	66	*-52%*	66	*-53%*	56	*-60%*	36	*-74%*
Croatia	79	51	*-36%*	47	*-41%*	47	*-41%*	38	*-52%*	27	*-66%*
Cyprus	9	4	*-52%*	4	*-53%*	4	*-53%*	4	*-53%*	3	*-68%*
Czech Rep.	251	143	*-43%*	137	*-46%*	136	*-46%*	113	*-55%*	73	*-71%*
Denmark	130	65	*-50%*	61	*-53%*	61	*-53%*	55	*-58%*	37	*-72%*
Estonia	38	29	*-24%*	28	*-27%*	28	*-27%*	26	*-31%*	10	*-73%*
Finland	173	102	*-41%*	101	*-41%*	101	*-41%*	96	*-44%*	53	*-69%*
France	1117	616	*-45%*	610	*-45%*	606	*-46%*	573	*-49%*	413	*-63%*
Germany	1235	850	*-31%*	800	*-35%*	795	*-36%*	720	*-42%*	514	*-58%*
Greece	283	121	*-57%*	112	*-60%*	100	*-65%*	93	*-67%*	66	*-77%*
Hungary	144	83	*-42%*	82	*-43%*	82	*-43%*	63	*-56%*	47	*-67%*
Ireland	63	44	*-31%*	44	*-31%*	44	*-31%*	43	*-32%*	24	*-62%*
Italy	1237	667	*-46%*	622	*-50%*	596	*-52%*	568	*-54%*	409	*-67%*
Latvia	69	40	*-42%*	39	*-44%*	39	*-44%*	30	*-57%*	16	*-76%*
Lithuania	84	43	*-49%*	39	*-54%*	39	*-54%*	34	*-59%*	19	*-78%*
Luxembourg	13	6	*-54%*	6	*-54%*	6	*-54%*	5	*-58%*	4	*-66%*
Malta	4	3	*-31%*	3	*-32%*	3	*-32%*	3	*-32%*	1	*-64%*
Netherlands	205	142	*-31%*	142	*-31%*	139	*-32%*	135	*-34%*	106	*-48%*
Poland	615	412	*-33%*	405	*-34%*	340	*-45%*	287	*-53%*	210	*-66%*
Portugal	227	137	*-40%*	130	*-43%*	126	*-45%*	122	*-46%*	92	*-60%*
Romania	460	256	*-44%*	231	*-50%*	230	*-50%*	171	*-63%*	104	*-77%*
Slovakia	77	54	*-30%*	53	*-31%*	53	*-31%*	47	*-39%*	29	*-63%*
Slovenia	41	30	*-27%*	30	*-27%*	30	*-28%*	15	*-62%*	11	*-74%*
Spain	934	597	*-36%*	518	*-45%*	513	*-45%*	485	*-48%*	363	*-61%*
Sweden	210	138	*-34%*	137	*-34%*	137	*-34%*	137	*-35%*	103	*-51%*
Un. Kingdom	1093	694	*-37%*	675	*-38%*	638	*-42%*	552	*-50%*	419	*-62%*
EU-28	9259	5604	*-39%*	5322	*-43%*	5157	*-44%*	4648	*-50%*	3308	*-64%*

VOC emissions in 2030, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*
Austria	171	102	*-40%*	100	*-41%*	100	*-41%*	89	*-48%*	52	*-70%*
Belgium	158	99	*-37%*	98	*-38%*	98	*-38%*	90	*-43%*	67	*-57%*
Bulgaria	139	67	*-51%*	60	*-57%*	60	*-57%*	52	*-62%*	32	*-77%*
Croatia	79	48	*-39%*	44	*-44%*	44	*-44%*	36	*-54%*	25	*-68%*
Cyprus	9	4	*-53%*	4	*-54%*	4	*-54%*	4	*-54%*	3	*-69%*
Czech Rep.	251	140	*-44%*	133	*-47%*	133	*-47%*	111	*-56%*	69	*-72%*
Denmark	130	63	*-51%*	59	*-55%*	59	*-55%*	54	*-58%*	35	*-73%*
Estonia	38	27	*-31%*	25	*-34%*	25	*-34%*	24	*-37%*	9	*-75%*
Finland	173	96	*-44%*	98	*-43%*	98	*-43%*	92	*-47%*	48	*-72%*
France	1117	591	*-47%*	590	*-47%*	586	*-48%*	560	*-50%*	396	*-65%*
Germany	1235	840	*-32%*	788	*-36%*	783	*-37%*	710	*-43%*	502	*-59%*
Greece	283	116	*-59%*	108	*-62%*	96	*-66%*	89	*-68%*	60	*-79%*
Hungary	144	81	*-44%*	80	*-45%*	79	*-45%*	61	*-58%*	45	*-69%*
Ireland	63	43	*-32%*	43	*-32%*	43	*-32%*	43	*-33%*	22	*-65%*
Italy	1237	646	*-48%*	610	*-51%*	587	*-53%*	555	*-55%*	400	*-68%*
Latvia	69	37	*-46%*	35	*-49%*	35	*-49%*	30	*-56%*	16	*-77%*
Lithuania	84	40	*-53%*	36	*-57%*	36	*-57%*	33	*-60%*	18	*-78%*
Luxembourg	13	6	*-55%*	6	*-55%*	6	*-55%*	5	*-58%*	4	*-67%*
Malta	4	3	*-30%*	3	*-31%*	3	*-31%*	3	*-31%*	1	*-64%*
Netherlands	205	141	*-31%*	140	*-32%*	138	*-33%*	133	*-35%*	103	*-50%*
Poland	615	403	*-34%*	399	*-35%*	335	*-45%*	281	*-54%*	192	*-69%*
Portugal	227	137	*-40%*	130	*-43%*	127	*-44%*	123	*-46%*	92	*-60%*
Romania	460	238	*-48%*	213	*-54%*	213	*-54%*	165	*-64%*	96	*-79%*
Slovakia	77	53	*-31%*	53	*-32%*	53	*-32%*	47	*-39%*	27	*-65%*
Slovenia	41	28	*-33%*	28	*-33%*	27	*-33%*	15	*-63%*	10	*-75%*
Spain	934	596	*-36%*	518	*-45%*	513	*-45%*	485	*-48%*	358	*-62%*
Sweden	210	132	*-37%*	132	*-37%*	132	*-37%*	131	*-37%*	98	*-53%*
Un. Kingdom	1093	684	*-37%*	666	*-39%*	631	*-42%*	546	*-50%*	410	*-62%*
EU-28	9259	5460	*-41%*	5199	*-44%*	5043	*-46%*	4569	*-51%*	3191	*-66%*

PM2,5 emissions in 2025, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	24	17	*-31%*	16	*-35%*	15	*-39%*	11	*-54%*	10	*-60%*
Belgium	28	19	*-33%*	18	*-36%*	16	*-43%*	15	*-46%*	14	*-52%*
Bulgaria	35	26	*-24%*	19	*-45%*	18	*-47%*	14	*-60%*	11	*-69%*
Croatia	15	11	*-26%*	7	*-56%*	6	*-58%*	5	*-66%*	3	*-78%*
Cyprus	3	1	*-70%*	1	*-72%*	1	*-72%*	1	*-73%*	1	*-75%*
Czech Rep.	43	34	*-21%*	28	*-34%*	28	*-35%*	23	*-47%*	18	*-59%*
Denmark	28	15	*-47%*	14	*-49%*	14	*-49%*	11	*-62%*	8	*-70%*
Estonia	20	13	*-36%*	12	*-42%*	12	*-42%*	10	*-48%*	4	*-80%*
Finland	29	21	*-25%*	21	*-27%*	21	*-28%*	18	*-37%*	13	*-55%*
France	271	184	*-32%*	166	*-39%*	162	*-40%*	154	*-43%*	124	*-54%*
Germany	123	87	*-29%*	82	*-33%*	78	*-36%*	73	*-41%*	67	*-45%*
Greece	62	32	*-49%*	24	*-61%*	17	*-72%*	16	*-75%*	13	*-79%*
Hungary	29	19	*-35%*	16	*-44%*	16	*-46%*	11	*-61%*	9	*-69%*
Ireland	13	9	*-29%*	9	*-29%*	9	*-31%*	9	*-32%*	8	*-43%*
Italy	147	128	*-12%*	113	*-23%*	86	*-41%*	82	*-44%*	75	*-49%*
Latvia	19	14	*-26%*	12	*-34%*	12	*-35%*	9	*-52%*	5	*-74%*
Lithuania	15	12	*-23%*	8	*-47%*	8	*-47%*	7	*-55%*	4	*-71%*
Luxembourg	3	2	*-42%*	2	*-42%*	2	*-42%*	2	*-47%*	2	*-51%*
Malta	1	0	*-75%*	0	*-79%*	0	*-79%*	0	*-79%*	0	*-82%*
Netherlands	24	17	*-29%*	16	*-32%*	16	*-35%*	15	*-38%*	14	*-44%*
Poland	225	216	*-4%*	197	*-13%*	174	*-22%*	154	*-31%*	124	*-45%*
Portugal	63	41	*-34%*	27	*-58%*	22	*-65%*	19	*-69%*	17	*-73%*
Romania	113	91	*-19%*	66	*-42%*	58	*-48%*	44	*-61%*	29	*-74%*
Slovakia	32	20	*-36%*	19	*-42%*	18	*-44%*	12	*-62%*	8	*-74%*
Slovenia	9	6	*-35%*	6	*-39%*	6	*-39%*	2	*-73%*	2	*-75%*
Spain	156	124	*-20%*	69	*-56%*	65	*-58%*	60	*-61%*	52	*-67%*
Sweden	31	25	*-19%*	25	*-19%*	25	*-19%*	21	*-33%*	14	*-55%*
Un. Kingdom	87	82	*-6%*	67	*-23%*	53	*-39%*	46	*-47%*	41	*-52%*
EU-28	1647	1266	*-23%*	1059	*-36%*	960	*-42%*	844	*-49%*	690	*-58%*

PM2,5 emissions in 2030, baseline and further control options. % reduction vs 2005

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*	2030	*% red*
Austria	24	16	*-34%*	15	*-38%*	14	*-42%*	11	*-55%*	9	*-62%*
Belgium	28	19	*-33%*	18	*-36%*	16	*-43%*	15	*-46%*	13	*-53%*
Bulgaria	35	24	*-30%*	17	*-52%*	16	*-53%*	12	*-64%*	9	*-75%*
Croatia	15	11	*-28%*	6	*-59%*	6	*-60%*	5	*-67%*	3	*-82%*
Cyprus	3	1	*-70%*	1	*-72%*	1	*-72%*	1	*-73%*	1	*-75%*
Czech Rep.	43	32	*-25%*	27	*-37%*	26	*-38%*	22	*-49%*	15	*-65%*
Denmark	28	13	*-53%*	13	*-55%*	13	*-55%*	10	*-64%*	7	*-75%*
Estonia	20	12	*-41%*	10	*-48%*	10	*-48%*	10	*-52%*	3	*-85%*
Finland	29	20	*-30%*	19	*-33%*	19	*-33%*	17	*-41%*	11	*-62%*
France	271	169	*-38%*	152	*-44%*	148	*-45%*	141	*-48%*	107	*-61%*
Germany	123	84	*-32%*	79	*-36%*	75	*-39%*	70	*-43%*	62	*-49%*
Greece	62	30	*-51%*	23	*-63%*	18	*-70%*	17	*-72%*	14	*-78%*
Hungary	29	18	*-37%*	16	*-46%*	15	*-48%*	11	*-63%*	8	*-73%*
Ireland	13	9	*-33%*	9	*-33%*	9	*-34%*	9	*-35%*	7	*-49%*
Italy	147	119	*-19%*	105	*-28%*	83	*-44%*	78	*-47%*	69	*-53%*
Latvia	19	12	*-34%*	11	*-42%*	11	*-43%*	8	*-54%*	4	*-80%*
Lithuania	15	11	*-28%*	7	*-52%*	7	*-52%*	6	*-57%*	4	*-75%*
Luxembourg	3	2	*-43%*	2	*-43%*	2	*-44%*	2	*-48%*	2	*-54%*
Malta	1	0	*-76%*	0	*-80%*	0	*-80%*	0	*-80%*	0	*-83%*
Netherlands	24	17	*-30%*	16	*-33%*	16	*-36%*	15	*-39%*	13	*-45%*
Poland	225	198	*-12%*	181	*-19%*	160	*-29%*	140	*-38%*	98	*-56%*
Portugal	63	41	*-35%*	26	*-59%*	22	*-65%*	19	*-69%*	16	*-74%*
Romania	113	84	*-25%*	59	*-48%*	52	*-54%*	41	*-64%*	23	*-80%*
Slovakia	32	20	*-38%*	18	*-43%*	18	*-45%*	12	*-62%*	7	*-78%*
Slovenia	9	6	*-40%*	5	*-44%*	5	*-44%*	2	*-74%*	2	*-76%*
Spain	156	125	*-20%*	70	*-55%*	66	*-58%*	61	*-61%*	50	*-68%*
Sweden	31	25	*-19%*	25	*-19%*	25	*-20%*	20	*-34%*	14	*-56%*
Un. Kingdom	87	82	*-6%*	65	*-26%*	52	*-40%*	46	*-48%*	38	*-56%*
EU-28	1647	1200	*-27%*	994	*-40%*	904	*-45%*	802	*-51%*	607	*-63%*

APPENDIX 7.2 ANNUAL HEALTH IMPACTS DUE TO AIR POLLUTION PER OPTION IN 2025 AND 2030, EU 28

IMPACTS 2025	EU28		Option 1	Opt 6A	Opt 6B	Opt 6C	Opt 6D
Acute Mortality (All ages)	Premature deaths	O3	17800	17500	17300	16500	15000
Respiratory hospital admissions (>64)	Cases	O3	19080	18775	18572	17803	16168
Cardiovascular hospital admissions (>64)	Cases	O3	84028	82710	81762	78162	70666
Minor Restricted Activity Days (MRADs all ages)	Days	O3	85600047	84247689	832916	79751306	72291776
Chronic Mortality (All ages) LYL (1)	Life years lost	PM	2712818	2528130	2346405	2163449	1983531
Chronic Mortality (30yr +) deaths (1)	Premature deaths	PM	306981	286271	265399	24488	224769
Infant Mortality (0-1yr)	Premature deaths	PM	1062	989	919	845	773
Chronic Bronchitis (27yr +)	Cases	PM	242262	225787	209296	193324	177412
Bronchitis in children (aged 6 to 12)	Added cases	PM	4620688	4306510	3992889	3688243	3384315
Respiratory Hospital Admissions (All ages)	Cases	PM	105003	97733	91027	83753	76791
Cardiac Hospital Admissions (>18 years)	Cases	PM	80583	75205	69965	64399	59086
Restricted Activity Days (all ages)	Days	PM	275871902	257139250	238147099	220117469	201831060
Asthma symptom days (children 5-19yr)	Days	PM	8183267	7627288	7076647	6551034	6012666
Lost working days (15-64 years)	Days	PM	136552072	127245001	118334181	109151738	100259715

Note (1) Alternative expressions of the same effect, not additive

IMPACTS 2030	EU28		Option 1	Opt 6A	Opt 6B	Opt 6C	Opt 6D
Acute Mortality (All ages)	Premature deaths	O3	17200	17000	16800	16000	14400
Respiratory hospital admissions (>64)	Cases	O3	20061	19751	19541	1874	16914
Cardiovascular hospital admissions (>64)	Cases	O3	87708	86383	85409	81673	73336
Minor Restricted Activity Days (MRADs all ages)	Days	O3	83560018	82295930	81380787	77947523	70210465
Chronic Mortality (All ages) LYL (1)	Life years lost	PM	2540459	2370845	2202668	2036090	1817522
Chronic Mortality (30yr +) deaths (1)	Premature deaths	PM	304106	283932	263538	243741	217902
Infant Mortality (0-1yr)	Premature deaths	PM	943	880	818	755	673
Chronic Bronchitis (27yr +)	Cases	PM	234058	218409	202726	187672	167765
Bronchitis in children aged 6 to 12	Added cases	PM	4459198	4161137	3863144	3576416	3196594
Respiratory Hospital Admissions (All ages)	Cases	PM	100929	94054	87642	8085	7213
Cardiac Hospital Admissions (>18 years)	Cases	PM	77246	7216	67154	61964	55314
Restricted Activity Days (all ages)	Days	PM	269964452	251973103	233769290	216594842	193573166
Asthma symptom days (children 5-19yr)	Days	PM	7733781	7218182	6707800	6222191	5568248
Lost working days (15-64 years)	Days	PM	126944403	118424645	110185096	101818106	90984180

Note (1) Alternative expressions of the same effect, not additive

APPENDIX 7.3 IMPACT REDUCTIONS PER MEMBER STATE AND PER OPTION IN 2025 AND 2030 (% REDUCTIONS VS IMPACTS IN 2005)

Million Years of life lost (YOLL), calculated with constant 2010 population. 2025

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	% red	2025	% red	2025	% red	2025	% red	2025	% red
Austria	5,17	3,20	*-38%*	3,03	*-41%*	2,91	*-44%*	2,56	*-50%*	2,37	*-54%*
Belgium	9,11	5,47	*-40%*	5,14	*-44%*	4,88	*-46%*	4,55	*-50%*	4,25	*-53%*
Bulgaria	6,92	3,64	*-47%*	3,46	*-50%*	3,28	*-53%*	2,98	*-57%*	2,77	*-60%*
Croatia	2,96	1,68	*-43%*	1,58	*-47%*	1,50	*-50%*	1,37	*-54%*	1,26	*-57%*
Cyprus	0,59	0,53	*-9%*	0,53	*-9%*	0,53	*-10%*	0,52	*-11%*	0,52	*-12%*
Czech Rep.	7,91	5,31	*-33%*	4,93	*-38%*	4,68	*-41%*	4,21	*-47%*	3,82	*-52%*
Denmark	2,94	1,68	*-43%*	1,61	*-45%*	1,56	*-47%*	1,41	*-52%*	1,30	*-56%*
Estonia	0,53	0,43	*-19%*	0,42	*-21%*	0,42	*-22%*	0,40	*-26%*	0,33	*-38%*
Finland	1,68	1,28	*-24%*	1,26	*-25%*	1,26	*-25%*	1,19	*-29%*	1,09	*-35%*
France	46,02	24,73	*-46%*	23,36	*-49%*	22,44	*-51%*	21,04	*-54%*	18,54	*-60%*
Germany	53,90	34,50	*-36%*	32,29	*-40%*	30,47	*-43%*	28,19	*-48%*	26,53	*-51%*
Greece	11,65	6,15	*-47%*	5,97	*-49%*	5,33	*-54%*	5,08	*-56%*	4,73	*-59%*
Hungary	8,41	5,06	*-40%*	4,76	*-43%*	4,46	*-47%*	3,96	*-53%*	3,66	*-57%*
Ireland	1,34	0,86	*-36%*	0,84	*-38%*	0,81	*-39%*	0,78	*-42%*	0,73	*-45%*
Italy	51,51	32,52	*-37%*	30,69	*-40%*	26,59	*-48%*	25,08	*-51%*	22,99	*-55%*
Latvia	1,10	0,83	*-24%*	0,80	*-27%*	0,79	*-28%*	0,72	*-35%*	0,64	*-42%*
Lithuania	1,76	1,37	*-22%*	1,30	*-26%*	1,27	*-28%*	1,17	*-34%*	1,07	*-39%*
Luxembourg	0,39	0,23	*-40%*	0,22	*-44%*	0,21	*-46%*	0,19	*-51%*	0,18	*-54%*
Malta	0,25	0,13	*-47%*	0,13	*-48%*	0,12	*-50%*	0,12	*-51%*	0,12	*-53%*
Netherlands	12,22	7,21	*-41%*	6,83	*-44%*	6,52	*-47%*	6,16	*-50%*	5,82	*-52%*
Poland	36,91	28,52	*-23%*	26,21	*-29%*	24,26	*-34%*	21,91	*-41%*	19,61	*-47%*
Portugal	8,21	3,67	*-55%*	3,29	*-60%*	2,98	*-64%*	2,73	*-67%*	2,49	*-70%*
Romania	20,18	11,62	*-42%*	10,83	*-46%*	10,25	*-49%*	8,97	*-56%*	7,87	*-61%*
Slovakia	3,80	2,75	*-28%*	2,58	*-32%*	2,41	*-37%*	2,10	*-45%*	1,89	*-50%*
Slovenia	1,43	0,85	*-41%*	0,80	*-44%*	0,76	*-47%*	0,62	*-57%*	0,58	*-59%*
Spain	28,57	16,21	*-43%*	14,46	*-49%*	13,63	*-52%*	12,69	*-56%*	11,54	*-60%*
Sweden	2,66	1,84	*-31%*	1,80	*-33%*	1,76	*-34%*	1,69	*-37%*	1,58	*-41%*
Un. Kingdom	29,96	20,14	*-33%*	18,35	*-39%*	16,45	*-45%*	15,19	*-49%*	14,35	*-52%*
EU-28	358,09	222,38	*-38%*	207,45	*-42%*	192,51	*-46%*	177,58	*-50%*	162,64	*-55%*

Million Years of life lost (YOLL), calculated with constant 2010 population. 2030

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	2,22	3,05	*-41%*	2,89	*-44%*	2,76	*-47%*	2,45	*-53%*	2,22	*-57%*
Belgium	4,04	5,28	*-42%*	4,96	*-46%*	4,70	*-48%*	4,40	*-52%*	4,04	*-56%*
Bulgaria	2,60	3,47	*-50%*	3,30	*-52%*	3,12	*-55%*	2,86	*-59%*	2,60	*-62%*
Croatia	1,22	1,66	*-44%*	1,56	*-48%*	1,47	*-50%*	1,35	*-54%*	1,22	*-59%*
Cyprus	0,54	0,56	*-5%*	0,56	*-5%*	0,55	*-5%*	0,55	*-6%*	0,54	*-7%*
Czech Rep.	3,53	5,05	*-36%*	4,69	*-41%*	4,44	*-44%*	4,00	*-49%*	3,53	*-55%*
Denmark	1,24	1,60	*-46%*	1,53	*-48%*	1,49	*-49%*	1,37	*-53%*	1,24	*-58%*
Estonia	0,32	0,42	*-21%*	0,41	*-23%*	0,41	*-24%*	0,39	*-27%*	0,32	*-40%*
Finland	1,06	1,25	*-25%*	1,24	*-26%*	1,23	*-26%*	1,17	*-30%*	1,06	*-37%*
France	16,86	23,19	*-50%*	21,85	*-53%*	20,96	*-54%*	19,71	*-57%*	16,86	*-63%*
Germany	24,70	32,88	*-39%*	30,67	*-43%*	28,88	*-46%*	26,75	*-50%*	24,70	*-54%*
Greece	4,50	5,94	*-49%*	5,77	*-50%*	5,21	*-55%*	4,97	*-57%*	4,50	*-61%*
Hungary	3,50	4,93	*-41%*	4,64	*-45%*	4,34	*-48%*	3,86	*-54%*	3,50	*-58%*
Ireland	0,69	0,82	*-39%*	0,80	*-41%*	0,77	*-42%*	0,74	*-45%*	0,69	*-49%*
Italy	21,67	30,84	*-40%*	29,18	*-43%*	25,53	*-50%*	24,08	*-53%*	21,67	*-58%*
Latvia	0,61	0,81	*-27%*	0,78	*-29%*	0,77	*-30%*	0,71	*-36%*	0,61	*-44%*
Lithuania	1,04	1,34	*-24%*	1,28	*-27%*	1,25	*-29%*	1,15	*-34%*	1,04	*-41%*
Luxembourg	0,17	0,22	*-43%*	0,21	*-46%*	0,20	*-49%*	0,18	*-53%*	0,17	*-57%*
Malta	0,12	0,13	*-47%*	0,13	*-48%*	0,12	*-49%*	0,12	*-50%*	0,12	*-52%*
Netherlands	5,53	6,93	*-43%*	6,58	*-46%*	6,28	*-49%*	5,94	*-51%*	5,53	*-55%*
Poland	17,51	26,78	*-27%*	24,79	*-33%*	22,87	*-38%*	20,58	*-44%*	17,51	*-53%*
Portugal	2,43	3,64	*-56%*	3,25	*-60%*	2,97	*-64%*	2,73	*-67%*	2,43	*-70%*
Romania	7,43	11,19	*-45%*	10,41	*-48%*	9,82	*-51%*	8,80	*-56%*	7,43	*-63%*
Slovakia	1,79	2,67	*-30%*	2,51	*-34%*	2,34	*-38%*	2,04	*-46%*	1,79	*-53%*
Slovenia	0,56	0,81	*-43%*	0,77	*-46%*	0,73	*-49%*	0,60	*-58%*	0,56	*-61%*
Spain	11,15	16,11	*-44%*	14,39	*-50%*	13,54	*-53%*	12,60	*-56%*	11,15	*-61%*
Sweden	1,56	1,81	*-32%*	1,77	*-33%*	1,74	*-35%*	1,67	*-38%*	1,56	*-42%*
Un. Kingdom	13,53	19,01	*-37%*	17,47	*-42%*	15,79	*-47%*	14,59	*-51%*	13,53	*-55%*
EU-28	152,10	212,41	*-41%*	198,35	*-45%*	184,27	*-49%*	170,35	*-52%*	152,10	*-58%*

Premature deaths from ozone (cases/yr) 2025

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	469	312	*-33%*	308	*-34%*	304	*-35%*	288	*-39%*	257	*-45%*
Belgium	316	265	*-16%*	262	*-17%*	259	*-18%*	248	*-22%*	221	*-30%*
Bulgaria	814	543	*-33%*	537	*-34%*	533	*-35%*	510	*-37%*	468	*-43%*
Croatia	358	222	*-38%*	218	*-39%*	215	*-40%*	200	*-44%*	174	*-51%*
Cyprus	51	42	*-18%*	42	*-18%*	42	*-18%*	41	*-20%*	39	*-24%*
Czech Rep.	547	374	*-32%*	368	*-33%*	364	*-33%*	344	*-37%*	307	*-44%*
Denmark	164	127	*-23%*	126	*-23%*	125	*-24%*	120	*-27%*	110	*-33%*
Estonia	38	28	*-26%*	28	*-26%*	28	*-26%*	27	*-29%*	25	*-34%*
Finland	99	71	*-28%*	71	*-28%*	70	*-29%*	69	*-30%*	63	*-36%*
France	2497	1704	*-32%*	1684	*-33%*	1667	*-33%*	1601	*-36%*	1451	*-42%*
Germany	3673	2715	*-26%*	2674	*-27%*	2649	*-28%*	2533	*-31%*	2279	*-38%*
Greece	924	643	*-30%*	633	*-31%*	624	*-32%*	605	*-35%*	564	*-39%*
Hungary	828	533	*-36%*	526	*-36%*	520	*-37%*	488	*-41%*	435	*-47%*
Ireland	56	50	*-11%*	49	*-13%*	49	*-13%*	48	*-14%*	46	*-18%*
Italy	5294	3674	*-31%*	3591	*-32%*	3530	*-33%*	3377	*-36%*	3007	*-43%*
Latvia	93	65	*-30%*	65	*-30%*	64	*-31%*	62	*-33%*	57	*-39%*
Lithuania	144	103	*-28%*	102	*-29%*	101	*-30%*	98	*-32%*	91	*-37%*
Luxembourg	15	12	*-20%*	12	*-20%*	12	*-20%*	11	*-27%*	10	*-33%*
Malta	26	19	*-27%*	19	*-27%*	18	*-31%*	18	*-31%*	16	*-38%*
Netherlands	380	338	*-11%*	334	*-12%*	330	*-13%*	316	*-17%*	284	*-25%*
Poland	1669	1172	*-30%*	1158	*-31%*	1139	*-32%*	1083	*-35%*	979	*-41%*
Portugal	591	449	*-24%*	443	*-25%*	440	*-26%*	428	*-28%*	399	*-32%*
Romania	1597	1074	*-33%*	1061	*-34%*	1052	*-34%*	986	*-38%*	903	*-43%*
Slovakia	307	203	*-34%*	200	*-35%*	197	*-36%*	185	*-40%*	165	*-46%*
Slovenia	135	85	*-37%*	84	*-38%*	83	*-39%*	77	*-43%*	67	*-50%*
Spain	2085	1609	*-23%*	1573	*-25%*	1564	*-25%*	1516	*-27%*	1402	*-33%*
Sweden	240	172	*-28%*	171	*-29%*	169	*-30%*	164	*-32%*	152	*-37%*
Un. Kingdom	1207	1192	*-1%*	1181	*-2%*	1167	*-3%*	1123	*-7%*	1040	*-14%*
EU-28	24614	17794	*-28%*	17517	*-29%*	17318	*-30%*	16566	*-33%*	15009	*-39%*

Premature deaths from ozone (cases/yr) 2030

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	% red	2025	% red	2025	% red	2025	% red	2025	% red
Austria	469	298	*-36%*	294	*-37%*	291	*-38%*	275	*-41%*	243	*-48%*
Belgium	316	258	*-18%*	255	*-19%*	252	*-20%*	241	*-24%*	214	*-32%*
Bulgaria	814	526	*-35%*	520	*-36%*	516	*-37%*	495	*-39%*	448	*-45%*
Croatia	358	212	*-41%*	208	*-42%*	206	*-42%*	191	*-47%*	165	*-54%*
Cyprus	51	43	*-16%*	43	*-16%*	43	*-16%*	42	*-18%*	40	*-22%*
Czech Rep.	547	359	*-34%*	353	*-35%*	349	*-36%*	330	*-40%*	292	*-47%*
Denmark	164	124	*-24%*	122	*-26%*	121	*-26%*	117	*-29%*	106	*-35%*
Estonia	38	27	*-29%*	27	*-29%*	27	*-29%*	26	*-32%*	24	*-37%*
Finland	99	69	*-30%*	69	*-30%*	68	*-31%*	67	*-32%*	61	*-38%*
France	2497	1642	*-34%*	1624	*-35%*	1607	*-36%*	1545	*-38%*	1389	*-44%*
Germany	3673	2623	*-29%*	2582	*-30%*	2558	*-30%*	2447	*-33%*	2185	*-41%*
Greece	924	632	*-32%*	624	*-32%*	615	*-33%*	597	*-35%*	553	*-40%*
Hungary	828	510	*-38%*	504	*-39%*	498	*-40%*	466	*-44%*	412	*-50%*
Ireland	56	49	*-13%*	49	*-13%*	49	*-13%*	47	*-16%*	45	*-20%*
Italy	5294	3546	*-33%*	3474	*-34%*	3418	*-35%*	3267	*-38%*	2896	*-45%*
Latvia	93	64	*-31%*	63	*-32%*	63	*-32%*	61	*-34%*	56	*-40%*
Lithuania	144	100	*-31%*	100	*-31%*	99	*-31%*	96	*-33%*	88	*-39%*
Luxembourg	15	11	*-27%*	11	*-27%*	11	*-27%*	11	*-27%*	10	*-33%*
Malta	26	18	*-31%*	18	*-31%*	18	*-31%*	17	*-35%*	16	*-38%*
Netherlands	380	329	*-13%*	325	*-14%*	322	*-15%*	308	*-19%*	274	*-28%*
Poland	1669	1130	*-32%*	1117	*-33%*	1099	*-34%*	1044	*-37%*	936	*-44%*
Portugal	591	441	*-25%*	435	*-26%*	432	*-27%*	420	*-29%*	390	*-34%*
Romania	1597	1041	*-35%*	1029	*-36%*	1020	*-36%*	958	*-40%*	869	*-46%*
Slovakia	307	194	*-37%*	192	*-37%*	189	*-38%*	177	*-42%*	156	*-49%*
Slovenia	135	81	*-40%*	80	*-41%*	79	*-41%*	73	*-46%*	63	*-53%*
Spain	2085	1574	*-25%*	1540	*-26%*	1531	*-27%*	1484	*-29%*	1366	*-34%*
Sweden	240	167	*-30%*	165	*-31%*	164	*-32%*	159	*-34%*	146	*-39%*
Un. Kingdom	1207	1171	*-3%*	1160	*-4%*	1147	*-5%*	1105	*-8%*	1018	*-16%*
EU-28	24614	17239	*-30%*	16980	*-31%*	16792	*-32%*	16067	*-35%*	14461	*-41%*

Square Kilometres of forest area exceeding acidification critical loads. 2025

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	63	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
Belgium	668	29	*-96%*	29	*-96%*	28	*-96%*	19	*-97%*	4	*-99%*
Bulgaria	0	0		0		0		0		0	
Croatia	1333	297	*-78%*	252	*-81%*	142	*-89%*	51	*-96%*	21	*-98%*
Cyprus	0	0		0		0		0		0	
Czech Rep.	1902	916	*-52%*	704	*-63%*	535	*-72%*	381	*-80%*	281	*-85%*
Denmark	1438	37	*-97%*	28	*-98%*	23	*-98%*	11	*-99%*	9	*-99%*
Estonia	119	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
Finland	25	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
France	15403	3199	*-79%*	1768	*-89%*	958	*-94%*	403	*-97%*	150	*-99%*
Germany	32633	4361	*-87%*	2762	*-92%*	1522	*-95%*	867	*-97%*	639	*-98%*
Greece	1217	198	*-84%*	149	*-88%*	94	*-92%*	73	*-94%*	73	*-94%*
Hungary	3326	1077	*-68%*	926	*-72%*	560	*-83%*	432	*-87%*	330	*-90%*
Ireland	696	4	*-99%*	3	*-100%*	3	*-100%*	1	*-100%*	0	*-100%*
Italy	1060	60	*-94%*	40	*-96%*	28	*-97%*	2	*-100%*	1	*-100%*
Latvia	5275	1066	*-80%*	878	*-83%*	790	*-85%*	614	*-88%*	472	*-91%*
Lithuania	6563	5781	*-12%*	5648	*-14%*	5556	*-15%*	5403	*-18%*	5024	*-23%*
Luxembourg	165	118	*-29%*	117	*-29%*	96	*-42%*	3	*-98%*	3	*-98%*
Malta	0	0		0		0		0		0	
Netherlands	4785	3816	*-20%*	3699	*-23%*	3576	*-25%*	3380	*-29%*	3229	*-33%*
Poland	52295	19166	*-63%*	13987	*-73%*	11506	*-78%*	7537	*-86%*	5887	*-89%*
Portugal	1387	190	*-86%*	168	*-88%*	140	*-90%*	135	*-90%*	116	*-92%*
Romania	2930	80	*-97%*	56	*-98%*	1	*-100%*	0	*-100%*	0	*-100%*
Slovakia	2103	523	*-75%*	402	*-81%*	217	*-90%*	47	*-98%*	42	*-98%*
Slovenia	203	4	*-98%*	3	*-99%*	3	*-99%*	0	*-100%*	0	*-100%*
Spain	2620	48	*-98%*	41	*-98%*	28	*-99%*	4	*-100%*	1	*-100%*
Sweden	19376	5243	*-73%*	4867	*-75%*	4572	*-76%*	4216	*-78%*	3836	*-80%*
Un. Kingdom	3315	967	*-71%*	760	*-77%*	542	*-84%*	395	*-88%*	309	*-91%*
EU-28	160900	47178	*-71%*	37287	*-77%*	30920	*-81%*	23972	*-85%*	2042 8	*-87%*

Square Kilometres of forest area exceeding acidification critical loads. 2030

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	63	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
Belgium	668	29	*-96%*	28	*-96%*	26	*-96%*	11	*-98%*	2	*-100%*
Bulgaria	0	0		0		0		0		0	
Croatia	1333	294	*-78%*	250	*-81%*	133	*-90%*	47	*-96%*	19	*-99%*
Cyprus	0	0		0		0		0		0	
Czech Rep.	1902	787	*-59%*	577	*-70%*	439	*-77%*	275	*-86%*	213	*-89%*
Denmark	1438	32	*-98%*	27	*-98%*	13	*-99%*	10	*-99%*	9	*-99%*
Estonia	119	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
Finland	25	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*	0	*-100%*
France	15403	2364	*-85%*	1452	*-91%*	759	*-95%*	216	*-99%*	113	*-99%*
Germany	32633	3561	*-89%*	2129	*-93%*	1098	*-97%*	623	*-98%*	434	*-99%*
Greece	1217	150	*-88%*	115	*-91%*	94	*-92%*	75	*-94%*	75	*-94%*
Hungary	3326	1065	*-68%*	872	*-74%*	524	*-84%*	430	*-87%*	260	*-92%*
Ireland	696	3	*-100%*	3	*-100%*	2	*-100%*	0	*-100%*	0	*-100%*
Italy	1060	48	*-95%*	40	*-96%*	28	*-97%*	2	*-100%*	1	*-100%*
Latvia	5275	1045	*-80%*	865	*-84%*	754	*-86%*	608	*-88%*	451	*-91%*
Lithuania	6563	5773	*-12%*	5612	*-14%*	5532	*-16%*	5399	*-18%*	5009	*-24%*
Luxembourg	165	118	*-29%*	116	*-29%*	68	*-59%*	3	*-98%*	3	*-98%*
Malta	0	0		0		0		0		0	
Netherlands	4785	3731	*-22%*	3612	*-25%*	3460	*-28%*	3219	*-33%*	3035	*-37%*
Poland	52295	16483	*-68%*	11756	*-78%*	9346	*-82%*	5765	*-89%*	4334	*-92%*
Portugal	1387	190	*-86%*	168	*-88%*	140	*-90%*	135	*-90%*	115	*-92%*
Romania	2930	69	*-98%*	56	*-98%*	1	*-100%*	0	*-100%*	0	*-100%*
Slovakia	2103	447	*-79%*	309	*-85%*	119	*-94%*	42	*-98%*	40	*-98%*
Slovenia	203	4	*-98%*	3	*-99%*	1	*-99%*	0	*-100%*	0	*-100%*
Spain	2620	44	*-98%*	35	*-99%*	27	*-99%*	4	*-100%*	1	*-100%*
Sweden	19376	4931	*-75%*	4634	*-76%*	4452	*-77%*	4044	*-79%*	3615	*-81%*
Un. Kingdom	3315	827	*-75%*	658	*-80%*	481	*-86%*	340	*-90%*	218	*-93%*
EU-28	160900	41995	*-74%*	33317	*-79%*	27496	*-83%*	21247	*-87%*	17948	*-89%*

Square Kilometres of ecosystem area exceeding eutrophication critical loads. 2025

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	% red	2025	% red	2025	% red	2025	% red	2025	% red
Austria	29569	17369	*-41%*	13823	*-53%*	11507	*-61%*	8524	*-71%*	6235	*-79%*
Belgium	253	28	*-89%*	10	*-96%*	5	*-98%*	1	*-99%*	1	*-100%*
Bulgaria	31978	14250	*-55%*	14182	*-56%*	14115	*-56%*	12943	*-60%*	11576	*-64%*
Croatia	28901	24465	*-15%*	23818	*-18%*	23389	*-19%*	21968	*-24%*	21038	*-27%*
Cyprus	2528	2528	*0%*	2528	*0%*	2528	*0%*	2528	*0%*	2528	*0%*
Czech Rep.	2094	1702	*-19%*	1583	*-24%*	1423	*-32%*	1213	*-42%*	1030	*-51%*
Denmark	4275	4234	*-1%*	4231	*-1%*	4227	*-1%*	4156	*-3%*	4068	*-5%*
Estonia	10886	4475	*-59%*	4356	*-60%*	4030	*-63%*	3482	*-68%*	2647	*-76%*
Finland	30047	7963	*-73%*	7144	*-76%*	6711	*-78%*	5611	*-81%*	4316	*-86%*
France	157035	121429	*-23%*	113945	*-27%*	104304	*-34%*	88184	*-44%*	74833	*-52%*
Germany	65668	50700	*-23%*	45879	*-30%*	40361	*-39%*	33971	*-48%*	31391	*-52%*
Greece	57928	55006	*-5%*	54533	*-6%*	54292	*-6%*	54121	*-7%*	53185	*-8%*
Hungary	23844	19136	*-20%*	17393	*-27%*	16169	*-32%*	15900	*-33%*	15856	*-34%*
Ireland	1621	615	*-62%*	595	*-63%*	539	*-67%*	443	*-73%*	342	*-79%*
Italy	98149	56516	*-42%*	52093	*-47%*	46273	*-53%*	38668	*-61%*	35439	*-64%*
Latvia	32738	26928	*-18%*	26034	*-20%*	25547	*-22%*	23354	*-29%*	20236	*-38%*
Lithuania	19343	18932	*-2%*	18874	*-2%*	18784	*-3%*	18354	*-5%*	16916	*-13%*
Luxembourg	1156	1117	*-3%*	1116	*-3%*	1106	*-4%*	1084	*-6%*	1065	*-8%*
Malta	0	0		0		0		0		0	
Netherlands	4142	3899	*-6%*	3861	*-7%*	3752	*-9%*	3530	*-15%*	3506	*-15%*
Poland	74127	59685	*-19%*	56348	*-24%*	54066	*-27%*	45796	*-38%*	40264	*-46%*
Portugal	32716	32590	*0%*	32430	*-1%*	32141	*-2%*	30670	*-6%*	28729	*-12%*
Romania	94774	88682	*-6%*	88121	*-7%*	87800	*-7%*	85212	*-10%*	81946	*-14%*
Slovakia	22184	19661	*-11%*	19353	*-13%*	19082	*-14%*	18512	*-17%*	17856	*-20%*
Slovenia	9716	2158	*-78%*	1593	*-84%*	1103	*-89%*	515	*-95%*	366	*-96%*
Spain	211578	202275	*-4%*	201083	*-5%*	198777	*-6%*	192785	*-9%*	181272	*-14%*
Sweden	91924	44863	*-51%*	42207	*-54%*	39439	*-57%*	33551	*-64%*	26665	*-71%*
Un. Kingdom	8924	4054	*-55%*	3624	*-59%*	2795	*-69%*	1755	*-80%*	1346	*-85%*
EU-28	1148097	885262	*-23%*	850757	*-26%*	814266	*-29%*	746831	*-35%*	684651	*-40%*

Square Kilometres of ecosystem area exceeding eutrophication critical loads. 2030

Country		Option 1		Option 6A		Option 6B		Option 6C		Option 6D	
	2005	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*	2025	*% red*
Austria	29569	16210	*-45%*	12569	*-57%*	10283	*-65%*	7278	*-75%*	5214	*-82%*
Belgium	253	25	*-90%*	6	*-98%*	4	*-98%*	1	*-100%*	1	*-100%*
Bulgaria	31978	14250	*-55%*	14115	*-56%*	14115	*-56%*	12943	*-60%*	11576	*-64%*
Croatia	28901	24105	*-17%*	23566	*-18%*	23080	*-20%*	21785	*-25%*	20617	*-29%*
Cyprus	2528	2528	*0%*	2528	*0%*	2528	*0%*	2528	*0%*	2528	*0%*
Czech Rep.	2094	1659	*-21%*	1508	*-28%*	1356	*-35%*	1071	*-49%*	875	*-58%*
Denmark	4275	4231	*-1%*	4230	*-1%*	4214	*-1%*	4140	*-3%*	4013	*-6%*
Estonia	10886	4419	*-59%*	4201	*-61%*	3891	*-64%*	3363	*-69%*	2517	*-77%*
Finland	30047	7322	*-76%*	6513	*-78%*	6198	*-79%*	5171	*-83%*	4022	*-87%*
France	157035	117867	*-25%*	108306	*-31%*	98435	*-37%*	82080	*-48%*	71303	*-55%*
Germany	65668	49440	*-25%*	43827	*-33%*	38191	*-42%*	32419	*-51%*	29743	*-55%*
Greece	57928	54678	*-6%*	54366	*-6%*	54185	*-6%*	53828	*-7%*	52852	*-9%*
Hungary	23844	18452	*-23%*	16611	*-30%*	15997	*-33%*	15884	*-33%*	15848	*-34%*
Ireland	1621	586	*-64%*	568	*-65%*	520	*-68%*	428	*-74%*	318	*-80%*
Italy	98149	54504	*-44%*	50186	*-49%*	43442	*-56%*	36505	*-63%*	33288	*-66%*
Latvia	32738	26468	*-19%*	25754	*-21%*	25048	*-23%*	22982	*-30%*	19959	*-39%*
Lithuania	19343	18923	*-2%*	18864	*-2%*	18762	*-3%*	18332	*-5%*	16834	*-13%*
Luxembourg	1156	1116	*-3%*	1106	*-4%*	1106	*-4%*	1071	*-7%*	1046	*-9%*
Malta	0	0		0		0		0		0	
Netherlands	4142	3886	*-6%*	3829	*-8%*	3683	*-11%*	3508	*-15%*	3439	*-17%*
Poland	74127	58839	*-21%*	54771	*-26%*	52450	*-29%*	43737	*-41%*	37690	*-49%*
Portugal	32716	32580	*0%*	32378	*-1%*	32024	*-2%*	30527	*-7%*	28404	*-13%*
Romania	94774	88362	*-7%*	87930	*-7%*	87373	*-8%*	84439	*-11%*	80852	*-15%*
Slovakia	22184	19416	*-12%*	19228	*-13%*	18923	*-15%*	18283	*-18%*	17336	*-22%*
Slovenia	9716	1936	*-80%*	1267	*-87%*	878	*-91%*	460	*-95%*	286	*-97%*
Spain	211578	201558	*-5%*	200233	*-5%*	197487	*-7%*	190457	*-10%*	178497	*-16%*
Sweden	91924	43196	*-53%*	40343	*-56%*	37594	*-59%*	31698	*-66%*	24834	*-73%*
Un. Kingdom	8924	3927	*-56%*	3529	*-60%*	2527	*-72%*	1635	*-82%*	1225	*-86%*
EU-28	1148097	870482	*-24%*	832334	*-28%*	794295	*-31%*	726551	*-37%*	665117	*-42%*

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PART 4/4

COMMISSION STAFF WORKING DOCUMENT

IMPACT ASSESSMENT

Accompanying the document

Communication from the Commission to the Council, the European Parliament, the European Economic and Social Committee and he Committee of the Regions a Clean Air Programme for Europe

Proposal for a Directive of the European Parliament and of the Council on the limitation of emissions of certain pollutants into the air from medium combustion plants

Proposal for a Directive of the European Parliament and of the Council on the reduction of national emissions of certain atmospheric pollutants and amending Directive 2003/35/EC

Proposal for a Council Decision on the acceptance of the Amendment to the 1999 Protocol to the 1979 Convention on Long-Range Transboundary Air Pollution to Abate Acidification, Eutrophication and Ground-level Ozone

{COM(2013) 917 final}
{COM(2013) 918 final}
{COM(2013) 919 final}
{COM(2013) 920 final}
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APPENDIX 7.4 EMISSION REDUCTIONS REQUIRED OF THE MEMBER STATES IN 2025 AND 2030 TO ACHIEVE THE IMPACT REDUCTION OBJECTIVES OF THE CENTRAL CASE OPTION 6C*

2025 central case; emission ceilings in Kilotons; % reduction vs 2005

Country	SO2	% red	NOx	% red	NH3	% red	VOC	% red	PM2,5	% red
Austria	12	*-52%*	71	*-69%*	50	*-20%*	90	*-47%*	11	*-54%*
Belgium	46	*-67%*	123	*-58%*	62	*-16%*	88	*-44%*	15	*-46%*
Bulgaria	81	*-91%*	63	*-62%*	58	*-11%*	55	*-61%*	14	*-60%*
Croatia	9	*-86%*	27	*-64%*	20	*-31%*	38	*-52%*	5	*-65%*
Cyprus	1	*-97%*	7	*-68%*	5	*-23%*	4	*-53%*	1	*-73%*
Czech Rep.	65	*-68%*	114	*-61%*	52	*-35%*	113	*-55%*	23	*-47%*
Denmark	9	*-56%*	63	*-65%*	44	*-40%*	54	*-59%*	11	*-62%*
Estonia	20	*-70%*	18	*-55%*	9	*-23%*	26	*-31%*	10	*-48%*
Finland	63	*-30%*	110	*-45%*	27	*-20%*	95	*-45%*	18	*-37%*
France	103	*-77%*	453	*-66%*	463	*-31%*	571	*-49%*	154	*-43%*
Germany	295	*-46%*	517	*-63%*	318	*-46%*	715	*-42%*	73	*-41%*
Greece	52	*-90%*	130	*-68%*	41	*-28%*	92	*-68%*	16	*-71%*
Hungary	17	*-86%*	53	*-66%*	48	*-38%*	63	*-57%*	11	*-61%*
Ireland	13	*-81%*	54	*-64%*	89	*-14%*	43	*-33%*	9	*-32%*
Italy	93	*-76%*	447	*-66%*	298	*-29%*	566	*-54%*	85	*-42%*
Latvia	3	*-47%*	22	*-39%*	13	*-1%*	30	*-57%*	9	*-52%*
Lithuania	11	*-74%*	29	*-54%*	40	*-10%*	34	*-59%*	7	*-55%*
Luxembourg	1	*-44%*	13	*-73%*	5	*-25%*	5	*-58%*	2	*-47%*
Malta	0,2	*-98%*	1	*-86%*	1	*-26%*	3	*-32%*	0,2	*-79%*
Netherlands	30	*-57%*	134	*-65%*	111	*-24%*	135	*-34%*	15	*-38%*
Poland	332	*-74%*	398	*-50%*	243	*-29%*	286	*-53%*	154	*-31%*
Portugal	23	*-79%*	76	*-72%*	55	*-22%*	118	*-48%*	19	*-69%*
Romania	55	*-92%*	111	*-64%*	115	*-29%*	171	*-63%*	44	*-61%*
Slovakia	20	*-78%*	42	*-55%*	17	*-41%*	45	*-41%*	12	*-62%*
Slovenia	5	*-88%*	17	*-66%*	14	*-26%*	15	*-62%*	2	*-73%*
Spain	152	*-89%*	418	*-72%*	256	*-30%*	488	*-48%*	61	*-61%*
Sweden	30	*-22%*	82	*-62%*	43	*-20%*	136	*-35%*	21	*-33%*
Un. Kingdom	153	*-82%*	450	*-70%*	240	*-22%*	550	*-50%*	46	*-47%*
EU-28	1697	*-79%*	4043	*-65%*	2740	*-30%*	4630	*-50%*	848	*-48%*

2030 central case; emission ceilings in Kilotons; % reduction vs 2005

Country	SO2	% red	NOx	% red	NH3	% red	VOC	% red	PM2,5	% red
Austria	11	*-54%*	60	*-74%*	51	*-20%*	89	*-48%*	11	*-55%*
Belgium	44	*-68%*	112	*-62%*	62	*-16%*	89	*-44%*	15	*-46%*
Bulgaria	53	*-94%*	55	*-67%*	58	*-11%*	51	*-63%*	12	*-64%*
Croatia	9	*-87%*	25	*-68%*	21	*-30%*	36	*-55%*	5	*-67%*
Cyprus	1	*-97%*	6	*-71%*	5	*-21%*	4	*-54%*	1	*-73%*
Czech Rep.	59	*-72%*	99	*-67%*	51	*-36%*	111	*-56%*	22	*-49%*
Denmark	9	*-58%*	55	*-70%*	43	*-41%*	53	*-59%*	10	*-64%*
Estonia	19	*-71%*	16	*-61%*	9	*-21%*	24	*-37%*	10	*-52%*
Finland	63	*-30%*	99	*-51%*	28	*-18%*	91	*-47%*	17	*-41%*
France	98	*-78%*	395	*-71%*	458	*-32%*	559	*-50%*	141	*-48%*
Germany	258	*-53%*	435	*-69%*	312	*-47%*	705	*-43%*	70	*-43%*
Greece	38	*-92%*	110	*-73%*	41	*-28%*	89	*-69%*	17	*-72%*
Hungary	16	*-88%*	46	*-70%*	49	*-37%*	61	*-58%*	11	*-63%*
Ireland	11	*-84%*	35	*-77%*	89	*-14%*	42	*-33%*	9	*-35%*
Italy	92	*-76%*	390	*-70%*	301	*-29%*	554	*-55%*	81	*-45%*
Latvia	3	*-47%*	19	*-47%*	13	*2%*	30	*-56%*	8	*-54%*
Lithuania	12	*-72%*	26	*-58%*	44	*-1%*	33	*-60%*	6	*-57%*
Luxembourg	1	*-44%*	10	*-79%*	5	*-25%*	5	*-59%*	2	*-48%*
Malta	0,2	*-98%*	1	*-89%*	1	*-27%*	3	*-31%*	0,1	*-80%*
Netherlands	28	*-59%*	121	*-68%*	109	*-25%*	133	*-35%*	15	*-39%*
Poland	278	*-78%*	338	*-58%*	244	*-29%*	280	*-54%*	140	*-38%*
Portugal	23	*-79%*	65	*-76%*	56	*-20%*	119	*-48%*	19	*-69%*
Romania	51	*-93%*	100	*-68%*	113	*-30%*	165	*-64%*	41	*-64%*
Slovakia	20	*-79%*	39	*-59%*	17	*-41%*	45	*-41%*	12	*-62%*
Slovenia	5	*-89%*	14	*-72%*	14	*-26%*	15	*-63%*	2	*-74%*
Spain	151	*-89%*	354	*-77%*	255	*-30%*	488	*-48%*	62	*-60%*
Sweden	32	*-16%*	75	*-65%*	43	*-19%*	131	*-38%*	20	*-34%*
Un. Kingdom	128	*-85%*	391	*-74%*	244	*-21%*	545	*-50%*	46	*-48%*
EU-28	1513	*-81%*	3490	*-70%*	2734	*-30%*	4551	*-51%*	806	*-51%*

APPENDIX 7.5 EMISSION REDUCTIONS COST EFFECTIVE IN INDIVIDUAL SECTORS IN 2025 AND 2030 TO ACHIEVE THE IMPACT REDUCTION OBJECTIVES OF THE CENTRAL CASE OPTION 6C*

2025 central case; emissions in Kilotons; % reduction vs Baseline (Option 1)

Sector										
	SO2	% red	NOx	% red	NH3	% red	VOC	% red	PM2,5	% red
Power generation	671	-19%	860	-19%	17	-30%	132	-23%	30	-50%
Domestic combustion	255	-36%	504	0%	20	0%	390	-52%	359	-31%
Industrial combustion	388	-35%	616	-31%	5	-14%	77	0%	43	-40%
Industrial Processes	347	-39%	167	-2%	60	-19%	773	-5%	147	-26%
Fuel extraction	0		0		0		290	-5%	7	0%
Solvent use	0		0		0		2328	-10%	0	
Road transport	5	0%	1210	0%	48	0%	293	0%	104	0%
Non-road machinery	31	-15%	684	-9%	1	-45%	271	-13%	37	-8%
Waste	1	-76%	1	-82%	173	0%	75	-13%	64	-29%
Agriculture	0	-100%	1	-96%	2416	-27%	0	-100%	58	-66%
total	1697	-31%	4043	-12%	2740	-25%	4630	-17%	848	-33%

2030 central case; emissions in Kilotons; % reduction vs Baseline (Option 1)

Sector										
	SO2	% red	NOx	% red	NH3	% red	VOC	% red	PM2,5	% red
Power generation	520	-18%	720	-20%	15	-33%	117	-28%	25	-53%
Domestic combustion	217,9	-35%	470	0%	19	0%	362	-51%	323,7	-30%
Industrial combustion	390	-36%	633	-32%	5	-15%	85	0%	45	-40%
Industrial Processes	348	-40%	167	-2%	60	-20%	778	-5%	149	-26%
Fuel extraction	0		0		0		275	-5%	6	0%
Solvent use	0		0		0		2342	-10%	0	
Road transport	5	0%	887	0%	46	0%	257	0%	102	0%
Non-road machinery	31	-15%	611	-8%	1	-45%	262	-7%	33	-5%
Waste	1	-77%	1	-84%	173	0%	74	-12%	64	-29%
Agriculture	0	-100%	1	-96%	2415	-27%	0	-100%	58	-66%
total	1513	-32%	3490	-14%	2734	-25%	4551	-17%	806	-33%

APPENDIX 7.6 IMPACT REDUCTIONS IN THE MEMBER STATES IN 2025 AND 2030 IN THE CENTRAL CASE OPTION 6C* COMPARED TO OPTION 1

2025 central case; impact % reduction vs baseline (Option 1)

Country	PM human mortality, years of life lost, million		Premature deaths due to ozone		Forest area exceeding acidification limits		Ecosystem area exceeding eutrophication limits	
		% red		% red		% red		% red
Austria	2,56	-20%	287	-7%	0		8338	-52%
Belgium	4,55	-17%	247	-6%	19	-36%	1	-95%
Bulgaria	2,97	-18%	508	-5%	0		11576	-19%
Croatia	1,37	-19%	199	-9%	51	-83%	21830	-11%
Cyprus	0,52	-2%	41	-2%	0		2528	0%
Czech Rep.	4,21	-21%	343	-7%	377	-59%	1183	-31%
Denmark	1,41	-16%	120	-5%	10	-72%	4144	-2%
Estonia	0,39	-8%	27	-4%	0		3197	-29%
Finland	1,19	-7%	68	-4%	0		5476	-31%
France	21,03	-15%	1596	-5%	403	-87%	87546	-28%
Germany	28,17	-18%	2525	-6%	865	-80%	33851	-33%
Greece	5,08	-17%	604	-5%	73	-63%	54080	-2%
Hungary	3,95	-22%	486	-8%	432	-60%	15898	-17%
Ireland	0,77	-10%	48	-2%	0	-91%	409	-33%
Italy	25,18	-23%	3369	-6%	2	-96%	38408	-32%
Latvia	0,72	-14%	62	-5%	587	-45%	22755	-15%
Lithuania	1,16	-15%	98	-4%	5380	-7%	18142	-4%
Luxembourg	0,19	-17%	11	-8%	3	-97%	1084	-3%
Malta	0,12	-7%	18	-5%	0		0	
Netherlands	6,16	-15%	316	-5%	3376	-12%	3530	-9%
Poland	21,88	-23%	1079	-7%	7435	-61%	45381	-24%
Portugal	2,73	-26%	423	-5%	132	-30%	30385	-7%
Romania	8,92	-23%	983	-7%	0	-100%	84115	-5%
Slovakia	2,09	-24%	185	-8%	44	-92%	18489	-6%
Slovenia	0,62	-27%	76	-10%	0	-100%	500	-77%
Spain	12,79	-21%	1506	-4%	4	-92%	191606	-5%
Sweden	1,68	-8%	164	-4%	4205	-20%	32800	-27%
Un. Kingdom	15,18	-25%	1121	-5%	394	-59%	1743	-57%
EU-28	177,58	-20%	16509	-6%	23791	-50%	738994	-17%

2030 central case; impact % reduction vs baseline (Option 1)

Country	PM human mortality, years of life lost, million		Premature deaths due to ozone		Forest area exceeding acidification limits		Ecosystem area exceeding eutrophication limits	
		% red		*% red*		*% red*		*% red*
Austria	2,45	*-20%*	274	*-7%*	0		7121	*-56%*
Belgium	4,40	*-17%*	241	*-5%*	11	*-62%*	1	*-95%*
Bulgaria	2,84	*-18%*	491	*-6%*	0		11576	*-19%*
Croatia	1,35	*-19%*	190	*-9%*	47	*-84%*	21622	*-10%*
Cyprus	0,55	*-2%*	42	*-2%*	0		2528	*0%*
Czech Rep.	3,99	*-21%*	329	*-7%*	271	*-66%*	1068	*-36%*
Denmark	1,36	*-15%*	117	*-4%*	10	*-70%*	4128	*-2%*
Estonia	0,39	*-8%*	26	*-4%*	0		3062	*-31%*
Finland	1,17	*-6%*	67	*-3%*	0		5060	*-31%*
France	19,70	*-15%*	1539	*-5%*	216	*-91%*	81731	*-31%*
Germany	26,72	*-19%*	2439	*-6%*	615	*-83%*	32316	*-35%*
Greece	4,97	*-16%*	595	*-5%*	75	*-50%*	53785	*-2%*
Hungary	3,85	*-22%*	465	*-8%*	430	*-60%*	15882	*-14%*
Ireland	0,74	*-9%*	47	*-4%*	0	*-91%*	381	*-35%*
Italy	24,19	*-22%*	3259	*-6%*	2	*-96%*	36140	*-34%*
Latvia	0,71	*-12%*	61	*-3%*	577	*-45%*	22428	*-15%*
Lithuania	1,15	*-14%*	95	*-5%*	5357	*-7%*	18044	*-5%*
Luxembourg	0,18	*-17%*	11	*0%*	3	*-97%*	1071	*-4%*
Malta	0,12	*-7%*	17	*-6%*	0		0	
Netherlands	5,94	*-14%*	308	*-5%*	3213	*-14%*	3508	*-10%*
Poland	20,55	*-23%*	1040	*-7%*	5693	*-65%*	43383	*-26%*
Portugal	2,72	*-25%*	415	*-5%*	132	*-30%*	30318	*-7%*
Romania	8,74	*-22%*	955	*-7%*	0	*-100%*	82945	*-6%*
Slovakia	2,04	*-24%*	177	*-8%*	42	*-91%*	18206	*-6%*
Slovenia	0,60	*-26%*	73	*-9%*	0	*-100%*	417	*-78%*
Spain	12,69	*-21%*	1473	*-4%*	1	*-97%*	188858	*-6%*
Sweden	1,66	*-8%*	159	*-4%*	4012	*-19%*	30859	*-29%*
Un. Kingdom	14,59	*-23%*	1103	*-5%*	338	*-59%*	1572	*-60%*
EU-28	170,35	*-20%*	16007	*-6%*	21047	*-50%*	718011	*-18%*

APPENDIX 7.7 INDICATIVE EMISSION TRAJECTORY TOWARDS ACHIEVING THE LONG-TERM OBJECTIVE IN 2050

SO2 emissions, kiloton. Indicative beyond 2025

	2025	2030	2035	2040	2045	2050
Austria	12	11	9	8	8	7
Belgium	46	43	40	38	35	33
Bulgaria	81	61	46	34	26	20
Croatia	9	8	7	6	5	5
Cyprus	1	1	1	1	1	1
Czech Rep.	65	53	43	34	28	22
Denmark	9	9	8	8	7	7
Estonia	20	18	17	16	15	14
Finland	63	55	49	43	38	33
France	103	94	87	79	73	67
Germany	295	245	203	169	140	116
Greece	52	40	31	24	20	15
Hungary	17	15	14	12	11	10
Ireland	13	10	8	7	5	4
Italy	93	85	77	70	64	58
Latvia	3	3	2	2	2	2
Lithuania	11	10	10	9	9	8
Luxembourg	1	1	1	1	1	1
Malta	0	0	0	0	0	0
Netherlands	30	27	24	22	19	17
Poland	332	252	191	145	110	83
Portugal	23	21	19	17	15	13
Romania	55	44	36	29	23	19
Slovakia	20	18	17	16	15	14
Slovenia	5	4	4	3	3	3
Spain	152	134	119	105	93	82
Sweden	30	30	29	28	27	26
Un. Kingdom	153	127	105	88	73	60
EU-28	1697	1437	1217	1030	873	739

NOx emissions, kiloton. Indicative beyond 2025

	2025	2030	2035	2040	2045	2050
Austria	71	60	50	42	36	30
Belgium	123	108	95	84	73	64
Bulgaria	63	54	47	41	35	30
Croatia	27	22	17	14	11	9
Cyprus	7	6	5	4	4	3
Czech Rep.	114	96	81	69	58	49
Denmark	63	56	49	43	38	34
Estonia	18	15	12	10	8	7
Finland	110	92	77	64	53	44
France	453	391	338	292	252	218
Germany	517	438	372	315	268	227
Greece	129	116	103	93	83	74
Hungary	53	45	38	32	28	23
Ireland	54	45	38	31	26	22
Italy	447	399	357	319	285	255
Latvia	22	18	15	13	11	9
Lithuania	29	24	19	16	13	11
Luxembourg	13	10	7	6	4	3
Malta	1	1	1	1	1	0
Netherlands	134	124	115	107	99	91
Poland	398	336	283	238	201	169
Portugal	76	68	60	54	48	43
Romania	111	95	81	69	59	50
Slovakia	42	37	33	29	25	22
Slovenia	17	13	11	9	7	6
Spain	418	348	289	241	200	167
Sweden	82	74	66	60	54	49
Un. Kingdom	450	383	327	279	238	203
EU-28	4043	3481	2997	2581	2222	1913

VOC emissions, kiloton. Indicative beyond 2025

	2025	2030	2035	2040	2045	2050
Austria	90	78	68	60	52	45
Belgium	88	81	75	69	64	59
Bulgaria	55	45	38	31	26	21
Croatia	38	34	30	27	25	22
Cyprus	4	4	3	3	2	2
Czech Rep.	113	98	84	73	63	54
Denmark	54	48	43	38	34	30
Estonia	26	21	16	13	10	8
Finland	95	82	71	61	52	45
France	571	517	468	423	383	347
Germany	715	653	597	545	498	455
Greece	92	80	69	60	52	45
Hungary	63	55	47	41	36	31
Ireland	43	36	30	26	22	18
Italy	566	505	450	401	357	318
Latvia	30	24	20	16	13	11
Lithuania	34	29	24	20	17	14
Luxembourg	5	5	4	3	3	3
Malta	3	2	2	2	2	1
Netherlands	135	123	112	102	93	85
Poland	286	241	203	171	144	122
Portugal	118	108	99	90	83	76
Romania	171	143	120	100	84	70
Slovakia	45	40	35	30	26	23
Slovenia	15	14	12	11	10	9
Spain	488	451	417	385	356	329
Sweden	136	123	111	100	90	81
Un. Kingdom	550	508	470	434	401	370
EU-28	4630	4155	3728	3346	3002	2694

PM2,5 emissions, kiloton. Indicative beyond 2025

	2025	2030	2035	2040	2045	2050
Austria	11	11	10	9	9	8
Belgium	15	15	14	14	13	13
Bulgaria	14	12	10	9	7	6
Croatia	5	4	4	3	3	2
Cyprus	1	1	1	1	1	1
Czech Rep.	23	19	16	13	11	9
Denmark	11	9	8	7	6	5
Estonia	10	7	5	3	2	1
Finland	18	15	13	11	9	8
France	154	141	130	119	109	100
Germany	73	68	63	58	54	50
Greece	16	15	14	14	13	13
Hungary	11	10	9	8	8	7
Ireland	9	8	7	7	6	5
Italy	85	74	65	57	50	43
Latvia	9	6	5	3	2	2
Lithuania	7	6	5	4	3	3
Luxembourg	2	2	2	2	1	1
Malta	0	0	0	0	0	0
Netherlands	15	14	13	12	11	10
Poland	154	117	89	68	51	39
Portugal	19	18	17	16	15	14
Romania	44	36	29	24	19	16
Slovakia	12	11	9	8	7	6
Slovenia	2	2	2	2	2	2
Spain	61	58	54	51	48	46
Sweden	21	19	17	16	14	13
Un. Kingdom	46	44	41	39	37	34
EU-28	848	750	663	586	518	458

NH3 emissions, kiloton. Indicative beyond 2025

	2025	2030	2035	2040	2045	2050
Austria	50	46	42	38	35	32
Belgium	62	59	56	53	50	48
Bulgaria	58	56	54	52	51	49
Croatia	20	18	17	15	14	13
Cyprus	5	4	4	4	3	3
Czech Rep.	52	50	48	46	44	43
Denmark	44	42	40	38	36	34
Estonia	9	8	8	7	7	6
Finland	27	26	24	22	20	19
France	463	436	411	387	365	343
Germany	318	296	275	256	238	222
Greece	41	38	36	34	33	31
Hungary	48	45	42	39	36	33
Ireland	89	84	80	76	72	68
Italy	298	280	264	249	234	221
Latvia	13	12	11	10	10	9
Lithuania	40	39	35	32	29	26
Luxembourg	5	4	4	4	4	4
Malta	1	1	1	1	1	1
Netherlands	111	107	104	101	98	95
Poland	243	226	211	196	183	170
Portugal	55	53	51	49	47	45
Romania	115	103	92	83	74	67
Slovakia	17	16	15	14	13	12
Slovenia	14	13	12	11	10	9
Spain	256	240	225	211	198	185
Sweden	43	41	39	38	36	34
Un. Kingdom	240	233	225	218	211	204
EU-28	2740	2579	2428	2286	2151	2025

ANNEX 8 SENSITIVITY ANALYSES AND RISK ASSESSMENTS

The interim objectives established in Chapter 6 are tested for robustness against variations of real-world conditions away from the assumptions used in the modelling exercise. This is done by conducting a series of sensitivity analyses.

1. TESTING THE ROBUSTNESS OF THE CENTRAL CASE FOR CHANGES TO THE TARGET YEAR

The target year of 2025 should be tested to ensure that it does not introduce any economic sub-optimality vis-a-vis a later target year (of 2030). The following options were identified.

	Option 1	Option 2	Option 3
Central Target Year	2025	2030	2030, with intermediate milestone for 2025

The sub-optimality test is done in two steps:

The first step test is to compare impact reduction costs in 2025 and in 2030 to determine if structural changes occurring during the period make certain cheaper pollution reduction options available in 2030, which were not in 2025. This has been addressed firstly by examining if the wedge between baseline and maximum technically feasible reduction becomes wider in 2030 than in 2025, which would indicate that additional potential measures come on stream; and secondly by calculating the cost-effectiveness of avoided premature deaths in 2025 and 2030 for Options 6A, 6B, 6C and 6D.

		1.Baseline	6A	6B	6C	6E.MTFR
2025	Premature deaths	307000	286000	265000	245000	225000
	cost, million €		221	1202	4629	47007
	reduction potential					82000
	cost per avoided premature death, M€		0,010	0,028	0,074	0,57
2030	Premature deaths	304000	284000	263000	243000	218000
	cost, million €		212	1032	4182	50582
	reduction potential					86000
	cost per avoided premature death, M€		0,010	0,025	0,69	0,59

While the baseline impacts are almost unchanged (1% lower) in 2030 than in 2025, the further reduction potential increases slightly (86 vs. 80 thousand premature deaths avoided). Average reduction costs per additional life saved are in the same range in 2030 and in 2025 for all gap closure levels. In fact, the 2025 and 2030 options include exactly the same technical measures, and the reason why average cost-effectiveness shows marginal changes between the two years is that the shares of the same measures in the overall reduction strategy change. Indeed the largest differences between the 2025 and 2030 options are in the residential combustion sector, where costs fall some 30% due to less pollution control measures needed as a consequence of fuel switching away from coal. On the other hand, intensification of small-scale biomass use makes the costs to close the entire gap to the technical potential (MTFR) higher than in 2025. It is concluded that the structural changes occurring between 2025 and 2030 do not make cheaper reduction options available.

The second step is to compare the technical measures required to achieve the gap-closure in 2025 with the structural changes occurring between 2025 and 2030: any measures that emerge as cost effective in 2025 but are not necessary in 2030 are in principle regret measures, as they would give raise to stranded costs on the extended (2030) timetable because certain declining activities are shut down or replaced.

As a rough illustrative example, consider the above methodology applied to coal-fired power generation. Broadly speaking a regret investment is where an abatement measure is applied to meet the 2025 reduction target, but the plant in question is retired between 2025 and 2030, and hence no abatement on it would be needed in 2030. But note that the investment is only a regret investment if the abatement equipment *itself* needs to be retired prematurely - if the equipment would in any case come to the end of its natural life before the plant was retired, there would be no wasted investment. Thus, regret investments are those equipment sets that are applied to plants that will be retired between 2025 and 2030, and where the equipment itself is retired early as a result. To identify these, we first take the number of sets (defined as thermal power capacity) of abatement equipment applied to meet the 2025 target, and check how many are still operational in 2030 (assuming they are applied gradually to the coal capacity over the period 2015-2025, and have a certain normal working life). We then compare these 2025 'survivors' with the number of sets of abatement equipment needed on a 2030 scenario to control the entire existing capacity. The excess constitutes the regret investments. The analysis was performed for each sector, and as a headline indicator for potential regret measures, the annualised costs are presented.

The following analysis refers to the central case option 6C* defined in **Error! Reference source not found.** of section 6.3.2; any emerging regret measures should be interpreted as an upper limit for any options less ambitious than 6C*. In this scenario, the rapid capital turnover assumed in the draft PRIMES2012-3 energy scenario, a small share of the additional measures of Option 6C* could turn out as regret investments in 2030. In total, these questionable measures affect 7 kt of SO2 (i.e., 1.2% of the additional 6C* reductions), of which 5 kt in the UK, 0.5 kt NOx (0.4% of the 6C* reductions) and 2.3 kt PM2.5 (2.5% of the 6C* improvements). Costs associated with these regret measures account for 0.6% of the costs of the 6C* Option. However, 50% of these costs emerge in a single country, the UK, where the PRIMES 2012-3[1] reference scenario suggests an almost complete phase-out of coal from power generation between 2025 and 2030. For the remaining 27 Member States, regret measures account on average for 0.3% of the costs of all 6C* measures.

Considering also the uncertainties around the baseline projection, it is concluded that the emission controls of the 6C* Option lead to only marginal potential regret investments.

2. INTERACTION WITH THE CLIMATE AND ENERGY PACKAGE

The previous section addresses the needs for air policy to carefully take into account the possible mismatches with investment cycles. This is even more important in the light of the future climate and energy policy framework, which may be expected to result in even deeper restructuring of the energy system than foreseen in the most recent PRIMES 2012-3 reference

[1] The current analysis is based on the most recent available reference energy scenario, which is the January 2013 draft that was consulted with the Member States in early 2013.

scenario, which already assumes the achievement of rather ambitious renewable energy targets by 2020 as well as substantial progress in energy efficiency, if not full achievement of the 20% target. It is therefore important to examine the possible interactions between air pollution reduction policy and a climate and energy policy of greater stringency. The effects of climate change mitigation policy in the main sectors in the relevant short-to-medium timescale, and the resulting interactions with air pollution reduction, are summarised as follows:

- Road transport sector: decarbonisation of the transport sector can operate at multiple levels, including the improvement of public transport options to reduce the overall vehicle/ton-km demand; the development of alternative vehicles and vehicle infrastructure, such as hybrids, plug-in hybrids and electric vehicles (hydrogen fuel cell vehicles in the longer term); and the promotion of available vehicles with lower fuel consumption. All these options are win-win solutions for climate and air quality, with the exception of the promotion of light-duty diesel vehicles which –though marginally better than gasoline vehicles on fuel efficiency- in the current situation emit a disproportionately higher amount of NOx. Recent advancements in gasoline engine technology (Gasoline Direct Injection, or GDI) have also enabled the development of highly fuel efficient gasoline engines, which however emit a large number of ultrafine particles (particle emissions from conventional gasoline engines are quasi-nil). In conclusion, decarbonisation of the transport sector can deliver strong benefits also for air quality, but conventional vehicles will maintain an important share of the market in the foreseeable future and will still need effective pollution control, in particular to manage the air quality implications of diesels and GDI.

- Non-road transport: Since in the short term technological breakthrough are not expected and currently there are limited technical options to specifically reduce NOx and PM emission from commercial aviation, only marine shipping is considered. LNG is a viable option to reduce CO2 emissions and at the same time SO2 and NOx emissions with no or reduced need for after-treatment. In principle, investment for pollution abatement installed on ships could become redundant if the vessel or its engine were scrapped a few years later to be substituted by LNG technology. However, the commissioning of large ships is planned long enough in advance to take into adequately account the lifetime of pollution abatement equipment.

- Residential sector: in a decarbonising world, the residential sector will reduce its energy use by more efficient (electrical) energy using products, by improving the energy performance of buildings for temperature control, and by using carbon-lean and carbon-free heating technologies. Among these options, all are win-win solutions for climate and air quality, with the exception of the promotion of domestic use of biomass. Uncontrolled combustion of biomass, in fact, is a potent source of fine particles, black carbon, and poly-aromatic hydrocarbons. A certain share of domestic biomass use can be compatible with air quality objectives, but a prerequisite is that expansion of such capacity happen with high standards in place: in order to avoid the potential high costs to replace highly polluting stoves and boilers a few years after installation, it must be considered a matter of priority to put in place stringent emission standards for small-scale appliances before they capture higher market shares. The contrary would generate sunk costs or unacceptable public health outcome.

- Electricity supply sector: decarbonisation of the power sector includes improved conversion efficiency, e.g. by expanded CHP capacity, switching to lower carbon fuels, switching to renewable sources, and more efficient and smarter transmission grids. Renewable sources are not only carbon neutral but also pollution free, again with the exception of biomass; however, strict regulation for large combustion plants can be an effective enabling factor for tapping the biomass potential while limiting to a minimum the detrimental consequences on human health. It is noteworthy, however, that a possible greater share of decentralised power sources in future could increase the share of combustion in installations smaller than 50MWTh, which are currently not regulated at EU level. Again, it will be important to have in place adequately high emission standards before such capacity expansion occurs, as it would be much more costly to retrofit the same installations at a later time. Biomass caveat aside, switching from coal plants to natural gas or to carbon-free sources provides substantial co-benefits for air quality. In principle, investment for pollution abatement installed on existing coal plants could be made redundant if there was a plan to shut down the plant a few years later and to substitute it by alternative technology. However, planning and building new power plants requires a long time, and national energy plans (which may include turning off old coal plants) can provide the necessary stability to take rational investment decisions on pollution abatement equipment taking into account its useful lifetime.

- Industry: substitution possibilities in energy intensive industries are more limited than in the power sector, as primary processes in iron & steel or cement making cannot be easily substituted by different techniques. The refinery sector is a special case, as decarbonisation will substantially reduce demand for oil products with consequent impacts for activity in the sector. However, the transition will take a long time, and the effect of climate policy on the demand for refinery products can be forecast sufficiently in advance to effectively plan the operation and investment requirements of the existing refining capacity.

- Solvents: solvent applications are not significantly affected by climate mitigation policy; there are no evident trade-offs between climate and air pollution policy. Limiting VOC emissions, conversely, reduces ozone formation which is also a potent short-lived climate forcer.

- Agriculture: most of air pollution reduction measures addressing agriculture are related to technical measures to control ammonia emissions. These measures are largely applicable irrespective of the livestock numbers or of other key parameters influencing methane emissions, and the interactions between climate and air policies as regards agricultural measures are not significant, with the exception of the win-win effect of methane reduction, which is not only a greenhouse gas but also a precursor of hemispheric background ozone.

In conclusion, there are substantial interactions between climate change and air pollution policies. A more ambitious climate policy is expected to make reaching the new air quality objectives cheaper by removing highly polluting sources such as coal plants or reducing domestic coal use; however, expanded biomass combustion can result in detrimental health impacts unless sufficiently stringent emission standards are put in place. Some sectors, such as the power and refineries sectors, may face in principle the risk that accelerated decarbonisation of electricity supply and of the transport sector could result in early retirement of large capacities and make redundant any additional pollution abatement investments on those plants. However, any future low-carbon economy roadmap scenario would seek to develop a cost-effective pathway to the agreed climate targets taking into account the need to minimise stranded cost risks; furthermore, the time horizon of the proposed air quality policy targets (2025-2030) will give sufficient time for plant operators to develop rational investment plans that give full value to the invested capital.

3. EMISSION REDUCTIONS DELIVERED BY FURTHER CLIMATE CHANGE MITIGATION POLICY

The Commission work programme for 2013 foresees a new climate and energy framework for the 2030 time horizon which should deliver benefits in terms of air quality. The form of this policy is not clear at the time of writing, but the following analysis has assumed a reduction in domestic GHG emissions below 1990 levels by 25% in 2020 and by 40% in 2030.[2]

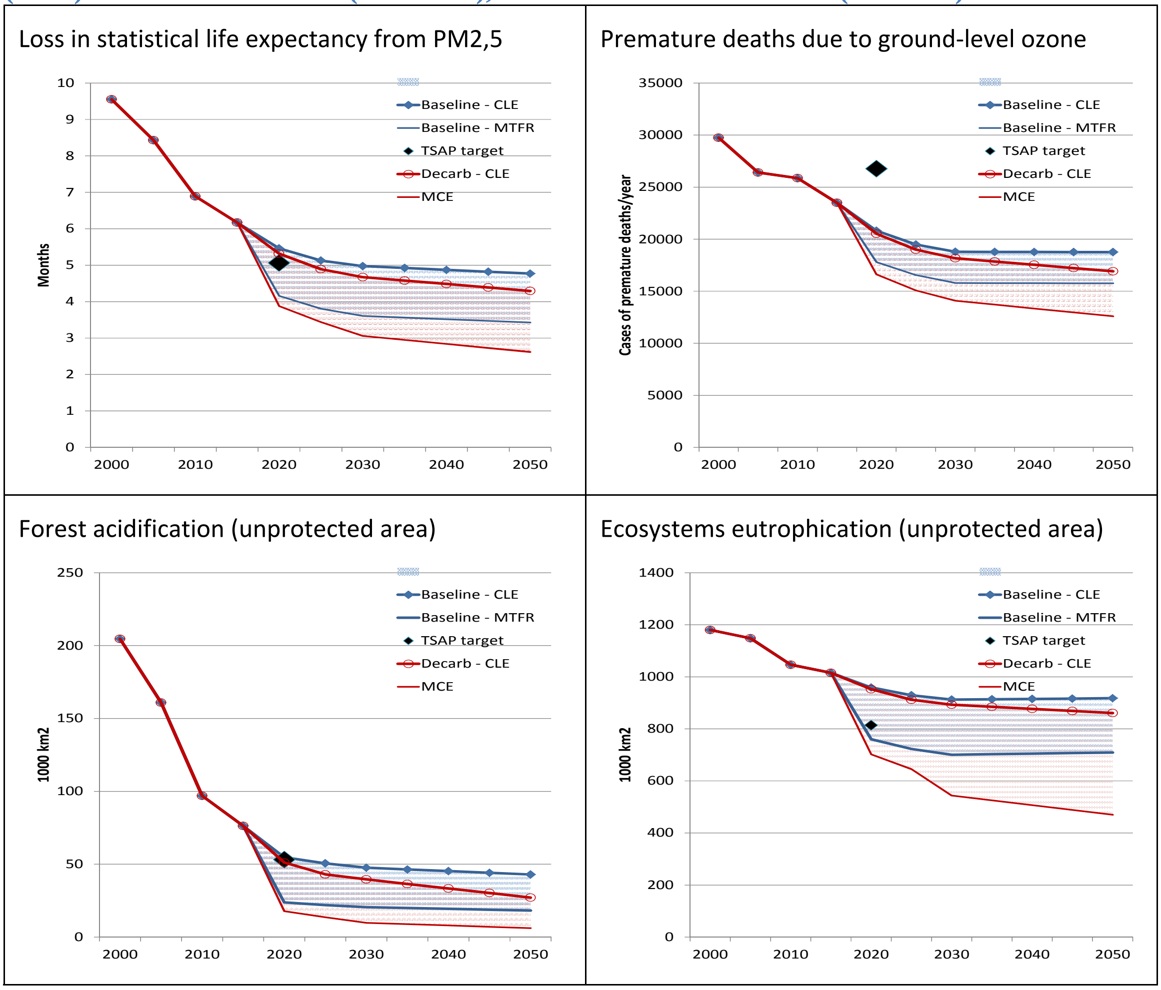
Based on this, decarbonisation measures alone could reduce health impacts from PM2,5 by approximately 5% in 2030 and 10% in 2050 compared to the current legislation baseline. This compares with reductions from additional air pollution measures of around 30% in both years. Decarbonisation of the economy has a more substantial impact on acidification and ground-level ozone, delivering as much as two thirds of the MTFR reductions by 2050. Decarbonisation would reduce eutrophication impacts only marginally.

Thus while the impacts of decarbonisation are clearly positive for air, the limited reductions PM and eutrophication mean that climate policy alone would not be sufficient to achieve the long-term air quality objective by 2050.

The following charts show the impact reductions that would be achieved by the baseline in the absence of further policies , by climate decarbonisation policy, by air pollution control measures (MTFR), and by a Maximum control effort (MCE) trajectory that combines decarbonisation and air pollution control measures; the additional reduction potential on eutrophication is in this case due to assumptions on hypothetical behavioural change reducing meat consumption in Europe:

2 Recent IIASA analysis (See Chapter 3.1, TSAP Report #6, IIASA, 2012B) based on the Global Climate Action/ effective technology scenario developed for the low carbon economy roadmap (SEC(2011) 288 final)

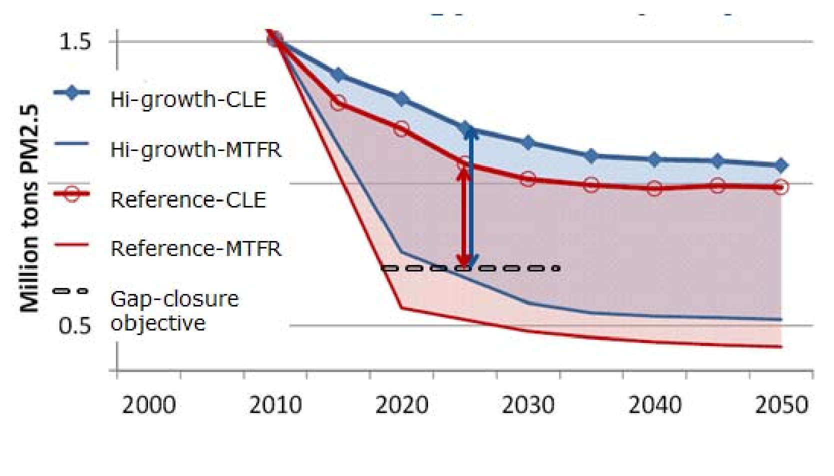
Figure A8.1: Impact reductions in the long term under different trajectories: current legisaltion (CLE) baseline and MTFR (blue lines), decarbonisation and MCE (red lines)



4. CHANGES TO THE GROWTH PROJECTIONS AND TO PROGRESS IN ENERGY EFFICIENCY AND RENEWABLES

Emissions are strongly correlated with economic activity, and higher growth would entail higher levels of baseline emissions. Interim objectives, although initially defined in terms of gap closure, will for policy purposes be expressed in terms of absolute impacts. Thus the objectives must be tested to ensure that the absolute impact reductions in question are still achievable on a higher-growth scenario. The concept is illustrated in Figure A8.2 below.

Figure A8.2: Achievability of environmental objectives on a higher growth scenario



The red lines illustrate the wedge between current legislation emissions and MTFR in the reference case. The blue lines represent the same wedge under a higher growth assumption. The gap closure target defined under reference projections would become in a higher growth case closer to the MTFR and consequently more expensive as additional measures would be required to achieve it.

To do this, emission reductions and associated control costs for achieving the environmental targets of the central scenario in absolute terms (i.e., in absolute YOLLs, km2, etc.) are calculated again starting from an alternative baseline representing higher growth. The scenario chosen for this purpose is the previous PRIMES 2010 reference scenario, which assumes GDP in 2025 and 2030 approximately 7% higher than in the PRIMES 2012-3 reference case (or an average annual growth rate 0,35% higher). Achievability of the targets under the PRIMES 2010 trajectory has been checked for different scenario variants that would achieve 75% gap closure on the PM mortality objective and increasingly stringent objectives on ozone and eutrophication targets. The conclusions are a fortiori valid for options closer to the baseline trajectory.

In addition to the PRIMES 2010 trajectory, sensitivity analyses were also done with PRIMES energy results of the 2012-3 EU "Baseline with adopted measures" scenario. This is a scenario done for climate policy purposes, which is similar to the corresponding reference scenario except in assumptions on renewable energy and energy efficiency policies. The 2012-3 reference case assumes that the EU renewable energy targets will be fully met and that the Energy Efficiency Directive (EED) adopted in 2012 is fully implemented. In the Baseline with adopted measures the deployment of renewables depends on currently adopted national policies and measures and the EED is not included insofar as effects on GHG emissions depend on the way in which transposition into national measures will take place. The analysis indicates therefore how much more expensive it would be to meet air pollution reduction objectives if progress on renewables and energy efficiency would turn out to be less than in the reference case.

Under the PRIMES2012-3 Baseline trajectory, the entire range of objectives would still be achievable, albeit at moderately higher costs (6-8% more for eutrophication reductions in the range 80-90% gap closure. Summary figures for these sensitivity analyses are presented in table A8.1.

Table A8.1: Impact reduction targets and emission control costs (million €/yr) in 2025 of different targets optimized for the trajectories PRIMES 2012-3 reference, PRIMES 2012-3 baseline, and PRIMES 2010 reference. Changes in costs are compared to current legislation costs. INF indicates target infeasible.

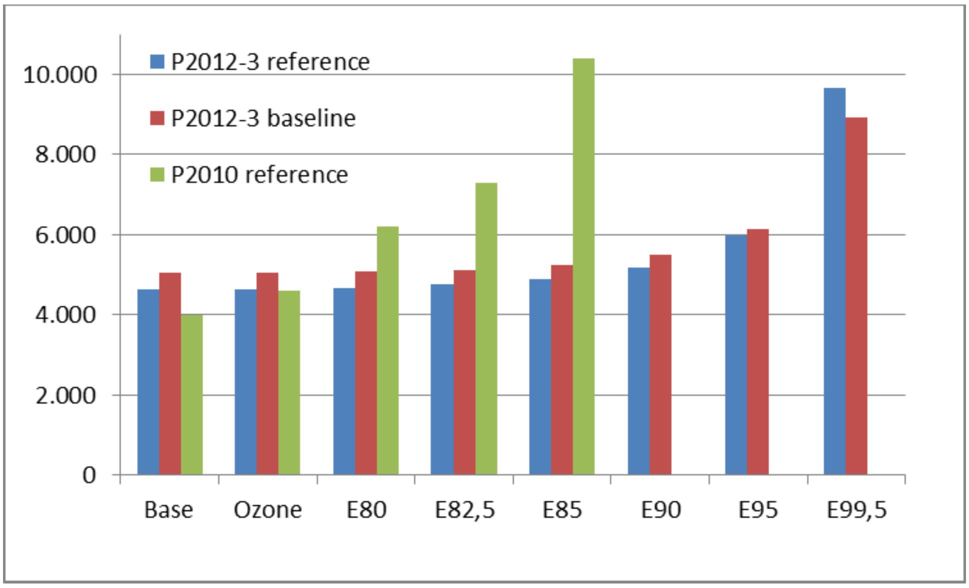
	Base	Ozone	E80	E82,5	E85	E90	E95	E99,5
Gap closure:								
PM mortality	75%	75%	75%	75%	75%	75%	75%	75%
Ozone	NA	46%	46%	46%	46%	46%	46%	46%
Eutrophication	NA	NA	80%	82,50%	85%	90%	95%	99,50%
compliance cost								
P2012-3 reference	4.629	4.648	4.680	4.766	4.884	5.195	5.971	9.653
P2012-3 baseline	5.036	5.053	5.069	5.127	5.228	5.493	6.150	8.936
P2010 reference	3.988	4.600	6.201	7.304	10.409	INF	INF	INF

However, it must be noted that the PRIMES 2010 and PRIMES 2012 scenarios differ in much more than only growth projections. The projected energy mix is different, for instance as a reflection of the improved understanding of the outcome of existing energy and climate mitigation policies and the inclusion of recent energy trends. As a result, PRIMES 2010 provides valuable information and a useful test of the feasibility of objectives in an uncertain future, but the interpretation of comparative emission control costs in detail requires further discussion:

For the 'health only' target (base), additional emission control costs (on top of those for current legislation) amount to 4.6 billion €/yr for the PRIMES 2012 scenario, and to close to 4 billion € under the P2010 trajectory. This would be counter-intuitive for an alternative scenario driven by higher growth only, and is a consequence of the higher use of biomass in the residential sector in P2012, which causes more emissions of primary PM2.5 which, when originating from small sources, are more expensive to abate than the emissions of secondary PM2.5 precursors (i.e., SO_2, NO_x, etc.) targeted in the P2010 case.

However, costs eventually increase faster for additional improvements of, eutrophication under P2010 (Figure A8.3). For the P2012 case, costs for further eutrophication improvements rise slowly until about 90% gap closure. For the P2010 trajectory, additional costs on top of the health-only case rapidly increase from 1.6 for the 80% case to 5.8 billion €/yr for the 85% case, while the range of 90% and beyond would not be feasible.

Figure A8.3: Variation of emission control costs (on top of the costs for the CLE scenarios) for achievements of health and environmental targets under the P2012 reference and baseline, and P2010 trajectories



While in the PRIMES 2012-3 reference case the pollution control expenditure increases by €32M and €118M respectively when moving to 80% and 82,5% eutrophication gap closure (even less in the PRIMES 2012-3 baseline), with the PRIMES 2010 assumptions the costs increase by €1,6bn and €2,7bn respectively.

This striking difference is entirely due to higher livestock number projections in the PRIMES 2010 scenario, which in turn drive higher ammonia emissions and higher costs to bring them down to the target levels identified by the pollution reduction objectives of the various options: on PRIMES 2010, the introduction of 80% and 82,5 eutrophication gap closure requires additional costs to control ammonia of €2,1bn and 2,9bn respectively (even higher than the €1,6bn and 2,7bn total cost increase, meaning that some other sectors would reduce their effort slightly). With 85% eutrophication gap closure, the ammonia reduction potential would be almost entirely exhausted, driving additional NOx reductions for almost €4bn to reach this eutrophication reduction target. For the same reason, stricter eutrophication reduction targets would not be achievable on PRIMES 2010.

The analysis presented above examines whether or not certain levels of environmental objectives would be feasible under economic growth and energy system assumptions diverging from the central ones, and how costly it would be to achieve them. A further question is the feasibility and compliance cost relate to the individual emission reduction commitments identified as most cost-effective under reference assumptions. In this context, the cost of achieving the emission ceilings of the central case option 6C* (see Annex 7, Appendix 7.4) has been calculated under the PRIMES 2012-3 "Baseline with adopted measures" assumptions (see above). All ceilings have been assessed to be within the feasible range; Table A8.2 summarises the resulting compliance costs.

Table A8.2: Costs of achieving the C6* emission ceilings in the EU28 in 2025 under the PRIMES 2012-3 reference and baseline with adopted measures assumptions

				EU-28	4680	5774	1094
SNAP sector	**ref**	**BL**	**diff.**	**SNAP sector**	**ref**	**BL**	**diff.**
Power generation	500	536	36	Solvent use	63	69	5
Domestic sector	1611	2609	998	Road transport	0	0	0
Industrial combust.	610	650	40	Non-road mobile	142	169	27
Industrial processes	384	393	9	Waste treatment	9	9	0
Fuel extraction	6	6	0	Agriculture	1356	1334	-22
				All Economy	**4680**	**5774**	**1094**

Table A8.2 shows that compliance costs would be 1094 M€/yr (23% higher), almost entirely (998 M€/year) for pollution abatement in residential combustion, demonstrating the high synergetic potential of energy efficiency measures to curb energy demand and associated pollution from buildings.

5. BURDEN SHARING BETWEEN MEMBER STATES

Option 6C* (**Error! Reference source not found.**) would require some 0,03% of the EU's GDP for expenditure in additional pollution abatement measures. However, the distribution of effort across Member States varies from 0,003% of GDP in Sweden to 0,168% of GDP in Bulgaria. This is a reflection both of different absolute GDP levels (the cost of the same piece of equipment would represent a higher share of GDP in a lower-income country); and of differences in past effort (a smaller reduction potential in countries with a longer pollution control tradition).

The effect of capping the direct additional expenditure as a percentage of GDP was assessed. The reduced costs for the capped Member States entails increased costs for other Member States, in particular neighbouring Member States upwind of those that reduce their effort, in order to meet the same objectives, and lower cost-effectiveness overall.

Table A8.3: Costs of achieving the C6* emission ceilings in the Member States in 2025 under the PRIMES 2012-3 reference and baseline with adopted measures

	Option 6C*		C15 (<= 0.16%)		C16 (<=0.15%)			changes relative to Option 6C*		
	M€	% of GDP	M€	% of GDP	M€	% of GDP			<0,16%	<0,15%
Austria	100,0	0,028	99,3	0,028	222,1	0,062		Austria	-1%	122%
Belgium	114,5	0,026	114,4	0,026	95,6	0,022		Belgium	0%	-16%
Bulgaria	80,7	0,168	76,7	0,160	71,9	0,150		Bulgaria	-5%	-11%
Croatia	39,8	0,064	39,0	0,063	93,3	0,150		Croatia	-2%	135%
Cyprus	1,2	0,006	1,0	0,005	1,0	0,005		Cyprus	-14%	-16%
Czech Rep.	118,6	0,059	117,5	0,059	300,8	0,150		Czech Rep.	-1%	154%
Denmark	32,5	0,011	32,5	0,011	44,3	0,015		Denmark	0%	36%
Estonia	7,4	0,034	7,4	0,035	7,8	0,036		Estonia	0%	5%
Finland	13,7	0,006	13,7	0,006	15,3	0,007		Finland	0%	12%
France	378,0	0,015	378,1	0,015	461,1	0,019		France	0%	22%

Germany	855,8	0,029	855,9	0,029	2.189,4	0,075		Germany	0%	156%
Greece	82,3	0,034	109,1	0,045	361,0	0,150		Greece	32%	338%
Hungary	93,0	0,080	101,3	0,087	173,8	0,150		Hungary	9%	87%
Ireland	26,1	0,012	26,0	0,012	20,2	0,009		Ireland	0%	-23%
Italy	595,2	0,033	594,1	0,033	1.653,3	0,091		Italy	0%	178%
Latvia	19,9	0,075	19,9	0,075	19,7	0,075		Latvia	0%	-1%
Lithuania	28,0	0,073	27,8	0,073	57,2	0,150		Lithuania	-1%	104%
Luxembourg	2,9	0,005	2,9	0,005	1,6	0,003		Luxembourg	0%	-45%
Malta	0,4	0,005	0,4	0,005	0,3	0,004		Malta	-5%	-17%
Netherlands	62,7	0,009	62,7	0,009	60,7	0,008		Netherlands	0%	-3%
Poland	736,7	0,142	736,8	0,142	780,3	0,150		Poland	0%	6%
Portugal	92,2	0,046	92,3	0,046	88,7	0,045		Portugal	0%	-4%
Romania	265,7	0,159	268,1	0,160	251,4	0,150		Romania	1%	-5%
Slovak Rep.	86,0	0,090	85,3	0,089	143,3	0,150		Slovak Rep.	-1%	67%
Slovenia	50,5	0,112	50,4	0,112	49,6	0,110		Slovenia	0%	-2%
Spain	268,6	0,019	268,4	0,019	270,0	0,019		Spain	0%	1%
Sweden	15,8	0,003	15,8	0,003	14,6	0,003		Sweden	0%	-8%
Un. Kingdom	512,0	0,023	512,0	0,023	616,6	0,028		Un. Kingdom	0%	20%
EU-28	4.680,2	0,030	4.708,6	0,031	8.065,0	0,052		EU-28	1%	72%
Maximum		0,168		0,160		0,150				

Table A8.3 shows the cost changes per Member state and for the EU28 when setting an upper bound to the maximum effort per country to a fixed percentage of GDP, while ensuring that all four main environmental objectives (PM-health, ozone, eutrophication and acidification) are met in each country. Setting a limit of 0,16% would in primis reduce the effort for Bulgaria for € 4M, and require a redistribution of effort resulting in costs for the EU28 28 M€ higher overall. Limiting the maximum effort at 0,15% would further save Bulgaria 5 M€ and Romania 17 M€, but overall costs for the EU would balloon to €3,7bn higher. This indicates that the scope for limiting individual efforts while maintaining the environmental and health benefits of option 6C* in all Member States is negligible, and confirms that the effort required on option 6C* is well balanced across Member States.

6. FURTHER EMISSION CONTROLS FROM INTERNATIONAL MARITIME SHIPPING

This section examines whether further reductions of ship emissions (i.e. beyond the emission reductions that will be delivered by the recently amended Directive on the sulphur content of marine fuels 2012/33/EU, and existing international standards in relation to SOx and NOx emissions as established in Annex VI to the MARPOL Convention) could emerge as cost-effective means for achieving the environmental objectives of the revised TSAP, i.e., to what extent they could substitute more expensive measures at land-based sources. The environmental objectives are those of the central case option 6C*.

For the purpose of this sensitivity analysis, two alternative scenarios cases are calculated: Scenario SN1 assumes sulphur and nitrogen emission control areas (SECAs and NECAs) in the 200 nautical miles zones (EEZ, Exclusive Economic Zone) of all EU countries. This would result in a 50% reduction of shipping SO_2 emissions relative to the baseline, and a 24% cut in NO_x. Scenario SN2 excludes further SECAs and foresees only the introduction of NECAs in EEZ of all EU countries (24% cut in NOx).

Table A8.4: SO_2 and NOx emission from marine activities in 2005 and 2025; baseline, a scenario with SECAs and NECAs in the EU's EEZs, and a variant with NECAs only; unit: kilotons

SO2	Baseline		SN1	SN2	NOx	Baseline		SN1	SN2
	2005	2025	SECA-NECA	NECA only		2005	2025	SECA-NECA	NECA only
Baltic Sea	130	7	7	7	Baltic Sea	220	193	131	131
Bay of Biscay	282	72	16	72	Bay of Biscay	474	457	311	311
Black Sea	27	7	6	7	Black Sea	47	42	38	38
Celtic Sea	14	2	1	2	Celtic Sea	22	19	13	13
Mediterranean Sea	764	183	104	183	Mediterranean Sea	1294	1186	963	963
North Sea	309	16	16	16	North Sea	518	476	323	323
Rest of NE Atlantic (within EMEP grid)	31	8	8	8	Rest of NE Atlantic (within EMEP grid)	54	51	51	51
Rest of NE Atlantic (outside EMEP grid)	112	28	14	28	Rest of NE Atlantic (outside EMEP grid)	192	184	144	144
Total	1668	321	171	321	Total	2821	2606	1973	1973

The additional measures for SECAs and NECAs reduce costs for these land-based sources in 2025 by 814 million €/yr in the SN1 scenario, and by 528 million €/yr in Scenario SN2 (Table A8.5). At the same time, the estimated costs for the NECA[3] are of 564 million €/yr in 2025. For SECAs in the 200 nm zones of all EU countries, cost estimates range between 1.3 billion €/yr in case scrubber-based compliance is used and 2.8 billion €/yr for use of low sulphur fuel.

Compared to the 6C*, total emission control costs (of land-based and marine sources) would increase by 10-40% in the SN1 case, and by less than 1% in SN2 with NECA only.

In conclusion, with the current assumptions on costs for low sulphur fuels, packages of SECAs and NECAs in the 200 nm zones of the EU Member States would be overall more expensive than some land-based measures available to achieve the targets of the base case. Scrubber-based compliance would substantially reduce the SECA costs, but would not close the cost-effectiveness gap in full compared to land-based emission reductions; note that this assessment is based on the reduction of impacts on land and does not take into consideration any of the additional benefits for the marine/coastal environment.

On the other hand, emission reductions associated with the designation of NECAs would be essentially as cost-effective as emission reductions on land, with a less than 1% difference in total pollution control costs which is well within the uncertainty range of the costs estimates, and indicates seaborne NOx reductions as an economically attractive option for the future.

Table A8.5: Comparison of emissions (kilotons) and emission control costs (million €/yr) of scenarios SN1 and SN2 for the reduction of emissions from international marine shipping. Changes in emissions refer to 2005, changes in costs to the costs of Option 1 (Baseline.)

	2005	Option 1	base case	SN1	SN2

[3] " Specific evaluation of emissions from shipping including assessment for the establishment of possible new emission control areas in European Seas (VITO, 2013)

SO2	7874	2520	1769	1773	1767
		-68%	-77%	-77%	-77%
NOx	11358	4588	4020	4125	4107
		-60%	-65%	-64%	-64%
PM2.5	1706	1274	859	859	865
		-25%	-49%	-49%	-49%
NH3	3942	3733	2765	2860	2842
		-5%	-30%	-27%	-28%
VOC	9312	5558	4593	4659	4619
		-40%	-51%	-50%	-50%
Costs for land-based		87673	+4745	+3931	+4217
Costs ships Low S fuel			0	+2771	+564
Total costs			+4745	+6702	+4781
Costs ships FGD			0	+1283	+564[4]
Total costs			+4745	+5214	+4781

Preliminary analysis of the cost-benefit outlook for the establishment of NECA in the Baltic sea leads indeed to conclude that NECAs could deliver substantial net benefits. The following table shows a summary of the costs and benefits (source: VITO 2013 and own elaboration) of NECA in the Baltic sea:

Table A8.6: Summary cost-benefit outlook for the establishment of NECA in the Baltic sea

Baltic sea	Tons Nox removed	control cost, M€	benefit per ton, low	benefit, low, M€	CBA, low	benefit per ton, high	benefit, high, M€	CBA, high
2020	29,6	32,6	3500	103,6	3,2	8900	263,4	8,1
2030	93,6	74,9	3500	327,6	4,4	8900	833,0	11,1

With a marginal benefit of reducing NOx emissions at sea between €3,500 and €8,900 per ton removed[5], the benefit-to-cost ratio for the establishment of NECA in the Baltic Sea can then be estimated between 3,2 and 8,1 in 2020 and between 4,4 and 11,1 in 2030; the economic impact assessment for the designation of a NECA in the North Sea (Danish Environment Protection Agency 2012)[6] estimated for the North Sea a benefit-to-cost ratio in the same range (1,6-6,8) although lower[7] than the Baltic estimate.

Reducing NOx emissions from international shipping in the EU sea areas could in sum deliver substantial benefits, and Member States that do so would need to take less action on land-based sources to meet the health and environmental objectives of the NECD. Since the emission reduction commitments of the NECD do not cover international maritime traffic emission, the possibility to allow a voluntary offset mechanism has been envisaged. Under such mechanism, a Member State that takes measures achieving demonstrable emission

4 The cost estimate for the NECA-only scenario is the same for low-sulphur fuel and scrubber-based compliance, as these two sub-options are relevant for SECA but not for NECA.

5 Latest update (EMRC, forthcoming) of previous values from the analysis supporting the TSAP 2005, (AEA, 2005), ranging between €2,500 and €6,900

6 Danish Ministry of the Environment, 2012

7 The study uses however outdated damage cost figures (AEA, 2005). The most recent update (EMRC, forthcoming) would yield a benefit-to-cost ratio 70-80% higher.

reductions in an area within the 200 nm of it coastline would be allowed to deduct a certain percentage (hereinafter "offset ratio") of the emission reductions achieved in that sea area from its calculated emissions for the purpose of compliance with the NECD. The following analysis is based –by way of example- on the case of designation of the sea areas within 200 nm of the EU coastline as NECA, and addresses two questions: a) since emissions occurring at sea -being farther away from population and terrestrial ecosystems- are on average less damaging than land-based emissions, which offset ratio could be allowed, while guaranteeing the integrity of the NECD's environmental objectives? And b) how much would the Member States' NOx control costs be reduced? Tables A8.7 and A8.8 address questions a and b respectively. In this analysis it is assumed that all Member States would designate their territorial waters + EEZ as NECA; since the Member States do not currently report emissions in their EEZ, the analysis assumes that the emission reductions achieved in each of the sea areas of table A8.3 is allocated to the neighbouring Member States proportionally to their EEZ surfaces in that sea area. Three options are explored for the offset ratio: 50%, 33% and 20%

Table A8.7: integrity of environmental objectives with NECA offsets: Member states not meeting the environmental improvements delivered by Option 6C*

2025	Offset ratio 50%	Offset ratio 33%	Offset ratio 20%
PM Health	AT, BG, HR, CY, HU, IT, SI, ES, GR, PT, RO, SK	AT, BG, HR, CY, HU, IT, SI, ES	IT (<1%)
Ozone	BE, HR, CY, DE, LU, MA, NL, SI, SE	CY	none
Eutrophication	none	none	none
Acidification	HU, IT, PT, RO, SI	SI	none

As shown in table A8.7, allowing an offset ratio of 50% would substantially compromise the achievement of environmental objectives in the majority of Member States. At the 33% offset ratio level, the impact would be rather modest, although some land-locked Member States (which do not obtain any offset on their NOx reduction commitment) would be affected. At the 20% offset level, only one Member State (Italy) would experience a very modest impact on the PM-health objective.

Table A8.8: NOx offsets and compliance cost savings with NECA offset ratios of 50, 33 and 20%, vs emission reduction commitments of Option 6C*

2025	6C* ceiling	Ceilings relative to 6C*				Expenditure relative to 6C*		
	kt NOx	50% o.r.	33% o.r.	20% o.r.		50% o.r.	33% o.r.	20% o.r.
Austria	71	0,0	0,0	0,0		0,0	0,0	0,0
Belgium	123	0,4	0,3	0,2		-0,7	-0,5	-0,3
Bulgaria	63	1,1	0,7	0,4		-1,9	-1,3	-0,8
Croatia	27	3,9	2,6	1,6		-3,8	-3,0	-2,3
Cyprus	7	6,9	4,5	2,7		0,0	0,0	0,0
Czech Rep.	114	0,0	0,0	0,0		0,0	0,0	0,0
Denmark	63	11,0	7,3	4,4		-2,4	-2,4	-2,2
Estonia	18	2,6	1,7	1,0		0,0	0,0	0,0
Finland	110	6,1	4,0	2,4		0,0	0,0	0,0
France	453	25,4	16,8	10,2		-34,4	-28,2	-21,0
Germany	517	6,1	4,0	2,4		-18,1	-12,5	-7,6

Greece	129	34,6	22,8	13,8		-1,1	-1,1	-1,1
Hungary	53	0,0	0,0	0,0		0,0	0,0	0,0
Ireland	54	1,0	0,7	0,4		-1,4	-1,0	-0,7
Italy	447	37,6	24,8	15,0		-77,7	-61,3	-46,9
Latvia	22	2,1	1,4	0,8		-0,4	-0,4	-0,3
Lithuania	29	0,4	0,3	0,2		-0,3	-0,2	-0,1
Luxembourg	13	0,0	0,0	0,0		0,0	0,0	0,0
Malta	1	3,9	2,6	1,5		0,0	0,0	0,0
Netherlands	134	7,7	5,1	3,1		-5,2	-4,9	-3,2
Poland	398	2,3	1,5	0,9		-4,2	-2,8	-1,7
Portugal	76	29,8	19,7	11,9		-14,7	-13,5	-10,5
Romania	111	0,9	0,6	0,4		-1,8	-1,2	-0,7
Slovak Rep.	42	0,0	0,0	0,0		0,0	0,0	0,0
Slovenia	17	0,0	0,0	0,0		0,0	0,0	0,0
Spain	418	46,4	30,6	18,5		-39,3	-31,7	-23,8
Sweden	82	12,0	7,9	4,8		-0,3	-0,3	-0,3
Un. Kingdom	450	36,3	23,9	14,5		-20,5	-16,8	-12,9
EU-28	4043	278,5	183,8	111,4		-228,2	-183,0	-136,6

Table A8.8 shows that at offset ratios of 50%, 33% and 20%, total pollution control costs for land sources would decrease in 2025 by 228, 183 and 137 M€/yr (EU28). Note that in the case of smaller insular or peninsular member states (e.g. GR, CY, MT) the potential offsets may be much larger than the NOx emission reductions required by the NECD. In such cases the offset would result in much smaller pollution control cost reduction for land sources. The functioning of the offset mechanism is elucidated through the case of NECA designation, but the application of the mechanism should not be limited to this measure or to NOX only: other measures going beyond EU legislation –for instance to shift from fuel oil to LNG, or to provide clean shore-side electricity to ships at berth- could also be eligible for offsetting NOx, SO2 and PM emissions.

7. POLICY INSTRUMENTS TO ACHIEVE THE INTERIM TARGETS: SOURCE CONTROLS AT EU LEVEL

This section examines the cost implications of implementing some of the measures identified as cost effective in the central emission reduction scenario as EU-wide source control measures rather than only setting emission ceilings through the NEC Directive and leaving the choice of technical measures entirely up to the Member States.

Leaving to the Member States the full decision as to which emission sources to control could in principle deliver the most flexible application of the technical measures best suited for the specific local conditions. However, EU source controls would help levelling the playing field and improving administrative efficiency; indeed in the public consultation 94% of government respondents advocated more stringent source controls at EU level.[8] Requiring the application of harmonised measures at EU level would result in a certain cost-effectiveness decrease, which may be well justified if proportionate in relation to the benefits. Several groups of measures have been identified, and the additional implementation cost estimated if

8 Either alone (34%) or in combination with more stringent NEC ceilings (57%)

they were taken at EU-wide scale compared to the 6C* Option implemented exclusively through the NEC Directive.[9] The following cases were examined:

- EU-wide source controls in agriculture
- EU-wide source controls for medium combustion plants (less than 50 MWth)
- Selection of measures that could be covered by updated Best Available Techniques (BAT) Conclusions under the Industrial Emissions Directive (IED) for the following activities: (i) Chemicals production and solvents use, (ii) Cement & Lime production, (iii) Glass manufacturing, (iv)Petroleum Refining

7.1. EU-wide source controls in agriculture

A recent review under the IED[10] concluded that reducing emissions from manure spreading offers the highest benefit-to-cost ratio. As a first analysis of this option, with a view to determining if and how ammonia emissions should be controlled at EU level, the following scenarios have been analysed:

- A1: Harmonised introduction of low-emission manure application techniques throughout the EU (for all farms with size larger than 15 Livestock Units)
- A2: Harmonised introduction of low-emission manure application techniques throughout the EU for all farms with size larger than 15 Livestock Units, as well as covered storage of manure and low-emission housing (new constructions only) for all animals except cattle

- The central case option 6C* for 2025, as benchmark case
- Option 6C* combined with the A1 measures taken EU-wide
- Option 6C* combined with the A2 measures taken EU-wide

The summary results are shown in table A8.9:

Table A8.9: Emission reductions delivered and costs implied by EU-wide packages of ammonia control measures for manure management

	cost vs baseline	cost vs 6C*	NH3 emission reduction
Measures A1	35	NA	92
Measures A2	54	NA	104
option 6C*	4.680	-	918
option 6C*+ A1	4.682	2	918
option 6C* +A2	4.691	11	918

The packages of measures A1 and A2 would deliver around 10% of the total ammonia emission reductions required by option 6C*, at a low cost (average ammonia removal cost between less than 400 € and 500 € per ton).

9 Note that measures related to product standards are always assumed to be taken at EU-wide scale due to single market provisions. These include: emission standards for road vehicles and non-road machinery; solvent content of consumer products; minimum standards under the Ecodesign directive.

10 COM(2013) 286.

If national emission ceilings (delivering the objectives of option 6C*) were complemented by EU-wide mandatory measures defined by scenarios A1 or A2, the loss of economic efficiency would be insignificant: respectively 2 or 11 M€ compared with total emission control costs of the 6C* option of 4680 M€/year (0,05 to 0,2%). This reflects the very attractive cost-effectiveness of the considered manure management measures essentially at all locations.

7.2. EU-wide source controls for Medium Combustion Plants (MCP)

Chapter 7 presents and analyses in detail the policy options to regulate air emissions from MCP (plants between 1 and 50 MW rated thermal input) at EU level. Chapter 7 concludes that a legislative instrument setting objectives that are proportionate and well-justified from a cost-benefit point of view could deliver yearly the reduction of 135 kiloton SO_2, 107 kiloton NO_x and 45 kiloton PM at the cost of 382 M€ (precise figures refer to 2025). Some of the associate technical measures, however, are already included in the bundle of measures that deliver the emission reductions of the policy options considered by this Impact Assessment. Table A8.10 compares the emission reductions, costs and average pollutant removal costs for MCP in Option 6C* and in the preferred option for EU-wide MCP controls described in Annex 12.

Table A8.10: Emission reductions delivered and costs implied by an EU-wide legislative instrument to control air emissions from MCP

	EU-wide MCP instrument			MCP measures in Option 6C*		
	kiloton abated	expenditure (M€)	average removal cost (€/ton)	kiloton abated	expenditure (M€)	average removal cost (€/ton)
SO2	135	183	1400	79	104	1316
NOx	107	83	800	108	86	796
PM	45	116	2500	13	30	2308
Total		382			220	

Note that the detailed analysis of Annex 12 is based on bottom-up information independent of the GAINS model-based analysis of the general Impact Assessment; these two approaches are complementary and give an indication of the uncertainties. Notwithstanding the uncertainties, the average removal costs are in good matching in the two cases. Pollution abatement expenditure is higher in the EU-wide instrument case for all pollutants except NO_x. In summary, the preferred Option for a EU-wide MCP control instrument would entail for the MCP segment extra costs of the order of 162 M€/year, around 3% of the total expenditure entailed by the central case Option 6C*.

7.3. Updated BAT Conclusions under the IED

Emission standards for industrial sectors expressed as emission levels associated with Best Available Techniques are established in the BAT conclusions of the BREFs (BAT Reference documents) under the Industrial Emissions Directive (IED). The BREFs are periodically revised to reflect updated information on state of the art techniques for pollution control.

Sensitivity cases have been investigated to explore the impact of implementing packages of measures in some specific sectors at EU-wide level, as could be the case if the underlying techniques were defined as BAT in the relevant BAT conclusions. The sectors identified are: Cement & lime, glass, refineries, Chemicals, and solvent using activities; the measures, selected on the basis of clear cost-effectiveness demonstrated through the modelling in the majority of the Member States, are the following:

- In the cement & lime sector: further (stage 2) SO2 control; further (stage 2 and 3) NOx control; high-efficiency dedusters
- In the glass sector: further (stage 2) SO2 control; high-efficiency dedusters
- In the petroleum refining sector: further (stage 3) SO2 control; high-efficiency dedusters; use of low-sulphur fuel oil; leak detection and repair programmes; covers on oil-water separators; flaring
- In the chemicals sector: further (stage 3) SO2 control in sulphuric acid production; high-efficiency dedusters in fertilizers production; leak detection and repair programmes
- In the solvents sector: incineration in application of adhesives and in polystyrene processing; use of water-based preservatives in wood products; use of water-based coatings in leather coating

The results for packages of measures in the 6 sectors grouped in 3 clusters are the following:

Table A8.11: Costs implied by harmonised EU-wide measures in specific sectors covered by the IED

EU28, M€	central case 6C*	Cement & lime, glass	Refineries	Chemicals and solvents
power generation	500	-15	-68	-3
Domestic	1611	-3	64	0
Industrial combustion	610	85	29	0
Industrial processes	384	0	-2	2
Fuel extraction	6	0	0	0
Solvent use	63	0	-3	1
Road transport	0	0	0	0
Non-road sources	142	0	0	0
Waste	9	0	0	0
Agriculture	1356	-5	3	1
Total	4680	62	24	1

Additional costs compared to Option 6C* are:

- 85M€ in the cement& lime and in the glass sector, replacing measures for 15 M€ in the power sector, 3 M€ in the domestic sector, and 5 M€ in agriculture; the total balance is additional 62 M€, or 1,4 % of the 6C* costs
- 29M€ in the petroleum refining sector, replacing measures for 2 M€ in other industries and 3 M€ in solvent applications; the total balance is additional 24 M€, or 0,5 % of the 6C* costs
- 2M € in the chemicals sector and 1M € in solvent applications, replacing measures for 3M € in the power sector; the total balance is almost neutral (+1M€)

ANNEX 9 SECTORIAL IMPACTS & COMPETITIVENESS PROOFING

1. CONTEXT AND DEFINITIONS

Competitiveness is a measure of an economy's ability to provide its population with high and rising standards of living and high rates of employment on a sustainable basis. In this analysis the concern is to establish the extent to which the proposed policy will (or could) impact on the competitive position of firms within the EU compared with firms operating in the rest of the world. In some cases firms operate both within the EU and outside the EU and if the proposed policy were likely to encourage those firms to switch production outside of the EU that would be considered a weakening of the EU's competitive position.

This annex complements the impact assessment accompanying the review of the Thematic Strategy on Air Pollution (TSAP review). One of the main objectives of the Review is to set a course that would –in the period beyond 2020- make further progress towards the resolution of problems associated with exposure to air pollution. This will require taking different actions depending on the sector involved and the kind of activity controlled, but in general would result in improving the air pollution standards of marketed products in their use phase (such as motor vehicles or heating appliances) or investing in pollution abatement equipment to reduce the amount of pollution generated by productive processes.

Investing in pollution abatement obviously represents a financial burden for the firms that have to make those investments, and different sectors may be more or less able to absorb that burden depending on the volume of investment needed, on the exposure to competition internationally (foreign producers of the same commodity) and also within the European market (domestic producers of potential substitutes).

2. SCOPING OF THE COMPETITIVENESS ANALYSIS

The objectives proposed by the TSAP review are defined in terms of reduction of health and environmental impacts, and of emission reductions by Member State and by pollutant required to deliver the impact reductions; at this stage, it is up to the Member States to decide in which sectors to reduce emissions; however, the TSAP review also identifies the technical measures that would be most cost effective to reduce emissions in each MS and thereby suggests a cost-effective burden sharing by sector. The Review also suggests that some of the measures could be cost-effectively taken also as EU-wide source controls, which could deliver additional co-benefits in terms of administrative certainty and level playfield, but it will be ultimately up to the co-legislators to decide which share of emission reductions should be delivered by EU measures, and which by national action.

In conclusion, the technical measures and costs per sector identified by the Review are only one of the possible ways to meet the objectives, and at implementation may and will change. None the less, this annex discusses those measures that are determined to be the most cost-effective way to meet the pollution reduction objectives of the Review.

The broad goal of this competitiveness analysis is to understand how meeting the proposed objectives of the TSAP review may affect individual economic sectors, whether specific sectors are particularly affected, and to identify possible mitigating measures that could reduce the burden on those sectors.

To do so, a sector-specific analysis is presented, where the cost-effective technical measures that may be taken in each sector to meet the proposed air quality objectives are presented, along with a brief analysis of the markets that supply pollution abatement technologies.

Implications of the direct costs of these proposed measures in terms of international trade flows and for SMEs are addressed as much as possible.
Pollution control measures, associated sectorial costs and impacts are discussed for three different levels of health and environmental improvements objectives in 2025; these levels correspond to policy options 6A, 6B and 6C of Chapter 6.
Broader economic impacts in terms of macro-economic aggregates are presented in Annex 7, to which this Annex is a complement.

3. SUPPLY OF ABATEMENT TECHNOLOGY

A brief analysis of the supply of abatement technology has been included in order to assess if there is the potential for a single supplier or single MS to benefit from enactment of the proposed regulation. If the regulation were found to favour one particular supply company, sector or member state this might be regarded as implying an (unintended) competition impact that would warrant further exploration.

Abatement technologies to reduce air emissions are manufactured by a range of companies ranging from the engineering or chemical companies to the energy specialist. For example, the energy giants Siemens (DE), Hitachi Europe GMBH (DE) and Alstom (FR) all provide multiple abatement techniques for various pollutants (NOx, SOx, dust and others). Other leading engineering European companies such as ABB (CH), Andritz (AT) and Fluor (UK) provide a wide range of abatement technologies such as SCR, FGD and electrostatic precipitators (ESP).

Some manufacturers are more specialised, that is the case of the Belgian Carmeuse, which is specialised in limestone product used for sulphur abatement and the Italian company Ansaldo which is specialised in in-furnace emission reduction systems (low NOx burners, air staging etc.). CMI (BE) is specialised in the design and construction of heat recovery steam generators. Similarly, Howden (UK) is a leading provider of rotary regenerative heat exchangers which are used for FGD and SCR. The British company Johnson Matthey is a leader in providing chemical catalysts. Finally, the Swiss Hug Engineers is a leader in diesel particulate filters and catalytic exhausts. All of these companies are large and have got multiple offices in and, for some, outside of the European Union. Whilst a majority of the abatement technologies manufacturers are large companies, there is a significant number of SMEs involved in the installations or the fitting of these technologies. Moreover, some more specific (specialist) technologies, particularly relevant for combustion engines, may be developed by smaller manufacturers.

This brief analysis supports the general conclusion that there is no one dominant supplier or dominant approach across the installations captured by the proposed regulation.

4. DEMAND FOR ABATEMENT TECHNOLOGIES: DETAILED MEASURES AND EXPENDITURE PER SUB-SECTOR

The type of additional pollution abatement measures identified through the modelling as the most cost-effective ones include:

- For SO2 abatement: controls on industrial process emissions; low sulphur coal/briquettes for small stoves; FGD/low S fuels for industrial furnaces; FGD for refineries and coke plants.

- For NOx abatement: SCR for cement plants; SCR/SNCR for mid-size boilers in power sector and industry; controls on some industrial process emissions
- For NH3 abatement: efficient application of urea fertilizer, or replacement by nitrate fertilizer; low nitrogen feed (pigs, dairy cows, poultry); low emission application of liquid and solid manures; closed storage of manures and new low emission housing (pigs, poultry)
- For primary PM control: modern biomass stoves with lower emissions and higher energy efficiency; reduction of agricultural waste burning; PM controls on some industrial processes
- For VOC control: modern biomass stoves with lower emissions and higher energy efficiency; further substitution with low solvent and water based products and processes; reduced agricultural waste burning

5. SECTORIAL MARKET ANALYSIS

Potentially significant competitiveness effects are assumed to be felt most significantly in sectors where international competition is greatest, specifically;

- Iron&steel
- Chemicals
- Petroleum refining
- Agriculture
- Other Energy intensive industries: e.g. glass sector

The GEM-E3 analysis (see Annex 7 for more details) has estimated the impacts in terms of trade flow for all sectors included in the analysis. The results are presented in the following table:

Table A9.1: EU28 import and export changes by sector on options 6A-6C

	6A		*6B*		*6C*	
Sectorial Imports in EU28 , % change						
	base	*health*	base	*health*	base	*health*
Agriculture	0,01%	0,02%	0,07%	0,08%	0,28%	0,30%
Electric Goods	0,00%	0,01%	0,02%	0,03%	0,08%	0,10%
Transport equipment	0,00%	0,01%	0,01%	0,03%	0,04%	0,07%
Petroleum Refining	0,00%	0,01%	0,01%	0,03%	0,04%	0,06%
Ferrous and non-ferrous metals	0,00%	0,01%	0,01%	0,03%	0,03%	0,06%
Chemical Products	0,00%	0,01%	0,01%	0,03%	0,05%	0,07%
Other energy intensive	0,00%	0,01%	0,00%	0,01%	0,01%	0,03%
Other Equipment Goods	0,00%	0,00%	0,01%	0,01%	0,02%	0,04%
Consumer Goods Industries	0,00%	-0,01%	-0,02%	0,00%	0,01%	0,00%
Sectorial Exports in EU28, % change						
	base	*health*	base	*health*	base	*health*
Agriculture	-0,03%	-0,02%	-0,11%	-0,09%	-0,47%	-0,44%
Electric Goods	0,00%	0,02%	0,02%	0,05%	0,10%	0,14%

Transport equipment	0,00%	0,02%	0,01%	0,04%	0,05%	0,10%
Petroleum Refining	-0,02%	-0,02%	-0,07%	-0,06%	-0,20%	-0,19%
Ferrous and non-ferrous metals	0,00%	0,02%	-0,02%	0,01%	-0,02%	0,03%
Chemical Products	0,00%	0,01%	0,00%	0,02%	0,00%	0,03%
Other energy intensive	0,00%	0,01%	-0,01%	0,01%	-0,03%	-0,01%
Other Equipment Goods	0,00%	0,03%	0,02%	0,07%	0,09%	0,16%
Consumer Goods Industries	0,00%	0,01%	-0,01%	0,01%	-0,06%	-0,03%

On options 6A-6C, imports to the EU of agricultural commodities would increase 0,01% to 0,3%, while exports would decrease -0,03 to-0,47%. Increased labour productivity due to health benefits ("health" case) could offset part of the export losses due to production cost increases due to the cost of compliance with air pollution reduction requirements. In terms of sectorial output (Table A9.2), on options 6A-6C the agricultural sector could lose between 0,01% and 0,20%. However, this result does not take into account the effects of increased crop yield due to ground-level ozone concentration reduction, which is estimated to be worth around €270M on option 6C, in the range of 0,1% of the total EU agricultural output, nor possible support schemes for the sector, discussed below in the sector-specific analysis. Similar conclusions can be drawn for the petroleum refining sector, although the magnitude of impacts –in particular on option 6C- is lower. The maximum output loss on option 6C would in this case be limited to -0,1%. None of the other sectors would incur substantial net losses, either because no significant effort is required of them on the policy options considered, or because they benefit from supplying pollution abatement equipment (chemical products as well as manufacturers of equipment).

Table A9.2: EU28 output changes by sector on options 6A-6C

	6A		*6B*		*6C*	
	Sectorial output inpact in the EU28, % change					
	base	*health*	base	*health*	base	*health*
Agriculture	-0,01%	0,00%	-0,06%	-0,04%	-0,22%	-0,20%
Chemical Products	0,00%	0,01%	0,01%	0,03%	0,03%	0,05%
Consumer Goods Industries	0,00%	0,00%	-0,01%	0,00%	-0,04%	-0,01%
Electric Goods	0,00%	0,02%	0,03%	0,05%	0,10%	0,13%
Ferrous and non-ferrous	0,00%	0,01%	-0,01%	0,02%	0,00%	0,03%
Petroleum Refining	-0,01%	0,00%	-0,03%	-0,02%	-0,10%	-0,08%
Other energy intensive	0,00%	0,01%	-0,01%	0,01%	-0,02%	0,01%
Other Equipment Goods	0,00%	0,01%	0,02%	0,05%	0,06%	0,11%
Transport equipment	0,00%	0,01%	0,01%	0,04%	0,04%	0,09%

indicators calculated as relative changes do not differ significantly for 2025 and 2030. Exact figures reported are for 2025.

The market sectors affected are identified above; in the following sections, for each of them basic information on market structure including breakdown by firm size and is provided along with the overall and average gross value added and turnover typical of firms of each size group by number of employees, and impacts on specific sectors and sub-sectors are taken individually.

5.1. Metals (iron and steel; and non-ferrous metals)

Employment in the steel sector reached a peak of around 1 million in the EU during the 1970's. Employment has declined to just over 400,000 in 2008 and the sector continues to face stiff competition from the new global steel producers of Eastern Asia, notably Korea and China. In spite of this stiff competition steel exports exceed imports. Basic data on the EU steel industry follows[11]:

- EU share of global steel exports (top ten exporters) in 2010: 14 %.
- Biggest markets for EU steel exports in 2010 (in decreasing order of importance): Turkey, USA, Algeria, Switzerland, Russia, India.
- EU steel imports fell by about 50% from 40.2 million tonnes in 2008 to 20.7 million tonnes in 2009. In comparison, the steel exports from the EU only fell by 11% from 35 million tonnes in 2008 to 31 million tonnes in 2009, thus turning the EU steel trade balance to surplus after several years of deficit. In 2010 this surplus halved when imports grew by 30% to almost 27 million tonnes and exports increased only by 5% to 33.7 million tonnes in total.

The above data indicates that the average value of steel imported was around €670 per tonne (value divided by tonnage) while the value of steel exported was nearly 1,000 € per tonne. This is a strong indicator that the steel exported is of a higher quality (perhaps because of finishing or fabrication differences) than imported steel. Some of the decline in steel imports may be attributable to economic down turn although as can be seen exports held up comparatively well.

The following figures show steel imports and exports from 2006 projected forward to 2014. The EU has, since 2009 maintained a healthy trade surplus in steel but it is also apparent that it is a globally traded commodity that has the potential to be impacted by price. It is likely that in general steel producers in the EU are price takers and therefore have limited capacity for passing cost, although the EU does have specialist steel fabrication facilities and these may provide some shelter from non EU competition.

[11] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/steel/#stats

Figure A9.1: EU27 imports of steel. Source: Eurofer, 2013[12]

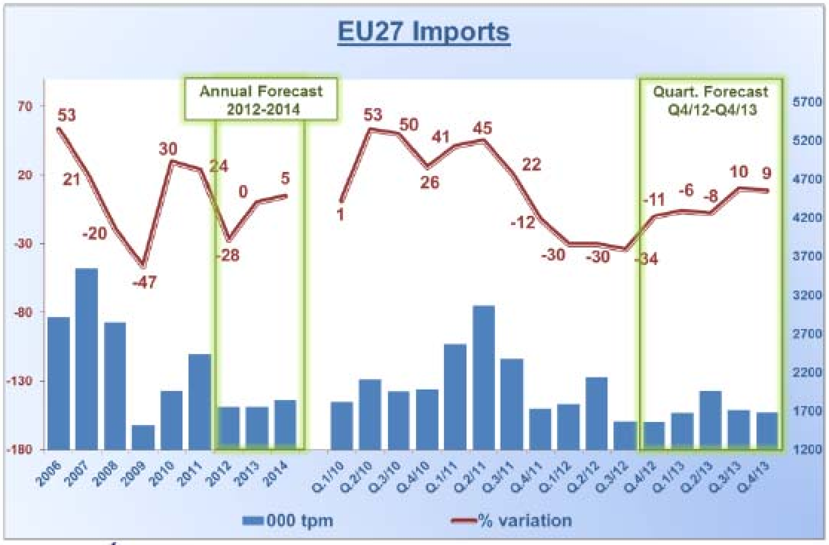
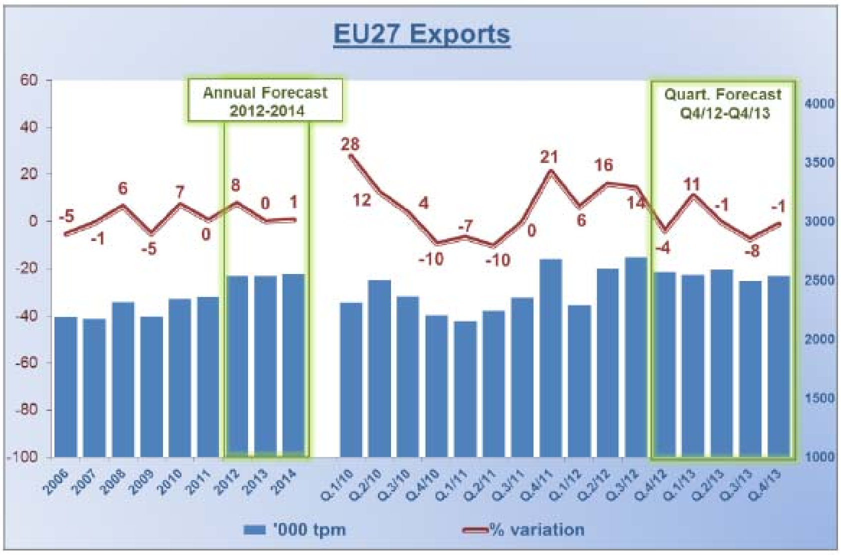


Figure A9.2: EU27 exports of steel. Source: Eurofer, 2013



Non-ferrous metals (principally Aluminium, Copper and Zinc) are important in manufacturing and production supply chains. The EU has limited raw material and mineral deposits, and the principal source is waste and scrap recycling. The EU has developed considerable specialism in these areas but the demand for such metals is greater than can be met through these routes. As a result the EU imports some €8 billion more than it exports (2009 figures). Basic data on the EU non-ferrous metals sector follows[13]:

- Imports (2009): €34 billion / Exports (2009): €26 billion (trade balance: - €8 billion).
- The share of the non-ferrous metals sector in EU manufacturing value added is 1.37 % (€23.4bn.).

[12] http://www.eurofer.org/index.php/eng/Issues-Positions/Economic-Development-Steel-Market
[13] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/non-ferrous-metals/

- The share in employment is 1.0 % (334 800 people).
- Turnover of the sector was €139 billion (2.0 %).

Basic metals industries (iron & steel; and non-ferrous metals)		Yearly costs, total and per subsector, M €					
		total	coke	natural gas	hard coal	HFO	Additional most cost-effective measures
Iron &Steel, combustion	6A	1,21			1,04	0,17	low sulphur coal (0,6%); low sulphur fuel oil (0,6%); high efficiency deduster
	6B	46,51	3,25		40,21	3,05	low sulphur coal (0,6%); low sulphur fuel oil (0,6%), high efficiency deduster, combustion modification, wet FGD
	6C	90,54	3,64	4,49	72,81	9,60	low sulphur coal (0,6%); low sulphur fuel oil (0,6%), high efficiency deduster, combustion modification, wet FGD
Iron & Steel, pig iron blast furnace	6A	0,61					Stage 2 & 3 SO2 controls for process emissions
	6B	4,38					Stage 3 SO2 controls for process emissions, EP (1 field)
	6C	6,28					Stage 3 SO2 controls for process emissions, EP (1 field), high efficiency deduster, good practices
I&S, Basic Oxygen furnace	6A	0,22					EP (1 field)
	6B	8,22					EP (1 field), high efficiency deduster
	6C	9,45					high efficiency deduster
I&S, Cast iron	6A	0,02					EP (1 field)
	6B	3,24					EP (1 field), high efficiency deduster, good practices
	6C	7,40					high efficiency deduster, good practices
I&S, Coke oven	6A	1,22					Stage 3 SO2 controls for process emissions
	6B	4,00					Stage 1, 2 &3 SO2 controls for process emissions, high efficiency deduster, good practices
	6C	8,39					Stage 1 &3 SO2 controls for process emissions, high efficiency deduster, good practices
I&S, Sinter plant	6A	4,16					Stage 1 & 2 SO2 controls for process emissions
	6B	17,81					Stage 2 & 3 SO2 controls for process emissions
	6C	39,54					Stage 3 SO2 controls for process emissions
Non ferrous metals, combustion	6A	0,63				0,63	high efficiency deduster
	6B	2,61			0,20	2,41	high efficiency deduster
	6C	6,83			2,08	4,75	high efficiency deduster
Non ferrous metals, aluminium	6A	1,51					high efficiency deduster in primary aluminium
	6B	1,52					high efficiency deduster in primary and secondary aluminium
	6C	1,52					high efficiency deduster in primary and secondary aluminium
Non ferrous metals, other	6A	1,43					Stage 2 SO2 controls for process emissions
	6B	15,71					Stage 1, 2 & 3 SO2 controls for process emissions
	6C	61,05					Stage 2 & 3 SO2 controls for process emissions

FGD: Flue Gas Desulphurisation; EP: Electrostatic Precipitator; combustion modification: limestone sorbent addition to solid fuel combustion.

Different stages of process emission controls are related to the production technologies, are site specific and depend onseveral parameters including raw material quality. Stages 1-3 group these measures by progressively increasing costs.

CODE	NACE_R2/SIZE_EMP	By size of company					
C241	Manufacture of basic iron and steel and of ferro-alloys	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		:	:	353	140	170	196
Turnover		144.289,96	:	:	1.945	10.646	129.285
Gross Value Added		22.109	219,72	304	312	1.463	19.793
Turnover per company					13,89	62,62	659,62

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the iron and steel industry identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 8 M €, equal to 0,006% of sectorial turnover and 0,04% of GVA
- In option 6B: 84 M€, equal to 0,06% of sectorial turnover and 0,4% of GVA
- In option 6C: 160 M€, equal to 0,11% of sectorial turnover and 0,72% of GVA

The largest share of this expenditure is for abatement of emissions in combustion units, in basic oxygen furnaces, and in sinter plants. Basic oxygen furnaces and sinter plants are generally embedded in large size industrial installations and are not expected to be a direct concern of SMEs. In all cases the additional required effort is less than 1% of GVA; the iron & steel sector also benefits from direct gains in terms of net output through demand for fabricated metal products as investment goods for pollution abatement.

CODE	NACE_R2/SIZE_EMP	By size of company					
C242	Manufacture of basic precious and other non-ferrous metals	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		3.583	2.284	377	260	419	183
Turnover		103.109	1.900	:	4.577	31.313	63.204
Gross Value Added		16.347	600	:	633	4.054	10.398
Turnover per company		28,78	0,83		17,6	74,73	345,38

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the non-ferrous metals industry identified as being the most cost-effective under the policy scenarios analysed is the following:

In option 6A: 3,5 M €, equal to 0,003% of sectorial turnover and 0,02% of GVA

- In option 6B: 20 M€, equal to 0,02% of sectorial turnover and 0,12% of GVA
- In option 6C: 70 M€, equal to 0,07% of sectorial turnover and 0,44% of GVA

Most of this expenditure is for abatement of smelter process emissions (SO2). In all cases the additional required effort is less than 0,5% of GVA.

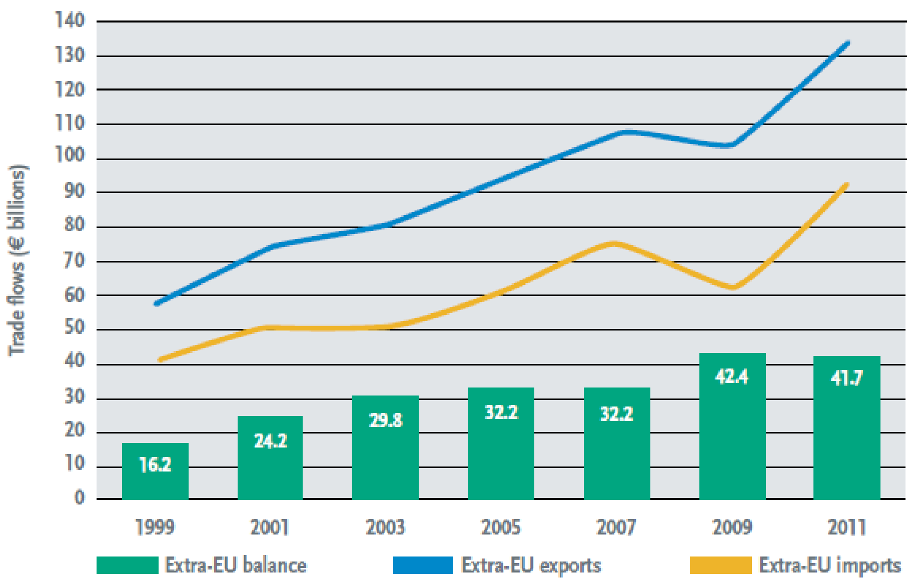
5.2. Chemicals

The chemicals sector is one of Europe's most competitive industrial sectors. Its work is focused on the manufacture of chemicals and the chemical transformation of materials into new substances or products. It covers a huge range of operations and outputs from basic organic and inorganic chemical products, through fertilizers, basic plastics, synthetics, rubbers, paints and varnishes to highly specialized consumer chemicals and polymers. Basic data on the EU chemicals sector follows[14]:

- EU chemicals exports in 2009: €118 billion.
- EU chemicals imports in 2009: €75 billion.
- Biggest markets for EU chemical exports: US, Canada, Switzerland, Asia (China, India, Japan and ASEAN countries).
- Accounting for around 30% of the total world chemicals production, the EU is the world's most important producer of chemicals. In 2008 it produced €566 billion worth of chemicals. More than one third of world's top thirty chemical companies have their headquarters in the EU. The largest European producer of chemicals is Germany, which accounts for about 25% of EU production. Around 30,000 chemical companies employ a total staff of about 1.2 million people in the EU. Another three million employees work in sectors using output of the chemical industry and thus depend on its competitiveness.
- The EU trades more than 40% of all chemicals traded globally, compared with circa 15% for the NAFTA countries and circa 30% for Asia.

The figure below shows the growing importance of chemicals in the EU economy with both imports and exports growing progressively since 1999.

Figure A9.3: EU27 chemicals sector trade balance



Source: Cefic (2012): http://www.cefic.org/Documents/FactsAndFigures/2012/International-Trade/Facts-and-Figures-2012-Chapter-International-Trade.pdf

[14] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/industrial-goods/chemicals/

Chemical industry

		Yearly costs, total and per subsector, M €					
		total	biomass	natural gas	oil products	coal	Additional most cost-effective measures
N - fertilizer production	6A	0,00					
	6B	2,54					
	6C	63,08					Combination of STRIP
Combustion in boilers	6A	0,33	0,14	0,00	0,07	0,12	
	6B	1,39	0,45	0,09	0,29	0,56	Combustion modification on oil and gas industrial boilers and furnaces; High efficiency deduster; Low sulphur fuel oil (0.6 %S);Low sulphur coal (0.6 %S)
	6C	20,27	7,54	2,21	2,34	8,18	Combustion modification on: oil and gas industrial boilers and furnaces, and solid fuels fired industrial boilers and furnaces; High efficiency deduster; Selective non-catalytic reduction on solid fuels fired industrial boilers and furnaces; Good housekeeping: industrial oil boilers; wet FGD; In-furnace control - limestone injection; Low sulphur fuel oil (0.6 %S)
Other combustion	6A	2,84	0,31	0,00	0,85	1,67	Low sulphur coal (0.6 %S); Low sulphur fuel oil (0.6 %S); wet flue gases desulphurisation; High efficiency deduster; EP (1 field)
	6B	7,27	0,88	0,14	2,23	4,03	Low sulphur coal (0.6 %S); Low sulphur fuel oil (0.6 %S); wet FGD; In-furnace control - limestone injection; Combustion modification on: oil and gas industrial boilers and furnaces, and solid fuels fired industrial boilers and furnaces; Selective catalytic reduction on solid fuels fired industrial boilers and furnaces; High efficiency deduster
	6C	22,82	2,60	3,48	9,89	6,85	Low sulphur coal (0.6 %S); Low sulphur fuel oil (0.6 %S); wet FGD; In-furnace control - limestone injection; Combustion modification on: oil and gas industrial boilers and furnaces, and solid fuels fired industrial boilers and furnaces; selective catalytic and non-catalytic reduction on solid fuels fired industrial boilers and furnaces; selective catalytic reduction on oil and gas industrial boilers and furnaces; Good housekeeping: industrial oil boilers; High efficiency deduster
Organic chemical industry - downstream units	6A	0,26					
	6B	0,85					Leak detection and repair program, stage IV
	6C	1,30					Leak detection and repair program, stage IV
Products incorporating solvents	6A	0,01					
	6B	0,06					Basic emissions management techniques
	6C	0,94					Basic emissions management techniques
Polystyrene processing	6A	0,00					6% Pentane expandable beads (85%) and recycled EPS waste (15%)
	6B	0,17					6% Pentane expandable beads (85%) and recycled EPS waste (15%)
	6C	4,21					6% Pentane expandable beads (85%) and recycled EPS waste (15%); Combination of the above options
Ind. Process: Nitric acid	6A	0,00					

	6B	0,12	
	6C	2,87	Process emissions - stage 1 NOx control
Ind. Process: Sulfuric acid	6A	7,67	Process emissions - stage 2 SO2 control
	6B	22,19	Process emissions - stage 1, 2 and 3 SO2 control
	6C	58,80	Process emissions - stage 2 and 3 SO2 control

Combination of STRIP: stripping and absorption techniques in the chemical industry for N-fertilizers production
FGD: Flue Gas Desulphurisation; EP: Electrostatic Precipitator

CODE	NACE_R2/SIZE_EMP	By size of company					
C20	Manufacture of chemicals and chemical products	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		28.611	18.067	3.379	2.993	2.844	853
Turnover		490.000	14.682	12.142,36	28.547	121.000	313.629
Gross Value Added		111.000	2.667,27	2.912	7.164	26.000	72.257
Turnover per company		17,13	0,81	3,59	9,54	42,55	367,68

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the chemicals industry identified as being the most cost-effective under the policy scenarios analysed is the following:

In option 6A: 12 M €, equal to 0,002% of sectorial turnover and 0,003% of GVA

- In option 6B: 32 M€, equal to 0,01% of sectorial turnover and 0,03% of GVA
- In option 6C: 174 M€, equal to 0,04% of sectorial turnover and 0,16% of GVA

In all cases the additional required effort is less than about one quarter of a % point of GVA of the Chemical sector.

Additional expenditure for pollution control in combustion installations may raise to up to 20% of the figures above; additional expenditure for process emission abatement would mainly be for NOx control in Nitrogen fertiliser production, and SO2 control in sulphuric acid plants.

- N-Fertilizers production and trade

INDICATORS/CODE (M€)	Mineral or chemical fertilizers, nitrogenous, n.e.c.	Fertilizers containing N, P and K, > 10% N	Fertilizers containing N, P and K, <= 10% N	TOTAL	% over production value
Exports value	29,1	465,9	64,0	559,0	12
Imports value	4,7	398,2	116,8	519,7	11
Production value	1.200,0	2.537,5	1.017,1	4.754,5	

Source: Generated from Eurostat database (2010 values used).

Additional costs for emission control could affect N-fertilizers trade fluxes due to the significant trade volumes (both imports and exports) of this commodity. In option 6C the additional control costs in this subsector would be of the order of 1% of the total production value.

- Sulphuric acid production and trade

INDICATORS/CODE (M€)	Chlorosulphuric acid	Sulphuric acid	TOTAL	% over production value
Exports value	0,42	77,93	78,34	21
Imports value	2,88	7,03	9,90	3
Production value	4,00	365,17	369,17	

Source: Generated from Eurostat database (2010 values used).

The EU is a net exporter of sulphuric acid (~18% of EU production value in 2010). There is a potential risk that additional costs for this sub sector (up to about 10% of the production value in option 6C) may be difficult to pass over to foreign traders.

5.3. Refining

The mineral oil and gas refinery industry is an important and strategic industry for the EU providing 42 % of the EU energy requirements and employing over 100 000 people.

Installations are broadly distributed around Europe. Refinery installations are typically very large and fully integrated plants, well connected to pipelines and infrastructure networks. Companies operating in the European refining sector can be categorised into 4 classes:

- So-called 'Majors' (Total, Shell, BP, Exxon) EU and non EU based companies operating worldwide in the exploration refining and distribution sectors
- Other EU based companies e.g. Repsol (ES), ENI (IT), Preem (SE), some of them historically stated-owned , operating on a more limited scope
- Smaller companies e.g, Motor Oil, Lyondell Basell, also operating on a more limited scope, mostly in refining activities (less upstream activities) which may be specialized (petrochemicals);
- National companies from non-EU countries operating European refinery plants, e.g. from crude-oil producers such as. Kuwait, Venezuela, Saudi Arabia and more recently Russia (Lukoil) or others like China (PetroChina)

There has been intense restructuring of the EU refining sector over the last 5 years with the emergence of new players from Asia and the Middle East. It is important to note that regions able to directly supply the European market with refined products (Russia, Middle East) are significantly increasing their refining capacities. Moreover, many EU refineries are 30 to 40 or more years old and therefore face financial and technological challenges to adapt to the current market situation due to their initial process configuration which is not flexible enough. Basic data on the EU refinery sector follows[15]:

- After Asia, leading with 25 %, the largest refining regions are North America and Europe with close to 20 % of the global capacity each
- In 2010, the EU countries together operated 104 oil refineries, corresponding to a refining capacity of 778 million Tons/day
- In 2009 the volume of oil processed in EU refineries was 660 million Tons/day (= 85% of total capacity). There is a situation of structural over-capacity. Approximately 20% of capacity was unused in the EU. As a result, in the period 2011-2012, 10% of the capacity

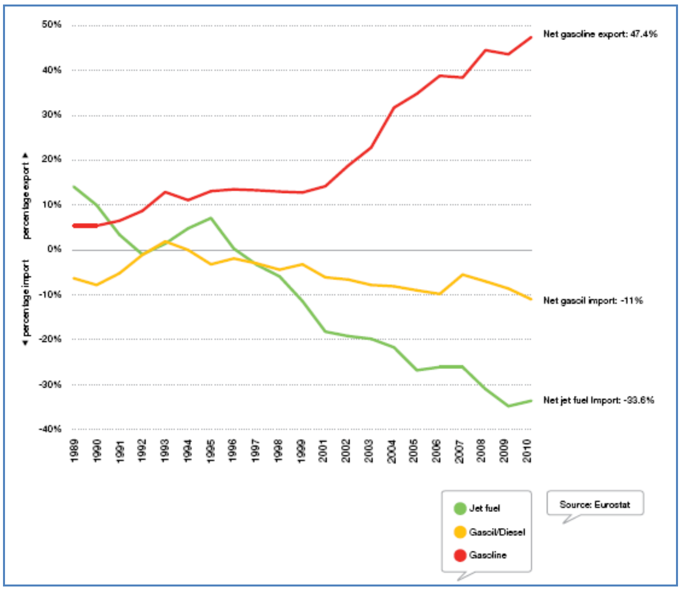
[15] Source: JRC- IPTS (2012)

has been lost due to closures and restructuring of the refining sector. In Europe over the last 20 years there has been a slow but steady increase in unused refining capacity, partially due to the delocalisation of the industry, the relatively weak demand and the progressive specialisation of the demand on middle distillates directly importable from neighbouring areas. Recently, the EU, is the only region that has seen a fall in both demand (-0.9 %) and refining capacity (-2 %) in 2010. This has led to a temporary increase of the refining utilisation rate

- The transport sector and in particular road transport (being almost fully dependent on oil) remains the most energy consuming sector. In the EU, as much as 77.5% of goods are transported by road which implies that industry depends on refined products
- EU gasoline and diesel exports in 2010 were 95 million tonnes per year and imports 288 million tonnes per year.
- There are growing production/consumption imbalances at the level of individual products. In particular the shift over the last decade of motor fuels from gasoline to diesel has resulted in a production deficit of diesel (10%) and a surplus of gasoline (40%) in the EU
- The diesel deficit is covered to a large extent by imports from Russia (35% of diesel imports) and the gasoline is exported mainly to the USA (40%)

The figure below shows the trend of growing gasoline surplus and gasoil deficit.

Figure A9.4: EU's foreign trade as a percentage of demand



Source: EUROPIA, 2011

Petroleum refining industry			
		Yearly costs, total and per subsector, M €	
		total	**Additional most cost-effective measures**
Extraction, processing and distribution of liquid fuels	6A	0,00	
	6B	0,00	
	6C	6,58	Improved ignition systems on flares; Vapour balancing on tankers and loading facilities

Combustion	6A	28,55	Low sulphur fuel oil (0.6 %S)
	6B	50,16	Low sulphur fuel oil (0.6 %S); Combustion modification on industrial boilers and furnaces
	6C	216,86	Low sulphur fuel oil (0.6 %S); wet FGD; high efficiency FGD; high efficiency deduster & good housekeeping; Combustion modification on industrial boilers and furnaces
Ind. Process: Crude oil & other products - input to Petroleum refineries	6A	3,45	Process emissions - stage 1 SO2 control; EP 1 field
	6B	52,78	Process emissions - stage 1, 2 & 3 SO2 control; EP 1 & 2 field; Leak detection and repair program, stage II
	6C	117,78	Process emissions - stage 2 & 3 SO2 control; high efficiency deduster
Steam cracking (ethylene and propylene production)	6A	0,00	Leak detection and repair program, stage II
	6B	0,07	Leak detection and repair program, stage II; COWS
	6C	0,79	Leak detection and repair program, stage I and II; COWS

COWS: Covers on Oil/Water separators; FGD: Flue gas Desulphurisation; EP: Electrostatic Precipitator

CODE	NACE_R2/SIZE_EMP	By size of company					
C19	Manufacture of coke and refined petroleum products	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		1.120	623	147	113	117	97
Turnover		500.187	3.104	907	9.607	13.514	472.985
Gross Value Added		23.514	238,88	111	375	1.377	21.400
Turnover per company		446,60	4,98	6,17	85,02	115,50	4.876,14

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the refining industry identified as being the most cost-effective under the policy scenarios analysed is the following:

In option 6A: 32 M €, equal to 0,006% of sectorial turnover and 0,13% of GVA

- In option 6B: 103 M€, equal to 0,02% of sectorial turnover and 0,43% of GVA
- In option 6C: 342 M€, equal to 0,07% of sectorial turnover and 1,45% of GVA

The largest share of this expenditure is for abatement of emissions in combustion installations and in process installations treating crude oil and other products. Both are generally embedded in large size industrial installations and are not expected to be a direct concern of SMEs. Investment for process emission abatement would mainly be for SO2 control.

In options 6A and 6B the additional required effort is less than 0.5 % of GVA and in 6C is less than 1.3 %.

5.4. Agriculture and livestock rearing

The EU is the world's largest importer and exporter of agricultural products. Europe imports mostly basic agricultural commodities, but its exports are based on high quality farm products and other processed agricultural products. Basic data on the EU agriculture sector follows[16]:

- Total trade in agricultural products amounted to almost €153 billion in 2007, split between EU imports from third countries of €77.4 billion and exports of €75.1 billion.

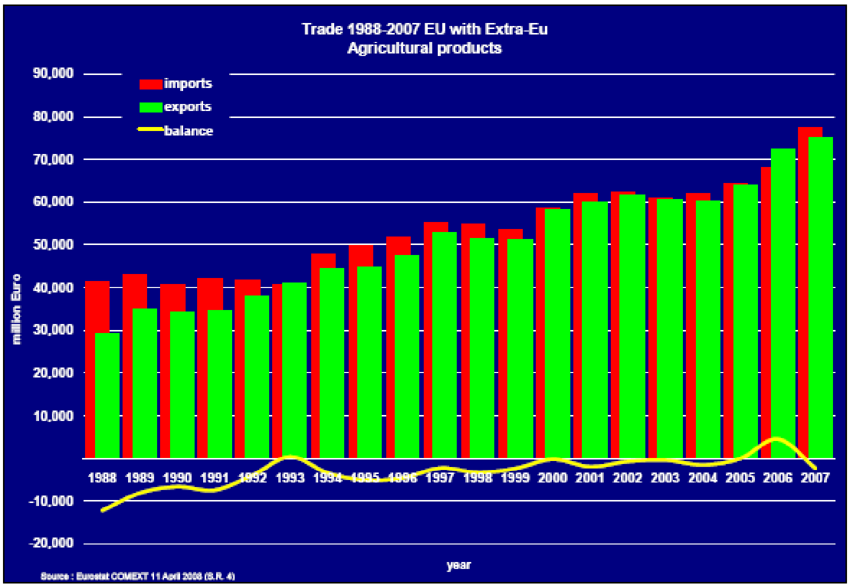
[16] http://ec.europa.eu/trade/creating-opportunities/economic-sectors/agriculture

- Since the 1995 enlargement to EU15, imports have increased by 55% and exports by 68%.
- Over the years, the trade deficit has been reduced from more than €10 billion in 1988 to €5 billion in 1995 with an all-time low in 2005, when it amounted to only €27 million. In 2006, for the first time, the EU had a trade surplus of €4.5 billion but the trade balance went back again to negative in 2007 (€2.4 billion).
- The EU is the first importer from developing countries.
- In 2007, the 10 largest suppliers to the EU accounted for 55% of total imports of agricultural products into the EU. **Brazil** ranked first with €12 billion (16%) followed by the **US** (9%) and **Argentina** (8%).
- The EU's ten most important customers for agricultural products accounted for 56% of total exports. The **US** was the largest customer, absorbing some 19% of EU exports, followed by **Russia** and **Switzerland** (10% and 7% respectively).

As regards trade projections, the EU is expected to maintain its position as a net exporter of pig and poultry meat and a net importer of beef and sheep meat.[17] Regardless that pig and beef are under heavy competition from third countries and are expected to decline over the coming years, mostly due to high labour costs, but partly due to animal welfare and environmental forthcoming legislation and associated costs.

The figure below shows the growth of agriculture products imports and exports in the EU economy since 1989.

Figure A9.5: EU agricultural sector trade balance



In 2010, Agricultural output was 348.934 M€ and GVA at basic prices was 145.305 M€ (Eurostat data).

[17] EC,,2012B: 'Prospects for Agricultural Markets and Income in the EU 2012-2022'.

Agriculture			
		Yearly costs, total and per subsector, M €	Additional most cost-effective measures
Dairy cows - liquid (slurry) systems	6A	13,4	LNF, LNA and CS variously combined
	6B	27,9	LNF, LNA and CS variously combined
	6C	142,0	LNF, LNA, CS and SA variously combined
Dairy cows - solid systems	6A	2,6	LNF, LNA_high and LNA_low variously combined
	6B	9,6	LNF, LNA_high and LNA_low variously combined
	6C	19,4	LNF, LNA_high and LNA_low variously combined
Other cattle - liquid (slurry) systems	6A	8,1	Combination of CS and LNA
	6B	11,8	Combination of CS and LNA
	6C	81,1	Combination of CS and LNA
Pigs - liquid (slurry) systems	6A	18,4	LN, LNA CS and SA variously combined
	6B	59,8	LN, LNA CS and SA variously combined
	6C	544,8	LNF, LNA, CS, SA and BF variously combined; Biofiltration
Pigs - solid systems	6A	1,5	Combination of LNF and LNA_high
	6B	4,0	LNF, LNA_high and LNA_low variously combined
	6C	8,9	LNF, LNA_high and LNA_low variously combined
Other poultry	6A	1,6	LNF, LNA and SA variously combined
	6B	17,9	LNF, LNA, SA and CS variously combined
	6C	136,5	LNF, LNA, SA, CS and BF variously combined; Animal house adaption; Biofiltration
Laying hens	6A	0,5	LNF, LNA, SA and CS variously combined
	6B	8,4	LNF, LNA, SA and CS variously combined
	6C	45,6	LNF, LNA, SA, CS, BF variously combined; Biofiltration; Animal house adaption
Fertilizer use - urea	6A	0,0	
	6B	141,2	Urea substitution
	6C	323,2	Urea substitution
Waste: Agricultural waste burning	6A	11,9	Reduced open burning of agricultural residues
	6B	11,9	Reduced open burning of agricultural residues
	6C	11,9	Reduced open burning of agricultural residues

LNA: Low ammonia application of manures

LNA_Low efficiency methods include slit injection, trailing shoe, slurry dilution, band spreading for liquid slurry, and incorporation of solid manure by ploughing into the soil the day after application

LNA_High efficiency methods involve the immediate incorporation by ploughing within four hours after application, deep and shallow injection of liquid manure and immediate incorporation by ploughing (within 12 hours after application) of solid manure

LNF: Low nitrogen feed

CS: Covered storage of manures

SA: Low emission housing

BF: Air purification

The annual costs of the set of measures in agriculture identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 59 M €, equal to 0017,% of sectorial output and 0,04% of GVA
- In option 6B: 285 M€, equal to 0,08% of sectorial output and 0,2% of GVA
- In option 6C: 1292 M€, equal to 0,38% of sectorial output and 0,9% of GVA

It is estimated that for option 6C, the total extra costs for the Pigs liquid systems subsector will be 41% of the total expenditure (1292 M€). This will be partly compensated by increased income from larger crop yields due to lower concentrations of ground-level ozone.

The EU produces around 22 million tonnes of pork meat annually, making it the world's second largest producer after China. Pig meat represents 21% of overall livestock production value. In several EU member states pig meat sector is the largest meat production sector, and two thirds of pig meat production in the EU is produced in 6 countries[18]. Key sector characteristics of EU27 are presented below:

	Pigs
Number of holdings (1000s)	2,750
Number of pigs (1000s)	152,000
Production (1000s tonnes of meat)	12,000
Production (1000s heads)	164,000
Production value of meat (€ million)	31,000
Regular labour force	641,000

Source: Eurostat (2010 or most recent year).

In Option 6C, the additional expenditure for the Pig industry (liquid and solid systems) is estimated at 553,6 M€, representing 1.8% of the meat production value.

Regarding the type of enterprises affected, pig production is generally an intensive, indoor, large scale business with a relatively low level of variability in production systems. Both pig and poultry play an important role in mixed livestock small holdings throughout the EU, particularly in the EU 12, but this system represents little in terms of overall herd size and still much less in terms of contribution to overall production. Poultry production in the EU is highly industrialised, with around 60% of chickens reared intensively in large purpose-built facilities, operated by large companies.

In Option 6C, 25% of the total expenditure on ammonia control measures is for mineral fertilizers (urea substitution), affecting the arable crop sector. This sector can be divided into the following:

[18] Germany, Spain, France; Poland, Denmark, the Netherlands

	Production value at basic price (M€)
CEREALS (including seeds)	44.580,76
INDUSTRIAL CROPS	16.977,92
FORAGE PLANTS	25.041,00
VEGETABLES AND HORTICULTURAL PRODUCTS	49.855,58
POTATOES (including seeds)	10.102,68
FRUITS	23.345,36
WINE	12.948,57
OLIVE OIL	3.947,52
OTHER CROP PRODUCTS	2.076,99
CROP OUTPUT	188.875,38

Source: Eurostat database (2010 values).

Costs for urea substitution would be 141M€ in option 6B and 323 M€ in 6C, equal to 0,07% and 0,17% of crop output, respectively. 19% of the total expenditure for option 6C is related to cattle, including dairy cows (liquid and solid systems) and other cattle (liquid slurry systems).

In 2010, the total economic turnover for the EU dairy industry was €117 billion, representing about 13% of the turnover for the total food and drink industry in Europe (€900 billion), and employing about 400,000 people, or 10%, of the 4 million working in the sector[19].

Option 6C costs for dairy cows systems sum up 161 M€, representing 0.13% of EU dairy industry 2010 turnover.

Medium term prospects for milk and dairy products appear favourable due to the continuing expansion of world demand. Global population and economic growth, and increasing preference for dairy products are expected to be the main drivers, fuelling EU exports and sustaining commodity prices.

Milk production in the EU is not as competitive as in some other parts of the world, due to the cost of milk quotas, animal welfare regulations and relatively high costs of land, buildings and labour[20]. However, fresh milk products are mainly produced and consumed locally due to their short shelf-life and are therefore not significantly exposed to EU-external trade.

Regarding Beef industry, in 2011 the total indigenous production of beef in the EU-27 was 8,371 thousand tonnes (13% of the world beef and veal production); 350 thousand tonnes of production was exported[21]. In 2010, the total economic turnover was around €90 billion, representing about 10% of the turnover for the total food and drink industry in Europe (€900 billion).

In Option 6C, expenditure in the sector "other cattle different from dairy cows" totals 81M€, or 0.09% of beef industry turnover for 2010.

[19] IUF Dairy Industry Research, http://cms.iuf.org/sites/cms.iuf.org/files/European%20Union%20Dairy%20Industry.pdf

[20] 'Competitiveness of the EU dairy industry' (LEI Wageningen UR, 2009).

[21] EC, 2011: ‘Prospects for Agricultural Markets and Income in the EU 2011-2020’.

Historically, the EU has been a major beef exporter. However, the year 2003 marked the shift in the EU beef trade balance, with beef and veal imports exceeding exports to date[22], due to reduced production and policy changes. While the trade balance was strengthened in 2010 and 2011, production has been declining steadily. The main underlying reason is that EU beef production is currently less competitive compared with third countries (primarily the MERCOSUR group), due to relatively more expensive feed and labour conditions, smaller livestock supplies, high levels of bio- security regulation, and smaller economies of scale[23]. In future, the competitive disadvantage of EU beef producers is likely to continue, albeit some competitiveness factors such as labour cost may even out.

In option 6C, additional expenditure in the poultry industry including laying hens and other poultry totals 182 M€, 14% of total additional ammonia control costs, representing 0,73% of the sector output.

The EU produces around 11 million tonnes of poultry meat annually and well over 35 billion eggs (Eurostat – figure is a minimum value as it excludes countries expected to be important producers, such as Italy and the UK). In value terms, poultry meat represents 13% of livestock production value, and eggs 4%. Poultry meat is the second most popular meat in the EU, representing 25% of EU meat consumption overall.[24] Key sector characteristics are presented in A9.3.

Table A9.3: Key characteristics of EU27 poultry industry (2010 or most recent prior to 2010 where not available). Source: Eurostat (except where specified in the notes)

	Broilers	Laying hens	Total
Number of holdings (1000s)	2,200	4,100	4,800(1)
Number of hens (1000s)	876,000	510,000	1,620,000(2)
Production (1000s tonnes of meat/eggs)	>> 6,100(3) ~ 11,000 (5)	>> 3,600(4) ~ 6,900(6)	n/a
Production (1000s heads/eggs)	>> 4,360,000(3)	>> 35,000,000(4)	n/a
Production value of meat/eggs (€ million)	17,000	7,700	24,700
Regular labour force (specialist poultry)(7)	n/a	n/a	1,000,000

Notes: (1) Total number of holdings is lower than the sum of its components as many holdings have both broilers and laying hens. (2) The total number of hens is higher than the sum of broilers and laying hens as there are also poultry classified as "other". (3) Meat production given as minimum values as Eurostat only has such data for 10-12 Members States. (4) Eggs production given as minimum values as Eurostat data excludes countries expected to be important producers, such as Italy and the UK. (5) JRC (2010) estimate. (6) **http://www.compassionlebensmittelwirtschaft.de/wp-content/uploads/2012/05/Info-1-Egg-production-in-the-EU.pdf.pdf** (7) It is likely that the actual labour force will be higher than this, as non-specialists are likely to be employed in poultry rearing, slaughter etc.

22 European Commission, DG Agriculture and rural development. Webpage: Beef and Veal. http://ec.europa.eu/agriculture/markets/beef/index_en.htm

23 European Commission, (2007), DG Enterprise and Industry, 'Competitiveness of the European Food Industry: An Economic and Legal Assessment 2007'. (EC, 2006)

24 Sources: 'Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS), Final report' (JRC,2010); 'Prospects for agricultural markets and income in the EU 2011–2020' (EC, 2011); 'Egg production in the EU' (Compassion in World Farming, 2012).

The EU is a net exporter of poultry meat, with over a quarter of production exported. EU exports increased significantly in the period 2008-2011, due to increasing demand from Asia, Africa and the Middle-East, combined with a relatively weak Euro. Exports are expected to gradually decrease again up to 2020, as the Euro strengthens. Main exports markets include Asia, Africa and the Middle-East, while sources of imports are Brazil and with Thailand being an increasingly important source of imports. The EU is also a net exporter of eggs (188,000 tonnes exported and 35,000 imported in 2009[25]); EU imports are limited by Salmonella legislation and imports are thus only allowed from Switzerland, Norway and Croatia[26].

Poultry production in the EU is highly industrialised, with around 60% of chickens reared intensively in large purpose-built facilities, operated by large companies that control all stages of production – breeding, hatching, feedstuff manufacture, and meat delivery. Some 40% are produced by independent farmers, generally under contract to a processor. The situation for laying hens is similar, with 60% of laying hen population reared in farms with > 40,000 heads (despite such farms making up only 0.1% of all farms).

In terms of contributions to emission reductions and of economic impacts on farms of different sizes, the following table presents a breakdown of ammonia emission reducitons in options 6A, 6B and 6C. Farm sizes are grouped by livestock units (LSU[27]), and in all cases it is assumed that very small farms of less than 15 LSU are exempted from all measures.

NH3 reductions

6A	15-50 LSU	50-500 LSU	>500 LSU
Cattle	18,20%	62,40%	19,40%
Pigs	4,70%	5,30%	90,00%
Poultry	0,10%	1,50%	98,40%
6B	**15-50 LSU**	**50-500 LSU**	**>500 LSU**
Cattle	17,00%	68,70%	14,30%
Pigs	4,30%	18,50%	77,20%
Poultry	0,10%	1,30%	98,60%
6C	**15-50 LSU**	**50-500 LSU**	**>500 LSU**
Cattle	17,50%	71,20%	11,30%
Pigs	5,80%	36,50%	57,70%
Poultry	1,30%	17,80%	80,90%

In Option 6C, small farms between 15 and 50 LSU cost-effectively deliver around 20% of ammonia emission reductions from cattle farming, 9% of the reductions from pig farming, and 2,5% from poultry farms; the cost shares borne by farms of the same sizes are comparable to the emission reduction shares. Although the implementation of specific measures remains under the responsibility of the Member States, this analysis shows that poultry farms below 50 LSU can be exempted without significantly compromising the environmental objectives of Option 6C (about 1 KT more ammonia would be emitted).

25 Compassion in World Farming, 2012
26 EUWEP, 2011.
27 Following Eurostat definition

However, for pigs and especially cattle, the share of emission reductions from farms below 50 LSU is larger, representing ammonia emission reductions of about 15 and 48 KT respectively, with associated emission control costs estimated at around 30 and 45 M€/year. Given that the potential for cost-effective ammonia reduction measures is very substantial in this segment, adequate support measures can be channelled through the EU rural development policy, provided that the Member States themselves give priority to air pollution.

5.5. Power sector

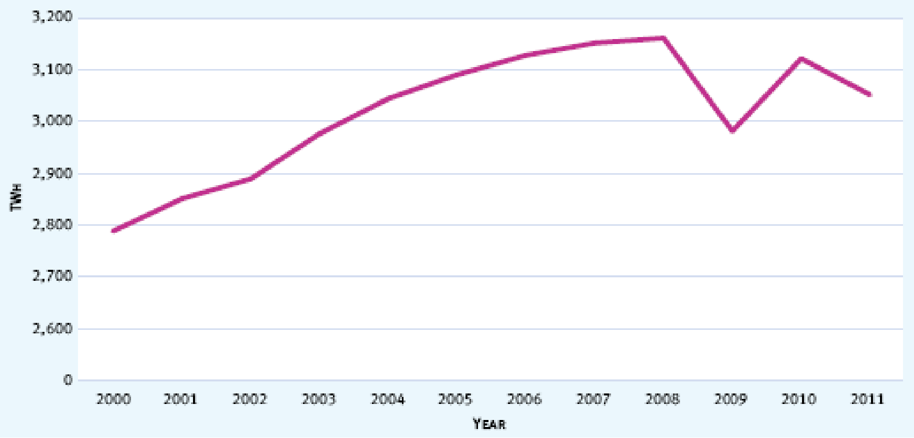
The European electricity mix is becoming more diverse: by 2020 renewable electricity is set to make up 35% of European power production, with fossil fuel fired plants increasingly operating as back-up. This step change implies a need for significant investment in power generation and transport capacity – and a coherent policy framework to support such investment and the necessary innovation.

Thermal generation - coal, gas and nuclear - today represents the backbone of the European power system. Challenges to thermal generation include climate change, supply security and volatile fossil fuel prices. Thermal generators also have specific features that are becoming more important as the share of variable (i.e. not constantly available) renewables grows. Basic data on the EU power sector follows[28]:

- European electricity sector gathers 3.500 companies and 2.000 distribution companies, with 800.000 employees.
- European electricity capacity s 900 GW and the annual generation 3.800 TWh
- After a decade of growth and a partial recovery in 2010 after the economic crisis of 2009, electricity demand fell again in 2011 as the European economy struggled with the prolonged sovereign debt crisis (Figure A9.7)
- The EU's renewables capacity increased yet again in 2011, reaching 34% of total installed capacity. Renewables progressively move to the centre of electricity systems and both capacity and generation are expected to be substantially higher in 2020 than today (Figure A9.8). By 2020 45% of all power plants will be renewable based, generating some 31% of Europe's electricity. Low-carbon electricity from nuclear and renewables will account for 56% of all electricity generated.

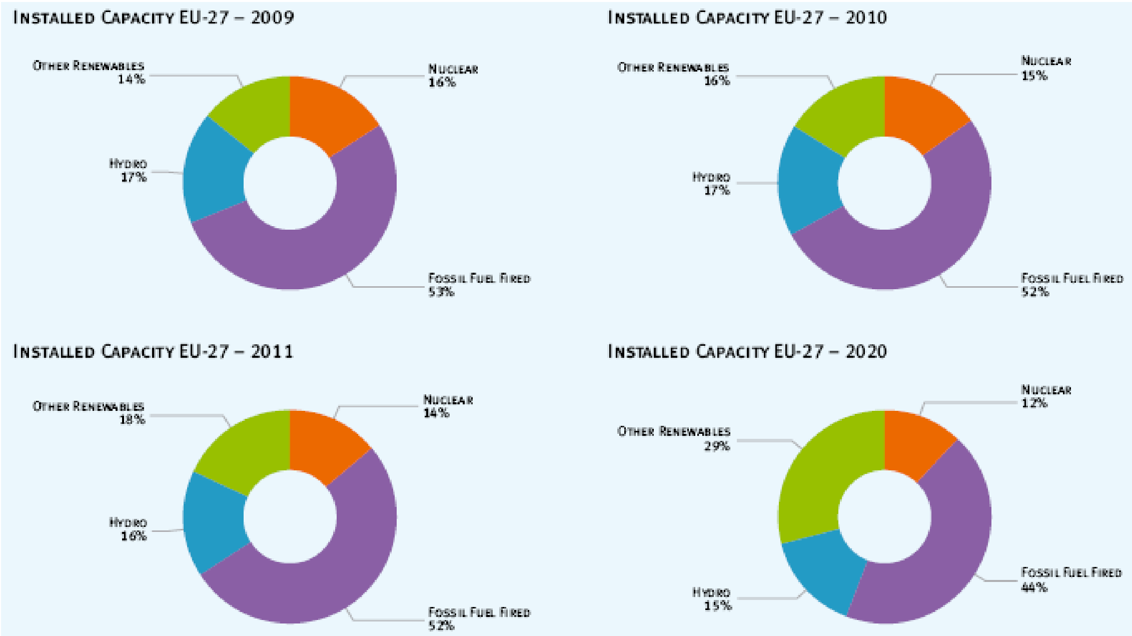
[28] Source: EURELECTRIC, 2012

Figure A9.6: Electricity demand (including network losses) in the EU 27, 2000-2011



Source: EURELECTRIC, 2012

Figure A9.7: Evolution of installed capacity in the EU-27



Source: EURELECTRIC, 2012

Power sector

		Yearly Costs, total and per subsector, M €						
		Total	**Coal**	**Biomass**	**Natural gas (incl. other gases)**	**Oil products**	**Waste fuel, renewable**	**Additional most cost-effective Measures**
Other Energy Sector – combustion	6A	1,05	1,03	0,00	0,00	0,00	0,02	Low sulphur fuel oil (0.6 %S); Low sulphur coal (0.6 %S); Combustion modification on solid fuels fired industrial boilers and furnaces; EP (1 field)
	6B	3,87	3,84	0,00	0,00	0,00	0,03	Low sulphur fuel oil (0.6 %S); wet FGD; In-furnace control - limestone injection; Low sulphur coal (0.6 %S); EP1 (field); Combustion modification on: oil and gas, and solid fuels fired industrial boilers and furnaces boilers and furnaces; Selective catalytic reduction on solid fuels fired industrial boilers and furnaces; High efficiency deduster
	6C	32,04	8,62	0,06	9,96	13,35	0,06	Low sulphur fuel oil (0.6 %S); wet FGD; In-furnace control - limestone injection; Low sulphur coal (0.6 %S); Combustion modification on oil and gas, and solid fuels fired industrial boilers and furnaces; Selective non-catalytic reduction on oil and gas, and on solid fuels fired industrial boilers and furnaces; Selective catalytic reduction on solid fuels fired industrial boilers and furnaces; High efficiency deduster; Good housekeeping: industrial oil boilers
Power & district heat plants with internal combustion engines	6A	0,04	-	-	0,00	0,04	-	Low sulphur fuel oil (0.6 %S); Euro 4, 5 and 6; Stage 5 and 2 control
	6B	0,58	-	-	0,00	0,58	-	Low sulphur fuel oil (0.6 %S); Euro 4, 5 and 6; Stage 5 and 3A control
	6C	1,29	-	-	0,00	1,29	-	Low sulphur fuel oil (0.6 %S); Euro 5 and 6; Stage 5 control

Power & district heat plants, existing; coal/lignite fired, large units (> 50 MW th)	6A	11,84	11,84	-	-	-	-	Low sulphur coal (0.6 %S); Combustion modification on existing brown coal power plants; High efficiency deduster
	6B	34,38	34,38	-	-	-	-	Low sulphur coal (0.6 %S); wet FGD; Combustion modification on existing hard and brown coal power plants; High efficiency deduster
	6C	51,24	51,24	-	-	-	-	Low sulphur coal (0.6 %S); wet FGD; Combustion modification on existing hard and brown coal power plants; Selective catalytic reduction on existing hard coal power plants; High efficiency deduster
Power & district heat plants existing, non-coal; for GAS - boilers	6A	0,81	-	0,81	0,00	0,00	0,00	Combustion modification on existing oil and gas power plants; EP (1 field)
	6B	16,90	-	16,40	0,00	0,50	0,00	Combustion modification on existing hard coal, and oil and power plants; wet FGD; High efficiency deduster
	6C	39,39	-	32,63	4,39	2,29	0,08	Wet FGD; Combustion modification on existing hard coal and oil and gas power plants; High efficiency deduster; Good housekeeping: industrial oil boilers
Power & district heat plants, existing; coal/lignite fired, small units (< 50 MW th)	6A	0,36	0,36	-	-	-	-	Low sulphur coal (0.6 %S); Combustion modification on existing brown coal power plants; High efficiency deduster
	6B	1,27	1,27	-	-	-	-	Low sulphur coal (0.6 %S); wet FGD; Combustion modification on existing brown coal power plants; High efficiency deduster
	6C	4,15	4,15	-	-	-	-	Low sulphur coal (0.6 %S); wet FGD; Combustion modification on existing brown coal power plants; High efficiency deduster
Power & district heat plants new, non-coal; for GAS - turbines	6A	1,77	-	1,77	-	0,00	0,00	EP (1 field)
	6B	17,75	-	17,75	-	0,00	0,00	High efficiency deduster
	6C	57,73	-	41,58	-	1,18	14,97	Selective non-catalytic reduction on other biomass and waste fuels for new powerplants; Selective catalytic reduction on new oil and gas power plants; High efficiency deduster
Power & district heat plants, new; coal/lignite fired, large units (> 50 MW th)	6A	0,13	0,13	-	-	-	-	Wet FGD
	6B	1,65	1,65	-	-	-	-	Wet FGD; High efficiency FGD; High efficiency deduster
	6C	78,17	78,17	-	-	-	-	Wet FGD; High efficiency FGD; Selective catalytic reduction on new hard and brown coal power plants; High efficiency deduster

CODE	NACE_R2/SIZE_EMP	By size of company					
D351	Electric power generation, transmission and distribution	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		45.037	41.883	708	704	697	441
Turnover		951.226	64.466	18.224	49.911	169.011	648.105
Gross Value Added		174.597	11.291	2.589	5.034	16.691	138.593
Turnover per company		21,12	1,54	25,74	70,90	242,48	1469,63

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

As can be seen from the above table the turnover of the largest firms in electric power generation is far higher than for the other sectors / uses identified, this reflects the concentration of the industry in a small number of substantial operators and a larger number of small niche operators (renewables). The former means that additional investment entailed by the policy would not likely affect SMEs.

The annual costs of the set of measures in the power sector identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 16 M €, equal to 0,002% of sectorial turnover and 0,01% of GVA
- In option 6B: 76 M€, equal to 0,01% of sectorial turnover and 0,04% of GVA
- In option 6C: 264 M€, equal to 0,03% of sectorial turnover and 0,15% of GVA

The largest proportion of this expenditure is for emissions abatement in new large units (> 50 MWth) of power and district heat plants coal/lignite fired, and in non-coal new power and district heat plants for gas turbines. Both are generally large size industrial installations and are not expected to be a direct concern of SMEs. In all cases the additional required effort is less than 0,2 % of GVA.

5.6. Other energy intensive industries

These include the pulp and paper sector, the cement sector, the lime sector, and the glass sector. Basic data on the EU energy intensive industries follows[29]:

5.6.1. Pulp and paper sector

- According to the latest structural data available, there were 19,377 firms employing 715,000 people in the sector in 2006.
- In 2006, "pulp manufacturing" represented 5% of added value and 2% of employment, "paper manufacturing" 39% and 29% and "articles of paper and paperboard" 56% and 69% respectively
- Apart from a slight fall in 2005, production in the "pulp, paper and paper products" sector increased steadily by more than 12% between 2002 and 2007. However, in 2008, production was 2.5% lower than in 2007, and turnover in 2008 was almost the same as in 2007, marking a change in the trend from previous years. Employment fell by 15% between 2000 and 2008.
- The EU is a net exporter of paper and paper articles, with a trade surplus of €11.5 billion in 2008. It is a net importer of pulp, with a trade deficit of €3.5 billion in the same year.
- In 2007, the EU accounted for 21.3% of the world pulp production of 194.2 Mt. but remains a net importer, mostly from the Americas. 80% of the pulp imported into the EU comes from Brazil, the US, Canada and Chile. Pulp producers in the southern hemisphere are playing an ever-increasing role, due to lower material and labour costs, and this is leading to a situation in which the pulp and paper companies, including European ones, are investing in these countries

[29] Sources: http://ec.europa.eu/enterprise/sectors/wood-paper-printing/index_en.htm
http://ec.europa.eu/enterprise/sectors/metals-minerals/non-metallic-mineral-products/index_en.htm

- For paper, the EU was the world's largest producer in 2007, providing 26% of the global total of 394 Mt. The main destinations for EU paper exports and paper articles are Russia, the US and Switzerland, which account for 12%, 10% and 9.5% of total EU27 exports respectively. Imports from Asia are developing rapidly, and in 2008 China became the third EU supplier for paper and paper articles, following Switzerland and the US. Imports from China have risen by 76% since 2005

5.6.2. Cement sector

The majority of EU cement producers are operating on a global level, with the USA as a major trading partner. Depending entirely on the demand of the building and civil engineering requirements, the cement industry provides direct employment in local areas and through a wide network of indirect jobs and activities related to the main manufacturing process. Environmental concerns are of paramount importance for the sector, and innovation includes the use of wastes as alternative raw materials and fuels.

- Output in the cement industry has been climbing steadily in recent years, up 23% between 1998 and 2007. Total tonnage produced in EU 27 in 2006 amounted to just over 267.1 million tonnes, with a value of € 19 billion. This represented approximately half of one per cent of total value added and a quarter of one per cent of numbers employed in total manufacturing
- Employment has been decreasing steadily over recent years, and in 2006, it is estimated that there were 56.500 direct jobs (EU 27)
- In 2007, 3% of production was exported outside the EU, whilst non-EU 27 imports supplied 7% of consumption
- The main destination for EU 27 cement and clinker exports is traditionally the USA, because of its unstable domestic demand. Imports, three-quarters of which are clinker, come mainly from far eastern Asian countries, like China, Thailand, and the Philippines
- Where European cement producers have identified demand for cement in non-EU countries, they have generally invested in manufacturing sites in those countries. As such, EU companies now own almost 60% of US production capacity, and have significant production facilities in the rest of the world

5.6.3. Lime sector

The EU lime industry is characterised by the existence of several big EU producers operating on an international stage, giving them access to global best practice and technology, and markets for a wide range of applications. Lime production technology and efficiency have evolved over several thousand years, to the extent that they represent the best possible in terms of environmental performance. Production of lime fell at the end of the 1980s as a result of changes in patterns of consumption, specifically the biggest consumer, the steel industry. Production started to grow again in the mid-1990s with the growing use of environmental applications, such as water, sludge, soil, acid gas, and disinfection treatments. Apart from these two applications, lime is also used in construction and clay soil stabilisation, chemicals, paper, food, feed, and healthcare, etc.

- In EU 27 in 2006, production was estimated at 28 million tonnes, roughly 12% of the 227 million tonnes produced worldwide. This was worth a value of some € 2.5 billions

- Numbers employed are estimated at 11.000

- Lime is a heavy product with a relatively low selling price, so transport costs dictate over what distance it can normally be transported on a regular basis under viable conditions. Only a very small percentage of total production is exported, and this is mainly to neighbouring countries. Where the biggest producer has identified potential markets, it has usually taken the decision to invest in production capacity in those markets

5.6.4. Glass sector

The glass industry is characterised by the existence of several large EU-based companies competing on world markets, economies of scale, the quality of its products, its capacity for technological innovation, and its skilled labour force. The European glass industry is made up of a number of distinct sectors, manufacturing products for a wide range of uses. The sectors are container glass which accounts for about 60% of output, flat glass (30%), and others.

- Total production in EU27 in 2007 is estimated to have reached 37.55 million tonnes, up on the 36.43 million tonnes produced in 2006. This represented about 30% of total world glass production. It was worth in the region of €39 billion (about €38.5 billion in 2006), representing about 32% of the value of total world production

- Numbers employed in 2006 is estimated at just under 237.000

- 70% of all glass products are produced in just 5 member States: Germany, France, Italy, Spain, and the UK

- About 80% of output is traded with other Member States. The figure for extra-EU trade is much lower, and EU exports were double the tonnage of imports into the EU in 2003. By 2007, this had changed to a situation whereby the EU (27) was a net importer, due principally to an increase of imports from outside the EU. There are many countries which the EU glass industry sees as having trading potential where there are tariff barriers.

Non-metallic minerals and pulp and paper sectors

Yearly costs, total and per subsector, M €

		total	**Coal**	**Biomass**	**Natural gas**	**Oil products**	**Additional most cost-effective Measures**
Paper and pulp production, combustion	6A	0,01	0	0	0	0,01	Low sulphur fuel oil (0.6 %S)
	6B	0,14	0	0,01	0	0,13	Low sulphur fuel oil (0.6 %S); combustion modification on solid fuels fired industrial boilers and furnaces
	6C	8,81	2,33	5,73	0,32	0,43	Low sulphur fuel oil (0.6 %S); combustion modification: on solid fuels fired industrial boilers and furnaces and on oil and gas industrial boilers and furnaces; high efficiency deduster; EP (1 field); wet FGD
Paper and pulp production, other combustion	6A	0,3	0,18	0,04	0	0,08	Low sulphur coal (0.6 %S); Low sulphur fuel oil (0.6 %S); wet FGD; EP (1 field); high efficiency deduster
	6B	1,68	0,62	0,49	0	0,57	Low sulphur coal (0.6 %S); low sulphur fuel oil (0.6 %S); wet FGD; In-furnace control - limestone injection; high efficiency deduster; EP (1 field); combustion modification on oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytic reduction on solid fuels fired industrial boilers and furnaces
	6C	6,17	1,36	1,85	0,7	2,26	Low sulphur coal (0.6 %S); Low sulphur fuel oil (0.6 %S); high efficiency deduster; EP; good housekeeping: industrial oil boilers; wet FGD; in-furnace control - limestone injection; combustion modification: on oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytyc and non-catalytic reduction on solid fuels fired industrial boilers and furnaces; selective catalytic reduction on oil and gas industrial boilers and furnaces

Paper and pulp mills	6A	1,09					Process emissions - stage 1 and 2 SO2 control
	6B	7,01					Process emissions - stage 1, 2 and 3 SO2 control
	6C	17,4					Process emissions - stage 1, 2 and 3 SO2 control
Cement combustion	6A	0,24	0,00	0,00	0,00	0,24	
	6B	1,04	0,02	0,00	0,00	1,02	Low sulphur coal (0.6 %S); combustion modification on solid fuels fired industrial boilers and furnaces
	6C	15,88	2,96	0,19	0,30	12,43	Low sulphur diesel oil - stage 2 (0.045 % S); wet FGD; in-furnace control - limestone injection; High efficiency deduster; combustion modification on: oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytic and non-catalytic reduction on solid fuels fired industrial boilers and furnaces
Cement production	6A	0,33					Process emissions - stage 2 SO2 control
	6B	40,84					Process emissions - stage 1 and 2 NOx control; high efficiency deduster; process emissions - stage 1 and 2 SO2 control
	6C	235,16					Process emissions - stage 2 and 3 NOx control; high efficiency deduster; process emissions - stage 1, 2 and 3 SO2 control
Glass combustion	6A	0,10	0,00	0,00	0,00	0,10	
	6B	0,46	0,01	0,00	0,00	0,45	Low sulphur coal (0.6 %S); Combustion modification on solid fuels fired industrial boilers and furnaces
	6C	6,95	1,29	0,09	0,13	5,44	Low sulphur diesel oil - stage 2 (0.045 % S); wet FGD; in-furnace control - limestone injection; high efficiency deduster; combustion modification on: oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytic and non-catalytic reduction on solid fuels fired industrial boilers and furnaces
Glass production	6A	1,25					High efficiency deduster; EP (1 field)
	6B	7,01					High efficiency deduster; process emissions - stage 1, 2 and 3 SO2 control
	6C	25,21					High efficiency deduster; process emissions - stage 1, 2 and 3 SO2 control
Lime combustion	6A	0,09	0,00	0,00	0,00	0,09	
	6B	0,38	0,01	0,00	0,00	0,38	Low sulphur coal (0.6 %S); combustion modification on solid fuels fired industrial boilers and furnaces
	6C	5,81	1,08	0,07	0,11	4,55	Low sulphur diesel oil - stage 2 (0.045 % S); wet FGD; in-furnace control - limestone injection; High efficiency deduster; combustion modification on: oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytic and non-catalytic reduction on solid fuels fired industrial boilers and furnaces
Lime production	6A	2,81					Process emissions - stage 1 and 2 SO2 control
	6B	10,3					Process emissions - stage 2 NOx control; process emissions - stage 1 and 2 SO2 control
	6C	42,49					Process emissions - stage 1, 2 and 3 NOx control; high efficiency deduster; process emissions - stage 1, 2 and 3 SO2 control
Other combustion	6A	0,08	0,00	0,00	0,00	0,08	
	6B	0,37	0,01	0,00	0,00	0,36	Low sulphur coal (0.6 %S); Combustion modification on solid fuels fired industrial boilers and furnaces
	6C	5,60	1,04	0,07	0,11	4,38	Low sulphur diesel oil - stage 2 (0.045 % S); wet FGD; in-furnace control - limestone injection; High efficiency deduster; combustion modification on: oil and gas and on solid fuels fired industrial boilers and furnaces; selective catalytic and non-catalytic reduction on solid fuels fired industrial boilers and furnaces
Other (gypsum, PVC…) production	6A	4,74					High efficiency deduster; EP (1 field)
	6B	10,91					High efficiency deduster; EP (1 field)
	6C	14,4					High efficiency deduster; EP (1 field); stripping and vent gas treatment

FGD: Flue Gas Desulphurisation; EP: Electrostatic Precipitator

CODE	NACE_R2/SIZE_EMP	By size of company					
C171	Manufacture of pulp, paper and paperboard	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		:	1.228	:	200	:	209
Turnover		80.000	:	506,51	1.855,53	13.791,76	60.617,98
Gross Value Added		:	:	124,94	415,94	2.937,7	12.989,51
Turnover per company					9,28		290,04

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the pulp and paper industry identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 1 M €, equal to 0,002% of sectorial turnover and 0,009% of GVA
- In option 6B: 9 M€, equal to 0,01% of sectorial turnover and 0,05% of GVA
- In option 6C: 32 M€, equal to 0,04% of sectorial turnover and 0,2% of GVA

The percentages above are calculated without taking into account turnover and GVA of companies with less than 10 employees.

The pulp manufacturing industry consists for the most part of large and very large firms, often multi-nationals, which are frequently involved with paper operations. They are very capital-intensive industries, as a new state-of-the-art pulp mill costs around €1 billion, or even more if it is part of a paper mill. Paper mills for "commodity grades" of paper, i.e. those intended for further cutting into sheets or rolls or subsequent conversion into products, are most often also large or very large and also quite capital-intensive, especially if there are several paper machines on one site. Plants producing speciality grades may be smaller. Conversely, most converting mills, i.e. those producing usable paper products, are SMEs.

None of the cases required additional effort bigger than 0.2% of the GVA.

The largest share of this expenditure is for the control of SO2 process emissions in paper and pulp mills. Regarding paper and pulp production, the higher costs are in combustion of biomass.

CODE	NACE_R2/SIZE_EMP	By size of company					
C235	Manufacture of cement, lime and plaster	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		:	:	103	102	118	80
Turnover		21.373	448	301	1.030	4.401	15.193
Gross Value Added		7.877	88,5	79	281	1.461	5.967
Turnover per company				2,92	10,10	37,30	189,92

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the cement, lime and plaster industry identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 8 M €, equal to 0,04% of sectorial turnover and 0,1% of GVA
- In option 6B: 63 M€, equal to 0,3% of sectorial turnover and 0,8% of GVA
- In option 6C: 313 M€, equal to 1,5% of sectorial turnover and 4% of GVA

Most of this expenditure belongs to the cement production industry for abatement measures of NOx and SO2 emissions (in case A3 75% of the expenditure is on this sector).

- <u>Cement production and trade</u>

INDICATORS/CODE (M€)	Cement clinker	Portland cement	Other hydraulic cements	TOTAL	% over production value
Exports value	189,2	383,6	71,5	644,3	5
Imports value	146,7	173,3	31,8	351,8	2

Production value	694,9	11.579,3	1.931,8	14.205,9	

Source: Generated from Eurostat database (2010 values used).

The table above shows that cement imports represents only 2% of the total cement production value; this indicates that the European cement sector has sufficient headroom to absorb additional pollution control measures, even if option 6C may require the commitment of substantial additional resources from this sector.

CODE	NACE_R2/SIZE_EMP	By size of company					
C231	Manufacture of glass and glass products	Total	0-9 employees	10-19 employees	20 -49 employees	50 -249 employees	250+ employees
Number of enterprises		:	:	1.289	882	713	230
Turnover		:	:	1.502	2.962	11.115	26.839
Gross Value Added		:	667	:	1.000	3.499	9.339
Turnover per company				1,17	3,36	15,59	116,69

Source: Generated from Eurostat database query on turnover and number of enterprises (2010 values used).

The annual costs of the set of measures in the glass industry identified as being the most cost-effective under the policy scenarios analysed is the following:

- In option 6A: 1,4 M €, equal to 0,003% of sectorial turnover and 0,01% of GVA
- In option 6B: 7,5 M€, equal to 0,02% of sectorial turnover and 0,05% of GVA
- In option 6C: 32 M€, equal to 0,08% of sectorial turnover and 0,2% of GVA

The majority of this expenditure is for the control of SO2 process emissions in glass production. None of the cases required additional effort bigger than 0.2% of the GVA.

6. Conclusions

Potential impacts on competitiveness concentrate in sectors that -being more exposed to international competition- will have more difficulty passing through additional costs to their markets, such as refineries, chemicals, iron & steel and agriculture. .It is likely that at least a sub set of these users will have difficulty in passing costs through to their current markets. Of these sectors, the most significantly affected would be agriculture and petroleum refining; in all these cases, however, the additional resources that would be committed under the policy options considered would be below or in the order of the 1% threshold of Gross Value Added, indicating headroom to absorb the additional costs.

Considering the type of installations and abatement measures involved, impacts on SMEs are considered significant for agricultural measures and for measures in medium-scale combustion plants.

Possible mitigation could focus on actions targeted at the specific sectors most likely to face international competition and measures for reducing impacts on SMEs. Applying exemptions/derogations to those sectors/uses facing the greatest international competition could be considered.

SMEs could be affected in the medium combustion plants (MCP) segment and in agriculture. SME impacts related to MCP are taken in Annex 12. For agriculture, all farms below the 15 animal heads are assumed to be exempted from further ammonia control measures. This threshold could be extended to poultry farms below 50 heads without significantly compromising the environment. For cattle farms below 50 heads, the earmarking by the Member States of appropriate resources under the rural development policy could provide the sector with adequate financing. For pig farms below 50 heads, both options (exemptions or financing through the rural development policy) could be considered by the Member States.

ANNEX 10 CONTROLLING METHANE EMISSIONS

In 2005, agricultural activities (mainly livestock farming) emitted almost half of the methane (CH_4) emissions in the EU-28. Another one third of emissions originated from waste treatment (from solid waste disposal and wastewater treatment), and 14% from fuel extraction and distribution (i.e., coal mining and distribution of natural gas).

1. PROJECTED METHANE EMISSIONS ASSUMING NO CHANGE TO CURRENT POLICIES

Methane emissions in the EU are expected to decline by more than 20% in 2025 compared to 2005 due to existing policies. Over the last years, EU countries have implemented a number of measures to reduce methane emissions in the future, which are summarised in table A10.1:

Table A10.1: recent measures to reduce methane emissions in the EU

Sector	*Member States*	*Technique applied*
Agriculture	Denmark	Community-scale anaerobic digestion for manure applied to 3.2% of dairy cows, 1.6% of other cattle, and 32% of pigs
Coal mining	Several countries	Gas recovery with flaring applied to between 28% and 63% of emissions from mining
Gas distribution networks	EU15	Replacement of 60% of grey cast iron networks and increased leakage control
Gas transmission pipelines	Estonia, Lithuania	Reduced leakage at compressor stations, applied to 20%
Gas and oil production and processing	EU15	Flaring of emissions from oil and gas production and processing
Energy combustion	Several countries	Wood burning in domestic sector -replacement and change of boilers to more energy and emission efficient boilers
Transport	Several countries	Fuel efficiency improvements
Municipal solid waste	Several countries	Treatment through large-scale composting, recycling, incineration, or landfill with gas recovery, complying with the Landfill Directive
Industrial wastewater	EU28	Extended aerobic treatment of industrial wastewater from food-, paper-, and organic chemical manufacturing industries
Domestic wastewater	EU28	Extended collection and treatment of domestic wastewater partly with gas recovery

Source: Lena Höglund-Isaksson, Wilfried Winiwarter and Pallav Purohit (2013) Non-CO_2 greenhouse gas emissions, mitigation potentials and costs in EU-28 from 2005 to 2050, Part I: GAINS model methodology, 30 September 2013, IIASA, Laxenburg.

These measures are projected to deliver a decline of more than 20% of CH_4 emissions by 2020 compared to 1990 and 24% in 2030 compared to 2005 in the baseline (reference projections including meeting renewable targets and the effort sharing decision).

Especially large reductions occur for waste treatment, where the progressing implementation of current EU legislation on solid waste disposal and waste water management, particularly in the new Member States, will lead to a sharp decline of CH_4 emissions in the coming years of more than 50% in 2030

The second largest contributions to emission reductions will come from energy i.e. improved gas distribution networks, for which losses will be cut by about 45% up to 2030 as well as the reduced use and production of coal and gas. In contrast, emissions from the agricultural sector are to decrease by some 2 % compared to 2005 (Table A10.2).

Table A10.2: Baseline emissions of CH4 by SNAP sector (kilotons)

	2005	2025	2030
Power generation	246	149	136
Domestic sector	1185	659	556
Industrial combustion	123	81	69
Industrial processes	663	641	632
Fuel extraction	2043	1170	1033
Solvents	0	0	0
Road transport	129	15	12
Off-road transport	15	15	14
Waste treatment	6657	3759	3598
Agriculture	9447	9511	9453
Sum	20508	16001	15504

2. DIFFERENCES BETWEEN MEMBER STATES

There are large differences in the evolution of methane emission between Member States. Many new Member States will reduce their CH_4 emissions by 30-47%, mainly as a result of the implementation of EU waste management regulations and the on-going upgrades of gas distribution networks. In contrast, emissions in most old Member States would decline less, as much of the waste management legislation has already been implemented in the past. Also, emissions from the agricultural sectors contribute a larger share to total emissions, and this sector is not expected to dramatically reduce its emissions in the future. For instance, only marginal changes are anticipated for, e.g, Belgium, Denmark and Ireland.

Table A10.3: Baseline emissions of CH4 by country (kilotons and change relative to 2005)

	2005	reference 2025	reference 2030	ref % of 2005 2025	ref % of 2005 2030
AUS	290	232	236	20%	20%
BELG	336	295	292	12%	13%
BULG	370	205	198	45%	46%
CROA	146	126	125	14%	14%
CYPR	39	32	38	18%	3%
CZRE	495	366	363	26%	27%
DENM	268	247	249	8%	7%
ESTO	49	48	46	3%	7%
FINL	216	189	190	12%	12%
FRAN	2983	2453	2437	18%	18%
GERM	2647	1821	1722	31%	35%
GREE	483	333	316	31%	35%
HUNG	428	243	226	43%	47%
IREL	610	600	595	2%	2%
ITAL	1965	1432	1394	27%	29%

LATV	87	68	67	22%	23%
LITH	161	126	120	22%	25%
LUXE	22	17	17	20%	21%
MALT	10	8	7	26%	32%
NETH	827	612	595	26%	28%
POLA	1773	1617	1564	9%	12%
PORT	570	458	445	20%	22%
ROMA	1245	1033	1009	17%	19%
SKRE	215	149	147	31%	31%
SLOV	103	83	80	20%	23%
SPAI	1635	1395	1371	15%	16%
SWED	280	226	231	19%	18%
UNKI	2234	1587	1423	29%	36%
EU28	20508	16001	15504	22%	24%

Source: IIASA

3. FURTHER REDUCTION POTENTIAL BEYOND THE BASELINE

Table A10.4 reports methane emissions by Member State in 2005, projected emissions in 2025 and 2030, and further emission reduction potential at zero cost for 2025 and 2030.

Table A10.4: CH4 emission by Member State (kilotons and change relative to 2005) in the baseline and by taking further measures (at zero cost or all available)

	2005	reference 2025	reference 2030	at zero costs 2025	at zero costs 2030	ref % of 2005 2025	ref % of 2005 2030	zerocost 2025	zerocost 2030
AUS	290	232	236	231	231	20%	20%	21%	20%
BELG	336	295	292	250	249	12%	13%	25%	26%
BULG	370	205	198	185	174	45%	46%	50%	53%
CROA	146	126	125	105	100	14%	14%	28%	31%
CYPR	39	32	38	28	32	18%	3%	28%	18%
CZRE	495	366	363	349	343	26%	27%	30%	31%
DENM	268	247	249	206	205	8%	7%	23%	24%
ESTO	49	48	46	40	38	3%	7%	18%	23%
FINL	216	189	190	184	184	12%	12%	15%	15%
FRAN	2983	2453	2437	2254	2234	18%	18%	24%	25%
GERM	2647	1821	1722	1723	1610	31%	35%	35%	39%
GREE	483	333	316	308	292	31%	35%	36%	40%
HUNG	428	243	226	209	195	43%	47%	51%	55%
IREL	610	600	595	565	566	2%	2%	7%	7%
ITAL	1965	1432	1394	1227	1173	27%	29%	38%	40%
LATV	87	68	67	57	54	22%	23%	34%	37%
LITH	161	126	120	103	94	22%	25%	36%	42%
LUXE	22	17	17	16	16	20%	21%	25%	27%
MALT	10	8	7	8	7	26%	32%	26%	32%
NETH	827	612	595	557	555	26%	28%	33%	33%
POLA	1773	1617	1564	1260	1174	9%	12%	29%	34%
PORT	570	458	445	416	404	20%	22%	27%	29%
ROMA	1245	1033	1009	940	918	17%	19%	25%	26%
SKRE	215	149	147	137	127	31%	31%	36%	41%
SLOV	103	83	80	77	74	20%	23%	25%	28%
SPAI	1635	1395	1371	1189	1078	15%	16%	27%	34%
SWED	280	226	231	225	229	19%	18%	20%	18%

UNKI	2234	1587	1423	1476	1315	29%	36%	34%	41%
EU28	20487	16001	15504	14324	13672	22%	24%	30%	33%

The baseline would cut methane emissions 221 in 2025 compared to 2005 and 24% in 2030. with a very broad variability for individual Member States, ranging from a 45% reduction in Bulgaria to a 2% reduction in Ireland. These changes not only result from changes in livestock but also from changes in the energy pattern such as changes in the production of gas and oil. Beyond the baseline reduction, a further 8% reduction could be delivered at zero cost with measures that are either cost neutral or pay for themselves through energy recovery, bringing the 2025 emissions to 30% below the 2005 level, with reductions between 7% and 51% at Member State level. In 2030 emission reductions at EU level could be 33% compared to 2005 based on a conservative assumption of using only currently available technologies.

ANNEX 11 DETAILED ANALYSIS OF SPECIFIC OBJECTIVES RELATED TO THE NECD

This Annex refers to the impacts of the policy options directly related to possible changes to the NEC D other than the costs and benefits related to the impact reduction options which have been described in Chapter 6 of this impact assessment.

1. OBJECTIVES

Chapter 4 outlined objectives where specific action under the NECD is relevant:

- *Facilitate action on residual local compliance problems;*
- *Promote enhanced policy co-ordination at Member State and regional/local level;*
- *Incorporate Gothenburg Protocol obligations into EU legislation and ratify the protocol;*
- *Proportionately tap the pollution reduction potential of contributing sectors;*
- *Address background pollution; and,*
- *Improve the information base for assessing policy implementation and effectiveness.*

  In addition, options for simplification and clarification are explored in the spirit of smarter regulation.

2. POLICY OPTIONS

In order to address the specific objectives outlined above, the following thematic areas (TAs) and issues and options were identified:

TA1 – Establish and implement NEC D national programmes for improved air quality governance

Option 1: Maintain the existing requirements for programmes and simply update the dates for the new reduction commitments for 2020 and 2025/30.

Option 2: **National programmes light –** as for Option 1, but in addition requiring that coherence with other relevant plans and programmes be ensured, in particular the air quality plans required under the AAQD 2008/50/EC and climate and energy policy/programmes.

Option 3: **Comprehensive coherent national air pollution control programmes** – as for Option 2 but in addition requiring that benefits for air quality be maximised, that the programmes be developed and reported in a harmonised way, that the effectiveness of programmes be reviewed regularly, and that corrective action be taken where needed to meet the commitment.

TA2 - Establish and report emission inventories and projections for relevant pollutants

Option 1: Strict minimum to monitor achievements of all proposed reduction commitments related to any (new) pollutant for which a reduction commitment would be established, emission inventories and projections would have to be established and reported.

Option 2: Coherence with the Convention on Long-Range Transboundary Air Pollution (CLRTAP) requirements, including the establishment and reporting to the Commission and the EEA of all emission/projection data under the CLRTAP protocols and decisions of the CLRTAP Executive Body, and in accordance with the EMEP reporting plan (except POPs which are covered by EU POPs regulation[30]).

TA3 – Establish environment monitoring and indicators

Option 1: No change of legislation, i.e. no obligation to monitor air pollution effects.

Option 2: Ecosystem monitoring representative of sensitive ecosystem types in the respective Member State, coordinated with the effects oriented monitoring programmes of the LRTAP Convention.

Option 3: Targeted ecosystem monitoring, focusing on Natura 2000 [31] protected areas for which EU legislation requires Member States to maintain a good conservation status.

Option 4: Comprehensive monitoring of air pollution health and ecosystem effects. Effects on ecosystems would be monitored both for protected areas and other ecosystems, while air pollution health monitoring would be required through collection of national health statistics.

TA4 – Simplify and streamline reporting legislation

Option 1: No change of legislation

Option 2: "Easy" simplification and harmonisation, by streamlining with the requirement under the PRTR Regulation[32] and the Monitoring Mechanism Regulation (MMR)[33], as well as reporting under the IED.

Option 3: Comprehensive streamlining, including the establishment of a fully harmonised EU system for reporting of emissions of "classical" air pollutants and greenhouse gases.

TA5 – ***Establish EU action on short-lived climate pollutants (SLCP)***

Option 1: No change of legislation

Option 2: Coherence with CLRTAP: focus on taking action from sources with significant emissions of black carbon when implementing the PM2.5 ceiling.

[30] EU POPs Regulation (EC) No 850/2004 of the European Parliament and of the Council of 29 April 2004 on persistent organic pollutants and amending Directive 79/117/EEC

[31] **92/43/EEC** Habitats Directive

[32] Regulation (EC) No 166/2006

[33] Regulation (EU) of the European Parliament and of the Council of 21 May 2013 on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

Option 3: Comprehensive SLCF policy action on black carbon, and tropospheric ozone.

3. Impact analysis

Methodology

The analysis follows the guidelines for impact assessments[34]. General considerations on the likely environmental, social and economic impacts, in particular administrative burden, are included. In addition the obstacles for compliance (in implementing the obligation) and opportunities for better regulation, in particular simplification have been analysed to the extent possible.

Environmental impacts

In addition to implementing the cost-effective reduction commitments to achieve the objectives of the TSAP 2013 the options are qualitatively analysed with respect to environmental performance[35]. Those are related to, *inter alia*:

- ensuring the availability of better quality and more complete data and information (data quality/completeness);
- enabling better compliance with domestic and international targets, commitments and requirements (compliance with domestic and/or international commitments);
- enabling future policy actions on air quality and short-lived climate pollutants (future policy development/implementation).

Compliance aspects and opportunities for better regulation

A qualitative analysis is provided of the degree of difficulty Member States would face in complying with a given option[36]. To the extent applicable the policy options are also qualitatively assessed for coherence with the better regulation objective[37], which aims to simplify and streamline legislation.

Economic impacts

Economic impacts of obligations for the MS, SMEs and industry are assessed only for measures that are additional to already existing EU legislation and international law. (Thus the economic impacts of obligations already existing under the CLRTAP and its protocols, for instance, are not assessed.)[5]

The administrative burden on Member States is quantified on the basis of the EU "Standard Cost Model" for those cases where the costs have been deemed to be significant. For most options it has not been possible to distinguish the costs for implementing a substantive obligation such as installing and running new ecosystem monitoring stations from the costs of providing the resulting information to the Commission. In those instances the sum of the two is given and termed "administrative burden".

[34] http://ec.europa.eu/governance/impact/index_en.htm

[35] Ratings: + or – is used to denote positive or negative impacts respectively, = signifies no impact, +/- low impact, ++/--, medium (significant) impact.

[36] Ratings in terms of likeliness: low (LL), medium (ML) and high (HL).

[37] Ratings in the range from negative, no influence and positive (--, 0, ++).

Social impacts
Most options assessed in this annex will have minor social impacts, if any, and so these are not specifically addressed. The main (positive) social impact of the options is better public information on air quality issues.

Impacts on employment, industry and SMEs
The impacts of the pollution reduction options on employment, industry and SMEs are given in Chapter 6 and Annex 9. There are only negligible additional impacts and (substantive and administrative) costs on those sectors as a result of the options analysed in this annex, since the information needs from the sectors (such as activity data and information related to abatement technologies) are already covered by EU legislation, in particular under the PRTR Regulation and the MMR.

Administrative burden calculation

The EU Standard Cost Model was used to assess the costs on public authorities in the Member States. The costs were estimated for the preferred option and when possible also for the other options covered in this annex. Both recurring (annual) and one-off (initial) costs were assessed.

The costing model was developed in two steps. In a first step 4 Member State experts were contacted providing their estimates on labour time necessary to implement the relevant options with identified significant administrative cost. This input was generalised into a costing model for the EU28. The details on the calculations of additional costs are given in the appendix to this annex.

4. SPECIFIC IMPACTS OF THE POLICY OPTIONS

TA1 - Establish and implement NEC D national programmes for air quality governance
The following impacts were assessed for each option:

Environmental impacts

The extent to which the option rectifies the current lack of coordination between different administrative levels in developing and implementing national programmes, improves identification of cost-effective measures at the national and local level, and so improves compliance prospects (or at least reduces total policy costs due to efficient combinations of measures).

Compliance and better regulation

The extent to which Member States would face an additional burden to transpose the legal requirement involved (for instance for Option 1, MS have already transposed the national programmes obligations and so compliance would not be an issue). Also, the extent to which better regulation opportunities are facilitated (in terms of streamlining administration and better coordinating efforts to reach the air quality objectives).

Economic impacts

There are no direct costs for industry and SMESs. The costs are entirely administrative on the public administration and the Commission and EEA. The administrative burden effort required of the MS to implement the option in practice has been quantified for the options (see appendix).

Comparison of options

The table below summarises the performance of the options in relation to the impacts assessed. Overall, Option 3 fully resolves the problems identified in the ex-post evaluations of the NEC Directive and in this IA.

Summary for TA 1 – National programmes

TA1 – National programmes	Environ-mental impacts	Com-pliance	Economic impacts	Better regulation	Admin burden
Option 1 - Only update the dates	=	LL	- -	0	Initial cost € 4.8 million Annual cost € 0.17 million
Option 2 - National programmes light	=	ML	0	++	Initial cost € 4.8 million Annual cost € 0.17 million
Option 3 - Comprehens ive national programmes	++	ML	++ Lower cost than cost-optimum technical measures	++	Initial cost € 5.2 million Annual cost € 0.18 million

It should be noted that the current LIFE+ programme may contribute to covering the costs related to MSs needs to develop national assessment tools for air quality assessment and management as part of their programme development.

TA2 Establish and report emission inventories and projections for relevant pollutants

Option 1: Strict minimum to monitor achievements of all proposed reduction commitments for pollutants. That is, for any new pollutant for which a reduction commitment would be provided, emission inventories and projections would have to be established and reported.

Environmental impacts

This is a necessary minimum to document compliance with the related reduction objectives.

Compliance and better regulation

Member States have already transposed the legal requirement in order to fulfil their obligations under CLRTAP and so compliance should not be an issue. Opportunities for better regulation are likely to be negligible.

Economic impacts

None (already required under international obligations (CLRTAP)).

Administrative burden

No change of administrative burden has been identified for the MS. The Commission and the EEA may have slightly decreased administrative burden due to harmonised reporting of emissions and projections for these substances, which facilitates EU reporting to the CLRTAP.

In summary

Overall this option partly resolves the problems identified in the ex-post evaluations of the NEC Directive and in this IA.

Option 2: Coherence with CLRTAP requirements, including the establishment and reporting to the Commission and the EEA of all emission/projection data under the CLRTAP protocols and decisions of the CLRTAP Executive Body, and in accordance with the EMEP reporting plan (except POPs which are covered by EU POPs regulation).

Environmental impacts

The requirement of producing the emission inventories and projections defined in EMEP reporting plan are covered under the CLRTAP to which the MS are Parties. The environmental impacts of this option are nevertheless likely to be significant since it provides complete information to EU citizens on emissions and projections for all classical air pollutants, including short-lived climate pollutants.

Compliance and better regulation

Member States have already transposed the legal requirement in order to fulfil their obligations under CLRTAP and so compliance should not be an issue. Opportunities for better regulation are likely to be significant particularly in the long term through better EU internal coordination between the MS and EU institutions (Commission and EEA).

Economic impacts

None (already required under international obligations).

Administrative burden

No change of administrative burden has been identified for the MS. The Commission and the EEA will gain in effectiveness due to harmonised MS reporting of emissions and projections for air pollutants, which facilitates EU reporting to the CLRTAP.

In summary

Overall this option fully resolves the problems identified in this IA.

Summary for TA 2 – Emission inventories/projections

TA2 – Emission inventories/ projections	Environmental Impacts	Compliance	Economic impacts	Better regulation
Option 1 Strict minimum	+	LL	0	0
Option 2 Coherence with CLRTAP	++	LL	+	0

TA3 – Establish environment monitoring and indicators

Option 1: No change of legislation, i.e. no obligation to monitor air pollution effects.

Environmental impacts

The emission reduction commitments are designed to reduce environmental impacts, and without data on the state of the environment, ex post assessment of the real impacts of the policy will remain extremely difficult. This will also substantially hamper future policy development.

Compliance and better regulation

Not applicable for compliance. Many opportunities for better regulation may be lost due to poor coordination between MS undertaking voluntary activities under the CLRTAP.

Economic impacts

None.

Administrative burden

Not applicable.

In summary

Overall this option does not address the problems and objectives identified in this IA.

Option 2: Ecosystem monitoring in sensitive ecosystems coordinated with the effects-oriented programmes of the LRTAP Convention.

Environmental impacts

Impact monitoring in protected ecosystems will allow assessment of the effectiveness of air policy and create synergy with the objectives and programmes under the LRTAP Convention. The option will substantially increase the knowledge base approach of the that Convention and help future EU policy development addressing transboundary air pollution and ecosystem effects.

Compliance and better regulation

Compliance obstacles are likely to be low. Most Member States have partly or fully implemented such monitoring programmes as part of their commitment under the LRTAP Convention.

Economic impacts

The economic impacts are on the public administration and assessed as administrative burden.

Administrative burden

The administrative cost includes the complementary setting up and operation of the monitoring compared to already existing monitoring of ecosystems, and the provision of the required information to the Commission and other bodies. The total cost for the monitoring in ecosystems is small although significant and detailed in annex A.

Option 3: Targeted ecosystem monitoring, focusing on Natura 2000[38] protected areas for which EU legislation requires Member States to maintain a good conservation status.

Environmental impacts

Impact monitoring in protected ecosystems will allow assessment of the effectiveness of air policy and of the progress towards the protection of Natura 2000 sites (including ex post evaluation of overall policy effectiveness). The latter will substantially help future policy development in both AQ and nature and habitats protection.

Compliance and better regulation

Compliance obstacles are likely to be low. Opportunities for better regulation occur for better coordination in MS when defining and implementing management plans for the Natura 2000 areas in areas where air pollution is significantly influencing ecosystems by acidification and eutrophication.

Economic impacts

The economic impacts are on the public administration and assessed as administrative burden.

Administrative burden

The administrative cost includes the setting up and operation of the monitoring (similar to a substantive cost) and the provision of the required information to the Commission and other bodies. The total cost for the monitoring in ecosystems is significant and detailed in annex A.

In summary

Overall this option provides the minimum respond to the problems and objectives pursued in this IA.

Option 4: Comprehensive monitoring of air pollution health and ecosystem effects. Effects on ecosystems would be monitored both for protected areas and other ecosystems, while air pollution health monitoring would be required through collection of national health statistics.

Environmental impacts

Full information would be made available on the effectiveness of air pollution policy in reducing ecosystem and health impacts, and on progress towards national and EU objectives. Future policy development/implementation would greatly improve and allow also ex-post evaluation of the air quality impacts on human health and the environment.

Compliance and better regulation

Compliance obstacles are likely to be high since the collection of health data is mainly national policy (subsidiarity) and related to health expenditures.

[38] **92/43/EEC** Habitats Directive

Opportunities for better regulation may be large for MS when defining and implementing management plans for public health and the environment.

Economic impacts

The economic impacts are on the public administration and assessed as administrative burden.

Administrative burden

The administrative cost includes the setting up and operation a comprehensive health and environment monitoring is likely to be significantly higher than Option 2, particularly for public health monitoring. The total cost for the monitoring in ecosystems is significant and higher than the Option 2 and detailed in annex A.

In summary

Overall this option provides a comprehensive response to the problems and objectives pursued in in this IA. However, this option is likely to pose significant challenges to implement and with high costs.

Summary for TA 3 – Environment monitoring

TA3 – environment monitoring	Environ-mental impacts	Com-pliance	Economic impacts	Better regulation	Admin burden
Option 1 - No change	- -	n.a.	0	- -	n.a.
Option 2 – Ecosystem monitoring coordinated with LRTAP Convention	++	LL	(-)	+	Initial cost € 1,5 million. Annual cost € 2.4 million
Option 3 – Targeted Natura 2000 ecosystem monitoring	++	LL	(-)	++	Initial cost € 4.5 million Annual cost € 7.5 million
Option 4 - Comprehensive monitoring	++	HL	(- -)	++	Initial cost € 4.5 million Annual cost € 7.5 million Health monitoring excluded

TA4 – Simplify and streamline reporting legislation

Option 1: **No change** of legislation

In summary

No distinctive environmental, compliance, economic or administrative implications, but overall this option does not pursue the objective for better regulation.

Option 2: "Easy" simplification and harmonisation, by streamlining with the requirement under the PRTR and MMD, as well as reporting under the IED. Ensuring coherence in MSs reporting under different pieces of EU legislation.

Environmental impacts

Streamlining of reporting instruments has positive and significant environmental impacts particularly in providing internally coherent data for national authorities, EU citizens and the EU as a whole.

Future policy development/implementation would greatly improve and also allow effective ex-post evaluation of air related policy (classical air pollutants and greenhouse gases).

Compliance and better regulation

Compliance obstacles are likely to be low. Opportunities for better regulation occur related to better coordination in MS. However at the EU institution level (Commission and EEA) the opportunities for better regulation will be limited.

Economic impacts

No economic impacts have been identified.

Administrative burden

The administrative cost for the public administration is likely to be insignificant. The administrative cost for the EU institutions will remain at the same level as today.

In summary

Overall this option provides the minimum response to the problems and objectives pursued in this IA.

Option 3: Comprehensive streamlining, including the establishment of a fully harmonised EU system for reporting of emissions of "classical" air pollutants and greenhouse gases.

Environmental impacts

A full harmonisation of reporting at the level of MS and EU will have great positive environmental benefits for national health and environmental authorities, EU citizens and the EU as a whole.

Future policy development/implementation would greatly improve and also allow comprehensive ex-post evaluation of the air quality policy.

Compliance and better regulation

Compliance obstacles are likely to be medium since the full harmonisation will require significant effort in MS and in the EU. Opportunities for better regulation may be large for MS and the EU.

Economic impacts

No economic impacts have been identified.

Administrative burden

The administrative cost for the public administration is likely to be small in the long term but significant in its initial phase for some MS. The administrative cost for the EU institutions (like the EEA) may be reduced.

In summary

Overall this option provides a comprehensive response to the problems and objectives pursued in in this IA. However, this option is likely to pose some challenges to implement at this stage due to costs and efforts required.

Summary for TA 4 – Simplify and streamline

TA4 – Simplify and streamline reporting	Environmental Impacts	Compliance	Economic impacts	Better regulation
Option 1 No change	=	0	n.a.	n.a.
Option 2 "Easy" streamlining	+	LL	0	+
Option 3 Comprehensive	++	ML	=	++

TA5 – Establish EU action on short-lived climate pollutants (SLCPs)

Option 1: No change of legislation

Overall this option does not address the problems objectives identified in the IA, namely to advance policy on short lived climate forcers.

Option 2: Coherence with CLRTAP and specifically the 2012 amendment of the CLRTAP Gothenburg Protocol.

Environmental impacts

The environmental impacts are likely to be significant and positive since MS will also have to take appropriate measures to reduce black carbon emissions, being harmful for human health and climate in the short term.

Future policy development/implementation will gain significantly from increased experience in applying measures not covered by EU legislation so far.

Compliance and better regulation

Compliance obstacles are unlikely (requirement under international obligations). Opportunities for better regulation are likely to exist but small for MS and the EU.

Economic impacts

Economic impacts are likely to be small if any.

Administrative burden

The administrative cost exists but is small since increased monitoring of black carbon emissions will be required. A detailed assessment is given in annex A.

In summary

Overall this option offers opportunities for MS at low or no cost, largely maintaining the subsidiarity in the precise choice of measure.

Option 3: Comprehensive SLCF policy action on black carbon, and tropospheric ozone.

Environmental impacts

The environmental impacts are likely to be significant and positive since MS will also have to take appropriate measures to reduce black carbon and methane emissions (an ozone precursor), being harmful for human health and climate in the short term.

Future policy development/implementation will gain significantly from increased experience in applying measures not covered by EU legislation so far and will allow the EU to promote international action on short-lived climate forcers.

Compliance and better regulation

Compliance obstacles are likely to be moderate since comprehensive action will demand resources and efforts in MS and EU institutions. Opportunities for better regulation are likely to be significant but for MS and the EU in better coordination of policy on air pollution and climate change.

Economic impacts

Economic impacts are likely to be significant but small (and not assessed here).

Administrative burden

The administrative cost is small since increased monitoring of black carbon emissions will be required. A detailed assessment is given in annex A.

In summary

Overall this option offers opportunities for MS at low cost, largely maintaining the subsidiarity in the precise choice of measure.

Summary for TA 5 – Action on SLCF

TA5 – EU action on SLCF	Environ-mental impacts	Com-pliance	Economic impacts	Better regulation	Admin burden
Option 1 - No change	=	n.a.	0	0	n.a.
Option 2 – Action on black carbon	+	LL	0	0	Initial cost €0.20 million
Option 3 - Compreh ensive action	++	ML	(not assessed)	+	Initial cost €0.20 million

5. OPTION COMPARISON

The comparison of options for each of the identified topic areas is based on qualitative criteria related to the effectiveness, the efficiency and coherence in achieving the specific objectives defined in section 4.3. The ratings applied are no effect (0), low (L), medium (M) and high (H).

Table on comparison of options

		Effectiveness	Efficiency	Coherence
TA1 – National programmes	Option 1	L	L	0
	Option 2	M	M	M
	Option 3	H	H	M
TA2 – Emission inventories/ projections	Option 1	L	L	L
	Option2	H	M	H
TA3 – environment monitoring	Option 1	0	0	0
	Option 2	M	H	M
	Option 3	M	M	H
	Option 4	H	M	H
TA4 – Simplify and streamline reporting	Option 1	0	0	0
	Option 2	M	M	M
	Option 3	H	M	H
TA5 – EU action on SLCF	Option 1	0	0	0
	Option 2	M	M	M
	Option 3	H	M	H

6. PREFERRED OPTION FOR REVISING THE NEC D

The preferred option combines the aspects of effectiveness, efficiency and coherence with those of issues on overall cost, compliance, subsidiarity and balance between costs and benefits.

Table on preferred options

	Preferred option	**Estimated cost (administrative burden)**
TA1 – National programmes	Option 3: Comprehensive coherent national air pollution control programmes –requiring that benefits for air quality be maximised …	Initial cost:€ 5.2 million Annual cost: € 0.18
TA2 – Emission inventories/ projections	Option 2: Coherence with CLRTAP requirements …	Insignificant
TA3 – environment monitoring	Option 2: Ecosystem monitoring coordinated with LRTAP Convention	Initial cost: € 1.5 million Annual cost: € 2.4 million
TA4 – Simplify and streamline reporting	Option 2: "Easy" simplification and harmonisation, Ensuring coherence in MSs reporting	Insignificant
TA5 – EU action on SLCF	Option 2: Coherence with CLRTAP and specifically the 2012 amendment of the CLRTAP Gothenburg Protocol.	Initial cost: € 0.20 million

7. MONITORING AND EVALUATION

The preferred options relate to changes in MS obligations with regard to the establishment and reporting of

- national air pollution control programmes;
- coherent emission inventories and projection for air pollutants;
- and ecosystem effects monitoring in protected areas;

The Commission supported by the EEA, will continue to annually collate the received data and information. This information will be discussed with the MS to systematically review and improve the effectiveness of the policy.

In addition, the CLRTAP regularly undertakes in-depth reviews of emission inventories and projections provided by the EU and its MS on which the EU will build any further efforts of improvements of the relevant legislation and practices.

APPENDIX 11.1 STANDARD COST MODEL FOR ASSESSMENT OF ADMINISTRATIVE BURDEN

The overall costs incurred on Member States public administrations, SMEs, industry and others related to the choices of options may be defined as substantive costs and administrative costs. The substantive costs for the options related to the choice of pollution reduction options are given in Chapter 6. This appendix summarises the additional costs for the options detailed in Appendix 11.2. Most of the options have no significant costs. Some of the analysed options are in reality a mix of substantive costs and administrative costs, such as the implementation of ecosystem monitoring.

No additional administrative burden has been identified for SMEs and industry. The entire additional cost for the preferred combined option will be on public administration.

The MS labour costs are based on 2010 statistics from EUROSTAT as the average cost for the (ISCO) categories 2 and 3[39].

Options related to national programmes – TA1

The estimated amount of administrative burden to prepare and implement national programmes varies between MSs depending on the MS size, the level of internal work of the administration as compared to outsourced work and the level of emission reductions aimed in the programmes. Based on interviews with experts from Member States (IE, BE, NL and DE) a simplified costing model was develop that sets the number of workdays to develop and adopt the national programme depending on country size (small MS below 10 million inhabitants, medium MS 10 to 30 million inhabitants, and large MS with more than 30 million inhabitants) as well as the national labour cost rates. The estimates for work days are upper estimates for MSs and may in several cases be significant below the tabled levels.

Table A11.1: Number of days for the preparation of initial national air pollution control programme

MS size/ outsource	High degree of outsourcing	No outsourcing
Small MS	1000	800
Medium MS	1200	1100
Large MS	1400	1300

Table A11.2: Number of days per year for the maintenance of national air pollution control programme

MS size/outsource	High degree of outsourcing	No outsourcing
Small MS	200	100

[39] EUROSTAT.

Medium MS	250	200
Large MS	300	250

To the extent known, the degree of outsourcing of work in the specific MS was accounted for- if not directly available such information (on high degree of outsourcing) was taken from the IA for the Monitoring Mechanism Regulation[40]. The administrative costs for complying with the requirement to consult with the public or neighbouring MSs were assessed to be insignificant in comparison to the efforts required to map measures and assess their effectiveness and costs. The preferred option for TA 1 Option 3 assumes a revision of the plans on average every 5 years. The estimated costs refer to the initial costs and average annual costs thereafter. Based in the interviews with MS the administrative costs for Option 1 and 2 were estimated to be only some 10 per cent less than for Option 3.

Options related to ecosystem monitoring - TA3

Member States cost for the monitoring of ecosystem effects are based on information from voluntary activities under the CLRTAP (see also consultant report "NEC CBA Report 3"[41]). As some of the monitoring under the CLRTAP (in particular dry deposition of nitrogen to ecosystems) can be very costly this impact assessment focuses on a core set of parameters for assessing air pollution ecosystem damage. The preferred option is to focus on obtaining information of air pollution effects on sensitive ecosystems in the respective Member State coordinated with effects-oriented ecosystems monitoring under the LRTAP Convention. Forests, grasslands and fresh water ecosystems are vulnerable and sensitive to air pollution. The number of ecosystems types defined under the Natura 2000 framework (categories 3, 6 and 9) has been used as a proxy of the number representative ecosystems types by Member State.

Each Member State would have to complement current effects-based ecosystem monitoring compared to current programmes under the LRTAP Convention and maintain at least one site per defined habitat type in these categories (table A11.3). Again the national labour costs were used to assess the costs for setting up, maintaining, analysing samples and reporting data.

Table A11.3: Number of habitat categories defined by Member States in categories 3 "Fresh water habitats" 6. " Natural and semi natural grassland formations" and 9 "Forests" that serve as a proxy for sensitive ecosystems

Member State	No of habits in category 3, 6 and 9	Member State	No of habits in category 3, 6 and 9	Member State	No of habits in category 3, 6 and 9
Austria	44	Germany	42	Poland	39
Belgium	26	Greece	44	Portugal	42
Bulgaria	49	Hungary	30	Romania	51

40 SEC (2011) 1407 final
41 AEA, 2008

Croatia	42	Ireland	18	Slovakia	42
Cyprus	19	Italy	65	Slovenia	32
Czech Republic	38	Latvia	26	Spain	53
Denmark	21	Lithuania	27	Sweden	39
Estonia	25	Luxembourg	19	U. K.	28
Finland	32	Malta	9		
France	59	Netherlands	22		

As all Member States are parties to the LRTAP Convention they also participate in the effects-oriented monitoring programmes. It is therefore assumed that half of the sensitive ecosystem types are covered by on-going activities and that only complementing the current network with new sites entails administrative costs. The required working days per new site were taken from NEC CBA Report 3 and defined for the setting up of the site, annual sampling and reporting. The costs for chemical and physical analysis of samples were taken from the same report and adjusted for by the national labour costs (using the U.K. estimates to normalise) as outlined above.

Table A11.4: Cost for individual samples for the assessment of ecosystem damage[42] as assessed for the U.K, see Appendix 11.3

Parameter	Frequency per year	Cost per sample/ parameter	Average annual cost
ANC	1	360	360
BS	0,25	360	90
Al, Al(KCl)	0,25	300	75
NO3 leach	1	216	216
C/N	0,25	576	144
N/P, N/K	0,25	1200	300
Arginine in foliage	0,5	300	150
Growth	1	1200	1200
			2535

Options related to action on short lived climate forcers –TA5

Member States comprehensively report emissions and projections under CLRTAP for all main classical air pollutants. The 2012 amendment to the Gothenburg Protocol includes an obligation to establish and report emissions and projections of black carbon but that amendment is not yet in force. EMEP is currently revising the guidelines and the guidebook for emission inventories and projections and planned to be part of CLRTAP reporting obligations from 2014 onwards. This impact assessment considers the obligation related to black carbon as additional. It should

[42] Taken from NEC CBA Report 3, (AEA, 2008)

be noted that the substantive cost related to the TA5 Option 2 refers to give priority to emission reduction measures which also significantly reduce black carbon is covered in the achievement of the overall reduction objectives for PM2.5 and thus part of the cost estimates in section xx.

Other significant administrative costs for MSs' administrations related to TA5 Option 2 occur only the first year for the updating and validation of the national inventory/projection system. The following years the additional costs to maintain and report are insignificant. It is assumed that the update and validation the first year corresponds to 40 days of work.

APPENDIX 11.2 ADMINISTRATIVE COSTS BY MEMBER STATE OF PREFERRED OPTIONS (€)

	National program		Ecosystem monitoring		BC inventories
Member State	initial cost, €	annual cost, €	initial cost, €	annual cost, €	initial cost, €
Austria	222085	5552	109932	166683	11104
Belgium	394518	16438	76931	116646	13151
Bulgaria	22320	558	12304	18656	1116
Croatia	55040	1376	26006	39432	2752
Cyprus	165799	4145	35439	53735	8290
Czech Republic	93942	3416	29208	44286	3416
Denmark	267896	6697	63290	95964	13395
Estonia	50927	1273	14323	21717	2546
Finland	204219	5105	73519	111472	10211
France	380044	16288	144145	218559	10858
Germany	379406	14593	110320	167271	11674
Greece	191100	6949	68796	104311	6949
Hungary	47155	1179	15915	24131	2358
Ireland	287148	11486	46518	70532	11486
Italy	338020	13001	152109	230633	10401
Latvia	35857	896	10488	15903	1793
Lithuania	35232	881	10702	16226	1762
Luxembourg	300853	7521	64307	97505	15043
Malta	92708	2318	9387	14232	4635
Netherlands	256846	10274	50856	77109	10274
Poland	112595	4331	30401	46095	3464
Portugal	163571	5948	56209	85226	5948
Romania	47873	1741	19976	30289	1741
Slovakia	57533	1438	27184	41218	2877
Slovenia	105522	2638	37988	57599	5276
Spain	273002	11700	93016	141034	7800
Sweden	276734	11069	97134	147278	11069
UK	362428	15533	65237	98915	10355

APPENDIX 11.3 MONITORING OF EFFECTS OF POLLUTANTS IN THE ENVIRONMENT

A. Geographical coverage of ecosystem monitoring sites

Member States should ensure that their network of monitoring sites covers at least a representative selection of all 'natural habitat types of Community interest' as listed under points "3. Freshwater habitats", 6. ”Natural and semi-natural grassland formations” and "9. Forests" of Annex I to Directive 92/43/EEC.

B. Key indicators, monitoring requirements and methodologies to use at monitoring sites in freshwater ecosystems.

Mandatory Indicators (unit)	Related effect	Minimum frequency	Existing monitoring networks
acid neutralizing capacity: ANC (μeq/L)	Biological damage, including sensitive receptors (micro- and macrophytes and diatoms); loss of fish stock or invertebrates.	Sampling from yearly (in autumn turnover) to monthly (streams),	ICP Waters, national networks, data provided for ICP Modelling and Mapping to calculate critical loads.

C. Key indicators, monitoring requirements and methodologies to use at monitoring sites in terrestrial ecosystems.

Mandatory indicators (unit)	Related effect	Minimum frequency	Existing monitoring networks
soil base saturation: BS (per cent)	Loss of soil nutrients (nutrient imbalances, growth reduction, susceptibility to other stress factors)	Every 4 years,	ICP Forests, ICP Integrated Monitoring, national networks, data provided for ICP Modelling and Mapping to calculate critical loads.
Soil acidity Exchangeable Al, Al_{KCl} (mg/g)	Soil CEC, soil acidity, nutrient availability	Every 4 year	ICP Integrated Monitoring
soil nitrate leaching $NO_{3,leach}$ (μeq/L/year)	Nitrogen saturation, nutrient imbalances, changes in vegetation structure, loss of biodiversity	Every year	ICP Forests, ICP Integrated Monitoring, national networks, data provided for ICP Modelling and Mapping

carbon-nitrogen ratio C/N (g/g)	Nitrogen saturation, nutrient imbalances, changes in vegetation structure, loss of biodiversity, links to climate change.	Every 4 years	to calculate critical loads.
Nutrient balance in foliage: (N/P, N/K, N/Mg) (g/g)	Nitrogen saturation, nutrient imbalances, changes in vegetation structure, loss of biodiversity	Every 4 years,	ICP Forests, ICP Integrated Monitoring, national networks, data provided for ICP Modelling and Mapping to calculate critical loads.
Arginin in foliage: (µmol/g)	Soil nitrogen status	Every 2 years	ICP Integrated Monitoring
Caused by ozone: Growth/yield reduction and leaf/foliar damage (per cent) Exceedance of flux-based critical levels (mmol m^{-2} projected leaf area)	Reduced biomass, reduced yield quantity and quality, reduced photosynthesis capacity, links to global change.	Every year, Hourly input parameters during growing season (ozone concentration, climate, soil water)	ICP Vegetation, ICP Forests, national networks.

[1]ICP manuals (except ICP Modelling and Mapping) provide information on site selection criteria, and additional indicators to make a proper assessment of ecosystem status

ANNEX 12 DETAILED ANALYSIS FOR MEDIUM COMBUSTION PLANTS (MCP)

1. RATIONALE FOR ACTION

The policy options described in Chapter 6 of this Impact Assessment entail the adoption of pollution control measures at the level of each Member State selected on the basis of highest cost-effectiveness. The resulting combination of measures includes further emission controls in the MCP sector. Annex 8 provides details on the estimated emission reductions and associated emission control costs for the MCP sector under the central case policy option 6C* described in Chapter 6.6.2 of the Impact Assessment. These emission reductions are estimated at 79 kiloton sulphur dioxide (SO_2), 108 kiloton nitrogen oxides (NOx), and 13 kiloton PM2,5 (PM), for total additional emission control costs of 220 M€/year.

This Annex sets out the deeper impact analysis of options to deliver emission reductions from MCP through an EU-wide legislative instrument. Introductory sections below also provide more details on the characteristics of the sector, already existing measures at Member State and international level and the data sets used.

2. CHARACTERISTICS OF THE SECTOR

2.1. Definition of MCP for the purpose of this assessment

The combustion of fuels (gas, liquid, and solid fuels, including biomass) is one of the main sources of emissions of NOx and, in case of solid and liquid fuels, particulate matter PM and SO2. Combustion plants are operated with a wide range of capacities, depending on their application. The “large” combustion plants (i.e. those having a rated thermal input of 50 MW or more) are mainly used for electricity generation, district heating and industrial applications. These plants are covered by several pieces of EU environmental law and their pollutant emissions are controlled via permit conditions based on the application of BAT and cannot exceed the EU-wide limits set for dust, NOx and SO2 in the Industrial Emissions Directive 2010/75/EU (IED) and its predecessors, Directive 2008/1/EC on Integrated Pollution Prevention and Control (IPPC) and Directive 2001/80/EC on Large Combustion Plants (LCP).

At the other end of the capacity spectrum are the “small” combustion plants, with a capacity of less than 1 MW, which are predominantly used for domestic or residential heating. Some of these plants are covered by the Ecodesign Directive 2009/125/EC. The implementing rules adopted in this context, while initially focusing primarily on energy efficiency, will also include product standards limiting emissions of air pollutants (NOx, PM, carbon monoxide (CO), etc depending on the type of plant and fuel used) in view of the outstanding air quality challenges described in Chapter 3 and Annex 4. This work is currently ongoing.

The combustion plants considered in this Annex (as in Chapter 7) are those falling between the two categories described above. These "medium" combustion plants with a rated thermal input between 1 and 50 MW are used for a wide variety of applications, including electricity generation, domestic/residential heating and cooling, providing heat/steam for industrial processes, etc. Therefore, MCP should be considered not as a single sector but as a cross-sectoral activity relevant for the industrial, tertiary/commercial and residential/domestic sectors alike. Furthermore, a number of different technologies are concerned including boilers, heaters, engines and turbines. The focus of this assessment is on hot water and steam boilers, industrial process heaters, combined heat and power (CHP) plants, gas, dual fuel and diesel engines and gas turbines, in order to provide a basis for defining consistent regulatory approaches. However, it does not cover industrial dryers, process kilns and furnaces in which there is direct contact between the combustion waste gases and the materials processed or produced (such as cement clinker, lime, ceramics or asphalt kilns, wood dryers, glass furnaces, non-ferrous metals furnaces, coke ovens, etc.), chemical reactors, and waste incineration or co-incineration plants. That is because these relate to different technologies some of which are being considered for regulation separately (e.g. furnaces).

It is furthermore noted that emissions of air pollutants from MCP are not yet regulated at an EU level except where these plants are part of an installation covered by the IED either as a "directly associated activity" to an IED activity operated within the installation (e.g. combustion plants providing heat or steam to an industrial process listed in Annex I of IED) or where the plant is part of a wider combustion activity on site with a total rated thermal input of 50 MW or more (in line with the aggregation rule set out in the chapeau to Annex I of the IED).

2.2. Development of an EU-wide dataset

As part of recent studies, data on combustion plants smaller than 50 MW was gathered directly from the Member States. This included data on numbers, capacities, fuel consumption and emissions from the plants, as well as information on relevant national legislation (where applicable), combustion techniques used, abatement measures typically applied, and the degree to which the combustion plants may already be regulated under the IED.

From these Member State data and through extrapolation based on a number of assumptions, an EU wide dataset concerning MCP was developed with which possible control options were assessed. Based also on the above mentioned characteristics of the sector, the dataset was separated into three capacity classes of 1-5 MW, 5-20 MW and 20-50 MW rated thermal input, each covering a comparable share of the fuel used and emissions from the MCP segment. However, the number of plants within each of the three classes is very different (see Table A12.1). While there are more than 100,000 combustion plants between 1 and 5 MW, the group between 5 and 20 MW counts 23,000 plants, while there are only about 5,000 plants between 20 and 50 MW). Also, the combustion technologies, dominant fuel types and application of certain technical measures to abate emissions may differ between these categories. By considering the three classes separately, the impacts of the various options could be considered in more detail, in particular where they might depend on the number of plants affected or on the technical applicability of certain measures.

Data was also collected on the combustion technology used. However, very limited information could be found on this, and there was significant variation for the Member States that have provided an indication of the split. Due to this limitation the technology types have been categorised into two groups: "boilers" and "turbines and engines". For Member States where no indication of the distribution between these two categories has been identified, the split has been assumed to be 80% boilers and 20%

turbines and engines for each of the three size categories, which is based on the average of the available data.

2.3. Reference situation in 2010

The reference dataset mentioned above has been compiled from sources dating from 2008 to 2012, and has therefore been taken to offer a good basis for establishing a detailed reference case for 2010 to underpin the present assessment.

Table A12.1 provides an overview of the reference situation (2010) of MCP operated in the EU-27 (number of plants, capacity, fuels used, emissions of SO2, NOx, and PM[43]).

It shows that the dominant fuel used in MCP is natural gas with 67% of the total fuel use (64% for 1-5 MW, 73% for 5-20 MW and 60% for 20-50 MW). Solid (biomass, coal) and liquid fuels each have a share of about 12%. In some countries the main fuel used differs significantly from the overall EU average (AMEC 2013b). It also shows that, whilst the three capacity classes are comparable in terms of total rated thermal input (40% for plants 1-5 MW, 34% for plants 5-20 MW and 26% for plants 20-50 MW), the 1-5 MW group outnumbers the other ones in terms of plant numbers (80%).

Table A12.1: Medium size combustion plants in EU-27 – reference situation 2010

Rated thermal input:	**1-5 MW**	**5-20 MW**	**20-50 MW**	***Total 1-50 MW***
Number of plants	113809	23868	5309	*142986*
Total rated thermal input (GW)	274	232	177	*683*
Annual fuel consumption (PJ/year):	1971	2325	1410	*5705*
Biomass	163	160	182	*505*
Other solid fuel	49	46	74	*169*
Liquid fuel	213	290	206	*709*
Natural gas	1268	1704	844	*3816*
Other gaseous fuel	277	125	104	*506*
SO_2 emissions (kt/year)	103	130	68	*301*
NO_x emissions (kt/year)	210	227	117	*554*
PM emissions (kt/year)	17	20	16	*53*

The three classes are also quite comparable in terms of emissions for the three pollutants considered. The 5-20 MW segment has the highest emissions (38-43% depending on the pollutant), closely followed by the 1-5 MW (32-38%) and the 20-50 MW (21-30%) segments. This reflects the fuel use split across capacity classes and the fact that the larger plants are more often and/or more strictly regulated at Member State level.

This is illustrated further in Figures A12.1 and A12.2.

43 Throughout this Annex, emission data concerning particulate matter is expressed as PM (particulate matter of any size). The relationship between PM and PM2.5 is complex and depends on the fuel used, the combustion technology and the abatement measures applied. For the existing stock of MCP a rough estimate is that the ratio between PM2.5 and PM is within the 30%-80% range. For the analysis presented in Chapter 7 of the Impact Assessment a factor of 50% is considered.

Figure A12.1: Number of MCP and capacity (2010)

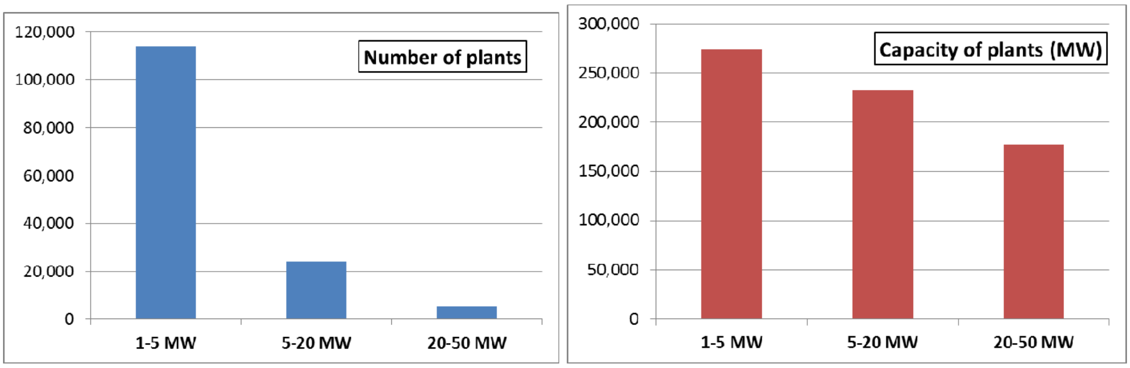


Figure A12.2 – Emissions (ktonnes/year) from MCP per capacity class for EU-27 (2010)

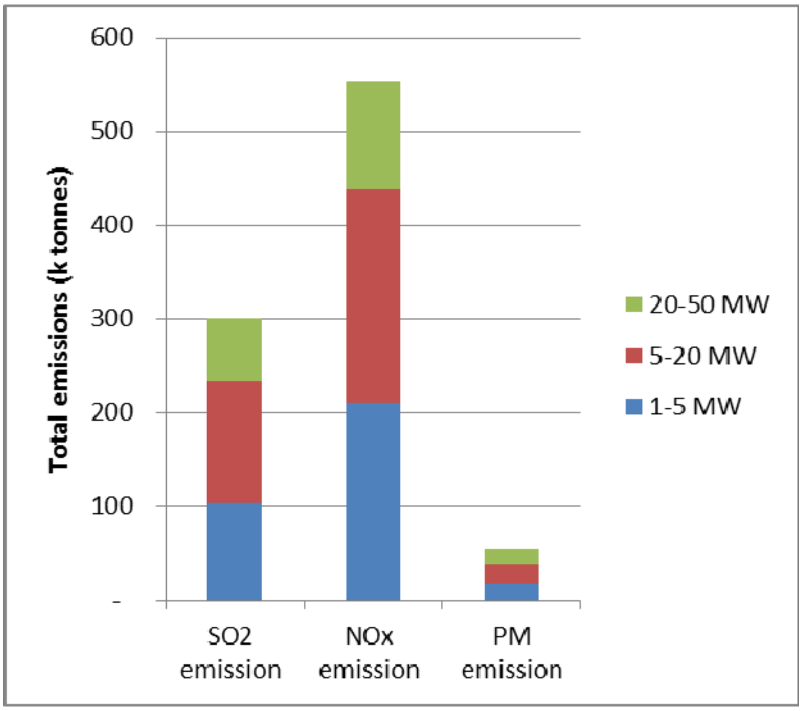


Table A12.2 provides a more detailed overview per Member State of the number of MCP and their total rated thermal input, split over the three size classes and Table A12.3 provides a similar overview of the 2010 emissions of SO_2, NOx and PM.

Table A12.2: Number of plants and capacity per Member State (2010)

	Number of plants			Total capacity (MWth)		
Size category	**1-5 MW**	**5-20 MW**	**20-50 MW**	**1-5 MW**	**5-20 MW**	**20-50 MW**
AT	2.516	441	110	5.979	5.193	3.471
BE	2.926	904	147	6.668	8.687	4.739
BG	1.670	434	73	3.968	4.136	2.305
CY	172	36	3	370	260	114
CZ	4.068	748	175	8.492	7.166	5.247
DE	35.500	3.480	767	84.354	33.170	26.227
DK	6.020	1.564	263	14.303	14.910	8.674
EE	537	174	29	1.203	1.794	1.025
EL	254	66	11	604	629	366
ES	5.811	1.510	254	13.807	14.392	8.373
FI	136	140	133	550	2.100	6.430
FR	13.399	2.951	1.600	31.839	28.124	52.744
HU	1.967	511	86	4.675	4.873	3.822
IE	1.397	363	61	3.319	3.460	2.013
IT	6.268	1.629	274	14.894	15.526	9.300
LT	889	231	39	2.112	2.202	1.281
LU	137	36	6	326	340	198
LV	641	144	28	1.926	1.898	1.157
MT	72	9	-	157	62	-
NL	6.995	2.250	110	21.000	23.000	3.700
PL	5.628	1.462	246	13.372	13.939	8.238
PT	778	202	34	1.848	1.927	1.176
RO	790	370	102	1.595	2.722	3.090
SE	916	784	198	2.749	9.405	6.913
SI	2.018	168	18	4.864	1.783	501
SK	1.986	581	91	4.223	5.114	2.695
UK	10.317	2.681	451	24.516	25.555	13.300
Total	113.809	23.868	5.309	273.714	232.367	177.099

Table A12.3: Emissions (ktonnes/year) per Member State (2010)

Emissions 2010 (kt/year)												
	1-5 MW			5-20 MW			20-50 MW			*TOTAL 1-50 MW*		
	SO2	NOx	PM	SO2	NOx	PM	SO2	NOx	PM	*SO2*	*NOx*	*PM*
AT	2.1	1.8	0.1	0.1	1.5	0.0	0.1	2.5	0.1	*2.3*	*5.9*	*0.2*
BE	5.1	15.3	1.4	6.6	19.9	1.9	3.6	10.9	1.0	*15.4*	*46.1*	*4.3*
BG	3.3	4.1	0.5	5.4	6.7	0.7	1.6	2.4	0.3	*10.3*	*13.2*	*1.6*
CY	0.6	0.1	0.6	0.4	0.1	0.3	0.5	2.0	0.0	*1.5*	*2.2*	*0.9*
CZ	1.8	1.9	0.3	1.2	2.0	0.3	4.1	2.2	0.2	*7.1*	*6.1*	*0.9*
DE	26.0	76.0	2.5	10.2	29.9	1.0	8.1	23.6	0.8	*44.3*	*129.5*	*4.3*
DK	11.5	8.5	1.5	19.1	11.3	2.0	4.5	8.8	1.2	*35.1*	*28.6*	*4.6*
EE	4.4	0.6	1.1	0.6	0.8	1.0	4.0	0.5	1.4	*9.1*	*1.8*	*3.5*
EL	0.5	0.6	0.1	0.8	1.0	0.1	0.2	0.4	0.1	*1.5*	*2.0*	*0.2*
ES	7.5	12.1	1.0	12.5	20.1	1.3	1.5	4.1	0.4	*21.5*	*36.3*	*2.6*
FI	0.6	1.7	0.2	1.8	1.9	0.3	3.7	4.4	0.3	*6.0*	*8.0*	*0.9*
FR	9.8	19.2	2.0	8.7	17.0	1.8	8.0	10.3	2.5	*26.5*	*46.5*	*6.2*
HU	1.6	2.9	0.1	2.6	4.7	0.1	2.1	2.7	0.3	*6.4*	*10.3*	*0.5*
IE	5.3	4.3	0.7	8.8	7.1	0.9	2.1	2.2	0.6	*16.2*	*13.7*	*2.2*
IT	9.4	12.9	0.8	15.6	21.5	0.9	3.7	9.1	0.7	*28.7*	*43.6*	*2.5*
LT	2.2	2.2	0.3	3.7	3.7	0.3	0.9	1.3	0.2	*6.8*	*7.3*	*0.8*
LU	0.0	0.2	0.0	0.0	0.4	0.0	0.0	0.2	0.0	*0.0*	*0.8*	*0.0*
LV	0.9	1.7	1.5	1.3	2.6	1.8	0.5	1.5	0.5	*2.7*	*5.8*	*3.7*
MT	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	*0.0*	*0.1*	*0.0*
NL	0.0	8.6	0.0	0.0	11.7	0.0	0.0	1.6	0.0	*0.0*	*21.9*	*0.0*
PL	0.8	9.4	0.3	13.0	18.7	2.0	11.0	5.4	4.0	*24.8*	*33.4*	*6.2*
PT	1.7	2.4	0.5	2.9	3.9	0.8	1.0	2.6	0.4	*5.5*	*8.9*	*1.7*
RO	0.7	1.4	0.1	2.0	3.8	0.3	1.5	3.7	0.3	*4.2*	*8.8*	*0.7*
SE	0.2	1.8	0.3	2.2	5.6	0.5	0.7	3.5	0.2	*3.1*	*10.9*	*1.1*
SI	0.1	1.4	0.1	0.2	0.2	0.1	0.1	0.5	0.0	*0.4*	*2.1*	*0.3*
SK	0.1	0.7	0.2	0.2	1.1	0.1	0.2	1.2	0.1	*0.6*	*3.0*	*0.4*
UK	7.0	18.7	1.0	9.4	30.1	1.6	4.0	9.0	0.6	*20.4*	*57.8*	*3.1*
EU-27	103.3	210.5	17.2	129.6	227.3	20.0	67.6	116.7	16.2	*300.5*	*554.5*	*53.4*

Table A12.4 provides an overview of EU-27 emissions in 2010 split per fuel type. For this assessment, five different fuel types have been assumed (the same ones that have to be reported on by Member States under the LCP Directive 2001/80/EC and the IED). The category “other solid fuel” covers coal and lignite, while “gaseous fuel other than natural gas” mainly concerns biogas, which is predominantly used in Germany. It shows that different fuel groups are associated with the largest share of emissions of the three pollutants concerned: SO_2 emissions are mainly related to the use of liquid fuels (some 62%), NOx emissions are strongly associated with natural gas firing and PM emissions are highest from biomass firing, in particular for the smaller combustion plants (up to 20 MW).

Table A12.4: Emissions per fuel type for EU-27 (2010) (ktonnes per year)

Emissions 2010 (kt/year) per fuel type						
EU-27	BIOMASS	OTHER SOLID FUEL	LIQUID FUEL	NATURAL GAS	GASEOUS FUEL OTHER THAN NATURAL GAS	*TOTAL*
Capacity class	SO2					
1-5 MW	13.8	16.8	64.5	-	8.1	*103.3*
5-20 MW	8.7	26.1	91.2	-	3.5	*129.6*
20-50 MW	10.4	21.7	30.4	-	5.1	*67.6*
TOTAL 1-50 MW	*33.0*	*64.7*	*186.1*	*-*	*16.7*	*300.5*
	NOx					
1-5 MW	22.6	11.7	21.5	134.4	20.1	*210.5*
5-20 MW	17.4	7.5	30.1	163.7	8.7	*227.3*
20-50 MW	14.7	9.1	13.6	72.8	6.6	*116.7*
TOTAL 1-50 MW	*54.7*	*28.3*	*65.2*	*370.9*	*35.4*	*554.5*
	PM					
1-5 MW	7.7	2.3	7.2	-	-	*17.2*
5-20 MW	8.3	4.0	7.8	-	-	*20.0*
20-50 MW	4.4	5.5	6.2	-	-	*16.2*
TOTAL 1-50 MW	*20.4*	*11.8*	*21.2*	*-*	*-*	*53.4*

2.4. Overview of current regulation

2.4.1. EU legislation

Currently, there is no EU legislation specifically addressing air emissions of polluting substances from combustion plants between 1 and 50 MW except for the cases set out below.

As mentioned, combustion units with a rated thermal input less than 50 MW may already be regulated under Directive 2010/75/EU on industrial emissions (IED) as part of installations where the combustion is a directly associated activity with a technical connection to the IED activity as well as where the total on-site combustion capacity is exceeding 50 MW. In those cases, the installation has to be operated in accordance with a permit issued by the competent authorities in the Member States, which contains conditions including emission limit values or equivalent provisions for the key polluting substances that are emitted, as well as monitoring requirements. These conditions have to be based on the application of the best available techniques (BAT).

Data was collected from Member States to identify the share of MCP that are part of IED installations. Although it is apparent that this may be the case for a greater proportion of 20-50 MW combustion plants compared to plants below 20 MW, the available information was not sufficiently robust to allow a quantitative estimate of the proportions per Member State.

A rough estimate is that 5% of plants in the 1-5 MW class, 10% of plants in the 5-20 MW class and 40% of plants in the 20-50 MW class are part of IED installations and, therefore, subject to the obligation to be covered by a BAT-based permit.

Council Directive 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels[44] requires Member States to ensure that heavy fuel oils are not used within their territory if their sulphur content exceeds 1% by mass. Until 31 December 2015, heavy fuel oils having a higher sulphur content may be used under certain conditions in combustion plants which do not fall under Directive 2001/80/EC (Large Combustion Plant Directive) when their monthly average SO_2 emissions do not exceed 1 700 mg/Nm³ (3% reference oxygen content)[45]. As from 1 January 2016, the same exemption applies under the abovementioned conditions for heavy fuel oils burned in combustion plants which do not fall within the scope of Chapter III of IED. In practice this means that SO_2 emissions from liquid fuel fired medium size combustion plants shall not be higher than 1 700 mg/Nm³. This Directive also sets a limit of 0,1% by mass for the sulphur content of gas oil.

2.4.2. Gothenburg Protocol

The Protocol to abate acidification, eutrophication and ground-level ozone (Gothenburg Protocol) was adopted in 1999 by the Parties to the Convention on Long-Range Transboundary Air Pollution (CLRTAP).[46] It entered into force in 2005 and sets emission ceilings for 2010 for four air pollutants: sulphur, nitrogen oxides, volatile organic compounds and ammonia. It also sets emission limit values for the key source categories (stationary, mobile and products). The Gothenburg Protocol was amended in 2012 to include national emission reduction commitments to be achieved in 2020 and beyond (See also Chapter 3 and Annex 4). Several of the annexes containing emission limit values to be adhered to by Parties were revised with updated sets of emission limit values and emission ceilings for fine particulate matter were added. The source-related annexes mostly cover combustion plants over 50 MW, but for some categories the threshold is lower than 50 MW. Annexes which are relevant to MCP can be summarised as follows:

- Annex IV: limit for sulphur content of gas oil: <0.1% by January 2008 (transposed in EU legislation via Directive 1999/32/EC, see above);
- Annex V (NOx): limit values for new stationary engines (gas engines and dual fuel engines greater than 1MW and diesel engines greater than 5MW) : limits vary between 95 and 225 mg/Nm³ (15% O_2) depending on the engine type and fuel used; exemptions may be granted for plants running less than 500 hours per year or plants used in particular local conditions;
- Annex X (dust[47]): non-binding emission levels for solid and liquid fuel fired boilers and process heaters between 1 and 50 MW: these levels vary between 20

[44] OJ L 121, 11.5.1999, p. 13, as last amended by Directive 2012/33/EU of the European Parliament and of the Council of 21 November 2012 (OJ L 327, 27.11.2012, p.1)

[45] 1700 mg/Nm³ represents the maximum emission level that would result from firing heavy fuel oil containing 1% sulphur (unabated emissions).

[46] http://www.unece.org/env/lrtap/multi_h1.html

[47] “dust” is a term used in Annex X, Part A of the Gothenburg Protocol (as amended in 2012) in the context of particular matter emissions, with the following explanation given: "In this section only, “dust” (…) means the

and 50 mg/Nm³ depending on the size and plant age (at various reference oxygen contents, depending on the fuel type).

Compliance with the emission limit values is not the only compliance option for Parties. Alternatively '*different emission reduction strategies that achieve equivalent overall emission levels for all source categories together*' may be applied. The Protocol nevertheless requires that, '*Each Party should apply best available techniques (…) to each stationary source covered by [the] annexes[…] , and, as it considers appropriate, measures to control black carbon as a component of particulate matter[…]*. .

2.4.3. Member States' national legislation

Several Member States have already taken action to reduce air pollution from MCPs in view of meeting present air quality standards and emission ceilings. From earlier information gathering it was clear that the emission limits applied nationally (or regionally) differed significantly across Member States. Some Member States have recently revised their legislation thereby establishing more stringent limit values for MCP.

Table A12.5 summarises the most recently information gathered on Member States' national legislation regulating combustion plants below 50 MW. It shows that at least 15 Member States are regulating all or part of the MCP, through a permit, emission limit values and/or monitoring requirements. In addition, some Member States set permit conditions for these plants on a case-by-case basis.[48]

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mass of particles, of any shape, structure or density, dispersed in the gas phase at the sampling point conditions which may be collected by filtration under specified conditions after representative sampling of the gas to be analysed, and which remain upstream of the filter and on the filter after drying under specified conditions." Hence, the term is equivalent with the term "PM" used elsewhere in this Annex.

[48] No information was obtained for Bulgaria, Croatia, Denmark, Greece, Hungary, Italy, Latvia, Lithuania, Luxembourg and Malta.

Table A12.5: Overview of national legislation regulating combustion plants below 50 MW

MS	Legislation	Permitting	Emission limits	Monitoring obligations
AT	BGBI.II Nr. 312/2011 concerning furnaces which are not steam boilers BGBI Nr.19/1989 idf. BGBL. II Nr. 153/2011 concerning steam boilers and gas turbines <50 MW.	No	✓	✓
BE/ FL	VLAREM II (Order of the Flemish Government of 1 June 1995 concerning General and Sectoral provisions relating to Environmental Safety).	✓	✓	✓
BE / WA	Unknown reference	Unknown	✓	✓
CY	The Control of Atmospheric Pollution (Non Licensable Installations) Regulation of 2004 (P.I. 170/2004)» as amended in 2008 by Regulations of 2008 (P.I. 198/2008)	No	✓	✓
CZ	Government Ordinance No. 146/2007 Coll. In wording No. 476/2009 Coll. (ELVs) Decree No. 205/2009 Coll. In wording No. 17/2010 Coll. (Monitoring)	No	✓	✓
EE	Välisõhu kaitse seadus, Vastu võetud 05.05.2004 RT I 2004, 43, 298 (ambient air protection act)	✓	✓ (permit specific)	✓ (permit specific)
FI	Environmental Protection Act Government Decree on environmental protection requirements for energy production installations with a total fuel capacity < 50 MW	✓	✓	Unknown
FR	Inspection des Installations Classées (Permitting – separate regimes for 2-20MW and 20-50MW) NOR: ATEP9760321A Version consolidée du 15/12/2008 (ELVs 2-20MW) ELVs for >20MW (various regulations, depending on age of plant)	✓	✓	✓
DE	(Verordnung über kleine und mittlere Feuerungsanlagen - 1. BImSchV (ELVs) Technical Instructions on Air Quality Control – TA Luft (24 July 2002) (Monitoring)	✓	✓	✓
IE	Air Pollution Act 1987 (IPPC related activities)	Only for IPPC related activities		
NL	BEES-B (Existing installations <50MW_{th}) BEMS (New installations and existing installations from 2017 on)	✓	✓ (general binding rules)	✓
PL	Environmental Protection Law (Permits) Emission standards regulation (ELVs for 1-50MW_{th}) Rozporzñdzenie Ministra Ârodowiska (Monitoring)	Not required	✓	✓
PT	Decree-Law 78/2004[49] Ordinance 675/2009[50]	✓	✓	✓
RO	Ministerial Order no 1798/2007 for the approval of the procedure of issuing the environmental permit ELVs in accordance with Ministerial Order no. 462/1993 – Technical conditions regarding air protection, Annex 2	✓	✓	✓
SK	References unknown	✓	✓	✓
SI	UREDBO o emisiji snovi v zrak iz malih in srednjih kurilnih naprav	✓	✓	✓

49 http://dre.pt/pdf1s/2004/04/080A00/21362149.pdf

50 http://dre.pt/pdf1sdip/2009/06/11900/0410804111.pdf

MS	Legislation	Permitting	Emission limits	Monitoring obligations
SE	Permit conditions for plants are set on a case-by-case basis.	Unknown	Case-by-case basis	?
ES	ELVs are set by Autonomous Communities. General binding rules do not exist.	X	X	X
UK	Environmental Permitting, England and Wales (2010) – Part B Regulations apply to boilers 20-50MW_{th}	✓ (>20MW)	✓ (>20MW)	✓ (>20MW)

3. POLICY OPTIONS

Based on the needs defined as part of the central impact and emission reduction case in chapter 6 and the developed insights of the MCP sector as well as stakeholder inputs (also reported in in the main impact assessment), a set of policy options have been identified. These have been defined in terms of the emission levels hat would be set and the regulatory procedures that would be followed.

3.1. Options determining the emission levels

Five policy options have been considered that differ in environmental emission level for reducing the emissions of SO_2, NOx and PM from MCPs:

- **Emission level option 1: no EU action**
  This default option assumes continuation of current policy measures at Member State level and no further measures for controlling emissions of SO_2, NOx or PM from MCP in the EU. It serves as a reference to calculate the impacts of the other policy options.

- **Emission level option 7A: "most stringent MS"**
  Under option 7A, EU wide emission limit values for SO_2, NOx and PM are set for all MCP (both new and existing) at the level of the most stringent legislation which is currently applicable in Member States for existing plants (for each of the fuel types and size classes considered).

- **Emission level option 7B: "LCP"**
  Option 7B is the application of the EU wide ELVs for all MCP (both new and existing) which are set out in the IED for existing combustion plants with a rated thermal input between 50 and 100 MW (Part 1 of Annex V of the IED).

- **Emission level option 7C: "primary NOx"**
  A variation of the option 7B, affecting only NOx, such that the only abatement measures required to be taken up for NOx would be combustion modifications (primary measures) and no secondary (end-of-pipe) measures. For SO_2 and PM the emission levels under this option are the same as for option B.

- **Emission level option 7D: "Gothenburg"**
  Option 7D is a variant of option 7C, whereby EU wide ELVs for NOx, SO2 and PM are differentiated for new and existing plants. It has been designed following analysis of previous options and to consider possible additional lower cost options (see section 3.3.5 on mitigation measures). It takes into account (i) that a longer application deadline could be set for existing plants than new plants (e.g. ELVs enter into force in 2022 for existing plants instead of 2018 when it would apply for new plants); (ii) that MCPs operating a limited amount of hours (less than 300

hours/year) are exempted from complying with the ELVs for all the pollutants to avoid excessive costs for minimal benefit, (iii) that secondary abatement measures for NOx will be cheaper to implement in new built plants as compared to retrofitting existing stock (see section 3.1.2); (iv) the need to align ELVs with those set out in the amended Gothenburg Protocol.

- **Emission level option 7E: “SULES”**
  Option 7E is a variation of option 7D, where the ELVs for new plants have been set according to the existing or future applicable ELVs for most stringent Member States.

A summary of the emission values corresponding to the above described assumptions and used for assessing the impacts of the different options is given in Appendix 12.1.

3.2. Regulatory options

Apart from the emission level options set out in section 2.1, which determine the environmental outcome, four different regulatory options have been considered and assessed. They vary mainly in terms of the administrative approach (and cost) through which MCP would be regulated, in particular whether or not a permit would be required.

- **Regulatory option R1: "integrated permit"**
  Under this option derived from the IPPC permitting regime, the operators of the combustion plants would be required to obtain an integrated permit issued by competent authorities in the Member States for operating the plant. This permit would cover all relevant environmental impacts of the plant’s operation. In addition to the EU-wide emission limit values for emissions of SO2, NOx and PM to air the permit may also, where relevant, set conditions concerning emissions to water and soil, as well as for energy use and waste generation. The public would have a right to participate in the decision-making process and this is also taken into account for the assessment.

- **Regulatory option R2: "air emissions permit"**
  Under this option, the operators of the combustion plants would be required to obtain a permit issued by competent authorities in the Member States, which would cover only emissions to air coming from the plant’s operation. In addition to the EU-wide emission limit values for SO2, NOx and PM, the permit would also set the associated requirements for monitoring and reporting.

- **Regulatory option R3: "registration"**
  Under this option, combustion plant operators would have to notify operation of the MCP (and the key administrative and technical information) for registration by the competent authorities in the Member States. The authorities would keep a register of the notified plants. The plants would be subject to the EU-wide emission limit values and monitoring requirements for SO2, NOx and PM.

- **Regulatory option R4: "general binding rules"**
  Under this option, MCP operators would not be obliged to obtain a permit, nor to notify competent authorities. Plants would be subject to the EU-wide emission limit values for SO2, NOx and PM to air and associated monitoring requirements.

The requirement under options R1 and R2 for each plant to have a permit would allow the consideration of the need for stricter conditions in order to ensure compliance with local air quality standards. In contrast with option R4 option R3 would allow mapping emissions of medium size plant and therefore improve knowledge and emission inventories, which would not be possible with option R4.

4. IMPACT ANALYSIS

4.1. Methodology, assumptions and uncertainties

4.1.1. Main methodology

The environmental, economic and social impacts of the options described in the previous section have been assessed on the basis of both quantitative and qualitative analysis. Impacts under emission level options 7A-7E were compared to those under option 1 (no EU action). For the administrative costs, the impacts of the regulatory approaches R1 to R4 were considered.

Emission reductions (reflecting environmental benefits), compliance costs (implementation of emission abatement measures), emission monitoring costs and administrative costs were calculated through a bottom-up modelling, using the database referred to in section 1.2 and described in more detail in the following sections.

The assessment of the abatement measures uptake, annualised compliance costs and emission reductions has been performed separately for the three capacity classes (1-5, 5-20 and 20-50 MW) to reflect differences in emission levels and abatement measures applied. The emissions and costs have been estimated on the basis of the information gathered for the reference year 2010, projecting forward to 2025 and 2030. These 2025 and 2030 forecasts have been estimated by scaling the 2010 results by Member State, using fuel type specific growth factors, which were developed using PRIMES 2012 data on fuel consumption. The total fuel consumed across all of the sectors of interest for MCP has been calculated for each Member State by fuel type. The growth factor is calculated as the difference between the fuel consumption in the projection year (2025 or 2030) and the reference year (2010). The factor can be negative as the fuel consumption projections incorporate projected improvements in efficiency and turn-over of plants. Fuel consumption by MCP has been assumed to change in direct proportion to changes in fuel consumption for the relevant sectors as a whole within the Member State.

Impacts for options 7A, 7B and 7C were calculated for both the years 2025 and 2030[51]. It is however generally noted that the trends for both years are very similar, with emissions and costs either the same or just a few per cent lower in 2030 as compared to 2025. These differences are primarily related to changes in activity[52] as the ELVs are not differentiated for new and existing plants, For options 7D and 7E impacts have been calculated for 2025 only but some differences are expected for 2030 as some of the ELVs for new plants are tighter than those for existing plants (and there will be a greater proportion of new plants in 2030 compared to 2025). Differences between 2025 and 2030 for option 7D are expected to be relatively minor as differences in costs will be mostly due to new engines and turbines - in 2030 they would represent about 3.4% of the total plants. The difference is expected to be much more pronounced for option 7E where variations between the ELVs applied for new and existing plants are large.

51 The analysis had been conducted under the assumption that all plants operated will comply with the EU wide ELVs set under the options at the time of the projection year (either 2025 or 2030)

52 Annex 5 of the Impact Assessment 'Detail description of Future air quality projections Assuming No Change in Current Policies'.

To avoid over complexity and to ease the comparison of options, only the results for 2025 will be presented and discussed, the full set of results obtained (for both the years 2025 and 2030) are reported in Appendices 12.2 and 12.3.

The bottom-up approach used for calculating the potential emission reductions and associated costs for MCP relies on an installation dataset (number of plants, fuels used, emissions, legislation in place) built up from Member State data and subsequently gap-filled, on literature data and expert judgement for applicable control measures and associated compliance costs. Inevitably, this involves a number of uncertainties and limitations, in particular concerning the input data and the modelling applied.

4.1.2. *Uncertainties with respect to input data*

The principal points to note concerning the installation dataset are the following:

- Greater uncertainty is associated with the data for smaller capacity classes due to their reliance on a greater proportion of extrapolation;
- Estimates for some of the larger Member States could have a disproportionate effect on the overall EU figures;
- Very limited information has been provided on sectoral breakdown and technology split and so for many Member States an average split had to be applied;
- Certain similar abatement techniques were combined into one group (e.g. different types of combustion modification).

4.1.3. *Modelling assumptions*

The approach for projecting emission reductions and costs was based on the current estimated plant stock (numbers, capacity, emissions etc.) dataset and then projected forward to 2025/2030 using PRIMES 2012 fuel consumption and activity data. The modelling further included the following assumptions:

Option 1 takes into account current legislation in each Member States. This option has been refined in the course of the assessment when modelling options 7D and 7E for 2025, to better take into account future emission limit values that have already been adopted by certain Member States. As a result, the compliance costs for options 7A, 7B and 7C may be slightly overstated for some Member States.

Control measures already implemented by Member States under their current legislation have been included under option 1. It is not necessarily the case that all of the combustion plants which are part of IED installations and hence should be covered by an integrated permit are already subject to such legislation. Although it may be expected that emission limits will already have been set in the permits for those plants, it could not be generally assessed at what level those limits would be set, except where national law is prescribing the limits (see section 1.4). Hence, only where such a limit was explicitly prescribed, MCP which are part of IED installations are assumed to be covered by it already. As a result, the overall costs and benefits associated with the policy options may be overstated for some Member States.

The administrative cost assessment assumes a static number of plants from 2010 until 2030 in the absence of any data on how this may change (total fuel consumption decreases by 13% over this period using the PRIMES 2012 data for combustion overall but this has been assumed to be related to energy efficiency improvements rather than a decline in plant numbers). Some Member States have reported that they expect the number of smaller plants to increase as there is a push for more decentralised heat and power supply. This could lead to an underestimation of the potential administrative costs.

In emission level options 7D and 7E new and existing plants have been modelled separately taking into account the ELVs that apply for each in the Member States in relation to national law (where available). In the calculations an average plant lifetime of 30 years has been assumed, corresponding to annual replacement rate (plant turnover) of 3.3%. The analysis assumes that the ELVs would apply to new plants from 2018 and to existing plants from 2022; the longer lead time for existing plant would allow planning any necessary upgrades within the normal investment cycle. In 2025 it is assumed that approximately 27% of plants in the EU would be new and have to meet the ELVs specified for new plants. The model considers that measures on new plants are 40% cheaper than measures on existing plants (retrofitting) for secondary (end-of-pipe) measures, and 60% for primary measures.

Options 7D and 7E take into account exemptions for plants operating less than 300 hours/year. This results in a reduction in costs in equal proportion (17,5%), while emissions are estimated to increase by only 1% due to the low number of operating hours (see details in section 3.3.6 on mitigation measures).

4.2. Environmental impacts

For each of the options 7A-7E, the emission reductions for SO_2, NO_x and PM in 2025 were assessed compared to "no EU action".

4.2.1. *SO2 emissions*

Table A12.6 presents the SO_2 emission forecasts for 2025. Without further EU action, SO_2 emissions of MCP are projected to decrease by 127 ktonnes (42%) due to changes in fuel mix (shift from coal to biomass) and activity. Under all the options 7A-7E total additional SO_2 emission reductions in 2025 (in comparison with option 1) are all very similar, ranging from 127 to 139 ktonnes.

Table A12.6: SO2 emissions (kt/year)

Emission level option:	2010	1: no EU action	7A: most stringent MS	7B: LCP and 7C: Primary NOx	7D: Gothenburg	7E: SULES
1-5 MW	103	58	**9**	**13**	**13**	**11**
5-20 MW	130	67	**12**	**17**	**13**	**12**
20-50 MW	68	49	**14**	**17**	**14**	**13**
TOTAL 1-50 MW	301	174	**35**	**47**	**39**	**37**
*Total emission **reduction** compared to "no EU action"*			***139***	***127***	***135***	***137***

4.2.2. *NOX emissions*

Table A12.7 presents the NO_X emission forecasts for 2025. Without further EU action, NO_X emissions of MCP are projected to decrease by 99 ktonnes (18%) due to changes in fuel mix and activity. In comparison with option 1, option 7B would further reduce emission by 303 ktonnes and under option 7A, the additional reduction would even be 338 ktonnes (i.e. 74% of 2025 emissions without EU action). When only primary NOx measures would be required (option 7C), the emission reduction compared to option 1 would be limited to 76 ktonnes (i.e. 17% of 2025 emissions without EU action). Differentiating measures between new and existing plants as under option 7D would reduce emissions by 107 ktonnes compared to a 'no EU action' scenario, while with option 7E reductions of 159 ktonnes are achieved.

Table A12.7: NOx emissions (kt/year)

Emission level option:	2010	1: no EU action	7A: most stringent MS	7B: LCP	7C: primary NOx	7D: Gothenburg	7E: SULES
1-5 MW	210	170	**46**	**63**	**140**	**131**	**112**
5-20 MW	227	188	**47**	**62**	**149**	**140**	**119**
20-50 MW	117	98	**24**	**42**	**90**	**78**	**66**
TOTAL 1-50 MW	554	455	**117**	**167**	**379**	**348**	**297**
*Total emission **reduction** compared to "no EU action"*			***338***	***288***	***76***	***107***	***159***

4.2.3. *PM emissions*

Table A12.8 presents the PM emission forecasts for 2025. Without further EU action, PM emissions are projected to decrease by a mere 5 ktonnes by 2025, due to changes in fuel mix (reduction in coal use is neutralised by increase in biomass use) and activity. As for SO_2, total additional PM emission reductions achieved by all options 7A-7E in comparison with option 1 are all very similar, ranging from 42 to 45 ktonnes.

Table A12.8: PM emissions (kt/year)

Emission level option:	2010	1: no EU action	7A: most stringent MS	7B: LCP and 7C: Primary NOx	7D: Gothenburg	7E: SULES
1-5 MW	17	13	**1**	**2**	**1**	**1**
5-20 MW	20	20	**1**	**2**	**1**	**1**
20-50 MW	16	14	**1**	**2**	**1**	**1**
TOTAL 1-50 MW	53	48	**3**	**6**	**3**	**3**
*Total emission **reduction** compared to "no EU action"*			***45***	***42***	***45***	**45**

4.2.4. *Overview of pollutant abatement achieved by the emission level options*

The table below show a summary of emission reductions achieved in the various abatement level options. It shows that the highest emission reductions -compared to the baseline Option 1- would be achieved for all pollutants under emission level option 7A. While reductions for PM and SO_2 do not substantially differ in the various options, NOx reductions vary considerably. Option 7C would deliver the least reductions for NOx, albeit still in the order of 76 kilotons/year. Option 7D reduces NOx emissions much less than options 7A and 7B but still very significantly: 107 kilotons/year. The additional 20 kilotons/year reduction of option 7D compared to option 7C is due to the stricter ELVs set for new combustion plants, in particular for engines and turbines to comply with the Gothenburg requirements. Option 7E delivers a total NOx reduction of 159 kilotons/year, where additional reduction compared to option 7D are achieved thanks to more stringent NOx emission limit values for new plants.

Emission reduction (kt/y)	2025				
Option:	**7A**	**7B**	**7C**	**7D**	**7E**
SO2	139	127	127	135	137
NOx	338	288	76	107	159
PM	45	42	42	45	45

4.3. Economic impacts

4.3.1. *Compliance costs*

To estimate the compliance costs due to the introduction of EU wide emission limit values as under options 7A-7E it was assessed whether additional abatement measures would have to be implemented within the combustion plants concerned compared to the situation without EU action. A set of compliance costs was developed for implementing a range of the most pertinent and applicable abatement measures on the basis of literature data available (Amec, 2013 and references therein). Capital and operational costs have been annualised using default values of a 4% discount rate and an annualisation period of 15 years. A model was applied to automatically identify which abatement measure would be required to achieve the emission levels defined under the different options.

Total costs per Member State were derived from the cost per plant multiplied by the number of plants for each fuel type. The number of plants per fuel type in a Member State was estimated using the percentage fuel mix applied to the total number of plants. When calculating total compliance costs per Member State, account has been taken of the extent to which emissions from medium combustion plants are already regulated under national legislation currently in place. Table A12.9 presents a summary of the average total compliance costs for EU 27 for options 7A-7E for the year 2025.

Table A12.9: Overview of incremental annualised compliance costs (€m/year)

Pollutant	Emission level option:	7A: most stringent MS	7B: LCP	7C: primary NOx	7D: Gothenburg	7E: SULES
SO_2	1-5 MW 5-20 MW 20-50 MW	210 123 44	90 68 27	90 68 27	83 72 28	100 80 30
	TOTAL 1-50 MW	377	185	185	183	210
NO_X	1-5 MW 5-20 MW 20-50 MW	1119 1018 543	821 785 311	27 18 3	36 35 12	187 178 91
	TOTAL 1-50 MW	2680	1,918	48	83	456
PM	1-5 MW 5-20 MW 20-50 MW	84 77 77	55 41 27	55 41 27	46 42 28	46 45 35
	TOTAL 1-50 MW	238	123	123	116	126
TOTAL	1-5 MW 5-20 MW 20-50 MW	1413 1218 665	966 895 365	171 127 57	165 149 68	332 302 156
	TOTAL 1-50 MW	3296	2226	355	382	790

The table shows that most of the compliance costs under options 7A and 7B are associated with NOx abatement, something that is indeed also reflected also in option 7E, where stringent NOx ELVs are set for new plants.

Option 7C requires combustion modifications but no secondary NOx measures, resulting in drastically lower compliance costs (around 10% of option 7A). The low costs are kept also under option 7D. In this case total compliance costs are only 2% higher than in emission level option 7C and about 12% of the costs under option 7A.

Table A12.10 provides more detail on the distribution of abatement costs between new and existing plants for the different combustion plant types, as studied in options 7D and 7E.

It can be seen that compliance costs for NOx in emission level option 7D are 83M€/year, of which about half of them allocated to new engines and turbines, in particular for the two categories 1-5MW and 5-20MW. Compliance costs for NOx in emission level option 7E rise to 456M€/year, most of them allocated to new boilers, in particular for the two categories 1-5MW and 5-20MW.

In option 7D cost associated to new boilers (7M€) are assumed to be half of those to retrofit existing boilers (13M€). Costs for new engines and turbines (47M€) where secondary measures are taken to comply with Gothenburg requirements are three times higher than for existing engines and turbines where no secondary measures would be required (16M€). In option 7E costs for new boilers are much higher than the one for existing boilers, due the more stringent emission limit values applied.

Table A12.10: Detailed overview of annualised compliance costs for NOx under options 7D and 7E (€m/year)

Figures rounded for presentation purposes (this might lead to minor differences in the totals)

Annualised compliance costs for NOx (€m/year)	Category	New boilers	Existing Boilers	New engines and turbines	Existing engines and turbines	TOTAL
Option 7D: Gothenburg	1-5 MW	3	6	19	7	36
	5-20 MW	2	6	21	7	35
	20-50 MW	1	2	7	2	12
	TOTAL 1-50 MW	**7**	**13**	**47**	**16**	**83**
Option 7E: SULE	1-5 MW	148	6	26	7	187
	5-20 MW	138	6	28	7	178
	20-50 MW	73	2	15	2	91
	TOTAL 1-50 MW	**359**	**13**	**68**	**16**	**456**

For comparison the compliance costs for NOx abatement per new plants in emission level options 7D and 7E are reported in Table A12.11.

Table A12.11: Annualised compliance costs for NOx for new plants under options 7D and 7E (€/plant)

	New boilers		New engines and turbines	
Emission level option	**7D**	**7E**	**7D**	**7E**
1-5 MW	140	6000	3100	4200
5-20 MW	440	26800	16000	21700
20-50 MW	1,10	63700	25100	52300
TOTAL 1-50 MW	225	11600	6000	8800

Compliance costs per Member State per emission level option 7D are reported in the tables of Appendix 12.4.

4.3.2. *Emission monitoring costs*

The introduction of emission limits for MCP also requires setting emission monitoring requirements, which allow verifying compliance with those limits. This involves either the use of on-site monitoring equipment (in case of continuous monitoring) or periodic monitoring by qualified experts using certified monitoring equipment and appropriate standardised sampling, measurement and analytical methods.

Based on a review of available information from existing national legislation as well as the IED requirements for 50-100 MW combustion plants, only periodic monitoring was assumed to be a reasonable option as the costs of continuous monitoring are considered prohibitively high.

The costs of a single emission monitoring campaign are summarised in the Table A12.12.

For this assessment, the monitoring frequency applied for combustion plants in the range 1-20 MW was once per three years and for combustion plants between 20 and 50 MW it was once per year. The resulting total annualised costs for operators are also reported in Table A12.12

Table A12.12: Costs of emission monitoring (NOx, SO2 and PM) –per monitoring event and total annualised costs

Costs for operators	Per monitoring event * (€)	Annualised costs (m€/year)
20-50 MW	7200	4
5-20 MW	4100	6
1-5 MW	2400	15

* For natural gas fired plants only NOx monitoring would be required and costs per monitoring event are assumed to be only 50% of the above mentioned costs.

4.3.3. *Administrative costs*

As described in section 2, MCP can be regulated in different manners in order to ensure that the emission limit values imposed are implemented and complied with. The different regulatory options R1 to R2 differ in the way the administrative procedures for regulating the plants (or broader installations) are set up and hence will result in different administrative costs for both the operators and authorities involved.

Regulatory options R1 and R2

For assessing the administrative costs of those options, the following elements have been considered:

Cost of bringing installations under the regulation: a one-off cost when a permit is granted:

- operators: costs incurred in understanding the legal requirements, preparing applications, responding to requests for information from regulators, etc;
- authorities: costs of producing application materials, consulting the public, determining the application, etc;

Cost of periodic reconsideration of permits: one-off cost when permit is reconsidered;

Ongoing subsistence costs:

- operators: administrative costs (i.e. non-technical) of providing monitoring reports, accommodating site visits by inspectors, reporting changes in operation, etc;
- authorities: costs of checking compliance, maintaining systems to make information available to the public, updating permit conditions (without amounting to a full reconsideration of the permit), etc;

Soil and groundwater baseline survey: one-off cost at the point of applying for a permit (noting that under this option an integrated approach would apply and not only air emissions would be regulated).

A summary of costs applied for calculating these administrative costs in option R1 is provided in Table 12.13. For the costs of bringing installations under the regulation, periodic reconsideration of permits and annual subsistence costs, these figures are mainly based on the information given in Annex 8 of the European Commission's Impact Assessment for the Proposal for a Directive on industrial emissions[53]. The cost data presented in that impact assessment have been uplifted to 2012 prices from assumed 2006 price levels.

For option R2, where only air emissions are regulated, administrative costs related to other environmental media (e.g. cost for soil & groundwater baseline survey, in Table 12.13) do not occur and have been excluded. As in this option no public participation is foreseen the costs for authorities, presented in Table A12.13, have been reduced by 25% in the calculations.

[53] SEC(2007) 1679.

Table A12.13: Elements of administrative costs under regulatory Option R1 (Integrated permit) and Option R2 (Emission permit)

		(€ per installation unless stated)
Cost of bringing installations under the regulation (one-off)		
Cost for operators	20-50 MW	23200
	5-20 MW	18500
	1-5 MW	13900
Cost for authorities	20-50 MW	10900
	5-20 MW	8800
	1-5 MW	6600
Cost of periodic reconsideration of permits (one-off)		
Cost for operators	20-50 MW	2900
	5-20 MW	2300
	1-5 MW	1700
Cost for authorities	20-50 MW	5800
	5-20 MW	4600
	1-5 MW	3500
Annual subsistence costs (ongoing)		
Cost for operators	20-50 MW	3500
	5-20 MW	2800
	1-5 MW	2100
Cost for authorities	20-50 MW	6900
	5-20 MW	5600
	1-5 MW	4200
Soil & groundwater baseline survey (only option R1)		
Cost for operators	All	4400 per survey

Regulatory options R3 and R4

Under regulatory options R3 and R4, plant operators would not need to apply for, and maintain, a permit. Therefore, no administrative costs are associated with permit application and reconsideration. Furthermore, as only air emissions would be regulated under these options, administrative costs related to other environmental media would not occur. However, given that notification and some form of periodic emission monitoring would be required, administrative costs associated with preparing, reporting and reviewing of the monitoring reports would be borne by operators and authorities. Therefore for assessing the administrative costs of these options only on-going subsistence costs have been considered. A summary of the cost figures applied under option R3 is given in Table A12.14. These figures are mainly based on the information given in Annex 8 of the European Commission's Impact Assessment for the Proposal for a Directive on industrial emissions.

For option R4, where no notification or register is kept by authorities, the costs have been reduced by 25% with respect to option R3.

Table A12.14: Regulatory option R3 (Registration) and R4 (General binding rules): elements of administrative costs

		Option R3 (€ per installation)	Option R4 (€ per installation)
Annual Subsistence Costs (on-going)			
Cost for operators	20-50 MW	1800	1350
	5-20 MW	1000	750
	1-5 MW	400	300
Cost for authorities	20-50 MW	2700	2025
	5-20 MW	1400	1050
	1-5 MW	500	375

Total administrative costs

When calculating total administrative costs per Member State based on the above mentioned costs per plant, account has been taken of the extent to which those plants would already be covered by permitting or monitoring regimes under national legislation currently in place. This approach is summarised in Table A12.15. The one-time costs of bringing installations under the regulation, periodic reconsideration of permits and the soil and groundwater baseline survey have been annualised over 20 years.

Table A12.15: Different components of administrative costs included in the assessment

Should the following administrative costs be applied?	No national legislation in place	National legislation in place		Plants which are part of IED installations
		With permitting	Without permitting	
Reg. Option R1 and R2 (Permitting)				
Permit Application Costs	Yes 100% option R1 75% option R2	No	Yes[1] 50% option R1 38% option R2	No
Permit Revision Costs	No	Yes 100% option R1 75% option R2	No	Yes 100% option R1 75% option R2
Annual Subsistence Costs under a Permitting Regime	Yes 100% option R1 75% option R2	No	Yes[1] 50% option R1 38% option R2	No
Soil & groundwater baseline survey	Yes for option R1 No for option R2	Yes for option R1 No for option R2	Yes for option R1 No for option R2	No
Reg. Option R3 and R4 (without permitting)				
Annual subsistence costs	Yes 100% option R3 75% option R4	No	No	No

Note [1]: For Member States with national legislation without permitting, permit application costs and subsistence costs under Regulatory Options R1 and R2 were assumed to be 50% less compared to Member States without national legislation. This is taking into consideration that operators and authorities in these Member States with national legislation already incur some level of costs associated with the regulations.

The sum of annualised administrative costs for operators and authorities under the four regulatory options, are provided in Table A12.16.

Table A12.16: Total annualised administrative costs (€m per year, 2012 prices)

	Regulatory option:	R1	R2	R3	R4
Operators	1-5 MW	124	67	4	3
	5-20 MW	34	20	3	2
	20-50 MW	7	3	2	0
	TOTAL 1-50 MW	**165**	**90**	**9**	**5**
Authorities	1-5 MW	104	78	6	5
	5-20 MW	31	24	4	3
	20-50 MW	9	4	2	1
	TOTAL 1-50 MW	**144**	**106**	**12**	**9**
Total	1-5 MW	228	145	10	8
	5-20 MW	65	44	7	5
	20-50 MW	16	7	4	1
	TOTAL 1-50 MW	**309**	**196**	**21**	**14**

4.3.4. *Total costs*

An overview of the total costs (compliance, monitoring, administrative) for operators is presented in Table A12.17, based on the figures from Tables A12.9, A12.12 and A12.16.

The total annualised costs for operators under the different options considered (emission level and regulatory) and their possible combinations range from 385 to 3486 M€.

Total costs in emission level options 7A, 7B and 7E are mainly determined by the compliance costs, while those are much less under options 7C and 7D.

Emission level option 7A would lead to an additional compliance cost in 2025 of nearly 3300 M€/year, which is about 1.5 times higher than option 7B. Under either of these options, more than 80% of costs are associated with NOx abatement measures due to the need to apply secondary measures in a high number of natural gas fired plants.

Total costs for option 7C and 7D, under regulatory options R3 and R4 are comparable and in the order of 400 M€. Under the same regulatory options (R3 and R4), emission level option 7E doubles the total costs to more than 800M€.

Table A12.17: Total annualised costs for operators (€m/year, figures rounded for presentation purposes)

Capacity	Year	2025																			
	Ambition level option:	Option 7A: most stringent MS				Option 7B: LCP				Option 7C: primary NOx				Option 7D: Gothenburg				Option 7E: SULES			
	Regulatory option:	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4	R1	R2	R3	R4
1-5 MW	Admin cost	124	67	4	3	124	67	4	3	124	67	4	3	124	67	4	3	124	67	4	3
	Monitoring cost	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	Compliance cost	1413	1413	1413	1413	966	966	966	966	171	171	171	171	165	165	165	165	332	332	332	332
	Total cost	*1552*	*1495*	*1432*	*1431*	*1105*	*1048*	*985*	*984*	*310*	*253*	*190*	*189*	*304*	*247*	*184*	*183*	*471*	*414*	*351*	*350*
5-20 MW	Admin cost	34	20	3	2	34	20	3	2	34	20	3	2	34	20	3	2	34	20	3	2
	Monitoring cost	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
	Compliance cost	1218	1218	1218	1218	895	895	895	895	127	127	127	127	149	149	149	149	302	302	302	302
	Total cost	*1258*	*1244*	*1227*	*1226*	*935*	*921*	*904*	*903*	*167*	*153*	*136*	*135*	*189*	*175*	*158*	*157*	*342*	*328*	*311*	*310*
20-50 MW	Admin cost	7	3	2	0	7	3	2	0	7	3	2	0	7	3	2	0	7	3	2	0
	Monitoring cost	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
	Compliance cost	665	665	665	665	365	365	365	365	57	57	57	57	68	68	68	68	156	156	156	156
	Total cost	*676*	*672*	*671*	*669*	*376*	*372*	*371*	*369*	*68*	*64*	*63*	*61*	*79*	*75*	*74*	*72*	*167*	*163*	*162*	*160*
TOTAL 1-50 MW	Admin cost	165	90	9	5	165	90	9	5	165	90	9	5	165	90	9	5	165	90	9	5
	Monitoring cost	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	Compliance cost	3296	3296	3296	3296	2226	2226	2226	2226	355	355	355	355	382	382	382	382	790	790	790	790
	Total cost	*3486*	*3411*	*3330*	*3326*	*2416*	*2341*	*2260*	*2256*	*545*	*470*	*389*	*385*	*572*	*497*	*416*	*412*	*980*	*905*	*824*	*820*

Whilst the integrated permitting option results in administrative costs of 165 M€/year, this is strongly reduced under the "lighter" regulatory options. A system of notification/registration and common rules under option R3 would allow reducing the administrative burden from avoided permit application costs, and the benefits of a standardised approach replacing permit conditions that vary from one authority to another.

Although the regulatory options considered do not have a direct environmental impact, the requirement under regulatory options R1 and R2 for each plant to have a permit would allow the consideration of the need for stricter conditions in order to ensure compliance with local air quality standards.

Also, concerning the regulatory options without a permit, option R3 would allow mapping emissions of medium size plant and therefore improving knowledge and emission inventories, which would not be possible with option R4.

4.3.5. *Impacts on small and medium-sized enterprises (SMEs)*

Data gathered from consultations with stakeholders indicates that about 75% of the MCP can be assumed to be operated within SMEs (about 53% in small and 23% in medium size enterprises). This varies between around 50% for 20-50 MW plants to more than 80% of 5-20 MW plants[54].

The direct economic impacts of potential legislation on SMEs can be assessed by comparing the total costs incurred per plant against the level of financial resources available to the operator for investment. Information available in Eurostat Structural Business Statistics includes gross operating surplus (GOS), which is the capital available to companies which allows them to repay their creditors, to pay taxes and eventually to finance all or part of their investment[55]. Considering that GOS can be used for financing investment, an indication of the economic impact is given by comparing the costs per plant against GOS per operator.

An assessment of the extent to which SMEs might be affected has been performed combining the sectorial distribution data gathered from consultations with stakeholders with the sectorial enterprise size data from Eurostat.

An indication of the total annual cost per enterprise as a proportion of GOS is given in Table A12.18.

In general, the economic impact on SMEs respect to GOS varies from 0.1 to 22%, depending on the option chosen and the size category of the plant.

High impacts, in the order of 10%, are incurred by small enterprises for all regulatory options and emission level options 7A and 7B and raise to 20% for

[54] For those sectors where Eurostat provides enterprise size categories, it is extremely unlikely that the sector-wide average proportion of micro-size enterprises (i.e. 71% to 94%) would be observed for 1-50 MW combustion plants. It is anticipated that this high proportion of micro enterprises relate to much smaller combustion plants (i.e. <1 MW) which are outside of the scope of the options considered in this study although some might operate in the smallest capacity class considered (i.e. 1-5 MW). Furthermore, in a number of cases, such combustion plants are typically a part of a bigger complex requiring more than 9 employees to maintain and operate, and therefore it is highly unlikely that any micro-size enterprises would operate them

[55] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Glossary:Gross_operating_surplus_(GOS)_-_NA

small enterprises operating a MCP in the category 20-50MW if emission level 7A is chosen.

For options 7C and 7D the impacts ranges from 0.1% to 2.5%, the highest figure again for small enterprises operating an MCP in the category 20-50MW. It is assumed that about 35% of MCPs in the 20-50MW category are run by small enterprises.

It should be noted that as explained under the description of the regulatory options [see section 2], several simplified requirements intentionally based on an approach entailing simplified permitting/registration (with respect, for instance, to requirements set in the Industrial Emission Directive) have been already taken into account in their design. In addition, the options considered in relation to emission monitoring and reporting have also been moderated, in view of the high number of SMEs concerned.

Additional mitigation measures aiming to further reduce economic impacts on SMEs under the various options have been also investigated. Several potential mitigating measures implemented in EU legislation have been identified and are in the section below.

Table A12.18: Total annual cost per enterprise as a proportion (%) of GOS

2025	Emission level option:	7A: most stringent MS				7B: LCP				7C: primary NOx				7D:Gothenburg				7E:SULES			
Enterprise size	**Regulatory option:**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**	**R1**	**R2**	**R3**	**R4**
Small	1-5 MW	2.8	2.7	2.6	2.6	2.0	1.9	1.8	1.8	0.6	0.5	0.3	0.3	0.6	0.5	0.3	0.3	0.9	0.8	0.6	0.6
	5-20 MW	13.7	13.6	13.4	13.4	10.2	10.0	9.9	9.9	1.8	1.7	1.5	1.5	2.1	1.9	1.7	1.7	3.7	3.6	3.4	3.4
	20-50 MW	21.7	21.5	21.5	21.4	12.0	11.9	11.9	11.8	2.2	2.1	2.0	2.0	2.5	2.4	2.4	2.3	5.3	5.2	5.2	5.1
Medium	1-5 MW	0.7	0.7	0.6	0.6	0.5	0.5	0.4	0.4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2
	5-20 MW	2.7	2.7	2.7	2.7	2.0	2.0	2.0	2.0	0.4	0.3	0.3	0.3	0.4	0.4	0.3	0.3	0.7	0.7	0.7	0.7
	20-50 MW	5.5	5.5	5.5	5.5	3.1	3.0	3.0	3.0	0.6	0.5	0.5	0.5	0.6	0.6	0.6	0.6	1.4	1.3	1.3	1.3

4.3.6. *Measures to mitigate impacts on SMEs*

The Commission's 2013 Communication on *Smart Regulation – Responding to the needs of small and medium-sized enterprises*[56] recognises that it may not always be possible or desirable to provide exemptions or lighter requirements for particular types of enterprises (including SMEs): *"It is acknowledged by SMEs and their representatives that SMEs cannot expect to be above the law. [...]Exemptions or lighter provisions for smaller businesses will not undermine overall public policy objectives pursued through the relevant regulations, for example in public and workplace health and safety, food safety or environmental protection."* [extract from COM(2013) 122 final]

The pollutants addressed in this impact assessment are mainly health related and location specific and providing blanket exemptions or derogations would work against the objectives of this legislative measure. Therefore, mitigation measures are examined with a view to identify those that would reduce the financial and administrative burden on SMEs whilst not running counter to the set objectives of the specific policy, and being enforceable at a reasonable cost.

4.3.6.1. *Phased implementation*

Phased implementation with a longer lead-in time for some companies can allow such companies more time to adapt and align their compliance actions with their 'normal' investment cycle. The IED (and its predecessors e.g. IPPC and LCP Directives) contain phased implementation requirements for existing installations in order to give those already in operation sufficient time to make the necessary upgrades and comply with their permits. Under this approach, the compliance costs are slightly reduced as companies have more scope to integrate achieving compliance into their investment cycle. Specifically, a lower proportion of older plants would be rendered prematurely obsolete as a result of the regulatory change. The eventual benefits would be unchanged on a per annum basis, but would be reduced overall due to the delay in accruing them. There is a slight risk with such an approach in that some operators may subsequently hold off replacing an existing plant with a new one thus reducing the overall benefits in the short term (i.e. they may choose to run their existing plant up to the deadline for compliance before replacing it) but the longer term benefits would be the same and a phased implementation should reduce overall economic impacts.

4.3.6.2. *Sectoral exemptions or derogations*

The main existing policy in which sectoral exemptions and derogations have been applied is the EU Emissions Trading System[57] (EU ETS). Industries covered by the EU ETS, which are deemed to be exposed to a significant risk of 'carbon leakage' receive a higher share of free allowances in the third trading period between 2013 and 2020. The EU ETS establishes a complex methodology for determining such sectors, where the criteria are based on percent of costs incurred by the sector respect to its gross added value (GVA) or the intensity of trade respect to third countries. It also establishes that a list of sectors at risk should be drawn up and revised every three years. The first carbon leakage list was adopted by the

56 COM(2013) 122 final

57 Directive 2009/29/EC, previously Directive 2003/87/EC.

Commission at the end of 2009 and amended in 2011 and 2012. These exemptions do not affect the environmental effectiveness of the EU ETS (which is determined by the overall cap) although they reduce the cost burden on certain sectors.

Any analogous approach for air pollutants emitted from MCP would however affect health and environmental impacts, because the only feasible sectoral approach would be to exempt specific sectors from the scope of the policy altogether. Measures have already been assessed regarding the implementation costs for all plant as a proportion of GOS, which provides a basis to reduce the burden. However there are no identifiable sectors for which the residual impact is particularly high[58]. Also given the much smaller economic impact of the MCP compared with the EU ETS, further measures on sectoral exemption would be disproportionate.

4.3.6.3. *Size-related exemptions and derogations*

The regulatory burden on SMEs can be lightened via exemptions or derogations for specific enterprises on the basis of their number of employees, turnover and/or balance sheet[59]. This could apply to the smallest (i.e. micro) enterprises only or include others within the SME definition. The Commission's 2013 Communication on *Smart Regulation – Responding to the needs of small and medium-sized enterprises*[60] identifies some examples of SME exemptions that have been proposed by the Commission and are now in the EU legislative procedure. The challenge for following this approach is that for MCPs the burden of costs are often shared between the owner of the MCP that may be a separate company to its operator. Given the significant variation in such shared set-ups across the EU, any attempts to separate out SME's from larger enterprises may inadvertently reduce the cost-effectiveness of the policy tool.

Micro-enterprises are extremely unlikely to be affected given that MCPs would normally not be operated by enterprises of very small size.

4.3.6.4. *Exemptions or derogations based on operating hours and/or emissions*

Softening the regulatory burden on specific companies is also possible via exemptions or derogations on the basis of metrics such as activity, product specifications, environmental impact indicators and the like. While this approach does not specifically target SMEs, the benefits of the exemption would be most relevant for those companies with the least resources available to shoulder any potential increase in regulatory burden, a category which is deemed more likely to include a higher proportion of SMEs (relative to the category of larger companies). For the policy options under consideration, a possible starting point would be current Member State legislation in the field. For instance, a number of Member

[58] Option 7D couple with regulatory option R3 would have an impact on SMEs that ranges from 0.1% to max 2.5% of GOS. In the case of EU ETS *'a sector is deemed to be exposed to a significant risk of carbon leakage when additional costs induced by the implementation of the directive would lead to a substantial increase of production costs, calculated as a proportion of GVA of at least 5%'.*

[59] In line with the SME definitions provided in Recommendation (2003/361/EC).

[60] COM(2013) 122 final

States have legislation in place covering combustion plants below 50 MW that exempt plants if they operate a low number of hours (e.g. <300 hours per year). The aim of this is to exempt back-up and emergency plants from having to make costly upgrades (and incurring administrative burden) with limited environmental benefit. Exempting plants with low operating hours and/or low overall emissions would have the potential to substantially reduce overall costs without impacting as much on the overall benefits. In order to assuring that any potential health benefits are safeguarded less strict measures could be still required for certain pollutants (e.g. less strict ELVs for PM).

Based on data provided by the Member States, 10-25% of MCP operates less than 300 hours per year. The analysis assumes, therefore, that 17.5% of plants (mid-point of the range 10-25%) would be exempted. This results in a reduction in costs in equal proportion (17,5%), while emissions are estimated to increase by only 1% due to the low number of operating hours.

4.3.6.5. *Financial support*

Reducing disproportionate burden on SMEs, while safeguarding delivering the policy objectives may also be achieved through the provision by Member States of financial support to particular companies (e.g. SMEs), in order to help meet the regulatory requirements. Such financial support may be direct (e.g. loans or support schemes) or indirect (e.g. reduced fees). Under these approaches, compliance costs for SMEs would be reduced, with no impact on benefits. Costs to Member States through the provision of financial support would be higher, depending on the specific support measures adopted.

4.3.6.6. *Non-financial support*

Support could be provided by the Commission and/or Member States in the form of guidance, template application/reporting forms and/or help desks to help companies understand how to comply with regulatory requirements and to make decisions on what actions are necessary. It might be possible and helpful to establish an approved abatement technology supplier list that companies could easily consult e.g. via a dedicated website. While not explicitly targeting SMEs, it is expected that SMEs would benefit most from such support, as they have fewer resources at their disposal to understand and implement new regulatory requirements. This approach would slightly reduce the transaction costs companies incur to meet the regulatory requirements, although it would entail some costs for competent authorities and/or the Commission (depending on who produced, delivered and administered the support scheme). The environmental benefits would be likely to increase slightly as regulatory compliance rates would increase and companies could possibly implement the necessary changes sooner.

4.3.6.7. *Conclusion on mitigation measures*

The mitigation measures selected as appropriate for a regulatory measure to control air pollutant emissions from MCP are listed in Table A12.19; where action would be at EU level these measures have been integrated in the design of certain policy options.

Table A12.19: Selected mitigation measures

Mitigation measure	Description
Phased implementation	Included in options 7D and 7E: New plants need to comply with set ELVs as of 2018, existing in 2022.
Derogations for existing installations	Included in options 7D and 7E: ELVs for new plants are set stricter than the one for existing plants.
Exemptions or derogations based on operating hours	Included in options 7D and 7E: Exemption for existing combustion plants which do not operate more than 300 hours per year (for PM emission an upper "safeguard" limit could be set).
Simplified permitting and reporting obligations	Included in options R2, R3, R4: Option R2 takes into consideration a light permitting regime, while no permit but only registration is considered in option R3 and simply notification under option R4.
Simplified monitoring obligations	Included in options (R1 to R4): Lighter monitoring requirements than those set in the Industrial Emission Directive are considered for all the options (R1 to R4). In all the options (R1 to R4) lighter monitoring requirements are set for the smaller plants: every three years for plants in the categories 1-5 and 5-20MW, annually for 20-50 MW plants.
Financial and non-financial support	Financial and non-financial support could be envisaged by Member State.

4.3.7. *Impacts on intra-EU competition*

Analysis of possible effects on competition (principally within the EU) of the various options shows that the overall effect of the additional costs on competition within and between sectors is relatively modest. This is because of the general applicability of the options, which bring the requirements for MCP more in line with those already imposed on larger installations. Clearly the absolute impacts would differ under the various options, i.e. depending on the levels at which ELVs are established and the regulatory approach taken. However, all of the options should have only very limited effects on liberalisation rules, no significant effect increasing barriers to entry and no effect on commercial rights. There is no one dominant supplier or dominant approach across the installations concerned. It is not envisaged that the options considered would impact on sectoral rules, unless specific exemptions were proposed. Neither option would appear to interfere with existing rules or corporate law. Member States will be affected in a similar way and base assumption would be that starting from the same level each country's average cost would be approximately the same, and that the differences are largely attributable to levelling up from a low base rather than any intrinsic country effect.

4.3.8. *Impacts on international competitiveness, trade, and investment flows*

The majority of MCP are used in local contexts meeting local heat and/or energy needs and those are unlikely to directly face international competition. There could be however some significant impact on competitiveness for certain industry sectors, particularly food and drink manufacturers and the greenhouse sector. These sectors face stiff competition from outside the EU. It is likely that at least a sub set of these users will have difficulty in passing on costs to their current markets and in the case of greenhouses there are well established competitors ready to compete from outside the EU. In food production the increasing commoditisation of the industry creates pressures for some producers and increases in costs will be difficult to pass on. Possible mitigation could focus on actions targeted at those specific sectors and are likely to be similar to the measures considered for reducing impacts on SMEs. Applying exemptions to those sectors / uses facing the greatest international competition could be an option and although quality and product differentiation may protect food and industry from some of the competition those arguments may be harder to make for greenhouses which compete with areas with abundant sunshine and warmth.

4.4. Social Impacts

The implementation of the proposed MCP instrument on the one hand will lead to costs for the companies that need to invest in pollution abatement equipment, but on the other hand generates income for the firms that manufacture and install the same equipment. The EU has a well-established abatement technology supply chain as the majority of the technologies currently being applied by larger combustion plants are also relevant for these smaller plants.

Where firms are able to pass on costs to downstream consumers, the additional production costs can be expected to have a small negative effect on real income through raising aggregate price levels, resulting in a reduction in consumption and consequently in employment.

Although general equilibrium effects may tip the balance one side or the other, a reasonable assumption is that that the overall effect would be fairly neutral.

It is acknowledged that certain specific sectors such as the food and drink sector and greenhouses, that find it difficult to pass on costs to consumers in light of international competition, could be adversely affected resulting in a reduction of production and, therefore, employment within the EU.

5. COMPARISON OF POLICY OPTIONS AND SELECTION OF PREFERRED OPTION

The comparison of options is based on qualitative or quantitative criteria related to the effectiveness, the efficiency and coherence in achieving the specific objectives defined in section 4.3 of the impact assessment, as follows:

1. Effectiveness:
   - Emission reduction;
2. Efficiency:
   - Pollutant abatement cost;
3. Coherence:

- EU compliance with international obligations;
- Administrative costs; Impacts on SMEs.

5.1. Emission reduction

The emission reductions of the options compared with "no EU action" in 2025 are (kt/y):

Option:	7A	7B	7C	7D	7E
SO2	139	127	127	135	137
NOx	338	288	76	107	159
PM	45	42	42	45	45

All options have the potential to make a substantial contribution to reducing the emission of pollutants.

5.2. Pollutant abatement cost

Table A12.20 summarises the pollutant abatement cost (€/t of pollutant reduced) for the five emission level options 7A-7E. The average abatement cost is calculated as the compliance cost divided by the associated emission reduction for each pollutant. This is compared to the range of damage costs avoided by reducing the same emissions (EMRC 2013, to be published). This shows that the abatement costs compare favourably with the damage costs under all options except for NOx where only options 7C, 7D and 7E are favourable from a cost-benefit perspective.

Table A12.20: Removal costs and avoided damage costs (€/t)

	Abatement cost per ton of pollutant reduced (€/t)					**Damage costs (€/t)**
Emission level option:	**7A**	**7B**	**7C**	**7D**	**7E**	
SO2	2600	1400	1400	1400	1500	7600 – 21200
PM	5200	2900	2900	2500	2800	14750-41650*
NO_X	7600	6300	500	800	2,900	5500-13900

* To allow comparison in this table, damage costs for PM2.5 (29500-83300€/t) have been reduced by half to account for the complex relationship between PM and PM2.5 (see footnote 1 to section 1.3 of this annex)

However, the costs associated to option 7E have a high sensitivity to the reference date chosen. Whereas for options 7A to 7D the costs for 2025 and 2030 are very close, this is not the case for option 7E where very stringent standards apply to new plants and costs increase with the rate of replacement of existing plants by new plants. In 2025 it is assumed that 27% of the plants will have been replaced; further replacement of existing plants by new plants after 2025 would entail significant additional NOx abatement costs in the order of 200-300€/ton per boiler and 3,900€/ton per engine or turbine.

5.3. EU compliance with international obligations

Out of the three options 7C, 7D and 7E that have the most favourable cost-benefit profile both options 7D and 7E allow the EU to fully comply with its international obligations under the Gothenburg Protocol. Option C does not allow such compliance for certain types of engines.

5.4. Administrative costs

The choice of the regulatory option has a limited impact on the cost-benefit ratio but is an important driver for administrative costs. The requirement under regulatory options R1 and R2 for each plant to have a permit would lead to higher administrative costs representing 18-29% of total costs but would also allow the consideration of the need for stricter conditions in order to ensure compliance with local air quality standards. Administrative costs are significantly lower for R3 (registration) and R4 (general binding rules) representing 1-2% of total costs. Unlike option R4, option R3 would allow mapping emissions of medium size plant and therefore improving knowledge and emission inventories.

5.5. Impacts on SMEs

By combining the emission level of options 7C or 7D having the most favourable cost-benefit profile with the low administrative cost regulatory options R3 or R4 the impact on SMEs are limited to 0.1 – 2.4% of the GOS. With emission level option 7E the impact on SMEs would reach 0.2 - 5.2% of GOS.

5.6. Option comparision summary

The comparison of options for each of the identified topic areas is based on qualitative criteria related to the effectiveness, the efficiency and coherence in achieving the specific objectives defined in section 4.3 of the impact assessment. The ratings applied are no effect (0), low (L), medium (M), high (H) and not applicable (NA).

	7A	**7B**	**7C**	**7D**	**7E**	**R1-R2**	**R3-R4**
Effectiveness	**H**	**H**	**H**	**H**	**H**	**NA**	**NA**
Efficiency	**L**	**H**	**H**	**H**	**M**	**NA**	**NA**
Coherence	**L**	**L**	**M**	**H**	**M**	**L**	**H**

The more detailed breakdown for the three criteria used to assess coherence is:

	7A	**7B**	**7C**	**7D**	**7E**	**R1-R2**	**R3-R4**
Administrative costs	**NA**	**NA**	**NA**	**NA**	**NA**	**L**	**H**

	7A	7B	7C	7D	7E	R1-R2	R3-R4
EU compliance with international obligations	**H**	**L**	**L**	**H**	**H**	**NA**	**NA**
Impacts on SMEs	**L**	**L**	**H**	**H**	**L**	**L**	**H**

In addition, unlike option R4, option R3 would allow mapping emissions of medium combustion plants and therefore improving knowledge and emission inventories, which would facilitate policy evaluation.

A summary table, showing the baseline and impacts of the options in 2025 is presented below (figures refer to regulatory option R3)

No EU action		Baseline 2025				
SO2 emissions (kt/y)		174				
NOx emissions (kt/y)		455				
PM emissions in (kt/y)		48				
Impact of policy options: emissions		7A	7B	7C	7D	7E
SO2 emission reduction (kt/y)		139	127	127	135 (79)•	137
NOx emission reduction (kt/y)		338	288	76	107 (108)•	159
PM* emission reduction (kt/y)		45	42	42	45 (26)•	45
Impact of policy options: costs		7A	7B	7C	7D	7E
Compliance costs for operators (M€/y)		3296	2226	355	382	790
Impact of policy options: total annual cost per enterprise as a proportion (%) of GOS		7A	7B	7C	7D	7E
Small enterprises	1-5 MW	2.6	1.8	0.3	0.3	0.6
	5-20 MW	13.4	9.9	1.5	1.7	3.4
	20-50 MW	21.5	11.9	2.0	2.4	5.2
Medium enterprises	1-5 MW	0.6	0.4	0.1	0.1	0.2
	5-20 MW	2.7	2.0	0.3	0.3	0.7
	20-50 MW	5.5	3.0	0.5	0.6	1.3

*for technical reasons this is expressed as total particulate matter; to be divided by a factor 2 to convert to PM2.5

Number in brackets (xx)[•] are calculated by IIASA 6C*, PM emission have been multiplied by a factor 2 to convert from PM2.5

5.7. Preferred option

The comparison indicates that the most favourable approach is emission level option 7D combined with regulatory option R3. This has a very favourable cost-benefit profile, combines low compliance costs with low administrative costs, allows the EU to fully comply with its international obligations, and limits the economic impacts on SMEs. This combination also incorporates the mitigation measures selected in section 3.3.6.7.

Whilst options 7D and R3 come out as most favourable for taking action at EU level, in particular situations such as for instance air quality management zones in non-compliance with the AAQD limit values, Members States and local authorities might need to adopt stricter abatement measures, such as those reflected in the emission level option 7E.

6. MONITORING AND EVALUATION

Monitoring of the implementation and impact of measures on MCP will be based on streamlined and targeted reporting requirements on the Member States focusing on the key data which are necessary to assess the extent to which the objectives of the legislation are being achieved. The Commission will evaluate the results of this policy in 2023. On that basis the legislation will be revised as necessary.

The following indicators will be monitored:

Objective	**Indicator**	**How monitored/calculated**	**Responsible authority**	**Reporting/review**
Emission reductions from MCP	Sectoral emissions of SO2, NOx, PM	Reporting of national emission totals from MCP estimated on the basis of plant registrations	Designated national authorities (reported by the MS)	MS interim reporting in tri-annual reporting in 2020 Review in 2023 based on MS implementation reports

APPENDIX 12.1 EMISSION VALUES FOR THE DIFFERENT OPTIONS

Emission values used for options 7A, 7B,and 7C

Option	Rated thermal input (MW)	SO_2 (mg/Nm^3)				NO_X (mg/Nm^3)					PM (mg/Nm^3)		
		Solid Biomass	**Other solid fuel**	**Liquid fuel**	**Other gaseous fuel**	**Solid Biomass**	**Other solid fuel**	**Liquid fuel**	**Natural gas**	**Other gaseous fuel**	**Solid Biomass**	**Other solid fuel**	**Liquid fuel**
Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of biomass and other solid fuels)													
Option 7A Most stringent MS	1-5	200	200	200	5	200	100	120	70	150	8	50	5
	5-20	200	200	200	5	145	100	120	70	164	5	20	5
	20-50	200	200	200	5	145	100	120	70	164	5	20	5
Option 7B: LCP	1-5	200	400	350	35	300	300	450	100	200	30	30	30
	5-20	200	400	350	35	300	300	450	100	200	30	30	30
	20-50	200	400	350	35	300	300	450	100	200	30	30	30
Option 7C: Primary NOx	1-5	200	400	350	35	700	880	650	290	290	30	30	30
	5-20	200	400	350	35	680	680	630	280	280	30	30	30
	20-50	200	400	350	35	680	680	490	490	250	30	30	30
Engines and turbines (reference oxygen content: 15%)													
Option 7A Most stringent MS	1-5	-	-	200	5	-	-	46	33	48	-	-	3
	5-20	-	-	200	5	-	-	46	33	33	-	-	3
	20-50	-	-	200	5	-	-	46	33	33	-	-	3
Option 7B: LCP	1-5	-	-	350	35	-	-	450	75	110	-	-	30
	5-20	-	-	350	35	-	-	450	75	110	-	-	30
	20-50	-	-	350	35	-	-	450	75	110	-	-	30
Option 7C: Primary NOx	1-5	-	-	350	35	-	-	470	250	210	-	-	30
	5-20	-	-	350	35	-	-	560	250	210	-	-	30
	20-50	-	-	350	35	-	-	430	310	250	-	-	30

Emission values used for option 7D

SO_2 (mg/Nm^3) *existing combustion plants*

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)						
	Rated thermal input (MW)	**SO_2 (mg/Nm^3)**				
		Solid Biomass	**Other solid fuels**	**Other liquid fuels than HFO**	**Heavy Fuel Oil (HFO)**	**Gaseous fuels other than natural gas**
	1<50	200	400	170	350	35
Engines and gas turbines (reference oxygen content: 15%)						
	Rated thermal input (MW)	**SO_2 (mg/Nm^3)**				
				Liquid fuels		**Gaseous fuels other than natural gas**
	1<50	-	-	60		15

NOx (mg/Nm3) existing combustion plants

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)							
	Rated thermal input (MW)	**NO_X (mg/Nm^3)**					
		Solid Biomass	**Other solid fuel**	**Other liquid fuels than HFO**	**Heavy Fuel Oil (HFO)**	**Natural gas**	**Gaseous fuels other than natural gas**
	1 - <50	650	650	200	650	200	250
Engines and gas turbines (reference oxygen content: 15%)							
	Rated thermal input (MW)	**NO_X (mg/Nm^3)**					
				Liquid fuels		**Natural gas**	**Gaseous fuels other than natural gas**
Gas Engines	1<50	-	-	-		190	190
Diesel Engines	1<50			1,850 (construction commenced before 17 May 2006) 190 (construction commenced on or after 18 May 2006)		-	-
Dual fuel engines	1<50			1,850		380	380
Gas turbines	1<50			200		150	200

PM (mg/Nm3) existing combustion plants

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)					
Rated thermal input (MW)	PM (mg/Nm^3)				
	Solid Biomass	Other solid fuels	Other liquid fuels than HFO	Heavy Fuel Oil (HFO)	
1<50	30	30	30	30	-
Engines and gas turbines (reference oxygen content: 15%)					
Rated thermal input (MW)	PM (mg/Nm^3)				
			Liquid fuels		
1<50	-	-	10		-

SO2 (mg/Nm3) new combustion plants

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)					
Rated thermal input (MW)	SO_2 (mg/Nm^3)				
	Solid Biomass	Other solid fuels	Other liquid fuels than HFO	Heavy Fuel Oil (HFO)	Gaseous fuels other than natural gas
1<50	200	400	170	350	35
Engines and gas turbines (reference oxygen content: 15%)					
Rated thermal input (MW)	SO_2 (mg/Nm^3)				
			Liquid fuels		Gaseous fuels other than natural gas
1<50	-	-	60		15

NOx (mg/Nm3) new combustion plants

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)							
	Rated thermal input (MW)	**NO_X (mg/Nm^3)**					
		Solid Biomass	**Other solid fuel**	**Other liquid fuels than HFO**	**Heavy Fuel Oil (HFO)**	**Natural gas**	**Gaseous fuels other than natural gas**
	1 - <50	300	300	200	300	100	200

Engines and gas turbines (reference oxygen content: 15%)						
	Rated thermal input (MW)	**NO_X (mg/Nm^3)**				
				Liquid fuel	**Natural gas**	**Gaseous fuels other than natural gas**
Gas, Dual Fuel and Diesel Engines	1<50	-	-	190	95	190
Gas turbines	1<50			75	50	75

PM (mg/Nm3) new combustion plants

Boilers (reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid fuels)					
	Rated thermal input (MW)	**PM (mg/Nm^3)**			
		Solid Biomass	**Other solid fuels**	**Liquid fuels**	
	1<50	20	20	20	-

Engines and gas turbines (reference oxygen content: 15%)					
	Rated thermal input (MW)	**PM (mg/Nm^3)**			
				Liquid fuels	
	1<50	-	-	10	-

Emission values used for option 7E
(emission values for existing plants are the same as for option 7D)

Rated thermal input (MW)	SO_2 (mg/Nm^3)				NO_X (mg/Nm^3)					particulate matter (mg/Nm^3)		
	Solid Biomass	Coal, lignite and other solid fuel	Liquid fuel	Gaseous fuel other than natural gas	Solid Biomass	Coal, lignite and other solid fuel	Liquid fuel	Natural gas	Gaseous fuel other than natural gas	Solid Biomass	Coal, lignite and other solid fuel	Liquid fuel
Combustion plants other than engines and gas turbines **(reference oxygen content: 3% in case of gaseous and liquid fuels and 6% in case of solid biomass, coal, lignite and other solid fuels)**												
1-5	150	200	200	5	200	100	120	70	70	8	5	5
5-20					145				70	5	5	
20-50												
Engines and gas turbines **(reference oxygen content: 15%)**												
1-50	-		60	2	-		46	33	33			3

Appendix 12.2 Emission for 2025 and 2030 for options 7A, 7B and 7C.

SO2 emissions (kt/year)

Emission level option:	2010	2025			2030		
		1: No EU action	7B: LCP	7A: most stringent MS	1: No EU action	7B: LCP	7A: most stringent MS
1-5 MW	103	58	13	9	56	12	9
5-20 MW	130	67	17	12	65	16	12
20-50 MW	68	49	17	14	45	15	13
TOTAL 1-50 MW	301	174	47	35	166	44	34

NOx emissions (kt/year)

Emission level option:	2010	2025				2030			
		1: no EU action	7C: primary NOx	7B: LCP	7A: most stringent MS	1: no EU action	7C: primary NOx	7B: LCP	7A: most stringent MS
1-5 MW	210	170	140	63	46	175	136	61	45
5-20 MW	227	188	149	62	47	192	147	61	47
20-50 MW	117	98	90	42	24	97	89	41	24
TOTAL 1-50 MW	554	455	379	167	117	463	372	163	116

PM emissions (kt/year)

	2010	2025			2030		
Emission level option:		1: No EU action	7B: LCP	7A: most stringent MS	1: No EU action	7B: LCP	7A: most stringent MS
1-5 MW	17	13	2	1	16	2	1
5-20 MW	20	20	2	1	19	2	1
20-50 MW	16	15	2	1	13	2	1
TOTAL 1-50 MW	53	48	6	3	48	6	3

APPENDIX 12.3 OVERVIEW OF ANNUALISED COMPLIANCE COSTS (€M/YEAR) UNDER OPTIONS 7C, 7B AND 7A (INCREMENTAL COSTS TO OPTION 1)

Pollutant	Capacity class	2025			2030		
	Emission level option:	7C: primary NOx	7B: LCP	7A: most stringent MS	7C: primary NOx	7B: LCP	7A: most stringent MS
SO_2	1-5 MW	90	90	210	86	86	188
	5-20 MW	68	68	123	64	64	113
	20-50 MW	27	27	44	25	25	40
	TOTAL 1-50 MW	185	185	377	174	174	341
NO_X	1-5 MW	27	821	1,119	27	811	1,075
	5-20 MW	18	785	1,018	18	773	994
	20-50 MW	3	311	543	3	314	534
	TOTAL 1-50 MW	48	1,918	2,680	48	1,898	2,603
PM	1-5 MW	55	55	84	53	53	82
	5-20 MW	41	41	77	41	41	75
	20-50 MW	27	27	77	26	26	75
	TOTAL 1-50 MW	123	123	239	121	121	232
Total	1-5 MW	171	966	1,413	166	950	1,345
	5-20 MW	127	895	1,218	123	878	1,183
	20-50 MW	57	365	665	54	365	649
	TOTAL 1-50 MW	355	2,225	3,296	343	2,193	3,176

APPENDIX 12.4 ANNUALISED COMPLIANCE COSTS (€M/YEAR) PER MEMBER STATE UNDER OPTION 7D

SO_2 compliance costs TOTAL 1-50 MW (€m/yr)	**Option 7D 2025**	**NOx compliance costs TOTAL 1-50 MW (€m/yr)**	**Option 7D 2025**	**PM compliance costs TOTAL 1-50 MW (€m/yr)**	**Option 7D 2025**
AT	5,3	AT	0,7	AT	0,5
BE	7,8	BE	5,9	BE	4,8
BG	1,4	BG	3,7	BG	3,7
CY	0,6	CY	0,1	CY	0,2
CZ	3,4	CZ	0,3	CZ	2,1
DE	63,9	DE	13,9	DE	18,8
DK	9,6	DK	4,0	DK	8,9
EE	4,7	EE	0,5	EE	2,9
EL	0,2	EL	0,4	EL	0,3
ES	8,1	ES	8,2	ES	6,4
FI	2,8	FI	0,9	FI	1,9
FR	29,0	FR	9,2	FR	18,2
HU	3,5	HU	2,8	HU	2,2
IE	10,0	IE	3,1	IE	8,6
IT	2,4	IT	7,0	IT	1,2
LT	3,5	LT	1,5	LT	2,2
LU	-	LU	0,2	LU	-
LV	0,9	LV	0,8	LV	3,8
MT	0,1	MT	-	MT	-
NL	-	NL	0,4	NL	0,1
PL	13,8	PL	1,9	PL	9,2
PT	2,3	PT	0,7	PT	3,6
RO	2,6	RO	2,6	RO	4,0
SE	2,2	SE	2,7	SE	5,9
SI	0,1	SI	0,9	SI	1,2
SK	0,2	SK	0,4	SK	2,3
UK	4,6	UK	10,6	UK	2,6

ANNEX 13 REFERENCES

AEA, 2005. Damages per tonne emission of PM2.5, NH3, SO2, NOx and VOCs from each
EU25 Member State (excluding Cyprus) and surrounding seas.
http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf

AEA, 2008. Analysis of the Costs and Benefits of Proposed Revisions to the National Emission Ceilings Directive.
http://ec.europa.eu/environment/air/pollutants/pdf/necd_cba_3.pdf

AEAT, 2007. Assessment of the benefits and costs of the potential application of the IPPC Directive (EC/96/61) to industrial combustion installations with 20-50 MW rated thermal input. Final Report to the European Commission.
http://www.cafe-cba.org/assets/ippc_ec_thernal_input.pdf

AMEC, 2012A. Collection and analysis of data to support the Commission in reporting in line with Article 73(2)(a) of Directive 2010/75/EU on industrial emissions on the need to control emissions from the combustion of fuels in installations with a total rated thermal input below 50 MW. Final Report for the European Commission.

AMEC, 2012B. Analysis and summary of the Member States' emission inventories 2007-2009 and related information under the LCP Directive (2001/80/EC). Final Report for the European Commission.

AMEC, 2013. Analysis of the impacts of various options to control emissions from the combustion of fuels in installations with a total rated thermal input below 50. To be published.

Compassion in World Farming, 2012. Egg production in the EU - Information sheet.
http://www.compassionlebensmittelwirtschaft.de/wp-content/uploads/2012/05/Info-1-Egg-production-in-the-EU.pdf.pdf

CSES, 2013. Fitness Check of the Legal Framework for the Type-Approval of Motor Vehicles.
http://ec.europa.eu/enterprise/sectors/automotive/files/projects/report-cses-fitness-check_en.pdf

Danish Ministry of the Environment, 2012. Economic Impact Assessment for the establishment of a NECA in the North Sea, Environmental Project no. 1427.
http://www2.mst.dk/Udgiv/publications/2012/06/978-87-92903-20-4.pdf

EC, 2006. Competitiveness of the European Food Industry: An Economic and Legal Assessment 2007.
http://ec.europa.eu/enterprise/sectors/food/files/competitiveness_study_en.pdf

EC, 2011. Prospects for Agricultural Markets and Income in the EU 2011-2020.
http://ec.europa.eu/agriculture/publi/caprep/prospects2011/fullrep_en.pdf

EC, 2012A. Consultation on options for revision of the EU Thematic Strategy on Air Pollution and related policies.
http://ec.europa.eu/environment/consultations/air_pollution_en.htm

EC, 2012B. Prospects for Agricultural Markets and Income in the EU 2012-2022.
http://ec.europa.eu/agriculture/publi/caprep/prospects2012/fullrep_en.pdf

ECN, 2008. Onderbouwing actualisatie BEES B: Kosten en effecten van de voorgenomen wijziging van het besluit emissie-eisen stookinstallaties B.
http://www.ecn.nl/docs/library/report/2008/e08020.pdf

Ecologic Institute, 2011. Final report for the assessment of the 6th environmental action programme.
http://www.ecologic.eu/files/attachments/Projects/2010/ecologic_6eap_report.pdf

Ecorys, 2013A. Report on the consultation on options for revision of the EU Thematic Strategy on Air Pollution and related policies.
http://ec.europa.eu/environment/air/pdf/review/TSAP%20Consultation%20report.pdf

Ecorys, 2013B. Services to assess the reasons for non-compliance with the ozone target values set by Directive 2008/50. To be published.

EEA, 2010. Air pollution — SOER 2010 thematic assessment.
http://www.eea.europa.eu/soer/europe/air-pollution

EEA, 2012A. Air Quality in Europe - 2012 Report.
http://www.eea.europa.eu/publications/air-quality-in-europe-2012

EEA, 2012B. Evaluation of progress under the EU National Emission Ceilings Directive - Technical report No 14/2012.
http://www.eea.europa.eu/highlights/publications/evaluation-progress-nec-2012

EEA, 2012C. Air pollution by ozone across Europe during summer 2012.
http://www.eea.europa.eu/publications/air-pollution-by-ozone-across-EU-2012

EEA, 2013A. European Union emission inventory report 1990–2011 under the UNECE Convention on Long-range Transboundary Air Pollution (LRTAP).
http://www.eea.europa.eu/publications/eu-emission-inventory-report-lrtap

EEA, 2013B. Air Implementation Pilot, Lessons learnt from the implementation of air quality legislation at urban level.
http://www.eea.europa.eu/publications/air-implementation-pilot-2013

EEA,2013C. NEC Directive status report 2012.
http://www.eea.europa.eu/publications/nec-directive-status-report-2012/at_download/file

EGTEI, 2010. Options for limit values for emissions of dust from small combustion installations < 50 MWth.
http://www.unece.org/fileadmin/DAM/env/documents/2010/eb/wg5/wg47/Informal%20documents/Info.%20doc%209_Options%20for%20PM%20ELVs%20for%20SCI%20%20final.pdf

EMRC, 2013. Cost-benefit Analysis of Policy Scenarios for the Revision of the Thematic Strategy on Air Pollution. To be published.

Entec UK, 2005. National Emission Ceilings Directive Review Task 1: In-depth analysis of the NEC national programmes.
http://ec.europa.eu/environment/air/pollutants/pdf/final_report.pdf

Entec, 2009. Study to inform on-going discussions on the proposal for a Directive on industrial emissions. Part 1: Combustion Activities. Final Report to the European Commission.

Environment Agency Austria, 2012. Review of the Air Quality Directive and the 4th Daughter Directive, Service request no 6 under FW contract ENV.C.3/FRA/2009.0008. Final report 2012.
http://ec.europa.eu/environment/air/pdf/review/SC6_final_report_v121210[1].pdf

EURELECTRIC, 2012. Power Statistics & Trends 2012 - synopsis.
http://www.eurelectric.org/media/69408/synopsis_2012_hr-2012-180-0001-01-e.pdf

Eurobarometer, 2013. Attitudes of Europeans towards air quality.
http://ec.europa.eu/public_opinion/archives/flash_arch_360_345_en.htm#360

Europia, 2011. Annual Report.
https://www.europia.eu/Content/Default.asp?PageID=412&DocID=35264

EUWEP, 2011. The EU Egg Industry - Welfare of Laying Hens, Presentation to Multi-Stakeholders Meeting on Implementation of Council Directive 1999/74/EC (Brussels,
19 January 2011).
http://ec.europa.eu/food/animal/welfare/farm/docs/19012011_4%20Industry%27s%20perspective%20-%20Williams.pdf

Finland's environmental administration, 2003. (Summary of) Best Available Techniques in Small 5-50 MW Combustion Plants in Finland. provided by personal communication with Competent Authority, 22.12.2008.
http://www.environment.fi/default.asp?contentid=23847&lan=fi

HTAP, 2010. Executive Summary of the LRTAP Task Force on Hemispheric Transport of Air Pollution (HTAP).
http://www.htap.org/

IIASA, 2012A. The potential for further controls of emissions from mobile sources in Europe.
http://ec.europa.eu/environment/air/pdf/review/TSAP-TRANSPORT-v2-20121128.pdf

IIASA, 2012B. TSAP-2012 Baseline: Health and Environmental Impacts.
http://ec.europa.eu/environment/air/pdf/tsap_impacts.pdf

IIASA, 2012C. Factors determining recent changes of emissions of air pollutants in Europe.
http://ec.europa.eu/environment/air/pdf/review/TSAP-DISTANCE-20120612[1].pdf

IIASA, 2012D. Future emissions of air pollutants in Europe – Current legislation baseline and the scope for further reductions.
http://ec.europa.eu/environment/air/pdf/review/TSAP-BASELINE-20120613[1].pdf

IIASA, 2012E. Emissions from households and other small combustion sources and their reduction potential.
http://ec.europa.eu/environment/air/pdf/review/TSAP-SMALL_SOURCES-20120612[1].pdf

IIASA, 2012F. Emissions from agriculture and their control potentials.
http://ec.europa.eu/environment/air/pdf/review/TSAP-AGRI-20121129_v21.pdf

IIASA, 2013A. Policy Scenarios for the Revision of the Thematic Strategy on Air Pollution.
http://ec.europa.eu/environment/air/pdf/review/TSAP-Report-10.pdf

IIASA, 2013B. Modelling compliance with NO2 and PM10 air quality limit values in the GAINS model.
http://ec.europa.eu/environment/air/pdf/review/TSAP-Report-.pdf

JRC, 2007. Small combustion installations: Techniques, emissions and measures for emission reduction. European Commission - Joint Research Centre.
http://publications.jrc.ec.europa.eu/repository/handle/111111111/229

JRC, 2010. Evaluation of the livestock sector's contribution to the EU greenhouse gas emissions (GGELS), Final report.
http://ec.europa.eu/agriculture/analysis/external/livestock-gas/full_text_en.pdf

JRC-IPTS, 2013. Market based instruments to reduce air emissions from household heating appliances: Analysis of scrappage policy scenarios. To be published.

LEI Wageningen UR, 2009, Competitiveness of the EU dairy industry.
http://www.lei.dlo.nl/publicaties/PDF/2009/2009-011.pdf

Norwegian Meteorological Institute, 2012A. Transboundary Acidification, Eutrophication
and Ground Level Ozone in Europe in 2010.
http://emep.int/publ/reports/2012/status_report_1_2012.pdf

Norwegian Meteorological Institute, 2012B.Transboundary air pollution by main pollutants (S, N, O3) and PM in 2010 - Belgium.
http://www.emep.int/publ/reports/2012/Country_Reports/report_BE.pdf

Sutton, M. A. et al., 2011. The European Nitrogen Assessment: Sources, Effects and Policy Perspectives. Cambridge University Press.

TFEIP, 2012. Black carbon inventory study.
http://tfeip-secretariat.org/2012-tfeip-meeting-bern/

TNO, 2012A. Survey of view of stakeholders, experts and citizens on the review of EU Air Policy. Part II: Detailed results.
http://ec.europa.eu/environment/air/pdf/review/Survey%20AQD%20review%20-%20Part%20II%20Detailed%20results.pdf

TNO, 2012B. Final report of the PM Workshop Brussels 18-19 June 2012. http://ec.europa.eu/environment/air/pdf/review/TNOreport_FinalMinutesPMWorkshop.pdf
Uk Government, 1993. Clean Air Act 1993.
http://www.legislation.gov.uk/ukpga/1993/11/contents

UNECE, 2011. Air Pollution Studies No20: Policy-relevant science questions.
http://www.unece.org/index.php?id=25373

UNEP, 2008. Atmospheric Brown Cloud Regional Assessment.
www.unep.org/pdf/ABCSummaryFinal.pdf

UNEP, 2011. Near-term climate protection and clean air benefits: actions for controlling short lived climate forcers.
http://www.unep.org/publications/ebooks/slcf/

VITO, 2011. Beste Beschikbare Technieken (BBT) voor nieuwe, kleine en middelgrote stookinstallaties, stationaire motoren en gasturbines gestookt met fossiele brandstoffen.
http://www.emis.vito.be/bbt-studie-stookinstallaties-en-stationaire-motoren-nieuwe-kleine-en-middelgrote

VITO, 2013. Specific evaluation of emissions from shipping including assessment for the establishment of possible new emission control areas in European Seas.
http://ec.europa.eu/environment/air/pdf/review/Main%20Report%20Shipping.pdf

WHO, 2013A. REVIHAAP and HRAPIE projects.
http://www.euro.who.int/en/what-we-do/health-topics/environment-and-health/air-quality/activities/health-aspects-of-air-pollution-and-review-of-eu-policies-the-revihaap-and-hrapie-projects

WHO, 2013B. Review of Evidence on Health Aspects of Air Pollution - REVIHAAP Project.
http://www.euro.who.int/__data/assets/pdf_file/0004/193108/REVIHAAP-Final-technical-report.pdf