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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

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TABLE OF CONTENTS

PART 1/4

1. INTRODUCTION 15

2. PROCEDURAL ISSUES, IMPACT ASSESSMENT BOARD, USE OF EXPERTISE AND CONSULTATION OF INTERESTED PARTIES 15

2.1. Procedural issues 15

2.2. Impact Assessment Board 15

2.3. Use of Expertise and Consultation of interested parties 16

3. REVIEW OF CURRENT POLICY, PROBLEM DEFINITION AND SUBSIDIARITY 17

3.1. The air pollution problem and the policy framework under review 17

3.1.1. The problem 17

3.1.2. The current policy framework 17

3.2. Review of the current policy framework 18

3.2.1. Past reduction of air pollutant emissions and impacts 18

3.2.2. Validity of objectives and scope, and overall coherence 19

3.3. Key outstanding problems 20

3.3.1. Health and environmental impacts of air pollution in the EU remain large 20

3.3.2. EU air quality standards are widely exceeded in densely-populated areas 22

3.3.3. The EU is not on track to meet its long-term air quality objective 23

3.4. The main underlying drivers or causes of the outstanding problem 24

3.4.1. Exceedance of EU air quality standards 24

3.4.1.1. Diesel emissions drive the NO2 and NOx compliance problems 24

3.4.1.2. Small scale combustion and concentrated local pollution drive the worst PM compliance problems 25

3.4.1.3. Poor co-ordination between national and local action, and lack of capacity at regional and local level 26

3.4.2. The EU is not on track to meet its long-term air quality objective 27

3.4.2.1. The remaining health impacts from PM and ozone are driven by emissions from a range of sectors 27

3.4.2.2. Agricultural ammonia emissions drive the remaining environmental impacts 27

3.4.2.3. Sustained background pollution means that local action alone cannot effectively reduce impacts 28

3.4.2.4. There remain gaps in the information base for assessing and managing air pollution 29

3.5. How will the problem evolve? 29

3.5.1. Future trends in air pollution impacts 30

3.5.2. *Compliance prospects under the current legislation scenario* 31
3.5.3. *Uncertainties and risks associated with baseline projections* 34
3.6. Who is affected and how?..35
3.7. Justification of EU action 35
3.7.1. *Why can the objectives not be achieved sufficiently by the Member States?* 36
3.7.2. *Can objectives be better achieved by action by the Community?*..............................36
4. OBJECTIVES 37
4.1. The long-term strategic objective 37
4.2. General objectives relating to updating the present strategy 37
4.2.1. *Ensure compliance with present air quality policies, and coherence with international commitments, by 2020 at the latest* 37
4.2.2. *Achieve substantial further reduction in health and environmental impacts in the period up to 2030* 37
4.3. Specific objectives 37
4.4. Coherence with other policies 38
4.5. Organisation of the remainder of the impact assessment 39
5. ACHIEVING THE COMPLIANCE OBJECTIVE BY 2020 AT THE LATEST.............................39
5.1. Options to achieve compliance with the existing air policy framework 39
5.1.1. *Option 1: No additional EU action* 39
5.1.2. *Options 5A-5E: Further EU action to facilitate compliance with the air quality framework* 41
5.2. Analysis of impacts..42
5.2.1. *Method* 42
5.2.2. *Environmental Impacts* 42
5.2.3. *Economic and Social Impacts*...45
5.3. Comparison of options...46
5.4. Conclusions..48
6. . ACHIEVING FURTHER HEALTH AND ENVIRONMENTAL IMPACT REDUCTIONS UP TO 2030 48
6.1. Methodology..49
6.2. The policy options 49
6.2.1. *Option 1: No further EU action*..49
6.2.2. *Options 6A-6E: Additional Technical Reduction Measures*......................................49
6.3. Impact of options 52
6.3.1. *Health and environmental impacts*..52
6.3.2. *Economic impacts* 53

6.3.2.1. Direct expenditure to reach compliance 53
6.3.2.2. Affected industries and sectorial impacts 54
6.3.2.3. Direct economic benefits due to reduced health and environmental impacts: 56
6.3.2.4. Generalized economic benefits from reduced health-related external costs 57
6.3.2.5. Broader economic impacts 57
6.3.3. *Social impacts* 59
6.4. Comparison of the options 59
6.5. Sensitivity analysis 61
6.5.1. *Changes in the target year* 62
6.5.2. *Interactions with climate policy* 62
6.5.3. *Marginal deviations from the preferred option* 63
6.5.4. *Targets for ozone, acidification and eutrophication* 64
6.5.5. *Addressing methane emissions* 65
6.5.6. *Robustness to variations in the key analytical assumptions* 66
6.5.7. *Burden sharing between Member States* 67
6.5.8. *Summary of sensitivity analysis* 67
6.6. Policy instruments to achieve the targets 68
6.6.1. *National Emission Ceilings Directive* 68
6.6.2. *Source controls* 68
6.7. Competitiveness and SME impacts 72
6.8. Trajectory to achieving the long-term objective by 2050 72
6.9. Conclusions 73
7. ANALYSIS OF OPTIONS TO REDUCE EMISSIONS FROM MEDIUM COMBUSTION PLANTS 74
7.1. Rationale for Action 74
7.2. Characteristics of the sector 74
7.3. Methodology 75
7.4. Policy options 75
7.5. Impact analysis 76
7.5.1. Environmental impacts 76
7.5.2. Economic impacts 77
7.5.3. Comparison of options 78
7.6. Conclusions and preferred option 79
8. SUMMARY 80
9. MONITORING AND EVALUATION 83
9.1. Monitoring and evaluation of the revised TSAP 83

9.2. Monitoring and evaluation of the revised NECD 84
9.3. Monitoring and evaluation of the proposed legal instrument on MCP 84
ANNEX 1 GLOSSARY 85
ANNEX 2 USE OF EXPERTISE AND CONSULTATION OF INTERESTED PARTIES 86
1.1. External expertise 86
1.2. Consultation of interested parties 87
1.1.1 Online consultations 87
1.1.2 Stakeholder meetings...90
ANNEX 3 AIR POLLUTION IMPACTS AND SOURCES..92
1. THE MAIN AIR POLLUTION IMPACTS 92
1.1. Health Effects 92
1.2. Acidification 93
1.3. Eutrophication...93
1.4. Ground-Level Ozone Pollution..94
1.5. Climate change 95
2. THE MAIN AIR POLLUTANTS AND THEIR ASSOCIATED IMPACT PATHWAYS...................95
3. THE MAIN SOURCES OF AIR POLLUTION 96
ANNEX 4 REVIEW OF THE EXISTING EU AIR QUALITY POLICY FRAMEWORK 98
1. INTRODUCTION 98
2. THE SCOPE AND PROCEDURE FOR THE REVIEW...98
2.1. What was reviewed? 98
2.2. How was the review organised? 100
2.2.1. Design of the review 100
2.2.2. Conduct of the review 100
2.2.3. Dissemination and use 101

PART 2/4

3. THE THEMATIC STRATEGY ON AIR POLLUTION 102
3.1. Objectives, scope and approach..102
3.2. Monitoring, Reporting and Evaluation 103
3.3. Relevance...104
3.4. Effectiveness...105
3.5. Efficiency...108
3.6. Relation of the TSAP analysis to emission ceilings and ambient air quality targets110
4. THE AMBIENT AIR QUALITY DIRECTIVES..110

4.1. Objectives, scope and approach 110
4.2. Monitoring, reporting and evaluation 111
4.3. Relevance 112
4.4. Effectiveness 114
4.5. Efficiency 121
5. THE NATIONAL EMISSION CEILINGS DIRECTIVE 122
5.1. Objectives, scope and approach 122
5.2. Monitoring and Evaluation 123
5.3. Relevance 123
5.4. Effectiveness 124
5.5. Efficiency 126
6. EU SOURCE CONTROL MEASURES 127
6.1. Objectives, scope and approach 127
6.2. Monitoring, reporting and evaluation 128
6.3. Relevance 128
6.4. Effectiveness 130
6.5. Efficiency 133
7. NATIONAL AND LOCAL SOURCE CONTROL MEASURES 135
7.1. Objectives, scope and approach 135
7.2. Monitoring, Reporting and Evaluation 135
7.3. Relevance 135
7.4. Effectiveness 136
7.5. Main orientations for the future 137
8. INTERNATIONAL ACTION TO REDUCE AIR POLLUTION 138
8.1. Objectives, scope and approach 138
8.2. Monitoring, Evaluation, and Enforcement Provisions 139
8.3. Relevance 140
8.4. Effectiveness 140
8.5. Efficiency 141
9. COHERENCE OF THE OVERALL FRAMEWORK 141
9.1. International pollution 141
9.2. Background and transboundary pollution within the EU 142
9.3. Local pollution 142
9.4. Analytical framework for the Thematic Strategy on Air Pollution 143
10. CONCLUSIONS AND ORIENTATIONS FOR THE REVIEW 143

10.1. Validity of objectives and scope, and overall coherence....143
10.2. Main outstanding problems....144
10.3. Main drivers of the outstanding problems....144
10.4. Orientations for the review....145
APPENDIX 4.1 SPECIFIC EVALUATION STUDIES LAUNCHED FOR INDIVIDUAL POLICY INSTRUMENTS AND THE DETAILED QUESTIONS ADDRESSED....146
1. THE THEMATIC STRATEGY ON AIR POLLUTION (TSAP)....146
2. THE AMBIENT AIR QUALITY DIRECTIVES (AAQD)....146
3. THE NATIONAL EMISSION CEILINGS DIRECTIVE (NECD)....146
4. SECTOR POLLUTION CONTROL POLICIES....147
APPENDIX 4.2 EU VERSUS INTERNATIONAL AIR QUALITY STANDARDS....148
APPENDIX 4.3 EXAMPLES OF NATIONAL AND LOCAL AIR QUALITY MANAGEMENT MEASURES153
APPENDIX 4.4: ILLUSTRATING LOCAL ACTION TO REDUCE AIR POLLUTANT --THE DRESDEN CASE 165
APPENDIX 4.5 MARKET BASED INSTRUMENTS (MBIS) FOR PROMOTING CLEAN HOUSEHOLD HEATING APPLIANCES....158
APPENDIX 4.6 LESSONS LEARNED FROM THE "AIR IMPLEMENTATION PILOT"....159
ANNEX 5 FUTURE AIR QUALITY PROJECTIONS ASSUMING NO CHANGE IN CURRENT POLICIES161
1. METHODOLOGY FOR PROJECTING FUTURE EMISSIONS AND AIR QUALITY IMPACTS....161
2. MAIN ASSUMPTIONS AND RELATED UNCERTAINTIES....161
3. EU POLICIES INCLUDED IN THE CURRENT LEGISLATION (CLE) BASELINE....163
4. FUTURE AIR POLLUTANT EMISSIONS UNDER THE CURRENT POLICY SCENARIO....166
4.1. Sulphur dioxide....166
4.2. Nitrogen oxides....167
4.3. Fine particulate matter....167
4.4. Ammonia....168
4.5. Volatile organic compounds....169

PART 3/4

5. BASELINE....177
5.1 Compliance with NO2 limit values....177
5.2 Compliance with PM10 limit values....179
5.3 Compliance with PM2,5 standards....182
6. FUTURE AIR POLLUTION IMPACTS UNDER THE BASELINE SCENARIO....183
6.1 Health impacts from PM2,5....183
6.2 Health impacts from ground level ozone....184

6.3 Eutrophication and biodiversity 185
6.4 Acidification 187
ANNEX 6 ELEMENTS OF A FUTURE EUROPEAN CLEAN AIR PROGRAMME TO SUPPORT MEMBER STATE ACTION ON REDUCING AIR POLLUTION 189
1. INTRODUCTION 189
2. ACTION TO IMPROVE THE URBAN AIR QUALITY 190
2.1. Action better identify and address key air pollution sources in urban areas 190
2.2. Action to improve the governance of air quality management at national and EU level 191
3. ACTION TO ABATE AGRICULTURAL AIR POLLUTION EMISSIONS 191
4. ACTION AT INTERNATIONAL LEVEL 192
ANNEX 7 ANALYSIS OF POLICY SCENARIOS RELATED TO TARGETS FOR THE PERIOD UP TO 2030 193
1. EMISSION REDUCTIONS DELIVERED BY THE RESPECTIVE OPTIONS 193
2. IMPACT REDUCTIONS DELIVERED BY THE RESPECTIVE OPTIONS FOR POST 2020 TARGETS 194
2.1. Health and environmental impacts 194
2.2. Economic impacts 195
2.2.1 Direct compliance costs 195
2.2.2. Affected industries and sectorial impacts 197
2.2.3. Direct economic benefits due to reduced health and environmental impacts 200
2.2.4. Broader economic impacts 201
2.3. Social impacts of gap-closure options 203
2.4. Monetised impacts of gap-closure options 204
3. POLICY INSTRUMENTS TO ACHIEVE THE INTERIM TARGETS 205
4. TRAJECTORY TO ACHIEVING THE LONG-TERM OBJECTIVE BY 2050 207
209
APPENDIX 7.1 EMISSION REDUCTIONS PER MEMBER STATE AND PER OPTION IN 2025 AND 2030 (% VS 2005) 210
APPENDIX 7.2 ANNUAL HEALTH IMPACTS DUE TO AIR POLLUTION PER OPTION IN 2025 AND 2030, EU 28 220
APPENDIX 7.3 IMPACT REDUCTIONS PER MEMBER STATE AND PER OPTION IN 2025 AND 2030 (% REDUCTIONS VS IMPACTS IN 2005) 222
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*230
APPENDIX 7.6 IMPACT REDUCTIONS IN THE MEMBER STATES IN 2025 AND 2030 IN THE CENTRAL CASE OPTION 6C* COMPARED TO OPTION 1 235

APPENDIX 7.7 INDICATIVE EMISSION TRAJECTORY TOWARDS ACHIEVING THE LONG-TERM OBJECTIVE IN 2050 237
ANNEX 8 SENSITIVITY ANALYSES AND RISK ASSESSMENTS 242
1. TESTING THE ROBUSTNESS OF THE CENTRAL CASE FOR CHANGES TO THE TARGET YEAR 242
2. INTERACTION WITH THE CLIMATE AND ENERGY PACKAGE 243
3. EMISSION REDUCTIONS DELIVERED BY FURTHER CLIMATE CHANGE MITIGATION POLICY 247
4. CHANGES TO THE GROWTH PROJECTIONS AND TO PROGRESS IN ENERGY EFFICIENCY AND RENEWABLES 248
5. BURDEN SHARING BETWEEN MEMBER STATES 252
6. FURTHER EMISSION CONTROLS FROM INTERNATIONAL MARITIME SHIPPING 253
7. POLICY INSTRUMENTS TO ACHIEVE THE INTERIM TARGETS: SOURCE CONTROLS AT EU LEVEL 257
7.1. EU-wide source controls in agriculture 258
7.2. EU-wide source controls for Medium Combustion Plants (MCP) 259
7.3. Updated BAT Conclusions under the IED 259
ANNEX 9 SECTORIAL IMPACTS & COMPETITIVENESS PROOFING 262
1. CONTEXT AND DEFINITIONS 262
2. SCOPING OF THE COMPETITIVENESS ANALYSIS 262
3. SUPPLY OF ABATEMENT TECHNOLOGY 263
4. DEMAND FOR ABATEMENT TECHNOLOGIES: DETAILED MEASURES AND EXPENDITURE PER SUB-SECTOR 263
5. SECTORIAL MARKET ANALYSIS 264
5.1. Metals (iron and steel; and non-ferrous metals) 266
5.2. Chemicals 270
5.3. Refining 273
5.4. Agriculture and livestock rearing 275
5.5. Power sector 282
5.6. Other energy intensive industries 286
5.6.1. Pulp and paper sector 286
5.6.2. Cement sector 287
5.6.3. Lime sector 287
5.6.4. Glass sector 288
6. CONCLUSIONS 292
ANNEX 10 CONTROLLING METHANE EMISSIONS 293
1. PROJECTED METHANE EMISSIONS ASSUMING NO CHANGE TO CURRENT POLICIES 293
2. DIFFERENCES BETWEEN MEMBER STATES 294

3. FURTHER REDUCTION POTENTIAL BEYOND THE BASELINE 295
ANNEX 11 DETAILED ANALYSIS OF SPECIFIC OBJECTIVES RELATED TO THE NECD 297
1. OBJECTIVES 297
2. POLICY OPTIONS 297
3. IMPACT ANALYSIS 299
4. SPECIFIC IMPACTS OF THE POLICY OPTIONS 300
5. OPTION COMPARISON 309
6. PREFERRED OPTION FOR REVISING THE NEC D 310
7. MONITORING AND EVALUATION 311
APPENDIX 11.1 STANDARD COST MODEL FOR ASSESSMENT OF ADMINISTRATIVE BURDEN ...312
APPENDIX 11.2 ADMINISTRATIVE COSTS BY MEMBER STATE OF PREFERRED OPTIONS (€) ...316
APPENDIX 11.3 MONITORING OF EFFECTS OF POLLUTANTS IN THE ENVIRONMENT 317
ANNEX 12 DETAILED ANALYSIS FOR MEDIUM COMBUSTION PLANTS (MCP) 319
1. RATIONALE FOR ACTION 319
2. CHARACTERISTICS OF THE SECTOR 319
2.1. Definition of MCP for the purpose of this assessment 319
2.2. Development of an EU-wide dataset 320
2.3. Reference situation in 2010 321
2.4. Overview of current regulation 325
2.4.1. EU legislation 325
2.4.2. Gothenburg Protocol 326
2.4.3. Member States' national legislation 327
3. POLICY OPTIONS 329
3.1. Options determining the emission levels 329
3.2. Regulatory options 330
4. IMPACT ANALYSIS 331
4.1. Methodology, assumptions and uncertainties 331
4.1.1. Main methodology 331
4.1.2. *Uncertainties with respect to input data* 332
4.1.3. *Modelling assumptions* 332
4.2. Environmental impacts 333
4.2.1. *SO2 emissions* 333
4.2.2. *NOX emissions* 333
4.2.3. *PM emissions* 334
4.2.4. *Overview of pollutant abatement achieved by the emission level options* 334

4.3. Economic impacts 335
4.3.1. *Compliance costs* 335
4.3.2. *Emission monitoring costs* 337
4.3.3. *Administrative costs* 338
4.3.4. *Total costs* 341
4.3.5. *Impacts on small and medium-sized enterprises (SMEs)* 343
4.3.6. *Measures to mitigate impacts on SMEs* 346
4.3.6.1. *Phased implementation* 346
4.3.6.2. *Sectoral exemptions or derogations* 346
4.3.6.3. *Size-related exemptions and derogations* 347
4.3.6.4. *Exemptions or derogations based on operating hours and/or emissions* 347
4.3.6.5. *Financial support* 348
4.3.6.6. *Non-financial support* 348
4.3.6.7. *Conclusion on mitigation measures* 348
4.3.7. *Impacts on intra-EU competition* 349
4.3.8. *Impacts on international competitiveness, trade, and investment flows* 350
4.4. Social Impacts 350
5. COMPARISON OF POLICY OPTIONS AND SELECTION OF PREFERRED OPTION 350
5.1. Emission reduction 351
5.2. Pollutant abatement cost 351
5.3. EU compliance with international obligations 352
5.4. Administrative costs 352
5.5. Impacts on SMEs 352
5.6. Option comparision summary 352
5.7. Preferred option 354
6. MONITORING AND EVALUATION 354
APPENDIX 12.1 EMISSION VALUES FOR THE DIFFERENT OPTIONS 355
APPENDIX 12.2 EMISSION FOR 2025 AND 2030 FOR OPTIONS 7A, 7B AND 7C. 360
APPENDIX 12.3 OVERVIEW OF ANNUALISED COMPLIANCE COSTS (€M/YEAR) UNDER OPTIONS 7C, 7B AND 7A (INCREMENTAL COSTS TO OPTION 1) 361
APPENDIX 12.4 ANNUALISED COMPLIANCE COSTS (€M/YEAR) PER MEMBER STATE UNDER OPTION 7D 362
ANNEX 13 REFERENCES 363

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

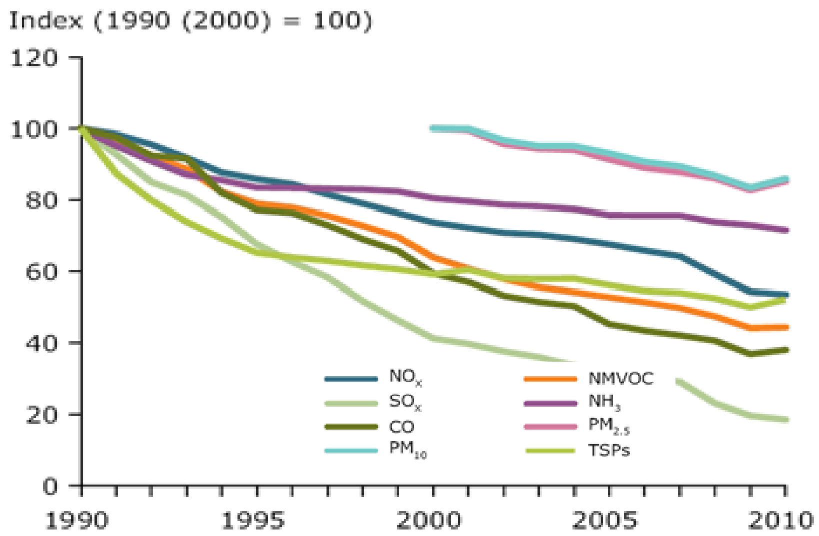
The current policy framework already allowed to significantly reduce air pollutant emissions and impacts. Figure 1 illustrates the substantial reduction in EU-wide emissions of the main pollutants delivered by policy between 1990 and 2010. In consequence the EU's huge acid rain (acidification) problem 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

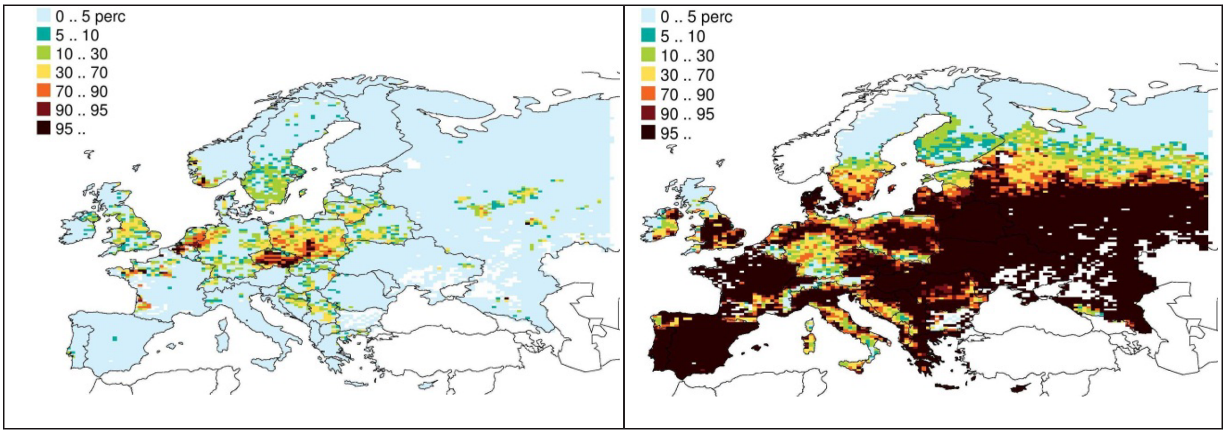
These costs include the impact of ill-health on those citizens who experience it, but also the direct cost to the economy. Air pollution causes more than 100 million workdays lost per year across Europe, with an economic damage in the range of €15 billion due to productivity losses. Although a full quantification 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.

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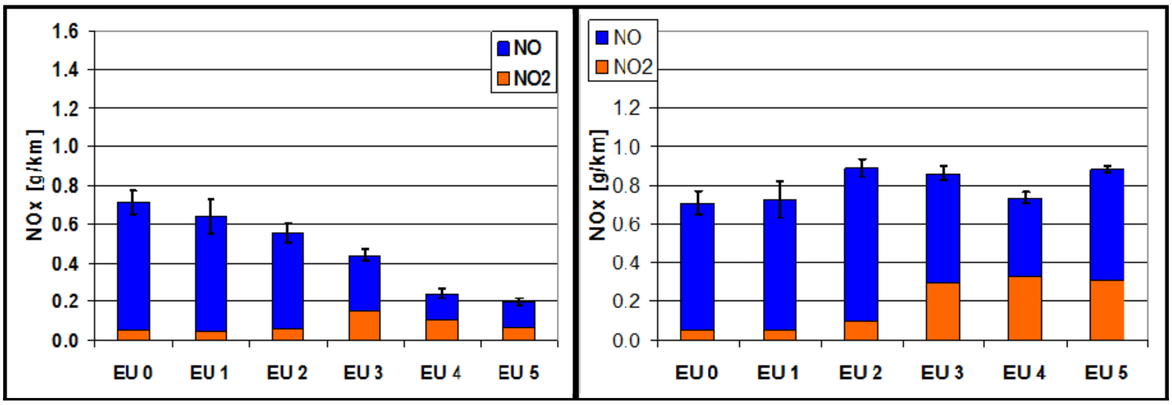
[37] Annex 3 presents the drivers and causes of air pollution in general. The detailed evaluation in Annex 4 identifies the specific causes and drivers set out here (see in particular the summary in Section 10.3 of Annex 4).

[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.

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).

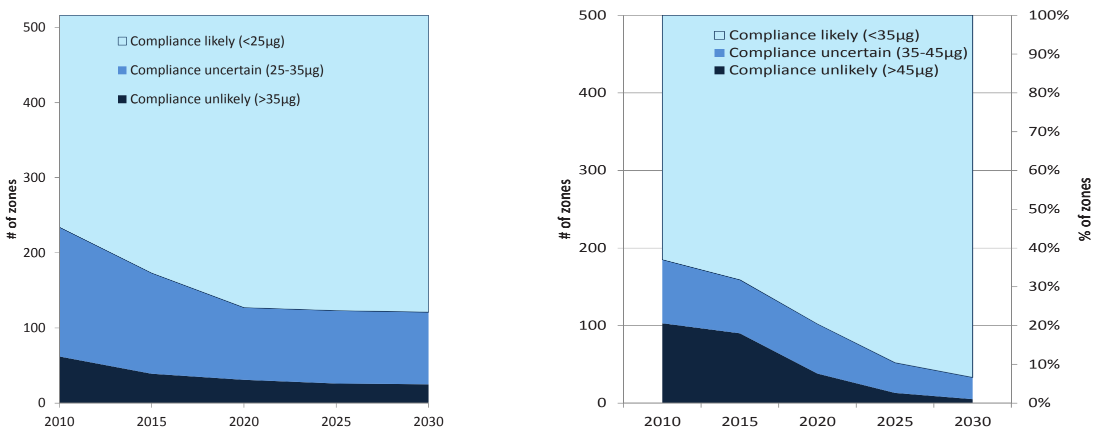
[69] NC= Not Calculated: 2015 is not a target policy year, and estimates for 2050 are too uncertain.

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.

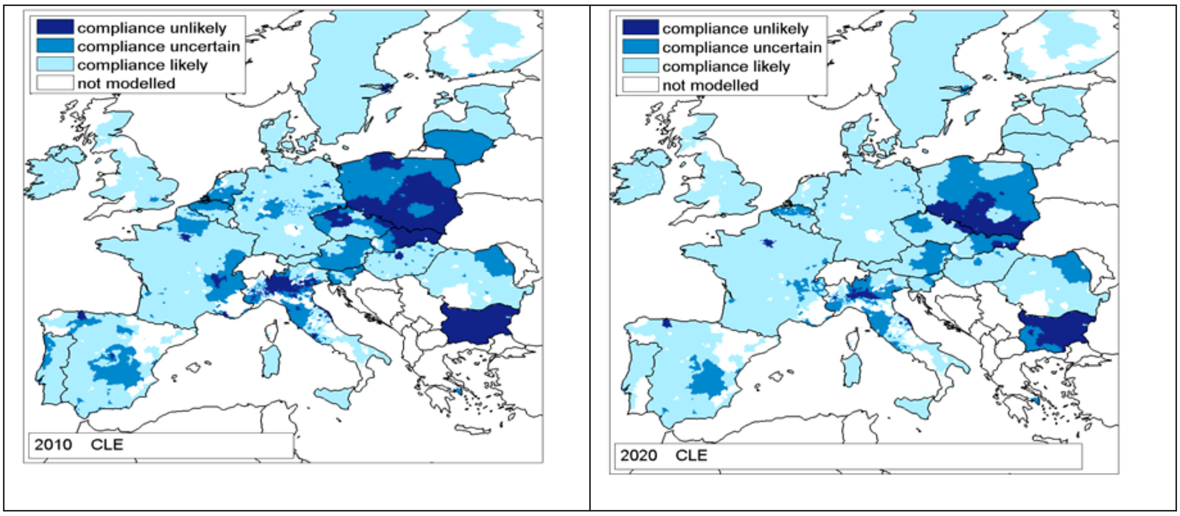
71 There is currently a target value (25µg/m^3) which in 2015 will become a binding limit value, but projections show that compliance will be very high, with around 96% of stations meeting the standard in 2015 and 99% in 2020. If the limit value were tightened in 2020 (to 20µg/m^3 as the AAQD provides 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 10µg/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

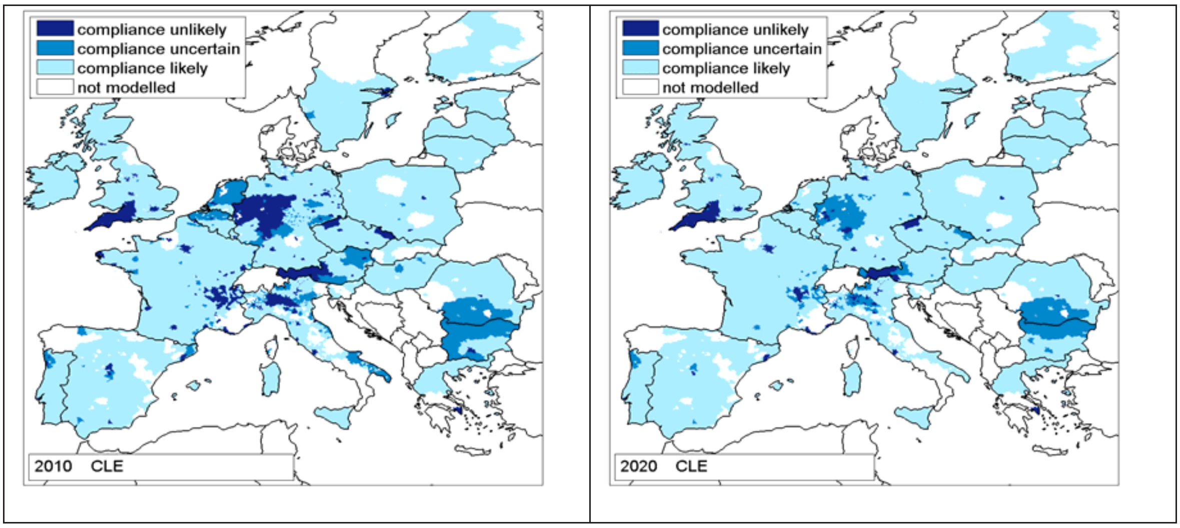
73 See new Krakow air quality action plan: http://www.wrotamalopolski.pl/root_BIP/BIP_w_Malopolsce/root_UM/podmiotowe/Konsultacje+projektow/Programy+i+projekty/Konsultacje+spoleczne+Aktualizacja+Programu+ochrony+powietrza+dla+wojewodztwa+malopolskiego/

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.

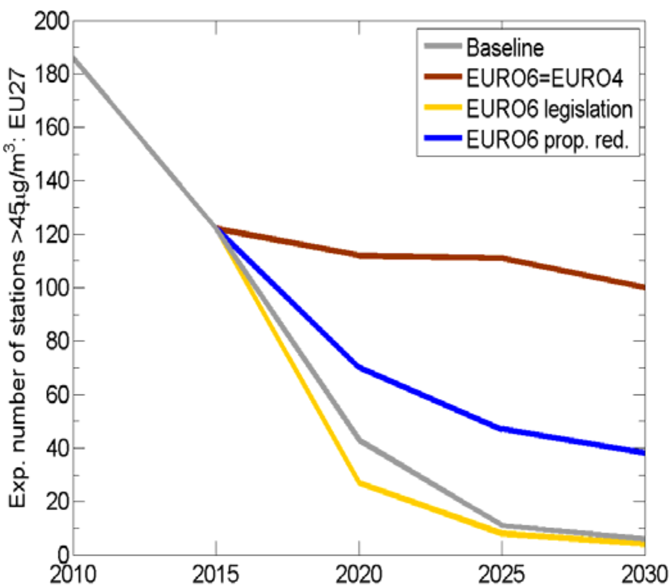
It is noted in this context that 6 Member States have so far failed to ratify the current Gothenburg Protocol despite several actions taken from the European Commission. Based on the compliance prospects shown above, this situation should be addressed at the earliest opportunity also to safeguard the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

[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

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.

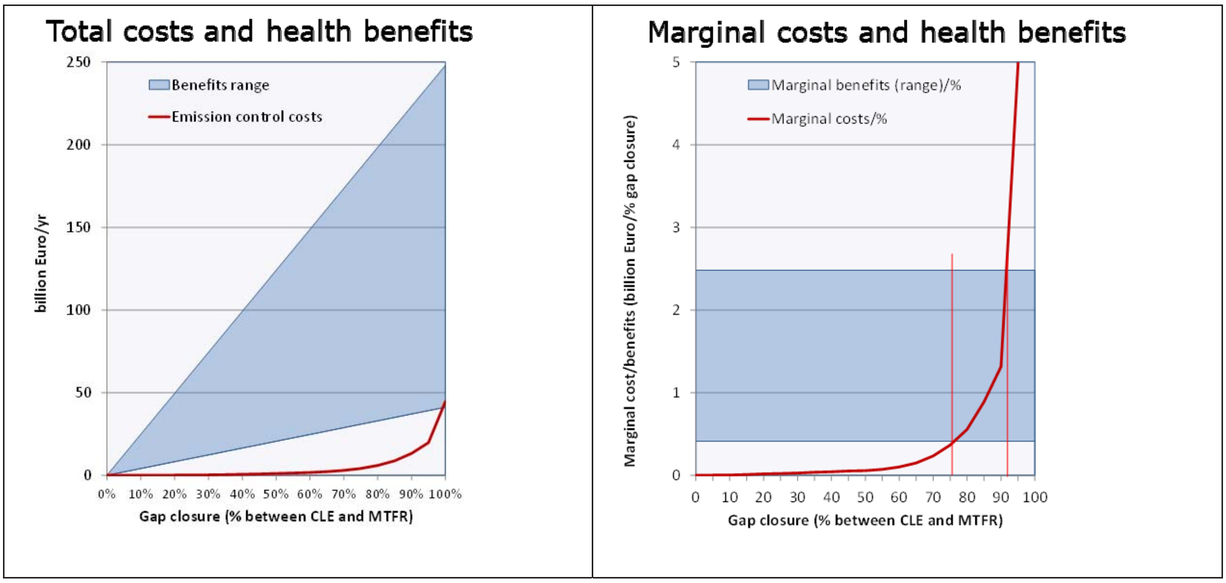
Total benefits are always larger than total costs and incremental benefits exceed incremental costs up to the level of option 6C. Even given the limitations of the quantified direct economic benefits, they alone exceed the compliance costs up to and including option 6B.

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]

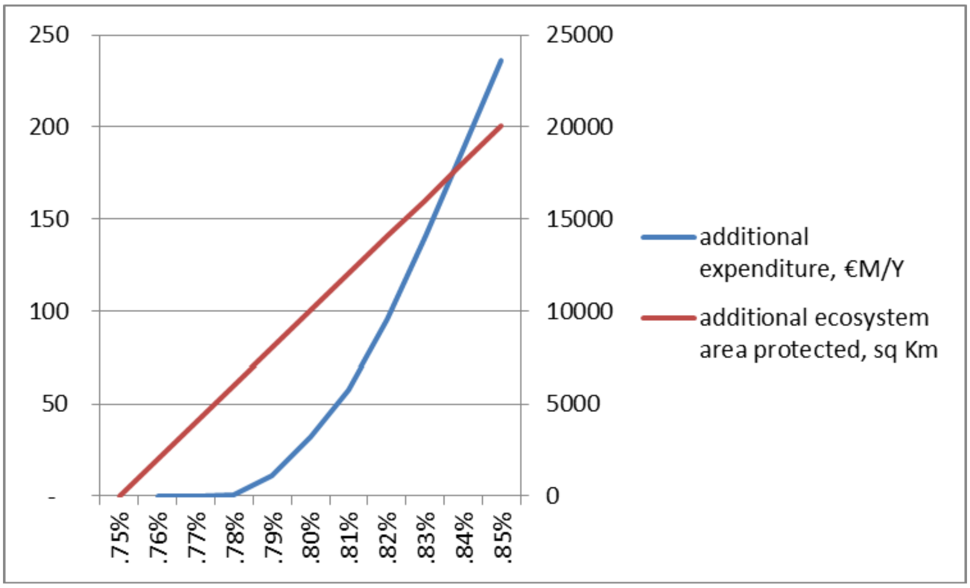
The majority of respondents to the public consultation stated that the EU air policy should give equal weight to human health and to the environment; almost 60% of government respondents, however, gave priority to human health.

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

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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.

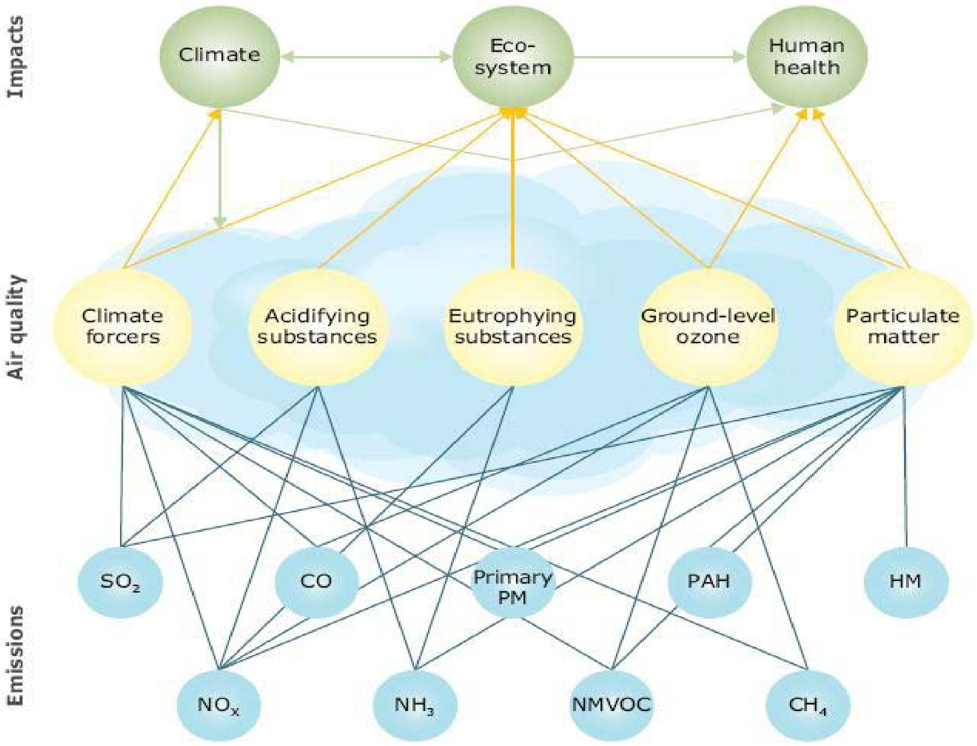
2. The main air pollutants and their associated impact pathways

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:

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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 4^{th} 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

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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