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The Final Policy Scenarios of the EU Clean Air Policy Package

TSAP Report #11

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Executive Summary

This report documents the key scenarios that informed the discussion and decision of the college of the European Commission on the Clean Air Policy package. Based on the PRIMES-2013 Reference scenario and the associated CAPRI projections of agricultural activities, the GAINS model has been used to explore the potential for environmental improvements offered by emission control measures that are not yet part of current legislation. Compared to the baseline projection in 2025, full application of readily available technical emission reduction measures in the EU could reduce health impacts from PM by another 30% and thereby gain more than 60 million life-years in the EU. It could save another 2,800 premature deaths per year because of lower ozone concentrations. Further controls of agricultural emissions could protect biodiversity at another 200,000 km^2 of ecosystems against excess nitrogen deposition, including 90,000 km^2 of Natura2000 areas and other protected zones. It could eliminate almost all likely exceedances of the air quality limit values for NO_2, and for PM10 values in the old Member States. It is estimated that the full implementation of all the measures that achieve the above-mentioned benefits would involve in 2025 additional emission control costs of approximately 47 billion €/yr (0.3% of GDP), compared to 88 billion €/yr (0.6%) that are spent under current legislation.

The report examines interim environmental targets that could serve for 2025 as milestones towards the long-term objective of the EU Environment Action Programme. In a most conservative perspective, considering monetized benefits only for human health and using the low valuation of the value of a lost life year (VOLY), net benefits are maximized at a 76% 'gap closure' between the current legislation baseline and the maximum feasible emission reductions. At this level, emission reduction costs (on top of current legislation) amount to 4.5 billion €/yr, while benefits from these measures are estimated at 44 billion €/yr.

The European Commission reached a final agreement on a slightly lower gap closure level (70%) for health effects for the new Clean Air Programme for Europe. To fully harvest the co-benefits from the climate policy target for 2030 that has been proposed by the European Commission in its Communication on the 2014 Energy and Climate package, the final Commission proposal also shifts the binding reduction commitments to the year 2030. These reduction commitments would maintain the level of marginal ratio of benefits to costs that is delivered by the 70% gap closure in 2025. Together with the current legislation, this would reduce the loss in statistical life expectancy in the EU from 8.5 months in 2005 to 4.1 months in 2030, i.e., by 52%, and gain about 180 million life years. The number of premature deaths attributable to exposure to ground-level ozone will decline by 34%. Lower nitrogen deposition will safeguard biodiversity in additional 150,000 km^2 of Natura2000 nature protection zones, and more than 98% of European forest areas will be protected against acidification. At costs of 0.02% of GDP, emissions would be cut for SO_2 by 77%, NO_x by 65%, PM2.5 by 50%, NH_3 by 27% and VOC by 54% relative to 2005. A more ambitious climate policy would decrease costs for attaining the reductions significantly. For the Climate Policy targets proposed in January 2014, structural changes in the energy system will lower the costs for implementing the measures required by current legislation by 5 billion €/yr. In addition, costs of additional measures to attain the new emission ceilings in 2030 will decline from 3.3 to 2.1 billion €/yr, i.e., by 1.2 billion €/yr. The proposed emission reductions for methane, which assume for 2030 implementation of all measures for which upfront investments will be recovered by later cost savings (e.g., in energy costs) during the remaining technical life time, would lead to cost-savings (compared to the baseline costs) of between 2.4 and 4.0 billion €/yr, depending on the assumptions on technological progress. Thereby, they would compensate a considerable fraction of the air pollution costs, which range between 2.1 and 3.3 billion €/yr.

List of acronyms

BAT	Best Available Technology
CAPRI	Agricultural model developed by the University of Bonn
CH_4	Methane
CLE	Current legislation
CO_2	Carbon dioxide
EC4MACS	European Consortium for Modelling Air Pollution and Climate Strategies
EU	European Union
GAINS	Greenhouse gas - Air pollution Interactions and Synergies model
GDP	Gross domestic product
IED	Industrial Emissions Directive
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control
kt	kilotons = 10^3 tons
MTFR	Maximum technically feasible emission reductions
NEC	National Emission Ceilings
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
O_3	Ozone
PJ	Petajoule = 10^{15} joule
PM10	Fine particles with an aerodynamic diameter of less than 10 µm
PM2.5	Fine particles with an aerodynamic diameter of less than 2.5 µm
PRIMES	Energy Systems Model of the National Technical University of Athens
SNAP	Selected Nomenclature for Air Pollutants; Sector aggregation used in the CORINAIR emission inventory system
SO_2	Sulphur dioxide
TSAP	Thematic Strategy on Air Pollution
VOC	Volatile organic compounds
YOLL	Years of life lost

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More information on the Internet

More information about the GAINS methodology and interactive access to input data and results is available at the Internet at http://gains.iiasa.ac.at/TSAP. All detailed data of the scenarios presented in this report can be retrieved from the GAINS-online model (http://gains.iiasa.ac.at/gains/EUN/index.login?logout=1).

Under the Scenario group 'TSAP Dec 2013', the following scenarios can be examined in an interactive mode:

Scenario label in GAINS Online	Scenario label in this report	Option in the Commission Impact Assessment
For 2025:		
PRIMES 2013 REF-CLE	REF	1
B1 - 2025-OPTION 6A in TSAP IA	B1	6A
B2- 2025-OPTION 6B in TSAP IA	B2	6B
B3 - 2025-OPTION 6C in TSAP IA	B3	6C
B4- 2025-OPTION 6C* in TSAP IA	B4	6C*
B6 - 2025-70% gap closure	B6	-
PRIMES 2013 REF-MTFR 2025	MTFR	6D
For 2030:		
PRIMES 2013 REF-CLE	REF-2030	-
B7 2030-Commission Proposal	B7	-
PRIMES 2013 REF-MFR 2030	MTFR-2030	

1 Introduction

On December 18, 2013, the European Commission adopted a Clean Air Policy Package with the aim to further reduce the impacts of harmful emissions from industry, traffic, energy plants and agriculture on human health and the environment (EC 2013a). The package includes a new Clean Air Programme for Europe with measures to ensure that existing targets are met in the short term, and new air quality objectives for the period up to 2030. The package also proposes a revised Directive on National Emission Ceilings with stricter national emission reductions for the six main pollutants, as well as a new Directive to reduce pollution from medium-sized combustion installations.

The proposal of the European Commission has been informed by quantitative modelling of baseline emissions and associated impacts, of the scope for further emission reduction options, and of cost-effective emission reduction strategies with the GAINS Integrated Assessment Modelling suite by the International Institute for Applied Systems Analysis (IIASA).

Between 2011 and 2013, IIASA conducted a series of analyses that prepared a common knowledge base for the final cost-effectiveness analysis of further options to improve air quality in Europe. In total, IIASA has calculated and analysed more than 300 scenario variants. These explored, inter alia, implications of different assumptions on economic baseline development, the impacts of future sectorial policies, the consequences of different assumptions on the effectiveness of implementation of current legislation (e.g., real world emissions of Euro-6 vehicles), alternative approaches and ranges of ambition levels of environmental targets. Key scenarios have been documented in the TSAP Report #1 (Amann et al. 2012a), TSAP Report #6 (Amann et al. 2012b), TSAP Report #7 (Amann et al. 2012c) and TSAP Report #10 (Amann et al. 2013). These reports have been presented to stakeholders, and comments received from stakeholders have been incorporated in the subsequent version of the analysis.

Based on the findings of TSAP Report #10, comments provided by stakeholders, and extensive further analyses with the GAINS model, in fall 2013 the Commission Services produced a comprehensive impact assessment for the revision of the EU air quality that laid out the main policy options (EC 2013b). This impact assessment provided the quantitative basis for discussions within the college of the European Commission, which led to the adoption of the final proposal in late 2013.

1.1 Objective of this report

This report documents the key scenarios (Scenario series B) that have led to the proposal of the European Commission on new Clean Air Policy package. It outlines the most relevant analyses after TSAP Report #10 (Scenario series A) that flowed into the Impact Assessment, as well as key scenarios that emerged during the negotiations within the Commission. The analysis – and the policy proposal - is based on the TSAP 2013 baseline scenario, which is fully consistent with the analytical groundwork developed for the Commission Communication on the 2014 Energy and Climate Package (EC 2014a).

1.2 Structure of the report

The report reviews the potential for environmental improvements offered by emission control measures that are not yet part of current legislation, and compares costs and benefits of cost-effective packages of measures to reduce negative health and vegetation impacts.

The remainder of Section 1 provides a brief summary of the methodology and lists the changes that have been applied to the databases since the TSAP Report #10. Section 2 introduces the TSAP 2013 Baseline projection of energy use and agricultural activities on which the subsequent analyses of future cost-effective policy interventions are based. Section 3 discusses baseline emissions as they are expected to emerge from the full implementation of current air pollution legislation, and reviews the scope for further emission reductions. It reviews assumptions on emission control measures, the scope for further emission reductions, the resulting improvements in European air quality impacts, and compares costs and benefits of the available additional measures.

Section 4 explores cost-effective policy scenarios, and introduces the scenarios that underpin the recent Clean Air Policy proposal of the European Commission. As a sensitivity case, the report examines the decline in emission control costs that would emerge as a side effect of the implementation of the recent Energy and Climate Policy Package that has been proposed by the European Commission. Conclusions are drawn in Section 5.

1.3 Methodology

This report employs the GAINS model system developed under the EC4MACS (European Consortium for Modelling of Air pollution and Climate Strategies) project, which was funded under the EU LIFE programme (www.ec4macs.eu).

The EC4MACS model toolbox (Figure 1.1) allows simulation of the impacts of policy actions that influence future driving forces (e.g., energy consumption, transport demand, agricultural activities), and of dedicated measures to reduce the release of emissions to the atmosphere, on total emissions, resulting air quality, and a basket of air quality and climate impact indicators. Furthermore, through the GAINS optimization tool (Amann et al. 2011b), the framework allows the development of cost-effective response strategies that meet environmental policy targets at least cost.

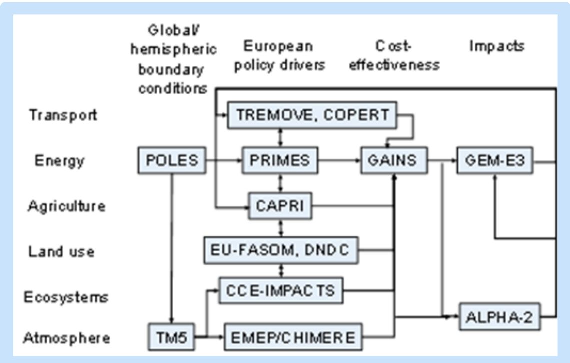


Figure 1.1: The EC4MACS model suite that describes the full range of driving forces and impacts at the local, European and global scale.

1.4 Changes since the last report

Since the last TSAP Report #10 (Amann et al. 2013), a number of changes have been implemented in the GAINS database.

A new baseline projection of future energy and agricultural activity trends has been implemented. This TSAP 2013 Baseline replaces the draft TSAP 2013 Baseline presented in TSAP Report #10. The draft baseline relied on the draft PRIMES-2012 Reference scenario and the corresponding CAPRI agricultural projections that were presented for comments to Member States in late 2012. The final TSAP 2013 Baseline includes the final 'PRIMES 2013 Reference' scenario as well as the corresponding projections of agricultural activities developed with the CAPRI model. (Capros 2013). Main features of the TSAP 2013 Baseline are summarized in Section 2. Thereby, the TSAP 2013 Baseline is fully consistent with the analytical basis of the Commission Communication on Energy and Climate policy (EC 2014a).

Most notably, compared to the earlier versions, the final PRIMES 2013 REF scenario suggests significantly higher consumption of gasoline as well as diesel, notably by passenger cars. In other words, the previous shift to diesel cars is less pronounced, and efficiency improvements are assumed somewhat less ambitious. As a consequence, future pollutant emissions from road transport are higher than projected previously.

In the GAINS database, minor corrections have been introduced to the number of diesel rail engines for a number of countries, which influence estimates of air pollution control costs for the baseline.

The Maximum Feasible Reduction (MTFR) scenario considers now the potential for further measures in the off-road sector. For all sources, one further stage with stringent NO_x controls comparable to Euro-V/VI levels of road vehicles is assumed; however, additional measures are only allowed if they are introduced Europe-wide, i.e., through Community legislation. In addition, (partial) retrofits of existing sources are considered.

2 The TSAP 2013 Baseline projection of energy use and agricultural activities

The final TSAP 2013 Baseline employs the projection of economic activities (e.g., energy use, transport, agricultural production, etc.) that has been developed for the Commission Communication on 'A policy framework for climate and energy in the period from 2020 to 2030' (EC 2014a).

2.1 The PRIMES 2013 Reference energy scenario

The PRIMES 2013 Reference energy scenario was finalized in July 2013, after four rounds of consultations with Member States' experts on Member State specific assumptions and draft modelling results (Capros 2013).

Population is assumed to follow the EUROSTAT population projection for the period 2010 to 2050, with slightly rising fertility rates, further life expectancy gains, and continued, but decelerating inward net migration to the EU. As a result, the EU population is projected to increase up to 2030 by six percent compared to 2005.

The Reference 2013 scenario mirrors the recent DG ECFIN projections of Gross Domestic Product (GDP) for the short and medium term (following the agreement reached in the Economic Policy Committee (EPC)) and the EPC/DG ECFIN Ageing Report 2012 (from first quarter 2012) for the long-run. The GEM-E3 model has been used to project the structure of the economy and gross value added generated by different sectors, consistently with the given GDP projection.

The GDP projection assumes a recovery from the current economic crisis, followed by steady GDP growth rates in the medium term (avg. 1.6%/year over the period 2015-2030, down from the 2.2%/year during 1996-2007).

The Reference 2013 scenario projection sees a continuation of trends towards higher share of services in GDP. Industrial activities will recover, with a shift in production towards higher value added products, rather than higher amounts of products. For energy-intensive industries recovery and then slow growth pace is projected. Non energy-intensive industries see a more significant growth. The remaining sectors - construction, agriculture and energy sector - see a rather slow growth of activity.

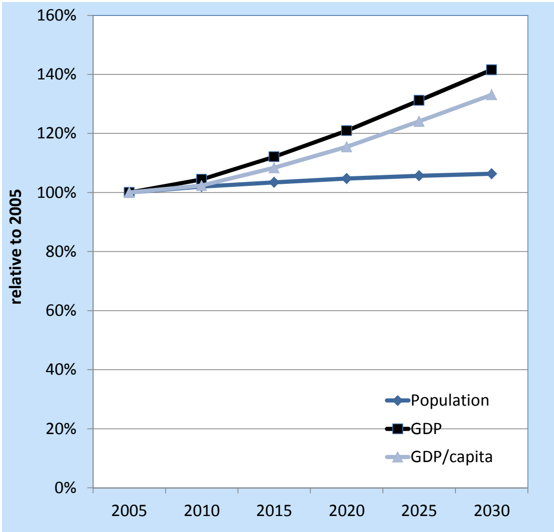


Figure 2.1: Projections of population, GDP and GDP/capita up to 2030 (relative to 2005)

World market prices for oil and coal are assumed to increase steadily in the coming decades, while prices for natural gas would decouple from the oil price and grow to a lesser extent, following large upward revisions for reserves of conventional and unconventional (tight sands, shale gas and coal bed methane) gas and oil.

The Reference 2013 scenario includes policies and measures adopted in the Member States by April 2012 and policies, measures and legislative provisions (including on binding targets) adopted or agreed in the first half of 2012 at EU level in such a way that there is almost no uncertainty with regard to their adoption. This concerns notably the Energy Efficiency Directive, on which political agreement was reached by that time. Details on policies and measures reflected in the Reference 2013 scenario are provided in Capros 2013.

The assumptions in the Reference 2013 scenario on economic development, enhanced energy efficiency and renewable energy policies and climate strategies lead to about 10% lower fuel consumption in 2030 compared to 2005 (Figure 2.2, Figure 2.3).

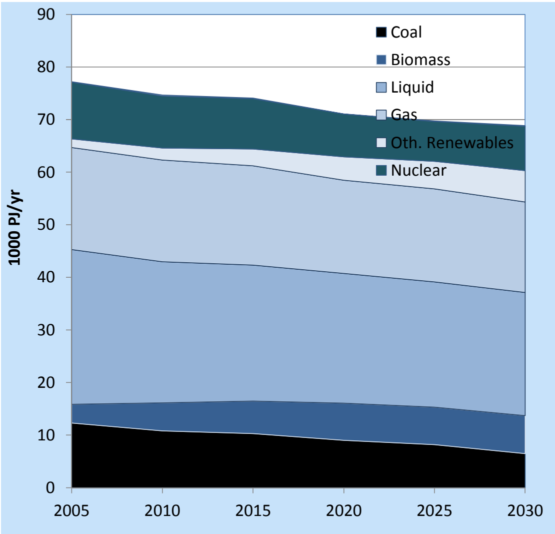


Figure 2.2: Energy consumption by fuel of the PRIMES-2013 Reference projection, EU-28

The adopted policies for renewable energy sources are expected to double biomass use in 2030 compared to 2005, and to triple energy from other renewable sources (e.g., wind, solar). In contrast, coal consumption is expected to decline by 50% by 2030, oil and nuclear is calculated to be 20% lower than in 2005, and natural gas consumption by 12%.

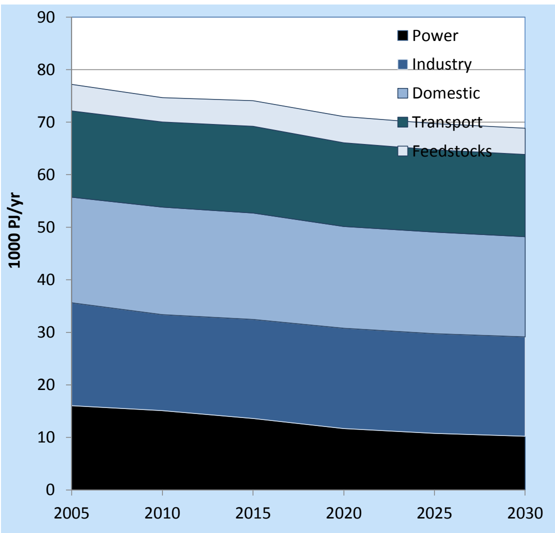


Figure 2.3: Energy consumption by sector of the PRIMES-2013 Reference projection, EU-28

On a sectorial basis, the rapid penetration of energy efficiency measures maintains constant or slightly decreasing energy consumption in the secondary and tertiary sectors despite the assumed sharp increases in production levels and economic wealth, while fuel input to power generation will drop by about one third (Figure 2.3, Table 2.2).

New legislation on fuel efficiency should stabilize the growth in fuel demand for total road transport despite the expected increases in travel distance and freight volumes.

The projected evolution of energy consumption by Member State is summarized in Table 2.3. Implications for future emissions and the scope for further emission reductions are explored in Section 2.

2.2 The 2013 CAPRI scenario of agricultural activities

The CAPRI model has been used to project future agricultural activities in Europe coherent with the macro-economic assumptions of the PRIMES-2013 Reference scenario and considering the likely impacts of the most recent agricultural policies. The evolution of livestock is summarized in Figure 2.4.

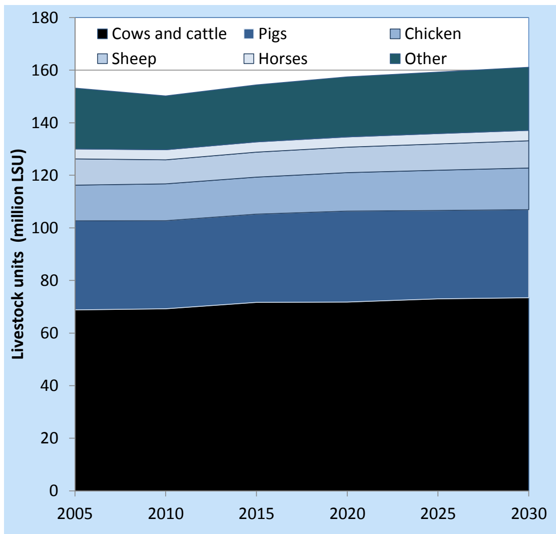


Figure 2.4: CAPRI projection of agricultural livestock in the EU-28 for the PRIMES-2013 Reference scenario (million livestock units)

Table 2.1: Baseline energy consumption by fuel in the EU-28 (1000 PJ, excluding electricity trade)

	2005	2010	2015	2020	2025	2030
Coal	12.3	10.8	10.3	9.0	8.2	6.5
Oil	29.4	26.8	25.9	24.7	23.8	23.4
Gas	19.4	19.3	18.9	17.7	17.7	17.2
Nuclear	10.8	9.9	9.6	8.1	7.6	8.4
Biomass	3.6	5.3	6.2	7.1	7.1	7.2
Other renewables	1.6	2.3	3.2	4.4	5.3	6.0
Total	77.1	74.5	74.0	71.0	69.7	68.7

Table 2.2: Baseline energy consumption by sector in the EU-28 (1000 PJ)

	2005	2010	2015	2020	2025	2030
Power sector	16.0	15.1	13.6	11.7	10.8	10.0
Households	20.1	20.5	20.3	19.4	19.3	19.1
Industry	19.6	18.3	18.9	19.1	19.0	18.9
Transport	16.4	16.2	16.5	15.9	15.7	15.7
Non-energy	5.0	4.6	4.9	5.0	5.0	5.0
Total	77.1	74.5	74.0	71.0	69.7	68.7

Table 2.3: Baseline energy consumption by country (PJ)

	2005	2010	2015	2020	2025	2030
Austria	1422	1450	1497	1441	1411	1383
Belgium	2561	2669	2556	2471	2252	2209
Bulgaria	849	766	754	754	761	722
Croatia	376	360	367	368	363	366
Cyprus	109	115	118	110	110	113
Czech Rep.	1875	1863	1793	1796	1777	1834
Denmark	853	856	808	763	740	746
Estonia	216	222	221	208	204	195
Finland	1462	1576	1715	1688	1719	1776
France	11646	11354	11241	10573	10319	10187
Germany	14770	14494	13498	12302	11504	10889
Greece	1341	1242	1182	1157	1084	1039
Hungary	1157	1089	1081	1059	1132	1179
Ireland	686	637	651	648	637	652
Italy	7977	7508	7303	7228	7113	7095
Latvia	192	202	208	214	217	220
Lithuania	367	288	295	299	333	361
Luxembourg	197	197	199	198	199	201
Malta	44	38	38	29	28	28
Netherlands	3451	3430	3651	3502	3377	3325
Poland	3890	4282	4622	4z811	4964	4988
Portugal	1148	1034	1019	1018	978	966
Romania	1643	1486	1533	1582	1571	1580
Slovakia	803	761	790	828	848	872
Slovenia	305	305	318	317	320	323
Spain	5968	5391	5612	5624	5882	5978
Sweden	2218	2156	2280	2296	2331	2318
UK	9673	8887	8741	7802	7566	7307
EU-28	77199	74658	74091	71085	69741	68852

3 Ranges of future emissions

This section outlines the range over which emissions and air quality could evolve in the future as a function of different levels of policy interventions. It presents emission projections, estimates of emission control costs, and air quality impact indicators for the current legislation baseline and the maximum technically feasible emission control cases.

3.1 Assumptions on further emission controls

3.1.1 Emission control legislation considered in the 'Current legislation' (CLE) scenario

In addition to the energy, climate and agricultural policies that are included in the energy and agricultural projection, the TSAP 2013 Baseline considers a detailed inventory of national emission control legislation (including the transposition of EU-wide legislation). It is assumed that these regulations will be fully complied with in all Member States according to the foreseen time schedule. For CO_2, regulations are included in the PRIMES calculations as they affect the structure and volumes of energy consumption. For non-CO_2 greenhouse gases and air pollutants, EU and Member States have issued a wide body of legislation that limits emissions from specific sources, or have indirect impacts on emissions through affecting activity rates. Most relevant for the Commission proposal on the Clean Air Policy package is the current legislation for CH_4 emissions that is assumed in the GAINS baseline projection (Box 1).

Box 1: Legislation considered for CH_4 emissions

- EU Landfill Directive (EC/31/1999)
- EU Waste Management Framework Directive (EC/98/2008)
- Ban on landfill of biodegradable waste in Austria, Belgium, Denmark, Germany, Netherlands, Sweden.
- EU urban wastewater treatment directive (EEC/271/1991)
- National legislation and national practices (e.g., the subsidy scheme for renewable energy in the Netherlands)

For air pollutants, the baseline assumes the regulations described in Box 2 to Box 6. However, the analysis does not consider the impacts of other legislation for which the actual impacts on future activity levels cannot yet be quantified. This includes compliance with the air quality limit values for PM, NO_2 and ozone established by the Air Quality directive, which could require, inter alia, traffic restrictions in urban areas and thereby modifications of the traffic volumes assumed in the baseline projection.

Although some other relevant directives such as the Nitrates directive are part of current legislation, there are some uncertainties as to how the measures can be represented in the framework of integrated assessment modelling for air quality.

The baseline assumes full implementation of this legislation according to the foreseen schedule. Derogations under the IPPC, LCP and IED directives granted by national authorities to individual plants are considered to the extent that these have been communicated by national experts to IIASA.

Box 2: Legislation considered for SO_2 emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs are considered according to the information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive.
- Directive on the sulphur content in liquid fuels
- Fuel Quality directive 2009/30/EC on the quality of petrol and diesel fuels, as well as the implications of the mandatory requirements for renewable fuels/energy in the transport sector
- MARPOL Annex VI revisions from MEPC57 regarding sulphur content of marine fuels
- National legislation and national practices (if stricter)

For NO_x emissions from transport, all scenarios presented here assume from 2017 onwards real-life NO_x emissions to be 1.5 times higher than the Euro-6 test cycle limit value. This results in about 120 mg NO_x/km for real-world driving conditions, compared to the limit value of 80 mg/km. As changes to the test procedure, e.g., using portable emissions measurement systems (PEMS), still need to be defined, between 2014 and 2017 emission factors of new cars are assumed at 310 mg NO_x/km. Also, inland vessels are excluded from Stage IIIB or higher emission controls, and railcars and locomotives not subject to Stage IV controls.

Box 3: Legislation considered for NO_x emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs included according to information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive
- For light duty vehicles: All Euro standards, including adopted Euro-5 and Euro-6, becoming mandatory for all new registrations from 2011 and 2015 onwards, respectively (692/2008/EC), (see also comments below about the assumed implementation schedule of Euro-6).
- For heavy duty vehicles: All Euro standards, including adopted Euro-V and Euro-VI, becoming mandatory for all new registrations from 2009 and 2014 respectively (595/2009/EC).
- For motorcycles and mopeds: All Euro standards for motorcycles and mopeds up to Euro-3, mandatory for all new registrations from 2007 (DIR 2003/77/EC, DIR 2005/30/EC, DIR 2006/27/EC). Proposals for Euro-4/5/6 not yet legislated.
- For non-road mobile machinery: All EU emission controls up to Stages IIIA, IIIB and IV, with introduction dates by 2006, 2011, and 2014 (DIR 2004/26/EC). Stage IIIB or higher standards do not apply to inland vessels IIIB, and railcars and locomotives are not subject to Stage IV controls.
- MARPOL Annex VI revisions from MEPC57 regarding emission NO_x limit values for ships
- National legislation and national practices (if stricter)

Box 4: Legislation considered for PM10/PM2.5 emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs included according to information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive
- For light and heavy duty vehicles: Euro standards as for NO_x
- For non-road mobile machinery: All EU emission controls up to Stages IIIA, IIIB and IV as for NO_x.
- National legislation and national practices (if stricter)

Box 5: Legislation considered for NH_3 emissions

- IPPC directive for pigs and poultry production as interpreted in national legislation
- National legislation including elements of EU law, i.e., Nitrates and Water Framework Directives
- Current practice including the Code of Good Agricultural Practice
- For heavy duty vehicles: Euro VI emission limits, becoming mandatory for all new registrations from 2014 (DIR 595/2009/EC).

Box 6: Legislation considered for VOC emissions

- Stage I directive (liquid fuel storage and distribution)
- Directive 96/69/EC (carbon canisters)
- For mopeds, motorcycles, light and heavy duty vehicles: Euro standards as for NO_x, including adopted Euro-5 and Euro-6 for light duty vehicles
- EU emission standards for motorcycles and mopeds up to Euro-3
- On evaporative emissions: Euro standards up to Euro-4 (not changed for Euro-5/6) (DIR 692/2008/EC)
- Fuels directive (RVP of fuels) (EN 228 and EN 590)
- Solvents directive
- Products directive (paints)
- National legislation, e.g., Stage II (gasoline stations)

3.1.2 Emission controls considered in the 'Maximum technically feasible reduction' (MTFR) scenario

The GAINS model contains an inventory of measures that could bring emissions down below the baseline projections. All these measures are technically feasible and commercially available, and the GAINS model estimates for each country the scope for their application in addition to the measures that are mandated by current legislation.

The 'Maximum technically feasible reduction' (MTFR) scenario explores to what extent emissions of the various substances could be further reduced beyond what is required by current legislation, through full application of the available technical measures, without changes in the energy structures and without behavioural changes of consumers. However, with the exception of non-road mobile machinery, the MTFR scenario does not assume premature scrapping of existing capital stock; new and cleaner devices are only allowed to enter the market when old equipment is retired.

While the MTFR scenario provides an indication of the scope for measures that do not require policy changes in other sectors (e.g., energy, transport, climate, agriculture), earlier analyses have highlighted that policy changes that modify activity levels could offer a significant additional potential for emission reductions. However, due to the complexity of the interactions with many other aspects, the potential for such changes is not quantified in this report. Thus, the analysis presented here should be seen as a conservative estimate of what could be achieved by policy interventions, as the scope is limited towards technical emission control measures.

3.2 Baseline emission trends and maximum technically feasible controls

3.2.1 Sulphur dioxide

Progressive implementation of air quality legislation together with the structural changes in the energy system will lead to a sharp decline of SO_2 emissions in the EU (Figure 3.1), so that in 2025 total SO_2 emissions would be almost 70% below the 2005 level. Most of these reductions come from the power sector (Table 3.1). Full implementation of the available technical emission control measures could bring SO_2 emissions down by up to 80% in 2025 compared to 2005.

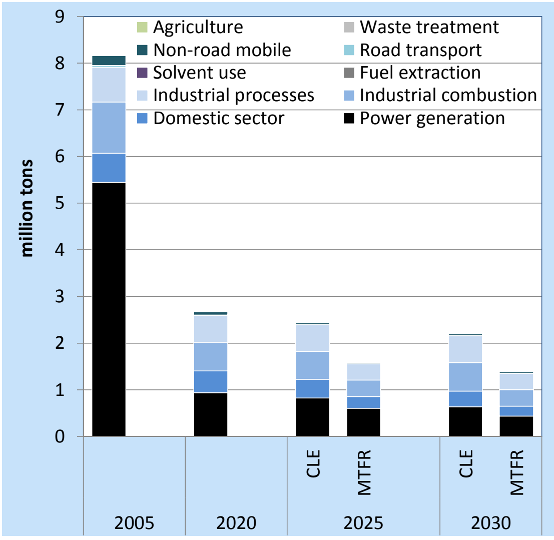


Figure 3.1: SO_2 emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28

Table 3.1: SO_2 emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025		2030	
					CLE	MTFR	CLE	MTFR
Power generation	5445	2739	1375	937	824	604	637	435
Domestic sector	623	624	520	467	399	250	336	213
Industrial combust.	1100	695	640	616	600	357	610	355
Industrial processes	743	626	578	577	570	344	575	345
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	36	7	6	5	5	5	5	5
Non-road mobile	215	137	109	71	37	29	37	29
Waste treatment	2	2	2	2	2	1	2	1
Agriculture	7	8	8	9	9	0	9	0
Sum	8172	4837	3238	2685	2446	1589	2211	1382

3.2.2 Nitrogen oxides

Also for nitrogen oxides (NO_x) emissions, implementation of current legislation will lead to significant declines, and for 2025 a 60% reduction is estimated. These changes emerge from measures in the power sector, and more importantly, from the implementation of the Euro-6 standards for road vehicles (Figure 3.2). Full implementation of additional measures for stationary sources could bring NO_x emissions in 2025 68% down compared to 2005 (Table 3.2).

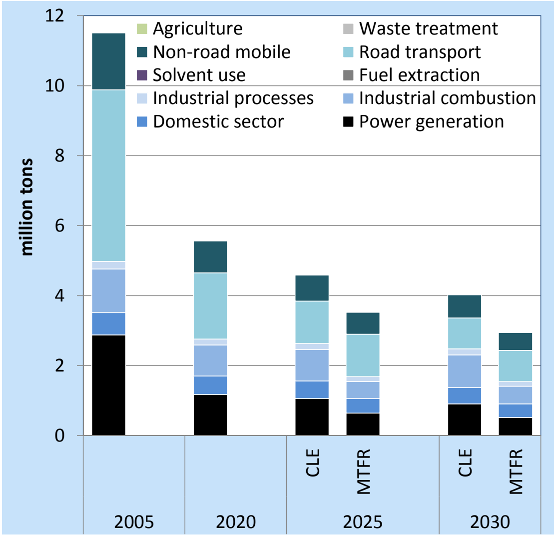


Figure 3.2: NO_x emissions of the TSAP 2013 Baseline

Table 3.2: NO_x emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025		2030	
					CLE	MTFR	CLE	MTFR
Power generation	2879	1908	1513	1172	1055	638	906	517
Domestic sector	632	619	580	532	506	417	471	389
Industrial combust.	1253	918	898	884	899	490	928	503
Industrial processes	213	184	172	174	171	137	172	137
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	4905	3751	2994	1890	1210	1210	887	887
Non-road mobile	1630	1400	1156	914	748	632	661	513
Waste treatment	8	7	6	6	5	1	5	1
Agriculture	16	17	19	21	21	1	21	1
Sum	11538	8805	7338	5591	4616	3527	4051	2948

3.2.3 Fine particulate matter

Progressive introduction of diesel particle filters will reduce fine particulate matter (PM2.5) emissions from mobile sources by about two thirds up to 2025; the remaining emissions from this sector will mainly originate from non-exhaust sources. While this trend is relatively certain, total PM2.5 emissions in Europe will critically depend on the development for small stationary sources, i.e., solid fuel use for heating in the domestic sector. The anticipated decline in solid fuel use for heating together with the introduction of newer stoves would reduce emissions from this sector by ~17% in 2025. However, more stringent product standards could cut emissions by up to two thirds.

Overall, total PM2.5 emissions in the EU-28 are expected to decline by 25% in the CLE case, while additional technical measures could cut them by up to 60% compared to 2005 (Figure 3.3, Table 3.3).

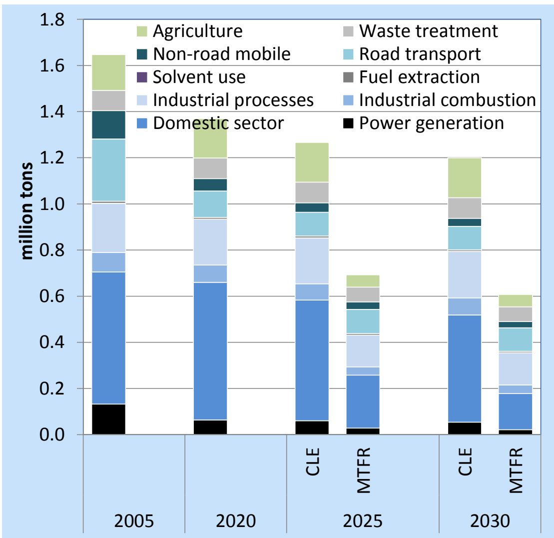


Figure 3.3: PM2.5 emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28

Table 3.3: PM2.5 emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025		2030	
					CLE	*MTFR*	*CLE*	*MTFR*
Power generation	132	92	70	63	60	28	53	21
Domestic sector	573	695	653	597	523	230	465	156
Industrial combust.	85	72	73	75	71	36	75	37
Industrial processes	213	190	196	199	199	138	201	139
Fuel extraction	9	8	8	7	7	7	6	6
Solvent use	0	0	0	0	0	0	0	0
Road transport	270	217	149	115	104	104	102	102
Non-road mobile	123	99	74	53	41	33	35	27
Waste treatment	88	88	89	89	90	64	90	64
Agriculture	155	155	164	171	172	53	172	54
Sum	1647	1616	1477	1370	1266	693	1200	607

3.2.4 Ammonia

Although ammonia (NH_3) emissions are subject to targeted controls in the agricultural sector and will be affected as a side impact of emission legislation for road transport (i.e., by improved catalytic converters), only slight changes in total emissions in the EU-28 are expected up to 2030.

Due to the absence of effective widespread legislation on the control of NH_3 emissions from the agricultural sector, the TSAP 2013 Baseline shows only little change in NH_3 emissions over time. For 2025, a 7% decline in the EU-28 is estimated. However, EU-wide application of emission control measures that are already implemented in some countries could cut NH_3 by about one third (Figure 3.4, Table 3.4).

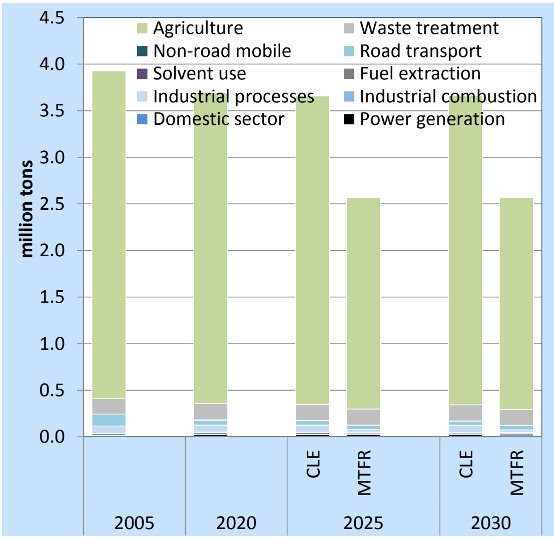


Figure 3.4: NH_3 emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28

Table 3.4: NH_3 emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025		2030	
					CLE	MTFR	CLE	MTFR
Power generation	14	22	22	25	24	22	23	20
Domestic sector	19	22	23	22	20	20	19	18
Industrial combust.	4	5	5	5	5	8*)	6	8*)
Industrial processes	78	73	74	75	75	28	75	28
Fuel extraction	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0
Road transport	128	88	67	54	48	48	46	46
Non-road mobile	2	2	2	2	2	1	2	1
Waste treatment	166	174	174	174	173	173	173	173
Agriculture	3518	3292	3336	3338	3311	2267	3319	2274
Sum	3928	3678	3702	3693	3658	2566	3663	2568

*) higher than in CLE due to NH_3 slip from SCR

3.2.5 Volatile organic compounds

The future trend in VOC emissions is strongly determined by measures for mobile sources and by dedicated controls of solvents emissions (Figure 3.5, Table 3.5).

Further implementation of the Euro-standards will significantly reduce VOC emissions from road vehicles. Legislation on solvents is expected to cut VOC emissions from this sector by about 20% in 2025 relative to 2005. There remains significant potential for further reductions for VOC emissions from solvents. Together with additional measures in households, these could cut total VOC emissions in the EU-28 by two thirds, compared to the 37% reduction in the baseline case.

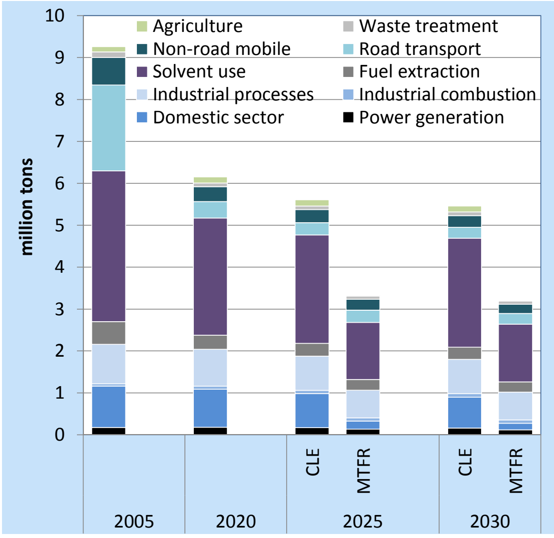


Figure 3.5: VOC emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28

Table 3.5: VOC emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025		2030	
					CLE	MTFR	CLE	MTFR
Power generation	176	196	185	181	172	132	162	117
Domestic sector	987	1080	1026	911	813	195	736	156
Industrial combust.	53	56	60	69	77	77	85	85
Industrial processes	943	875	878	884	815	659	819	663
Fuel extraction	538	386	364	332	305	254	289	242
Solvent use	3600	3037	2882	2795	2584	1364	2603	1375
Road transport	2047	1100	593	392	293	293	257	257
Non-road mobile	657	538	414	355	314	259	281	223
Waste treatment	133	120	95	89	86	74	84	74
Agriculture	125	126	137	146	146	0	146	0
Sum	9259	7512	6635	6152	5604	3308	5460	3191

3.2.6 Methane emissions

In 2005, about half of the methane (CH_4) emissions in the EU originated from agriculture, and half from other sectors (e.g., waste treatment). Emissions from these other sectors are expected to decline significantly as a side-effect of regulations for solid waste, waste water treatment, occupational safety, etc. However, only modest declines can be currently expected for agricultural emissions, so that for 2030 the TSAP 2013 baseline (which is fully coherent with the analyses for the 2014 Commission proposal on Energy and Climate policies) total methane emissions are expected to shrink by about 25% (Figure 3.6). It is also clear, however, that there is significant potential for further reductions, part of it at rather low or even negative costs.

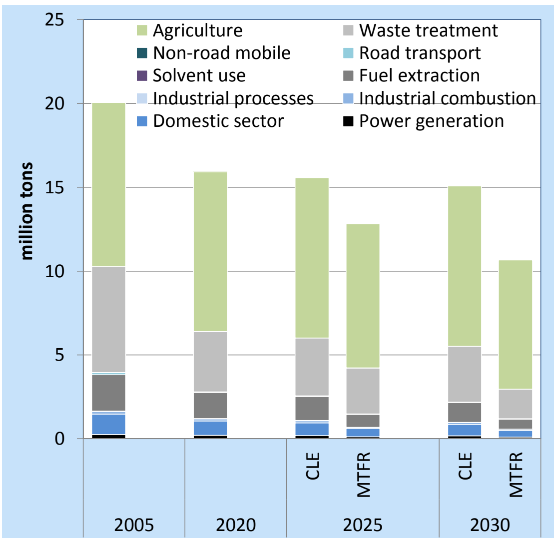


Figure 3.6: CH_4 emissions of the TSAP 2013 Baseline; Current legislation (CLE) and Maximum Technically Feasible Reductions (MTFR), EU-28

Table 3.6: CH_4 emissions of the TSAP 2013 Baseline scenario, by SNAP sector, EU-28 (kilotons)

	2005	2010	2015	2020	2025	2030
Power generation	253	252	215	204	185	171
Domestic sector	1216	1118	1009	856	761	671
Industrial combust.	157	131	140	124	121	119
Industrial processes	27	23	22	21	21	20
Fuel extraction	2162	1714	1628	1550	1435	1180
Solvent use	0	0	0	0	0	0
Road transport	135	84	47	34	27	26
Non-road mobile	4	4	4	4	4	4
Waste treatment	6311	5790	3686	3599	3451	3324
Agriculture	9793	9525	9588	9527	9566	9559
Calibration	430	430	430	430	430	430
Sum	20487	19070	16768	16349	16001	15504

3.2.7 Emissions of non-EU countries

Due to the long-range transport of air pollutants, air quality within the EU is substantially influenced by emissions outside the territories of EU Member States. While emissions from non-EU countries and marine shipping are not in the focus of this report, the impact calculations for the EU Member States need to consider the likely development of emissions outside the EU and the potential for further emission reductions in these areas.

For the non-EU countries, calculations assume for 2020 the activity projections and current legislation control measures that have been used for the negotiations of the revised Gothenburg protocol (Amann et al. 2011a). Beyond 2020, the energy projections developed within the FP7 EnerGeo project (www.energeo-project.eu), together with information on the penetration of already agreed national emission control measures (see Table 3.7 and Table 3.8).

Table 3.7: Baseline emissions of SO_2, NO_x and PM2.5 for non-EU countries (kt and change relative to 2005)

	SO_2			NO_x			PM2.5		
	2005	2025	2030	2005	2025	2030	2005	2025	2030
Albania	19	16	19	19	21	23	9	8	8
Belarus	85	87	90	178	167	172	54	53	54
Bosnia-H	225	47	57	33	25	27	20	9	9
FYR Macedonia	104	19	17	35	20	19	12	5	5
R Moldova	7	3	4	27	16	16	10	10	10
Norway	24	20	20	173	134	126	51	43	42
Russia	1923	1634	1691	2979	1766	1765	758	791	810
Serbia-M	454	92	99	165	85	82	71	47	46
Switzerland	17	10	10	94	43	36	10	7	7
Turkey	1462	2124	2316	859	1130	1284	350	446	474
Ukraine	1063	412	532	875	587	643	392	357	423
Non-EU	5383	4463	4856	5438	3992	4192	1740	1776	1886
Change to 2005		*-17%*	*-10%*		*-27%*	*-23%*		*+2%*	*+8%*

Table 3.8: Baseline emissions of NH_3 and VOC for non-EU countries (kilotons and change relative to 2005)

	NH_3			VOC		
	2005	2025	2030	2005	2025	2030
Albania	17	20	21	34	26	25
Belarus	117	161	164	200	152	147
Bosnia-H	18	26	28	44	27	26
FYR Macedonia	9	9	9	23	12	11
R Moldova	16	18	18	30	21	20
Norway	24	33	35	202	100	101
Russia	492	563	575	2678	1644	1629
Serbia-M	64	49	46	169	105	99
Switzerland	62	62	62	120	79	78
Turkey	416	518	549	697	550	539
Ukraine	253	293	303	591	336	325
Non-EU	1488	1751	1810	4788	3051	3000
Change to 2005		*18%*	*22%*		*-36%*	*-37%*

3.2.8 Emissions from marine shipping

For marine shipping activities, this report uses historic and future emissions of air pollutants as provided by the recent VITO report to DG-ENV (Campling et al. 2012) (see Table 3.9). The VITO inventory and projections distinguish activities of 11 vessel categories in 8 Sea regions (Figure 3.7), as well as within the Territorial Seas of the EU Member States, i.e., within 12 nm from the coast, and in the 200 nm Exclusive Economic Zones.

In 2005, ships emitted about 1.7 million tons of SO_2, which was about 20 % of the emissions from land-based sources in the EU-28. Emissions of NO_x (2.8 million tons) were equivalent to 25% land-based emissions. About 30% of these emissions occurred within 12 nm from the coast. Emissions from the Exclusive Economic Zones (200 nm) were approximately 75% of the total.

Under baseline assumptions, emissions of SO_2 from the European seas will decrease by 82% in 2020 compared to 2005. Emissions of NO_x will drop by 13%. After 2020, emissions increase due to growing transport volume, and by 2030 will be 12-13% higher than in 2020.

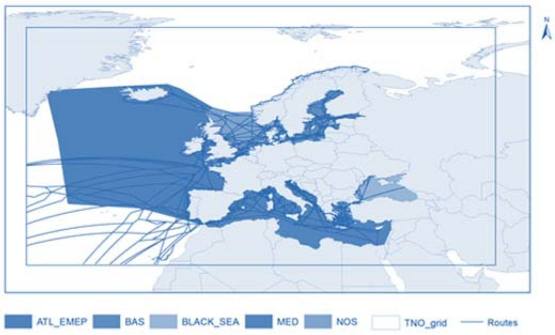


Figure 3.7: Sea regions distinguished in the VITO emission study, and main shipping routes

Table 3.9: Baseline emissions of SO_2, NO_x and PM2.5 for sea regions (kilotons)

	SO_2			NO_x			PM2.5		
	2005	2025	2030	2005	2025	2030	2005	2025	2030
Baltic Sea	130	6	7	220	193	202	14	9	10
Bay of Biscay	282	71	78	474	457	488	34	25	27
Black Sea	27	7	8	47	42	44	3	2	2
Celtic Sea	14	2	2	22	19	20	2	1	1
Mediterranean Sea	764	183	198	1294	1186	1255	87	62	67
North Sea (incl. English Channel)	309	16	17	518	476	503	37	24	26
Rest of NE Atlantic (within EMEP grid)	31	8	9	54	51	54	4	3	3
Rest of NE Atlantic (TNO grid outside EMEP)	112	28	30	192	184	196	14	10	11
Non-EU	1668	321	349	2821	2606	2762	194	137	148
Change to 2005		*-81%*	*-79%*		*-8%*	*-2%*		*-29%*	*-24%*

3.3 Air quality impacts

As a starting point for the cost-effectiveness analysis of measures to improve air quality in Europe, this section reviews the baseline evolution of the air quality impacts along a selected set of indicators, and outlines the scope for further improvements that could be achieved through implementation of the additional measures of the MTFR scenario. This report explores the impacts of emission changes within the EU-28, assuming for non-EU countries and for marine shipping the baseline emissions that are outlined in Sections 3.2.7 and 3.2.8.

Implications of additional measures in these regions on air quality within the EU have been analysed in TSAP Report #10 (Amann et al. 2013).

Following the practices of the 2005 Thematic Strategy on Air Pollution, emission control scenarios are evaluated along their impacts on five air quality impact indicators:

- Premature mortality (life shortening) from exposure to fine particulate matter (with Years of Life Lost (YOLLs) as quantitative metric),
- premature mortality from exposure to ground-level ozone (with cases of premature deaths as a quantitative metric),
- the area of ecosystems where biodiversity remains threatened by nitrogen deposition in excess of the critical loads (km^2 of ecosystems),
- forest area threatened by acidification, i.e., receiving acidifying deposition above their critical loads (km^2 of forests),
- attainment of air quality limit values for ambient NO_2 and PM10 concentrations.

3.3.1 Health impacts from PM2.5

The decrease in the precursor emissions of ambient PM2.5 of the TSAP 2013 Baseline projection suggests a decline of the loss of statistical life expectancy attributable to the exposure to fine particulate matter (PM2.5) from 8.5 months in 2005 to 5.3 months in 2025. However, in Belgium, Poland, the Czech Republic, Hungary and Romania people would still lose more than six months even in 2030 (Figure 3.8).

With the additional technical measures that could be implemented within the EU, in 2030 life shortening could be further reduced by up to 1.4 months, or down to about 3.6 months on average.

Overall, despite implementation of current emission control legislation, population in the EU-28 would still lose between 200 and 220 million years of life after 2020 (Figure 3.9). The additional measures could gain approximately 60 million life years.

Despite progress, the TSAP 2013 Baseline would not meet the environmental target for health impacts from PM that has been established in the 2005 Thematic Strategy on Air Pollution for 2020. Instead of the 47% improvement in years of life lost (YOLL) relative to 2000, the current legislation case of the TSAP 2013 would reach only a 45% reduction.

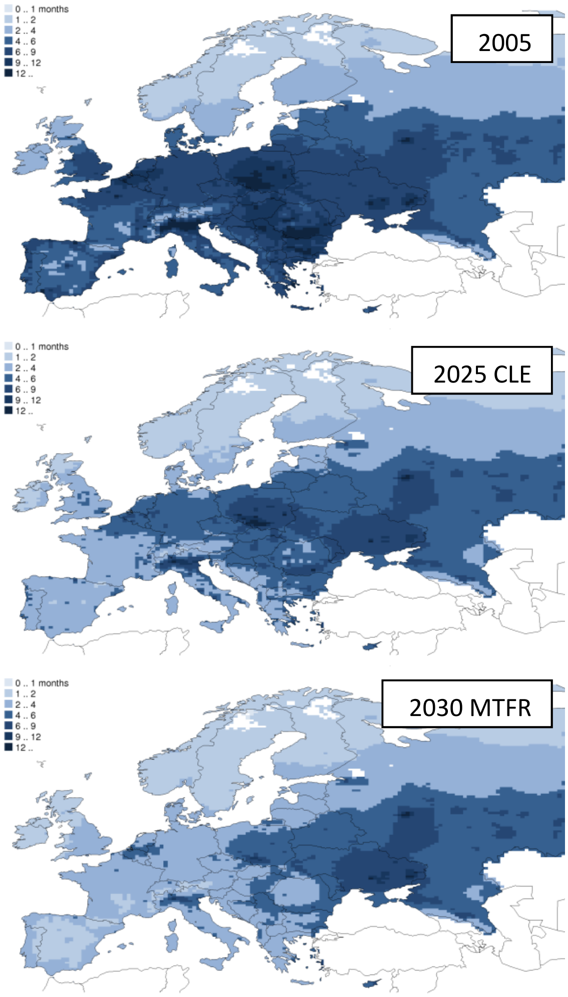


Figure 3.8: Loss in statistical life expectancy from exposure to PM2.5 from anthropogenic sources; top: 2005, mid: 2025 CLE, bottom: MTFR 2030

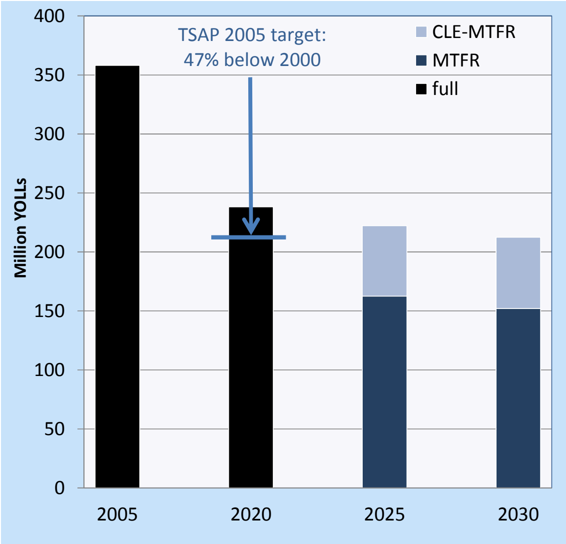


Figure 3.9: Years of life lost (YOLLs) due to exposure to fine particulate matter, EU-28

3.3.2 Health impacts from ground-level ozone

The TSAP 2013 Baseline suggests for 2025 approximately 18,000 cases of premature deaths from exposure to ground-level ozone in the EU-28 (Figure 3.11). This is safely below the 10% reduction target (25,000 cases) that was established by the 2005 Thematic Strategy on Air Pollution for 2020 relative to 2000, mainly due to more optimistic expectations on the development of hemispheric background ozone levels.

Additional emission reduction measures within the EU-28 could save another 2,800 cases of premature deaths.

The spatial pattern of the health-relevant SOMO35 indicator, and how this will be influenced by the different emission reduction scenarios, is presented in Figure 3.10.

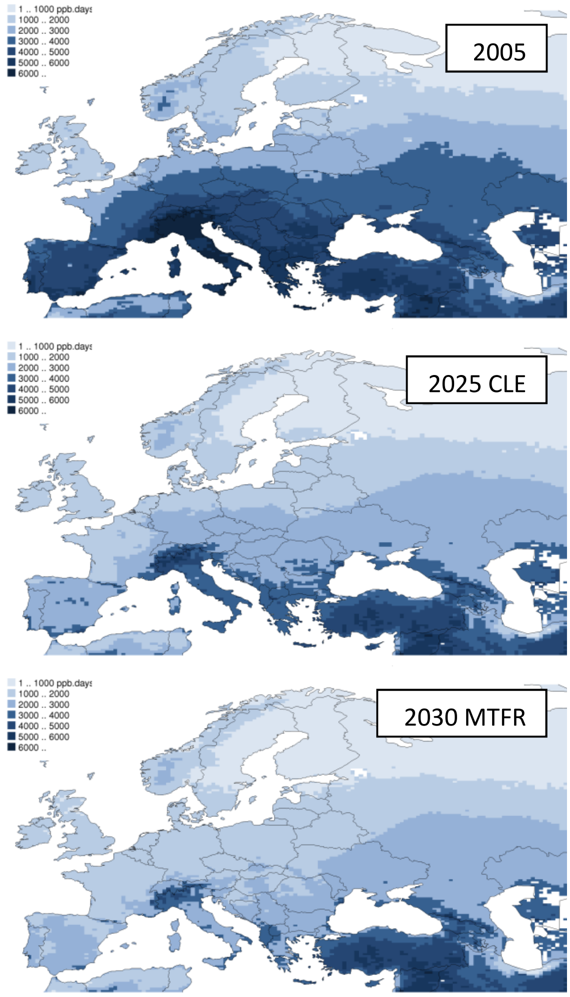


Figure 3.10: The SOMO35 indicator that is related to premature mortality from ground-level ozone

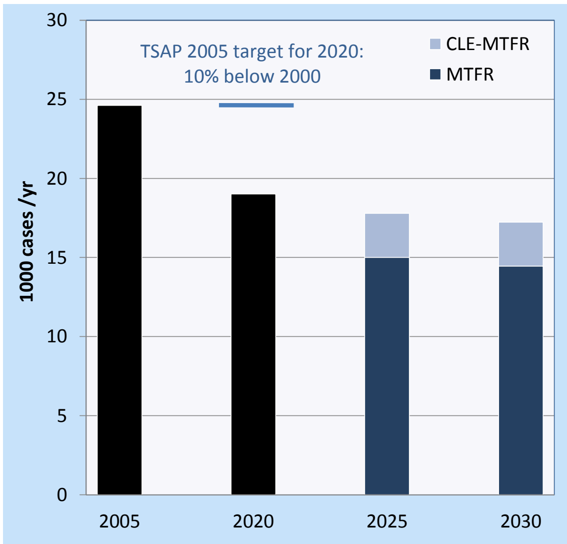


Figure 3.11: Cases of premature deaths due to exposure to ground-level ozone, EU-28

3.3.3 Eutrophication

Threat to biodiversity of Natura2000 areas

In addition to fragmentation and climate change, excess nitrogen deposition constitutes an important threat to biodiversity in areas that are protected under the Birds Directive and the Habitat Directive (i.e., Natura2000 areas).

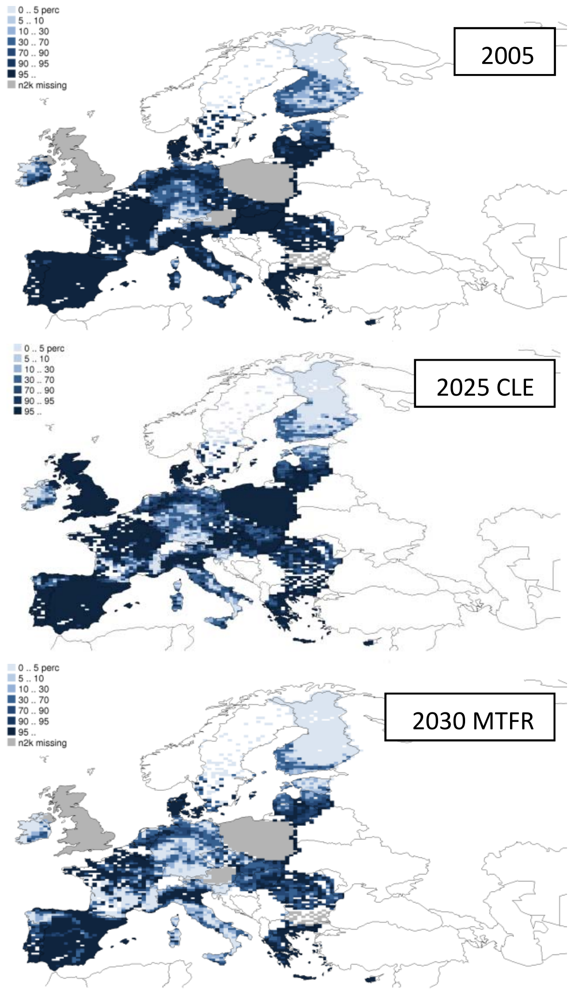


Figure 3.12: Percentage of Natura2000 areas with nitrogen deposition above their critical loads for eutrophication.

For 2005, it is calculated that biodiversity was under threat from excess nitrogen deposition in 77% (423,000 km^2) of the protected zones. By 2025, the expected declines in NO_x emissions would reduce the threatened area to 62%, leaving 335,000 km^2 unprotected. By 2030, full application of the available reduction measures, especially for ammonia emissions, could provide protection to another 100,000 km^2 of the nature protection areas in Europe (Figure 3.12).

No targets for Natura2000 areas have been established in the 2005 TSAP.

Threat to biodiversity of all ecosystems

In 2005, more than 1.1 million km^2 (i.e., 66%) of the European ecosystems were exposed to nitrogen deposition that exceeded their critical loads for eutrophication. The future development will be mainly influenced by the fate of NH_3 emissions. In 2025, the TSAP2013 Baseline would reduce the area under threat to 0.88 million km^2. The available additional emission reduction measures could safeguard another 220,000 km^2 (Figure 3.14) in 2030.

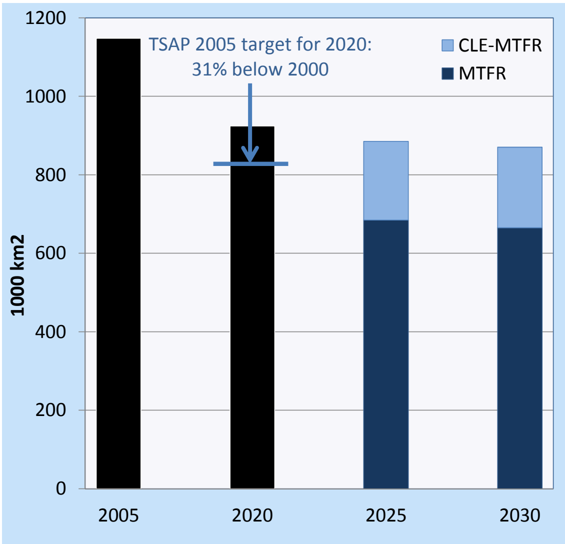


Figure 3.13: Ecosystems area with nitrogen deposition in excess of the critical loads for eutrophication, EU-28

Due to slow progress in the reduction of NH_3 emissions, the TSAP 2013 Baseline would fail to meet the environmental targets for eutrophication of the 2005 Thematic Strategy on Air Pollution. Instead of the 31% improvement in ecosystems area with nitrogen deposition above critical loads for eutrophication relative to 2000, the TSAP 2013 would achieve only a 25% reduction in 2020 (Figure 3.13).

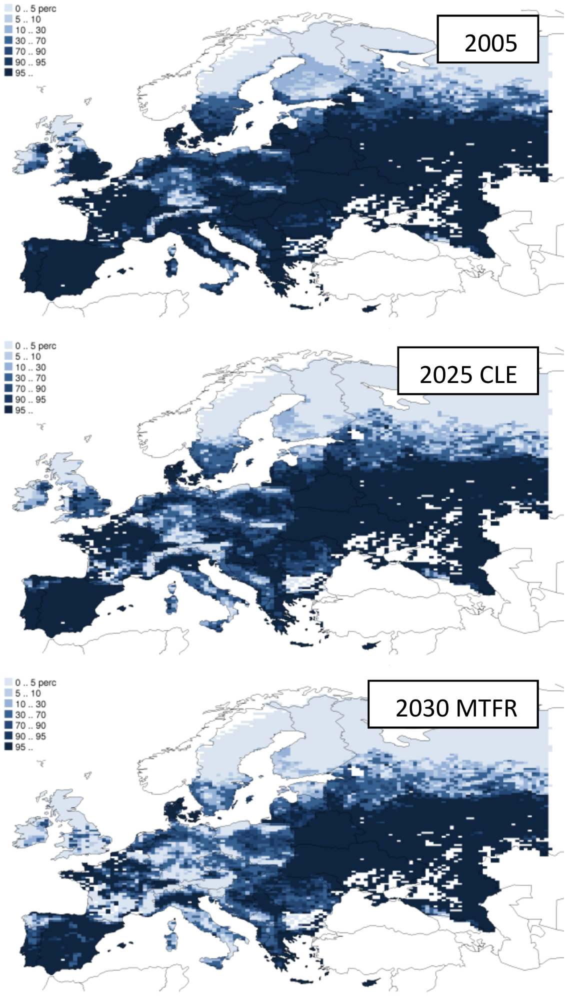


Figure 3.14: Percentage of ecosystems area with nitrogen deposition above their critical loads for eutrophication.

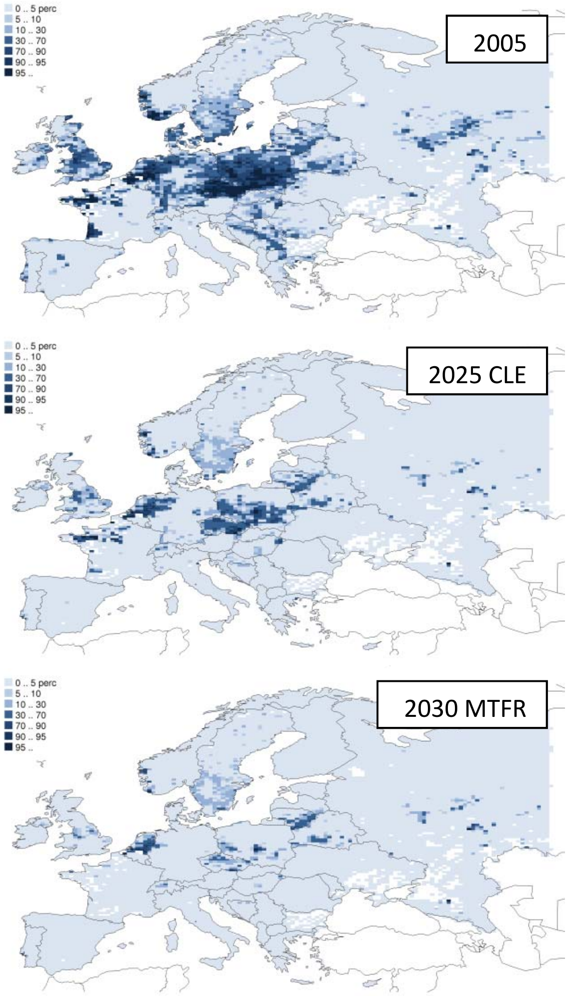


Figure 3.15: Percentage of forest area with acid deposition above the critical loads for acidification. Top: 2005, mid: 2025 CLE, bottom: MTFR 2030

3.3.4 Acidification of forest soils

With the 2012 data set on critical loads (Posch et al. 2011), it is calculated that in 2005 critical loads for acidification have been exceeded in a forest area of 160,000 km^2, i.e., in about 12% of the forests within the EU-28 for which critical loads have been reported.

Especially the anticipated further decline in SO_2 emissions will resolve the threat for another 110,000 km^2 up to 2025. Additional measures could provide sustainable conditions for another 30,000 km^2 up to 2030, and leave only 1.4% of European forests threatened by acidification (Figure 3.15). These measures would especially benefit the former ‘black triangle’ (i.e., in Poland, Czech Republic and the eastern parts of Germany), while residual problems would remain in the Netherlands due to high ammonia density.

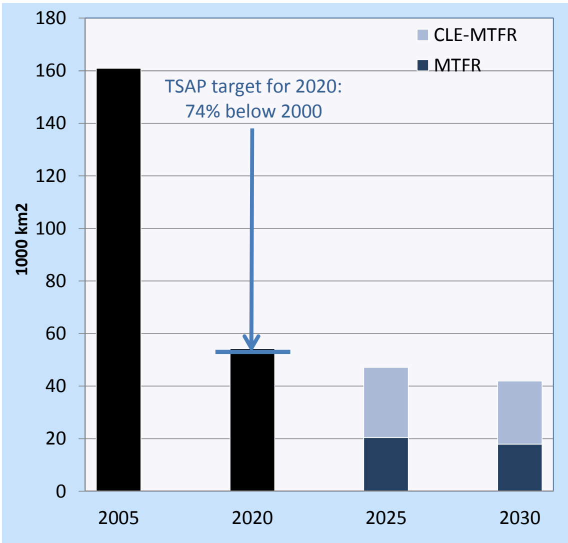


Figure 3.16: Forest area with acid deposition in excess of the critical loads for acidification, EU-28

In 2020, the TSAP 2013 Baseline would almost achieve the 74% target for acidification of the TSAP 2005 (Figure 3.16).

3.3.5 Compliance with NO_2 limit values

The GAINS assessment estimates future compliance with NO_2 limit values for more than 2000 urban sites in the EU, for which sufficient monitoring data have been provided to AIRBASE. However, this sub-set of stations is not necessarily representative for all stations in the EU, and there are large differences in station numbers across Member States. To facilitate representative conclusions, stations have been allocated to their respective air quality management zones established under the Air Quality Directive. The analysis presented here determines the compliance status in each of 496 zones along the highest concentration modelled at any AIRBASE monitoring site located within the zone.

It has been shown for NO_2 that achievement of the annual limit value of 40 μg/m^3 is more demanding than compliance with the hourly limit value of 200 μg/m^3. Thus, modelling for NO_2 is restricted to the annual limit value.

To reflect unavoidable uncertainties in monitoring data, modelling techniques and future meteorological conditions, three compliance categories with the annual limit value are distinguished: Computed annual mean concentrations of NO_2 below 35 μg/m^3 indicate likely compliance. If concentrations are computed in the range between 35 and 45 μg/m^3, compliance is possible but uncertain due to the factors mentioned above. This is also the range where additional local measures (e.g., traffic management) have a realistic chance to achieve safe compliance, even under unfavourable conditions. In contrast, compliance is unlikely if computed NO_2 concentrations exceed 45 μg/m^3.

On this basis, it is estimated that the number of air quality management zones in the EU-28 where compliance with the current limit values is unlikely will decline from about 100 zones (21%) in 2010 to 33 zones (7%) in 2020 under baseline conditions. However, this estimate is conservative as it does not consider benefits from local measures (e.g., traffic management or low emission zones), which could be quite effective for reducing the large share of NO_2 from near-by emission sources.

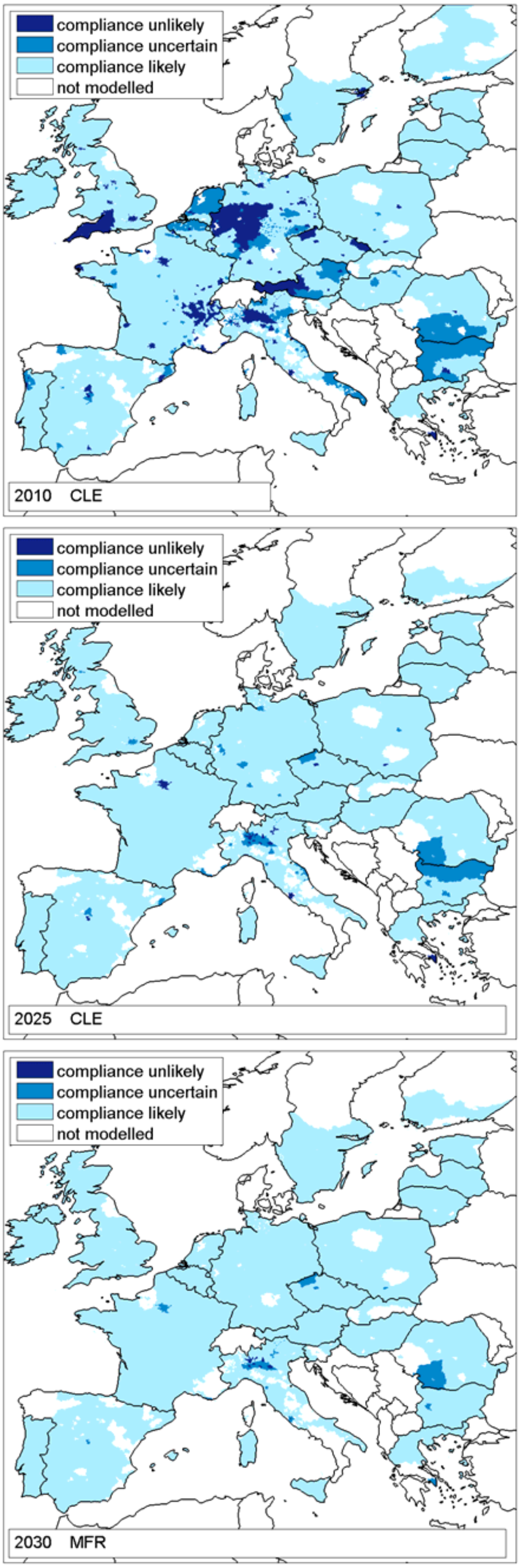


Figure 3.17: Compliance with air quality limit values for NO_2 in the air quality management zones

Conversely, in 2020 safe compliance will be achieved in ~80% of the zones, compared to 61% in 2010 (Table 3.10).

Obviously, by 2020 Europe will not fully reach the ultimate target of bringing all Europe in compliance. However, as shown in Figure 3.18, Europe will be significantly progressing towards such a target, with non-compliances rapidly decreasing following fleet renewal.

Table 3.10: Compliance with NO_2 limit values (number and % of zones).

	Compliance					
	un-likely	un-certain	likely	un-likely	un-certain	likely
2010	106	88	303	*21.3%*	*17.7%*	*61.0%*
2020	33	63	401	*6.6%*	*12.7%*	*80.7%*
2025	9	32	456	*1.8%*	*6.4%*	*91.8%*
2030	1	21	475	*0.2%*	*4.2%*	*95.6%*
2030 MTFR	1	15	481	*0.2%*	*3.0%*	*96.8%*

Table 3.11: Population living in air quality management zones with different compliance with the NO_2 limit values (million people, % of European population)

	Compliance					
	un-likely	un-certain	likely	un-likely	un-certain	likely
2010	125.9	73.0	231.8	*29%*	*17%*	*54%*
2020	63.6	49.3	317.9	*15%*	*11%*	*74%*
2025	27.3	43.9	359.6	*6%*	*10%*	*83%*
2030	4.7	44.4	381.6	*1%*	*10%*	*89%*
2030 MTFR	4.7	28.9	397.1	*1%*	*7%*	*92%*

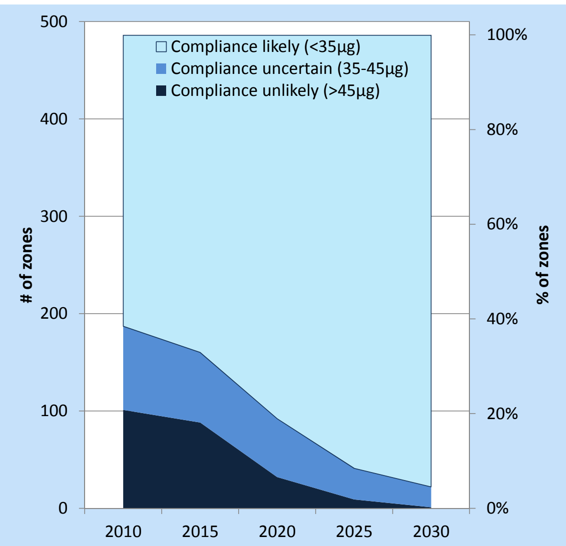


Figure 3.18: Compliance with air quality limit values for NO_2 in the air quality management zones

3.3.6 Compliance with PM10 limit values

For PM10, the limit of 35 allowed daily exceedances of 50 µg/m^3 is more difficult to attain than the annual mean limit value of 40 µg/m^3. However, there is a strong linear correlation between the 36th highest daily values and the annual mean concentrations, both in observations and model results. As an annual mean of 30 µg/m^3 corresponds well to the 36th highest daily concentration of 50 µg/m^3, this threshold is used as the criteria for the GAINS modelling, which is conducted on an annual mean basis. As for NO_2, uncertainty ranges of ±5 µg/m^3 are employed.

For the 503 zones for which sufficient monitoring data are available, it is calculated that in 2010 about 60 zones (12%) did significantly exceed the PM10 limit value. The decrease in precursor emissions of the TSAP 2013 Baseline should halve this number to about 30 by 2020 (Figure 3.19). As for NO_2, this estimate does not consider additional measures at the urban scale, which could achieve further improvements.

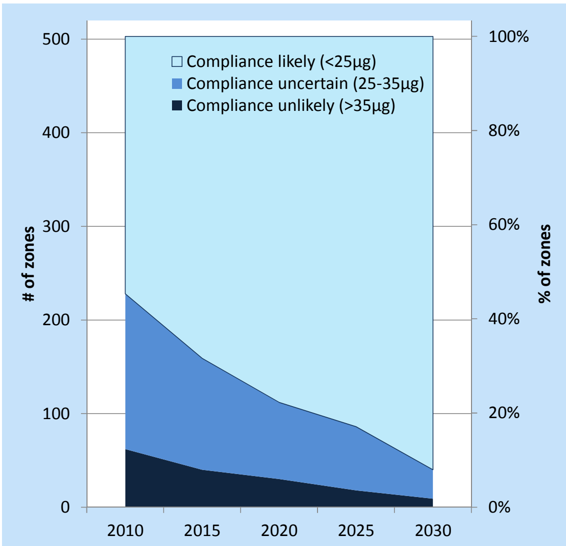


Figure 3.19: Compliance of the air quality management zones with air quality limit values for PM10

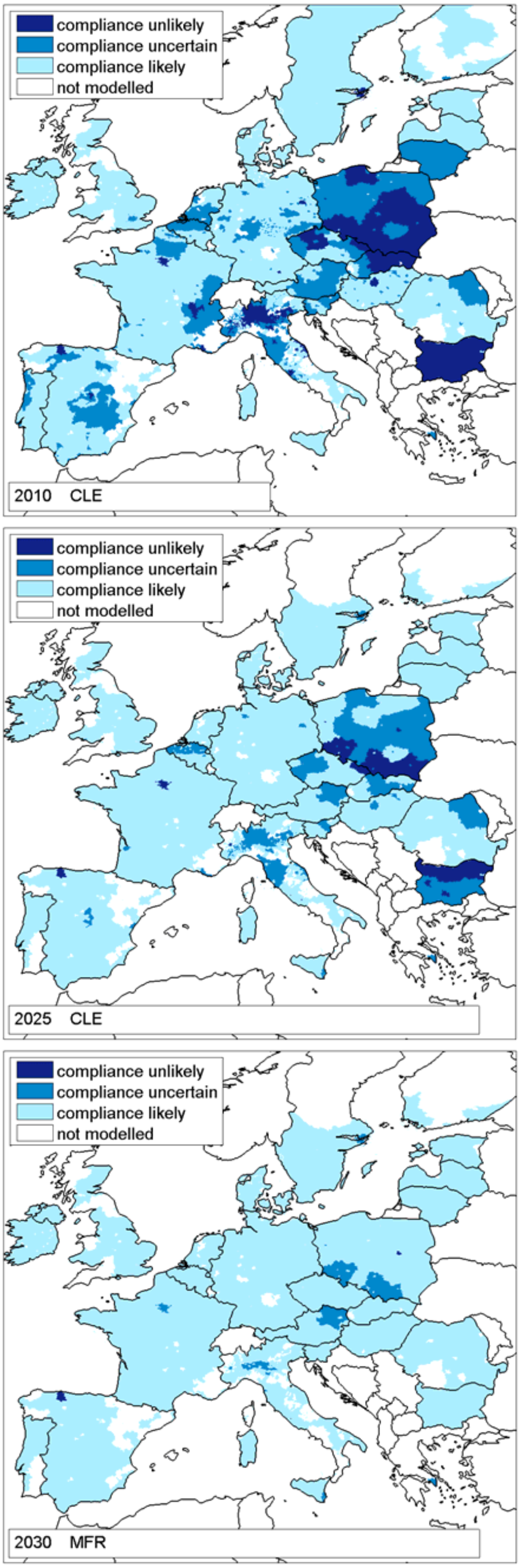


Figure 3.20: Compliance with the air quality limit values for PM10 in the air quality management zones

After 2020, problems will prevail in the new (EU-13) Member States, due to continued reliance on solid fuels for domestic heating. Technical emission control measures, together with the switch to cleaner fuels and/or to centralized heating systems could bring down PM10 concentrations below the limit value also in urban areas in this region. The bottom panel in Figure 3.20 illustrates the MTFR case that does not assume additional expansion of central heating systems.

Table 3.12: Compliance with PM10 limit values in 2025 (number and % of zones)

	Compliance					
	unlikely	un-certain	likely	unlikely	un-certain	likely
2010	62	166	275	*12%*	*33%*	*55%*
2020	30	82	391	*6%*	*16%*	*78%*
2025	18	68	417	*4%*	*14%*	*83%*
2030	9	31	463	*2%*	*6%*	*92%*
MTFR	2	15	486	*0%*	*3%*	*97%*

Table 3.13: Population living in air quality management zone with different compliance with PM10 limit values (million people, % of European population)

	Compliance					
	unlikely	un-certain	likely	unlikely	un-certain	likely
2010	80.8	128.6	211.4	*19%*	*31%*	*50%*
2020	47.8	75.9	297.1	*11%*	*18%*	*71%*
2025	31.3	77.2	312.2	*7%*	*18%*	*74%*
2030	12.9	52.4	355.5	*3%*	*12%*	*84%*
MTFR	2.5	30	388.2	*1%*	*7%*	*92%*

3.4 Costs and benefits of further emission reduction measures

As shown above, despite the significant improvements from the implementation of the current EU air pollution legislation, there is clear evidence that the objectives of the EU Environment Action Programme will not be met by the baseline scenarios. It is also clear that there is scope for additional improvements of air quality in Europe (Table 3.15). As further measures involve additional costs, the question arises about meaningful and balanced interim targets towards the achievement of the objectives of the Environment Action Programme.

Costs for implementing the air pollution control measures required by the currently decided legislation will increase from 0.43% of GDP in 2005 to 0.61% of GDP in 2020, and then decrease to 0.58% in 2030 (Table 3.14). Full implementation of all additional measures that are currently technically available (MTFR) would increase air pollution control costs by 0.32% of the EU GDP.

Table 3.14: Air pollution control costs of the TSAP 2013 CLE and MTFR scenarios (EU-28)

	2005	2025	2030
	Costs for implementing current legislation		
bn €/yr	47.76	88.33	90.17
% of GDP	*0.43%*	*0.61%*	*0.58%*
	Costs for MTFR		
bn €/yr		135.4	140.7
% of GDP		*0.93%*	*0.90%*
	Additional costs for MTFR (on top of CLE)		
bn €/yr		47.1	50.6
% of GDP		*0.32%*	*0.32%*

As shown in the preceding sections, these additional measures would result in lower exposure of population and vegetation to harmful pollution and thereby reduce negative impacts to human health and nature. The scope for improvements of the impact indicators from further emission reductions is summarized in Table 3.15.

Table 3.15: Summary of impact indicators for the TSAP 2013 CLE and MTFR scenarios (EU-28)

	2005	2025	2030
	Health impacts PM (million years of life lost – YOLLs)		
CLE	358	222	212
MTFR		163	152
	Premature deaths from O_3 (1000 cases/yr)		
CLE	24614	17794	17239
MTFR		15009	14461
	Eutrophication (Ecosystems area with nitrogen deposition above critical loads, km^2)		
CLE	1148	885	870
MTFR		684	665
	Acidification (Forest area with acid deposition above critical loads, km^2)		
CLE	161.0	47.1	42.0
MTFR		20.4	17.9

Health benefits from lower exposure to particulate matter and ozone have been monetized based on the benefit methodology assessment described in Holland et al. 2008.

Total health benefits of the MTFR measures in 2025 range from 58 to 246 billion €/yr (compared to the CLE case), depending on the valuation concept (Table 3.16).

Table 3.16: Monetized health benefits, differences between the CLE and the MTFR scenario (€million/year). Total health benefits include ranges based on different variants for values of life year lost (VOLY) and values of statistical life (VOSL)

Endpoint	2025	2030
Particulate matter		
Chronic mortality (all ages; median VOLY)	42,605	41,623
Infant mortality (0-1yr; median VSL)	198	185
Morbidity	16,187	16,388
Ozone		
Acute mortality (all ages; median VOLY)	161	160
Morbidity	595	599
Total health benefits		
Mortality only (median VOLY, median VSL for infant mortality)	42,424	41,968
Mortality and morbidity (median VOLY, median VSL for infant mortality)	57,996	57,759
Range	57,966 – 198,377	57,759 – 207,054

Prevailing uncertainties in the monetization of the value of human life and morbidity estimates are reflected through variants for values of life year lost (VOLY) and values of statistical life (VOSL). The morbidity category includes a range of effects including hospital admissions, chronic bronchitis, days of restricted activity (including work loss days) and respiratory medication use. More details on the approach and results are described in the companion TSAP Report #12.

Non-health benefits

In addition to the health benefits, lower emissions will also cause further benefits for vegetation (e.g., agricultural crops, timber production, biodiversity, etc.) and wild life (e.g., from reduced acidification). However, the monetization of such non-health benefits is complex and not fully matured. A full analysis of these benefits is provided in the accompanying TSAP Report #12.

4 Cost-effective further emission controls

4.1 Towards a rational choice of an ambition level: Costs and benefits of intermediate measures

In essence, the proposal of an appropriate ambition level for further measures remains a political choice and has to reflect implicit value judgements of decision makers.

To offer a rational basis for the choice of an ambition level for revision of the Thematic Strategy, costs of additional measures between the CLE and MTRF cases have been compared against their benefits. For this purpose, the GAINS optimization analysis has been conducted for a series of increasingly stringent 'gap closure' targets for PM health impacts (Table 4.1).

Table 4.1: Evolution of emissions (kt) and costs (million €/yr, on top of CLE) between the current legislation (CLE) and the Maximum Technically Feasible Reductions (MTFR) in 2025, EU-28. Percentage changes refer to emissions of 2005.

		CLE	B1	B2	B3	MTFR
	2005	Gap closure				
		0%	25%	50%	75%	100%
SO_2	8172	2446	2188	1903	1693	1589
		-70%	*-73%*	*-77%*	*-79%*	*-81%*
NO_x	11538	4616	4535	4484	4096	3527
		-60%	*-61%*	*-61%*	*-64%*	*-69%*
PM2.5	1647	1266	1059	963	847	693
		-23%	*-36%*	*-42%*	*-49%*	*-58%*
NH_3	3928	3658	3390	3122	2767	2566
		-7%	*-14%*	*-21%*	*-30%*	*-35%*
VOC	9259	5604	5322	5157	4648	3308
		-39%	*-43%*	*-44%*	*-50%*	*-64%*
Costs			218	1197	4622	47091
% of GDP			*0.002%*	*0.008%*	*0.032%*	*0.324%*

It turns out that, while costs of the full implementation of all available emission control measures (the MTFR case) amount to 47.1 billion €/yr in 2025, a large share of the potential gains in human health can be achieved at comparatively little costs. For instance, approximately 75% of the possible health improvements could be attained for approximately 10% of the MTFR costs (Figure 4.1).

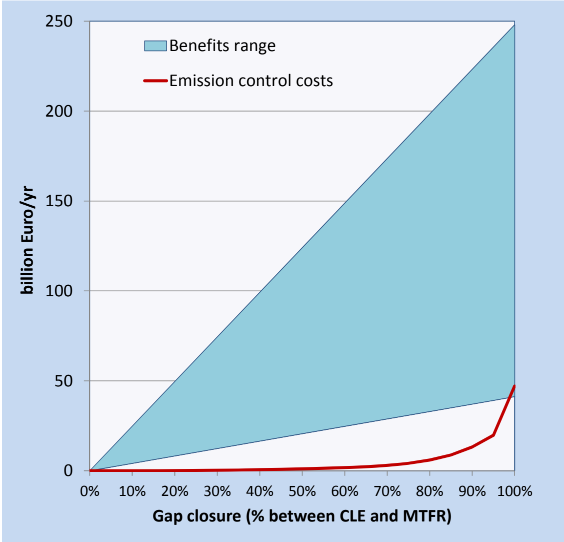


Figure 4.1: Total emission control costs and their health benefits in 2025

Also, for most of the available measures, health benefits alone exceed emission control costs by a large margin. Even for the maximum feasible reductions, costs just match the lowest estimate of health benefits

However, according to economic theory, an optimal allocation of resources will seek to maximize net benefits, which occurs at the point where marginal benefits of further emission reductions equal marginal costs.

A comparison of the marginal costs of increasingly stringent gap closure targets for human health with their marginal benefits indicates a range for the optimal ambition level between a 75% and 92% gap closure, depending on the choice of the methodology for the benefit assessment (Figure 4.2).

In view of the prevailing uncertainties, this report adopts a deliberately cautious approach to the monetization of benefits. In this analysis, benefits consider only adult mortality from PM and ozone, applying the most conservative valuation method. Estimates exclude infant mortality, improved morbidity and all non-health related impacts from better air quality (e.g., better protection of biodiversity, reduced crop and timber losses, lower material damage, etc.).

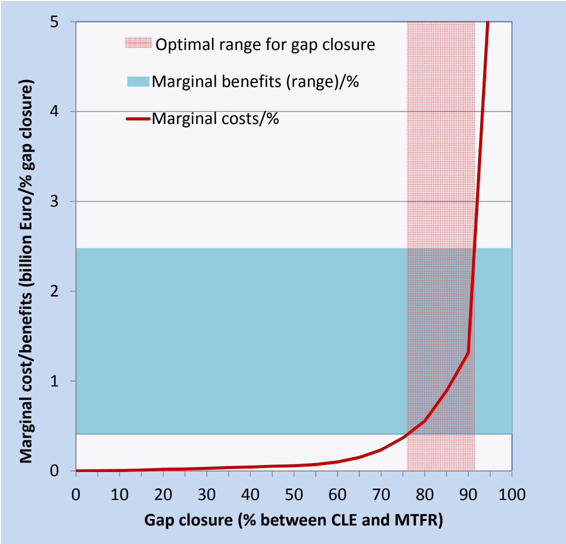


Figure 4.2: Marginal emission control costs and marginal health benefits in 2025

With the most conservative perspective, marginal benefits (i.e., 424 million €/% gap closure) equal marginal costs at a 76% gap closure between CLE and MTFR in 2025, while the uncertainty range extends up to a 92% gap closure for more comprehensive valuations or more optimistic assumptions. In addition, consideration of the non-health benefits would justify even higher ambition levels as a rational choice.

4.2 Sensitivity analyses

4.2.1 Considering non-health benefits

The inability to quantify monetary benefits, e.g., to ecosystems, does not imply that improvements for these impacts are without value, and additional emission control measures could be justified for such non-quantifiable benefits.

As a starting point, Table 4.3 presents the side-effects of the B1 to B3 scenarios that have been optimized for PM health impacts on other environmental impacts. The optimization for PM health impacts, which linked to population exposure to ambient PM2.5, addresses all precursor emissions for ambient PM2.5 (i.e., primary PM2.5 as well as SO_2, NOx, NH_3 and VOC as precursors for secondary aerosols). Since these pollutants also have impacts on ground-level ozone, eutrophication and acidification, reductions of these emissions, even if they are motivated to reduce ambient PM2.5 levels, will also result in benefits for the other endpoints. For ozone, the B3 scenario would avoid another 1220 cases of premature deaths from lower ozone exposure compared to the CLE case. It would protect another 140,000 km^2 of ecosystems from eutrophication, and 13,000 km^2 from acidification.

Table 4.2: Impact indicators of the scenarios that have been optimized for health impacts, EU-28, 2025. [YOLLs millions, ozone: cases of premature deaths/yr, eutrophication and acidification: 1000 km^2 of forests/ecosystems]. Changes refer to 2005.

	2005	CLE	B1	B2	B3	MTFR
		Gap closure				
		0%	25%	50%	75%	100%
YOLLs	358	222	207	192	178	163
		-38%	*-42%*	*-46%*	*-50%*	*-55%*
Ozone	24614	17794	17517	17318	16566	15009
		-28%	*-29%*	*-30%*	*-33%*	*-39%*
Eutro.	1148	885	851	814	747	685
		-23%	*-26%*	*-29%*	*-35%*	*-40%*
Acidif.	161	47	37	31	24	20
		-71%	*-77%*	*-81%*	*-85%*	*-87%*

To explore the implications of a more comprehensive monetization of benefits, even if these might be more difficult to quantify in monetary terms, the additional scope for the potential from low-cost measures was explored through a further scenario (B4) that establishes additional targets for ozone and eutrophication. Based on the findings of TSAP Report #10 and searching for low-cost options for reaping ‘low hanging fruits’ for these other environmental effects, a 46% gap closure target was adopted for ozone and an 80% target for eutrophication. Scenario B4 applies these targets in addition to a 75% gap closure for YOLLs (see Scenario B3), which emerges from a most conservative estimate of PM health benefits. Taking up comments from stakeholders on TSAP Report #10, the cost-effectiveness of this exploratory scenario was enhanced by imposing these targets in an EU-wide context, without requesting minimum improvements in each Member State.

Compared to the YOLL-only scenario B3, the more stringent targets reduce the number of premature deaths from ground-level ozone in the EU-28 by 57 cases, and protect another 8,000 km^2 of ecosystems from excess nitrogen deposition (Table 4.3). This requires additional reductions of NO_x by 52 kt, of NH_3 by 27 kt, and of VOC by 18 kt. Although these additional measures would relieve the pressure on SO_2 and PM2.5 (by 4 kt), total emission control costs would increase by 51 mio €/yr (Table 4.4).

Table 4.3: Impact indicators of the B4 scenario with more ambitious targets for non-health effects, EU-28, 2025. [YOLLs million, ozone: cases of premature deaths/yr, eutrophication and acidification: 1000 km^2 of forests/ecosystems]. Changes refer to 2005.

	2005	CLE	B3	B4	MTFR
	Gap closure targets (between CLE and MTFR)				
YOLL		0%	75%	75%	100%
Ozone		0%	-	46%	100%
Eutro		0%	-	80%	100%
YOLLs	358	222	178	178	163
		-38%	*-50%*	*-50%*	*-55%*
Ozone	24614	17794	16566	16509	15009
		-28%	*-33%*	*-33%*	*-39%*
Eutro.	1148	885	747	739	685
		-23%	*-35%*	*-36%*	*-40%*
Acidif.	161	47	24	24	20
		-71%	*-85%*	*-85%*	*-87%*

Table 4.4: Emissions (kt) and costs on top of CLE (million €/yr) of the B4 scenario with more ambitious targets for non-health effects, EU-28, 2025. Changes refer to 2005.

	2005	CLE	B3	B4	MTFR
SO_2	8172	2446	1693	1697	1589
		-70%	*-79%*	*-79%*	*-81%*
NO_x	11538	4616	4096	4044	3527
		-60%	*-64%*	*-65%*	*-69%*
PM2.5	1647	1266	847	851	693
		-23%	*-49%*	*-48%*	*-58%*
NH_3	3928	3658	2767	2740	2566
		-7%	*-30%*	*-30%*	*-35%*
VOC	9259	5604	4648	4630	3308
		-39%	*-50%*	*-50%*	*-64%*
Costs			4622	4673	47091
% GDP		0.608%	0.032%	0.032%	0.324%

4.2.2 Variations of the gap closure target for health

While the model analysis suggests the most conservative estimate of marginal health benefits to equalize marginal costs at a 76% YOLL gap closure, negotiations in a policy context might consider other aspects that cannot be fully quantified in a model framework. Such considerations might result in a deviation from the optimal point that has been established with the quantitative analysis.

To inform negotiations on the implications of modified ambition levels around the 76% gap closure, a series of optimizations (B5 to B9) has explored, in five percent intervals, targets in the range between 65% and 85% gap closure for YOLL. Costs vary between 2.5 and 9.7 billion €/yr (Table 4.5), with especially large differences for the domestic sector (Table 4.6, Figure 4.3).

Table 4.5: Emissions (kt) and costs on top of CLE (million €/yr) for gap closures between 65% and 85%, EU-28, 2025. Changes refer to 2005.

	B5	B6	B3	B8	B9
	Gap closure target for YOLL				
	65%	70%	75%	80%	85%
SO_2	1769	1736	1706	1667	1633
	-78%	*-79%*	*-79%*	*-80%*	*-80%*
NO_x	4311	4184	4096	4040	3902
	-63%	*-64%*	*-65%*	*-65%*	*-66%*
PM2.5	889	864	847	817	798
	-46%	*-48%*	*-49%*	*-50%*	*-52%*
NH_3	2914	2872	2767	2728	2669
	-26%	*-27%*	*-30%*	*-31%*	*-32%*
VOC	4833	4719	4648	4595	4460
	-48%	*-49%*	*-50%*	*-50%*	*-52%*
Costs	2481	3339	4622	6620	9717
% GDP	*0.017%*	*0.023%*	*0.032%*	*0.046%*	*0.067%*

Table 4.6: Additional emission control costs (on top of CLE) for the different targets (million €/yr)

	B5	B6	B3	B8	B9
	Gap closure target for YOLL				
	65%	70%	75%	80%	85%
Power gen.	195	249	469	827	1448
Domestic	1028	1439	1680	2853	4097
Ind. comb.	383	445	641	840	1128
Ind. process	233	277	331	407	488
Fuel extract.	0	0	6	6	6
Solvent use	24	38	56	63	252
Road transp.	0	0	0	0	0
Non-road	25	137	140	156	180
Waste	8	9	9	9	9
Agriculture	586	745	1292	1459	2109
Total costs	2481	3339	4622	6620	9717

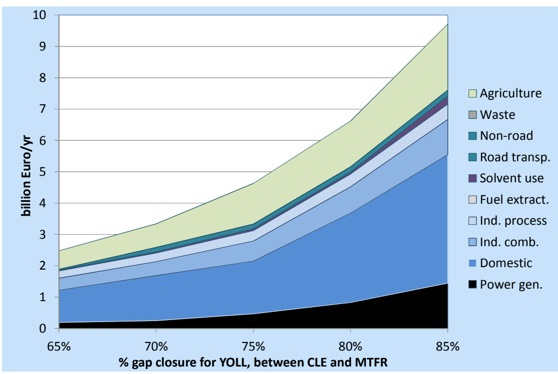


Figure 4.3: Emission control costs per SNAP sector for gap closure targets between 65% and 85%

4.3 The ambition level endorsed by the European Commission

In December 2013, the college of the European Commission reached agreement on a gap closure level for health effects five percent lower than the theoretically optimal 75%. While achieving much of the envisaged health improvements of the 75% gap closure, this B6 scenario alleviates the economic burden for some of the most affected sectors and reduces total air pollution control costs by about 25%.

The monetized health benefits of the B6 scenario of 40 billion €/yr would be achieved at costs of 3.3 billion €/yr in 2025 under baseline assumptions. However, as discussed above, this scenario falls short of maximizing net health benefits, which would occur at a 76% gap closure.

The B6 scenario represents the most cost-effective solution to a 70% gap closure target for the EU-wide YOLL indicator between the current legislation and MTFR scenario in 2025, based on the PRIMES 2013 Reference projection. As discussed in the following section, the marginal costs of this scenario have been used in the Commission Proposal to determine the precise gap closure level for 2030, rather than to set emission ceilings for 2025.

4.4 The Commission proposal for 2030

The European Commission recognized that a considerable portion of the additional emission reductions that are implied by the B6 scenario would emerge as a side effect of the climate policy target for 2030 that has been proposed by the European Commission in its Communication on the 2014 Energy and Climate package (EC 2014b).

In order to fully harvest these co-benefits from the proposed climate targets, in its Clean Air Policy Package the European Commission has proposed to maintain the B6 ambition level in terms of marginal benefits to costs ratio, and to establish corresponding emission ceilings for the year 2030.

This should not only maximize the co-benefits from the structural changes that will lead to the achievement of the EU climate policy targets, but also avoid potential regret investments from premature retirement of newly installed pollution control equipment that might become superfluous if climate policy measures would abandon the underlying activity. (It has been shown in TSAP Report #10, however, that for the PRIMES climate policy scenarios the potential for such regret investments is rather small.)

Scenario B7 maintains the level of marginal costs of the B6 scenario for 2025. In the year 2030, this particular level of marginal costs corresponds to a 67% gap closure under the assumptions of the PRIMES 2013 baseline (i.e., the CLE and MTFR cases of the PRIMES baseline for 2030). The GAINS optimization has been used to establish the least-cost allocation of emission reductions that meet the chosen gap closure target.

However, note that the chosen level of gap closure does not maximize net health benefits; as shown above, the optimal gap closure, i.e., where marginal benefits equal marginal costs, would be 75% in 2025 (instead of 70%), and 72% (instead of 67%) in 2030.

While no explicit reduction commitments are set for 2025, Member States must limit their emissions in that year to the levels defined on the basis of a linear reduction trajectory between their levels of 2020 and the Commission proposal for 2030.

4.4.1 Emission control costs

In 2030, the B7 scenario involves additional emission control costs of 3.3 billion €/yr, which represents an increase of about 4% compared to the costs for implementing current legislation in 2030.

The costs of 3.3 billion €/yr constitute about 0.02% of the GDP in the EU-28 that is assumed for 2030. This share varies widely across Member States, essentially due to differences in economic wealth. While the additional measures would require up to 0.18% in Bulgaria, they account for only 0.001% of the GDP in Sweden (Table 4.7).

Table 4.7: (Additional) emission control costs of the B7 scenario in 2030, by country (million €/yr, % of GDP)

	CLE		B7 in 2030		MTFR in 2030	
Austria	1983	*0.560%*	66	*0.019%*	1099	*0.310%*
Belgium	2469	*0.575%*	110	*0.026%*	853	*0.199%*
Bulgaria	1212	*3.191%*	67	*0.176%*	752	*1.981%*
Croatia	423	*0.755%*	26	*0.047%*	440	*0.786%*
Cyprus	138	*0.651%*	0	*0.001%*	47	*0.219%*
Czech Rep.	1936	*1.111%*	106	*0.061%*	1269	*0.728%*
Denmark	1117	*0.405%*	18	*0.007%*	814	*0.296%*
Estonia	298	*1.588%*	4	*0.022%*	363	*1.935%*
Finland	1422	*0.636%*	5	*0.002%*	1035	*0.463%*
France	12208	*0.494%*	289	*0.012%*	7828	*0.317%*
Germany	13535	*0.474%*	489	*0.017%*	5702	*0.200%*
Greece	1723	*0.770%*	51	*0.023%*	1142	*0.510%*
Hungary	1070	*0.922%*	72	*0.062%*	697	*0.600%*
Ireland	1192	*0.440%*	8	*0.003%*	518	*0.191%*
Italy	11146	*0.621%*	418	*0.023%*	3967	*0.221%*
Latvia	360	*1.756%*	2	*0.008%*	613	*2.991%*
Lithuania	397	*1.192%*	14	*0.042%*	664	*1.992%*
Luxembourg	204	*0.422%*	2	*0.005%*	45	*0.092%*
Malta	103	*1.386%*	0	*0.002%*	17	*0.236%*
Netherlands	3407	*0.474%*	47	*0.007%*	965	*0.134%*
Poland	9992	*2.040%*	638	*0.130%*	6849	*1.398%*
Portugal	1495	*0.743%*	67	*0.033%*	922	*0.458%*
Romania	2605	*1.997%*	180	*0.138%*	3010	*2.308%*
Slovakia	826	*1.064%*	78	*0.101%*	852	*1.097%*
Slovenia	467	*1.082%*	34	*0.080%*	147	*0.341%*
Spain	8624	*0.601%*	231	*0.016%*	5130	*0.357%*
Sweden	1484	*0.318%*	4	*0.001%*	635	*0.136%*
UK	8327	*0.311%*	303	*0.011%*	4199	*0.157%*
EU-28	90165	*0.575%*	3331	*0.021%*	50575	*0.323%*

The largest share (40%) of the additional costs would emerge in the domestic sector, followed by the agricultural sector, where 23% of the costs would occur. However, these sectors carry only small shares in the costs for implementing current legislation. By 2030, the domestic sector will carry 10% of the costs of currently decided emission controls, and the agricultural sector 2%. For comparison, 58% of total costs emerge for road transport sources, for which however the B7 scenario does not foresee additional measures (Table 4.8).

Table 4.8: (Additional) emission control costs of the B7 scenario in 2030, by sector (million €/yr, increase compared to CLE)

	CLE	B7 in 2030		MTFR in 2030	
Power gen.	7124	228	*3%*	3658	*51%*
Domestic	8928	1372	*15%*	19622	*220%*
Ind. comb.	2567	499	*19%*	1850	*72%*
Ind. process	5032	280	*6%*	4054	*81%*
Fuel extract.	619	0	*0%*	556	*90%*
Solvent use	1147	39	*3%*	12214	*1065%*
Road transp.	52633	0	*0%*	0	*0%*
Non-road	10331	127	*1%*	2901	*28%*
Waste	1	9	*1105%*	9	*1196%*
Agriculture	1784	779	*44%*	5711	*320%*
Sum	90165	3331	*4%*	50575	*56%*

4.4.2 Emissions

In 2030, the cost-effective allocation of emission reduction measures to achieve the B7 targets would imply for the EU-28 a decline of SO_2 emissions by 81% below the 2005 level (Figure 4.4). NO_x would decline by 69%, PM by 51%, NH_3 by 27% and VOC by 50%. The cost-effective emission ceilings for the B7 scenario in 2030 are shown in Table 4.9 to Table 4.13.

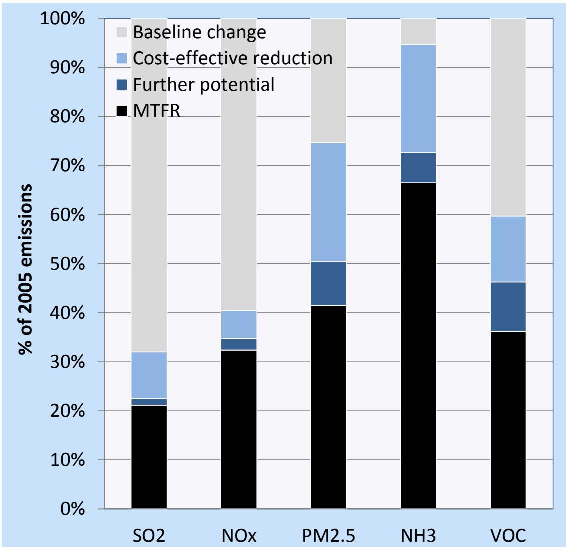


Figure 4.4: (Cost-effective) changes of 2005 emissions in 2030 (EU-28)

Table 4.9: SO_2 emissions of the scenarios for 2030, by country and by sector (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	25	13	*-47%*	12	*-50%*	11	*-55%*
Belgium	140	58	*-59%*	45	*-68%*	44	*-68%*
Bulgaria	890	112	*-87%*	53	*-94%*	52	*-94%*
Croatia	68	20	*-70%*	9	*-87%*	6	*-91%*
Cyprus	38	2	*-95%*	2	*-95%*	1	*-98%*
Czech Rep.	208	74	*-64%*	59	*-72%*	56	*-73%*
Denmark	21	9	*-56%*	9	*-58%*	8	*-63%*
Estonia	66	22	*-67%*	19	*-71%*	15	*-78%*
Finland	90	64	*-29%*	63	*-30%*	59	*-35%*
France	444	117	*-74%*	97	*-78%*	92	*-79%*
Germany	549	295	*-46%*	258	*-53%*	246	*-55%*
Greece	505	50	*-90%*	38	*-92%*	25	*-95%*
Hungary	129	27	*-79%*	16	*-88%*	15	*-88%*
Ireland	71	14	*-80%*	12	*-83%*	11	*-85%*
Italy	382	142	*-63%*	94	*-75%*	73	*-81%*
Latvia	5	3	*-40%*	3	*-46%*	2	*-54%*
Lithuania	42	25	*-41%*	12	*-72%*	10	*-77%*
Luxembourg	2	2	*-21%*	1	*-44%*	1	*-56%*
Malta	11	0	*-97%*	0	*-98%*	0	*-99%*
Netherlands	70	32	*-54%*	29	*-59%*	26	*-63%*
Poland	1256	453	*-64%*	276	*-78%*	261	*-79%*
Portugal	111	49	*-56%*	26	*-77%*	17	*-84%*
Romania	706	99	*-86%*	51	*-93%*	45	*-94%*
Slovakia	92	46	*-50%*	19	*-79%*	19	*-80%*
Slovenia	40	6	*-85%*	5	*-89%*	4	*-89%*
Spain	1328	232	*-83%*	152	*-89%*	130	*-90%*
Sweden	38	32	*-16%*	32	*-16%*	31	*-19%*
UK	850	214	*-75%*	138	*-84%*	124	*-85%*
EU-28	8172	2211	*-73%*	1530	*-81%*	1382	*-83%*
Power gen.	5445	637	*-88%*	532	*-90%*	435	*-92%*
Domestic	623	336	*-46%*	219	*-65%*	213	*-66%*
Ind. comb.	1100	610	*-44%*	392	*-64%*	355	*-68%*
Ind. process	743	575	*-23%*	349	*-53%*	345	*-54%*
Fuel extract.	0	0		0		0	
Solvent use	0	0		0		0	
Road transp.	36	5	*-86%*	5	*-86%*	5	*-86%*
Non-road	215	37	*-83%*	31	*-85%*	29	*-87%*
Waste	2	2	*-10%*	1	*-79%*	1	*-79%*
Agriculture	7	9	*24%*	0	*-100%*	0	*-100%*
Sum	8172	2211	*-73%*	1530	*-81%*	1382	*-83%*

Table 4.10: NO_x emissions of the scenarios for 2030, by country and by sector (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	230	65	*-72%*	64	*-72%*	54	*-76%*
Belgium	295	134	*-55%*	108	*-63%*	95	*-68%*
Bulgaria	167	60	*-64%*	58	*-65%*	41	*-75%*
Croatia	76	33	*-56%*	26	*-66%*	14	*-81%*
Cyprus	21	6	*-70%*	6	*-70%*	4	*-81%*
Czech Rep.	296	112	*-62%*	101	*-66%*	83	*-72%*
Denmark	182	61	*-66%*	57	*-69%*	46	*-75%*
Estonia	40	16	*-61%*	16	*-61%*	10	*-74%*
Finland	201	99	*-51%*	99	*-51%*	82	*-59%*
France	1351	441	*-67%*	401	*-70%*	332	*-75%*
Germany	1397	530	*-62%*	439	*-69%*	380	*-73%*
Greece	407	126	*-69%*	112	*-72%*	92	*-77%*
Hungary	155	52	*-66%*	48	*-69%*	35	*-77%*
Ireland	150	43	*-71%*	38	*-75%*	28	*-82%*
Italy	1306	456	*-65%*	405	*-69%*	360	*-72%*
Latvia	36	20	*-44%*	20	*-44%*	15	*-58%*
Lithuania	62	28	*-54%*	28	*-55%*	22	*-65%*
Luxembourg	47	10	*-79%*	10	*-79%*	9	*-80%*
Malta	10	1	*-89%*	1	*-89%*	1	*-92%*
Netherlands	380	143	*-62%*	122	*-68%*	105	*-72%*
Poland	797	379	*-52%*	358	*-55%*	280	*-65%*
Portugal	268	92	*-65%*	76	*-71%*	57	*-79%*
Romania	311	127	*-59%*	102	*-67%*	81	*-74%*
Slovakia	95	47	*-51%*	39	*-59%*	31	*-67%*
Slovenia	50	16	*-69%*	14	*-71%*	12	*-75%*
Spain	1513	434	*-71%*	380	*-75%*	300	*-80%*
Sweden	216	76	*-65%*	76	*-65%*	64	*-70%*
UK	1480	441	*-70%*	397	*-73%*	316	*-79%*
EU-28	11538	4051	*-65%*	3599	*-69%*	2948	*-74%*
Power gen.	2879	906	*-69%*	766	*-73%*	517	*-82%*
Domestic	632	471	*-25%*	471	*-25%*	389	*-39%*
Ind. comb.	1253	928	*-26%*	702	*-44%*	503	*-60%*
Ind. process	213	172	*-19%*	167	*-21%*	137	*-36%*
Fuel extract.	0	0		0		0	
Solvent use	0	0		0		0	
Road transp.	4905	887	*-82%*	887	*-82%*	887	*-82%*
Non-road	1630	661	*-59%*	604	*-63%*	513	*-69%*
Waste	8	5	*-35%*	1	*-89%*	1	*-89%*
Agriculture	16	21	*25%*	1	*-95%*	1	*-95%*
Sum	11538	4051	*-65%*	3599	*-69%*	2948	*-74%*

Table 4.11: PM2.5 emissions of the scenarios for 2030, by country and by sector (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	24	16	*-34%*	11	*-55%*	9	*-62%*
Belgium	28	19	*-33%*	15	*-47%*	13	*-53%*
Bulgaria	35	24	*-30%*	13	*-64%*	9	*-75%*
Croatia	15	11	*-28%*	5	*-66%*	3	*-82%*
Cyprus	3	1	*-70%*	1	*-72%*	1	*-75%*
Czech Rep.	43	32	*-25%*	21	*-51%*	15	*-65%*
Denmark	28	13	*-53%*	10	*-64%*	7	*-75%*
Estonia	20	12	*-41%*	10	*-52%*	3	*-85%*
Finland	29	20	*-30%*	17	*-39%*	11	*-62%*
France	271	169	*-38%*	141	*-48%*	107	*-61%*
Germany	123	84	*-32%*	70	*-43%*	62	*-49%*
Greece	62	30	*-51%*	18	*-71%*	14	*-77%*
Hungary	29	18	*-37%*	11	*-63%*	8	*-73%*
Ireland	13	9	*-33%*	9	*-35%*	7	*-49%*
Italy	147	119	*-19%*	80	*-45%*	69	*-53%*
Latvia	19	12	*-34%*	10	*-45%*	4	*-80%*
Lithuania	15	11	*-28%*	7	*-54%*	4	*-75%*
Luxembourg	3	2	*-43%*	2	*-48%*	2	*-54%*
Malta	1	0	*-76%*	0	*-80%*	0	*-83%*
Netherlands	24	17	*-30%*	15	*-38%*	13	*-45%*
Poland	225	198	*-12%*	135	*-40%*	98	*-56%*
Portugal	63	41	*-35%*	19	*-70%*	16	*-74%*
Romania	113	84	*-25%*	40	*-65%*	23	*-80%*
Slovakia	32	20	*-38%*	12	*-64%*	7	*-78%*
Slovenia	9	6	*-40%*	3	*-70%*	2	*-76%*
Spain	156	125	*-20%*	61	*-61%*	50	*-68%*
Sweden	31	25	*-19%*	24	*-23%*	14	*-56%*
UK	87	82	*-6%*	46	*-47%*	38	*-56%*
EU-28	1647	1200	*-27%*	804	*-51%*	607	*-63%*
Power gen.	132	53	*-59%*	28	*-79%*	21	*-84%*
Domestic	573	465	*-19%*	317	*-45%*	156	*-73%*
Ind. comb.	85	75	*-12%*	46	*-46%*	37	*-56%*
Ind. process	213	201	*-5%*	150	*-30%*	139	*-34%*
Fuel extract.	9	6	*-33%*	6	*-33%*	6	*-33%*
Solvent use	0	0		0		0	
Road transp.	270	102	*-62%*	102	*-62%*	102	*-62%*
Non-road	123	35	*-72%*	32	*-74%*	27	*-78%*
Waste	88	90	*3%*	64	*-27%*	64	*-27%*
Agriculture	155	172	*11%*	58	*-63%*	54	*-65%*
Sum	1647	1200	*-27%*	804	*-51%*	607	*-63%*

Table 4.12: NH_3 emissions of the scenarios for 2030, by country and by sector (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	63	68	*8%*	51	*-19%*	47	*-26%*
Belgium	74	73	*-1%*	62	*-16%*	60	*-19%*
Bulgaria	65	64	*-1%*	59	*-10%*	57	*-12%*
Croatia	29	30	*2%*	22	*-24%*	19	*-36%*
Cyprus	6	6	*-4%*	5	*-18%*	4	*-31%*
Czech Rep.	80	62	*-22%*	52	*-35%*	51	*-36%*
Denmark	73	51	*-31%*	46	*-37%*	39	*-47%*
Estonia	12	13	*9%*	11	*-8%*	8	*-29%*
Finland	34	31	*-8%*	29	*-15%*	24	*-29%*
France	675	639	*-5%*	476	*-29%*	424	*-37%*
Germany	593	565	*-5%*	362	*-39%*	294	*-50%*
Greece	57	48	*-16%*	42	*-26%*	39	*-32%*
Hungary	78	67	*-13%*	51	*-34%*	48	*-38%*
Ireland	104	101	*-3%*	97	*-7%*	86	*-18%*
Italy	422	389	*-8%*	311	*-26%*	299	*-29%*
Latvia	13	15	*19%*	14	*6%*	13	*-3%*
Lithuania	44	51	*15%*	47	*7%*	33	*-26%*
Luxembourg	6	6	*-11%*	5	*-24%*	5	*-27%*
Malta	2	2	*-8%*	1	*-24%*	1	*-35%*
Netherlands	146	111	*-24%*	110	*-25%*	109	*-25%*
Poland	344	332	*-3%*	255	*-26%*	228	*-33%*
Portugal	71	73	*3%*	60	*-16%*	50	*-29%*
Romania	161	141	*-12%*	123	*-24%*	112	*-31%*
Slovakia	28	24	*-16%*	18	*-37%*	17	*-42%*
Slovenia	19	17	*-12%*	14	*-24%*	14	*-28%*
Spain	366	349	*-5%*	258	*-29%*	209	*-43%*
Sweden	54	49	*-9%*	44	*-17%*	39	*-27%*
UK	308	287	*-7%*	245	*-21%*	239	*-22%*
EU-28	3928	3663	*-7%*	2871	*-27%*	2568	*-35%*
Power gen.	14	23	*65%*	15	*9%*	20	*43%*
Domestic	19	19	*0%*	19	*0%*	18	*-3%*
Ind. comb.	4	6	*63%*	5	*43%*	8	*135%*
Ind. process	78	75	*-4%*	74	*-5%*	28	*-64%*
Fuel extract.	0	0		0		0	
Solvent use	0	0		0		0	
Road transp.	128	46	*-64%*	46	*-64%*	46	*-64%*
Non-road	2	2	*11%*	1	*-39%*	1	*-52%*
Waste	166	173	*4%*	173	*4%*	173	*4%*
Agriculture	3518	3319	*-6%*	2538	*-28%*	2274	*-35%*
Sum	3928	3663	*-7%*	2871	*-27%*	2568	*-35%*

Table 4.13: VOC emissions of the scenarios for 2030, by country (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	171	102	-40%	89	-48%	52	-70%
Belgium	158	99	-37%	88	-44%	67	-57%
Bulgaria	139	67	-51%	52	-62%	32	-77%
Croatia	79	48	-39%	41	-48%	25	-68%
Cyprus	9	4	-53%	4	-54%	3	-69%
Czech Rep.	251	140	-44%	108	-57%	69	-72%
Denmark	130	63	-51%	53	-59%	35	-73%
Estonia	38	27	-31%	24	-37%	9	-75%
Finland	173	96	-44%	92	-46%	48	-72%
France	1117	591	-47%	556	-50%	396	-65%
Germany	1235	840	-32%	708	-43%	502	-59%
Greece	283	116	-59%	93	-67%	60	-79%
Hungary	144	81	-44%	60	-59%	45	-69%
Ireland	63	43	-32%	43	-32%	22	-65%
Italy	1237	646	-48%	570	-54%	400	-68%
Latvia	69	37	-46%	35	-49%	16	-77%
Lithuania	84	40	-53%	36	-57%	18	-78%
Luxembourg	13	6	-55%	5	-58%	4	-67%
Malta	4	3	-30%	3	-31%	1	-64%
Netherlands	205	141	-31%	134	-34%	103	-50%
Poland	615	403	-34%	273	-56%	192	-69%
Portugal	227	137	-40%	123	-46%	92	-60%
Romania	460	238	-48%	167	-64%	96	-79%
Slovakia	77	53	-31%	46	-40%	27	-65%
Slovenia	41	28	-33%	15	-63%	10	-75%
Spain	934	596	-36%	484	-48%	358	-62%
Sweden	210	132	-37%	131	-38%	98	-53%
UK	1093	684	-37%	562	-49%	410	-62%
EU-28	9259	5460	-41%	4598	-50%	3191	-66%

Table 4.14: VOC emissions of the scenarios for 2030, by sector (kilotons and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Power gen.	176	162	-8%	117	-34%	117	-34%
Domestic	987	736	-25%	356	-64%	156	-84%
Ind. comb.	53	85	59%	85	59%	85	59%
Ind. process	943	819	-13%	786	-17%	663	-30%
Fuel extract.	538	289	-46%	289	-46%	242	-55%
Solvent use	3600	2603	-28%	2384	-34%	1375	-62%
Road transp.	2047	257	-87%	257	-87%	257	-87%
Non-road	657	281	-57%	249	-62%	223	-66%
Waste	133	84	-37%	75	-43%	74	-45%
Agriculture	125	146	17%	0	-100%	0	-100%
Sum	9259	5460	-41%	4598	-50%	3191	-66%

4.4.3 Measures and instruments to achieve the additional emission reductions

For each country, the GAINS optimization model considers costs and impacts of about 2000 individual emission reduction measures, and determines cost-effective portfolios of emission control measures that achieve the prescribed environmental quality targets at least cost. In the GAINS cost-minimization approach, the application rates of all 2000 measures serve as decision variables, and thus the cost-optimal solution specifies the implementation rate for each measure, between the current legislation baseline and the maximum feasible reduction cases (Wagner et al. 2013).

Figure 4.5 to Figure 4.9 summarize for each country and pollutant by how much, and in which sector, emissions would be reduced in the cost-effective allocation of the B7 scenario compared to the emissions of the current legislation baseline.

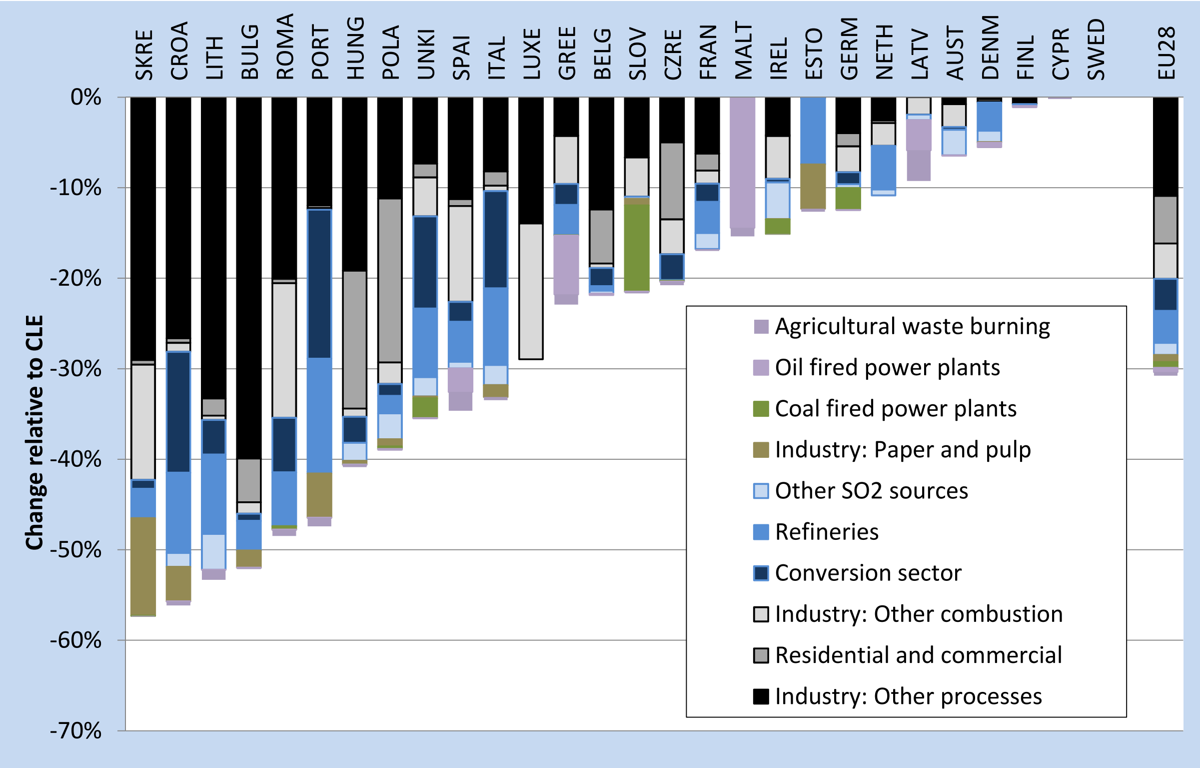


Figure 4.5: Further reductions of SO_2 emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions

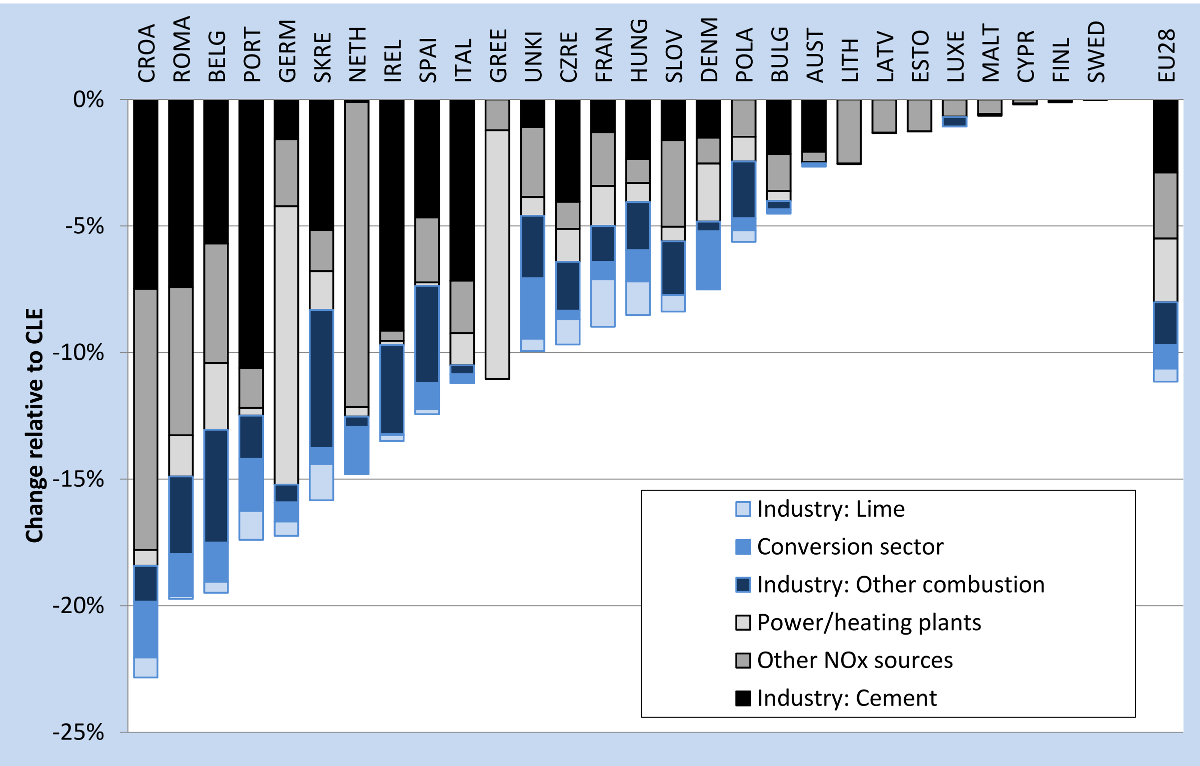


Figure 4.6: Further reductions of NO_x emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions

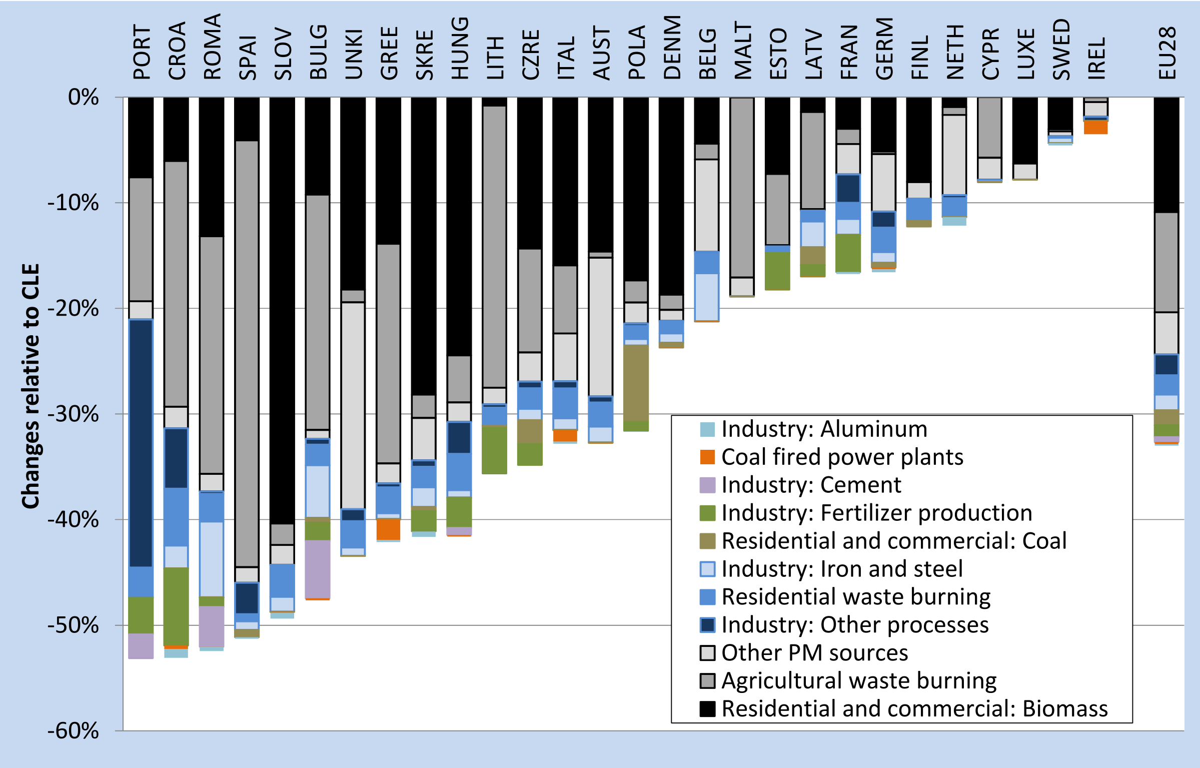


Figure 4.7: Further reductions of PM2.5 emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions

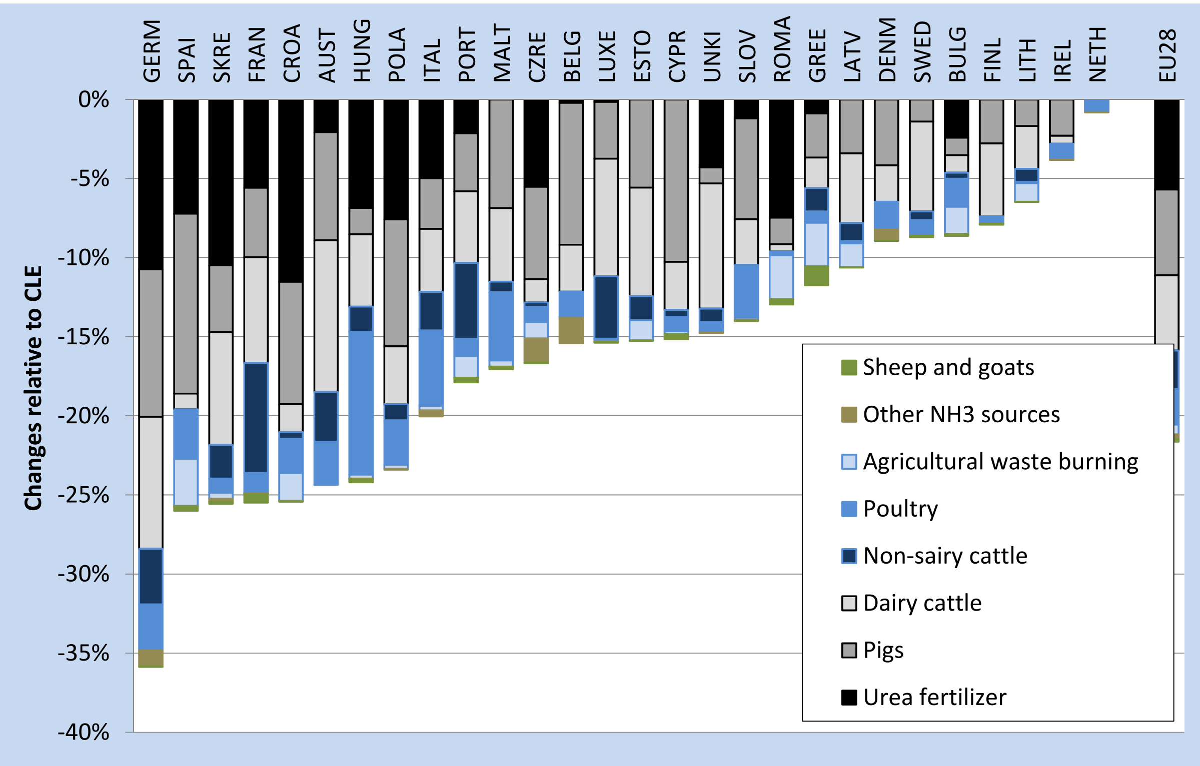


Figure 4.8: Further reductions of NH_3 emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions

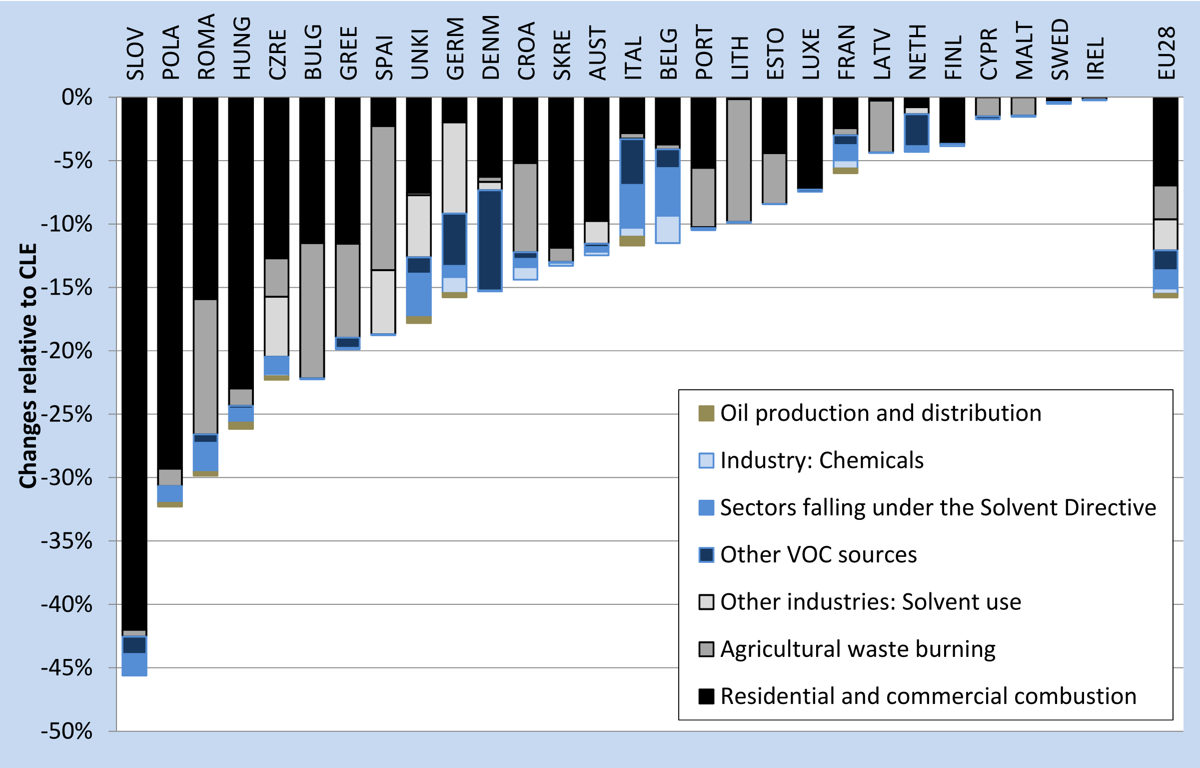


Figure 4.9: Further reductions of VOC emissions (beyond the baseline) of the B7 scenario, relative to baseline emissions

4.4.4 Air quality impacts

Premature mortality from PM2.5

Together with the current legislation, the additional measures in the B7 scenario would reduce the loss in statistical life expectancy in the EU from 8.5 months in 2005 to 4.1 months, i.e., by 52% (Table 4.15). Thus, life shortening will exceed five months in the old Member States only in a few areas in the Benelux countries and northern Italy. In the new Member States, the anticipated prevalence of solid fuel use for domestic heating will prohibit further reductions (Figure 4.10). Overall, these measures will gain about 180 million life years to the European population.

A fuller assessment of monetized health benefits, including infant mortality and morbidity, is presented in the accompanying TSAP Report #12.

Table 4.15: Loss of statistical life expectancy from exposure to PM2.5 from anthropogenic sources (months)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	7.4	4.4	*-41%*	3.5	*-52%*	3.2	*-57%*
Belgium	10.2	5.9	*-42%*	5.0	*-51%*	4.5	*-56%*
Bulgaria	11.1	5.6	*-50%*	4.6	*-59%*	4.2	*-62%*
Croatia	8.1	4.5	*-44%*	3.7	*-54%*	3.3	*-59%*
Cyprus	6.4	6.1	*-5%*	6.0	*-6%*	5.9	*-7%*
Czech Rep.	9.1	5.8	*-36%*	4.6	*-49%*	4.0	*-55%*
Denmark	6.4	3.5	*-46%*	3.0	*-53%*	2.7	*-58%*
Estonia	4.8	3.8	*-21%*	3.5	*-27%*	2.9	*-40%*
Finland	3.7	2.8	*-25%*	2.7	*-29%*	2.4	*-37%*
France	8.8	4.4	*-50%*	3.8	*-57%*	3.2	*-63%*
Germany	7.9	4.8	*-39%*	4.0	*-49%*	3.6	*-54%*
Greece	12.3	6.3	*-49%*	5.3	*-57%*	4.7	*-62%*
Hungary	10.1	5.9	*-41%*	4.7	*-54%*	4.2	*-58%*
Ireland	3.6	2.2	*-39%*	2.0	*-44%*	1.9	*-49%*
Italy	10.2	6.1	*-40%*	4.8	*-53%*	4.3	*-58%*
Latvia	5.9	4.3	*-27%*	3.9	*-33%*	3.3	*-44%*
Lithuania	6.3	4.8	*-24%*	4.2	*-34%*	3.8	*-41%*
Luxembourg	9.2	5.2	*-43%*	4.4	*-52%*	3.9	*-57%*
Malta	7.1	3.8	*-47%*	3.5	*-50%*	3.4	*-52%*
Netherlands	8.8	5.0	*-43%*	4.3	*-51%*	4.0	*-55%*
Poland	11.6	8.4	*-27%*	6.4	*-45%*	5.5	*-53%*
Portugal	9.2	4.1	*-56%*	3.1	*-67%*	2.7	*-70%*
Romania	11.3	6.3	*-45%*	4.9	*-56%*	4.1	*-63%*
Slovakia	8.3	5.9	*-30%*	4.5	*-46%*	3.9	*-53%*
Slovenia	8.5	4.8	*-43%*	3.7	*-57%*	3.3	*-61%*
Spain	7.4	4.2	*-44%*	3.3	*-56%*	2.9	*-61%*
Sweden	3.4	2.3	*-32%*	2.2	*-37%*	2.0	*-42%*
UK	5.8	3.7	*-37%*	2.9	*-50%*	2.6	*-55%*
EU-28	8.5	5.0	*-41%*	4.1	*-52%*	3.6	*-58%*

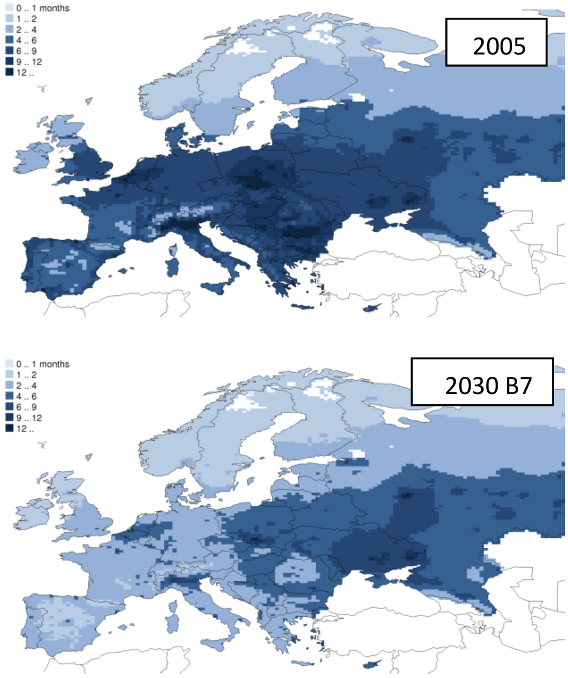


Figure 4.10: Loss in statistical life expectancy from exposure to PM2.5 from anthropogenic sources

Premature mortality from ground-level ozone

With the measures of the B7 scenario, the number of premature deaths attributable to exposure to ground-level ozone is computed to decline by 34% between 2005 and 2030 (Table 4.16).

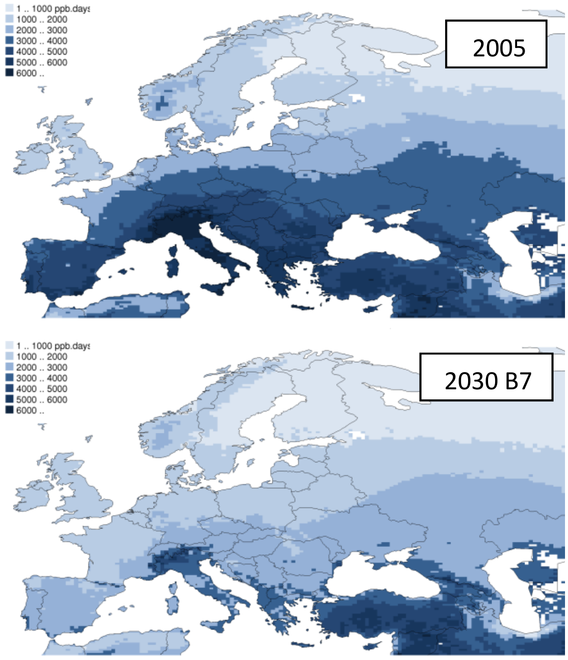


Figure 4.11: The SOMO35 indicator that is related to premature mortality from ground-level ozone

Larger improvements (more than 40%) occur in central Europe (Austria, Hungary, Slovakia), while changes in the UK will be limited to a few percentage points as a consequence of high NO_x emission densities and the non-linear ozone chemistry.

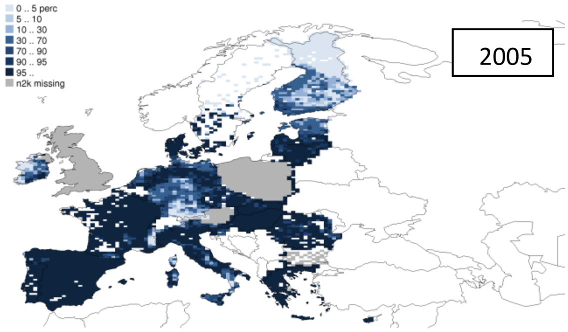
Table 4.16: Premature deaths attributable to exposure to ground-level ozone (cases/yr)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	469	298	*-36%*	277	*-41%*	243	*-48%*
Belgium	316	258	*-18%*	242	*-23%*	214	*-32%*
Bulgaria	814	526	*-35%*	497	*-39%*	448	*-45%*
Croatia	358	212	*-41%*	193	*-46%*	165	*-54%*
Cyprus	51	43	*-16%*	42	*-18%*	40	*-22%*
Czech Rep.	547	359	*-34%*	331	*-39%*	292	*-47%*
Denmark	164	124	*-24%*	117	*-29%*	106	*-35%*
Estonia	38	27	*-29%*	26	*-32%*	24	*-37%*
Finland	99	69	*-30%*	67	*-32%*	61	*-38%*
France	2497	1642	*-34%*	1551	*-38%*	1389	*-44%*
Germany	3673	2623	*-29%*	2455	*-33%*	2185	*-41%*
Greece	924	632	*-32%*	601	*-35%*	553	*-40%*
Hungary	828	510	*-38%*	470	*-43%*	412	*-50%*
Ireland	56	49	*-13%*	48	*-14%*	45	*-20%*
Italy	5294	3546	*-33%*	3303	*-38%*	2896	*-45%*
Latvia	93	64	*-31%*	61	*-34%*	56	*-40%*
Lithuania	144	100	*-31%*	96	*-33%*	88	*-39%*
Luxembourg	15	11	*-27%*	11	*-27%*	10	*-33%*
Malta	26	18	*-31%*	17	*-35%*	16	*-38%*
Netherlands	380	329	*-13%*	310	*-18%*	274	*-28%*
Poland	1669	1130	*-32%*	1049	*-37%*	936	*-44%*
Portugal	591	441	*-25%*	421	*-29%*	390	*-34%*
Romania	1597	1041	*-35%*	964	*-40%*	869	*-46%*
Slovakia	307	194	*-37%*	179	*-42%*	156	*-49%*
Slovenia	135	81	*-40%*	74	*-45%*	63	*-53%*
Spain	2085	1574	*-25%*	1487	*-29%*	1366	*-34%*
Sweden	240	167	*-30%*	160	*-33%*	146	*-39%*
UK	1207	1171	*-3%*	1111	*-8%*	1018	*-16%*
EU-28	24614	17239	*-30%*	16160	*-34%*	14461	*-41%*

Eutrophication

Natura2000 areas

With the emission reductions of the B7 scenario, the area of Natura2000 nature protection zones where biodiversity is not threatened by excess nitrogen deposition will increase by 150,000 km^2 compared to 2005. Thus, these measures would push improvement from 22% in the baseline case to more than one third.



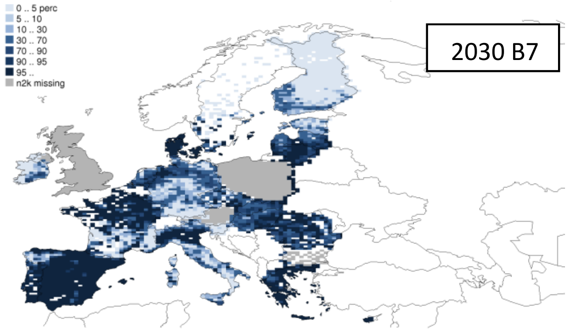


Figure 4.12: Percentage of Natura2000 area with nitrogen deposition above their critical loads for eutrophication.

Table 4.17: Natura2000 area with nitrogen deposition above their critical loads for eutrophication (1000 km^2 and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria							
Belgium							
Bulgaria							
Croatia	0.0	0.0		0.0		0.0	
Cyprus	0.8	0.8	*-1%*	0.8	*-1%*	0.8	*-1%*
Czech Rep.	1	0.7	*-33%*	0.4	*-57%*	0.3	*-67%*
Denmark	1.6	1.6	*0%*	1.6	*-1%*	1.5	*-5%*
Estonia	3.3	1.7	*-49%*	1.3	*-61%*	0.8	*-75%*
Finland	2.1	0.6	*-70%*	0.5	*-75%*	0.4	*-79%*
France	116.8	84.8	*-27%*	61.8	*-47%*	47.4	*-59%*
Germany	54.3	40.1	*-26%*	27.8	*-49%*	22.9	*-58%*
Greece	17.1	16.4	*-4%*	16.3	*-5%*	16.0	*-7%*
Hungary	13	10.2	*-21%*	8.9	*-32%*	8.8	*-32%*
Ireland	0.1	0.0	*-62%*	0.0	*-72%*	0.0	*-81%*
Italy	58.9	30.3	*-49%*	20.6	*-65%*	17.4	*-70%*
Latvia	5.1	4.2	*-17%*	3.8	*-25%*	3.3	*-36%*
Lithuania	5.5	5.4	*-2%*	5.2	*-5%*	4.9	*-11%*
Luxembourg	0.3	0.3	*6%*	0.3	*0%*	0.3	*-5%*
Malta							
Netherlands	4.1	3.9	*-5%*	3.6	*-13%*	3.4	*-16%*
Poland							
Portugal	9.3	9.2	*-1%*	8.8	*-6%*	8.2	*-12%*
Romania	22.3	20.2	*-9%*	19.2	*-14%*	17.9	*-20%*
Slovakia	10.8	9.2	*-15%*	8.6	*-20%*	8.1	*-25%*
Slovenia	6.3	1.2	*-81%*	0.3	*-95%*	0.2	*-97%*
Spain	91.5	87.6	*-4%*	82.8	*-10%*	75.6	*-17%*
Sweden	2.5	1.1	*-58%*	0.9	*-64%*	0.7	*-73%*
UK							
EU-28	426.8	329.4	*-23%*	273.4	*-36%*	238.9	*-44%*

Eutrophication, all ecosystems

Lower nitrogen deposition will not only benefit biodiversity in the protected Natura2000 estimates, but will bring benefits to all ecosystems in Europe (Figure 4.13).

The additional measures of the B7 scenario would provide protection against excess nitrogen deposition for 50% more ecosystems area (+120,000 km^2) than the baseline projection (Table 4.18), especially in the central and western parts of Europe.

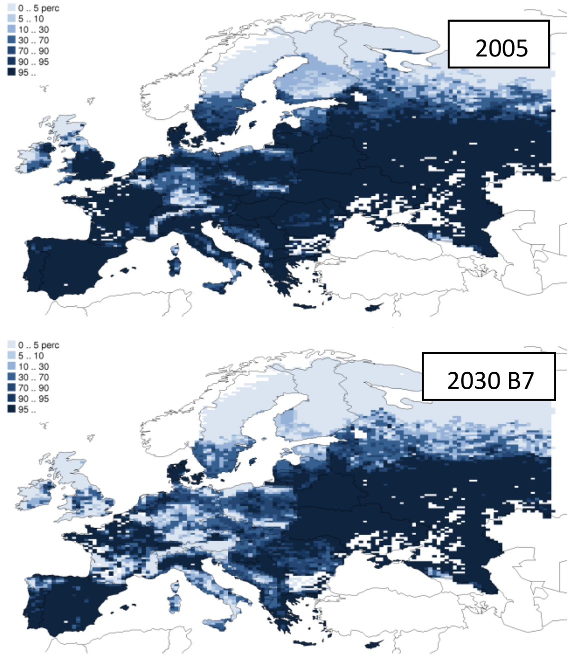


Figure 4.13: Percentage of ecosystems area with nitrogen deposition above their critical loads for eutrophication

Table 4.18: Ecosystems area with nitrogen deposition above their critical loads for eutrophication (1000 km^2 and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	29.6	16.2	*-45%*	8.5	*-71%*	5.2	*-82%*
Belgium	0.3	0.0	*-92%*	0.0	*-100%*	0.0	*-100%*
Bulgaria	32	14.3	*-55%*	12.9	*-60%*	11.6	*-64%*
Croatia	28.9	24.1	*-17%*	22.0	*-24%*	20.6	*-29%*
Cyprus	2.5	2.5	*1%*	2.5	*1%*	2.5	*1%*
Czech Rep.	2.1	1.7	*-21%*	1.2	*-44%*	0.9	*-58%*
Denmark	4.3	4.2	*-2%*	4.2	*-3%*	4.0	*-7%*
Estonia	10.9	4.4	*-59%*	3.5	*-68%*	2.5	*-77%*
Finland	30	7.3	*-76%*	5.5	*-82%*	4.0	*-87%*
France	157	117.9	*-25%*	88.8	*-43%*	71.3	*-55%*
Germany	65.7	49.4	*-25%*	35.3	*-46%*	29.7	*-55%*
Greece	57.9	54.7	*-6%*	54.0	*-7%*	52.9	*-9%*
Hungary	23.8	18.5	*-22%*	15.9	*-33%*	15.8	*-33%*
Ireland	1.6	0.6	*-63%*	0.5	*-70%*	0.3	*-80%*
Italy	98.1	54.5	*-44%*	38.8	*-60%*	33.3	*-66%*
Latvia	32.7	26.5	*-19%*	23.4	*-29%*	20.0	*-39%*
Lithuania	19.3	18.9	*-2%*	18.4	*-5%*	16.8	*-13%*
Luxembourg	1.2	1.1	*-7%*	1.1	*-10%*	1.0	*-13%*
Malta	0	0.0		0.0		0.0	
Netherlands	4.1	3.9	*-5%*	3.6	*-13%*	3.4	*-16%*
Poland	74.1	58.8	*-21%*	46.4	*-37%*	37.7	*-49%*
Portugal	32.7	32.6	*0%*	30.9	*-5%*	28.4	*-13%*
Romania	94.8	88.4	*-7%*	85.0	*-10%*	80.9	*-15%*
Slovakia	22.2	19.4	*-13%*	18.5	*-17%*	17.3	*-22%*
Slovenia	9.7	1.9	*-80%*	0.5	*-95%*	0.3	*-97%*
Spain	211.6	201.6	*-5%*	191.4	*-10%*	178.5	*-16%*
Sweden	91.9	43.2	*-53%*	33.4	*-64%*	24.8	*-73%*
UK	8.9	3.9	*-56%*	1.8	*-80%*	1.2	*-86%*
EU-28	1148.1	870.5	*-24%*	747.8	*-35%*	665.1	*-42%*

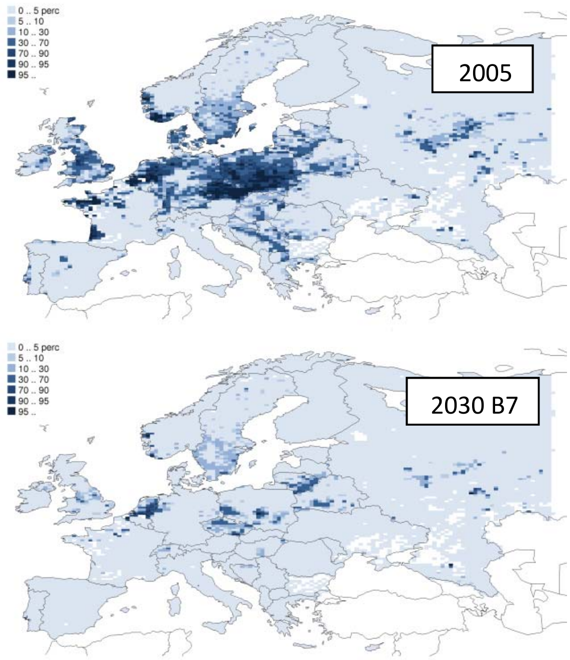


Figure 4.14: Percentage of forest area with acid deposition above the critical loads for acidification.

Acidification

There will also be large reductions in the threat to forests from acidification. The measures of the B7 scenario would achieve sustainable conditions for more than 98% of European forest areas by bringing acid deposition below the critical loads. Compared to 2005, the residual area under threat would shrink by 89% in 2030 (Figure 4.14, Table 4.19).

Table 4.19: Forest area with acid deposition above the critical loads for acidification (1000 km^2 and change to 2005)

	2005	CLE 2030		B7 2030		MTFR 2030	
Austria	0.1	0.0	*-100%*	0.0	*-100%*	0.0	*-100%*
Belgium	0.7	0.0	*-96%*	0.0	*-97%*	0.0	*-100%*
Bulgaria	0	0.0		0.0		0.0	
Croatia	1.3	0.3	*-77%*	0.1	*-96%*	0.0	*-99%*
Cyprus	0	0.0		0.0		0.0	
Czech Rep.	1.9	0.8	*-59%*	0.3	*-83%*	0.2	*-89%*
Denmark	1.4	0.0	*-98%*	0.0	*-99%*	0.0	*-99%*
Estonia	0.1	0.0	*-100%*	0.0	*-100%*	0.0	*-100%*
Finland	0	0.0		0.0		0.0	
France	15.4	2.4	*-85%*	0.4	*-97%*	0.1	*-99%*
Germany	32.6	3.6	*-89%*	0.9	*-97%*	0.4	*-99%*
Greece	1.2	0.1	*-88%*	0.1	*-94%*	0.1	*-94%*
Hungary	3.3	1.1	*-68%*	0.4	*-87%*	0.3	*-92%*
Ireland	0.7	0.0	*-100%*	0.0	*-100%*	0.0	*-100%*
Italy	1.1	0.0	*-96%*	0.0	*-98%*	0.0	*-100%*
Latvia	5.3	1.0	*-80%*	0.6	*-88%*	0.5	*-91%*
Lithuania	6.6	5.8	*-13%*	5.4	*-18%*	5.0	*-24%*
Luxembourg	0.2	0.1	*-41%*	0.0	*-98%*	0.0	*-99%*
Malta	0	0.0		0.0		0.0	
Netherlands	4.8	3.7	*-22%*	3.3	*-31%*	3.0	*-37%*
Poland	52.3	16.5	*-68%*	6.4	*-88%*	4.3	*-92%*
Portugal	1.4	0.2	*-86%*	0.1	*-90%*	0.1	*-92%*
Romania	2.9	0.1	*-98%*	0.0	*-100%*	0.0	*-100%*
Slovakia	2.1	0.4	*-79%*	0.0	*-98%*	0.0	*-98%*
Slovenia	0.2	0.0	*-98%*	0.0	*-100%*	0.0	*-100%*
Spain	2.6	0.0	*-98%*	0.0	*-100%*	0.0	*-100%*
Sweden	19.4	4.9	*-75%*	4.1	*-79%*	3.6	*-81%*
UK	3.3	0.8	*-75%*	0.4	*-89%*	0.2	*-93%*
EU-28	160.9	42.0	*-74%*	22.7	*-86%*	17.9	*-89%*

Compliance with NO_2 and PM10 limit values

The additional measures in B7 will also benefit compliance with the NO_2 and PM10 limit value. For NO_2, compliance will be likely (or possible with additional local measures) for all zones but one (located in Italy, Figure 4.15). For PM10, compliance seems within reach for all but seven zones (mainly in Poland, Figure 4.16), for which enhanced conversion to cleaner fuels for home heating would be required.

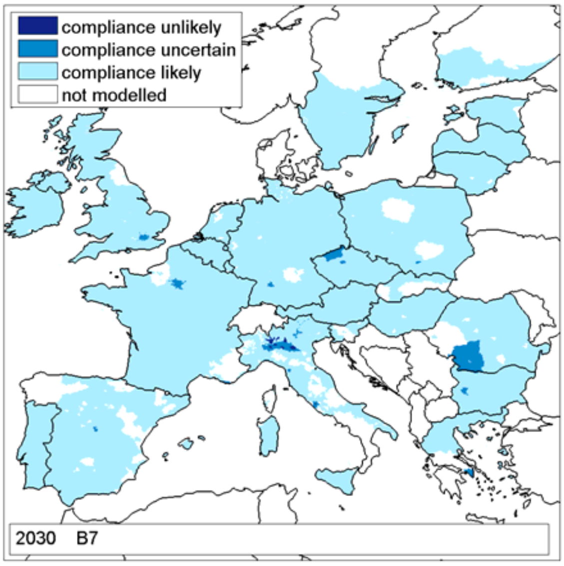


Figure 4.15: Compliance of the air quality management zones with the limit values for NO_2 for the B7 scenario in 2030

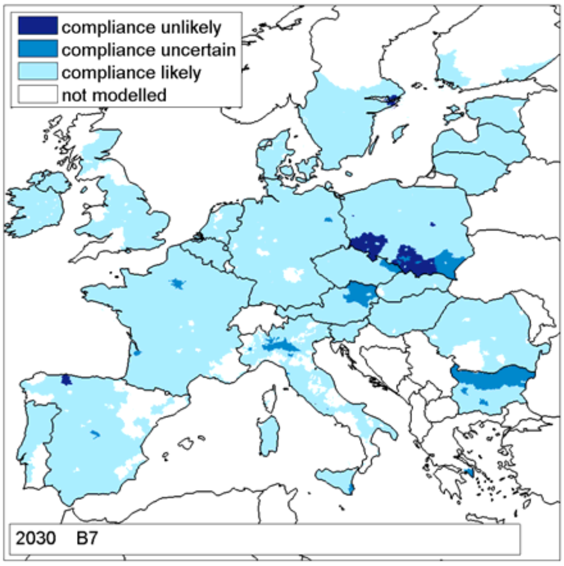


Figure 4.16: Compliance of the air quality management zones with the limit values for PM10 for the B7 scenario in 2030

4.4.5 Achieving emissions ceilings of the B7 scenario under the climate policy targets

The TSAP 2013 Baseline projection, for which the B7 scenario has been developed, relies on the PRIMES 2013 Reference projection. Thereby it takes account of the impacts of policies and measures adopted in the Member States by April 2012, as well as of policies, measures and legislative provisions (including on binding targets) adopted or agreed in the first half of 2012 at EU level. Notably, the PRIMES 2013 Reference projection does not reflect the recent proposal of the European Commission on the Energy and Climate Package for 2030 with a target of 40% reduction in greenhouse gas emissions relative to 1990. On the other hand, the Commission proposal for the Clean Air Policy Package has adopted 2030 as a target year, with the aim to reap the full co-benefits of the proposed climate policies for air pollution control.

To examine the coherence of the Clean Air Policy proposal with the final version of the Energy and Climate Communication of the Commission, the feasibility and costs for achieving the B7 emission ceilings have been assessed for a climate policy scenario (i.e., with a 40% reduction of GHGs and a 30% share of renewable energy).

It is found that under the Climate Policy scenario the structural changes in the energy system will diminish costs for implementing the current air pollution legislation by 5 billion €/yr compared to the TSAP 2013 Baseline, essentially through lower energy consumption and the switch to cleaner fuels, which also reduces the need for air pollution controls. Major declines in costs for the implementation of the current air quality legislation emerge in the domestic sector, for road transport and for non-road mobile machinery (Table 4.20). Additional costs for achieving the B7 emission ceilings would decline from 3.3 to 2.1 billion €/yr, i.e., by more than one third. Results for Member States are provided in Table 4.21.

Table 4.20: Comparison of air pollution emission control costs in 2030 of the TSAP 2013 Baseline and the Climate policy scenario (million €/yr)

	Difference in baseline costs for CLE	Additional costs (on top of CLE) for meeting the B7 ceilings under	
	(Climate policy – TSAP 2013)	TSAP 2013 Baseline	Climate policy scenario
Power gen.	619	228	218
Domestic	-2026	1372	518
Ind. comb.	-205	499	299
Ind. process	-75	280	203
Fuel extract.	-12	0	1
Solvent use	0	39	48
Road transp.	-1758	0	0
Non-road	-1543	127	36
Waste	0	9	7
Agriculture	0	779	751
Sum	-4998	3331	2079

Table 4.21: Air pollution control costs and emissions by Member State, under the TSAP 2013 Baseline and the Climate policy scenario.

	Air pollution control costs			SO_2 emissions (kt)			NO_x emissions (kt)		
	Delta in CLE costs [1)]	additional to CLE: B7 under TSAP 2013	additional to CLE: B7 under Climate policy	Current legislation: TSAP 2013	Current legislation: Climate policy	B7 emission ceilings	Current legislation: TSAP 2013	Current legislation: Climate policy	B7 emission ceilings
Austria	-91	66	35	13	12	12	65	59	64
Belgium	-133	110	74	58	55	45	134	123	108
Bulgaria	-37	67	62	112	117	53	60	59	58
Croatia	-11	26	27	20	21	9	33	32	26
Cyprus	11	0	0	2	2	2	6	6	6
Czech Rep.	30	106	89	74	74	59	112	108	101
Denmark	-68	18	11	9	9	9	61	58	57
Estonia	-13	4	2	22	22	19	16	15	16
Finland	-118	5	1	64	55	63	99	93	99
France	-1113	289	133	117	114	97	441	409	401
Germany	-569	489	395	295	296	258	530	468	439
Greece	202	51	24	50	45	38	126	106	112
Hungary	-48	72	53	27	24	16	52	48	48
Ireland	-63	8	3	14	14	12	43	40	38
Italy	-654	418	270	142	139	94	456	422	405
Latvia	26	2	2	3	3	3	20	20	20
Lithuania	-18	14	14	25	25	12	28	26	28
Luxembourg	-22	2	1	2	1	1	10	9	10
Malta	-1	0	0	0	0	0	1	1	1
Netherlands	179	47	3	32	28	29	143	123	122
Poland	-280	638	292	453	386	276	379	349	358
Portugal	-58	67	42	49	46	26	92	87	76
Romania	-79	180	135	99	97	51	127	121	102
Slovakia	-4	78	78	46	48	19	47	45	39
Slovenia	-45	34	21	6	5	5	16	14	14
Spain	-533	231	117	232	208	152	434	391	380
Sweden	-132	4	2	32	30	32	76	71	76
UK	-1356	303	194	214	195	138	441	404	397
EU-28	-4998	3331	2079	2211	2069	1530	4051	3705	3599

	PM2.5 emissions (kt)			NH_3 emissions (kt)			VOC emissions (kt)		
	Current legislation: TSAP 2013	Current legislation: Climate policy	B7 emission ceilings	Current legislation: TSAP 2013	Current legislation: Climate policy	B7 emission ceilings	Current legislation: TSAP 2013	Current legislation: Climate policy	B7 emission ceilings
Austria	16	15	11	68	68	51	102	98	89
Belgium	19	18	15	73	73	62	99	97	88
Bulgaria	24	22	13	64	64	59	67	64	52
Croatia	11	10	5	30	30	22	48	47	41
Cyprus	1	1	1	6	6	5	4	4	4
Czech Rep.	32	29	21	62	62	52	140	134	108
Denmark	13	12	10	51	50	46	63	60	53
Estonia	12	10	10	13	13	11	27	23	24
Finland	20	18	17	31	31	29	96	87	92
France	169	158	141	639	638	476	591	574	556
Germany	84	80	70	565	558	362	840	791	708
Greece	30	29	18	48	48	42	116	110	93
Hungary	18	17	11	67	67	51	81	77	60
Ireland	9	8	9	101	101	97	43	42	43
Italy	119	109	80	389	388	311	646	619	570
Latvia	12	11	10	15	15	14	37	35	35
Lithuania	11	10	7	51	51	47	40	38	36
Luxembourg	2	2	2	6	6	5	6	5	5
Malta	0	0	0	2	2	1	3	3	3
Netherlands	17	16	15	111	110	110	141	135	134
Poland	198	158	135	332	331	255	403	356	273
Portugal	41	39	19	73	73	60	137	134	123
Romania	84	77	40	141	141	123	238	223	167
Slovakia	20	20	12	24	24	18	53	53	46
Slovenia	6	5	3	17	17	14	28	25	15
Spain	125	120	61	349	348	258	596	585	484
Sweden	25	24	24	49	48	44	132	128	131
UK	82	85	46	287	286	245	684	666	562
EU-28	1200	1102	804	3663	3648	2871	5460	5210	4598

4.4.6 Emission ceilings for methane

In addition to its role as a potent greenhouse gas, there is increasing recognition of the importance of methane (CH_4) as a precursor to background ozone at the hemispheric scale. Background levels of ozone have significantly increased in the last decades (inter alia due to growing emissions in other regions in the Northern Hemisphere), and a further increase would effectively counteract the benefits of NO_x and VOC emission reductions within Europe. Reducing methane emissions is therefore a clear opportunity for synergy between climate and air quality policies.

In view of these arguments, the Commission has proposed a target for methane emissions that could be achieved at low or zero costs.

Analysis with the GAINS model highlights significant reductions in future EU methane emissions that will emerge as a consequence of the full implementation of already agreed legislation (see Box 1, Table 4.22). However, there is also clear evidence for a remaining potential for further methane reductions that could be achieved at low or zero costs.

Based on this information, the European Commission has suggested national emission ceilings for CH_4 as part of the future air quality package. The proposed ceilings assume for 2030 implementation of all measures for which upfront investments will be recovered by later cost savings (e.g., in energy costs) during the remaining technical life time (based on a private investors perspective with a 10% interest rate). These measures include maximum recovery and utilization of associated gas during oil production, enhanced farm-scale anaerobic digestion for non-dairy cattle, as well as increased control frequency of gas distribution networks. However, the emission ceilings do not include measures for which technological progress is believed to lead to low cost potentials (i.e., genetically modified breeding).

In total, it is estimated that for the TSAP 2013 baseline these measures with negative life cycle costs could reduce CH_4 emissions in the EU-28 by 33% below the 2005 level, compared to the 24% reduction of the current legislation case. These estimates are fully consistent with the analyses conducted for the Commission proposal on the 2014 Energy and Climate Package.

Implementation of the portfolio of negative cost measures that are implied by the emission ceilings would lead to annual cost-savings (compared to the baseline costs) of between 2.4 and 4.0 billion €, depending on the assumptions on technological progress. For comparison, costs for the B7 air pollutant emission ceilings are estimated at 3.3 billion €/yr for the TSAP 2013 Baseline and at 2.1 billion €/yr for the Climate Policy scenario.

Table 4.22: CH_4 emissions by country (kilotons and change to 2005)

	2005	CLE 2030		COM proposal		MTFR 2030	
Austria	290	236	*-19%*	234	*-19%*	162	*-44%*
Belgium	336	292	*-13%*	249	*-26%*	171	*-49%*
Bulgaria	370	198	*-46%*	174	*-53%*	126	*-66%*
Croatia	146	125	*-14%*	100	*-31%*	60	*-59%*
Cyprus	39	38	*-3%*	34	*-15%*	28	*-28%*
Czech Rep.	495	363	*-27%*	343	*-31%*	181	*-63%*
Denmark	268	249	*-7%*	205	*-24%*	147	*-45%*
Estonia	49	46	*-7%*	38	*-23%*	21	*-58%*
Finland	216	190	*-12%*	184	*-15%*	155	*-28%*
France	2983	2437	*-18%*	2234	*-25%*	1535	*-49%*
Germany	2647	1722	*-35%*	1610	*-39%*	1176	*-56%*
Greece	483	316	*-35%*	292	*-40%*	243	*-50%*
Hungary	428	226	*-47%*	195	*-55%*	115	*-73%*
Ireland	610	595	*-2%*	566	*-7%*	379	*-38%*
Italy	1965	1394	*-29%*	1173	*-40%*	861	*-56%*
Latvia	87	67	*-23%*	54	*-37%*	32	*-63%*
Lithuania	161	120	*-25%*	94	*-42%*	50	*-69%*
Luxembourg	22	17	*-21%*	16	*-27%*	10	*-52%*
Malta	10	7	*-32%*	6	*-41%*	5	*-54%*
Netherlands	827	595	*-28%*	555	*-33%*	398	*-52%*
Poland	1773	1564	*-12%*	1174	*-34%*	782	*-56%*
Portugal	570	445	*-22%*	404	*-29%*	244	*-57%*
Romania	1245	1009	*-19%*	918	*-26%*	758	*-39%*
Slovakia	215	147	*-31%*	127	*-41%*	69	*-68%*
Slovenia	103	80	*-23%*	74	*-28%*	53	*-49%*
Spain	1635	1371	*-16%*	1078	*-34%*	871	*-47%*
Sweden	280	231	*-18%*	229	*-18%*	174	*-38%*
UK	2234	1423	*-36%*	1315	*-41%*	837	*-63%*
EU-28	20487	15504	*-24%*	13676	*-33%*	9643	*-53%*

5 Conclusions

The final policy scenarios of the Clean Air Policy package

In December 2013, the European Commission adopted a Clean Air Policy package with the aim to further reduce the impacts of harmful emissions from industry, traffic, energy plants and agriculture on human health and the environment. This report documents the key scenarios that informed the discussion and decision of the college of the European Commission.

To establish full coherence with the analytical groundwork developed for the Commission Communication on the 2014 Energy and Climate package, the analysis for the Clean Air Policy package has been based on the PRIMES-2013 Reference scenario and the associated CAPRI projections of agricultural activities. The GAINS model system has been used to explore how the European Union could progress towards the objectives of the Environment Action Programme, i.e., to achieve 'levels of air quality that do not give rise to significant negative impacts on, and risks to, human health and environment'. In particular, the analysis reviews the potential for environmental improvements offered by emission control measures that are not yet part of current legislation, and compares costs and benefits of cost-effective packages of measures.

There is significant scope for cost-effective air quality improvements

In addition to the significant reductions in emissions that will emerge from the full implementation of already agreed legislation, the report reveals a large scope for further air quality improvements. Compared to the baseline projection in 2025, full application of readily available technical emission reduction measures in the EU could reduce health impacts from PM by another 30% and thereby gain more than 70 million life-years in the EU. It could save another 2,500 premature deaths per year because of lower ozone concentrations. Further controls of agricultural emissions could protect biodiversity at another 200,000 km^2 of ecosystems against excess nitrogen deposition, including 95,000 km^2 of Natura2000 areas and other protected zones. It could eliminate almost all likely exceedances of PM10 air quality limit values in the old Member States, while in the urban areas of new Member States additional action to substitute solid fuels in the household sector with cleaner forms of energy would be required. Such Europe-wide emission controls would also eliminate in 2030 almost all non-compliance with EU air quality standards for NO_2.

Further emission reductions could require up to 47 billion €/yr

However, these further environmental improvements require additional efforts to reduce emissions, which are associated with additional costs. It is estimated that the full implementation of all currently available technical measures (that achieve the above-mentioned benefits) would involve in 2025 additional emission control costs of approximately 47 billion €/yr (0.3% of GDP), compared to 88 billion €/yr (0.6%) that are spent under current legislation.

Marginal health benefits justify 76% of the possible further emission reductions

The report examines interim environmental targets that could serve for 2025 as milestones towards the long-term objective of the Sixth Environment Action Programme. As a rational approach, it compares marginal costs of further emission reductions against their marginal benefits. In a most conservative perspective, considering monetized benefits only for human health and using the low valuation of the value of a lost life year (VOLY), net benefits are maximized at a 76% 'gap closure' between the current legislation baseline and the maximum feasible emission reductions. At this level, emission reduction costs (on top of current legislation) amount to 4.5 billion €/yr, while health benefits from these measures are estimated at 44 billion €/yr. However, this comparison ignores additional benefits to agricultural crops and natural vegetation, for which the quantification is difficult and uncertain.

There are additional measures that could yield further benefits for agricultural crops and natural vegetation at low costs

The inability to quantify these non-health benefits in monetary terms, however, does not imply that improvements for these impacts are without value, and additional emission control measures could be justified for such non-quantifiable benefits. A sensitivity case confirms that there is scope for further improvements of ozone and eutrophication at comparably low costs. However, while the model analysis suggests for the most conservative estimate of marginal health benefits the theoretically optimal level (i.e., where marginal costs equal marginal benefits) at a 76% gap closure target for human health, negotiations in a policy context might consider other aspects that cannot be fully quantified in a model framework. Such considerations might result in a deviation from the optimal point that has been established with the quantitative analysis. Sensitivity analyses for gap closure targets between 65% and 80% suggest a cost range between 2.5 and 9.7 billion €/yr.

The Commission proposal for 2030

In December 2013, the college of the European Commission reached agreement on a gap closure level for health effects 5% lower than the theoretically optimal 75%. It was also noted that a considerable share of the additional emission reductions would emerge as a side effect of the climate policy target for 2030 that has been proposed by the European Commission in its Communication on the 2014 Energy and Climate package. To fully harvest these co-benefits from the proposed climate targets, the final Commission proposal sets emission ceilings for the year 2030 that would maintain the marginal benefits to costs ratio delivered by the 70% gap closure in 2025.

In the year 2030, this particular level of marginal costs corresponds to the 67% gap closure under the assumptions of the PRIMES 2013 baseline (i.e., the CLE and MTFR cases of the PRIMES baseline for 2030). Note that the chosen level of marginal benefits does not maximize net health benefits; as shown above, the optimal gap closure, i.e., where marginal benefits equal marginal costs, would be 75% in 2025 (instead of 70%), and 72% (instead of 67%) in 2030.

At costs of 0.02% of GDP, the emission ceilings would reduce health impacts from particulate matter by 52% in 2030, cutting SO_2 by 77%, NO_x by 65%, PM2.5 by 50%, NH_3 by 27% and VOC by 54% relative to 2005

Together with the current legislation, the additional measures would reduce the loss in statistical life 2expectancy in the EU from 8.5 months in 2005 to 4.1 months, i.e., by 52%, and gain about 180 million life years. The number of premature deaths attributable to exposure to ground-level ozone will decline by 34%. Lower nitrogen deposition will safeguard biodiversity in an additional 150,000 km^2 of Natura2000 nature protection zones, and more than 98% of European forest areas will be protected against acidification.

The cost-effective allocation of emission reduction measures to achieve these air quality improvements implies for the EU-28 a decline of SO_2 emissions by 81% below the 2005 level. NO_x would decline by 69%, PM by 51%, NH_3 by 27% and VOC by 50%.

Additional emission control costs amount to 3.3 billion €/yr. This represents an increase of about 4% compared to the costs for implementing current legislation, and constitutes about 0.02% of the GDP in the EU-28 that is assumed for 2030. This share varies widely across Member States, essentially due to differences in economic wealth. The largest portion (40%) of the additional costs would emerge in the domestic sector, followed by the agricultural sector, where 23% of the costs would occur. However, these sectors are less affected by existing legislation, for which only 10% of the costs emerge in the domestic sector and 2% in agriculture. For comparison, 58% of total costs of current legislation emerge for road transport sources, for which however the Commission proposal does not foresee additional measures.

A more ambitious climate policy would decrease costs for attaining the ceilings significantly. For instance, for the Climate Policy targets that have been recently proposed by the European Commission, structural changes in the energy system will lower the costs for implementing the measures required by current legislation by 5 billion €/yr. In addition, costs of additional measures to attain the new emission ceilings in 2030 will decline from 3.3 to 2.1 billion €/yr, i.e., by 1.2 billion €/yr.

The European Commission has also suggested national emission ceilings for CH_4 as part of the future air quality package. The proposed ceilings assume for 2030 implementation of all measures for which upfront investments will be recovered by later cost savings (e.g., in energy costs) during the remaining technical life time (e.g., maximum recovery and utilization of associated gas during oil production, enhanced farm-scale anaerobic digestion for non-dairy cattle, as well as increased control frequency of gas distribution networks). In 2030, these measures could reduce CH_4 emissions in the EU-28 by 33% below the 2005 level, compared to the 24% decline for the current legislation. Implementation of these negative cost measures would lead to cost-savings (compared to the baseline costs) of annually between 2.4 and 4.0 billion €, depending on the assumptions on technological progress. Thereby, they would compensate a considerable fraction of the air pollution costs of 2.1 to 3.3 billion €/yr.

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