NEC Scenario Analysis Report Nr. 7

Baseline Emission Projections and Further Cost-effective Reductions of Air Pollution Impacts in Europe - A 2010 Perspective

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Glossary of terms used in this report

CAFE	Clean Air For Europe Programme
CAPRI	Agricultural model developed by the University of Bonn
CCE	Coordination Centre for Effects at the Netherlands Environmental Assessment Agency
CLE	Current legislation
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO_2	Carbon dioxide
EFMA	European Fertilizer Manufacturer Association
EMEP	European Monitoring and Evaluation Programme
EU	European Union
GAINS	Greenhouse gas - Air pollution Interactions and Synergies model
GW	Gigawatt
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control
kt	kilotons = 10^3 tons
LREM	Long Range Energy Modelling Scenarios developed by the National Technical University of Athens for DG Transport and Energy
Mt	megatons = 10^6 tons
N_2O	Nitrous oxide
NEC	National Emission Ceilings
NH_3	Ammonia
MRR	Maximum emission Reductions considered in the RAINS model (excluding structural changes)
NO_x	Nitrogen oxides
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
RAINS	Regional Air Pollution Information and Simulation model
SNAP	Selected Nomenclature for Air Pollutants; Sector aggregation used in the CORINAIR emission inventory system
SO_2	Sulphur dioxide
TSP	Total suspended particulate matter
VOC	Volatile organic compounds

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Executive Summary

In its Thematic Strategy on Air Pollution (TSAP), the European Commission has outlined a strategic approach towards cleaner air in Europe and established interim environmental objectives for the year 2020. As one of the main policy instruments, the Thematic Strategy announced the revision of the Directive on National Emission Ceilings (2001/81/EC) with new emission ceilings that should lead to the achievement of the agreed interim objectives.

Following a series of analyses on potential emission ceilings, this report re-examines, for the most recent perspectives on future economic development and climate policies, cost-effective emission ceilings for air pollutants that would achieve in 2020 the environmental objectives of the TSAP. Recognizing the crucial influence and the inherent uncertainties of these factors on the cost-effective allocation of air pollution control measures, the analysis explores emission ceilings for two alternative sets of energy projections. Both projections reflect post-economic crisis perspectives on economic growth and correspond to the Climate & Energy Package of the European Commission. They differ, however, in their assumptions on the implementation of the targets for renewable energy. Furthermore, the analysis considers the most recent agreements on EU legislation for emissions from industrial and mobile sources as well as on international ship emissions. It uses updated information on the economic and environmental development perspectives of non-EU countries, and incorporates latest scientific information on environmental sensitivities (critical loads).

The cost-effectiveness analysis presented in this report employs targets for health and environmental indicators that correspond, as closely as possible, to the environmental objectives of the Thematic Strategy. To maintain a comparable level of environmental ambition despite the changes in the modelling methodology, the analysis employs as quantitative environmental targets the relative improvements of impact indicators that are implied by the environmental objectives of the TSAP.

To achieve these targets, the cost-effective portfolio would increase reduction efforts in 2020 for SO_2 emissions from 74% (75%) in the current legislation (CLE) baseline to 76% (78%) compared to 2000. (Numbers in brackets refer to the PRIMES 2010 activity projection with the target for renewable energy). Cuts in NO_x emissions would tighten slightly from 55% (56%) to 57% (58%), for PM2.5 emissions from 41% (39%) to 47% (43%), and of NH_3 emissions from 8% to 25%. VOC emissions would decline slightly, mainly as a side-effect of emission controls for other pollutants (PM, NO_x) that simultaneously reduce VOC emissions.

In 2020, these additional measures involve additional air pollution control costs for the EU-27 of €1.4 billion/yr (€1.5 billion/year). These come on top of the €89.5 billion/yr (€88.6 billion/yr) for implementing current legislation. Thus, additional costs would account for 0.010% (0.011%) of GDP in 2020. Some 75% of the additional costs emerge for the control of agricultural emissions, approximately 20% for stricter measures in the industrial sector, and less than 10% for further measures in the domestic and power sectors. Thereby, the cost-effective allocation puts more emphasis on sectors that are presently carrying a smaller share of air pollution control costs, and puts less burden on sectors that are currently bearing the larger part of costs for air pollution control. Air pollution control costs in the 2010 baseline with lower GHG emissions are €968 million per year lower than in the 2009 scenario, highlighting an important co-benefit of greenhouse gas mitigation.

1 Introduction

In its Thematic Strategy on Air Pollution (TSAP), the European Commission has outlined a strategic approach towards cleaner air in Europe (CEC, 2005) and established interim environmental objectives for the year 2020. As one of the main policy instruments, the Thematic Strategy announced the revision of the Directive on National Emission Ceilings (2001/81/EC) with new emission ceilings that should lead to the achievement of the agreed interim objectives. Earlier analyses in this series of NEC reports have pointed out any cost-effective effective allocation of further emission reduction measures in the European Union depends crucially on the exogenous assumptions about the future levels of economic activities, on climate policy measures and on the development of emissions of countries and sea regions that surround the EU territory.

This report re-examines, for the most recent perspectives on future economic development and climate policies, cost-effective emission ceilings for air pollutants SO_2, NO_x, PM2.5, NH_3 and VOC that would achieve in 2020 the environmental objectives of the TSAP. The analysis explores emission ceilings for two alternative sets of energy projections. Both projections reflect post-economic crisis perspectives on economic growth and correspond to the Climate & Energy Package of the European Commission. They differ, however, in their assumptions on the implementation of the targets for renewable energy. Furthermore, the analysis considers the most recent agreements on EU legislation for emissions from industrial and mobile sources as well as on international ship emissions. It uses updated information on the economic and environmental development perspectives of non-EU countries, and incorporates latest scientific information on environmental sensitivities (critical loads).

The remainder of the report is organized as follows: Section 1 provides a brief account of earlier analyses, summarizes the changes that have been introduced since the NEC Report #6 (Amann, M *et al.*, 2008), and describes the boundary conditions that have been used for the analysis in this report. Section 2 introduces the projections of energy and agricultural activities that served as input to the calculations. Section 3 presents baseline emission projections that result from the implementation of the current EU policies on emission controls. Section 4 recalls the environmental objectives of the Thematic Strategy on Air Pollution and describes how they have been translated into quantitative targets for the analysis. Section 5 presents optimized emission reductions that meet these environmental targets. Conclusions are drawn in Section 6.

1.1 Earlier analyses for the revision of the NEC directive

In 2006 the analysis of revised emission ceilings started from an updated baseline projection of emissions and air quality impacts as would be expected from the envisaged evolution of anthropogenic activities taking into account the impacts of the presently decided legislation on emission controls. These draft baseline projections have been presented to stakeholders in September 2006 (Amann *et al.*, 2006c). In a further step, analysis explored sets of cost-effective measures that achieve the environmental ambition levels of the Thematic Strategy. This assessment has been presented to the meeting of the NECPI working group on December 18, 2006, and is documented in Amann *et al.*, 2006a. This NEC Report #2 analyzed potential emission ceilings that emerge from the environmental objectives established in the second round, and studies the robustness of the identified emission reduction requirements against a range of uncertainties. In March 2007, NEC Report #3 (Amann *et al.*, 2006b) introduced numerous methodological changes into the assessment to maintain a scientifically up-to-date analytical tool and explored their implications on the achievement of the TSAP objectives. NEC Report #4 (Amann *et al.*, 2007a) finalized the baseline assessment and produced the final projections for the NEC analysis. In June 2007, NEC Report #5 (Amann *et al.*, 2007b) re-examined the translation of the environmental objectives of the Thematic Strategy on Air Pollution into the updated model environment. Most importantly, it demonstrated the crucial influence of climate policies proposed by the European Commission on future air pollution emissions. NEC Report #6 (Amann, M *et al.*, 2008) presented emission ceilings based on the Climate and Energy Package, as well as various sensitivity cases.

All these scenario analyses employed as the central analytical tool the GAINS model, an extended version of the RAINS model, that allows, inter alia, the study of interactions between air pollution control and greenhouse gas mitigation. The methodology of the GAINS model and the differences to the RAINS methodology has been summarized in Amann *et al.*, 2006a. The different optimization approaches are documented in Wagner *et al.*, 2006 and Wagner *et al.*, 2007. In January 2007, the GAINS model was reviewed by a team of experts from Member States and stakeholders; the findings of the review are available on http://www.iiasa.ac.at/rains/reports/gains-review.pdf.

1.2 Changes since the NEC Report #6

Since the publication of NEC Report #6 a number of data underlying the analysis of the TSAP targets have been updated. The following paragraphs provide a brief summary of the changes. Details can be extracted from a comparison of the scenarios presented in the GAINS model that is accessible over the Internet (http://www.iiasa.ac.at/web-apps/apd/RainsWeb/); see scenario group "NEC Report Nr 7".

Following the CLRTAP Task Force on Emission Inventories and Projections (TFEIP) approval of the latest proposal of the emission reporting format (NFR) and its relation to the UNFCCC Common Reporting Format (CRF) and SNAP, the allocation of GAINS source categories to SNAP sectors has been updated. Thereby sectoral emissions presented in this report are not completely comparable with results presented in earlier reports, however the changes are marginal. The updated allocation of GAINS sectors to SNAP1 and NFR sectors can be extracted from the GAINS on-line model.

1.2.1 Activity projections

This report analyzes for the 27 Member States two scenarios of future energy consumption that have been developed with the PRIMES energy model:

- the PRIMES Baseline 2009 scenario (as of December 2009), which we will denote as **NEC_PRIMES09** scenario or **P09** for short in the results tables;
- the PRIMES Reference 2010 scenario, which we will denote as **NEC_PRIMES10** scenario or **P10** for short in the results tables.

Both scenarios take into account the effects of economic crisis in 2008 and 2009. The NEC_PRIMES09 includes objectives of the EU Climate and Energy (C&E) package except the target for renewable energy. The NEC_PRIMES10 scenario is a further development of the NEC_PRIMES09, which fully incorporates the renewable energy target.

For non-EU countries which have not provided national projections the analysis employs the energy projection of the World Energy Outlook 2009 of the International Energy Agency (Table 1.1).

For agricultural activities, historical data for the period 1990-2005 were validated drawing on FAO, EUROSTAT and most recent national data (provided within the Gothenburg Protocol review process) for the livestock numbers. Data on mineral fertilizer use have been cross-checked with recent statistical information from EFMA, IFA, FAO and national information. For the EU-27, the consistency with statistical data from EUROSTAT was of utmost priority.

Projections of future agricultural for the 27 Member States and Norway, Albania, Bosnia-Herzegovina, FYRO Macedonia, Norway, and Serbia-Montenegro are derived from most recent CAPRI run of December 2009 (cf. Witzke *et al.*, 2010). For these projections assumptions on macro-economic development have been harmonized with those underlying the PRIMES calculations. For Switzerland the national projection provided in 2009 during the Gothenburg revision process has been used. For other countries (Belarus, Iceland, Moldova, Russia, Turkey, and Ukraine) FAO projections (Bruinsma, 2003) have been employed (Table 1.1).

Table 1.1: Activity projections considered in this report

	NEC_PRIMES09 (PR09)	NEC_PRIMES10 (PR10)	Agricultural projection
Albania	WEO 2009	WEO 2009	CAPRI Bl. 2009
Austria	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Belarus	WEO 2009	WEO 2009	FAO 2009
Belgium	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Bosnia- Herzegovina	WEO 2009	WEO 2009	CAPRI Bl. 2009
Bulgaria	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Croatia	PRIMES 2009	PRIMES 2009	CAPRI Bl. 2009
Cyprus	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Czech Rep.	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Denmark	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Estonia	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Finland	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
France	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Germany	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Greece	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Hungary	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Iceland	WEO 2009	WEO 2009	FAO 2009
Ireland	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Italy	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Latvia	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Lithuania	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Luxembourg	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Macedonia	PRIMES 2009	PRIMES 2009	CAPRI Bl. 2009
Malta	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Moldova	WEO 2009	WEO 2009	FAO 2009
Netherlands	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Norway	PRIMES 2009	PRIMES 2009	CAPRI Bl. 2009
Poland	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Portugal	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Romania	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Russia	WEO 2009	WEO 2009	FAO 2009
Serbia-Montenegro	WEO 2009	WEO 2009	CAPRI Bl. 2009
Slovakia	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Slovenia	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Spain	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Sweden	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009
Switzerland	Nat. projections 2009	Nat. projections 2009	Nat. projections 2009
Turkey	PRIMES 2009	PRIMES 2009	FAO 2009
Ukraine	WEO 2009	WEO 2009	FAO 2009
UK	PRIMES Bl 2009	PRIMES Ref. 2010	CAPRI Bl. 2009

1.2.2 Critical loads

The critical load (CL) information used in the GAINS impact calculations were updated with the 2008 version of the European database on spatially-explicit critical loads and dynamic modelling data (2008 CL database) provided by the Coordination Centre for Effects (CCE) (Hettelingh *et al.*, 2008). The 2008 CL database covers a broader area of sensitive ecosystems within Europe than the 2006 CL database, mainly because the CCE background database now also includes critical loads for semi-natural vegetation.

Calculations of atmospheric dispersion of pollutants over Europe use the five-year average of meteorological conditions, i.e. 1996, 1997, 1998, 2000 and 2003. Details can be found in Amann *et al.*, 2007b.

1.2.3 Health impacts calculation

While population data have not been updated as such, for establishing targets on human health affected by $PM_{2.5}$ we now calculate years of life lost (YOLL) in a given year by using the actual population projection for people above 30 years of age in that year. In particular, for the year 2000 YOLL calculation we use 2000 population data, and for the year 2020 YOLL calculation we use 2020 population data assuming constant shares for people above 30 within the total population. This means that changes in population size are now taken into account, rendering the YOLL calculation more consistent with the calculation of statistical loss of life at the level of the individual citizen: in the year 2000 all people alive were exposed to the air quality in the year 2000, and thus in 2020 the people who will be alive and living in EU-27 Member states will be exposed to the air pollution in the year 2020.

We also need to re-emphasize at this stage that the YOLLs calculated in this report and previous NEC reports by IIASA represent the years of statistical life lost weighted by the population number, and they do *not* represent the annual loss of statistical life years, an indicator used in other studies.

1.2.4 Boundary conditions

A comprehensive assessment of future air quality in the EU requires information on the fate of emissions from sources outside the EU that are transported into the EU territory.

For some non-EU countries the recent PRIMES assessment was available. For the remaining countries energy-related activity projections were taken from the World Energy Outlook 2009 of the International Energy Agency (IEA) (IEA, 2009), which relies on more recent statistical information about current energy use than the scenarios that have been used in GAINS before. An exception has been made for Switzerland, since for this country a national scenario is available that is newer than the IEA projection. Changes in activity projections and detailed assumptions about the legislation in non-EU countries are documented in the EC4MACS interim assessment report (Amann *et al.*, 2009). In general, future emissions resulting from these projections are significantly lower than the projections used in the NEC Report #6.

For the non-EU countries the baseline scenario considers an inventory of current national legislation on air pollution controls in the various countries. Assumptions about emission controls in the power sector have been cross-checked with detailed information from the database on world coal-fired power plants (IEACCC, 2009). The database includes information on types of control measures installed on existing plants as well as on plants under construction. Recently several non-EU countries (Albania, Bosnia and Herzegovina, Kosovo, Croatia, Macedonia, Montenegro and Serbia) signed the treaty on the European "Energy Community". Under this treaty, signatories agree to implement selected EU legislation, including the Large Combustion Plants Directive (LCPD – 2001/80/EEC) from 2018 onwards and the Directive on Sulphur Content in Liquid Fuels (1999/32/EC) from 2012 onwards. For countries that have currently only observer status within the Energy Community (Moldova, Turkey, Ukraine) only national legislation has been implemented.

For international shipping the emission projection developed by Cofala *et al.*, 2007 is used (Table 1.2) with an update to take into account decisions of the International Maritime Organization taken at the meeting of its Marine Environment Protection Committee in 2008 (IMO MEPC57; see MARTEK, 2009). Thus, emissions from ships are updated from those used in the NEC Report #6.

Table 1.2: Emission standards assumed for international shipping

- Worldwide reduction of maximum sulphur content in marine bunker fuels to 3.5% in 2012 and 0.5% in 2020. Due to the 2018 review clause of the agreement for the 2020 standard it is assumed that in practice the 0.5% S standard will be in force from 2025 only.
- Reduction of the sulphur content of marine fuels in all sulphur control areas (SECAs) down to 1.0% from 2010 and down to 0.1% from 2015.
- NO_x emission limit values for newer vessels:
    - Ships produced between 2000 and 2010 need to meet Tier I emission standards that are by up to 10% stricter than those for pre-2000 ships.
    - Post-2010 vessels need to meet Tier II standards, which require a reduction by up to 25%.
    - From 2016 onwards a Tier III standard (80% reduction) will be in force for vessels operating in designated NO_x emission control areas.

These measures have been assumed for national and international shipping. More details are provided in Cofala *et al.*, 2007.

This legislation will reduce future emissions compared to the baseline projection without the legislation. However, with the exception of SO_2 and PM in the North Sea and the Baltic Sea, emissions in 2020 are still expected to be higher than in 2000 for two reasons. First, shipping activities are expected to grow, and second, the agreed implementation schedule which will show full effect only after 2020. In particular, NO_x and VOC emissions in 2020 will be 1.5 to 3 times higher than in 2000 (Table 1.3).

Table 1.3: Emissions for 2000 and 2020 assumed for the modelling domain outside the EU-27 [kt], cf. Amann *et al.*, 2009

	SO_2		NO_x		PM2.5		NH_3		VOC	
	2000	2020	2000	2020	2000	2020	2000	2020	2000	2020
Albania	11	11	17	18	8	7	23	24	29	26
Belarus	172	89	181	150	46	48	117	150	210	185
Bosnia-H.	193	44	38	22	14	13	18	19	49	29
Croatia	97	20	64	48	17	13	29	33	106	70
F.Y.R.O. Macedonia	109	15	33	20	13	7	11	9	28	14
Moldova	9	5	21	19	9	8	37	17	25	25
Norway	28	24	199	136	56	30	24	22	380	86
Russia (European Part)	1994	1827	2981	2116	580	639	567	541	3046	2434
Serbia-M.	452	92	137	91	68	46	70	56	132	114
Switzerland	16	12	101	68	11	8	52	52	143	81
Turkey	1827	1779	823	800	328	291	404	474	845	424
Ukraine	1349	1145	912	651	338	345	301	285	636	536
Sum	6258	5064	5507	4139	1488	1454	1652	1683	5628	4024
NE Atlantic	494	804	723	1015	56	91	0	0	24	52
Baltic Sea	188	12	276	387	21	6	0	0	10	22
Black Sea	56	90	81	114	6	10	0	0	3	6
Medit. Sea	1070	1714	1564	2231	121	198	0	0	53	115
North Sea	443	28	649	915	50	13	0	0	23	49
Sum	2251	2649	3292	4662	254	319	0	0	114	244

2 Activity projections

In this report we examine cost-effective emission ceilings in 2020 for two alternative baseline scenarios, i.e., the NEC_PRIMES09 and the NEC_PRIMES10 projections. For reference, activity statistics for the year 2000 are presented in Table 2.1 to Table 2.3and Figure 2.1.

Table 2.1: Primary energy consumption in 2000 [PJ]. Source: GAINS (based on national and EUROSTAT energy balances)

	Coal	Biomass, waste	Heavy fuel oil	Diesel	Gasoline, LPG	Natural gas	Nuclear	Other renew.	Electr. import[1)]	Total
Austria	115	131	99	258	163	316	0	155	-5	1232
Belgium	271	124	163	451	486	621	520	2	16	2653
Bulgaria	268	23	54	52	72	140	196	10	-17	798
Cyprus	1	0	48	24	26	0	0	1	0	100
Czech Rep.	816	21	89	120	131	375	147	6	-36	1670
Denmark	166	73	92	159	138	186	0	16	2	833
Estonia	103	21	10	16	14	31	0	0	-3	192
Finland	188	280	86	166	149	167	243	53	43	1374
France	526	510	713	1877	1406	1607	4484	250	-250	11122
Germany	3343	330	682	2429	2439	3152	1832	116	16	14339
Greece	382	42	178	279	241	71	0	19	0	1213
Hungary	152	17	86	88	115	419	153	4	12	1046
Ireland	111	6	87	130	128	144	0	4	1	610
Italy	455	92	1347	1197	1361	2501	0	292	160	7405
Latvia	6	40	15	21	18	46	0	10	6	161
Lithuania	4	26	43	24	30	86	91	1	-5	301
Luxembourg	5	2	1	55	40	28	0	1	21	152
Malta	0	0	18	7	7	0	0	0	0	32
Netherlands	288	81	268	309	671	1516	42	4	68	3248
Poland	2281	170	207	285	354	522	0	8	-23	3803
Portugal	155	116	208	203	235	89	0	44	3	1053
Romania	283	120	168	121	131	598	59	53	-3	1531
Slovakia	138	0	38	36	55	270	178	17	-10	723
Slovenia	57	19	10	50	41	35	51	14	-5	272
Spain	852	175	627	1028	909	677	672	125	16	5082
Sweden	85	346	119	264	270	54	619	285	17	2060
UK	1417	88	454	1075	1947	3754	919	22	51	9727
EU-27	12467	2856	5907	10723	11576	17405	10206	1513	76	72728

[1)] Exports are indicated by negative numbers.

Table 2.2: Energy consumption of the EU-27 by fuel and sector in 2000 [PJ]. Source: GAINS (based on national and EUROSTAT energy balances)

	Coal	Biomass, waste	Heavy fuel oil	Diesel	Gasoline LPG	Natural gas	Nuclear	Other renew.	Electr.[1)]	Total
Power sector	9777	1099	1887	134	0	5788	10206	1476	-10772	19595
Industry	1801	421	1453	235	1000	3728	0	0	3847	12485
Conversion	305	26	746	10	215	779	0	0	1788	3869
Domestic	554	1310	142	2783	648	6431	0	36	4957	16862
Transport	0	0	76	7359	7480	36	0	0	256	15208
Non-energy	29	0	1602	203	2232	644	0	0	0	4710
Sum	12467	2856	5907	10723	11576	17405	10206	1513	76	72728

[1)] The power sector reflects gross power generation (reported with a negative sign); the conversion sector includes own use of energy industries as well as transmission and distribution losses; Total refers to domestic consumption excluding net electricity exports. Exports are indicated by negative numbers.

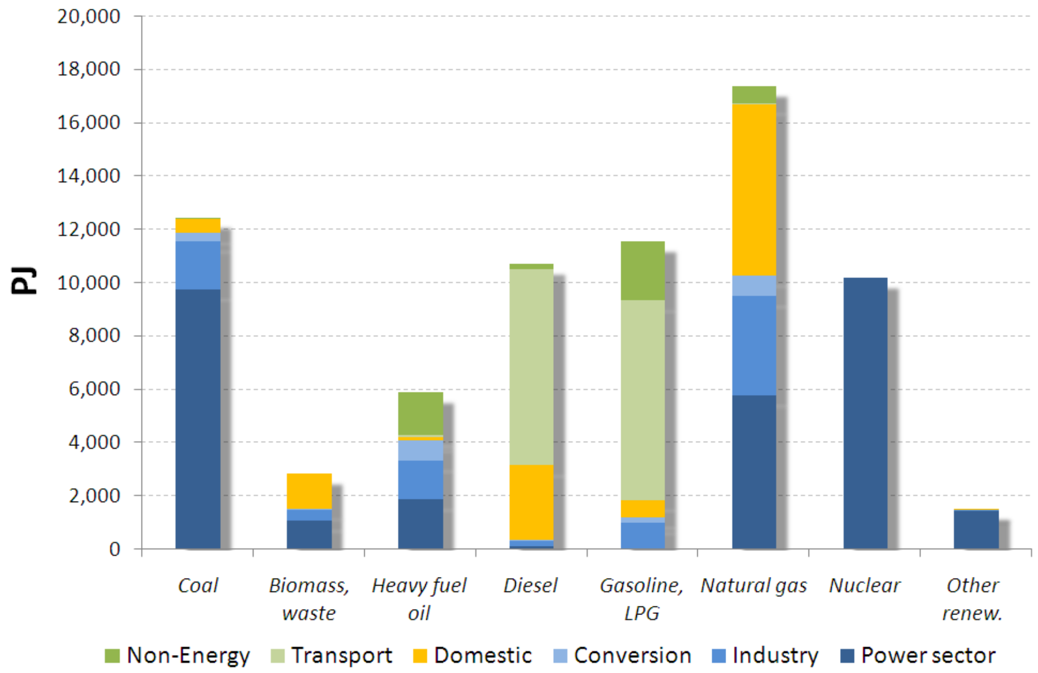

Figure 2.1 Energy consumption of the EU-27 in 2000 by fuel and sector

Table 2.3: Agricultural activities in the year 2000. (Source: GAINS, based on EUROSTAT and national statistics)

	Cattle	Pigs	Chicken and poultry	Sheep and goats	Horses	Fertilizer consumption	Fertilizer production
	1000 animal heads					kt N	
Austria	2155	3348	11787	395	82	121	185
Belgium	3001	7266	39728	176	73	145	1440
Bulgaria	652	1512	14963	3595	374	145	404
Cyprus	54	419	3435	579	7	8	0
Czech Rep.	1609	3315	32043	118	26	262	306
Denmark	1868	11922	21831	91	150	252	133
Estonia	253	300	2366	32	4	22	38
Finland	1057	1298	12570	107	57	167	245
France	20310	14930	270989	10788	444	2571	1494
Germany	14538	23400	121792	2743	735	2014	1308
Greece	566	936	29709	14449	130	285	216
Hungary	805	4834	31244	1219	79	320	290
Ireland	6558	1732	15338	7957	75	408	248
Italy	7245	8307	176722	12464	313	785	428
Latvia	367	394	3537	39	20	29	0
Lithuania	898	936	6373	39	75	98	530
Luxembourg	200	83	72	8	3	17	0
Malta	19	80	830	17	1	0	
Netherlands	4070	13118	104972	1487	118	300	1300
Poland	5723	15447	111900	337	550	896	1497
Portugal	1172	2359	41195	4145	80	113	125
Romania	4569	5848	69143	8679	888	239	915
Slovakia	647	1488	12446	399	10	82	286
Slovenia	493	604	4538	118	14	34	0
Spain	6074	22716	172584	26892	319	1258	884
Sweden	1684	1918	16900	437	300	189	94
UK	11135	6483	169773	42264	291	1036	490
EU-27	97722	154992	1498779	139575	5218	11795	12855

2.1 Macro-economic assumptions about the future development

The PRIMES energy projections employ assumptions on population development published by EUROSTAT (EUROSTAT, 2008). These projections see a continued dynamic immigration trend so that total population as well as labour force within the EU will grow at low but positive rates over the entire projection period. In 2000 total population in the now EU-27 countries was 483 million, in 2020 the number is projected to rise to 514 million (+6% relative to 2000) and to 520 million (+8% relative to 2000) by 2030. Population increases are expected in most of the old EU Member States (EU-15), while for most new Member States (EU-12) population is expected to decline in the future.

The baseline scenario assumes for the EU-27 that economic recovery will partly compensate for some of the loss in GDP during the recent recession, but not fully catch up the earlier projections in the long run. All economic sectors will be permanently affected. For instance, for 2020 an 8% lower GDP is assumed now compared to the pre-crisis projection. Assumptions on economic growth after the recovery remain unchanged, i.e., at 2.2% per year between 2016 and 2020, 1.8% per year between 2020 and 2025, and 1.65% per year between 2025 and 2030.

Growth patterns differ across the EU. Old Member States in northern and central Europe suffer more from the recession than the others. They will recover more slowly, but stay on a significant and positive growth path over the long term. While the new Member States have undergone an important depression too, it is assumed that their recovery will be more pronounced than the EU average. Slower growth rates are assumed in the longer run as these countries approach the performance of the old Member States. For southern Member States similar growth patterns are assumed, however with somewhat lower long-term prospects than those of the new Member States. Together with the GDP projection, this implies an annual increase in per-capita GDP of about 2 % per year in the long run in real terms.

The underlying macroeconomic assumptions of the NEC_PRIMES09 and the NEC_PRIMES10 scenario are identical and summarized in Table 2.4.

Table 2.4: Assumptions on population development and economic growth of the NEC_PRIMES09 baseline projection (Source: PRIMES model calculations)

	Population (million people)			GDP (billion €)			GDP/cap (€/person)		
	2000	2020	Change	2000	2020	Change	2000	2020	Change
Austria	8.0	8.7	9%	225.0	310.4	38%	28124	35595	27%
Belgium	10.2	11.3	11%	278.8	389.5	40%	27228	34406	26%
Bulgaria	8.2	7.2	-12%	16.9	34.7	105%	2065	4819	133%
Cyprus	0.7	1.0	38%	11.7	22.5	93%	16899	23716	40%
Czech Rep.	10.3	10.5	3%	83.4	154.1	85%	8112	14620	80%
Denmark	5.3	5.7	6%	194.8	245.9	26%	36553	43436	19%
Estonia	1.4	1.3	-4%	7.6	15.4	103%	5547	11779	112%
Finland	5.2	5.5	6%	138.8	201.4	45%	26841	36618	36%
France	58.9	65.6	11%	1589.8	2144.4	35%	27014	32684	21%
Germany	82.2	81.5	-1%	2177.2	2723.1	25%	26500	33425	26%
Greece	10.9	11.6	6%	160.9	290.7	81%	14760	25143	70%
Hungary	10.2	9.9	-3%	72.0	114.8	59%	7046	11603	65%
Ireland	3.8	5.4	43%	123.7	221.7	79%	32733	41050	25%
Italy	56.9	61.4	8%	1367.8	1678.6	23%	24030	27330	14%
Latvia	2.4	2.2	-10%	8.8	17.4	98%	3689	8102	120%
Lithuania	3.5	3.2	-8%	14.3	30.3	112%	4085	9419	131%
Luxembourg	0.4	0.6	28%	25.4	47.3	87%	59000	86055	46%
Malta	0.4	0.4	13%	4.5	6.8	49%	11947	15767	32%
Netherlands	15.9	16.9	7%	480.8	637.9	33%	30317	37745	25%
Poland	38.7	38.0	-2%	210.0	406.1	93%	5433	10698	97%
Portugal	10.2	11.1	9%	142.8	179.6	26%	13997	16167	16%
Romania	22.5	20.8	-7%	60.4	135.0	123%	2691	6482	141%
Slovakia	5.4	5.4	1%	30.3	73.3	142%	5607	13492	141%
Slovenia	2.0	2.1	4%	24.0	44.0	83%	12055	21359	77%
Spain	40.1	51.1	28%	773.9	1285.2	66%	19324	25147	30%
Sweden	8.9	9.9	11%	259.7	380.3	46%	29316	38610	32%
UK	58.8	65.7	12%	1623.9	2372.9	46%	27621	36129	31%
EU-27	481.1	513.8	7%	10107.0	14163	40%	21010	27563	31%

2.2 The PRIMES energy projections

Based on these assumptions about macro-economic development and policies on climate and renewable energy (Table 2.5), the PRIMES model projects the EU-27 total primary energy consumption to increase by 5% between 2000 and 2020 for the scenario without the renewable energy target (i.e., the NEC_PRIMES09 scenario), and by 3% in the scenario that achieves the renewable energy target (i.e., the NEC_PRIMES10 scenario).

Table 2.5: Policies and regulations considered in the baseline that affect CO_2 emissions

- EU directives and regulations aiming at efficiency improvements, e.g., for energy services, buildings, labelling, lighting, boilers
- Regulation on new cars (involving a penalty for car manufacturers if the average new car fleet exceeds 135 g CO_2/km in 2015, 115 in 2020, 95 in 2025 – in test cycle)
- Strong national policies supporting use of renewable energy; however compliance with the 20% target share of renewable energy is not mandatory
- Co-generation Directive
- Carbon Capture and Storage (CCS) demonstration plants
- Harmonisation of excise taxes on energy
- The Emission Trading Scheme (ETS) Directive

Most markedly, in both scenarios use of biomass will increase, i.e., by 57% in the baseline partially meeting the renewable target (P09), and by 111% with a baseline fully meeting the renewable target (P10). Other forms of renewables will grow by 120% (193%) (numbers in brackets refer to the scenario). Coal consumption on the other hand will decline by 9% (17%). Natural gas consumption grows by 15% (3%). As a consequence, in these scenarios CO_2 emissions of the EU-27 in 2020 are 3.5% (10%) below 2000, and thus 2% (9%) below 1990 (Table 2.6 to Table 2.9), Figure 2.2.

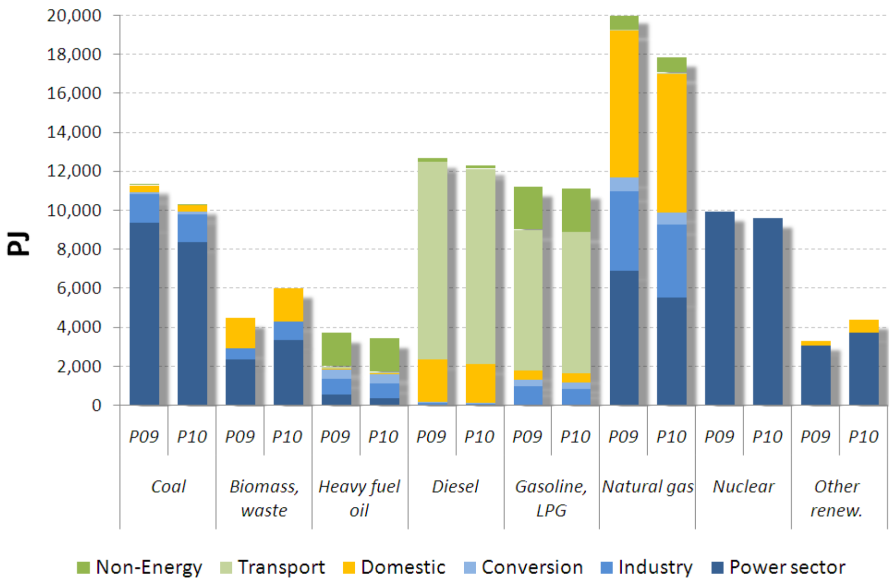

Figure 2.2 Energy consumption of the EU-27 in the NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10) scenarios for 2020

Table 2.6: Primary energy consumption of the energy projection in the NEC_PRIMES09 scenario without the renewable energy target in 2020 [PJ]. Source: GAINS, based on the PRIMES model

	Coal	Biomass, waste	Heavy fuel oil	Diesel	Gasoline LPG	Natural gas	Nuclear	Other renew.	Electr. import[1)]	Total
Austria	105	182	56	357	172	418	0	177	-1	1466
Belgium	165	137	147	481	395	705	519	28	42	2619
Bulgaria	299	37	43	86	83	134	235	25	-37	904
Cyprus	2	2	33	30	39	18	0	8	0	131
Czech Rep.	620	109	86	230	200	371	370	18	-35	1970
Denmark	114	137	29	164	136	180	0	49	6	813
Estonia	121	29	9	28	15	37	0	5	-12	231
Finland	191	335	67	161	145	183	412	58	28	1580
France	318	561	344	1982	1216	1875	5089	414	-223	11577
Germany	2808	678	460	1972	2070	3799	373	600	46	12807
Greece	355	53	126	331	274	203	0	63	17	1423
Hungary	107	79	52	167	154	503	188	17	12	1279
Ireland	108	17	47	206	146	189	0	27	7	746
Italy	708	266	561	1384	1280	3374	137	482	122	8314
Latvia	2	64	6	52	26	61	0	13	1	224
Lithuania	4	47	26	53	44	150	66	4	-1	392
Luxembourg	1	3	1	102	38	62	0	3	13	222
Malta	0	0	9	9	8	6	0	2	1	35
Netherlands	354	148	223	354	775	1324	43	106	-4	3324
Poland	2242	277	236	670	483	690	118	23	-19	4719
Portugal	91	132	112	242	211	168	0	93	26	1076
Romania	310	163	113	235	190	534	183	105	-27	1806
Slovakia	153	47	29	79	86	297	217	22	-9	921
Slovenia	81	22	15	109	38	52	65	18	-6	396
Spain	708	318	492	1687	873	1647	639	386	-15	6733
Sweden	77	416	78	233	294	74	787	269	-34	2192
UK	1306	234	301	1251	1816	3009	509	328	33	8786
EU-27	11350	4492	3704	12653	11206	20061	9951	3339	-70	76687

[1)] Exports are indicated by negative numbers.

Table 2.7: Energy consumption of the EU-27 in 2020 by fuel and sector for the energy projection in the NEC_PRIMES09 scenario without the renewable energy target [PJ]. Source: GAINS, based on the PRIMES model

	Coal	Biomass, waste	Heavy fuel oil	Diesel	Gasoline LPG	Natural gas	Nuclear	Other renew.	Electr.[1)]	Total
Power sector	9382	2383	583	66	0	6935	9951	3084	-13667	14334
Industry	1463	548	822	125	1009	4046	0	0	4462	13850
Conversion	126	0	474	8	305	711	0	0	2010	5399
Domestic	330	1561	44	2190	487	7540	0	255	6822	20473
Transport	0	0	80	10105	7204	39	0	0	302	17731
Non-energy	49	0	1700	159	2201	790	0	0	0	4900
Sum	11350	4492	3704	12653	11206	20061	9951	3339	-71	76687

[1)] The power sector reflects gross power generation (reported with a negative sign); the conversion sector includes own use of energy industries as well as transmission and distribution losses; Total refers to domestic consumption excluding net electricity exports. Exports are indicated by negative numbers.

Table 2.8: Primary energy consumption of the energy projection in NEC_PRIMES10 scenario that meets the renewable energy target in 2020 [PJ]. Source: GAINS, based on the PRIMES model

	Coal	Biomass, waste	Heavy fuel oil	Diesel	Gasoline LPG	Natural gas	Nuclear	Other renew.	Electr. import[1)]	Total
Austria	106	222	54	340	172	333	0	196	-1	1424
Belgium	145	199	136	464	313	622	519	57	42	2497
Bulgaria	253	52	42	85	83	118	235	34	-37	865
Cyprus	2	2	31	29	38	18	0	9	0	129
Czech Rep.	612	125	86	227	200	344	370	29	-35	1959
Denmark	98	139	29	161	136	162	0	64	6	794
Estonia	108	37	7	27	15	35	0	8	-12	225
Finland	167	372	62	152	144	159	382	63	28	1529
France	176	1078	307	1930	1173	1506	4922	503	-223	11374
Germany	2684	735	429	1933	2090	3470	373	813	46	12574
Greece	318	76	127	313	267	167	0	101	17	1387
Hungary	108	97	51	166	154	463	188	27	12	1266
Ireland	93	26	46	199	146	141	0	53	7	710
Italy	635	461	427	1356	1281	3074	137	684	122	8178
Latvia	19	68	6	47	26	41	0	14	1	221
Lithuania	4	59	26	52	44	133	66	4	-1	387
Luxembourg	1	5	1	100	38	58	0	5	13	220
Malta	0	0	8	9	8	6	0	2	1	34
Netherlands	350	164	223	349	771	1275	43	119	-4	3289
Poland	2053	430	211	654	482	647	118	39	-19	4615
Portugal	73	154	111	232	209	119	0	109	26	1033
Romania	291	191	111	229	187	504	183	118	-27	1786
Slovakia	129	70	28	78	82	280	223	27	-9	906
Slovenia	64	42	13	106	38	45	65	23	-6	391
Spain	603	386	483	1603	868	1413	639	577	-15	6557
Sweden	53	490	77	225	285	38	645	305	-34	2083
UK	1172	350	296	1228	1847	2676	509	443	33	8554
EU-27	10315	6029	3432	12294	11098	17847	9619	4425	-70	74987

[1)] Exports are indicated by negative numbers.

Table 2.9: Energy consumption of the EU-27 in 2020 by fuel and sector for the energy projection in NEC_PRIMES10 scenario that meets the renewable energy target in 2020 [PJ]. Source: GAINS, based on the PRIMES model

	Coal	Biomass , waste	Heavy fuel oil	Diesel	Gasoline LPG	Natural gas	Nuclear	Other renew.	Electr.[1)]	Total
Power sector	8374	3388	391	38	0	5560	9619	3764	-13363	13421
Industry	1453	937	746	83	881	3721	0	0	4402	13637
Conversion	128	0	473	8	294	647	0	0	1959	5253
Domestic	310	1704	41	2002	478	7089	0	661	6629	20105
Transport	0	0	80	10004	7243	39	0	0	303	17669
Non-energy	49	0	1700	159	2202	790	0	0	0	4901
Sum	10315	6029	3431	12294	11098	17847	9619	4425	-71	74987

[1)] Power sector reflects gross power generation (reported with a negative sign); the conversion sector includes own use of energy industries as well as transmission and distribution losses; Total refers to domestic consumption excluding net electricity exports. Exports are indicated by negative numbers.

Table 2.10: Energy-related CO_2 emissions [Mt CO_2] for 1990, 2000, 2005 and the two PRIMES energy projections in 2020. Source: PRIMES energy model

				NEC_PRIMES09		NEC_PRIMES10	
	1990	2000	2005	2020	% change 1990-2020	2020	% change 1990-2020
Austria	55.2	65.4	78.9	74.4	35%	68.1	23%
Belgium	106.2	129.4	129.5	120.6	14%	107.2	1%
Bulgaria	72.4	50.5	54.0	55.0	-24%	49.4	-32%
Cyprus	4.4	6.9	7.9	8.3	89%	8.0	82%
Czech Rep.	154.8	127.1	126.4	115.3	-26%	112.6	-27%
Denmark	51.7	54.2	51.5	45.8	-11%	42.9	-17%
Estonia	39.2	15.6	16.8	18.7	-52%	17.0	-57%
Finland	54.4	56.7	56.4	53.7	-1%	51.7	-5%
France	352.9	405.9	422.2	368.9	5%	322.5	-9%
Germany	959.8	883.7	851.7	751.0	-22%	715.1	-25%
Greece	71.2	103.3	111.3	110.7	55%	102.6	44%
Hungary	65.5	58.5	61.1	62.9	-4%	60.4	-8%
Ireland	30.9	44.8	47.6	47.4	53%	42.2	37%
Italy	386.9	463.6	489.6	473.5	22%	441.9	14%
Latvia	19.2	7.1	7.8	9.1	-53%	9.2	-52%
Lithuania	32.5	12.1	14.4	16.5	-49%	15.5	-52%
Luxembourg	10.6	8.9	12.3	13.0	22%	12.4	17%
Malta	1.8	2.2	2.7	1.8	2%	1.7	-3%
Netherlands	152.2	169.6	175.8	158.1	4%	153.7	1%
Poland	332.2	320.6	318.2	355.8	7%	332.1	0%
Portugal	39	63.8	69.7	56.0	44%	50.2	29%
Romania	166.7	95.3	105.9	106.8	-36%	102.2	-39%
Slovakia	53.3	40.3	40.7	46.1	-13%	42.2	-21%
Slovenia	13.2	15.2	16.7	22.5	71%	19.8	50%
Spain	203.3	307.7	368.0	374.9	84%	342.9	69%
Sweden	50.5	53.4	53.2	45.9	-9%	40.0	-21%
UK	566.9	552.0	557.5	458.0	-19%	421.5	-26%
EU-27	4046.9	4113.6	4247.7	3970.7	-2%	3684.7	-9%

2.3 Projections of agricultural activities

Projections developed with the CAPRI model include recent changes in European agricultural policies as specified in Table 2.11. It needs to be stressed that requirements for bio-fuel production have been made consistent with the PRIMES energy projections.

Table 2.11: Assumptions on agricultural policies included in the agricultural baseline

- The 'Health Check' of the Common Agricultural Policy (CAP) as in Council regulations (EC) No 72/2009, 73/2009, 74/2009 of 19 January 2009 on modifications to the Common Agricultural Policy
- Abolition of the 'Set aside' (regulation 73/2009) and milk quota regulations
- Agricultural premiums are largely decoupled from production levels
- The WTO December 2008 Falconer proposal (TN/AG/W/4/Rev.4)
- Bio-fuels as projected by PRIMES

For the EU-27 as a whole, these projections anticipate between 2000 and 2020 for cattle a 17% decline in livestock numbers, for sheep a reduction by 18% and increases of 13% and 15% in the numbers of pigs and poultry, respectively. Use of nitrogen fertilizers is estimated to decline in the EU-27 by about 5% (Table 2.12).

Table 2.12: Projections of agricultural activities for the year 2020 (Source: GAINS, based on CAPRI, FAO and national submissions)

	Cattle	Pigs	Chicken and poultry	Sheep and goats	Horses	Fertilizer consumption	Fertilizer production
	1000 animal heads					kt N	
Austria	1770	3232	14761	395	85	125	226
Belgium	2502	7193	47538	171	73	112	1440
Bulgaria	590	504	19941	1452	265	176	349
Cyprus	44	427	4553	770	7	12	0
Czech Rep.	860	2157	38103	114	23	363	305
Denmark	1170	12983	21634	80	157	219	0
Estonia	174	442	2281	35	5	33	51
Finland	747	1529	11958	89	64	159	292
France	17531	16878	255872	8155	459	2194	1374
Germany	10317	29504	130952	2684	836	1757	1250
Greece	661	804	33323	13523	102	213	93
Hungary	522	3373	41418	1337	71	373	311
Ireland	6072	1628	14755	5141	86	314	0
Italy	6284	9841	201175	8929	333	772	445
Latvia	323	361	4892	58	16	52	0
Lithuania	593	1207	8026	42	64	134	1000
Luxembourg	153	98	119	9	4	15	0
Malta	11	63	716	28	3	1	219
Netherlands	3703	11493	95017	2001	129	225	1535
Poland	4503	24980	180059	349	339	1153	1735
Portugal	1424	2389	36613	4052	95	88	152
Romania	2176	6236	94801	10009	938	381	1400
Slovakia	409	588	14979	277	6	103	250
Slovenia	405	423	3423	258	19	33	0
Spain	6849	30829	220981	21396	630	981	795
Sweden	1258	1571	17781	496	300	196	65
UK	9758	4419	207160	31913	510	984	660
EU-27	80811	175155	1722831	113763	5617	11169	13947

2.4 Input data for VOC related activities

Projections of VOC-related activities are based to the maximum possible extent on data provided by national sources. New information received in 2009 from Belgium, France and Switzerland has been incorporated into the GAINS databases. Furthermore, assumptions on applicability and replacement rates have been validated with information recently provided by the CLRTAP Expert Group on Techno-Economic Issues (EGTEI).

Further, the calculation of VOC emissions from air transport (landing and take-off cycles only) has been made consistent with the methodology for NO_x emissions, so that it now employs kerosene consumption and related emission factors. (Earlier GAINS calculations relied on total emissions as reported by countries). This methodological improvement results in some changes in calculated emissions, but assures better internal consistency and a better match with the most recent reporting round to the EU and CLRTAP.

3 Baseline emission projections for current legislation on air pollution

The analysis of emission ceilings for 2020 assumes as a starting point the implementation of all emission control legislation as is already laid down in national laws, the implementation of further emission control measures for heavy duty vehicles (EURO-VI, CEC, 2007) and the recently politically agreed Industrial Emissions Directive of the EU (EU, 2010), which for the purpose of this report is part of the Current Legislation case since it is scheduled to be in force by the end of 2010 or early 2011.

However, the analysis does not consider the impacts of other legislation for which the actual impacts on future activity levels cannot be quantified yet. This includes compliance with the air quality standards 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 projections.

Our assessment calculates for 2020 emissions as they would result as a consequence of the assumed economic activities, country- and sector-specific emission factors and the progressing implementation rates of already decided emission control legislation as currently laid down in national laws.

The Current Legislation (CLE) case considers a detailed inventory of national emission control legislation (including the transposition of EU-wide legislation) as of mid 2010 (Table 3.1 to Table 3.6), and assumes that these regulations will be fully implemented in all Member States according to the foreseen time schedule. This Current Legislation case, however, does not consider additional existing EU legislation or international regulations that are not yet put into national legislation (e.g., additional measures that are necessary to comply with the National Emission Ceilings Directive, etc.).

For CO_2, regulations are included in the PRIMES calculations as they affect the structure and volumes of energy consumption (Table 2.5).

For the Industrial Emissions Directive the analysis assumes emission limit values for boilers in industry and in the power plant sector (the so-called less strict BAT case if they are more stringent than current national legislation). The exact timing of introduction of these standards in each Member State can be extracted from the GAINS-online model.

Table 3.1: Legislation considered in the CLE projection for SO_2 emissions

- Large combustion plants in accordance with the new Industrial Emissions Directive
- Directive on the sulphur content in liquid fuels
- Directives on quality of petrol and diesel fuels, as well as the implications of the mandatory requirements for renewable fuels/energy in the transport sector
- IPPC requirements for industrial processes as currently laid down in national legislation
- Sulphur content of gasoil used by non-road mobile machinery and inland waterway vessels (reduction from 1000 ppm to 10 ppm) according to the Proposal COM(2007) 18 of the Directive of the European Parliament and of the Council to amend Directives 98/70/EC and 1999/32/EC.
- National legislation and national practices (if stricter)

Table 3.2: Legislation considered in the CLE projection for NO_x emissions

- Large combustion plants in accordance with the new Industrial Emissions Directive
- EURO-standards, including adopted EURO-5 and EURO-6 for light duty vehicles
- EURO-standards, including adopted EURO V and EURO VI for heavy duty vehicles
- EU emission standards for motorcycles and mopeds up to Euro 3
- Legislation on non-road mobile machinery
- Higher real-life emissions of EURO-II and EURO-III for diesel heavy duty and light duty vehicles compared with the test cycle
- IPPC requirements for industrial processes as currently laid down in national legislation

Table 3.3: Legislation considered in the CLE projections 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*

Table 3.4: Legislation considered in the CLE projection for VOC emissions

- Stage I Directive (liquid fuel storage and distribution)
- Directive 96/69/EC (carbon canisters)
- EURO-standards, including adopted EURO-5 and EURO-6 for light duty vehicles
- EU emission standards for motorcycles and mopeds up to Euro 3
- Fuel Directive (RVP of fuels)
- Solvents Directive
- Products Directive (paints)

Table 3.5: Legislation considered in the CLE projections for PM2.5 emissions

- Large combustion plants in accordance with the new Industrial Emissions Directive
- EURO-standards, including the adopted EURO-5 and EURO-6 standards for light duty vehicles
- EURO-standards, including adopted EURO V and EURO VI for heavy duty vehicles.
- Legislation on non-road mobile machinery
- IPPC requirements for industrial processes as currently laid down in national legislation
- National legislation and national practices (if stricter)

With these measures the PRIMES baseline energy projections together with the national projections of agricultural activities suggest for 2020 excess of the 2010 national emission ceilings of the NEC Directive (European Community, 2001) for NO_x for Ireland and Luxembourg (Table 3.6), for NH_3 for Belgium, Germany and Spain. (The NO_x ceiling for Luxembourg, which were calculated on a 'fuel used' basis, are unattainable on a 'fuel sold' concept, which is used by the GAINS model.)

Table 3.6: Emissions of the NEC_PRIMES09 (P09) and the NEC_PRIMES10 (P10) cases in 2020 compared to the national emission ceilings for 2010 and the emissions in 2000 [kt]

	SO_2				NO_x				PM2.5			
	2000	NEC 2010	P09 2020	P10 2020	2000	NEC 2010	P09 2020	P10 2020	2000	NEC 2010	P09 2020	P10 2020
Austria	32	39	19	18	204	103	94	93	23		13	13
Belgium	170	99	81	81	330	176	170	162	33		20	21
Bulgaria	891	836	132	118	178	247	68	64	62		33	33
Cyprus	47	39	5	4	22	23	13	12	3		1	1
Czech Rep.	265	265	106	105	307	286	151	149	43		25	27
Denmark	29	55	11	11	210	127	85	83	27		19	20
Estonia	85	100	16	14	37	60	21	20	20		7	8
Finland	79	110	42	33	222	170	125	122	33		21	22
France	611	375	199	193	1535	810	572	578	378		207	212
Germany	618	520	329	317	1702	1051	708	692	145		83	84
Greece	547	523	112	107	331	344	242	236	55		33	34
Hungary	452	500	64	63	180	198	86	85	45		23	23
Ireland	135	42	28	27	139	65	69	67	13		8	7
Italy	746	475	234	220	1330	990	679	661	162		82	83
Latvia	10	101	4	5	38	61	22	22	14		15	15
Lithuania	52	145	15	15	53	110	29	29	11		10	11
Luxembourg	2	4	1	1	37	11	17	17	3		2	2
Malta	24	9	1	1	9	8	3	3	1		0	0
Netherlands	73	50	32	33	411	260	170	170	29		16	16
Poland	1490	1397	468	440	793	879	429	419	136		105	108
Portugal	291	160	64	63	267	250	106	102	104		58	59
Romania	783	918	145	141	314	437	156	154	135		106	110
Slovakia	104	110	42	40	97	130	57	56	25		10	10
Slovenia	101	27	17	16	55	45	27	26	12		6	6
Spain	1522	746	311	303	1440	847	695	677	143		90	90
Sweden	44	67	29	27	231	148	97	97	31		19	20
UK	1182	585	227	227	1779	1167	663	640	113		53	53
EU-27	10385	8297	2732	2626	12251	9003	5553	5433	1798		1065	1089

Table 3.7: Emissions by SNAP sector of the NEC_PRIMES09 (P09) and the NEC_PRIMES10 (P10) baselines in 2020 compared to the emissions in 2000 [kt]

	SO_2			NO_x			$PM_{2.5}$		
	2000	2020		2000	2020		2000	2020	
SNAP sector		P09	P10		P09	P10		P09	P10
1: Power generation	7178	955	894	2648	1182	1106	196	41	38
2: Domestic	712	423	401	700	656	635	527	356	380
3: Industrial combust.	1391	639	619	1302	934	932	107	89	92
4: Industrial processes	698	586	583	176	150	149	305	236	237
5: Fuel extraction	0	0	0	0	0	0	9	7	7
6: Solvents	0	0	0	0	0	0	0	0	0
7: Road traffic	149	6	6	5505	1544	1527	328	87	88
8: Off-road sources	247	114	114	1899	1073	1070	161	66	65
9: Waste management	4	5	5	10	6	6	86	88	88
10: Agriculture	6	4	4	12	8	8	80	95	95
SUM	10385	2732	2626	12251	5553	5433	1798	1065	1089

Table 3.8: Emissions of the NEC_PRIMES09 (P09) and the NEC_PRIMES10 (P10) cases in 2020 compared to the national emission ceilings for 2010 and the emissions in 2000 [kt]

	NH_3				VOC			
	2000	NEC 2010	P09 2020	P10 2020	2000	NEC 2010	P09 2020	P10 2020
Austria	60	66	59	59	199	159	111	113
Belgium	84	74	75	75	226	139	129	131
Bulgaria	69	108	60	60	137	175	79	81
Cyprus	7	9	6	6	14	14	5	5
Czech Rep.	86	80	68	68	226	220	148	151
Denmark	91	69	52	52	147	85	74	74
Estonia	11	29	11	11	45	49	21	22
Finland	35	31	30	30	166	130	90	94
France	704	780	625	626	1738	1050	720	740
Germany	627	550	607	607	1611	995	870	871
Greece	56	73	52	52	332	261	147	150
Hungary	78	90	70	70	159	137	104	106
Ireland	125	116	110	110	81	55	49	49
Italy	428	419	384	385	1827	1159	777	781
Latvia	13	44	12	12	67	136	49	50
Lithuania	38	84	45	46	67	92	53	55
Luxembourg	6	7	5	5	14	9	7	7
Malta	2	3	2	2	6	12	3	3
Netherlands	149	128	124	124	269	185	156	156
Poland	317	468	356	356	579	800	343	359
Portugal	77	90	69	69	302	180	176	177
Romania	138	210	151	151	429	523	301	308
Slovakia	31	39	24	24	98	140	56	58
Slovenia	20	20	16	16	55	40	31	33
Spain	392	353	363	363	1191	662	646	647
Sweden	56	57	45	45	276	241	120	121
UK	322	297	284	284	1395	1200	673	675
EU-27	4021	4294	3706	3708	11659	8848	5938	6018

Table 3.9: Emissions by SNAP sector of the NEC_PRIMES09 (P09) and the NEC_PRIMES10 (P10) baselines in 2020 compared to the emissions in 2000 [kt]

	NH_3			VOC		
	2000	2020		2000	2020	
SNAP sector		P09	P10		P09	P10
1: Power generation	9	17	18	126	134	143
2: Domestic	18	19	20	1139	642	706
3: Industrial combust.	3	5	5	46	46	63
4: Industrial processes	75	74	74	1181	932	925
5: Fuel extraction	0	0	0	709	338	338
6: Solvents	0	0	0	3781	2716	2716
7: Road traffic	73	22	22	3561	497	494
8: Off-road sources	1	1	1	928	467	468
9: Waste management	180	184	184	103	85	85
10: Agriculture	3662	3384	3384	84	80	80
SUM	4021	3706	3708	11659	5938	6018

4 Environmental objectives

4.1 The objectives of the Thematic Strategy on Air Pollution

In its Thematic Strategy on Air Pollution (CEC, 2005), the European Commission has established health and environmental interim objectives for the year 2020 to guide the ambition level of further measures to reduce the impacts of air pollution in Europe. These environmental objectives were expressed in terms of relative improvements compared to the situation as assessed with the same methodology for the year 2000 (Table 4.1).

Table 4.1: Environmental objectives of the Thematic Strategy expressed as percentage improvements relative to the situation in the year 2000

	Unit of the indicator	Percentage improvement compared to the situation in 2000
Life years lost from particulate matter (YOLLs)	Years of life lost	47 %
Area of forest ecosystems where acid deposition exceeds the critical loads for acidification	km^2	74 %
Area of freshwater ecosystems where acid deposition exceeds the critical loads for acidification	km^2	39 %
Ecosystems area where nitrogen deposition exceeds the critical loads for eutrophication	km^2	43 %
Premature mortality from ozone	Number of cases	10 %
Area of forest ecosystems where ozone concentrations exceed the critical levels for ozone[1)]	km^2	15 %

Note: [1)] This effect has not been explicitly modelled in RAINS. The environmental improvements in the area of forest ecosystems exceeding ozone levels resulting from emission controls that are targeted at the other effect indicators have been determined in an ex-post analysis.

4.2 Application of the TSAP objectives to the NEC analysis

Since the analyses conducted under the Clean Air For Europe (CAFE) program that led to the adoption of the policy objectives in the Thematic Strategy on Air Pollution, a number of methodological improvements have been introduced into the GAINS model. These include, inter alia, a more accurate representation of nitrogen deposition to individual ecosystems (using 'ecosystem-specific' calculations of nitrogen deposition), the use of multi-year meteorological conditions, improved representations of $PM_{2.5}$ concentrations in urban areas and revised critical loads estimates. Analyses that are documented in the earlier NEC Reports #1 to #6 (Amann *et al.*, 2006c, Amann *et al.*, 2006a, Amann *et al.*, 2006b, Amann *et al.*, 2007a, Amann *et al.*, 2007b, Amann, M. *et al.*, 2008) examined different approaches for translating the quantitative objectives given in the TSAP into the updated modelling environment without altering the environmental ambition level of the TSAP. For eutrophication, the TSAP objective calls for a 43% reduction in unprotected ecosystems areas calculated with grid-average depositions. The more accurate methodology for assessing nitrogen deposition to ecosystems on the basis of ecosystem-specific depositions implies significantly higher efforts in terms of emission reductions if the same relative improvement in the area of unprotected ecosystems were to be achieved.

In this NEC report #7 we have taken a pragmatic approach to ensure maximal compatibility with the methodology for quantifying the environmental impact indicators that have been used for the analyses leading to the Thematic Strategy on Air Pollution. The methodology used is described in Box 1.

Box 1: Methodology for ensuring maximum compatibility between the *grid-average* deposition calculation for eutrophication using in the TSAP and the more detailed *ecosystem-specific* critical load information.

The TSAP stipulates a 43% reduction in unprotected areas when calculated based on grid-average depositions. We have taken the following steps to ensure that this target is indeed achieved when using the more recent and detailed ecosystem-specific critical load information:

1) First, we have calculated the areas of unprotected ecosystems using the exact CAFE emissions scenario that underlies the TSAP targets. This calculation was done with the grid-average critical load data, and indeed a 43% improvement relative to the year 2000 was found.

2) This calculation was repeated with the same emissions but the new, ecosystem-specific critical load information. It was found that the emissions implied a 31% improvement relative to the year 2000. Thus, this 31% improvement is the best proxy for what the TSAP targets would have looked like had the ecosystem-specific critical loads been used at the time the TSAP was formulated, instead of the grid averages.

3) Starting from the NEC_PRIMES baselines P09 and P10, the gap closure procedure in the year 2020 was applied to all Member states so that the overall target of -31% for the unprotected areas was achieved when using the ecosystem-specific critical loads. We then used the optimization algorithm to find the most cost-effective solution to achieve this overall target and found a set of cost-effective emission ceilings for P09 and P10, respectively.

5) Finally, to check the consistency of these cost-effective ceilings with the TSAP targets we used the ceilings to calculate the unprotected areas *on the basis of the grid-average depositions* and found that they are indeed reduced by 43% relative to 2000. Thus, we have achieved consistency between the grid-average approach used in the formulation of the TSAP and the ecosystem-specific approach that incorporates more recent scientific findings on harmful effects on ecosystems.

It has been shown earlier that all other methodological changes (such as multi-year meteorological conditions, improved representation of PM2.5 concentrations in cities) and the inclusion of Bulgaria and Romania into the target setting analyses do not lead to significant distortions in the efforts required to meet the environmental objectives. It should be noted that health impacts now are based on the representative population for the respective year.

Table 4.2 summarizes the environmental targets that are used in this report. The values for the year 2000 have been recalculated with the EMEP model in the context of the EC4MACS interim assessment (Amann *et al.*, 2009).

Table 4.2: Environmental targets used for the optimization analysis presented in this report

	Unit	Effect estimate for the year 2000 for the EU-27	Environmental objective of the TSAP in terms of relative improvement in relation to the year 2000 for EU-25	Resulting target for the NEC analysis (EU-27)
YOLLs	Million years of life lost (million YOLLs)	200.8	-47%	106.4
Eutrophication	1000 km^2 of unprotected ecosystems (using the grid-average deposition)	976.2	-43%	565.5
Acidification of forest soils	1000 km^2 forest area with acid deposition exceeding critical loads	280.3	-74%	72.8
Ozone	Cases of premature deaths attributable to ground-level ozone	22707	-10%	20436

Note: The objectives of the TSAP for acidification of freshwater catchment areas and for vegetation impacts from ozone are not explicitly considered in the RAINS/GAINS optimization framework. Progress for these indicators is determined in an ex-post analysis from the emission patterns that meet the objectives listed in Table 4.1.

5 Cost-effective emission reductions

A series of optimization runs has been conducted to assess cost-effective sets of emission reductions that achieve the environmental objectives listed in Table 4.1 in terms of the targets listed in Table 4.2.

5.1 Emission reductions and costs

The envisaged emission ceilings must be set in such a way that they simultaneously address all environmental impact targets. The GAINS optimization has been used to identify the least-cost set of emission reductions for the activity projections with the two alternate baselines NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10). Based on the assumed projections of economic activities, meeting the TSAP objectives would involve a reduction (between 2000 and 2020) of SO_2 emissions by 76% to 78%, of NO_x by 57% to 58%, of PM2.5 by 43% to 47%, of NH_3 emissions by 25% and of VOC by 49% to 50% (Table 5.1).

Table 5.1: Emission levels for EU-27 for scenarios based on the two alternative baselines NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10), for the CLE case, the cases that meet the environmental targets laid out in the Thematic Strategy (TSAP) at lowest costs and the maximum reduction case (MRR). The TSAP and MRR case are obtained with the RAINS optimization mode of GAINS, i.e., excluding structural changes.

		SO_2		NO_x		PM2.5		NH_3		VOC	
	Year	2020 [kt]	Change to 2000	2020 [kt]	Change to 2000	2020 [kt]	Change to 2000	2020 [kt]	Change to 2000	2020 [kt]	Change to 2000
	2000	10385		12251		1798		4021		11659	
P09	CLE	2732	-74%	5553	-55%	1065	-41%	3706	-8%	5938	-49%
P09	TSAP	2481	-76%	5252	-57%	944	-47%	3021	-25%	5869	-50%
P09	MRR	1862	-82%	4495	-63%	573	-68%	2253	-44%	4045	-65%
P10	CLE	2626	-75%	5433	-56%	1089	-39%	3708	-8%	6018	-48%
P10	TSAP	2324	-78%	5176	-58%	1032	-43%	3012	-25%	5970	-49%
P10	MRR	1779	-83%	4434	-64%	574	-68%	2254	-44%	4068	-65%

We now report emission reductions and costs relative to their respective baseline scenarios. Figure 5.1 may help to follow the steps. First, we have calculated the additional measures and costs for reaching the TSAP objective starting from the NEC_PRIMES09 (P09) baseline (Step 1). Then we calculated the additional measures and costs for reaching the TSAP objective starting from the NEC_PRIMES10 (P10) baseline (Step 2). Results of these calculations are shown in Table 5.2 (columns 'TSAP').

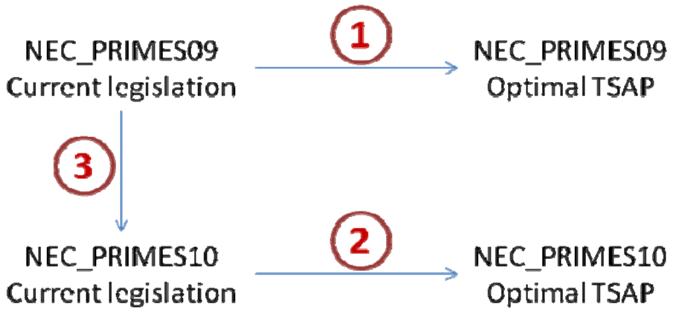

Figure 5.1 Schematic illustration of the steps taken to calculate the costs for reaching the TSAP objectives (see text).

As an additional piece of information we have also calculated the difference in air pollution control costs between the NEC_PRIMES09 and NEC_PRIMES10 baseline scenarios (Step 3 in Figure 5.1). This cost difference represents the cost co-benefit for air pollution control costs, when starting from a scenario with a lower energy consumption (NEC_PRIMES10), and it is shown in the last column of Table 5.3. This cost difference does *not* take into account the cost for additional GHG mitigation measures that are present in the NEC_PRIMES10 relative to the NEC_PRIMES09 scenario, but only the air pollution control costs.

For SO_2, further measures emerge mainly in the power sector, for households and in industry. The majority of NO_x reductions would come from industrial energy combustion. $PM_{2.5}$ emission reductions would occur in the waste management and agriculture sectors. For the NEC_PRIMES09 baseline scenario we also observe significant reductions in SNAP sector 4 (Industrial processes). This is a qualitative difference to the results of the NEC_PRIMES10, where this sector contributes no $PM_{2.5}$ emission reductions. Lower absolute levels of SO_2 and NO_x in P10 compared to P09 (cf. Table 5.2) imply less of a need to reduce $PM_{2.5}$. Ammonia reductions involve action in the agricultural sector.

Table 5.2: Amount of emissions to be reduced through end-of-pipe measures in the optimized scenarios compared to the respective current legislation (CLE) cases by SNAP sector, for the two energy scenarios NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10) [kt].

	SO_2		NO_x		PM2.5		NH_3		VOC	
SNAP sector	P09	P10	P09	P10	P09	P10	P09	P10	P09	P10
1: Power generation	-22	-46	-66	-62	0	0	0	0	0	0
2: Domestic	-97	-93	-2	-1	-1	0	0	0	0	0
3: Industrial combust.	-80	-97	-215	-176	0	0	0	0	0	0
4: Industrial processes	-47	-61	-8	-7	-43	0	-1	-1	0	0
5: Fuel extraction	0	0	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0	0	0
7: Road traffic	0	0	0	0	0	0	0	0	0	0
8: Off-road sources	0	0	0	0	0	0	0	0	0	0
9: Waste management	-2	-1	-3	-3	-20	-17	0	0	0	0
10: Agriculture	-4	-4	-8	-8	-57	-40	-684	-695	-69	-48
Sum	-251	-302	-302	-258	-121	-57	-686	-696	-69	-48

We have obtained the optimized scenarios with the RAINS-optimization mode of GAINS. The RAINS-mode of the GAINS model only uses end-of-pipe measures from the RAINS/GAINS database. The lowest level of emissions that can be achieved through full application of these measures is referred to in the subsequent parts of this report as the “MRR” (Maximum Reductions with the measures contained in the RAINS model) case.

With these assumptions, costs of the additional measures (on top of the costs for the current legislation (CLE) case) to meet the TSAP objectives – starting from the NEC_PRIMES09 (NEC_PRIMES10) baseline scenario – are estimated at €1.4 (1.5) billion/year (Table 5.3, columns ‘TSAP’). Thereby, additional emission control costs in 2020 amount to 0.010% (0.0011%) of GDP for the EU27 as a whole.

Some 70% of the costs for additional measures emerge in the agricultural sector, which, however, bears only four percent of the air pollution control costs for current legislation in 2020. While, on average, costs of additional measures to achieve the TSAP objectives amount to 0.010% to 0.011% of GDP, there are substantial variations between the Member States depending on the measures needed but also on the level of GDP, ranging from 0.00% to 0.108% (0.134% for P10) of GDP (Table 5.4).

The last column in Table 5.3 shows the co-benefits in air pollution control costs arising from changing the energy system from that of P09 to that of P10, i.e., the difference in emission control costs between the two current legislation (CLE) cases P09 and P10 (Step 3 in Figure 5.1 as described above). For example, total air emission control cost in P10 is 968 million €/yr lower than in P09. This could be taken into account when comparing the total extra costs for achieving the TSAP objectives between the two scenarios.

Table 5.3: Emission control costs [million €/yr] in 2020 by SNAP sector for the Current Legislation (CLE) cases (in absolute terms), and extra costs for achieving the TSAP objectives and the MRR case (Maximum Reductions with the measures considered in the RAINS model), for both baseline scenarios NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10). The last column shows the difference in air emission control costs between the two CLE cases P09 and P10. For example, total emission control cost in the P10 baseline is 968 million €/yr lower than in the P09 baseline.

SNAP sector	P09 CLE	P09 TSAP	P09 MRR	P10 CLE	P10 TSAP	P10 MRR	Cost co-benefit Cost savings between P10 and P09
1: Power generation	12633	46	2666	11024	74	2323	-1609
2: Domestic	7520	51	18060	7655	49	19533	135
3: Industrial combust.	2657	201	1912	2582	173	1870	-75
4: Industrial processes	4704	30	3486	4712	40	3482	8
5: Fuel extraction	980	0	728	975	0	730	-5
6: Solvents	1429	0	12985	1429	0	10773	0
7: Road traffic	46777	0	0	47358	0	0	580
8: Off-road sources	9471	0	0	9468	0	0	-3
9: Waste management	1	2	10	1	2	10	0
10: Agriculture	3364	1085	12111	3364	1163	12098	0
SUM	89536	1414	51957	88569	1501	50819	-968

Figure 5.2 shows additional air pollution control costs by Member State as a percentage of GDP in 2020. The first bar (black) shows costs of achieving the TSAP objectives in the P09 case relative to the P09 CLE case, the second bar (blue) shows the costs of achieving the TSAP objectives in the P10 case relative to the P10 CLE case. At the level of EU-27, additional costs for reaching the TSAP objectives are slightly higher for the P10 case than for the P09 case (blue typically than black for EU-27).

The cost co-benefit, representing the savings on air pollution control costs between the P09 and P10 current legislation scenario, is shown in red as the third column. For individual countries this figure is given in the last column in Table 5.4. Finally, the last bar in Figure 5.2 in green shows net extra air pollution control costs on top of the P09 CLE case, changing the energy system to the P10 case and achieving the TSAP objectives on the basis of the P10 energy system. This last column is obtained by taking the costs for implementing the TSAP with the P10 baseline, and subtracting the cost-co-benefits from using the P10 baseline instead of the P09 baseline.

We illustrate this now for the EU-27 as a whole in Figure 5.3. Achieving the TSAP targets starting from the P09 baseline costs 1414 million €/yr (Table 5.3), or 0.010% of GDP (black bar). Achieving the TSAP targets starting from the P10 baseline costs 1501 million €/yr (Table 5.3), or 0.011% of GDP (black bar). Changing the energy system from P09 to P10 reduces air pollution control costs by 968 million €/yr (0.007% of GDP, last column Table 5.4). The green bar finally is obtained by calculating 1501 million €/yr – 968 million €/yr = 533 million €/yr (= 0.004% of GDP). It represents the net cost of achieving the TSAP objectives relative to the P09 baseline, in case the climate policy would force the energy system to change to the P10 case. Again, the additional cost for the climate policy driving the change from P09 to P10 is not included in the calculation.

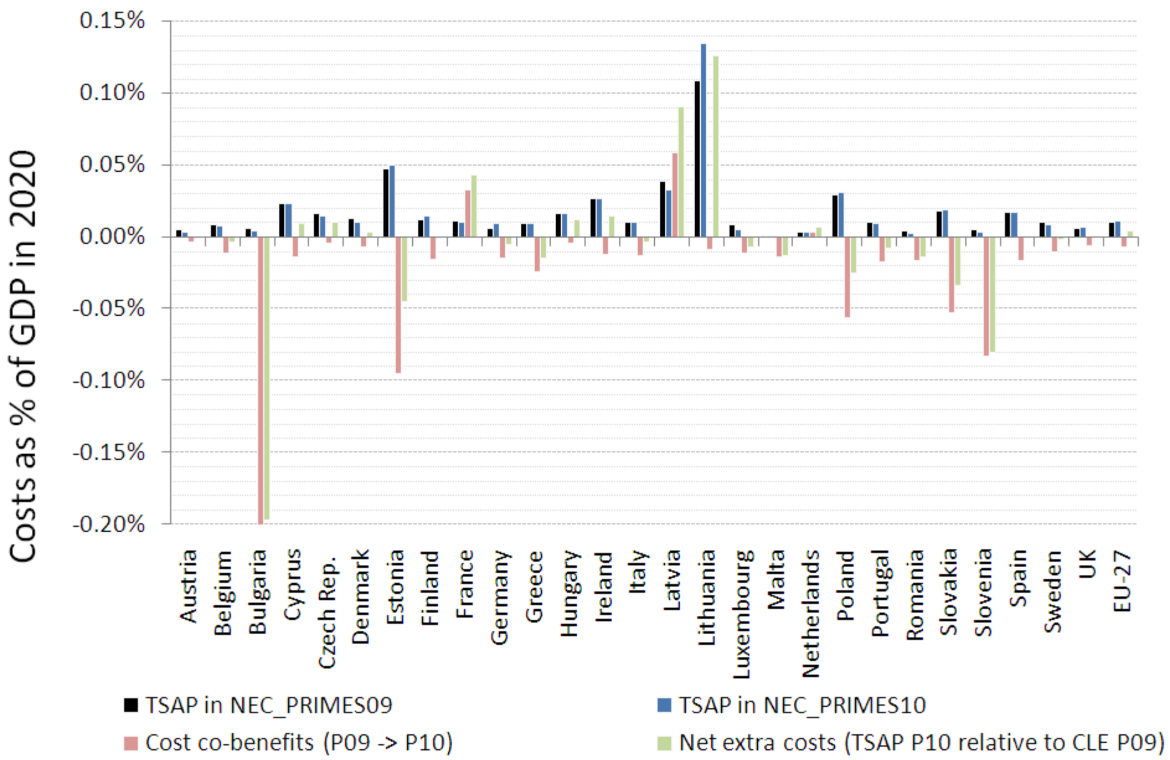

Figure 5.2 Additional air pollution control costs by Member State expressed as a percentage of GDP

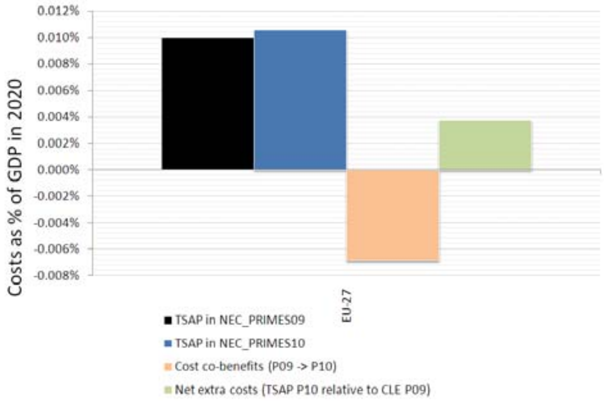

Figure 5.3 Costs in 2020 for the cost-optimal scenarios and the difference in emission control costs in the two baseline scenarios and net extra emission control costs for achieving the TSAP objectives in P10 as compared to the current legislation case of the P09 scenario (see text).

Table 5.4: Air pollution emission control costs in 2020 per country, for the Current Legislation (CLE) cases and the cases that meet the environmental objectives of TSAP. The last column shows the difference between air pollution control costs in the CLE cases for NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10), expressed as % of the GDP in 2020. The -0.007% for the EU-27 represents the -968 million €/yr in Table 5.3.

	P09				P10				
	CLE mln €/yr	% of GDP in 2020	TSAP mln €/yr	% of GDP in 2020	CLE mln €/yr	% of GDP in 2020	TSAP mln €/yr	% of GDP in 2020	Cost co-benefit (% of GDP see text)
Austria	1861	0.60	15	0.005	1849	0.60	11	0.003	-0.004
Belgium	2356	0.60	31	0.008	2310	0.59	29	0.008	-0.012
Bulgaria	1317	3.80	2	0.005	1247	3.60	1	0.004	-0.201
Cyprus	323	1.43	5	0.023	320	1.42	5	0.023	-0.014
Czech Rep.	2339	1.52	25	0.016	2333	1.51	22	0.014	-0.004
Denmark	1464	0.60	32	0.013	1447	0.59	24	0.010	-0.007
Estonia	367	2.38	7	0.047	352	2.28	8	0.050	-0.095
Finland	1132	0.56	24	0.012	1100	0.55	29	0.014	-0.016
France	10779	0.50	226	0.011	11477	0.54	222	0.010	0.033
Germany	16115	0.59	154	0.006	15720	0.58	242	0.009	-0.015
Greece	2150	0.74	27	0.009	2080	0.72	26	0.009	-0.024
Hungary	1466	1.28	19	0.016	1461	1.27	18	0.016	-0.005
Ireland	830	0.37	59	0.027	804	0.36	59	0.026	-0.012
Italy	9098	0.54	169	0.010	8870	0.53	168	0.010	-0.014
Latvia	378	2.17	7	0.039	388	2.23	6	0.032	0.058
Lithuania	456	1.50	33	0.108	453	1.49	41	0.134	-0.009
Luxembourg	418	0.88	4	0.008	412	0.87	2	0.005	-0.011
Malta	65	0.97	0	0.000	65	0.95	0	0.000	-0.014
Netherlands	3380	0.53	17	0.003	3399	0.53	20	0.003	0.003
Poland	9005	2.22	119	0.029	8776	2.16	125	0.031	-0.056
Portugal	1509	0.84	18	0.010	1478	0.82	17	0.009	-0.017
Romania	2526	1.87	6	0.004	2504	1.85	3	0.002	-0.017
Slovakia	704	0.96	13	0.018	665	0.91	14	0.019	-0.053
Slovenia	619	1.41	2	0.005	582	1.32	1	0.003	-0.083
Spain	9612	0.75	221	0.017	9400	0.73	222	0.017	-0.016
Sweden	2016	0.53	37	0.010	1975	0.52	33	0.009	-0.011
UK	7252	0.31	145	0.006	7101	0.30	154	0.007	-0.006
EU-27	89536	0.63	1414	0.010	88568	0.63	1501	0.011	-0.007

5.2 Detailed results: Emissions

Table 5.1 Emissions of SO_2 by Member State for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	32	19	18	16	18	18	15
Belgium	170	81	70	62	81	68	62
Bulgaria	891	132	132	80	118	118	69
Cyprus	47	5	5	2	4	4	2
Czech Rep.	265	106	99	93	105	98	92
Denmark	29	11	11	10	11	11	10
Estonia	85	16	14	12	14	12	11
Finland	79	42	40	37	33	30	29
France	611	199	182	134	193	174	130
Germany	618	329	318	300	317	304	289
Greece	547	112	111	60	107	106	57
Hungary	452	64	59	30	63	58	30
Ireland	135	28	26	21	27	23	20
Italy	746	234	234	161	220	220	148
Latvia	10	4	3	3	5	4	4
Lithuania	52	15	13	7	15	8	8
Luxembourg	2	1	1	1	1	1	1
Malta	24	1	1	1	1	1	1
Netherlands	73	32	31	30	33	32	31
Poland	1490	468	372	299	440	332	279
Portugal	291	64	60	33	63	58	34
Romania	783	145	144	76	141	141	74
Slovakia	104	42	41	22	40	40	21
Slovenia	101	17	17	13	16	16	12
Spain	1522	311	253	176	303	235	171
Sweden	44	29	29	28	27	27	27
UK	1182	227	197	155	227	184	153
EU-27	10385	2732	2481	1862	2626	2324	1779

Table 5.2 Emissions of SO_2 by SNAP sector for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
SNAP sector		CLE	TSAP	MRR	CLE	TSAP	MRR
1: Power generation	7178	955	933	807	894	848	746
2: Domestic	712	423	326	250	401	308	241
3: Industrial combust.	1391	639	560	334	619	522	324
4: Industrial processes	698	586	539	347	583	521	345
5: Fuel extraction	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0
7: Road traffic	149	6	6	6	6	6	6
8: Off-road sources	247	114	114	114	114	114	114
9: Waste management	4	5	3	3	5	3	3
10: Agriculture	6	4	0	0	4	1	0
SUM	10385	2732	2481	1862	2626	2324	1779

Table 5.3 Emissions of NO_x by Member State for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	204	94	94	81	93	93	82
Belgium	330	170	155	142	162	150	138
Bulgaria	178	68	67	53	64	63	50
Cyprus	22	13	12	8	12	11	8
Czech Rep.	307	151	144	113	149	142	112
Denmark	210	85	79	74	83	77	73
Estonia	37	21	16	13	20	16	13
Finland	222	125	120	110	122	118	109
France	1535	572	546	472	578	559	487
Germany	1702	708	692	609	692	679	597
Greece	331	242	222	199	236	214	190
Hungary	180	86	81	64	85	80	64
Ireland	139	69	60	53	67	60	52
Italy	1330	679	669	548	661	652	537
Latvia	38	22	21	19	22	21	19
Lithuania	53	29	26	24	29	26	23
Luxembourg	37	17	17	16	17	17	16
Malta	9	3	3	3	3	3	3
Netherlands	411	170	168	150	170	168	150
Poland	793	429	413	353	419	405	346
Portugal	267	106	97	87	102	94	85
Romania	314	156	153	104	154	152	102
Slovakia	97	57	53	39	56	52	38
Slovenia	55	27	27	25	26	26	24
Spain	1440	695	616	553	677	618	541
Sweden	231	97	91	87	97	91	88
UK	1779	663	610	499	640	589	488
EU-27	12251	5553	5252	4495	5433	5176	4434

Table 5.4 Emissions of NO_x by SNAP sector for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
SNAP sector		CLE	TSAP	MRR	CLE	TSAP	MRR
1: Power generation	2648	1182	1116	831	1106	1044	791
2: Domestic	700	656	654	492	635	633	481
3: Industrial combust.	1302	934	720	461	932	757	471
4: Industrial processes	176	150	143	92	149	141	91
5: Fuel extraction	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0
7: Road traffic	5505	1544	1544	1544	1527	1527	1527
8: Off-road sources	1899	1073	1073	1073	1070	1070	1070
9: Waste management	10	6	3	3	6	3	3
10: Agriculture	12	8	0	0	8	1	0
SUM	12251	5553	5252	4495	5433	5176	4434

Table 5.5 Emissions of $PM_{2.5}$ by Member State for 2000, the current legislation case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	23	13	12	8	13	13	8
Belgium	33	20	19	15	21	20	15
Bulgaria	62	33	27	9	33	32	8
Cyprus	3	1	1	1	1	1	1
Czech Rep.	43	25	23	14	27	26	14
Denmark	27	19	19	8	20	19	8
Estonia	20	7	6	3	8	7	3
Finland	33	21	21	10	22	21	9
France	378	207	195	107	212	209	108
Germany	145	83	79	63	84	82	63
Greece	55	33	26	16	34	27	16
Hungary	45	23	19	10	23	21	10
Ireland	13	8	8	6	7	7	6
Italy	162	82	77	62	83	79	62
Latvia	14	15	13	3	15	14	3
Lithuania	11	10	7	3	11	8	3
Luxembourg	3	2	2	2	2	2	2
Malta	1	0	0	0	0	0	0
Netherlands	29	16	15	13	16	16	13
Poland	136	105	99	69	108	105	67
Portugal	104	58	40	15	59	52	15
Romania	135	106	74	20	110	107	20
Slovakia	25	10	8	6	10	10	6
Slovenia	12	6	5	3	6	6	3
Spain	143	90	76	54	90	76	54
Sweden	31	19	19	15	20	20	15
UK	113	53	52	42	53	52	42
EU-27	1798	1065	944	573	1089	1032	574

Table 5.6 Emissions of $PM_{2.5}$ by SNAP sector for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
SNAP sector		CLE	TSAP	MRR	CLE	TSAP	MRR
1: Power generation	196	41	41	31	38	38	29
2: Domestic	527	356	355	107	380	380	108
3: Industrial combust.	107	89	89	51	92	92	52
4: Industrial processes	305	236	193	126	237	237	126
5: Fuel extraction	9	7	7	7	7	7	7
6: Solvents	0	0	0	0	0	0	0
7: Road traffic	328	87	87	87	88	88	88
8: Off-road sources	161	66	66	66	65	65	65
9: Waste management	86	88	68	64	88	71	64
10: Agriculture	80	95	38	35	95	55	35
SUM	1798	1065	944	573	1089	1032	574

Table 5.7 Emissions of NH_3 by Member State for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	60	59	51	32	59	53	32
Belgium	84	75	70	65	75	70	65
Bulgaria	69	60	57	47	60	58	47
Cyprus	7	6	4	3	6	4	3
Czech Rep.	86	68	56	49	68	57	49
Denmark	91	52	48	46	52	49	46
Estonia	11	11	7	5	11	7	5
Finland	35	30	27	24	30	27	24
France	704	625	489	345	626	490	346
Germany	627	607	486	362	607	470	362
Greece	56	52	40	33	52	40	33
Hungary	78	70	49	36	70	49	36
Ireland	125	110	89	65	110	89	64
Italy	428	384	293	206	385	293	206
Latvia	13	12	8	7	12	9	7
Lithuania	38	45	34	21	46	34	21
Luxembourg	6	5	4	4	5	5	4
Malta	2	2	2	2	2	2	2
Netherlands	149	124	117	110	124	116	110
Poland	317	356	292	228	356	293	228
Portugal	77	69	61	40	69	61	40
Romania	138	151	137	70	151	140	70
Slovakia	31	24	17	12	24	16	12
Slovenia	20	16	14	9	16	14	9
Spain	392	363	288	201	363	285	201
Sweden	56	45	38	32	45	39	33
UK	322	284	242	202	284	242	201
EU-27	4021	3706	3021	2253	3708	3012	2254

Table 5.8 Emissions of NH_3 by SNAP sector for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
SNAP sector		CLE	TSAP	MRR	CLE	TSAP	MRR
1: Power generation	9	17	17	23	18	18	23
2: Domestic	18	19	19	18	20	20	18
3: Industrial combust.	3	5	4	7	5	5	8
4: Industrial processes	75	74	74	28	74	73	28
5: Fuel extraction	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0
7: Road traffic	73	22	22	22	22	22	22
8: Off-road sources	1	1	1	1	1	1	1
9: Waste management	180	184	184	184	184	184	184
10: Agriculture	3662	3384	2699	1968	3384	2689	1968
SUM	4021	3706	3021	2253	3708	3012	2254

Table 5.9 Emissions of VOC by Member State for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	199	111	111	73	113	113	74
Belgium	226	129	128	108	131	130	109
Bulgaria	137	79	77	40	81	78	40
Cyprus	14	5	5	4	5	5	4
Czech Rep.	226	148	148	82	151	151	82
Denmark	147	74	74	45	74	74	45
Estonia	45	21	20	14	22	21	14
Finland	166	90	90	56	94	94	58
France	1738	720	720	480	740	740	497
Germany	1611	870	870	583	871	871	584
Greece	332	147	139	88	150	142	88
Hungary	159	104	102	59	106	104	59
Ireland	81	49	49	30	49	49	30
Italy	1827	777	776	622	781	780	623
Latvia	67	49	48	18	50	49	18
Lithuania	67	53	50	29	55	51	30
Luxembourg	14	7	7	6	7	7	6
Malta	6	3	3	2	3	3	2
Netherlands	269	156	156	125	156	156	125
Poland	579	343	341	223	359	358	224
Portugal	302	176	170	115	177	171	115
Romania	429	301	277	129	308	305	129
Slovakia	98	56	56	38	58	57	38
Slovenia	55	31	30	17	33	32	17
Spain	1191	646	630	468	647	631	468
Sweden	276	120	120	95	121	121	96
UK	1395	673	673	494	675	675	493
EU-27	11659	5938	5869	4045	6018	5970	4068

Table 5.10 Emissions of VOC by SNAP sector for 2000, the current legislation (CLE) case, the cost-optimal case that meets the TSAP environmental objectives and maximum reductions MRR [kt]

	2000	2020					
			P09			P10	
SNAP sector		CLE	TSAP	MRR	CLE	TSAP	MRR
1: Power generation	126	134	134	134	143	143	143
2: Domestic	1139	642	642	135	706	706	142
3: Industrial combust.	46	46	46	46	63	63	63
4: Industrial processes	1181	932	932	712	925	925	706
5: Fuel extraction	709	338	338	271	338	338	270
6: Solvents	3781	2716	2716	1690	2716	2716	1690
7: Road traffic	3561	497	497	497	494	494	494
8: Off-road sources	928	467	467	467	468	468	468
9: Waste management	103	85	85	81	85	85	81
10: Agriculture	84	80	12	12	80	32	12
SUM	11659	5938	5869	4045	6018	5970	4068

5.3 Detailed results: Impacts

Table 5.11 Loss in statistical life expectancy attributable to the exposure of PM2.5 from anthropogenic sources, for 2000, the current legislation (CLE) cases, scenarios that meet the TSAP environmental objectives and the MRR, for the two NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10) scenarios [months]

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	7.4	3.7	3.4	2.6	3.6	3.4	2.6
Belgium	12.5	6.6	6.0	4.9	6.6	6.0	4.9
Bulgaria	8.0	3.9	3.7	2.6	3.9	3.8	2.6
Cyprus	4.5	3.6	3.6	3.5	3.6	3.6	3.5
Czech Rep.	9.0	4.6	4.2	3.3	4.6	4.2	3.3
Denmark	6.7	3.6	3.3	2.7	3.6	3.3	2.7
Estonia	4.8	3.1	2.9	2.3	3.1	2.9	2.3
Finland	2.7	1.9	1.9	1.6	1.9	1.8	1.5
France	7.9	3.8	3.5	2.5	3.8	3.5	2.5
Germany	9.5	4.9	4.4	3.6	4.8	4.4	3.6
Greece	7.1	4.0	3.8	3.1	4.1	3.9	3.1
Hungary	10.3	5.3	4.7	3.5	5.2	4.8	3.5
Ireland	3.6	2.0	1.8	1.5	1.9	1.7	1.5
Italy	8.0	4.0	3.8	3.1	3.9	3.7	3.0
Latvia	5.0	4.0	3.7	2.6	4.0	3.7	2.6
Lithuania	5.6	3.7	3.4	2.9	3.7	3.4	2.8
Luxembourg	9.7	4.7	4.3	3.4	4.7	4.3	3.3
Malta	5.9	4.2	4.2	3.9	4.2	4.2	3.8
Netherlands	11.8	6.2	5.7	4.8	6.1	5.7	4.8
Poland	9.1	5.3	4.8	3.8	5.2	4.7	3.7
Portugal	7.6	3.5	2.9	1.9	3.5	3.2	1.9
Romania	8.6	4.9	4.4	2.9	4.9	4.7	2.9
Slovakia	9.2	4.6	4.1	3.2	4.5	4.1	3.1
Slovenia	8.3	4.1	3.8	2.9	4.1	3.8	2.9
Spain	4.9	2.4	2.2	1.8	2.4	2.2	1.8
Sweden	3.3	2.0	1.9	1.6	2.0	1.9	1.6
UK	6.7	3.4	3.0	2.5	3.3	3.0	2.5
EU-27	8.0	4.1	3.8	3.0	4.1	3.8	2.9

Table 5.12 Loss in years of life lost (YOLLs) attributable to the exposure of PM2.5 from anthropogenic sources, for 2000, the current legislation (CLE) cases, scenarios that meet the TSAP environmental objectives and the MRR, for the two NEC_PRIMES09 (P09) and NEC_PRIMES10 (P10) scenarios [million YOLLs]. Please note the comments in Section 1.2.3.

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	3.2	1.8	1.6	1.3	1.8	1.6	1.3
Belgium	6.8	3.9	3.6	3.0	3.9	3.6	2.9
Bulgaria	3.3	1.6	1.5	1.1	1.6	1.6	1.1
Cyprus	0.1	0.2	0.2	0.2	0.2	0.2	0.2
Czech Rep.	4.6	2.7	2.5	1.9	2.7	2.5	1.9
Denmark	1.9	1.1	1.0	0.8	1.1	1.0	0.8
Estonia	0.3	0.2	0.2	0.2	0.2	0.2	0.2
Finland	0.7	0.6	0.6	0.5	0.6	0.5	0.5
France	23.9	13.1	11.9	8.7	13.1	12.1	8.7
Germany	43.8	24.0	21.8	17.6	23.7	21.5	17.4
Greece	4.0	2.7	2.6	2.1	2.7	2.6	2.1
Hungary	5.3	2.9	2.6	2.0	2.9	2.7	1.9
Ireland	0.6	0.5	0.4	0.4	0.5	0.4	0.4
Italy	25.7	14.0	13.2	10.7	13.8	13.0	10.6
Latvia	0.6	0.5	0.4	0.3	0.5	0.4	0.3
Lithuania	1.0	0.7	0.6	0.5	0.7	0.6	0.5
Luxembourg	0.2	0.1	0.1	0.1	0.1	0.1	0.1
Malta	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Netherlands	9.9	5.8	5.3	4.5	5.7	5.3	4.5
Poland	16.2	11.1	10.1	8.0	11.0	10.0	7.9
Portugal	4.0	2.1	1.8	1.2	2.1	2.0	1.2
Romania	9.0	5.7	5.2	3.4	5.7	5.5	3.4
Slovakia	2.2	1.4	1.2	1.0	1.4	1.2	0.9
Slovenia	0.9	0.5	0.5	0.4	0.5	0.5	0.3
Spain	10.4	6.6	6.0	4.9	6.5	5.9	4.9
Sweden	1.6	1.1	1.0	0.8	1.0	1.0	0.8
UK	20.5	11.6	10.4	8.5	11.5	10.3	8.5
EU-27	200.9	116.4	106.4	84.0	115.6	106.4	83.2

Table 5.13 Ecosystems area [km^2] with nitrogen deposition exceeding the critical loads for eutrophication. Calculations using *grid-average deposition* (as in the TSAP). As mentioned in Section 4, this calculation method approach has not been used for the target setting in the optimization, but only to check consistency between the TSAP objectives and the ecosystem-specific approach.

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	34356	14629	6468	629	14287	6383	620
Belgium	5122	2523	1481	514	2516	1461	514
Bulgaria	20409	6463	4635	230	6463	4635	0
Cyprus	660	1113	639	261	1113	639	261
Czech Rep.	27626	27456	27352	27192	27456	27349	27190
Denmark	3566	3191	2810	1949	3186	2749	1949
Estonia	11522	5376	2902	1904	5308	2863	1901
Finland	100445	42767	29141	16922	42519	28544	16611
France	159556	112107	79390	26725	111212	78706	26814
Germany	62718	40744	29676	15491	40389	28370	15305
Greece	44027	39900	36950	32753	39564	36456	32336
Hungary	19700	12744	11199	8912	12693	11175	8899
Ireland	1699	1394	988	325	1389	981	317
Italy	47612	30224	20634	5814	29773	20429	5814
Latvia	32870	24885	20336	16462	24792	20336	16417
Lithuania	18766	18243	16909	13544	18215	16834	13475
Luxembourg	1006	1002	909	862	1002	909	862
Malta							
Netherlands	3655	3178	2996	2777	3178	2986	2776
Poland	83072	77448	70990	52246	77243	70750	51831
Portugal	15806	12518	10716	3353	12460	10666	2955
Romania	7908	303	155	2	299	169	2
Slovakia	20531	20049	19436	15828	20034	19408	15661
Slovenia	8946	2524	496	34	2378	502	33
Spain	157271	136771	121394	88817	136263	120950	88022
Sweden	74387	43097	36866	28952	42800	36609	28769
UK	13006	2366	463	22	1757	462	22
EU-27	976242	683015	555931	362520	678289	551321	359356

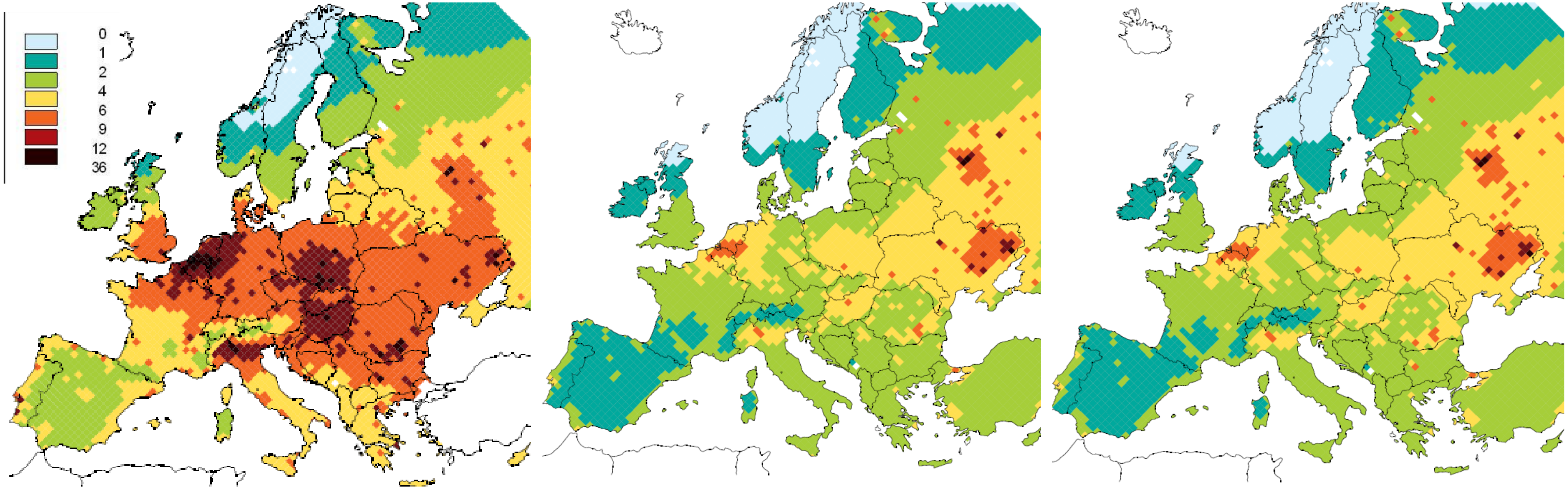

Figure 5.4 Loss in statistical life expectancy [months] attributable to the exposure of fine particles in the year 2000 (left panel) and for the optimized scenarios in 2020 (middle panel: cost-optimal solution based on the NEC_PRIMES09 baseline, right panel: cost-optimal solution based on the NEC_PRIMES10 baseline). There are in fact very few visible differences between the middle and the right panel, for example in the south and east of Germany.

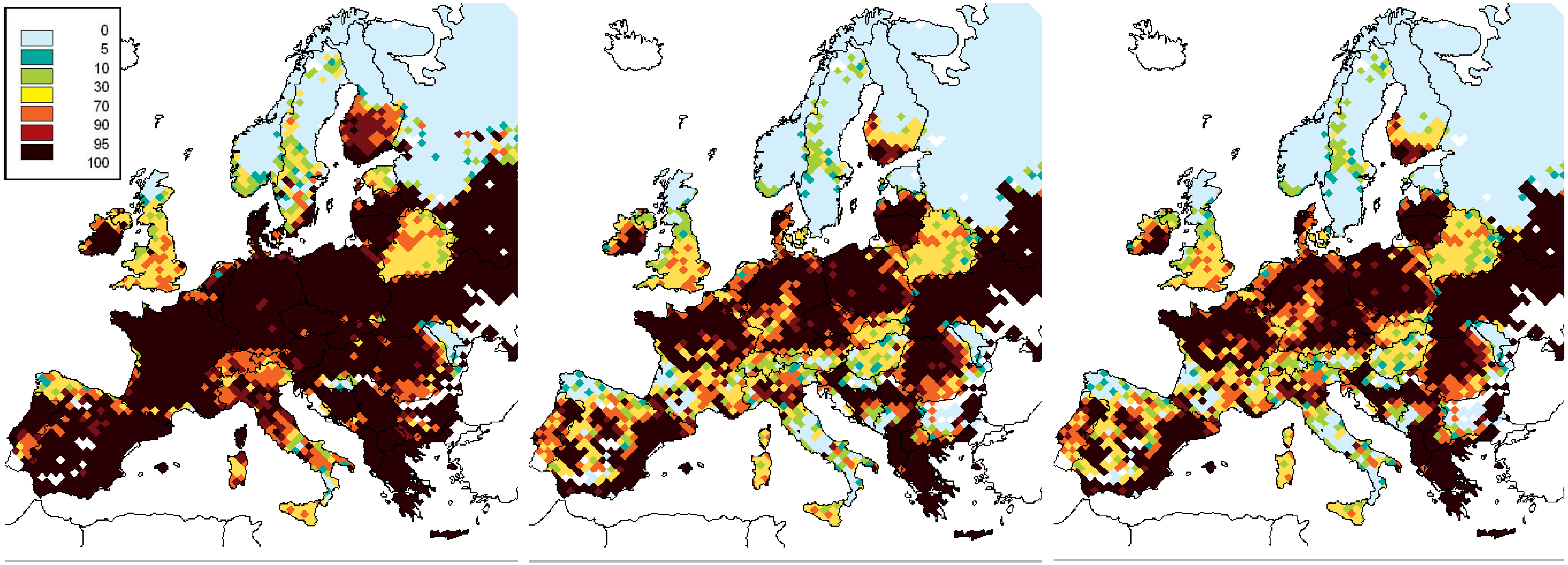

Figure 5.5: Percentage of ecosystems area where nitrogen deposition exceeds the critical loads for eutrophication in the year 2000 (left panel) and for the optimized scenarios that are reaching the TSAP targets in 2020 (middle panel: base on the NEC_PRIMES09 scenario; right panel: based on the NEC_PRIMES10 scenario). Calculation using grid-average deposition.

Table 5.14 Ecosystems area [km^2] with nitrogen deposition exceeding the critical loads for eutrophication. Calculations using *ecosystem-specific deposition* (as in the earlier NEC reports up to #5). As mentioned in Section 4, this calculation method approach has been used for the target setting in the optimization

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	40105	28479	18314	3262	27978	18243	3158
Belgium	6241	5246	4532	2791	5206	4480	2773
Bulgaria	42749	28557	19437	11460	27420	19437	11460
Cyprus	1210	1636	1424	1295	1636	1424	1274
Czech Rep.	27626	27573	27549	27470	27567	27549	27469
Denmark	3584	3584	3583	3582	3584	3583	3582
Estonia	17312	8068	5524	3751	7933	5502	3727
Finland	113866	63519	53580	40408	62288	53005	40383
France	176439	154841	130458	82844	154547	130458	83496
Germany	85901	65889	54008	36132	65525	52525	35875
Greece	52609	51825	50270	46932	51738	50004	46712
Hungary	20805	20564	17538	12926	20562	17538	12911
Ireland	2177	1931	1815	1607	1927	1811	1602
Italy	81754	61504	43466	24865	61256	42601	23796
Latvia	35637	32906	30236	25558	32862	30288	25436
Lithuania	19018	19018	18817	18409	19016	18809	18399
Luxembourg	1015	1006	1003	1001	1006	1003	1001
Malta							
Netherlands	4115	3831	3690	3596	3826	3684	3596
Poland	90117	88881	85633	79197	88783	85464	79029
Portugal	29402	19092	12856	3045	18900	12732	2965
Romania	18870	1603	550	67	1532	565	67
Slovakia	20532	20479	20111	19833	20479	20048	19829
Slovenia	10756	6358	3282	136	6166	3600	126
Spain	177636	165458	152937	111192	165059	152372	109633
Sweden	85028	55404	49997	42598	55048	49757	42517
UK	23894	15320	12382	8523	15061	12183	8450
EU-27	1188398	952572	822992	612480	946905	818665	609266

Table 5.15 Forest area [km^2] with acid deposition exceeding the critical loads for acidification.

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	584	0	0	0	0	0	0
Belgium	1777	912	729	516	885	710	516
Bulgaria	608	0	0	0	0	0	0
Cyprus	0	0	0	0	0	0	0
Czech Rep.	6952	4992	4344	3105	4978	4073	3051
Denmark	1773	337	237	191	308	234	190
Estonia	34	0	0	0	0	0	0
Finland	6220	1807	1537	1382	1703	1474	1358
France	20083	4637	3278	833	4632	3278	833
Germany	58576	20767	13413	6225	19928	12266	5847
Greece	1485	248	109	41	244	103	40
Hungary	3054	914	543	44	662	471	2
Ireland	1737	516	350	167	502	323	161
Italy	0	0	0	0	0	0	0
Latvia	6622	1212	1037	655	1171	1016	647
Lithuania	6306	5658	5368	4745	5656	5191	4712
Luxembourg	149	126	121	1	126	121	1
Malta							
Netherlands	4831	4356	4255	4084	4351	4240	4081
Poland	68212	33701	26465	17776	32754	25122	16995
Portugal	2730	863	591	53	801	564	50
Romania	43967	4243	3656	969	3903	3356	865
Slovakia	2600	1414	914	3	1391	706	0
Slovenia	450	3	1	0	2	1	0
Spain	3424	30	29	29	29	29	29
Sweden	28684	2170	1680	1103	2104	1607	1070
UK	9443	2757	2020	1374	2712	1939	1362
EU-27	280301	91663	70677	43296	88842	66824	41810

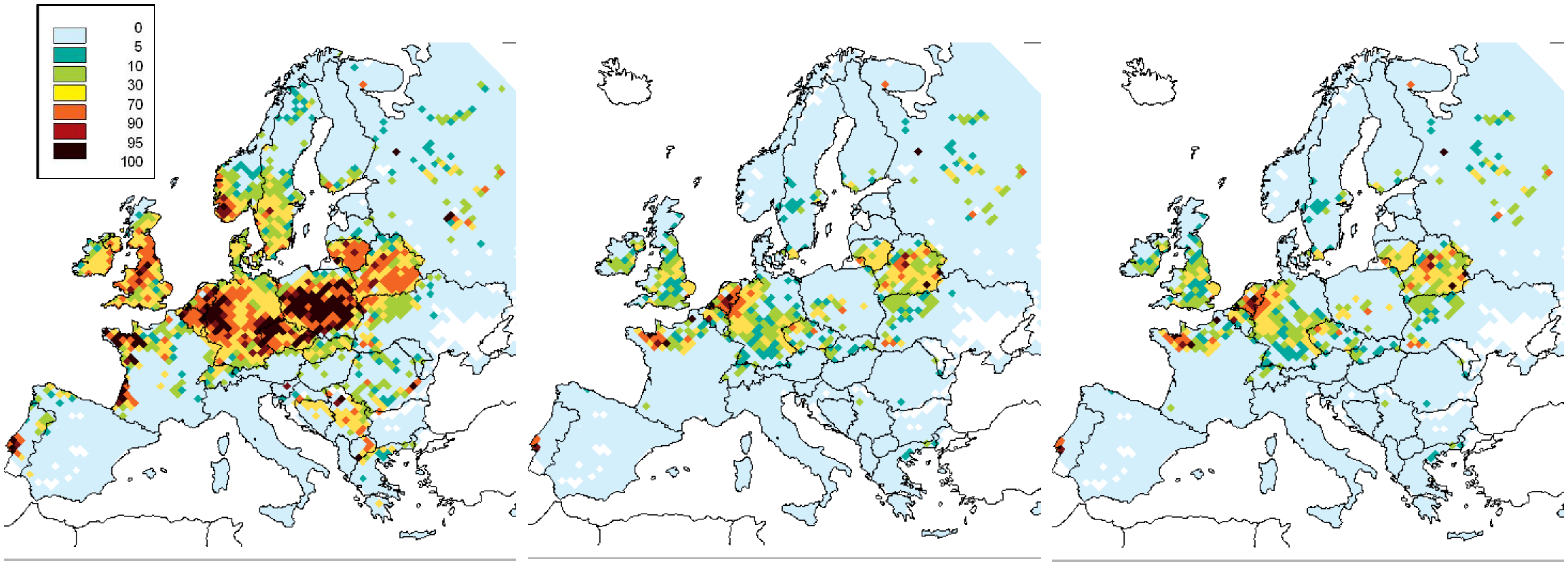

Figure 5.6: Percentage of forest area where acid deposition exceeds the critical loads for acidification in the year 2000 (left panel) and for the optimized scenarios that are reaching the TSAP targets in 2020 (middle panel: base on the NEC_PRIMES09 scenario; right panel: based on the NEC_PRIMES10 scenario).

Table 5.16 Cases of premature mortality attributable to exposure to ground-level ozone [cases per year]

	2000	2020					
		P09			P10		
		CLE	TSAP	MRR	CLE	TSAP	MRR
Austria	438	280	276	245	278	275	244
Belgium	394	337	333	296	337	334	297
Bulgaria	487	366	360	322	363	358	320
Cyprus	30	26	26	26	26	26	26
Czech Rep.	554	368	359	309	365	357	307
Denmark	173	150	148	137	150	148	136
Estonia	20	18	18	17	18	18	17
Finland	46	46	46	44	46	46	44
France	2655	1847	1815	1656	1848	1824	1664
Germany	4324	2961	2928	2620	2953	2925	2616
Greece	604	502	493	458	499	490	455
Hungary	749	511	499	435	507	497	434
Ireland	64	79	79	75	79	79	75
Italy	4787	3333	3296	3001	3316	3286	2993
Latvia	49	42	42	39	42	41	39
Lithuania	78	62	61	57	62	61	57
Luxembourg	31	22	22	19	22	22	19
Malta	24	19	19	17	19	19	17
Netherlands	418	333	330	289	333	330	289
Poland	1415	1010	990	878	1003	985	872
Portugal	495	447	435	408	445	435	406
Romania	1073	793	780	681	789	779	678
Slovakia	242	164	159	134	162	158	133
Slovenia	110	73	72	63	72	71	62
Spain	1915	1538	1495	1410	1530	1497	1406
Sweden	176	159	157	148	159	157	148
UK	1353	1665	1657	1535	1667	1660	1536
EU-27	22704	17151	16895	15319	17090	16878	15290

6 Summary

This report examines cost-effective emission ceilings for the air pollutants SO_2, NO_x, PM2.5, NH_3 and VOC that achieve in 2020 the environmental objectives of the Thematic Strategy on Air Pollution. Recognizing the crucial influence of climate and agricultural policies on the cost-effective allocation of emission control measures, the analysis adopts two energy projections from the PRIMES model that correspond to the Climate & Energy Package of the European Commission (one of them also satisfying the renewable energy target), as well as recent projections for agricultural activities from the CAPRI model as the central starting point. The baseline emission projections also reflect current air pollution control policies.

The cost-effectiveness analysis presented in this report employs targets for health and environmental indicators that correspond, as closely as technically possible, to the environmental objectives of the Thematic Strategy on Air Pollution (TSAP). The analysis adopts the environmental objectives that are expressed in the TSAP as relative improvements of impact indicators for human health and ecosystems. Thereby, the impact indicator for health effects from fine particulate matter, i.e., the number of life years lost (YOLLs) from PM2.5, should decline by 47% between 2000 and 2020. The area of ecosystems that is not protected against excess nitrogen deposition threatening biodiversity should be reduced by 43% in comparison to 2000;[1] forest area receiving unsustainable levels of acid deposition should shrink by 74%, and the cases of premature deaths attributable to the exposure to ground-level ozone should decline by at least 10% (Figure 6.1)[2].

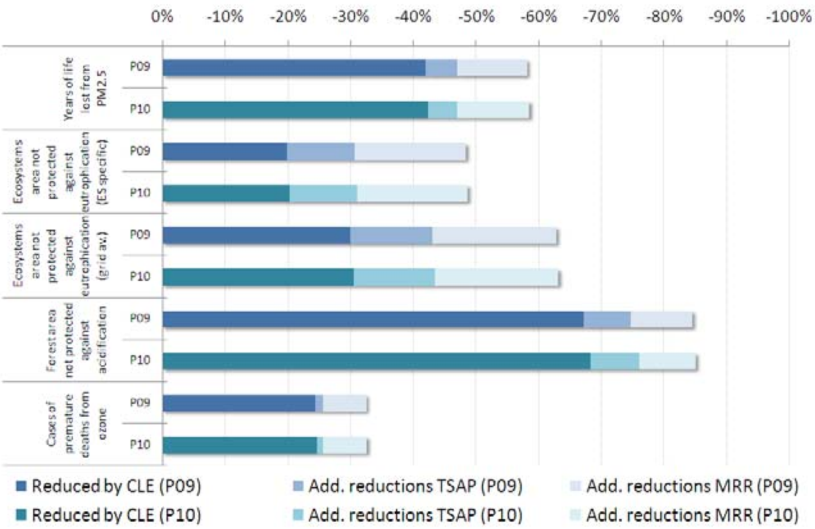

Figure 6.1 Relative changes in environmental impact indicators in the EU-27 resulting from current legislation (CLE) in 2020 and the additional reductions in line with the TSAP, as well as maximum reductions, compared to 2000

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[1] A reduction of 43% based on grid averages as they were used for CAFE translates into a reduction of 31% when ecosystem (ES) specific critical loads are being used.

[2] The Thematic Strategy on Air Pollution has specified additional targets for the protection of freshwater ecosystems against acidification and for vegetation damage from ground-level ozone. However, these targets have not been used as primary targets for the GAINS optimization, but their achievement through the optimized scenarios presented in this report has been confirmed in an ex-post analysis.

The analysis for this report converted the TSAP objectives into quantitative modelling targets for the selected impact indicators taking into account updated exogenous assumptions and methodological improvements in the model analysis. Earlier reports demonstrated that achieving the numerical TSAP objectives for eutrophication based on a more spatially (i.e., ecosystem-) specific computation of nitrogen deposition would imply significantly higher economic efforts compared to an analysis that uses the coarser spatial resolution that has been employed in the development of the original TSAP objectives. To preserve the original TSAP objectives and at the same time employ the most up-to-date scientific information, the TSAP objectives for grid average deposition have been translated into ecosystem-specific deposition data by calculating the ecosystem-specific deposition for the CAFE emission scenarios that formed the basis of the TSAP. In this way the TSAP objectives have been adjusted to the most recent critical load information, which is reflected in the current analysis.

To achieve these targets, the cost-effective portfolio would increase reduction efforts in 2020 for SO_2 emissions from 74% (75%) in the current legislation (CLE) baseline to 76% (78%) compared to 2000. (Numbers in brackets refer to the PRIMES 2010 activity projection with the target for renewable energy). Cuts in NO_x emissions would tighten slightly from 55% (56%) to 57% (58%), for PM2.5 emissions from 41% (39%) to 47% (43%), and of NH_3 emissions from 8% to 25%. VOC emissions would decline slightly, mainly as a side-effect of emission controls for other pollutants (PM, NO_x) that simultaneously reduce VOC emissions (Figure 6.2).

In 2020, these additional measures involve additional air pollution control costs for the EU-27 of €1.4 billion/yr (€1.5 billion/year). These come on top of the €89.5 billion/yr (€88.6 billion/yr) for implementing current legislation. Thus, additional costs would account for 0.010% (0.011%) of GDP in 2020. Some 75% of the additional costs emerge for the control of agricultural emissions, approximately 20% for stricter measures in the industrial sector, and less than 10% for further measures in the domestic and power sectors (Figure 6.3, right bars). Thereby, the cost-effective allocation puts more emphasis on sectors that are presently carrying a smaller share of the costs of air pollution control, and puts less burden on the sectors that are currently bearing the larger part of costs for air pollution control (Figure 6.3, left bars). Air pollution control costs in the 2010 baseline with lower GHG emissions are €968 million per year lower than in the 2009 scenario, highlighting an important co-benefit of greenhouse gas mitigation.

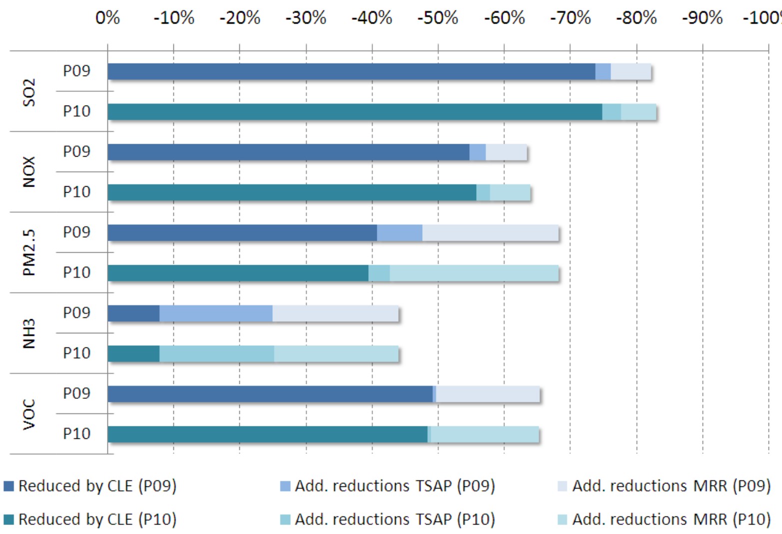

Figure 6.2 Emission reductions in the EU-27 resulting from current legislation in 2020 and additional reductions for scenarios meeting the TSAP objectives, as well as maximum reductions, in relation to 2000 levels.

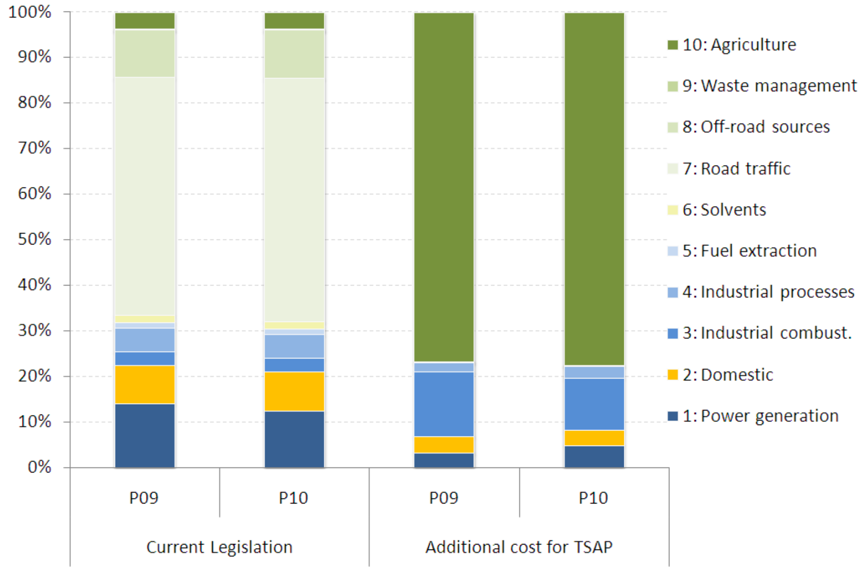

Figure 6.3 Distribution of air pollution control costs by SNAP sector in 2020 - for the Current legislation (CLE) case (left bars) and the additional costs (right bars).

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