Two Draft Baseline Scenarios for the Clean Air for Europe (CAFE) Program

First Interim Report

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European Commission
Directorate General for Environment,
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for the study on
Development of the Baseline and Policy Scenarios and
Integrated Assessment Modelling Framework for the
Clean Air for Europe (CAFE) programme – LOT 1

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1 Introduction

In its Clean Air For Europe (CAFE) program, the European Commission will explore the necessity, scope and cost-effectiveness of further action to achieve the long-term environmental policy objectives for air quality of the European Union. A central step in this analysis is the assessment of the likely future baseline development of air quality as it can be expected to evolve from the envisaged evolution of anthropogenic activities taking into account the effects of the presently decided legislation on emission controls.

This First Interim Report presents the initial results of such a baseline assessment. The analysis combines recent information on expected trends in energy consumption, transport, industrial and agricultural activities with validated databases describing the present structure and technical features of the various emissions sources in all 25 Member States of the European Union. It considers the penetration of already decided emission control legislation in the various Member States in the coming years and thereby outlines a likely range for the future emissions of air pollutants up to 2020. In a further step, the analysis sketches the resulting evolution of air quality in Europe and quantifies the consequences on the effects of air pollution on human health and vegetation using a range of indicators.

This report presents the general assumptions and findings of the analysis conducted to date. It restricts itself to the presentation of aggregated results for two groups of countries, i.e., the EU-15 and the New Member States. Obviously, all calculations are carried out at a national and sectoral level, and consequently all assumptions and results are available for each Member State of the European Union. It is, however, beyond the scope of this report to present this detailed information. Instead, the interested reader is invited to explore detailed results with the Internet version of the RAINS model, which can be freely accessed at http://www.iiasa.ac.at/web-apps/tap/RainsWeb/.

2 Methodology

2.1 The RAINS model

The analysis builds on the Regional Air Pollution Information and Simulation (RAINS) model, which describes the pathways of pollution from its anthropogenic driving forces to the various environmental impacts. In doing so, the model compiles for all European countries databases with the essential information on all aspects listed above and links this data in such a way that the implications of alternative assumptions on economic development and emission control strategies can be assessed.

The RAINS model developed by the International Institute for Applied Systems Analysis (IIASA) combines information on economic and energy development, emission control potentials and costs, atmospheric dispersion characteristics and environmental sensitivities towards air pollution (Schöpp *et al.*, 1999). The model addresses threats to human health posed by fine particulates and ground-level ozone as well as risk of ecosystems damage from acidification, excess nitrogen deposition (eutrophication) and exposure to elevated ambient levels of ozone. These air pollution related problems are considered in a multi-pollutant context (Figure 2.1), quantifying the contributions of sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3), non-methane volatile organic compounds (VOC), and primary emissions of fine (PM2.5) and coarse (PM10-PM2.5) particles (Table 2.1). The RAINS model also includes estimates of emissions of relevant greenhouse gases such as carbon dioxide (CO_2) and nitrous oxide (N_2O). Work is progressing to include methane (CH_4) as another direct greenhouse gas as well as carbon monoxide (CO) and black carbon (BC) into the model framework.

Table 2.1: Multi-pollutant/multi-effect approach of the RAINS model.

	Primary PM	SO_2	NO_x	VOC	NH_3
Health impacts:					
- PM	√	√	√	√	√
- O_3			√	√	
Vegetation impacts:					
- O_3			√	√	
- Acidification		√	√		√
- Eutrophication			√		√

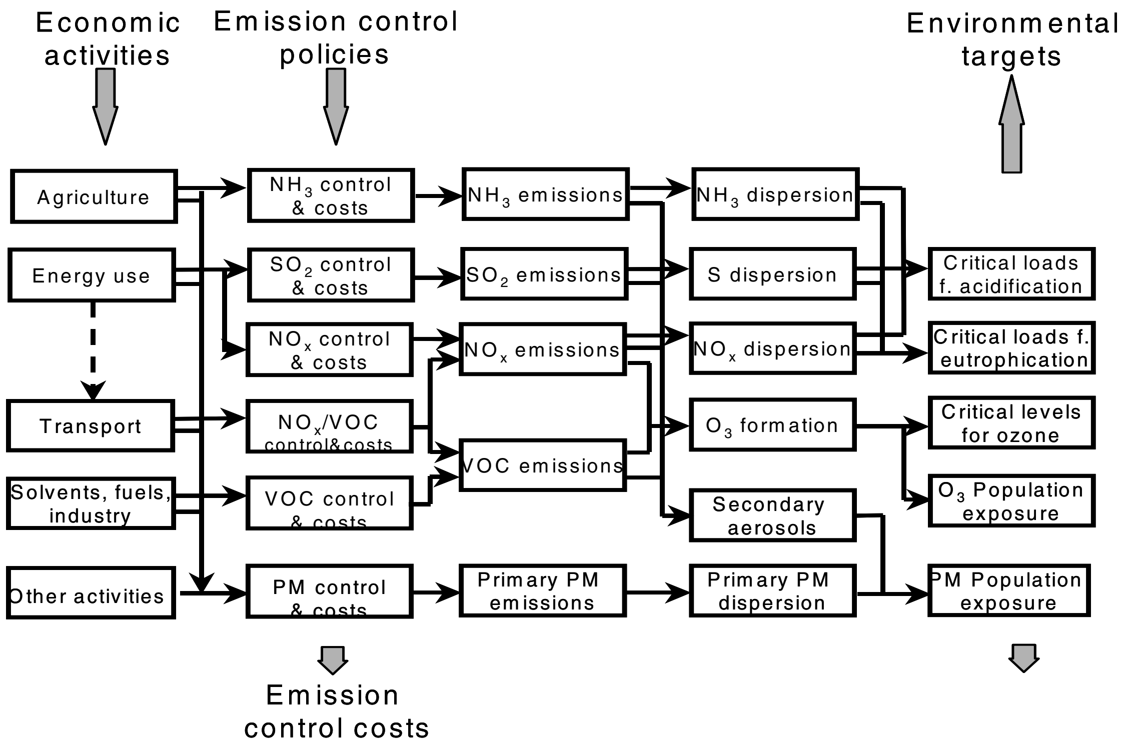


Figure 2.1: Flow of information in the RAINS model.

A detailed description of the RAINS model, on-line access to certain model parts as well as all input data to the model can be found on the Internet (http://www.iiasa.ac.at/rains).

The RAINS model and its scientific basis are presently being reviewed by a team of experts to judge the scientific credibility of the model approach. The review team is expected to present its finding in the course of 2004.

2.2 Scenario analysis and optimisation

The RAINS model framework makes it possible to estimate, for a given energy- and agricultural scenario, the costs and environmental effects of user-specified emission control policies (the "scenario analysis" mode), see Figure 2.2. Furthermore, an optimisation mode can be used to identify the cost-minimal combination of emission controls meeting user-supplied air quality targets, taking into account regional differences in emission control costs and atmospheric dispersion characteristics. The optimisation capability of RAINS enables the development of multi-pollutant, multi-effect pollution control strategies. In particular, the optimisation can be used to search for cost-minimal balances of controls of the six pollutants (SO_2, NO_x, VOC, NH_3, primary $PM_{2,5}$, primary $PM_{10-2.5}$ (= PM coarse)) over the various economic sectors in all European countries that simultaneously achieve user-specified targets for human health impacts (e.g., expressed in terms of reduced life expectancy), ecosystems protection (e.g., expressed in terms of excess acid and nitrogen deposition), and violations of WHO guideline values for ground-level ozone (Figure 2.2).

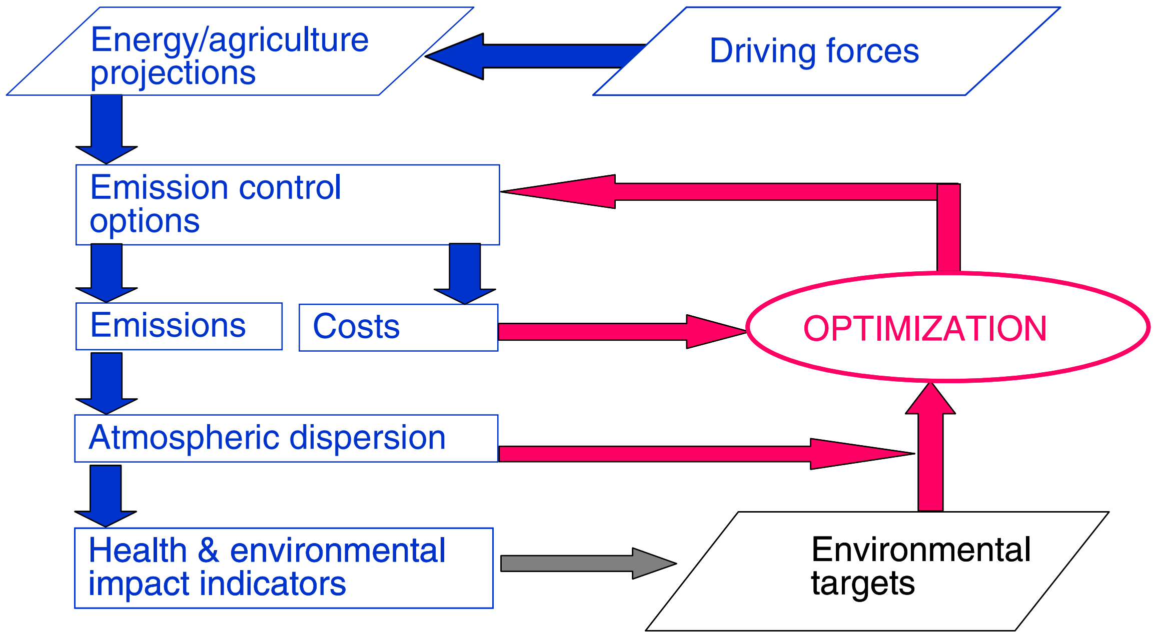


Figure 2.2: The iterative concept of the RAINS optimisation.

2.3 Preparation and review of the RAINS databases

From October 2003 to March 2004, the databases of the RAINS model that describe the national situations in terms of driving forces, energy consumption, agricultural activities, emission source structures and emission control potentials have been reviewed by national experts. IIASA hosted a series of bilateral consultations with experts from Member States and industrial stakeholders to examine the draft RAINS databases and improve them to reflect to the maximum possible extent the country-specific conditions as seen by the various experts without compromising international consistency and comparability (Table 2.2).

These consultations reviewed the energy projections produced by the PRIMES model for each country and identified

- discrepancies in the base year 2000 energy statistics between the energy balances published by EUROSTAT in 2002 (as have been used for the PRIMES analysis) and revised information provided by the Member States to EUROSTAT after this date,
- factual discrepancies between the energy projections produced by the PRIMES model and recent national energy policies,
- and different opinions on the future energy development (e.g., sectoral growth rates, development of energy prices, potential change in national energy policies, etc.).

Comments provided by national experts were communicated to the PRIMES modelling team and will be used to develop a revised PRIMES energy scenario. In addition, the discussions screened the RAINS databases on emissions and penetration of emission control measures, addressing

- discrepancies between national year 2000 emission inventories reported by Member States to the Convention on Long-range Transboundary Air Pollution and the RAINS calculations,
- the envisaged penetration of new emission control legislation in each country, and
- the country-specific potential for applying further emission control measures.

These consultations generated a wealth of well-documented new information, which helped to revise the RAINS databases so that national emission inventories can now be better reproduced relying on national information while maintaining international consistency and comparability of the assessment.

However, due to the tight time table of the CAFE program, there was insufficient time available for many national experts to produce all revised information before the deadlines for the analysis. Thus, some information provided by national experts after the deadlines could not yet be incorporated into the databases of the RAINS model. For the same reasons, it was not possible for the RAINS team to reconfirm their interpretation of received national information with the national experts. Therefore, **all analysis presented in this First Interim Report has to be considered as provisional,** pending the full implementation of all provided information and confirmation of the revised databases by national experts. Equally, it was not yet possible to implement the national energy and agricultural projections received from Member States for this First Interim Report. According to the work plan of CAFE, it is envisaged to complete these outstanding tasks by June.

Table 2.2: Bilateral consultations between IIASA and experts from Member States and industrial stakeholders on the RAINS databases.

Country or organization	*Meeting date*	*No of experts*	*Comments on RAINS databases*	*Comments on PRIMES*	*National scenario Energy*	*National scenario Agri-culture*
Denmark	-	-	16/1/04	-	Y	Y
Latvia	-	-	08/10/03	-	-	Y
EUROPIA	2-3/10/03	2	05/12/03 –23/3/04	-		
EURELECTRIC	30-31/10/03	4	-	-		
Hungary	14/11/03	1	-	-	-	-
Germany	20-21/11/03	4	19/12/03 – 23/3/04	Y	-	-
Czech Republic	25/11/03	3	19/12/03 – 7/4/04	Y	-	Y
ACEA	12/12/03	10	-	-		
Italy	15-16/12/03	2	19/1/04 – 2/4/04	Y	Y	-
France	8-9/1/04	5	31/3/04 – 15/4/04	Y	Y	-
Sweden	22-23/11/04	3	29/1/04 – 4/4/04	Y	Y	Y
UK	26-28/1/04	8	19/2/03 – 6/4/04	Y	-	Y
Spain	4-5/2/04	5	30/3/04 – 13/4/04	Y	-	-
Portugal	12-13/2/04	5	27/2/04 – 8/4/04	Y	Y	Y
Belgium	16-17/2/04	7	08/3/04 – 6/4/04	Y	Y	-
Austria	23/2/04	11	24/2/04 – 19/4/04	-	-	Y
Ireland	4-5,19/3/04	2	12 – 19/3/04	Y	-	Y
ESVOC	8/3/04	3	-	-	-	
Finland	8-9/3/04	3	19/03/04 – 19/4/04	Y	(Y)	-
Lithuania	10/3/04	2	24/4/04	Y	-	-
Estonia	12/3/04	2	17/3/04	-	-	-
Slovakia	15/3/04	3	22/3/04	Y	-	-
Poland	17-18/3/04	2	17/3/04 – 07/4/04	-	-	-
Slovenia	22/3/04	2	24/3/04 – 8/4/04	-	Y	Y
Netherlands	25-26/3/04	4	16/3/04 – 18/04/04	Y	-	Y
19 + 4		**94**	**21**	**14**	**7**	**10**

3 Energy projections

Recognizing the inherent uncertainties in the predictions of some of the drivers that influence future emissions (e.g., economic development, energy prices, policy preferences, etc.), CAFE will accept a range of baseline projections that reflects a plausible range of future development. The policy debate will then focus on environmental targets that lead to further improvements of air quality and will explore the implications of alternative baseline projections on achieving these targets. Thus, there is no need to reach full consensus of all stakeholders on all assumptions of each baseline projection, as long as overall plausibility and consistency is maintained.

In practice, CAFE will use four baseline scenarios on energy development:

- A Europe-wide consistent view of energy development with certain assumptions on climate policies (as produced by the PRIMES energy model).
- As a variant, a Europe-wide consistent view of energy development without climate policies. For this purpose, CAFE employs the Energy and Transport Trends for 2030 of DG Transport and Energy.
- A compilation of official national projections of energy development with climate policies that reflect the perspectives of the individual governments of Member States. By their nature, there will be no guarantee for international consistency in the main assumptions across countries (e.g., economic development, energy prices, use of flexible mechanisms for the Kyoto Protocol, assumptions on post-Kyoto regimes, etc.).
- A revised version of the PRIMES projection with certain assumptions on climate policies, which maintains Europe-wide consistency in important features (e.g., assumptions on energy prices, electricity imports and exports, etc.) while incorporating to the maximum possible extent national perspectives.

For agriculture, CAFE will use

- a set of Europe-wide consistent projections of agricultural activities without CAP reform, and
- a compilation of national projections of activities supplied by Member States.
- In addition, it is foreseen that a 'CAP reform' projection will be made available by DG Agriculture once the policy plans are agreed.

As of now, the analysis incorporates the two PRIMES energy baseline projections (with and without further climate measures) and the pre-CAP reform agricultural scenario. The other scenarios will be included in the RAINS databases in the coming months, so that in summer 2004 the full range of baseline projections will be available for analysis within the CAFE program.

3.1 The baseline projection without further climate measures

The analysis adopts the baseline energy projection of the 'European energy and transport – Trends to 2030' outlook of the Directorate General for Energy and Transport of the European Commission (CEC, 2003) as a starting point. This projection does not assume any further climate measures beyond those already adopted in 2002.

Even in absence of further policies to curb CO_2 emissions, the projection expects production of fossil primary energy within the EU to continue to decline throughout the period to 2020, after peaking in the period 2000-2005. Renewable sources of energy are likely to receive a significant boost as a result of policy and technology progress. Despite the evidence of some saturation for some energy uses in the EU, energy demand is expected to continue to grow throughout the outlook period though at rates significantly smaller than in history.

The EU energy system remains dominated by fossil fuels over the next 25 years and their share rises marginally from its level of just under 80 percent in 1995. The use of solid fuels is expected to continue to decline until 2010 both in absolute terms and as a proportion of total energy demand. Beyond 2015, however, due to the power generation problems that will ensue from the decommissioning of a number of nuclear plants, and the partial loss of competitiveness of gas based generation due to higher natural gas import prices, the demand for solid fuels is projected to increase modestly. Spurred by its very rapid penetration in new power generation plant and co-generation, gas is by far the fastest growing primary fuel. Its share in primary energy consumption is projected to increase from 20 percent in 1995 to 26 percent in 2010. The share of oil in primary consumption is projected to be relatively stable over the period to 2020.

Under baseline assumptions, the technology of electricity and steam generation improves leading to higher thermal efficiency, lower capital costs and greater market availability of new generation technologies. The assumed improvement, however, is not spectacular and no technological breakthrough occurs during the projection period in the baseline scenario. The use of electricity is expected to expand by 1.7 percent per year over the projection period and its growth is expected to be especially rapid in the tertiary and in the transportation sector. Total power capacity requirements for the EU increase by some 300 GW in the 1995-2020 period and a similar amount of new capacity will be required for the replacement of decommissioned plants. Thus the EU is projected to build 594 GW of new plants over 1995-2020 in order to cover its growing needs and replace the decommissioned plants.

The use of traditional coal and oil plants is expected to decline very rapidly. Due to the decommissioning of older plants, there is a modest decline in the capacity of nuclear plants while nearly half of the thermal plant currently utilised by independent producers is also expected to be scrapped. These declines in capacity are more than made up from the dramatic increase in gas turbine combine cycle plants and small gas turbines. These increase by nearly 10 times over the projection period to exceed 380 GW or almost 45 percent of the total installed capacity by 2020.

The rising share of fossil fuels will lead to an increase in the carbon intensity of the EU energy system. Together with the modest increase in energy demand, this will lead to an increase in CO_2 by 16 percent in the 1995-2020 period. In absolute terms, the increase in emissions originated from combustion of natural gas more than make up for the sharp decline

in emissions resulting from the decline in the use of solid fuels. Energy intensity improvements act in favour of moderating the rise of CO_2 emissions, but the overall carbon intensity does not improve.

3.2 The energy projection with further climate measures

The projection of the implication of further climate measures attempts to quantify how the decarbonisation of the energy system would take place due to climate policies. Based on the guidance received from DG ENV's Climate Change unit, without prejudging the actual implementation of the Kyoto agreement and of possible post-Kyoto regimes, the "with climate policies" scenario assumes for 2010 for all energy consumers a revenue-neutral "shadow price" of € 12 per tonne of CO_2. It is thus implicitly assumed that any measures having a compliance cost higher than this will not be undertaken by the EU's energy system, but that other sectors (e.g., non-CO_2 greenhouse gases emitting sectors) would reduce their emissions, or that flexible instruments in the Kyoto Protocol would be used. In addition, the possibility of using carbon sinks would add to the flexibility. Concerning "post-Kyoto", it was assumed that the "shadow price" of carbon dioxide would increase linearly to € 20 per tonne of CO_2 in 2020. Thus, in 2015, the "shadow price" is assumed to be € 16 per tonne of CO_2. The key assumptions made for the modelling exercise are available on the CIRCA web site.

Table 3.1: Energy consumption by fuel for the EU-15 (PJ).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	1733	1571	1325	1439	1305	914	722
Hard coal	5544	4012	3791	4727	3619	3027	2910
Other solids	3242	3583	3672	3723	3661	3968	4253
Heavy fuel oil	4785	3712	3541	3296	3569	3461	3231
Middle distillates	9737	10748	11302	11755	10630	11109	11472
Gasoline	9611	9918	9896	10005	9786	9670	9704
Natural gas	16015	20792	22612	23878	20615	22317	24208
Hydrogen	0	3	8	19	3	8	19
Renewable	213	782	921	1039	824	979	1203
Hydropower	1009	1028	1062	1086	1181	1219	1243
Nuclear	9328	9642	9398	8318	9642	9415	8200
Total EU-15	61218	65791	67527	69285	64836	66087	67166

Table 3.2: Energy consumption by fuel for the New Member States (PJ).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	843	749	581	532	694	532	483
Hard coal	2521	2174	2268	2292	1929	1863	1476
Other solids	500	465	455	441	530	500	492
Heavy fuel oil	570	548	545	533	551	537	529
Middle distillates	678	842	918	977	836	900	962
Gasoline	749	929	1031	1126	927	1022	1108
Natural gas	1841	2316	2707	3033	2341	2785	3346
Hydrogen	0	0	1	1	0	1	1
Renewable	2	36	65	99	38	70	108
Hydropower	57	84	88	89	85	89	92
Nuclear	620	626	622	621	626	625	626
Total NMS	8381	10778	11296	11765	8557	8923	9224

Table 3.3: Energy consumption by sector for the EU-15 (PJ).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	12421	14224	15040	16712	13834	14480	15726
Industry	15499	16151	16720	17228	16086	16519	16932
Households	15086	16832	17465	18040	16556	17070	17586
Transport	13652	15720	16313	17164	15584	16026	16730
Non-energy use	3982	4325	4472	4542	4334	4482	4548
Total EU-15	60640	67252	70010	73685	66395	68577	71521

Table 3.4: Energy consumption by sector for the New Member States (PJ).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	3185	3351	3578	3749	3213	3353	3399
Industry	2544	2321	2382	2452	2293	2332	2398
Households	2220	2511	2739	2954	2457	2641	2842
Transport	1088	1380	1540	1695	1377	1526	1664
Non-energy use	437	460	505	541	461	506	543
Total	9475	10022	10744	11391	9802	10357	10846

Table 3.5: Total primary energy consumption (on TPES basis, PJ/year) for the two PRIMES scenarios.

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	964	1070	1111	1175	1205	1235	1284
Belgium	2165	2239	2301	2317	2202	2245	2228
Denmark	821	811	823	850	798	810	829
Finland	1323	1502	1514	1531	1475	1494	1498
France	10645	11817	12266	12678	11606	12020	12282
Germany	13153	13479	13335	13233	13202	12908	12629
Greece	1187	1491	1580	1644	1441	1515	1566
Ireland	574	716	748	785	703	730	761
Italy	6901	7174	7337	7502	7020	7167	7269
Luxembourg	131	180	187	197	177	181	188
Netherlands	2716	2919	3012	3131	2849	2916	3021
Portugal	967	1144	1256	1374	1124	1225	1332
Spain	4649	5541	5942	6243	5484	5797	6064
Sweden	1960	2197	2214	2228	2176	2174	2156
UK	9079	9185	9427	9854	9039	9186	9511
Total EU-15	57236	61466	63055	64743	60501	61605	62618
Cyprus	96	116	125	135	114	122	131
Czech Republic	1633	1646	1677	1683	1617	1630	1587
Estonia	184	192	193	187	183	185	172
Hungary	971	1050	1079	1106	1024	1035	1061
Latvia	127	154	168	179	151	161	168
Lithuania	277	264	302	336	260	291	320
Malta	37	48	52	53	46	49	48
Poland	3643	3878	4166	4458	3761	3972	4191
Slovakia	708	659	707	752	640	671	703
Slovenia	267	301	306	313	299	300	300
Total NMS	7944	8308	8775	9203	8096	8417	8681
Total EU-25	65180	69773	71830	73946	68598	70022	71299

Table 3.6: Total national CO_2 emissions for the two PRIMES scenarios. RAINS calculations including CO_2 emissions from non-energy use of fuels and cement and lime production, in Mt CO_2. Consequently, these numbers are higher than the energy–related CO_2 emissions calculated by the PRIMES model.

		No further climate measures		*With further climate measures*	
	2000	*2010*	*2020*	*2010*	*2020*
Austria	63	67	73	64	67
Belgium	125	125	137	121	128
Denmark	55	49	48	48	45
Finland	68	68	73	64	65
France	413	447	491	428	455
Germany	904	945	1003	903	870
Greece	97	118	126	112	117
Ireland	43	50	53	49	51
Italy	467	468	486	456	460
Luxembourg	9	13	14	12	13
Netherlands	180	189	201	183	191
Portugal	70	79	93	77	87
Spain	302	329	370	319	344
Sweden	70	79	94	77	87
UK	567	541	587	531	542
Total EU-15	3433	3568	3848	3444	3523
Cyprus	8	9	10	9	10
Czech Republic	123	104	104	100	89
Estonia	15	16	15	16	12
Hungary	59	64	71	62	64
Latvia	7	9	11	8	9
Lithuania	12	17	22	17	20
Malta	3	4	4	3	3
Poland	313	321	352	307	331
Slovakia	40	41	49	39	43
Slovenia	15	17	18	17	15
Total NMS	594	603	656	578	597
Total EU-25	4027	4171	4505	4022	4120

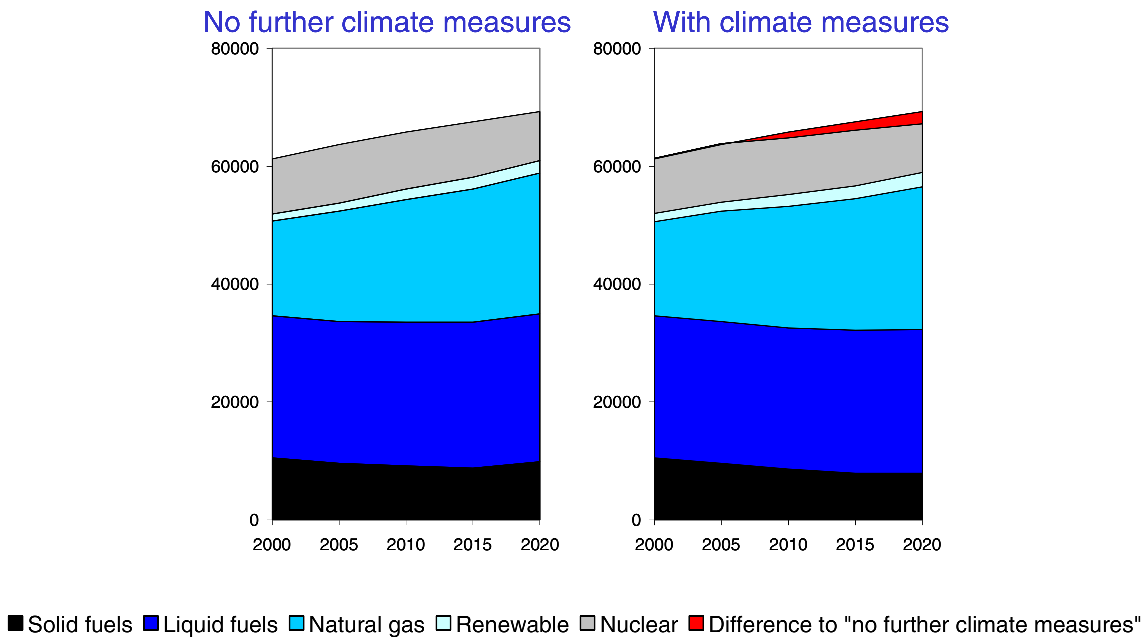


Figure 3.1: Energy use by fuel for the EU-15 (in PJ/year).

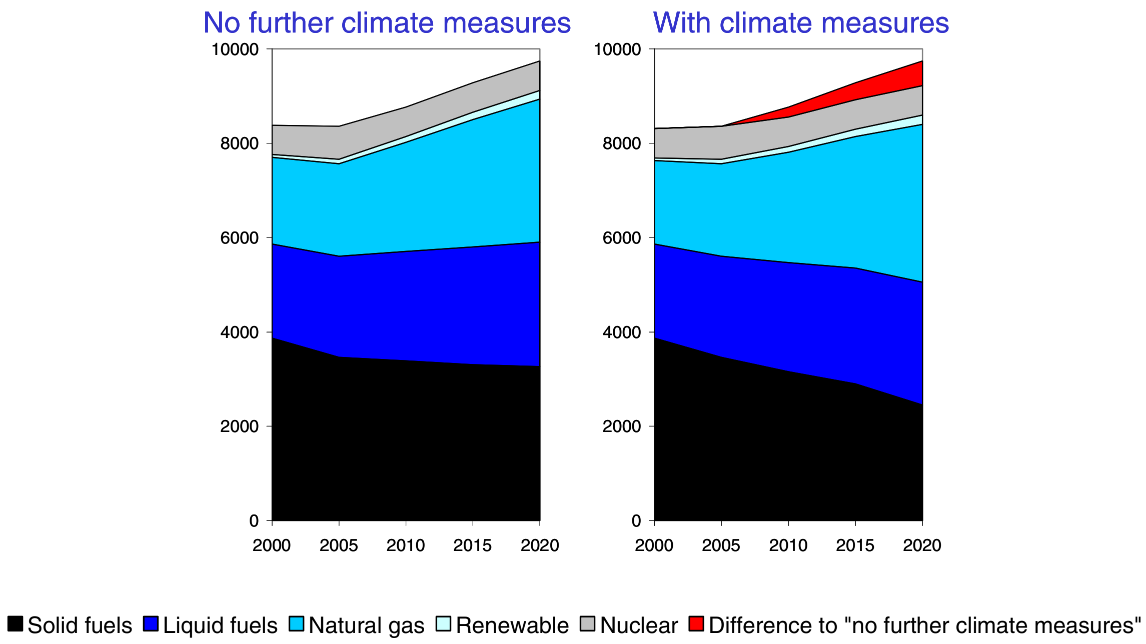


Figure 3.2: Energy use by fuel for the New Member States (in PJ/year).

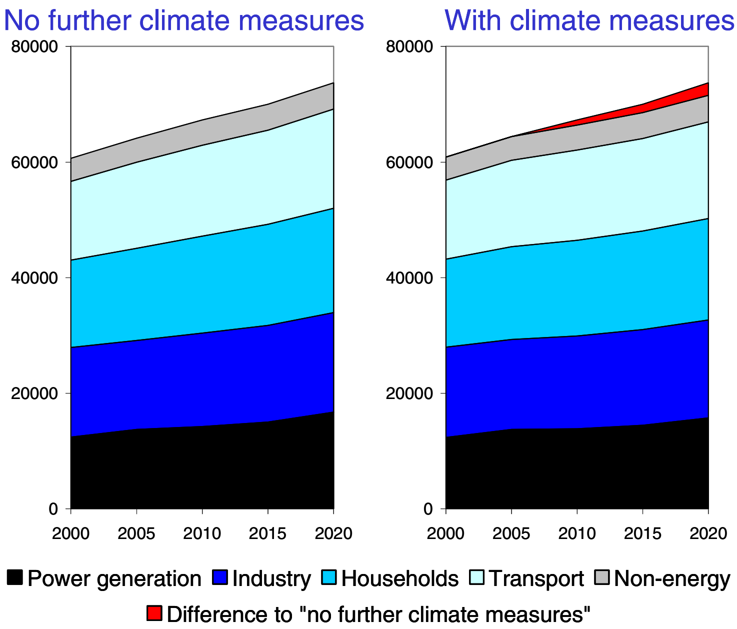


Figure 3.3: Energy use by sector for the EU-15 (in PJ/year).

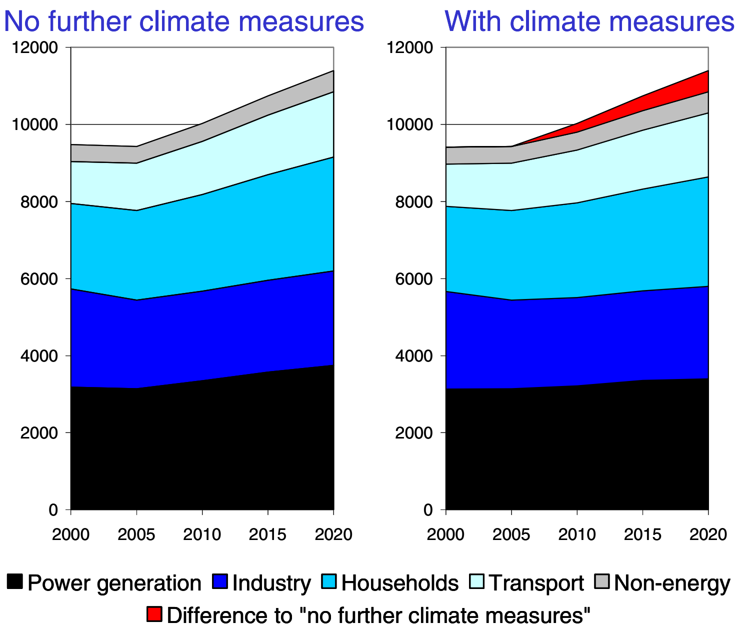


Figure 3.4: Energy use by sector for the New Member States (in PJ/year).

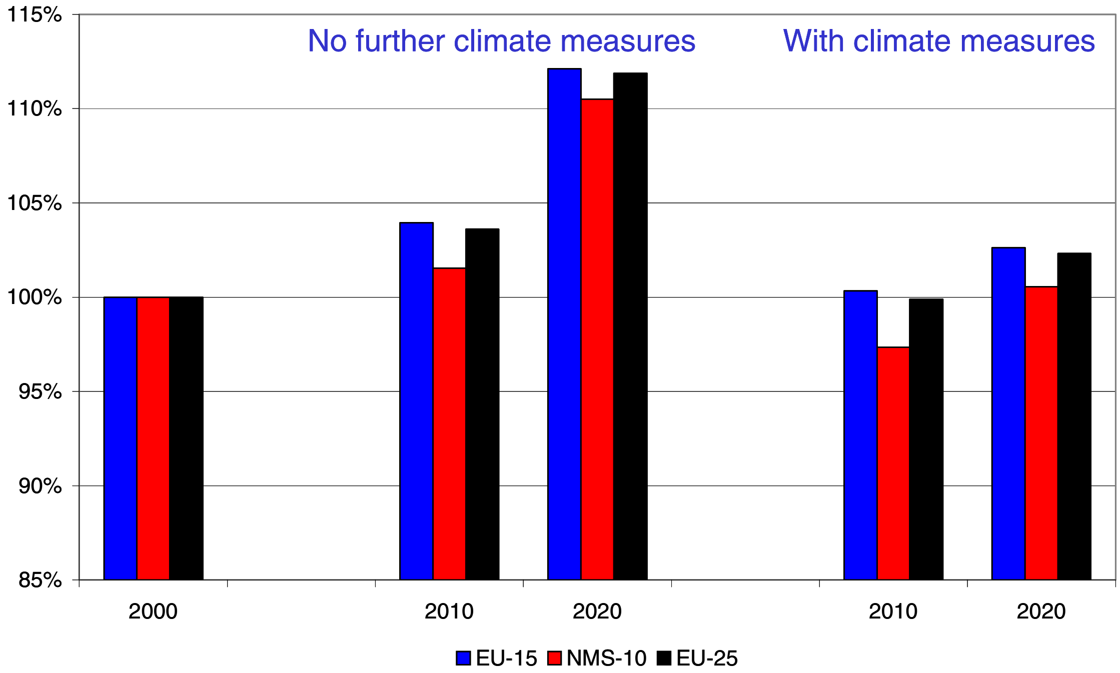


Figure 3.5: CO_2 emissions of the two baseline energy projections, relative to 2000.

4 Emission projections

4.1 Sulfur dioxide

4.1.1 Base year emissions

With improved information on country-specific data received during the bilateral consultations, the RAINS model reproduces national emission estimates for SO_2 with only minor discrepancies, basing its calculations on reported activity levels (energy consumption, agricultural activities), country-specific emission factors and application rates of emission control measures (Figure 4.1, Table 4.7). For the EU-15, the RAINS estimate deviates by 0.3 percent, and for the New Member States by 0.8 percent.

Important discrepancies remain for Greece and Luxembourg, where the RAINS model estimates higher emissions than the national reports, and for Portugal and Slovakia, where RAINS estimates are lower than the numbers given in the official inventories. For Luxembourg, the larger RAINS estimate is a consequence of the fact that RAINS calculates emissions for all fuel sold in a country, while the numbers reported by Luxembourg refer only the fuel consumed within the country. For the other countries, resolution of the discrepancies requires further national information, especially if countries reported different emission figures to different organizations over time.

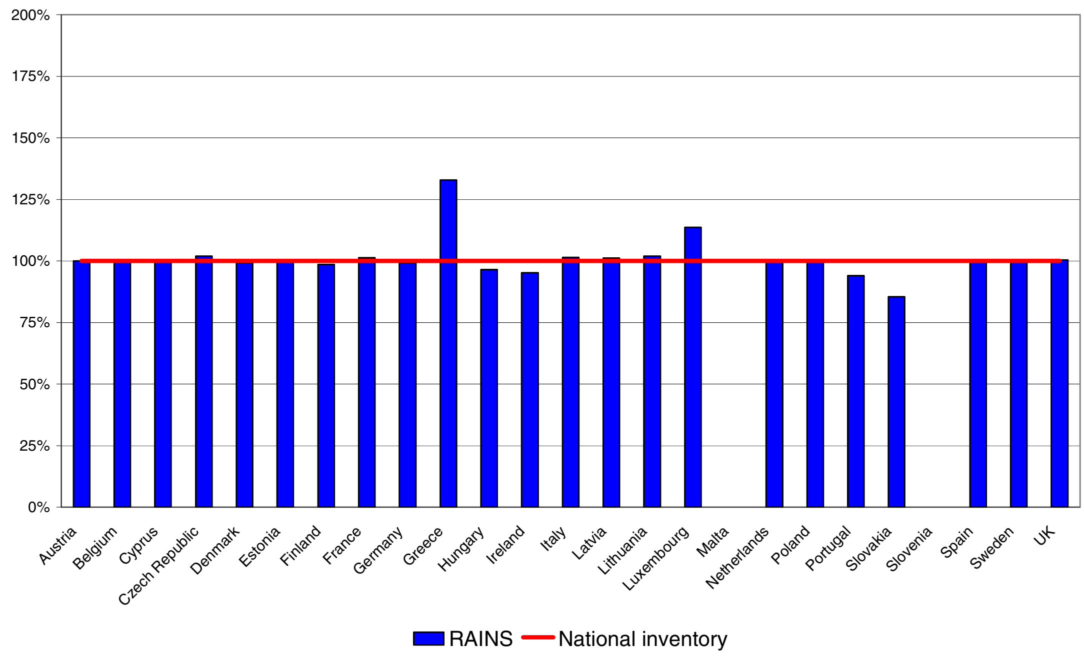


Figure 4.1: Comparison of national emission inventories for SO_2 with the RAINS estimates (for the year 2000).

4.1.2 Future development

Based on the representation of the base year inventory, the RAINS model projects the future fate of emissions based on the changes in the volumes of emission generative activities (as given, e.g., by the PRIMES energy projection) and the penetration of emission control legislation. For SO_2, the baseline scenario assumes EU legislation listed in Table 4.1 as well as stricter national legislation, if applicable. However, these projections do not consider caps on total national emissions imposed by the National Emission Ceilings directive, but explore only source-specific emission control legislation. Thus, further measures that could possibly be under considerations in individual countries in order to meet emission ceilings, but which are not yet laid down in legislation, are excluded from consideration.

Table 4.1: Legislation on SO_2 emissions considered for the CAFE baseline scenarios.

Large Combustion Plant Directive
S Content of Liquid Fuels Directive
Directives on quality of petrol and diesel fuels
IPPC legislation on process sources
National legislation and national practices (if stricter)

The baseline projections suggest SO_2 emissions to significantly decrease in the future. Compared to the year 2000, SO_2 emissions in the EU-15 are expected to decline by 55 percent in 2010 and by 63 percent in 2020 for the "no further climate measures" scenario. CO_2 reducing measures in the "with climate measures" scenario would increase the SO_2 reduction in 2010 to 58 percent and in 2020 to 66 percent. In both cases, largest reductions result for coal combustion, partly due to the decline in coal consumption (for 2020 -16 percent for the "no further climate measures scenario, -50 percent for the climate scenario compared to 2000), and partly due to full implementation of the large combustion plant directive. For the New Member States, SO_2 emissions are calculated to decline in 2010 by 40 percent and in 2020 by 63 percent in the "no further climate measures" case and up to 70 percent in 2020 for the climate case.

The draft SO_2 emission projections for 2010 are in many cases lower than the ceilings laid down in the National Emission Ceilings Directive (Table 4.7). For the EU-15, total SO_2 emissions are computed to under-run the collective ceiling between 22 and 25 percent. With the present data in the RAINS database and based on the PRIMES energy projections, a need for stricter control measures seem to emerge only for the Netherlands, while the SO_2 emissions from many other countries are expected to be between 20 and 70 percent below the ceiling. For the New Member States, overall SO_2 emissions in 2010 are calculated 40 percent below the emission ceiling, with only Malta exceeding the ceiling.

Table 4.2: SO_2 emissions by fuel type for the EU-15 (kt SO_2).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	714	162	139	116	136	99	64
Hard coal	1904	559	410	274	497	319	176
Other solids	216	177	179	179	181	193	204
Heavy fuel oil	1875	772	717	637	733	698	617
Middle distillates	361	163	165	165	161	163	162
Gasoline	30	20	20	21	19	19	20
Natural gas	19	18	18	18	17	18	18
Process emissions	851	781	770	780	771	758	768
Total	5969	2652	2418	2190	2516	2267	2028

Table 4.3: SO_2 emissions by fuel type for the New Member States (kt SO_2).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	942	530	326	213	473	244	170
Hard coal	1131	726	600	466	649	498	331
Other solids	45	30	26	23	33	28	26
Heavy fuel oil	333	179	163	131	178	159	129
Middle distillates	71	11	11	11	11	11	11
Gasoline	11	1	1	1	1	1	1
Natural gas	0	0	0	0	0	0	0
Process emissions	167	150	153	158	148	151	155
Total	2700	1627	1280	1002	1492	1091	823

Table 4.4: SO_2 emissions by sector for the EU-15 (kt SO_2).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	3284	930	750	550	836	659	449
Industry	1233	661	639	611	635	597	570
Households	390	185	163	151	181	158	145
Transport	322	200	202	204	199	201	203
Process emissions	740	675	664	674	665	652	661
Total	5969	2652	2418	2190	2516	2267	2028

Table 4.5: SO_2 emissions by sector for the New Member States (kt SO_2).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	1777	1054	737	495	941	582	349
Industry	402	278	286	280	266	266	256
Households	290	141	100	67	134	90	60
Transport	63	4	3	3	4	3	3
Process emissions	167	150	153	158	148	151	155
Total	2700	1627	1280	1002	1492	1091	823

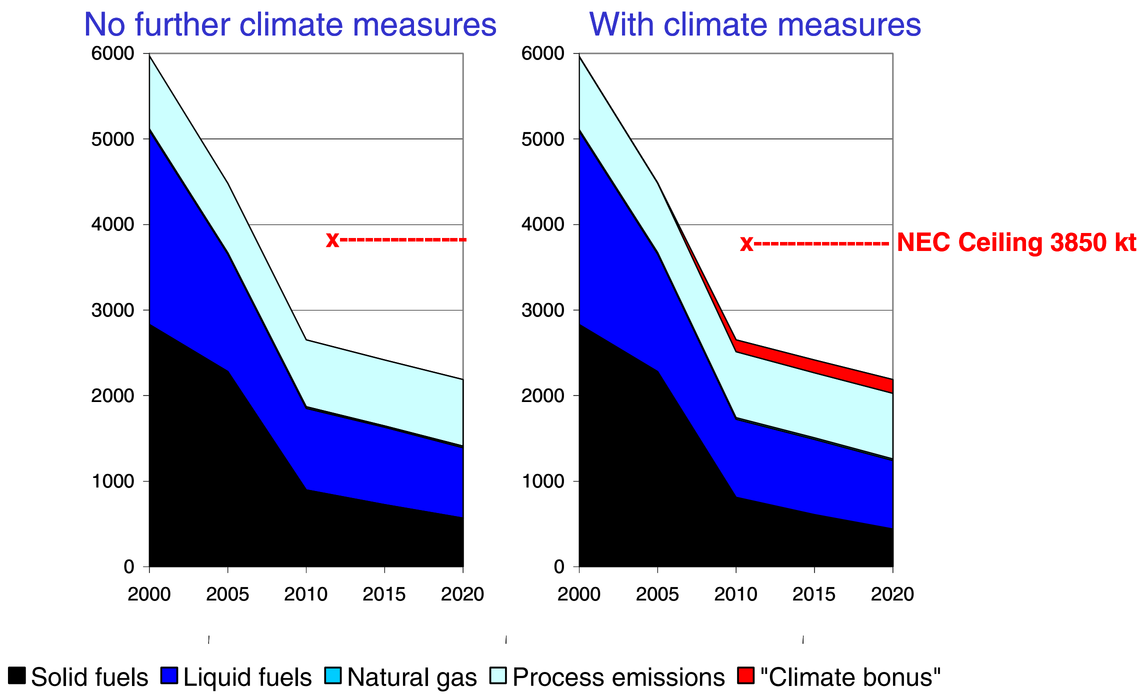


Figure 4.2: SO_2 emissions by fuel for the EU-15 (in kt).

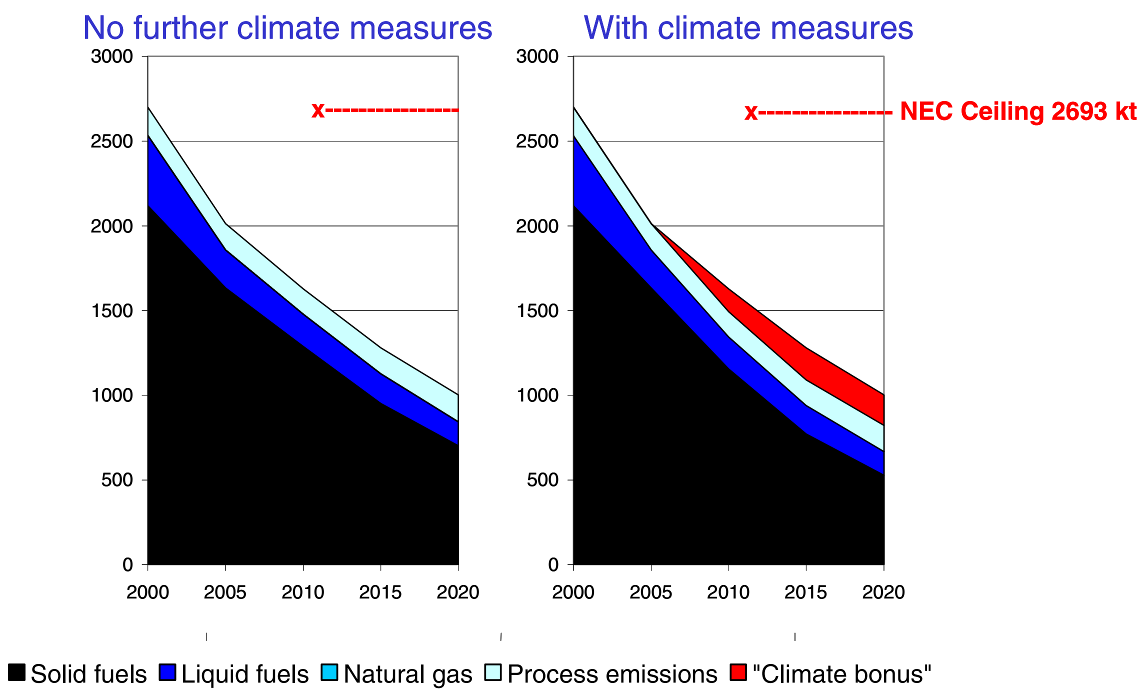


Figure 4.3: SO_2 emissions by fuel for the New Member States (in kt).

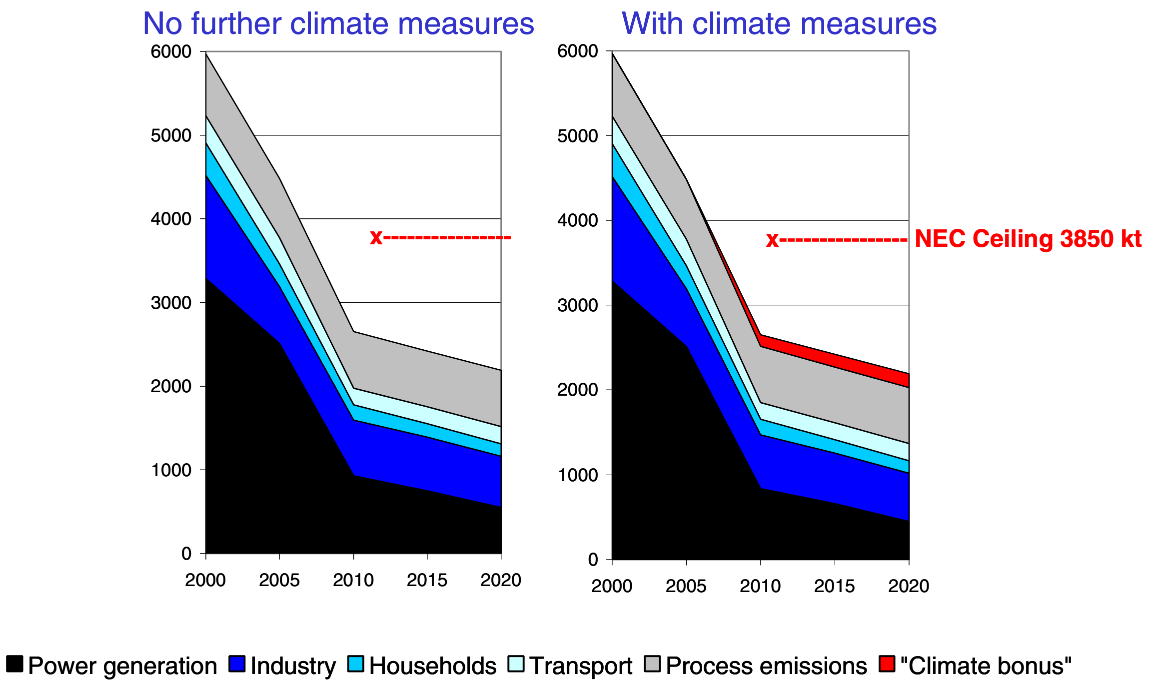


Figure 4.4: SO_2 emissions by sector for the EU-15 (in kt).

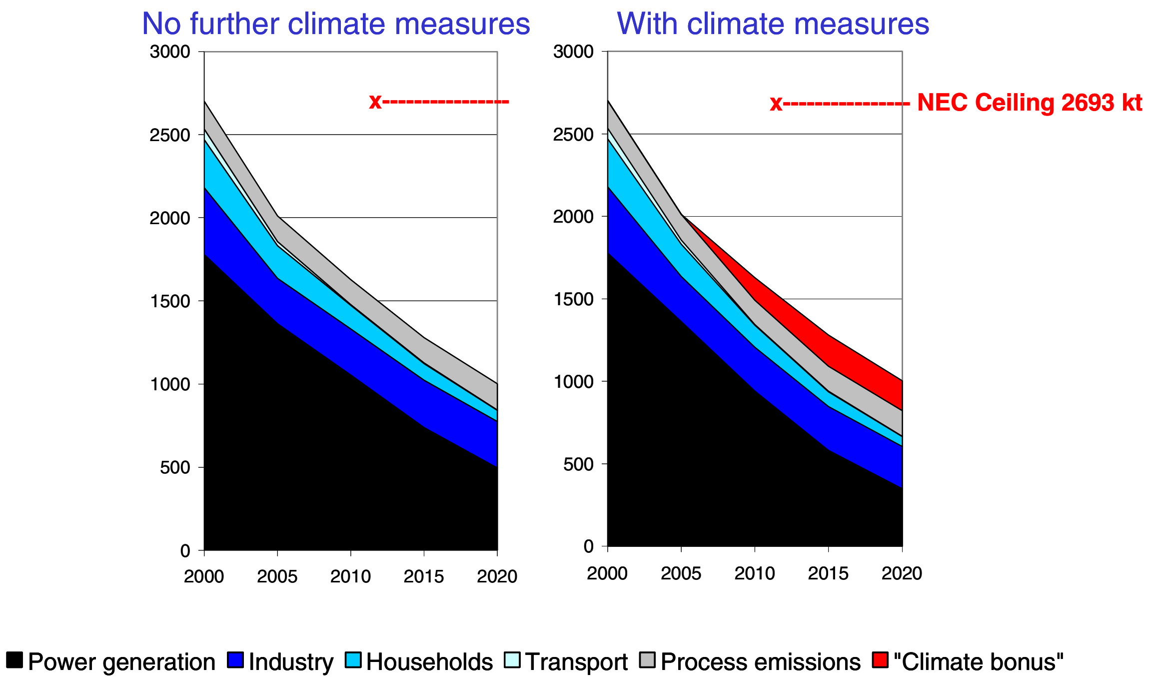


Figure 4.5: SO_2 emissions by sector for the New Member States (in kt).

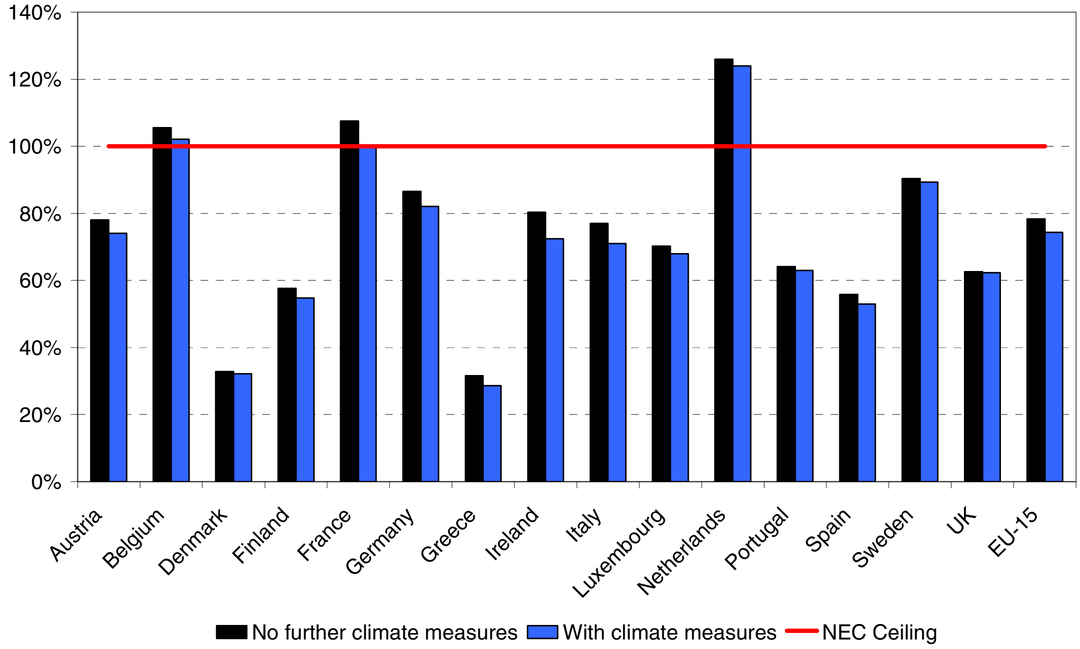


Figure 4.6: Estimated SO_2 emissions for 2010 compared with the emission ceilings for SO_2 for the EU-15.

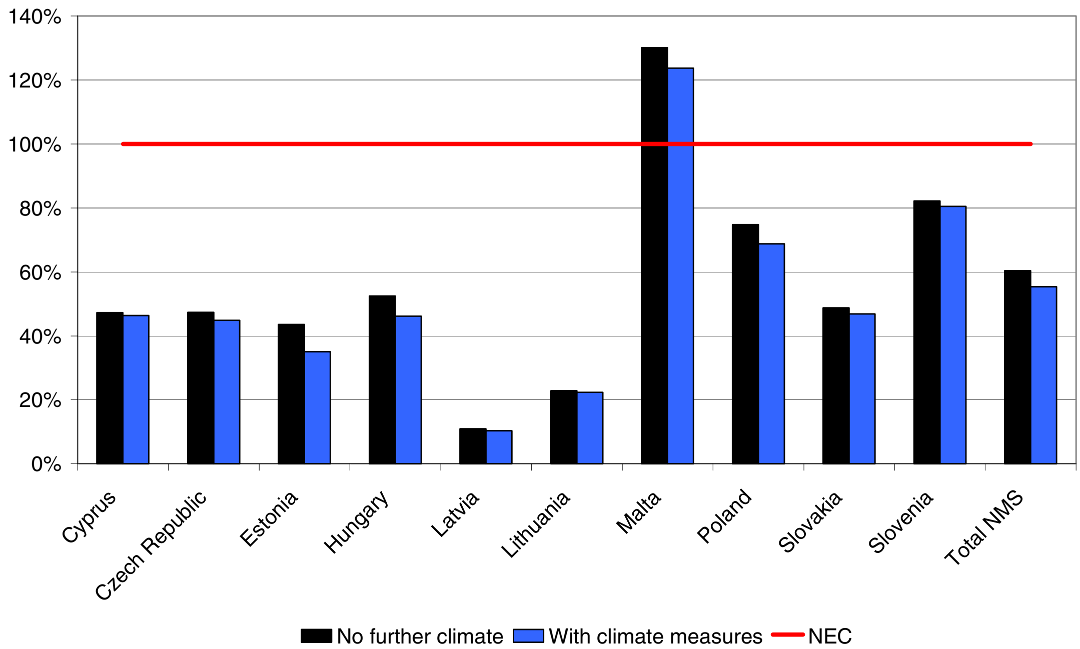


Figure 4.7: Estimated SO_2 emissions for 2010 compared with the emission ceilings for SO_2 for the New Member States.

Table 4.6: Total SO_2 emissions (kt) for the two PRIMES scenarios.

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	38	30	29	28	29	27	26
Belgium	186	105	99	97	101	95	92
Denmark	29	18	16	14	18	16	14
Finland	82	63	63	62	60	59	58
France	649	404	364	339	374	339	317
Germany	641	450	411	426	427	375	363
Greece	476	165	163	110	150	141	103
Ireland	133	34	27	20	30	25	20
Italy	745	366	347	298	337	344	291
Luxembourg	4	3	2	2	3	2	2
Netherlands	89	68	69	70	67	67	68
Portugal	251	103	93	87	101	88	84
Spain	1400	416	397	350	395	374	332
Sweden	58	61	60	62	60	59	59
UK	1189	366	278	225	364	257	199
Total EU-15	5969	2652	2418	2190	2516	2267	2028
Cyprus	57	18	19	10	18	19	10
Czech Rep.	249	126	93	70	119	86	57
Estonia	91	44	18	11	35	14	9
Hungary	487	262	147	95	231	115	95
Latvia	16	11	10	9	10	9	7
Lithuania	40	33	31	25	32	28	23
Malta	26	12	12	3	11	11	2
Poland	1513	1045	882	722	962	749	572
Slovakia	124	54	46	38	52	41	31
Slovenia	97	22	21	19	22	20	16
Total NMS	2700	1627	1280	1002	1492	1091	823
Total EU-25	8669	4279	3698	3192	4008	3358	2850

Table 4.7: SO_2 emission estimates for 2000 and for 2010 (kt).

	Base year inventory 2000		*Emissions for 2010*		
	RAINS	*National estimate*	*NEC ceiling*	*RAINS, no further climate measures*	*RAINS, with further climate measures*
Austria	38	38	39	30	29
Belgium	186	186	99	105	101
Denmark	29	29	55	18	18
Finland	82	80	110	63	60
France	649	654	375	404	374
Germany	641	638	520	450	427
Greece	476	483	523	165	150
Ireland	133	131	42	34	30
Italy	745	752	475	366	337
Luxembourg	4	3	4	3	3
Netherlands	89	92	50	63	62
Portugal	251	263	160	103	101
Spain	1400	1380	746	416	395
Sweden	58	57	67	61	60
UK	1189	1165	585	366	364
Total EU-15	5969	5951	3385	2652	2516
Cyprus	57	50	39	18	18
Czech Rep.	249	251	265	126	119
Estonia	91	91	100	44	35
Hungary	487	485	500	262	231
Latvia	16	17	101	11	10
Lithuania	40	49	145	33	32
Malta	26		9	12	11
Poland	1513	1511	1397	1045	962
Slovakia	124	124	110	54	52
Slovenia	97	96	27	22	22
Total NMS	2700	2722	2693	1627	1492
Total EU-25	8669	8683	6078	4279	4008

4.2 Nitrogen oxides

4.2.1 Base year emissions

Also for NO_x, the RAINS databases allow rather accurate reconstruction of the nationally reported emission inventories for the year 2000. For the EU-15 as a whole, the draft RAINS estimate deviates by only one percent, and by 0.3 percent for the New Member States (Table 4.14, Figure 4.8). As for SO_2, the major discrepancies occur for Greece and Luxembourg. There are certain discrepancies with national estimates at the sectoral level, which are expected to be resolved in the forthcoming months.

The emission factors for mobile sources applied in the earlier RAINS calculations were entirely based on data developed within the Auto/Oil project. In contrast, the present RAINS implementation for the CAFE program incorporates information on country-specific emission factors for vehicles as provided by national experts, under the condition that sufficient supplementary documentation on the methodologies applied by countries was supplied, so that international consistency is maintained.

It should be mentioned that the RAINS estimates presented in this First Interim Report reflect higher than expected real-life NO_x emissions from heavy duty trucks subject to EURO-II and EURO-III as pointed out by the ARTEMIS project. Thus, the RAINS estimates for mobile sources are higher than the numbers given in the national inventories of some countries, which do not yet include this recent information.

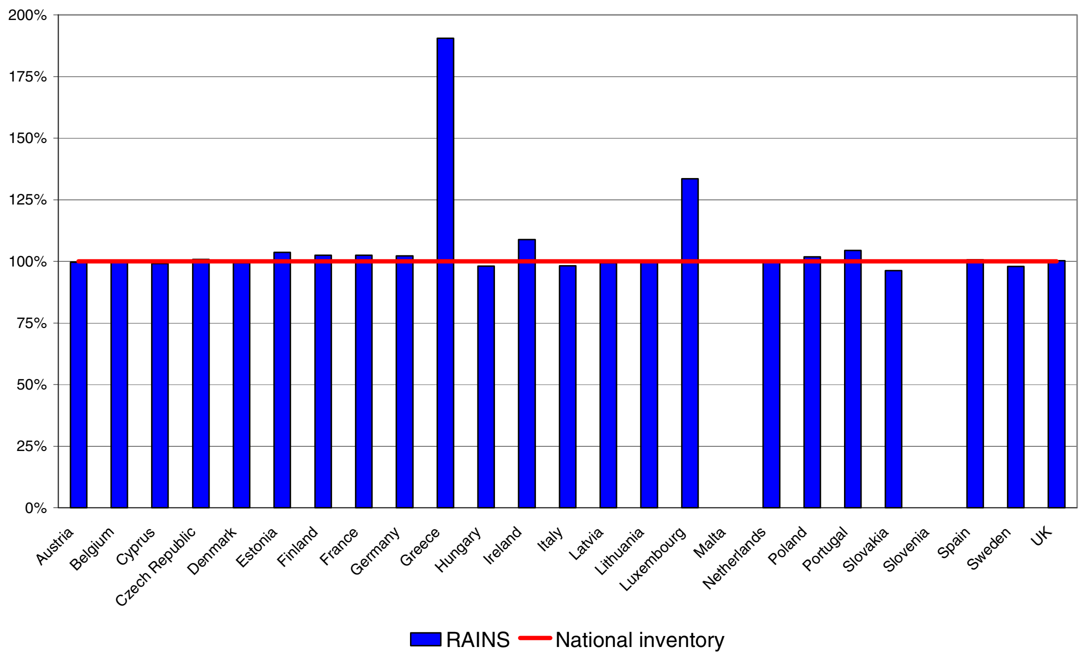


Figure 4.8: Comparison of national emission inventories for NO_x with the RAINS estimates (for the year 2000).

4.2.2 Future development

As for SO_2, the RAINS computation of future NO_x emissions is based on the projected volumes of emission generating activities (as provided by the PRIMES energy projections), country-specific emission factors that capture the composition of emission sources in each Member State and the penetration of emission controls as prescribed by legislation (Table 4.8).

Table 4.8: Legislation on NO_x emissions considered for the CAFE baseline scenarios.

Large Combustion Plant Directive
Auto/Oil EURO standards
Standards for motorcycles and mopeds
Legislation on non-road mobile machinery
Implementation failure of EURO-II and III for HDT
IPPC legislation on process sources
National legislation and national practices (if stricter)

For the two PRIMES energy projections, NO_x emissions from the EU-15 are expected to decline by 29 percent in 2010 and by 47 percent in 2020 compared to the year 2000 (Table 4.9 to Table 4.12, Figure 4.9 to Figure 4.12). Largest decreases will result from the measures in the power generation sector (-39 percent in 2010) and for mobile sources (-33 percent in 2010). For the New Member States, NO_x emissions are computed to decline by 30 percent in 2010 and by 54 percent in 2020 in case of no further climate measures.

The provisional analysis of the baseline projection indicates for most of the 15 old Member States potential difficulties in reaching the NO_x levels laid down in the Emission Ceilings Directive in 2010, while essentially all New Member States would stay well below the preliminary ceilings (Figure 4.13, Figure 4.14, Table 4.14). In total, the EU-15 would exceed the ceilings between 6.5 and 8.5 percent in 2010, while the NO_x emissions from the New Member States would remain 35 percent below the ceilings. In 2015, however, progressing implementation of the stricter EURO-IV emission limit values for mobile sources would push NO_x emissions from the EU-15 between nine and 11 percent below the 2010 target, depending on the energy scenario.

Table 4.9: NO_x emissions by fuel type for the EU-15 (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	150	81	59	60	71	46	40
Hard coal	990	487	369	260	426	287	152
Other solids	278	284	292	287	292	317	328
Heavy fuel oil	509	336	309	278	324	301	271
Middle distillates	4516	3657	2860	2338	3613	2808	2279
Gasoline	1942	687	490	452	683	482	441
Natural gas	959	972	1006	1024	957	986	1018
Process emissions	593	581	581	586	573	570	573
Total	9938	7085	5966	5286	6939	5798	5104

Table 4.10: NO_x emissions by fuel for the New Member States (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	141	113	83	41	103	69	36
Hard coal	438	317	305	178	282	251	118
Other solids	36	35	35	33	40	39	37
Heavy fuel oil	50	34	30	26	34	29	25
Middle distillates	489	379	285	217	375	278	210
Gasoline	243	87	54	54	87	54	53
Natural gas	140	113	120	131	112	122	135
Process emissions	117	87	86	89	87	86	88
Total	1654	1165	999	768	1120	927	703

Table 4.11: NO_x emissions by sector for the EU-15 (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	1520	928	804	692	870	750	636
Industry	915	751	753	744	734	729	719
Households	532	545	543	538	529	522	515
Transport	6377	4281	3286	2728	4235	3228	2662
Process emissions	593	581	581	586	573	570	573
Total	9938	7086	5967	5288	6940	5800	5105

Table 4.12: NO_x emissions by sector for the New Member States (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Power generation	560	412	376	214	376	321	169
Industry	161	123	121	121	120	116	113
Households	96	92	91	89	89	86	84
Transport	720	452	324	256	447	317	248
Process emissions	117	87	86	89	87	86	88
Total	1654	1165	999	768	1120	927	703

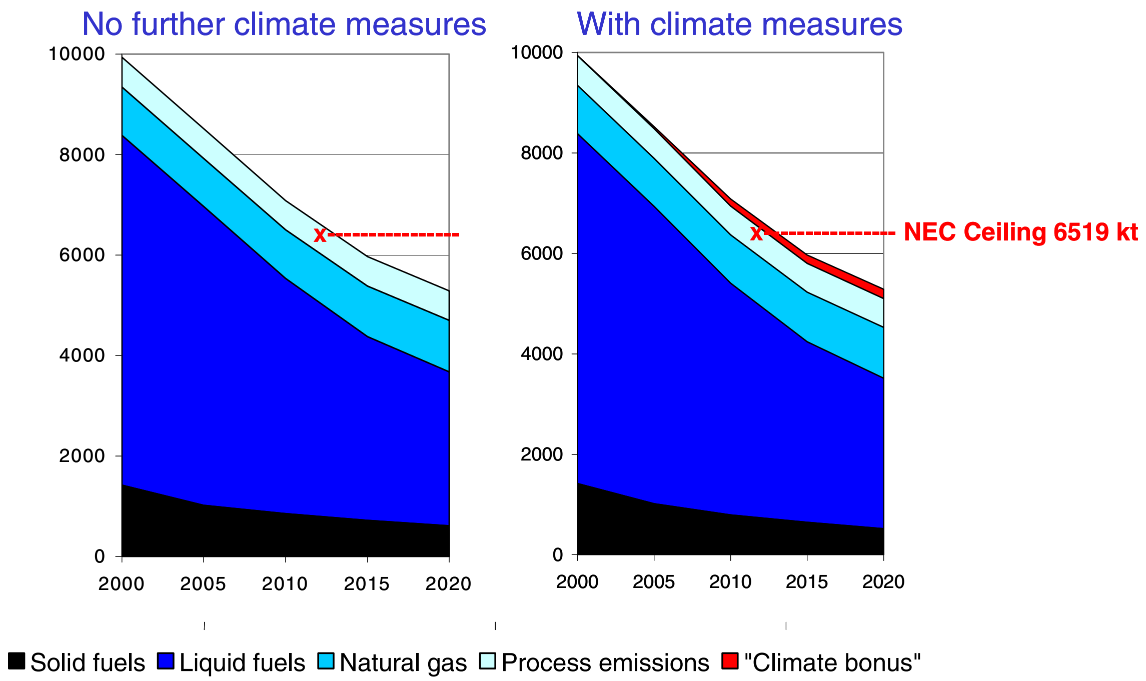


Figure 4.9: NO_x emissions by fuel for the EU-15 (kt).

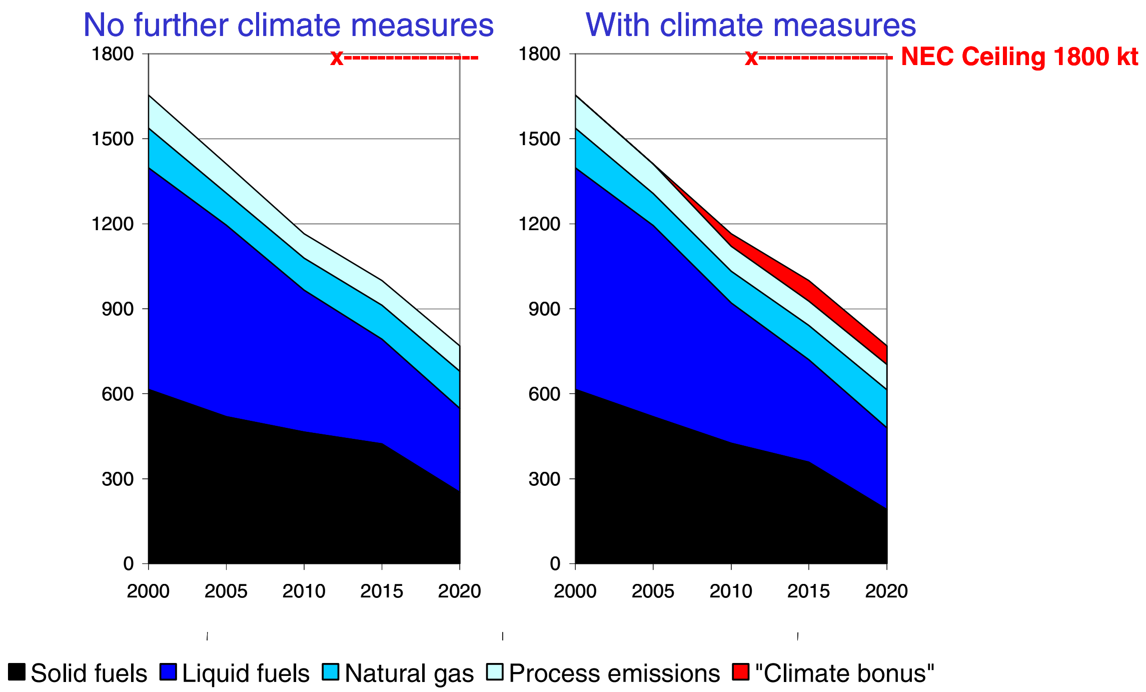


Figure 4.10: NO_x emissions by fuel for the EU-15 (kt).

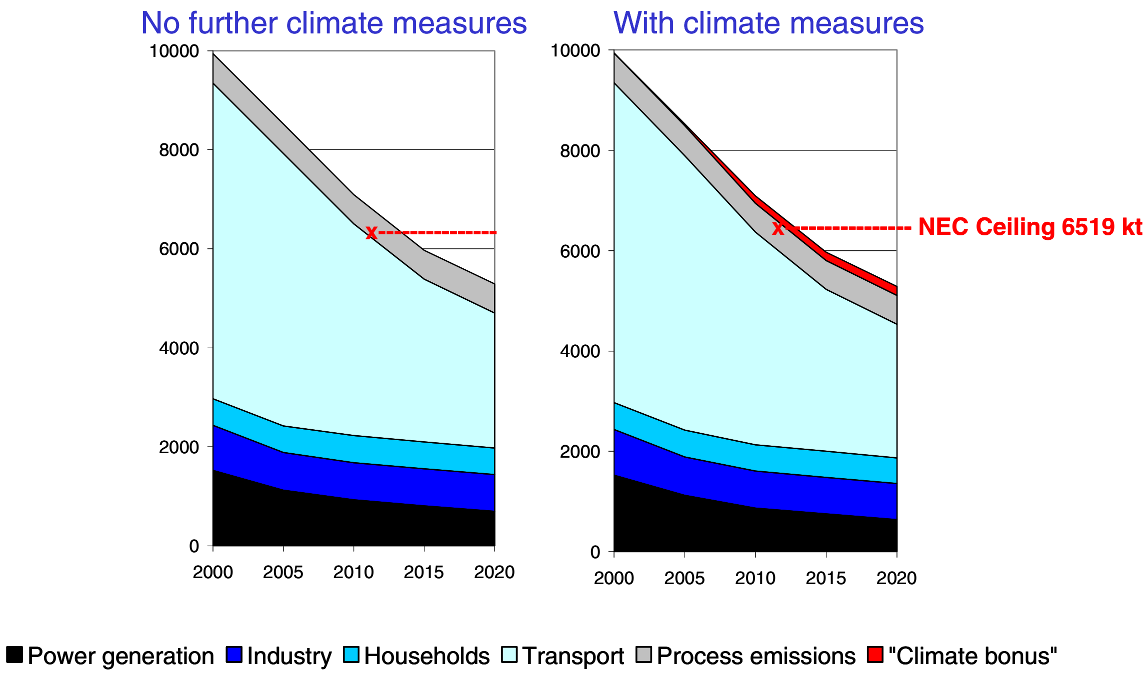


Figure 4.11: NO_x emissions by sector for the EU-15 (kt).

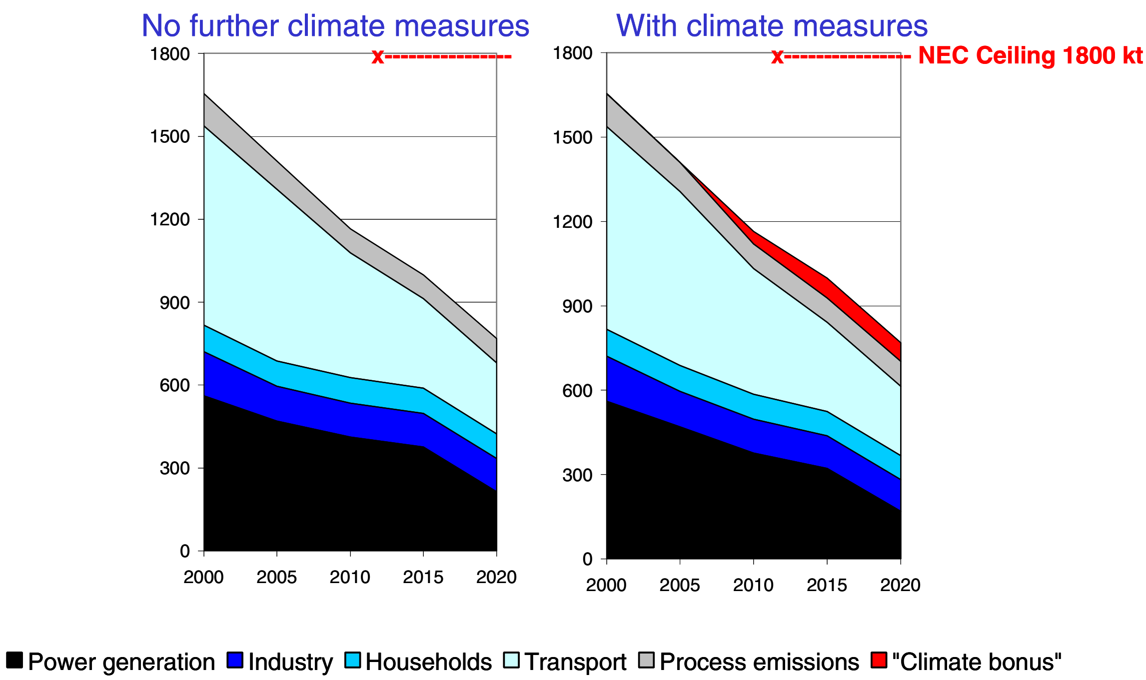


Figure 4.12: NO_x emissions by sector for the New Member States (kt).

Table 4.13: Total NO_x emissions for the two PRIMES scenarios (kt).

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	192	157	132	123	156	130	119
Belgium	334	227	215	196	222	208	188
Denmark	207	146	124	105	143	121	103
Finland	214	150	129	112	147	127	111
France	1431	1051	862	812	1015	828	772
Germany	1643	1175	962	906	1155	938	874
Greece	329	274	255	227	267	245	222
Ireland	128	93	75	61	88	72	59
Italy	1392	980	832	669	965	822	657
Luxembourg	32	27	20	18	27	19	17
Netherlands	405	327	272	259	323	267	253
Portugal	322	233	202	167	230	198	162
Spain	1303	938	805	668	913	778	643
Sweden	251	193	169	150	190	165	145
UK	1755	1115	913	814	1099	882	779
Total EU-15	9938	7086	5967	5288	6940	5800	5105
Cyprus	31	22	20	19	23	20	20
Czech Rep.	295	187	158	117	182	151	102
Estonia	37	28	20	16	27	19	14
Hungary	191	132	108	92	128	100	85
Latvia	36	30	22	18	29	20	15
Lithuania	49	41	34	29	40	32	27
Malta	9	6	4	4	6	4	4
Poland	844	616	544	393	585	498	365
Slovakia	104	65	58	52	63	54	46
Slovenia	58	39	31	28	39	30	25
Total NMS	1654	1165	999	768	1120	927	703
Total EU-25	11592	8251	6966	6056	8060	6727	5808

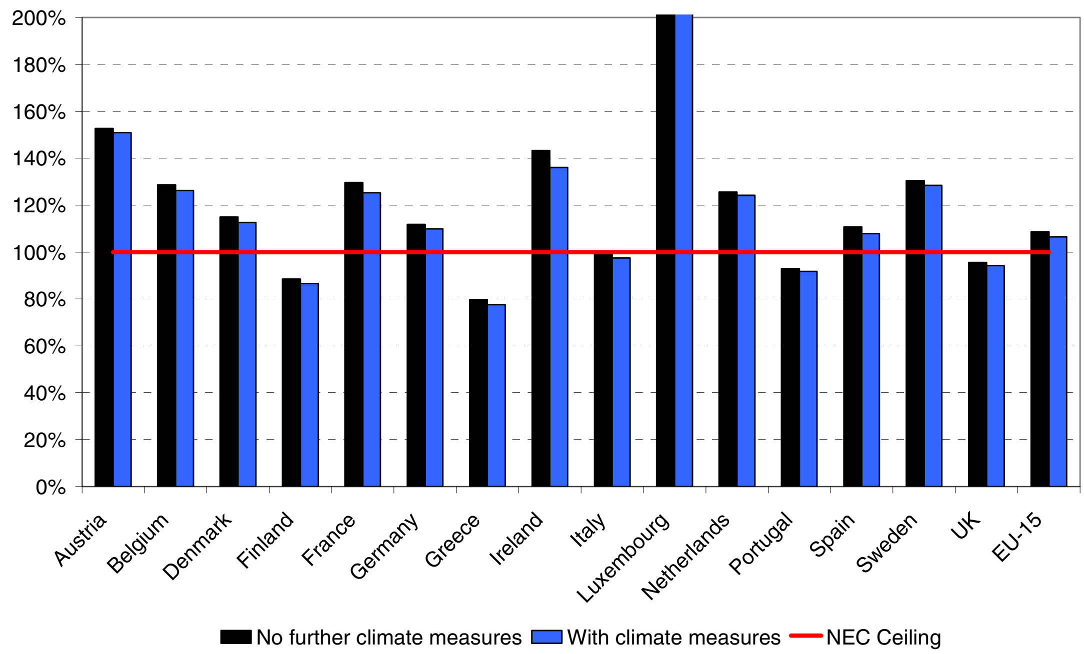


Figure 4.13: Projected NO_x emissions for the year 2010 compared to the national emission ceilings, for the EU-15.

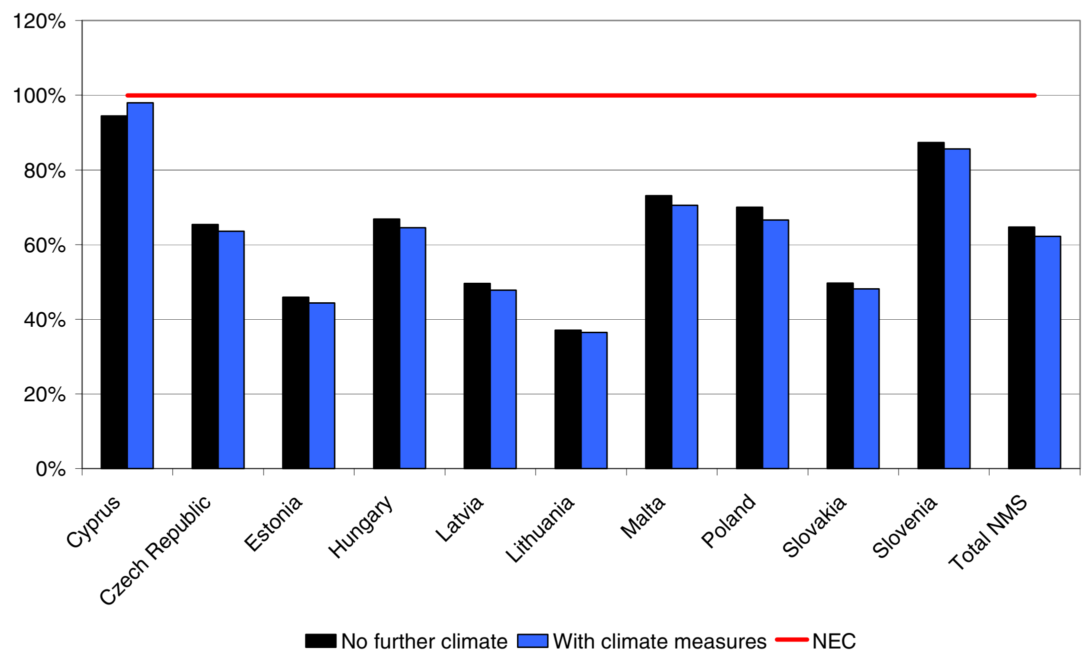


Figure 4.14: Projected NO_x emissions for the year 2010 compared to the national emission ceilings, for the New Member States.

Table 4.14: NO_x emissions (kt) estimates for 2000 and for 2010.

	Base year inventory 2000		*Emissions for 2010*		
	RAINS	*National estimate*	*NEC ceiling*	*RAINS, no further climate measures*	*RAINS, with further climate measures*
Austria	192	193	103	157	156
Belgium	334	333	176	227	222
Denmark	207	208	127	146	143
Finland	214	212	170	150	147
France	1431	1441	810	1051	1015
Germany	1643	1584	1051	1175	1155
Greece	329	321	344	274	267
Ireland	128	125	65	93	88
Italy	1392	1361	990	980	965
Luxembourg	32	17	11	27	27
Netherlands	405	413	260	327	323
Portugal	322	296	250	233	230
Spain	1303	1326	847	938	913
Sweden	251	253	148	193	190
UK	1755	1749	1167	1115	1099
Total EU-15	9938	9832	6519	7086	6940
Cyprus	31	23	23	22	23
Czech Rep.	295	321	286	187	182
Estonia	37	37	60	28	27
Hungary	191	187	198	132	128
Latvia	36	35	61	30	29
Lithuania	49	55	110	41	40
Malta	9		8	6	6
Poland	844	838	879	616	585
Slovakia	104	106	130	65	63
Slovenia	58	58	45	39	39
Total NMS	1654	1976	1800	1165	1120
Total EU-25	11592	11808	8316	8251	8060

4.3 Volatile Organic Compounds (VOC)

4.3.1 Base year emissions

In comparison to SO_2 and NO_x, it is more difficult to reproduce nationally reported VOC emissions with internationally consistent sets on emission factors. Thus, the RAINS model shows larger discrepancies with national estimates, although the overall number for the EU-15 differs by not more than 0.16 percent, while for the New Member States the disagreement increases to five percent (Figure 4.15, Table 4.19). Insufficient insight into the calculation methods applied in some Member States makes it difficult to judge the quality of some of these national VOC inventories, so that for all following calculations caveats on the uncertainties of the emission inventories must be kept in mind.

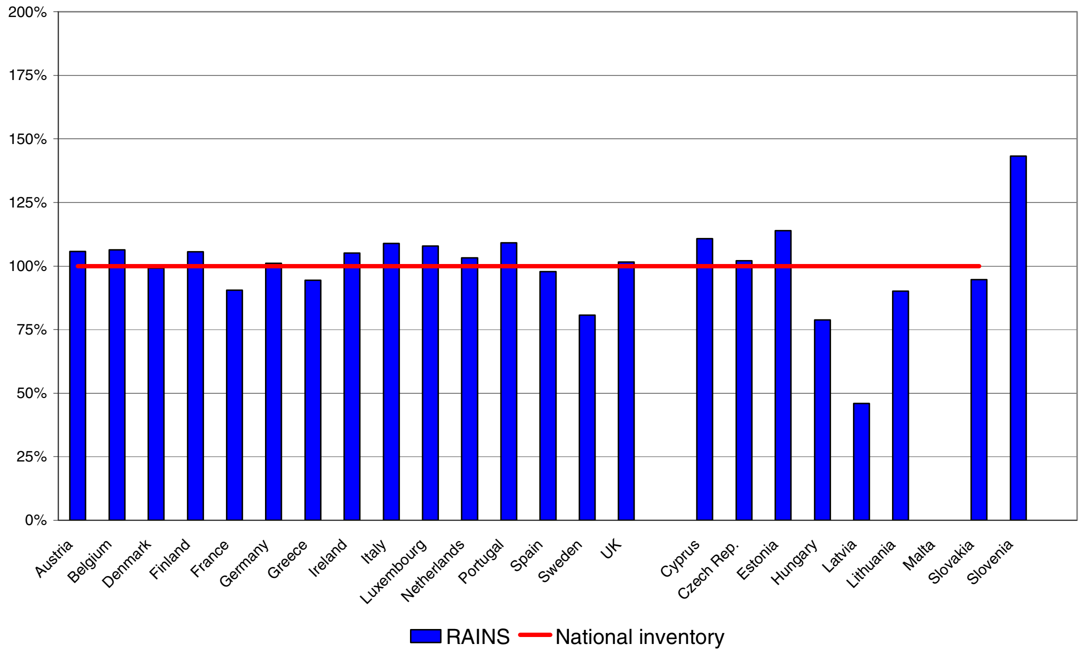


Figure 4.15: Comparison of national emission inventories for VOC with the RAINS estimates (for the year 2000).

4.3.2 Future development

Table 4.15: Legislation on VOC emissions considered for the CAFE baseline scenarios.

Stage I Directive
Directive 91/441 (carbon canisters)
Auto/Oil EURO standards
Fuel Directive (RVP of fuels)
Solvents Directive
Product Directive (paints)
National legislation, e.g., Stage II

Under the assumptions of the baseline scenario and with the emission control legislation listed in Table 4.15, VOC emissions are expected to decrease in the EU-15 in 2010 by 33 percent compared to 2000 and by 41 percent in 2020. There are only minor impacts of the "with climate measures" scenario, mainly due to variations in the transport volumes. In the New Member States, VOC emissions in 2010 are computed to be 15 percent lower than in 2000, and 33 percent lower in 2020. In both regions, the decline in emissions from mobile sources adds the largest contribution to the VOC decrease (Figure 4.16 to Figure 4.19).

While the initial analysis indicates for some Member States in the EU-15 a potential need for further measures to achieve the emission ceilings, VOC emissions from the EU-15 as a whole would be three percent below the ceiling (Table 4.19). New Member States, however, would under-run the ceiling by 45 percent.

Table 4.16: VOC emissions by SNAP sectors for the EU-15 (kt).

SNAP sector	*2000*	*2010*	*2015*	*2020*
1: Combustion in energy industries	71	65	60	54
2: Non-industrial combustion plants	520	466	437	383
3: Combustion in manufacturing industry	40	34	35	36
4: Production processes	1027	977	938	931
5: Extraction and distribution	605	472	463	460
6: Solvent use	3318	2600	2542	2590
7: Road transport	3122	1094	794	715
8: Other mobile sources and machinery	756	579	420	351
9: Waste treatment	110	111	111	111
Total	9569	6398	5799	5629

Table 4.17: VOC emissions by SNAP sectors for the New Member States (kt).

SNAP sector	*2000*	*2010*	*2015*	*2020*
1: Combustion in energy industries	42	35	35	31
2: Non-industrial combustion plants	150	128	108	92
3: Combustion in manufacturing industry	8	7	6	7
4: Production processes	133	142	152	160
5: Extraction and distribution	78	72	66	55
6: Solvent use	354	337	343	363
7: Road transport	405	272	140	86
8: Other mobile sources and machinery	75	70	52	35
9: Waste treatment	2	2	2	2
Total	1247	1065	903	831

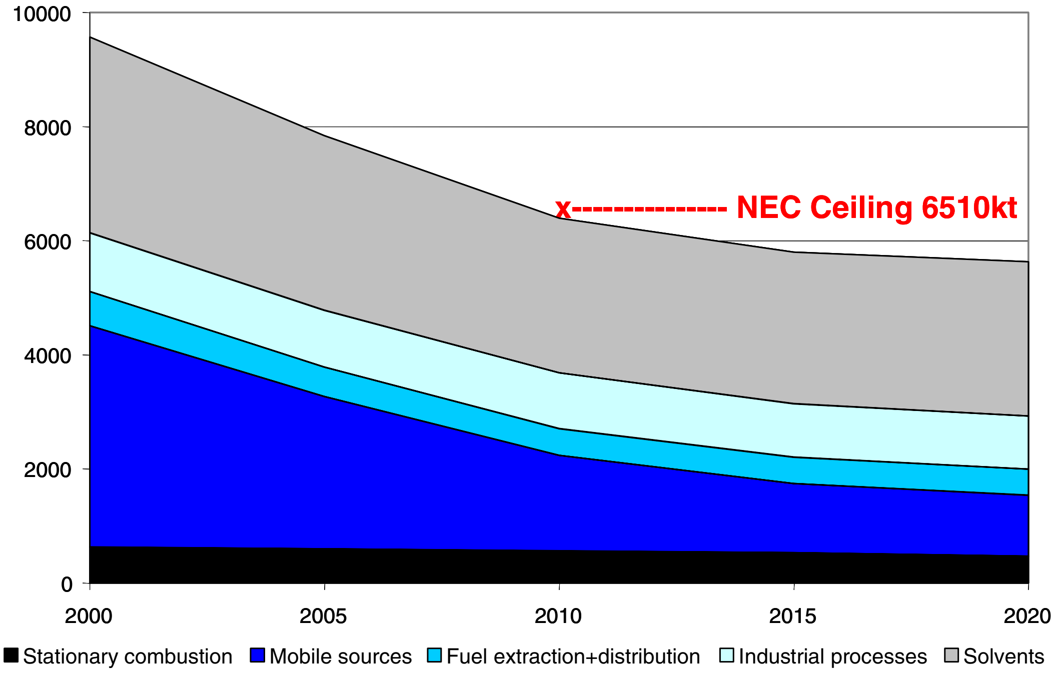


Figure 4.16: VOC emissions for the "no further climate measures" scenario (kt) for the EU-15.

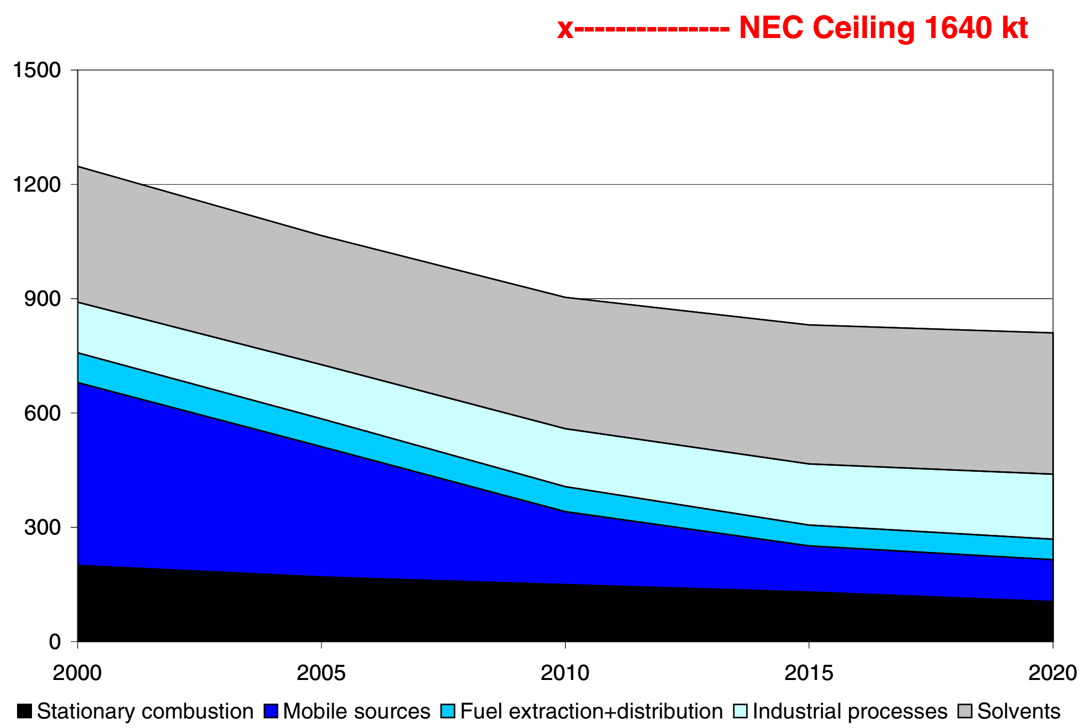


Figure 4.17: VOC emissions for the "no further climate measures" scenario (kt) for the New Member States.

Table 4.18: Total VOC emissions (kt) for the two PRIMES scenarios.

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	201	164	157	157	165	157	157
Belgium	248	173	174	175	172	173	175
Denmark	131	86	81	81	86	81	81
Finland	169	130	115	106	130	115	106
France	1563	1024	943	937	1026	943	936
Germany	1622	1141	960	867	1140	959	868
Greece	288	180	166	166	180	166	165
Ireland	95	72	68	70	72	68	70
Italy	1646	971	812	732	970	813	732
Luxembourg	16	11	11	12	11	11	12
Netherlands	287	237	236	242	237	236	241
Portugal	311	216	212	221	217	212	222
Spain	1119	832	790	794	833	790	795
Sweden	245	176	168	168	175	168	167
UK	1521	902	853	863	901	852	862
Total EU-15	9462	6316	5748	5593	6315	5744	5589
Cyprus	16	11	11	11	11	11	11
Czech Rep.	225	150	139	137	150	138	136
Estonia	38	34	29	29	34	29	29
Hungary	135	83	77	72	83	77	72
Latvia	32	24	16	14	24	16	14
Lithuania	64	49	40	38	49	40	38
Malta	6	4	4	4	4	4	4
Poland	589	453	427	417	452	422	411
Slovakia	84	62	60	63	62	60	63
Slovenia	58	33	28	25	33	28	25
Total NMS	1247	903	831	810	902	824	803
Total EU-25	10708	7219	6579	6403	7217	6569	6392

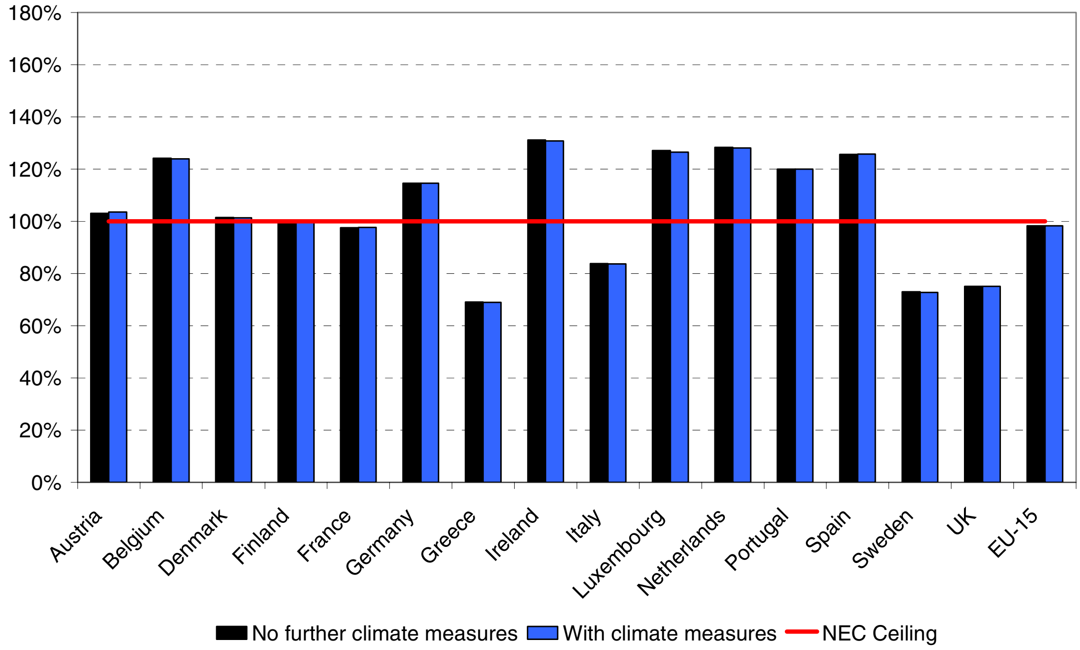


Figure 4.18: Projected VOC emissions for the year 2010 compared to the national emission ceilings, for the EU-15.

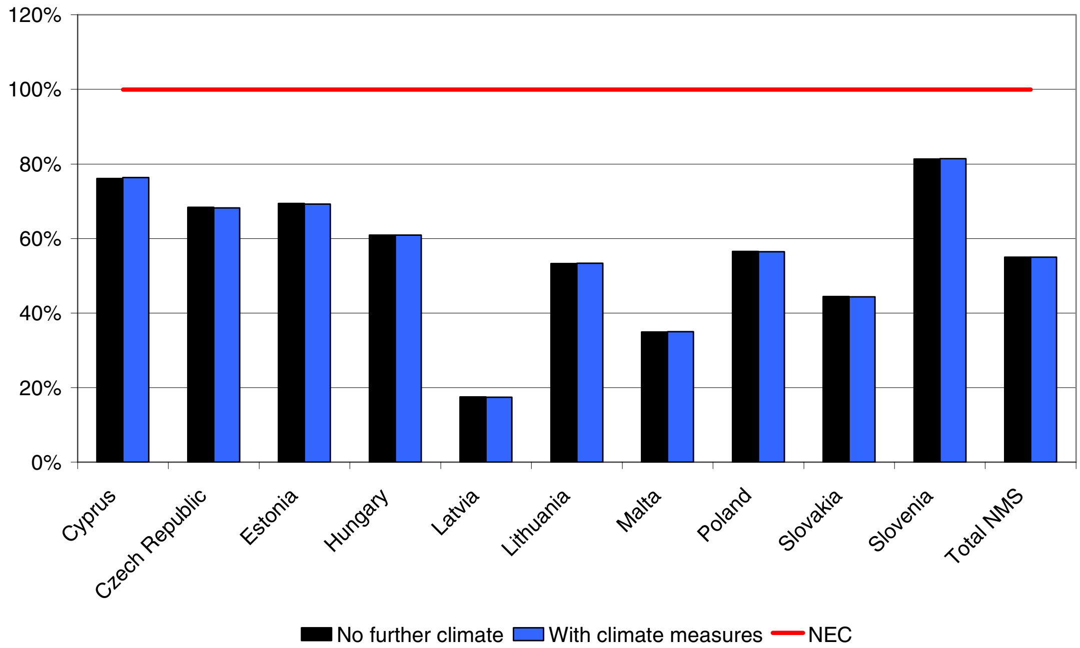


Figure 4.19: Projected VOC emissions for the year 2010 compared to the national emission ceilings, for the New Member States.

Table 4.19: VOC emission estimates for 2000 and for 2010 (kt).

	Base year inventory 2000		*Emissions for 2010*		
	RAINS	*National estimate*	*NEC ceiling*	*RAINS, no further climate measures*	*RAINS, with further climate measures*
Austria	201	190	159	164	165
Belgium	248	233	139	173	172
Denmark	131	132	85	86	86
Finland	169	160	130	130	130
France	1563	1726	1050	1024	1026
Germany	1622	1605	995	1141	1140
Greece	288	305	261	180	180
Ireland	95	90	55	72	72
Italy	1646	1512	1159	971	970
Luxembourg	16	15	9	11	11
Netherlands	287	278	185	237	237
Portugal	311	285	180	216	217
Spain	1119	1144	662	832	833
Sweden	245	304	241	176	175
UK	1521	1498	1200	902	901
Total EU-15	9462	9478	6510	6316	6315
Cyprus	16	14	14	11	11
Czech Rep.	225	220	220	150	150
Estonia	38	34	49	34	34
Hungary	135	172	137	83	83
Latvia	32	69	136	24	24
Lithuania	64	71	92	49	49
Malta	6		12	4	4
Poland	589	599	800	453	452
Slovakia	84	89	140	62	62
Slovenia	58	40	40	33	33
Total NMS	1247	1308	1640	903	902
Total EU-25	10708	11300	8150	7222	7217

4.4 Ammonia (NH_3)

4.4.1 Base year emissions

While the provisional databases in the RAINS model reproduce for the year 2000 total ammonia emissions of the EU-15 with only 0.8 percent difference to the national estimates, there are still large discrepancies for individual countries. Further national information is necessary to understand the reasons for the differences and to improve the model estimates. For the new Member States, RAINS results in 1.2 percent higher emissions than the national estimates (Table 4.24, Figure 4.20)

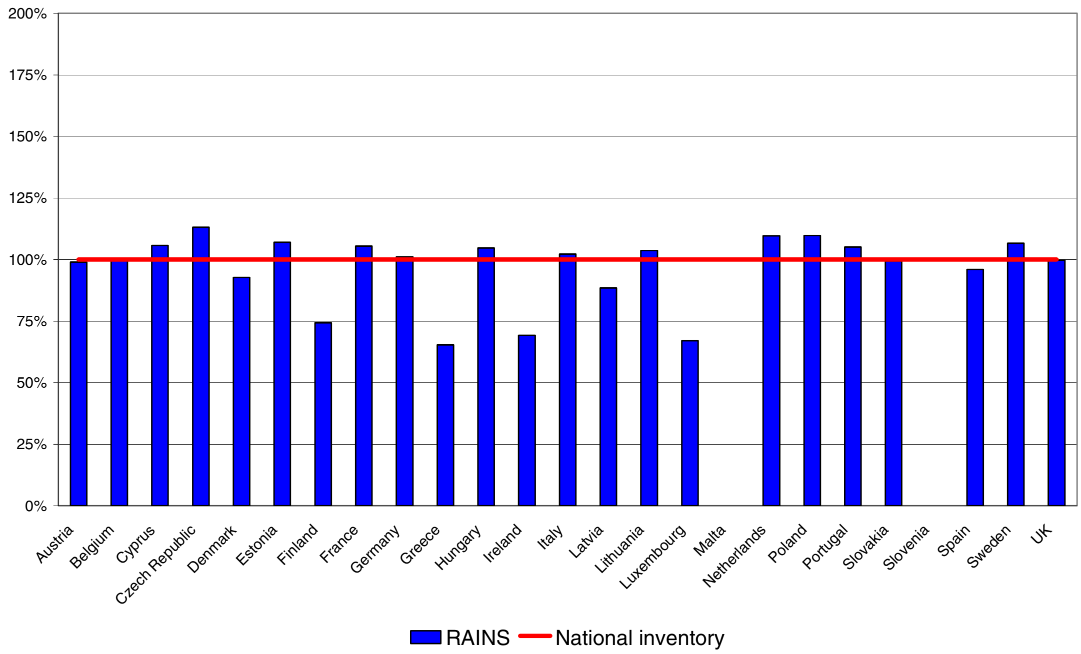


Figure 4.20: Comparison of national emission inventories for NH_3 with the RAINS estimates (for the year 2000).

4.4.2 Future development

For ammonia emissions, no specific control measures in addition to different national practices are assumed for the baseline projection (Table 4.20).

Table 4.20: Legislation on NH_3 emissions considered for the CAFE baseline scenarios.

No EU-wide legislation
National legislations
Current practice

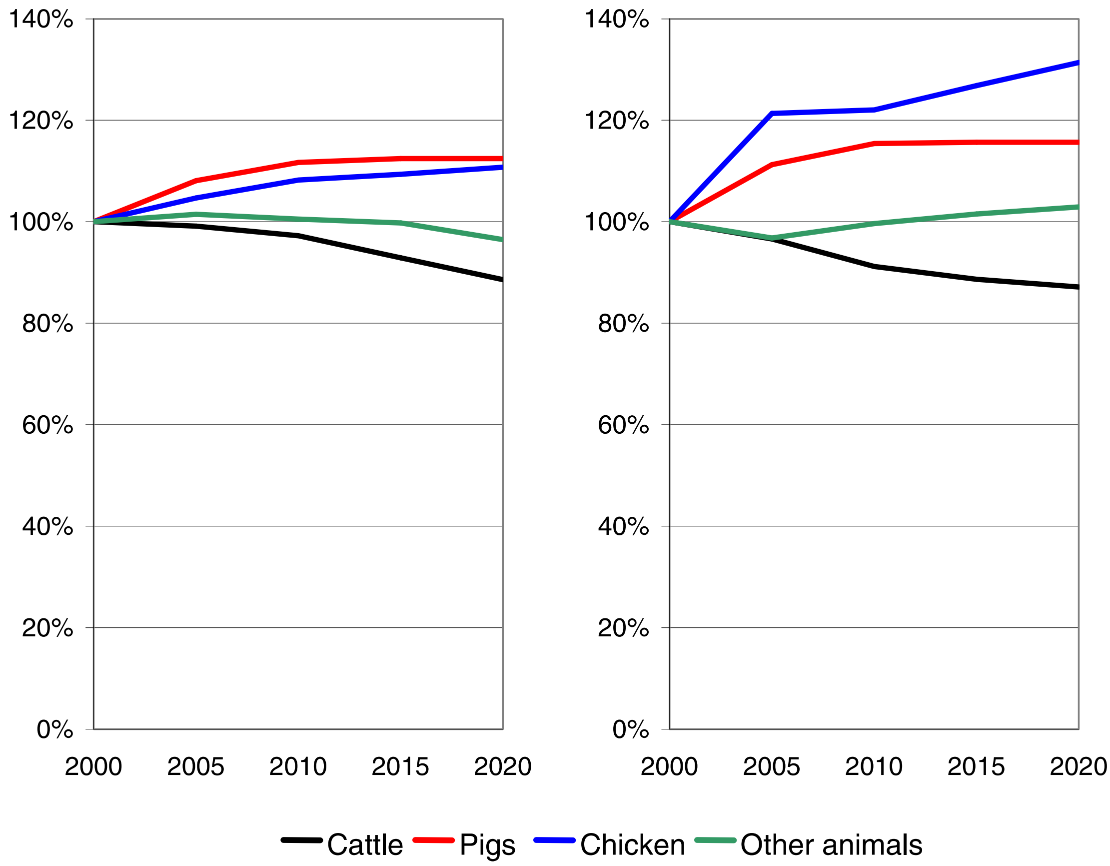


Figure 4.21: Development of animal numbers for EU-15 (left panel) and New Member States (right panel) relative to the year 2000, pre-CAP reform scenario.

With the changes in animal numbers as presented in Figure 4.21, no significant changes in the amount of NH_3 emissions are calculated for the future (Figure 4.22 to Figure 4.25). While in 2010 the total ammonia emissions of the EU-15 countries should be slightly below the total emission ceiling, for some countries compliance with the ceiling would require additional emission control measures, if the agricultural projections of the pre-CAP reform scenario materialize.

Table 4.21: NH_3 emissions for the EU-15 (kt).

	2000	*2010*	*2015*	*2020*
Cattle	1336	1267	1227	1179
Other animals	1078	1184	1191	1191
Industry	709	671	661	651
Fuel combustion	111	85	64	66
Total	3234	3206	3143	3086

Table 4.22: NH_3 emissions for the New Member States (kt).

	2000	*2010*	*2015*	*2020*
Cattle	160	153	144	141
Other animals	211	243	250	253
Industry	187	188	197	203
Fuel combustion	10	11	11	9
Total	569	594	600	606

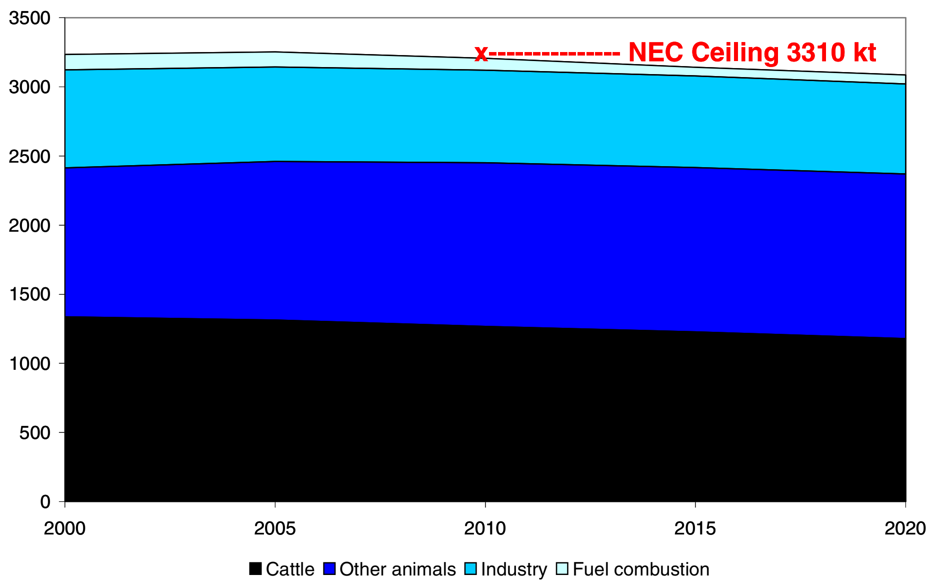


Figure 4.22: NH_3 projections for the EU-15 for the pre-CAP reform scenario (kt).

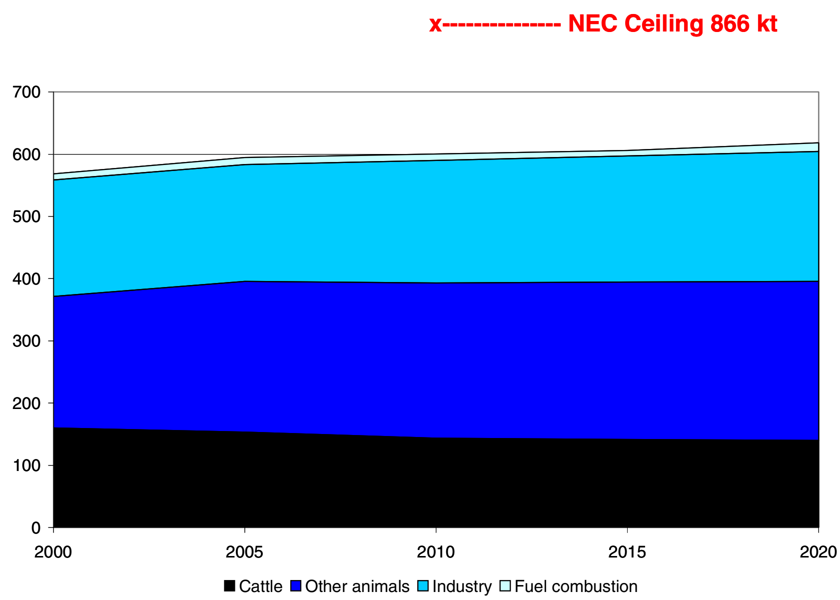


Figure 4.23: NH_3 projections for the pre-CAP reform scenario for the New Member States (in kt).

Table 4.23: Total NH_3 emissions (kt).

		Pre-CAP reform		
	2000	*2010*	*2015*	*2020*
Austria	54	56	55	54
Belgium	81	79	78	76
Denmark	94	93	92	91
Finland	38	38	37	37
France	727	732	716	701
Germany	638	624	614	606
Greece	55	54	52	52
Ireland	129	131	127	123
Italy	434	421	411	402
Luxembourg	5	4	4	4
Netherlands	159	154	152	150
Portugal	67	69	68	67
Spain	394	382	376	370
Sweden	51	51	49	48
UK	309	320	312	307
Total EU-15	3235	3208	3144	3088
Cyprus	6	6	6	6
Czech Rep.	66	63	63	64
Estonia	10	11	12	12
Hungary	78	83	84	85
Latvia	12	14	15	16
Lithuania	50	55	56	57
Malta	1	1	1	1
Poland	309	328	329	335
Slovakia	32	32	32	33
Slovenia	18	20	20	20
Total NMS	582	613	618	630
Total EU-25	3817	3821	3762	3718

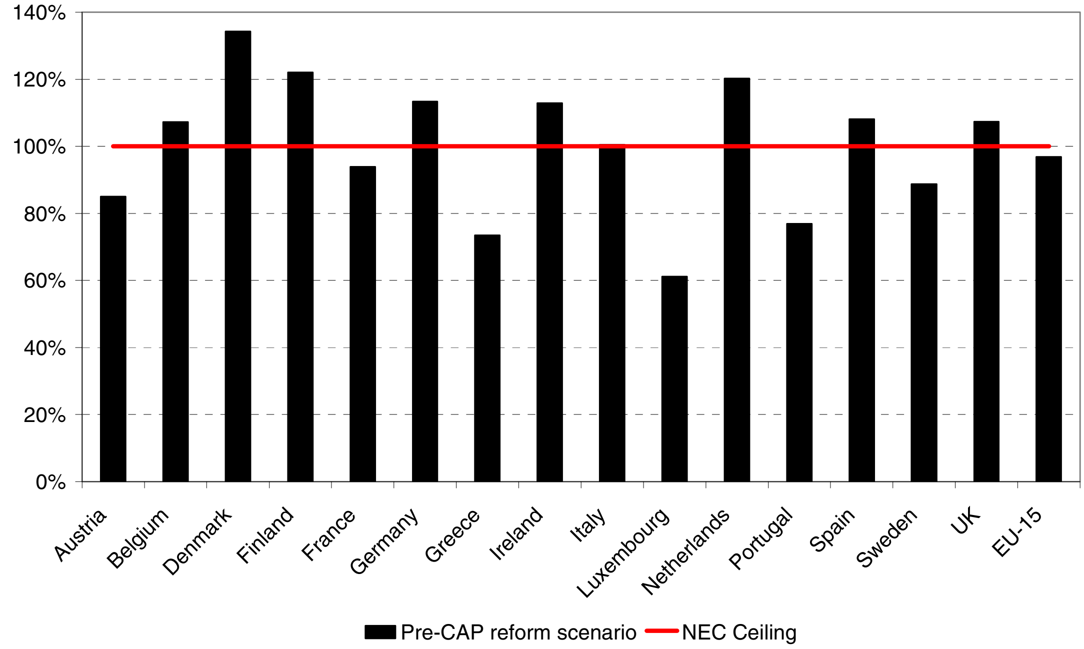


Figure 4.24: Projected NH_3 emissions for the year 2010 compared to the national emission ceilings, for the EU-15.

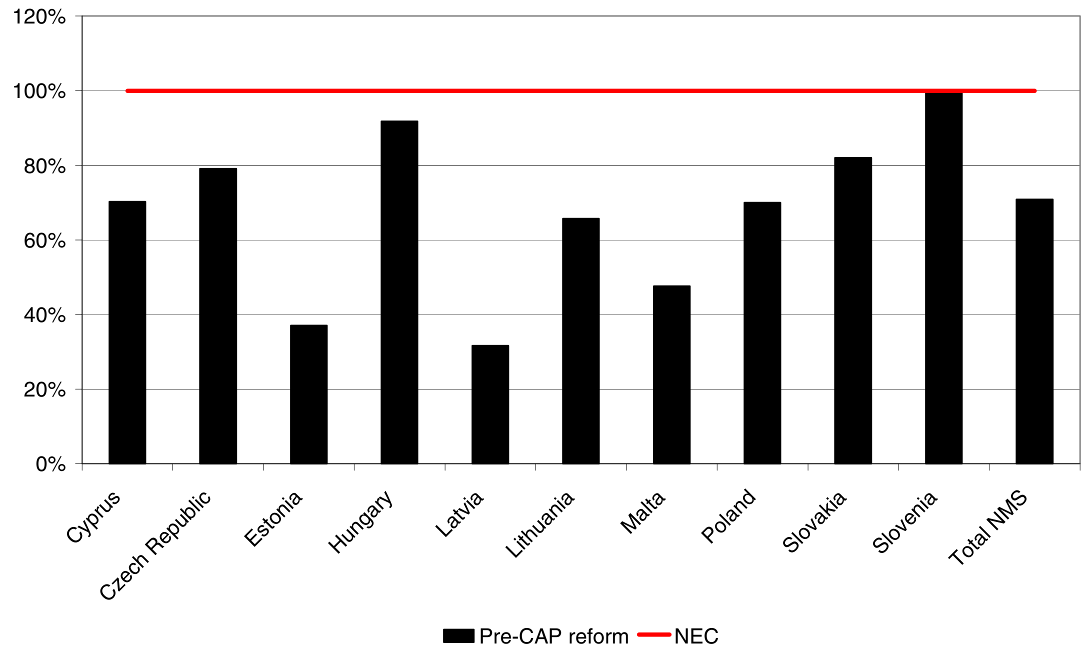


Figure 4.25: Projected NH_3 emissions for the year 2010 compared to the national emission ceilings, for the EU-15.

Table 4.24: NH_3 emissions (kt) estimates for 2000 and for 2010.

	Base year inventory 2000		*Emissions in 2010*	
	RAINS	*National estimate*	*NEC ceiling*	*RAINS, pre-CAP reform*
Austria	54	54	66	56
Belgium	81	81	74	79
Denmark	94	89	69	93
Finland	38	33	31	38
France	727	784	780	732
Germany	638	596	550	624
Greece	55	74	73	54
Ireland	129	122	116	131
Italy	434	429	419	421
Luxembourg	5	7	7	4
Netherlands	159	152	128	154
Portugal	67	97	90	69
Spain	394	386	353	382
Sweden	51	58	57	51
UK	308	297	297	319
Total EU-15	3234	3261	3310	3207
Cyprus	6	9	9	6
Czech Rep.	66	77	80	63
Estonia	10	9	29	11
Hungary	78	71	90	83
Latvia	12	12	44	14
Lithuania	50	50	84	55
Malta	1		3	1
Poland	309	322	468	328
Slovakia	32	30	39	32
Slovenia	18	18	20	20
Total NMS	677	690	866	613
Total EU-25	3911	3950	4176	3820

4.5 Fine particulate matter

4.5.1 Base year emissions

While the RAINS model applies a uniform and reviewed methodology using country-specific emission factors to compute primary emissions of fine particles, only few countries have reported national estimates. Thus, a comparison of the RAINS estimates with national figures is only possible to a limited extent (Figure 4.26, Figure 4.27). Generally, disagreements with the available estimates for PM are larger than for other pollutants. However, in absence of well-documented inventories for the majority of Member States, it is difficult to judge the quality of the RAINS calculations.

For the year 2000, RAINS estimates for the EU-15 about one third of the primary PM10 emissions (660 kt) to originate from industrial process emissions and other non-combustion sources. The transport sector contributes another 490 kt (including non-exhaust emissions), while wood combustion in small stoves is calculated to emit 360 kt. In the New Member States, the largest share of primary PM10 emissions was caused by the combustion of coal, mainly in the domestic sector.

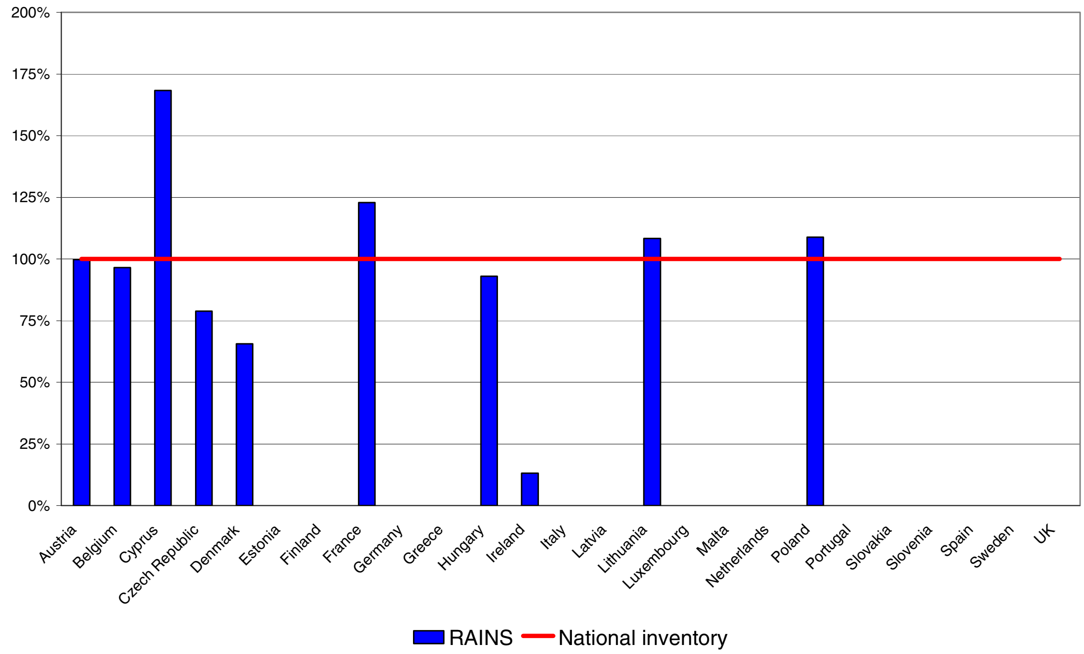


Figure 4.26: Comparison of national emission inventories for PM10 with the RAINS estimates (for the year 2000).

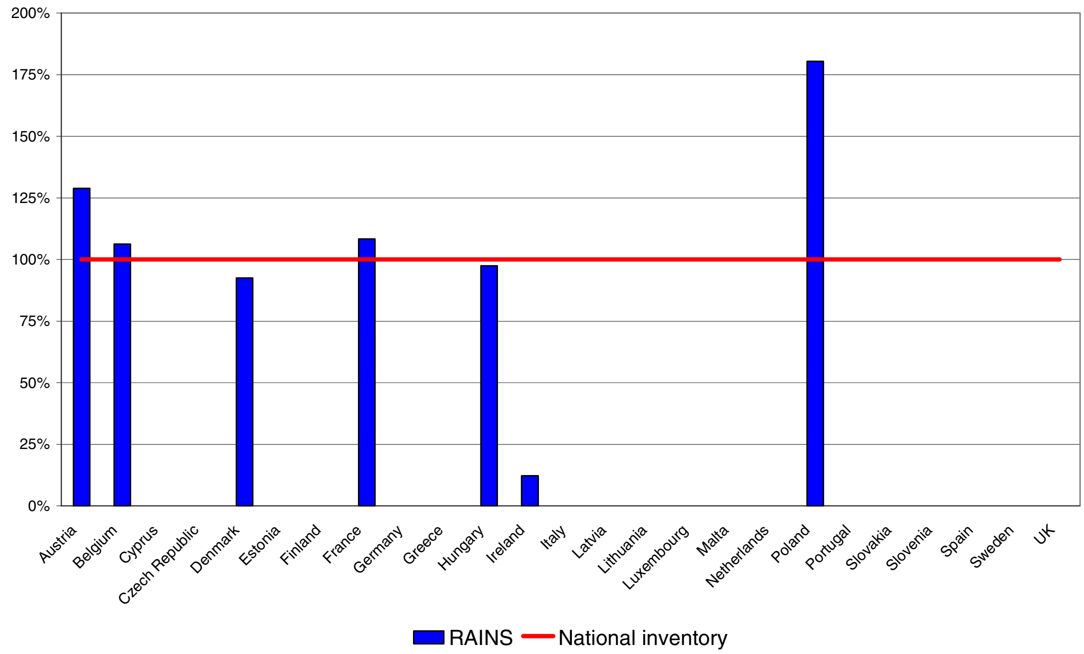


Figure 4.27: Comparison of national emission inventories for PM2.5 with the RAINS estimates (for the year 2000).

4.5.2 Future development

Table 4.25: Legislation on PM emissions considered for the CAFE baseline scenarios.

LCP Directive
Auto/Oil EURO standards
Standards for motorcycles and mopeds
Legislation on non-road mobile machinery
IPPC legislation on process sources
National legislation and national practices (if stricter)
LCP Directive

With the measures listed in Table 4.25, primary PM10 emissions from stationary combustion of fossil fuels are expected to significantly decline in the coming years. Emissions from mobile sources (including non-exhaust emissions) show a declining trend too, but less steep than the stationary sources. Overall, it is estimated that PM10 emissions decrease in the baseline scenario from 2000 to 2010 by approximately 25 percent in the EU15 and by more than 30 percent in the New Member States. For 2020, total primary PM10 emissions would be 32 percent lower in the EU-15 and 47 percent in the New Member States.

Calculations suggest a stronger decline in the fine fraction of PM, i.e., for PM2.5. For the EU-15, primary emissions of PM2.5 would under the assumptions of the baseline scenario be 29

percent below the year 2000 levels, and 40 percent in 2020. In the New Member States, PM2.5 is calculated to decline by 31 and 49 percent, respectively.

Table 4.26: Primary PM10 emissions by fuel type for the EU-15 (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	32	19	16	18	15	11	11
Hard coal	151	67	55	66	60	44	36
Other solids	363	277	260	230	284	267	236
Heavy fuel oil	42	29	27	24	27	26	23
Middle distillates	410	256	199	170	252	195	166
Gasoline	77	70	62	62	71	63	63
Natural gas	2	2	2	2	2	2	2
Process emissions	659	604	604	609	597	594	596
Total	1736	1324	1225	1181	1309	1202	1134

Table 4.27: Primary PM10 emissions by fuel type for the New Member States (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	82	36	27	25	34	24	20
Hard coal	177	105	86	67	95	71	47
Other solids	92	79	75	59	83	76	60
Heavy fuel oil	4	4	3	3	4	3	3
Middle distillates	49	29	21	17	29	21	17
Gasoline	8	8	8	9	8	8	9
Natural gas	0	0	0	0	0	0	0
Process emissions	144	120	118	118	118	116	115
Total	556	381	340	297	372	320	270

Table 4.28: PM10 emissions by SNAP sectors for the EU-15 (kt).

SNAP sector	2000	*No further climate measures* 2010	2015	2020	*With further climate measures* 2010	2015	2020
1: Combustion in energy industries	120	78	73	88	67	58	53
2: Non-industrial combustion plants	433	293	266	233	299	271	237
3: Combustion in manufacturing industry	161	106	105	106	104	102	102
4: Production processes	265	249	252	256	245	246	250
5: Extraction and distribution	35	28	25	24	26	22	20
6: Solvent use	326	208	174	169	207	172	167
7: Road transport	171	128	97	72	125	95	70
8: Other mobile sources and machinery	73	73	73	72	73	73	72
9: Waste treatment	154	163	164	164	163	164	164
Total	1738	1327	1228	1184	1309	1202	1134

Table 4.29: PM10 emissions by SNAP sectors for the New Member States (kt).

SNAP sector	2000	*No further climate measures* 2010	2015	2020	*With further climate measures* 2010	2015	2020
1: Combustion in energy industries	106	68	63	58	61	50	39
2: Non-industrial combustion plants	229	148	122	87	147	117	84
3: Combustion in manufacturing industry	40	20	21	21	20	20	19
4: Production processes	40	27	26	27	27	26	26
5: Extraction and distribution	24	17	16	14	16	14	12
6: Solvent use	36	24	20	20	24	20	20
7: Road transport	23	15	10	7	14	9	6
8: Other mobile sources and machinery	15	15	15	15	15	15	15
9: Waste treatment	45	48	49	49	48	49	49
Total	559	382	340	298	372	320	271

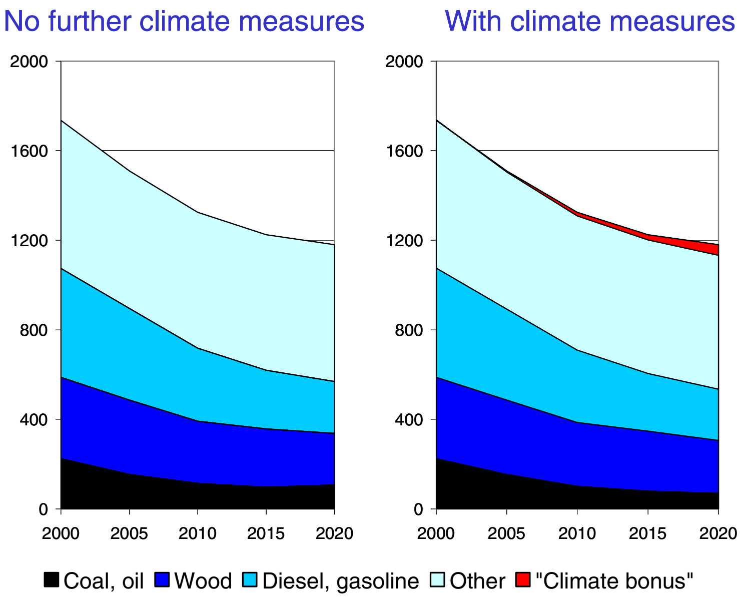


Figure 4.28: PM10 emissions by fuel for the EU-15 (kt).

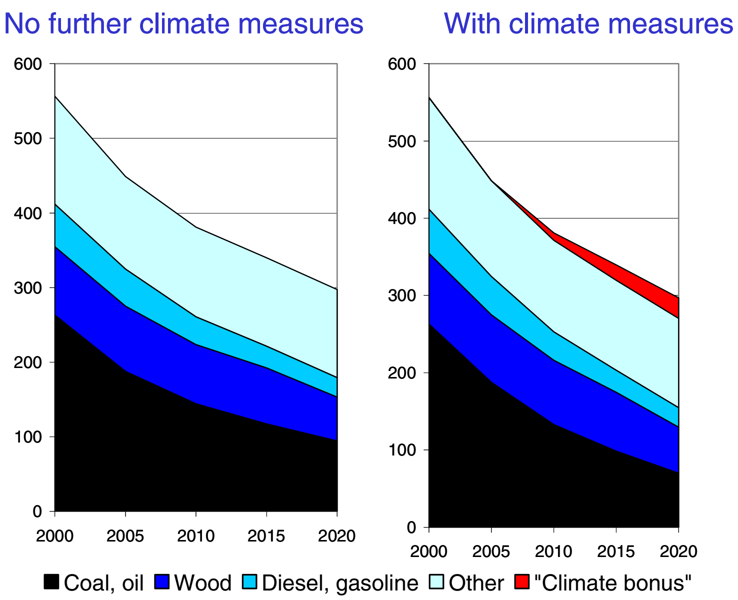


Figure 4.29: PM10 emissions by fuel for the New Member States (kt).

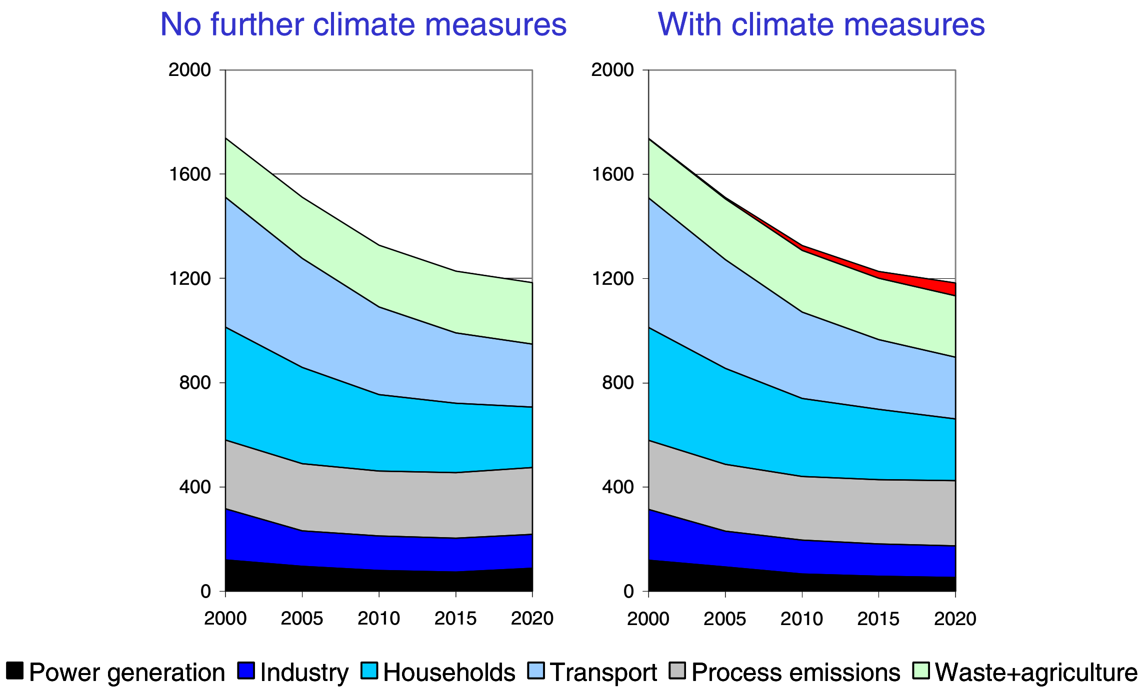


Figure 4.30: PM10 emissions by sector for the EU-15 (kt).

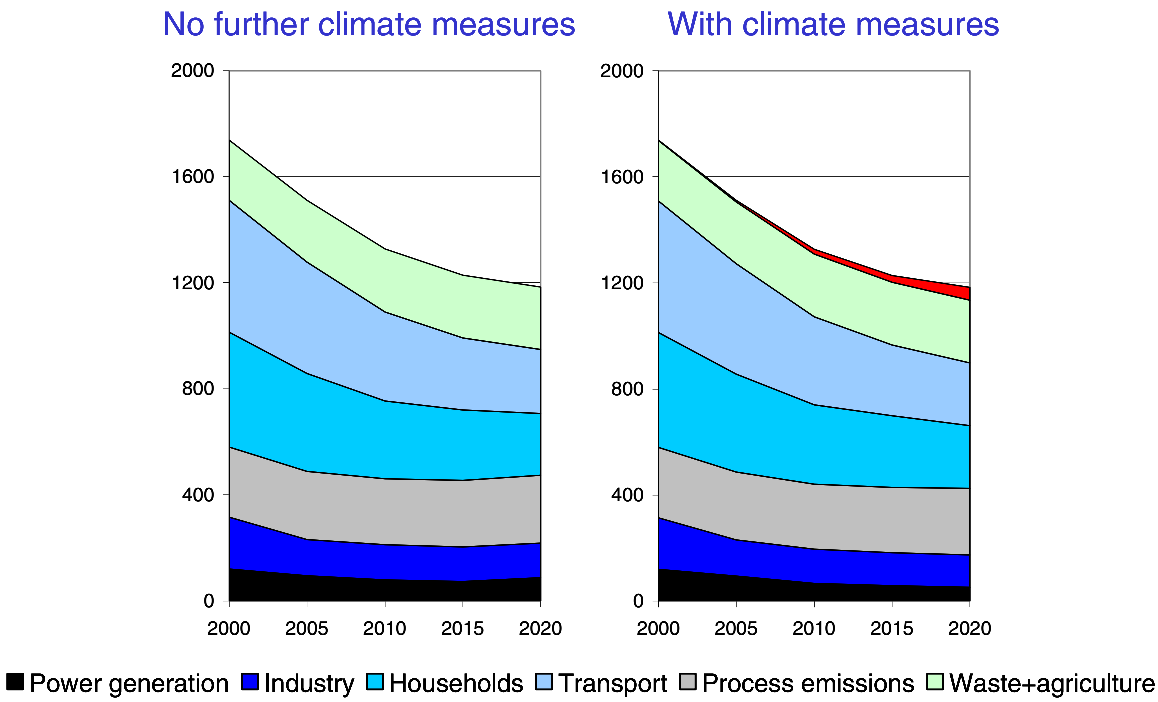


Figure 4.31: PM10 emissions by sector for the New Member States (kt).

Table 4.30: Total primary emissions of PM10 (kt) for the two PRIMES scenarios.

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	47	42	39	37	42	39	37
Belgium	63	43	41	40	42	40	38
Denmark	34	28	26	24	28	26	24
Finland	42	37	35	33	37	34	32
France	358	274	255	248	272	251	232
Germany	254	218	205	204	212	197	191
Greece	66	68	64	62	65	60	58
Ireland	20	17	15	14	17	15	14
Italy	264	176	156	144	174	154	141
Luxembourg	4	4	3	3	4	3	3
Netherlands	58	52	50	48	52	49	48
Portugal	58	48	47	47	48	48	47
Spain	227	157	146	138	155	144	133
Sweden	40	31	29	27	30	28	26
UK	202	131	116	114	130	113	108
Total EU-15	1738	1327	1228	1184	1309	1202	1134
Cyprus	5	5	5	5	5	5	5
Czech Rep.	83	53	45	37	51	43	33
Estonia	42	18	12	9	18	10	8
Hungary	50	38	38	37	37	34	32
Latvia	10	8	7	6	7	7	5
Lithuania	20	18	17	15	18	16	14
Malta	1	1	1	1	1	1	1
Poland	299	206	182	155	202	172	145
Slovakia	28	22	21	20	21	20	19
Slovenia	21	14	13	11	13	12	8
Total NMS	559	382	340	298	372	320	271
Total EU-25	2296	1708	1568	1482	1681	1522	1405

Table 4.31: PM emission (kt) estimates for 2000.

	PM10		*PM2.5*	
	RAINS	*National estimate*	*RAINS*	*National estimate*
Austria	47	47	35	27
Belgium	63	65	38	36
Denmark	34	20	23	13
Finland	42	54	36	38
France	358	545	277	299
Germany	254		166	
Greece	66		50	
Ireland	20	17	13	12
Italy	264		202	
Luxembourg	4		3	
Netherlands	58	62	37	38
Portugal	58	438	45	371
Spain	227		163	
Sweden	40	64	30	43
UK	202	187	130	108
Total EU-15	1738		1249	
Cyprus	5	1	3	
Czech Rep.	83	43	55	
Estonia	42		22	
Hungary	50	46	36	20
Latvia	10		7	
Lithuania	20	1	17	
Malta	1		1	
Poland	299	282	211	135
Slovakia	28		18	
Slovenia	21		15	
Total NMS	629		445	
Total EU-25	2367		1694	

Table 4.32: Primary PM2.5 missions by fuel type for the EU-15 (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	22	15	12	14	11	8	8
Hard coal	88	41	32	37	36	25	22
Other solids	351	267	250	221	273	257	227
Heavy fuel oil	31	22	21	19	21	20	18
Middle distillates	367	206	146	114	202	143	111
Gasoline	54	42	35	34	43	36	34
Natural gas	1	2	2	2	2	2	2
Process emissions	333	298	300	302	295	296	298
Total	1247	893	799	741	885	787	720

Table 4.33: Primary PM2.5 emissions by fuel type for the New Member States (kt).

		No further climate measures			*With further climate measures*		
	2000	2010	2015	2020	2010	2015	2020
Brown coal	45	23	17	16	22	15	13
Hard coal	122	73	59	44	66	49	32
Other solids	89	77	73	57	80	74	58
Heavy fuel oil	3	3	2	2	3	2	2
Middle distillates	44	24	15	11	24	15	11
Gasoline	7	5	5	5	5	5	5
Natural gas	0	0	0	0	0	0	0
Process emissions	75	62	62	62	62	61	61
Total	385	266	233	197	262	221	181

Table 4.34: Primary emissions of PM2.5 by SNAP sector for the EU-15 (kt).

		No further climate measures			*With further climate measures*		
SNAP sector	2000	2010	2015	2020	2010	2015	2020
1: Combustion in energy industries	77	53	48	55	45	39	36
2: Non-industrial combustion plants	393	276	253	222	282	258	226
3: Combustion in manufacturing industry	115	80	81	81	79	79	79
4: Production processes	120	113	114	116	111	111	113
5: Extraction and distribution	4	3	3	3	3	3	2
6: Solvent use	269	136	99	88	136	98	86
7: Road transport	162	121	92	68	118	89	66
8: Other mobile sources and machinery	68	68	68	67	68	68	67
9: Waste treatment	42	44	44	44	44	44	44
Total	1249	894	801	743	886	788	720

Table 4.35: Primary emissions of PM2.5 by SNAP sector for the New Member States (kt).

SNAP sector	2000	*No further climate measures* 2010	2015	2020	*With further climate measures* 2010	2015	2020
1: Combustion in energy industries	58	43	39	37	39	32	25
2: Non-industrial combustion plants	192	128	108	78	128	104	76
3: Combustion in manufacturing industry	23	14	15	15	14	14	14
4: Production processes	19	11	11	11	11	11	11
5: Extraction and distribution	3	2	2	2	2	2	1
6: Solvent use	30	15	11	10	15	11	10
7: Road transport	22	14	9	6	13	9	6
8: Other mobile sources and machinery	14	13	13	13	13	13	13
9: Waste treatment	25	26	26	26	26	26	26
Total	385	266	233	197	262	221	182

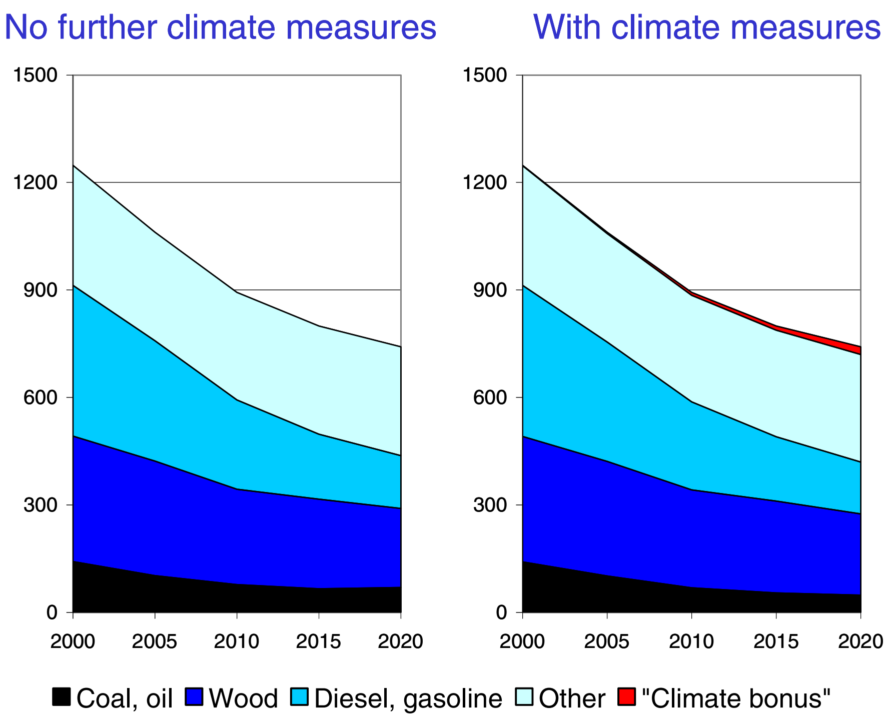


Figure 4.32: PM2.5 emissions by fuel for the EU-15 (in kt).

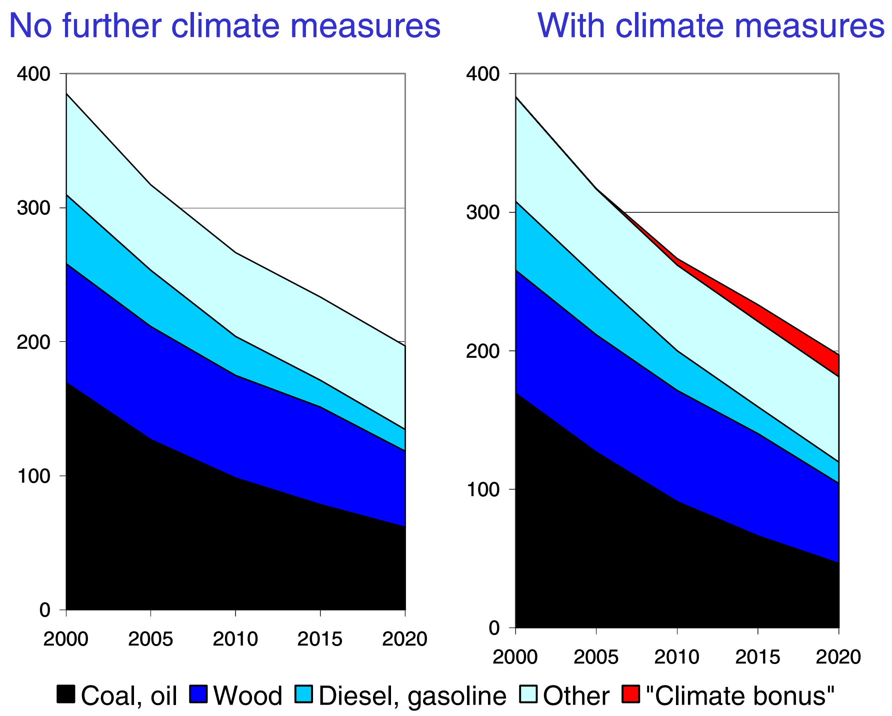


Figure 4.33: PM2.5 emissions by fuel for the New Member States (in kt).

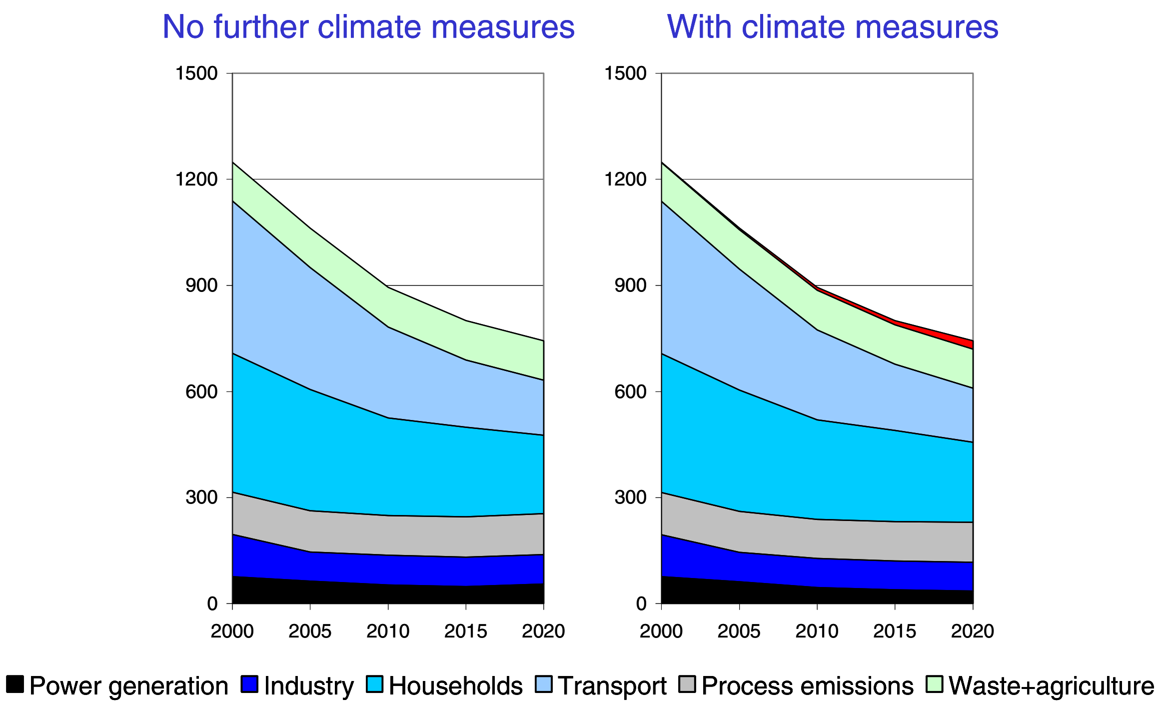


Figure 4.34: PM2.5 emissions by sector for the EU-15 (in kt).

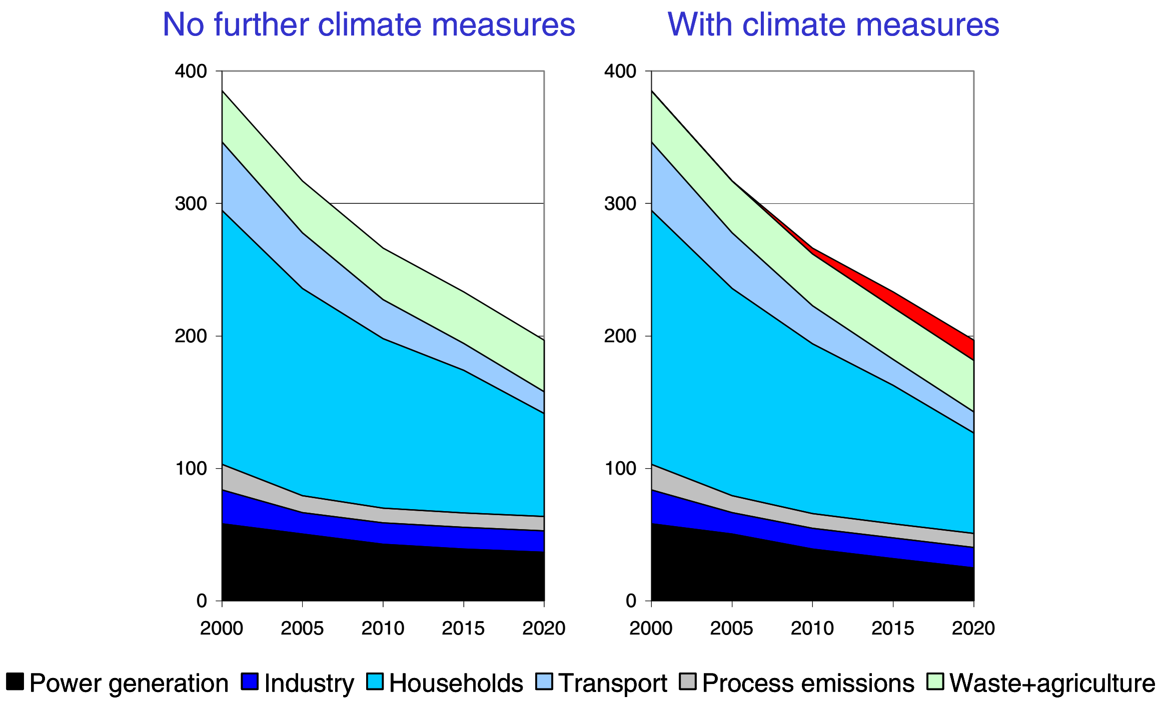


Figure 4.35: PM2.5 emissions by sector for the New Member States (in kt).

Table 4.36: Total primary emissions of PM2.5 (kt) for the two PRIMES scenarios.

		No further climate measures			*With further climate measures*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	35	29	27	25	30	27	25
Belgium	38	24	23	21	24	22	20
Denmark	23	18	16	15	18	16	15
Finland	36	31	28	26	31	28	26
France	277	196	176	162	196	175	156
Germany	166	132	120	117	129	116	110
Greece	50	50	47	44	48	44	42
Ireland	13	11	9	8	10	9	8
Italy	202	126	106	93	125	105	92
Luxembourg	3	2	2	2	2	2	2
Netherlands	37	29	27	25	29	27	25
Portugal	45	38	37	36	38	37	37
Spain	163	107	96	86	106	95	84
Sweden	30	21	19	17	21	19	17
UK	130	80	67	65	79	66	61
Total EU-15	1249	894	801	743	886	788	720
Cyprus	3	3	3	3	3	3	3
Czech Rep.	55	34	28	23	33	27	20
Estonia	22	13	9	7	13	8	6
Hungary	36	26	25	24	26	23	21
Latvia	7	6	5	4	6	5	4
Lithuania	17	14	14	12	14	13	11
Malta	1	1	1	1	1	1	1
Poland	211	146	127	104	145	121	98
Slovakia	18	14	13	13	13	12	12
Slovenia	15	10	9	7	10	8	6
Total NMS	385	266	233	197	262	221	182
Total EU-25	1634	1161	1034	940	1148	1010	902

5 Air quality and impacts

5.1 PM2.5

The Eulerian EMEP model has been used to calculate changes in the anthropogenic contribution to ambient concentrations of PM2.5 in Europe resulting from the changes in the precursor emissions (primary PM2.5, SO_2, NO_x, NH_3).

However, at the moment, the scientific peers do not consider the modelling of total particulate mass of the EMEP model (and of all other state-of-the-art models) as accurate and robust enough for policy analysis. Thus, one should not base an integrated assessment on estimates of total PM mass concentrations.

The largest deficiencies have been identified in the quantification of the contribution of natural sources (e.g., mineral dust, organic carbon, etc.) and water. The quantification of secondary organic aerosols (SOA) is not considered mature enough to base policy analysis on. A certain fraction of SOA is definitely caused by anthropogenic emissions, but some estimates suggest that the contribution from natural sources might dominate total SOA. Clarification of this question is urgent to judge whether the inability of contemporary atmospheric chemistry models to quantify SOA is a serious deficiency for modelling the anthropogenic fraction of total PM mass.

In contrast, the modelling of secondary inorganic aerosols is considered reliable within the usual uncertainty ranges. This applies especially to sulphur aerosols. The lack of formal validation of the nitrate calculations is explained by insufficient monitoring data with known accuracy; the model performs reasonably well for other nitrogen-related compounds.

The validation of calculations for primary particles is hampered by insufficient observational data on PM composition. Primary particles comprise a variety of chemical species, some of which (e.g., organic aerosols) originate also from secondary particle formation. Work at EMEP is underway to use improved emission inventories of black carbon, which are themselves only in a research phase, to use black carbon monitoring data as a tracer for emissions of primary particles. In principle, however, modelling of the dispersion of largely non-reactive substances like primary particles is generally considered as a not too ambitious undertaking. Thus, with some further evidence from EMEP/MSC-W on the performance of the Eulerian model for black carbon, an integrated assessment could rely on EMEP's dispersion calculations for primary particles over Europe.

Thus, there are arguments that the present modelling capabilities allow quantification of the dispersion of (most of) the fine particles of anthropogenic origin. This permits calculating changes in PM concentrations over Europe due to changes in anthropogenic emissions, and to estimate the health impacts that can be attributed to anthropogenic emission controls. On the other hand, it is not possible to make any statements on the absolute level of PM mass concentrations, and subsequently not on the absolute health impacts of the total particle burden in the atmosphere. This limitation, however, does not seem to impose unbalanced restrictions on the overall analysis, since also the evidence from the available epidemiological studies does not allow drawing conclusions about the total health impacts.

Figure 5.1 presents the modelled anthropogenic contribution to rural PM2.5 concentrations (primary anthropogenic PM and secondary inorganic aerosols) for the emissions of the year 2000 for the meteorological conditions of 1999 and 2003. The graphs show a substantial influence of the inter-annual meteorological variability on PM2.5 concentrations. Since at present model calculations are only available for these two years and no statement on the representativeness of these meteorological conditions can be made, the further calculations presented in this report use the mean meteorological conditions from these years as a basis.

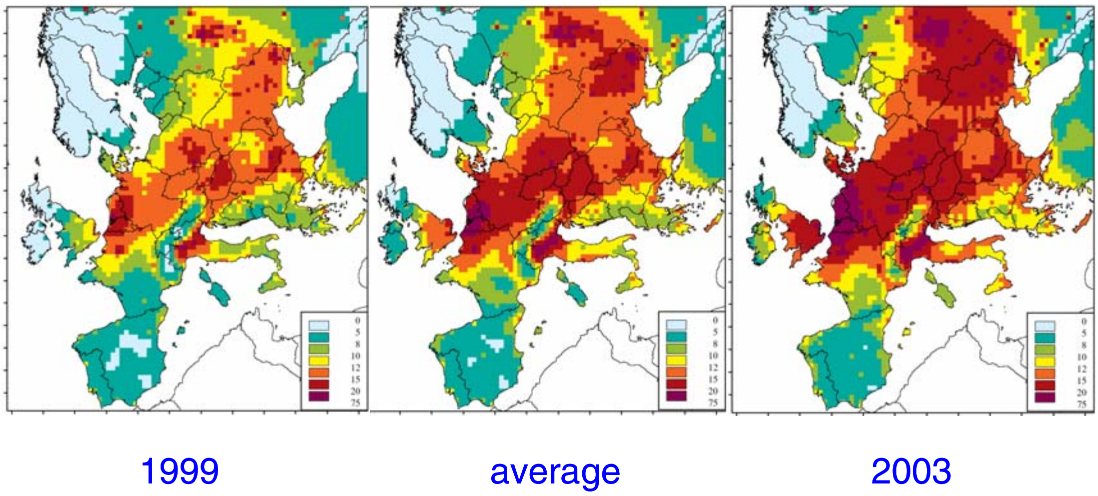


Figure 5.1: Identified anthropogenic contribution to rural concentrations of PM2.5 (annual mean concentrations, µg/m^3), for the emissions of the year 2000 calculated for the meteorological conditions of 1999 (left panel) and the meteorological conditions of 2003 (right panel). For the further analysis, the mean meteorology (center panel) is used. These calculations do not reproduce the total observed mass of PM2.5, since the contributions from natural sources and secondary organic aerosols, which originate to a certain extent from anthropogenic sources, are not quantified.

As shown in Figure 5.2, the decline in emissions of primary particles as well as in the precursor emissions for secondary aerosols is calculated to lead to significant reductions of PM2.5 concentrations throughout Europe. While the absolute levels given in the graphs cannot be directly compared with observations, the changes in PM2.5 levels over time shown in this series of graphs should give a lower estimate of reductions in PM2.5 levels that can be expected from the declines in emissions. It should be kept in mind, however, that in reality these changes will be masked by the inter-annual meteorological variability as indicated in Figure 5.1.

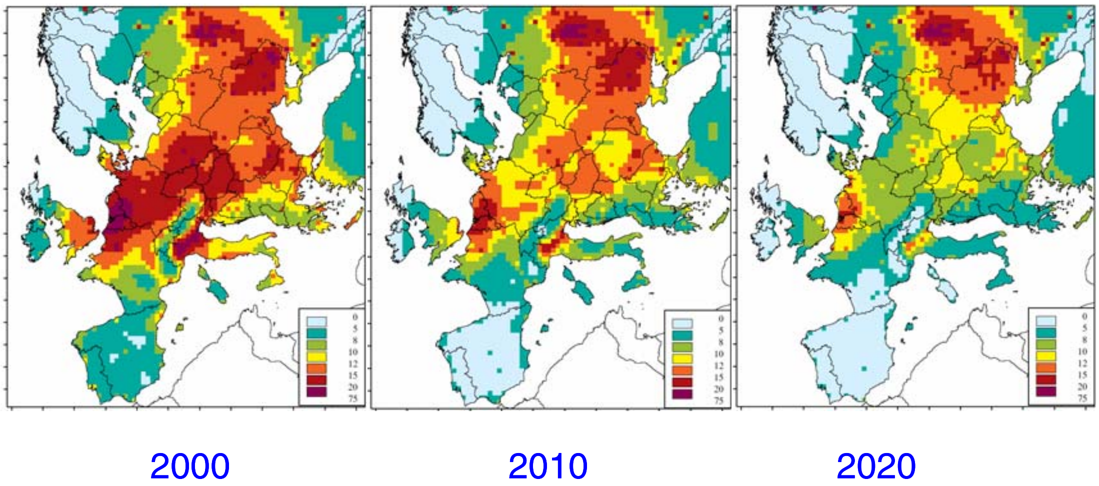


Figure 5.2: Identified anthropogenic contribution to modeled rural PM2.5 concentrations (annual mean, μg/m^3) for the baseline emissions of the year 2000 (left panel), the year 2010 (center panel) and for 2020 (right panel).

5.2 Losses in life expectancy due to anthropogenic PM2.5

Based on a methodology described in Amann et al. (2004), the RAINS model estimate changes in the loss in statistical life expectancy that can be attributed to changes in anthropogenic emissions (ignoring the role of secondary organic aerosols). This calculation is based on the assumption that health impacts can be associated with changes in PM2.5 concentrations. RAINS applies a linear concentration-response function and associates all changes in the identified anthropogenic fraction of PM2.5 with health impacts. Thereby, no health impacts are calculated for PM form natural sources and for secondary organic aerosols. It transfers the rate of relative risk for PM2.5 identified by Pope *et al.*, 2002 for 500.000 individuals in the United States to the European situation and calculates mortality for the population older than 30 years. Thus, the assessment in RAINS does not quantify infant mortality. Awaiting results from the City-Delta project, the provisional estimates presented in this First Interim Report assume PM2.5 from primary emissions in urban areas to be 25 percent higher than in the surrounding rural areas.

Results from these provisional estimates are presented in Figure 5.3. The reductions of the baseline emissions will significantly reduce calculated losses in life expectancy in the European Union, although even in 2020 for large parts of the population life expectancy losses attributable to anthropogenic PM exceed six months.

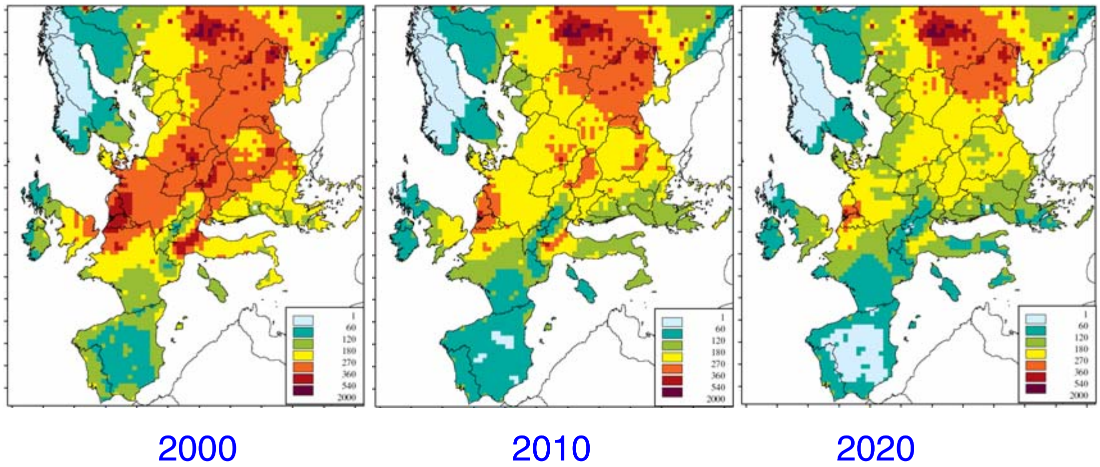


Figure 5.3: Loss in statistical life expectancy that can be attributed to the identified anthropogenic contributions to PM2.5 (in days).

5.3 Ozone

The Eulerian EMEP model has also been used to calculate changes in ozone concentrations resulting from the emissions of the baseline scenario.

Following the findings of the WHO review of health impacts of particulate matter and ozone, the joint WHO/UNECE Task Force on Health at its 7th session (6-7 May 2004) has concluded to relate health impacts of ozone (premature mortality) with the maximum daily eight-hour mean concentrations taking into account the full year. Since the EMEP model results have not yet been evaluated along this metric, this report cannot present a health impact assessment for ozone.

Instead, Figure 5.4 presents the evolution of the excess ozone that is considered harmful for forest trees, using the AOT40 (accumulated ozone over a threshold of 40 ppb) as a metric. The updated manual for critical levels (UN/ECE, 2004) specifies a no-effect critical level of 5 ppm.hours for trees. Related to this quantity, significant excess ozone is calculated for 2000 for large parts of the European Union. Baseline emission reductions will improve the situation, but will not be sufficient to eliminate the risk even by 2020.

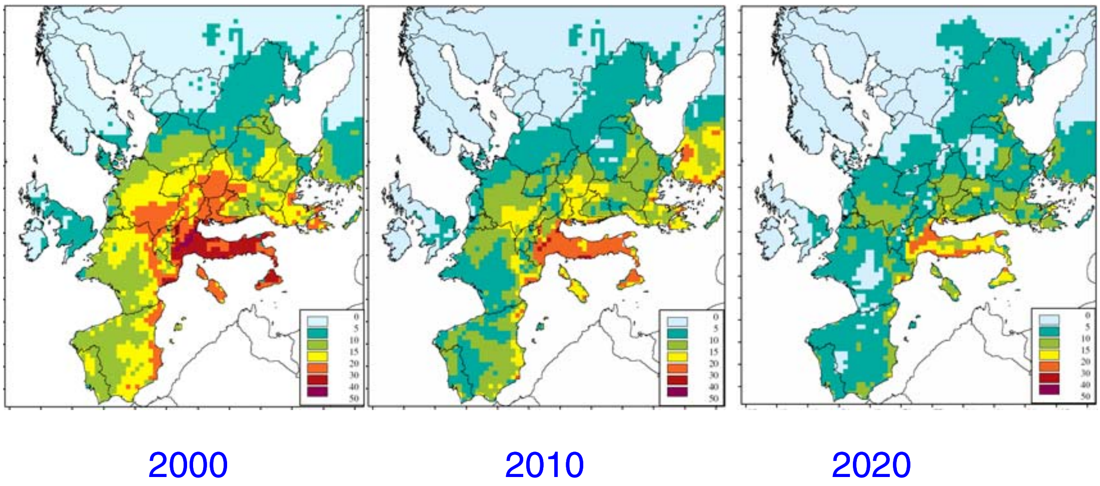


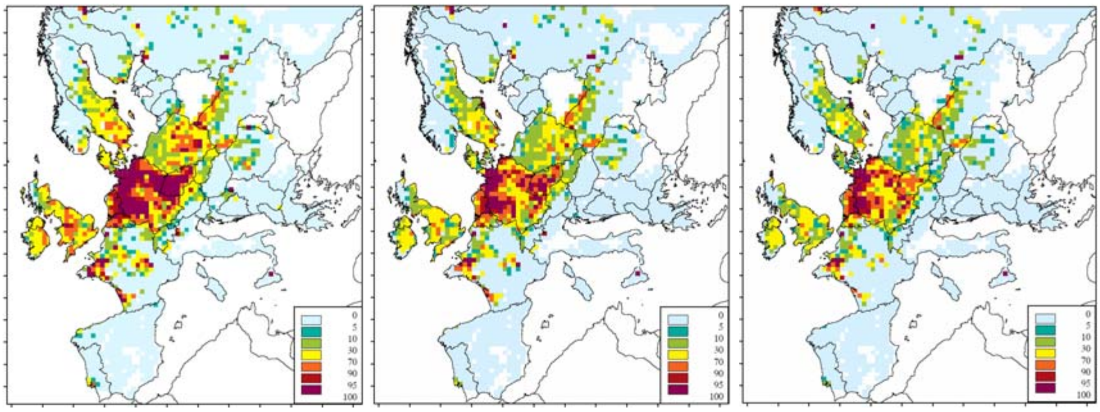
Figure 5.4: Rural AOT40 for forests (in ppm.hours) calculated for the baseline scenario, based on mean meteorological conditions of 1999 and 2003. The critical level for forest trees indicating a no-effect threshold is set at 5 ppm.hours.

5.4 Acid deposition

The baseline projections also suggest improvements in ecosystems protection against acid deposition. However, due to improved scientific insight which now allows reliable calculation of specific deposition rates for individual land use types (forests, open land, etc.), a systematic underestimation of deposition to forests that was inherent to earlier calculations could be removed. Thus, substantially larger quantities of sulfur and nitrogen deposition is now calculated for forest ecosystems than was calculated earlier, e.g., for the NEC directive.

Figure 5.5 displays the evolution of forest area over time receiving acid deposition above their critical loads (using the 2003 critical loads data). Obviously, the situation is expected to improve, but substantial areas are calculated to remain at risk. This is mainly due to the almost constant levels of ammonia emissions, which make ammonia to the dominating source of acidification in the future.

This calculation has to be considered as preliminary, and further analysis involving the scientific effects community will be necessary to provide a comprehensive interpretation of these results. In a similar way, further analysis will be able to assess acidification of aquatic ecosystems.



2000 2010 2020

Figure 5.5: Percentage of forest area receiving acid deposition above the critical loads for the baseline emissions for 2000, 2010 and 2020. Results averaged from the calculations for 1999 and 2003 meteorological conditions, using ecosystem-specific deposition for forests. Critical loads data base of 2003.

6 Conclusions

This First Interim Report on CAFE emission scenarios presents a first perspective on the likely future development of emissions and air quality in Europe in absence of further legal measures to control emissions. While this assessment brings together for the first time a wide range of updated information on economic development, energy policies, emission inventories, atmospheric dispersion and impacts of air pollution, it has to be considered as provisional since information in all these fields needs further refinement and validation.

However, despite the large number of outstanding improvements in detail, the overall picture at the European scale as presented in this report is unlikely to change dramatically. Thus, a preliminary conclusion would suggest that the full implementation of the present legislation on emission controls will lead to significant reduction of emissions in the future, both in the EU-15 and in the New Member States. However, these improvements are not likely to fully eliminate all negative impacts of air pollution within the time period analyzed in this report.

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