NEC Scenario Analysis Report Nr. 1

Baseline scenarios for the revision of the NEC Emission Ceilings Directive

Part 2: Health and environmental impacts

September 2006

Background document for the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020

Brussels

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Introductory note:

This report provides a preview on the NEC baseline projections of air pollutant emissions as a basis for the discussions at the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020, Brussels, September 29, 2006. Detailed information on emission projections for individual countries and sectors will be made available on the Internet (www.iiasa.ac.at/web-apps/apd/RainsWeb/index.html) before the Conference.

Glossary of terms used in this report

CAFE	Clean Air For Europe Programme
CAP	Common Agricultural Policy
CAPRI	Agricultural model developed by the University of Bonn
CH_4	Methane
CLE	Current legislation
CO_2	Carbon dioxide
EEA	European Environment Agency
EFMA	European Fertilizer Manufacturer Association
EMEP	European Monitoring and Evaluation Programme
EU	European Union
GW	Gigawatt
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control
kt	kilotons = 10^3 tons
Mt	megatons = 10^6 tons
N_2O	Nitrous oxides
NEC	National Emission Ceilings
NH_3	Ammonia
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	Sector aggregation system of the CORINAIR emission inventory
SO_2	Sulphur dioxide
SOMO35	Sum of excess of daily maximum 8-h means over the cut-off of 35 ppb calculated for all days in a year
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
WHO	World Health Organisation

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6 Health and environmental impacts

This section provides a preliminary assessment of the health and environmental impacts of the baseline emissions projected for the various scenarios for the year 2020. Due to time constraints in producing this report before the Conference on Air Pollution and Greenhouse Gas Emission Projections for 2020, this assessment relies on approximations conducted with the reduced-form functional relationships of the RAINS model, while the full impact assessment is usually carried out based on calculations with the comprehensive EMEP Eulerian atmospheric transport model for the emissions of a particular scenario. Thus, the quantitative results presented in this report have to be considered as indicative to allow a timely assessment of air quality impacts for the Conference. **However, they should not be directly compared with quantitative estimates of the environmental impacts presented in the reports of the CAFE programme without considering the methodological differences.** A full assessment of the environmental impacts of the baseline scenarios will be presented together with the first policy analysis scenarios in December 2007.

One of the shortcomings of this preliminary assessment relates to the quantification of impacts for countries outside the EU-25, which could only partially be completed due to lack of data.

Among other modifications, the assessment of ecosystems protection against acidification and eutrophication presented in this report employs the most recent database on critical loads as approved by the UNECE Working Group on Effects in August 2006, while the CAFE assessment relied on the 2004 version of this database.

Further methodological improvements are underway to be completed before the final impact assessment in the course of the policy scenario analyses at the end of 2006. These will include:

- an improved methodology to estimate urban pollution levels, based on the outcomes of the City-Delta III project,
- the consideration of the inter-annual meteorological variability through the analysis of the meteorological conditions of five different years,
- updated estimates of the projected pollution levels in the non-EU countries and their impacts on background levels in the EU,
- an improved representation of the formation of ground-level ozone,
- revised assumptions on the likely development of hemispheric ozone background levels,
- revised projections of emissions from marine activities,
- updated projections of the emissions on the non-EU countries and their impacts on background air quality in the EU-25.

6.1 Health impacts of fine particulate matter

The preliminary analysis of health impacts of fine particulate matter indicates for the national energy projections – for the EU-25 as a whole – a loss in statistical life expectancy attributable to PM2.5 similar to the impacts of the CAFE baseline scenario (5.5 months in 2020), compared to 7.7 months in 2000 (Table 6.1). While the new estimate for the base year is somewhat lower than in the CAFE analysis due to modifications in the emission inventories of PM2.5, the impacts estimated for 2020 remain constant despite significantly higher emissions of energy-related air pollutants (SO_2, NO_x and PM2.5) than resulting from the CAFE baseline projection. This is caused by the lower projection of agricultural ammonia emissions, mainly due to the impacts of the mid-term review of the CAP reform.

Table 6.1: Preliminary estimates of loss in statistical life expectance attributable to the human exposure to fine particulate matter (PM2.5) originating from anthropogenic emission sources (months)

	2000	*2020*		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	6.7	5.0	4.7	5.0
Belgium	12.9	9.2	8.8	9.3
Cyprus	4.4	4.1	4.1	4.2
Czech Rep.	8.9	6.4	6.1	5.8
Denmark	5.7	4.3	4.2	4.6
Estonia	3.6	3.2	2.8	2.9
Finland	2.3	2.1	2.0	2.1
France	7.5	5.4	5.5	5.6
Germany	9.1	6.2	5.9	6.7
Greece	6.1	4.9	4.8	5.0
Hungary	10.7	8.4	7.7	7.6
Ireland	4.0	2.5	2.4	2.7
Italy	7.3	5.6	5.2	5.3
Latvia	4.3	3.8	3.5	3.4
Lithuania	5.4	4.5	4.4	4.6
Luxembourg	9.3	6.4	6.2	6.8
Malta	5.9	5.1	4.9	5.2
Netherlands	11.7	8.4	8.0	8.7
Poland	9.3	7.2	7.1	6.7
Portugal	6.3	3.6	3.3	3.2
Slovakia	9.2	7.0	6.6	6.4
Slovenia	7.7	6.0	5.6	5.7
Spain	4.7	3.0	2.9	3.0
Sweden	2.9	2.4	2.3	2.7
UK	7.0	4.5	4.4	4.8
EU-25	7.7	5.5	5.3	5.5
Bulgaria				
Croatia				
Romania				
Turkey				
Norway				
Switzerland				

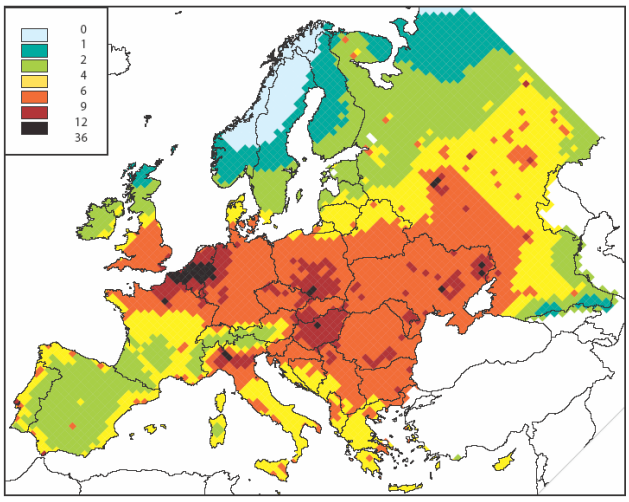

Figure 6.1: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for the emissions of the year 2000 (in months)

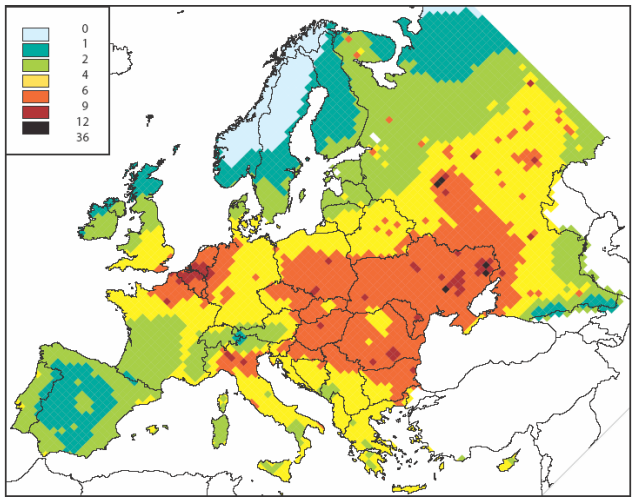

Figure 6.2: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for the emissions of the national energy projections for the year 2020 (in months)

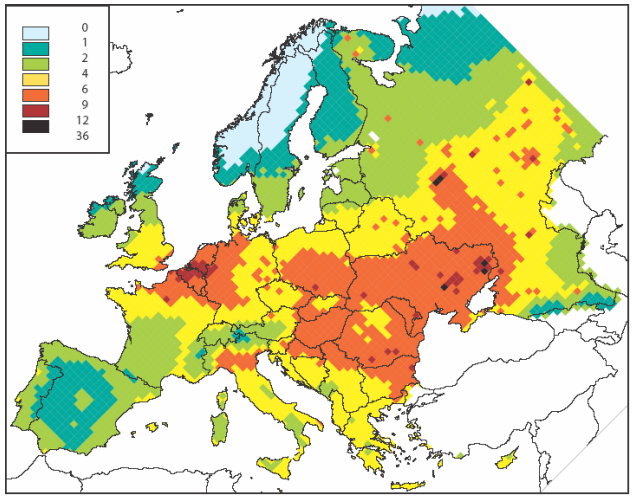

Figure 6.3: Loss in statistical life expectancy attributable to the exposure to PM2.5 from anthropogenic sources for CAFE baseline scenario for 2020 (in months)

6.2 Premature mortality attributable to ground-level ozone

Due to time constraints in producing this report, only a very preliminary analysis with numerous assumptions could be conducted for the health impacts of ground-level ozone. While all quantitative conclusions from the applied methodology must be interpreted with extreme caution, somewhat meaningful findings can only be drawn from a comparison of the impact estimates for the year 2020. This limitation is caused, inter alia, by the nature of the applied ozone formation model that is only designed for changes in emissions in a narrow range around the levels that are likely for the year 2020. Furthermore, the available coefficients of this model have been developed for an earlier (lower) assumption on the development of hemispheric background ozone, and they do not reflect latest information on the development of emissions from ships and from the non-EU countries. Furthermore, due to important non-linearities in ozone formation the full assessment, which will be produced for the follow-up policy scenario analysis, could change this estimate result significantly.

With this caveats, the indicative assessment suggests slightly higher numbers of premature deaths attributable to ozone. Compared to the CAFE baseline scenario the increase ranges between five and nine percent, depending on the energy projection, and is mainly related to higher NO_x emissions.

Table 6.2: Preliminary estimates of the number of cases of premature deaths attributable to the human exposure to ground-level ozone. In particular, the estimate for the year 2000 reflects a zero-order approximation only (see note below). These numbers should not be used for drawing robust conclusions.

	2000)*	*2020*		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria		366	343	327
Belgium		433	418	416
Cyprus		24	23	24
Czech Rep.		475	448	397
Denmark		173	167	162
Estonia		20	19	18
Finland		56	54	52
France		2481	2334	2302
Germany		3945	3813	3580
Greece		496	488	479
Hungary		606	576	524
Ireland		83	79	80
Italy		3796	3621	3493
Latvia		55	52	50
Lithuania		51	50	47
Luxembourg		30	29	28
Malta		20	19	18
Netherlands		473	456	455
Poland		1130	1114	997
Portugal		475	461	443
Slovakia		195	185	167
Slovenia		92	84	80
Spain		1929	1875	1720
Sweden		186	181	176
UK		1901	1860	1854
EU-25		19490	18750	17888
Bulgaria				
Croatia				
Romania				
Turkey				
Norway				
Switzerland				

*) No robust assessment available at this time.

6.3 Protection of ecosystems against acidification

Furthermore, initial estimates are available for the protection of ecosystems against acidification and eutrophication. Since, at time of writing this report, the revised estimate for the CAFE baseline projection is not completed, no comparisons to earlier estimates can be drawn in this background paper.

6.3.1 Forests

Table 6.3: Preliminary estimates of forest area with acid deposition above critical loads for acidification

	Forest area with acid deposition above critical loads for acidification [km^2]				*Percent of forest area with acid deposition above critical loads for acidification*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	372	0	0		1%	0%	0%	
Belgium	4797	1600	1082		76%	25%	17%	
Cyprus	0	0	0		0%	0%	0%	
Czech Rep.	8875	4363	2867		79%	39%	26%	
Denmark	1176	171	90		37%	5%	3%	
Estonia	0	0	0		0%	0%	0%	
Finland	3534	1947	1563		2%	1%	1%	
France	17032	10888	8857		10%	6%	5%	
Germany	62743	29418	20726		62%	29%	21%	
Greece	960	260	257		10%	3%	3%	
Hungary	50	0	0		1%	0%	0%	
Ireland	2012	788	680		47%	19%	16%	
Italy	0	0	0		0%	0%	0%	
Latvia	354	0	0		1%	0%	0%	
Lithuania	12797	8792	8389		73%	50%	48%	
Luxembourg	272	170	167		33%	21%	20%	
Malta								
Netherlands	5116	5014	4927		91%	89%	87%	
Poland	50820	16554	15352		58%	19%	17%	
Portugal	4304	1046	1042		20%	5%	5%	
Slovakia	4602	1748	1569		24%	9%	8%	
Slovenia	666	2	2		13%	0%	0%	
Spain	946	77	51		1%	0%	0%	
Sweden	40097	11331	8538		18%	5%	4%	
UK	11122	4341	3805		56%	22%	19%	
EU-25	232647	98554	79992		19%	8%	7%	
Bulgaria	0	0	0		0%	0%	0%	
Croatia	652	0	0		9%	0%	0%	
Romania	3316	144	100		5%	0%	0%	
Turkey								
Norway	1769	375	248		3%	1%	0%	
Switzerland	1748	656	701		15%	6%	6%	

6.3.2 Semi-natural vegetation

Table 6.4: Preliminary estimates of semi-natural ecosystems with acid deposition above critical loads for acidification

	Area with semi-natural ecosystems with acid deposition above critical loads for acidification [km^2]				*Percent of area with semi-natural ecosystems with acid deposition above critical loads for acidification*			
	2000		2020		2000		2020	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Belgium	433	182	112		59%	25%	15%	
Cyprus	0	0	0		0%	0%	0%	
France	3371	2665	2507		36%	28%	27%	
Germany	714	231	97		22%	7%	3%	
Ireland	403	4	3		9%	0%	0%	
Italy	0	0	0		0%	0%	0%	
Netherlands	1094	985	904		64%	58%	53%	
UK	16865	4031	3519		34%	8%	7%	
EU-25	22886	8100	7139		21%	8%	7%	

6.3.3 Freshwater ecosystems

Table 6.5: Preliminary estimates of freshwater ecosystems with acid deposition above critical loads

	Catchment area of freshwater ecosystems with acid deposition above critical loads for acidification [km^2]				*Percent of Catchment area of freshwater ecosystems with acid deposition above critical loads for acidification*			
	2000		2020		2000		2020	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Finland	29	13	11		0%	0%	0%	
Italy	0	0	0		0%	0%	0%	
Sweden	28114	18056	16380		10%	6%	6%	
UK	674	268	225		9%	3%	3%	
EU-25	28825	18352	16612		9%	6%	5%	
Norway	58470	36886	34180		18%	11%	11%	
Switzerland	122	74	67		74%	45%	41%	

6.4 Protection of ecosystems against eutrophication

6.4.1 Forests

Table 6.6: Preliminary estimates of forest area with nitrogen deposition above critical loads for eutrophication

	Forest area with nitrogen deposition above critical loads for eutrophication [km^2]				*Percent of forest area with nitrogen deposition above critical loads for eutrophication*			
	2000	2020			2000	2020		
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	35184	26455	24268		98%	74%	68%	
Belgium	6306	6171	6141		100%	98%	97%	
Cyprus	1526	1521	1521		66%	66%	66%	
Czech Rep.	11163	10788	10755		100%	97%	96%	
Denmark	3010	2582	2548		96%	82%	81%	
Estonia	9155	3934	2252		43%	18%	11%	
Finland	80992	35748	36806		34%	15%	15%	
France	169343	160350	158575		99%	94%	93%	
Germany	99965	95200	94321		99%	94%	93%	
Greece	9326	9326	9326		100%	100%	100%	
Hungary	10262	6882	5870		98%	66%	56%	
Ireland	4081	3793	3786		96%	89%	89%	
Italy	77693	62459	55653		87%	70%	62%	
Latvia	25847	25617	25104		96%	95%	93%	
Lithuania	17651	17651	17651		100%	100%	100%	
Luxembourg	821	821	821		100%	100%	100%	
Malta					0%	0%	0%	
Netherlands	2645	2577	2559		99%	96%	96%	
Poland	86439	82992	83381		98%	94%	94%	
Portugal	20159	20030	19578		95%	94%	92%	
Slovakia	19230	17026	16331		100%	88%	85%	
Slovenia	5264	5246	5240		100%	100%	100%	
Spain	77597	68674	67123		91%	81%	79%	
Sweden	40840	18111	17300		18%	8%	8%	
UK	18392	14671	14383		92%	74%	72%	
EU-25	832916	698645	681344		68%	57%	56%	
Bulgaria	45764	40037	39360		95%	83%	81%	
Croatia	3469	2801	2766		50%	40%	40%	
Romania	60546	59648	59635		96%	95%	95%	
Turkey					0%	0%	0%	
Norway					0%	0%	0%	
Switzerland	9273	6726	6991		94%	68%	71%	

6.4.2 Semi-natural ecosystems

Table 6.7: Preliminary estimates of semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication

	Area with semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of area with semi-natural ecosystems with nitrogen deposition above critical loads for eutrophication*			
	2000		2020		2000		2020	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Belgium	421	269	267		57%	36%	36%	
Cyprus	1556	1564	1560		89%	90%	90%	
France	7332	6939	6855		78%	74%	73%	
Germany	1696	1093	1079		52%	34%	33%	
Ireland	3890	2862	2945		83%	61%	63%	
Italy	10796	9339	8344		30%	26%	23%	
Netherlands	1442	1247	1221		84%	73%	71%	
UK	4394	462	483		8%	1%	1%	
EU-25	31656	23771	22752		28%	21%	20%	
Norway	10806	4271	4271		3%	1%	1%	
Switzerland	7000	4096	3480		55%	32%	27%	

6.4.3 Freshwater ecosystems

Table 6.8: Preliminary estimates of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication

	Catchment area of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication [km²]				*Percent of catchment area of freshwater ecosystems with nitrogen deposition above critical loads for eutrophication*			
	2000		2020		2000		2020	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Italy	10796	9339	8344		30%	26%	23%	
Netherlands	10796	9339	8344		30%	26%	23%	
EU-25	10796	9339	8344		30%	26%	23%	
Switzerland	10796	9339	8344		30%	26%	23%	

6.4.4 All ecosystems

Table 6.9: Preliminary estimates of total ecosystems area with nitrogen deposition above critical loads for eutrophication

	Total ecosystems area with nitrogen deposition above critical loads for eutrophication [km^2]				*Percent of total ecosystems area with nitrogen deposition above critical loads for eutrophication*			
	2000		2020		2000		2020	
		National energy projections	PRIMES €20 scenario	CAFE baseline projection		National energy projections	PRIMES €20 scenario	CAFE baseline projection
Austria	35184	26455	24268		98%	74%	68%	
Belgium	6727	6440	6409		95%	91%	91%	
Cyprus	3082	3085	3081		76%	76%	76%	
Czech Rep.	11163	10788	10755		100%	97%	96%	
Denmark	3010	2582	2548		96%	82%	81%	
Estonia	9280	3933	2252		41%	18%	10%	
Finland	80992	35748	36806		34%	15%	15%	
France	176680	167296	165423		98%	93%	92%	
Germany	101663	96297	95401		98%	92%	92%	
Greece	9326	9326	9326		100%	100%	100%	
Hungary	10262	6882	5870		98%	66%	56%	
Ireland	7970	6655	6731		89%	75%	75%	
Italy	88492	71801	63996		70%	57%	51%	
Latvia	25847	25617	25104		96%	95%	93%	
Lithuania	17651	17651	17651		100%	100%	100%	
Luxembourg	821	821	821		100%	100%	100%	
Malta								
Netherlands	4092	3830	3786		93%	87%	86%	
Poland	86439	82992	83381		98%	94%	94%	
Portugal	20159	20030	19578		95%	94%	92%	
Slovakia	19230	17026	16331		100%	88%	85%	
Slovenia	5264	5246	5240		100%	100%	100%	
Spain	77597	68674	67123		91%	81%	79%	
Sweden	40840	18111	17300		18%	8%	8%	
UK	22788	15138	14863		31%	20%	20%	
EU-25	864593	722381	704005		65%	54%	53%	
Bulgaria	45764	40037	39360		95%	83%	81%	
Croatia	3469	2801	2766		50%	40%	40%	
Romania	60546	59648	59635		96%	95%	95%	
Turkey								
Norway	10806	4271	4271		3%	1%	1%	
Switzerland	16320	10871	10520		72%	48%	46%	

7 Conclusion

As a preparation for the revision of the National Emission Ceilings Directive, this report revisits the baseline projections on future European emissions and air quality that have been produced for the CAFE (Clean Air For Europe) programme for the European Union. It examines the implications of updated information on how Member States see the future development of their energy and agricultural systems, and which factors and assumptions have largest impacts on the projections of future emissions.

In 2004, the baseline analysis of the CAFE programme developed the following main conclusions:

- Emissions of air pollutants will further decline in the EU in the coming two decades. This is a consequence of progressing implementation of already decided emission control legislation, and of ongoing structural changes in the energy system. Largest declines are foreseen for energy related emissions, especially for SO_2, NO_x, VOC and primary PM2.5, while for emissions from agricultural activities lower declines are anticipated.
- Despite the projected decline in emissions, poor air quality will remain a threat to European population. Especially the exposure to fine particulate matter will result in significant shortening of statistical life expectancy.
- Also for vegetation, emissions will not decline sufficiently to safeguard sustainable conditions for the European forests, semi-natural ecosystems (e.g., nature protection areas) and freshwater bodies. While acidification will decline substantially, eutrophication from excess nitrogen deposition will remain a wide-spread threat throughout Europe.
- The relevance of emission sources will change due to legislation imposed on the currently largest contributors. Traditional “large polluters” will reduce their contributions and other sources will take over. Depending on the pollutant of concern, ships, industrial processes, small combustion sources, off-road machinery and agriculture will emerge as the main sources.
- Emissions from marine shipping will surpass emissions from land-based sources in the EU.
- The development in the energy and agricultural sectors are a main determinant for future emissions of air pollutants.

These conclusions also hold from the refined analysis conducted for the revision of the NEC Directive. The additional information on alternative projections of energy and agricultural activities collected for this analysis reinforces especially the last finding about the sensitivity of emission projections against the assumptions on future anthropogenic driving forces. Modified assumptions on agricultural trends and policies yield two times larger reductions of ammonia emissions than foreseen in the CAFE analysis. Conversely, different perspectives on the development of the energy sector result in up to 40 percent higher baseline emissions of SO_2, NO_x and PM2.5. The analysis reveals a particular strong association between assumptions on climate policy and air pollutant emissions, but indicates emission projections to be more robust against different assumptions about future oil prices or other energy policy issues.

The compilation of national energy projections discloses substantial differences to the CAFE baseline energy projection that has been developed in 2004 with the PRIMES energy model. National perspectives envisage significantly higher use of coal and diesel than the Europe-wide scenario. Most importantly, collectively for the EU-25 these national projections result in 2020 in a two percent increase in CO_2 emissions compared to the base year emissions of the Kyoto protocol.

Coherence between different policy areas is also an issue for the national projections in relation to the current Emission Ceilings Directive with 2010 as a target year. Taking into consideration the current national legislation communicated to IIASA by the national experts, emission projections for 2010 exceed for some Member States the national emission ceilings by a considerable margin. Largest discrepancies occur for NO_x, where the projected emissions of 11 out of 25 Member States exceed the national ceilings by more than 25 percent. Furthermore, for several Member States their national energy projections imply increasing emissions after the year 2010.

All issues outlined above, i.e., the dominant influence of assumptions on climate policy, the effectiveness of the implementation of the recent changes in agricultural policies, and the coherence with other policy fields will be critical elements in the forthcoming development of proposals for revised national emission ceilings.