CAFE Scenario Analysis Report Nr. 1

Baseline Scenarios for the Clean Air for Europe (CAFE) Programme

Final 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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EXECUTIVE SUMMARY

Clean Air For Europe
The Baseline Assessment

CLEAN AIR FOR EUROPE - THE BASELINE ASSESSMENT

Clean air is essential for a good quality of life and it enhances the social well being of European citizens. Scientific assessments reveal a range of harmful effects from the past and present levels of air pollution in Europe:

- Human health is seriously threatened by the exposure to fine particulate matter and ground-level ozone, causing several thousands of Europeans dying prematurely and reducing the life expectancy of Europeans by five to six months.
- The vitality of European forests and natural ecosystems is significantly weakened through multiple pathways of pollution: serious damage is caused by high ozone concentrations, acid deposition ("acid rain") and by excess nitrogen deposition endangering the biodiversity of plant communities.
- Thousands of European lakes and streams were not able to cope with the increased amounts of acid deposition and thus have lost their fauna and flora.
- Damage to agricultural crops caused by ground-level ozone reaches economically important dimensions.

In its Sixth Environmental Action Programme the European Union calls for action to improve air pollution to a level that does not give rise to harmful effects on human health and the environment.

New scientific insights

Recent advances in scientific research has improved – and changed – our understanding of how air pollution damages human health and the environment:

- While early medical studies found associations between peak levels of air pollution and health effects, more refined scientific methods reveal significant impacts of life-long exposure to ozone and small particles also at lower concentrations. Such levels typically prevail throughout Europe for most of the year. Overall health impacts resulting from this long-term exposure might be larger than those from peak exposure.
- New studies show that exposure to small particles (below a diameter of 2.5 µm, PM2.5) is associated with substantially increased mortality, especially from cardio-vascular and cardio-pulmonary diseases. Present levels of PM2.5 in Europe are now estimated to reduce the statistical life expectancy in European population by approximately nine months, comparable to the impacts of traffic accidents. Thus, these newly identified impacts of fine particles by far exceed those identified earlier for ozone.
- Following the recent decline in acid deposition, initial recovery has been observed for a number of acidified lakes. However, complete chemical recovery and full restoration of wildlife can take several decades, especially for many forest soils.
- Improved understanding of the nitrogen cycle reveals serious threats for biodiversity from excess nitrogen deposition from the atmosphere throughout Europe.

There is now common scientific understanding that all the important air quality problems mentioned above are strongly interrelated. All these pollutants are subject to long-range transport in the atmosphere, so that concentrations experienced at a given site originate from a large number of diverse emission sources across Europe. Thus, effective strategies for reducing pollution levels cannot be developed solely at the local scale, but need international cooperation.

The approach: Clean Air For Europe (CAFE)

The European Union has established a comprehensive legal framework to protect Europe's air quality. In its "Clean Air For Europe" (CAFE) programme the EU is currently revisiting this legislation. As a basis for future policy initiatives, CAFE brings together information on the likely development of air quality in Europe, taking into account the full effect of all emission control legislation "in the pipeline" and future economic development.

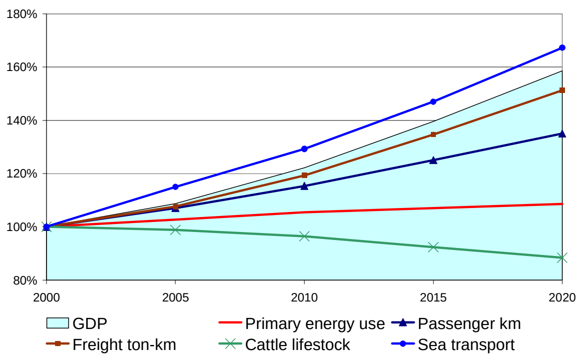
With the involvement of all major European stakeholders CAFE compiles a common knowledge base that will guide the development of future policy proposals to improve air quality in Europe.

More information: www.euro.who.int/eprise/main/WHO/Progs/AIQ/Activities/20020530_1
http://europa.eu.int/comm/environment/ air/cafe/index.htm

How will air quality develop in Europe up to 2020?

Even with accelerated economic growth …

Emissions and, consequently, air quality are critically driven by human activities in a wide range of economic sectors. Thus, assumptions on economic growth are a critical input to such an assessment, since they determine how the different emission generating activities increase or decrease in the future. Obviously, it is difficult to accurately predict the sectoral economic development for the coming two decades.



Economic development pathway of the EU-25 assumed for the CAFE baseline air quality projection

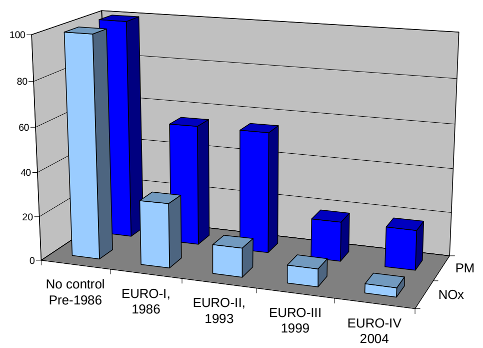
Reflecting this fundamental uncertainty, CAFE adopts multiple (and sometimes conflicting) projections of economic development to illustrate the possible range of future air quality in Europe.

One CAFE baseline relies on 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 assumes continuation of current trends in the energy sector. Thus, energy demand is expected to continue to grow throughout the outlook period, though at rates significantly smaller than in history. The use of solid fuels is expected to continue to decline until 2010 and to rise after 2015 to compensate the decommissioning of a number of nuclear plants. Natural gas is by far the fastest growing primary fuel, reaching considerable market shares in new power generation and co-generation plants. Renewable sources of energy are likely to receive a significant boost as a result of policy and technology progress. Despite significant improvements in energy efficiency, overall carbon intensity of the EU energy system is expected to remain constant. In the absence of further climate measures beyond those already adopted in 2002, CO_2 emissions would increase by 16 percent between 1995 and 2020.

As an alternative projection, the CAFE assessment employs the national energy projections of the EU Member States.

… with present emission control legislation in force …

The European Union has established a comprehensive legislative framework that allows for economic development while moving towards sustainable air quality. A large number of directives specify minimum requirements for emission controls from specific sources, such as large combustion plants, vehicles, off-road machinery, solvents use, paints, etc.



Evolution of EU emissions limit values for passenger cars relative to the uncontrolled emissions

Many of these emission sources are now strictly controlled, so that individual vehicles or power plants now typically emit 90-95 percent less than 20 years ago.

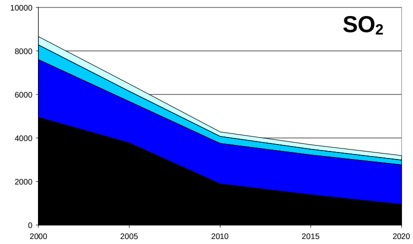
For each country overall emissions are constrained through national emission ceilings, demanding for 2010 EU-wide cuts between 50 and 70 percent compared to 1990, depending on the pollutant. In addition, local authorities must manage to comply with the EU air quality limit values to avoid local pollution "hot spots". After certain transition periods, all this legislation is fully applicable also to the New Member States.

The CAFE baseline assessment quantifies for each Member State the impacts of the legislation on future emissions.

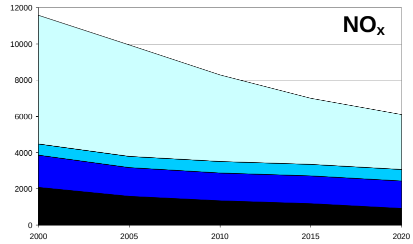
More information: http://europa.eu.int/eur-lex/en/lif/reg/en_register_15102030.html

… emissions are projected to decline up to 2020 …

Emissions of most air pollutants are expected to decline in the EU-25 even under the assumption of accelerated economic growth. Particularly large reductions are foreseen for sulfur dioxide (SO_2) as a consequence of the Large Combustion Plant Directive, while ammonia (NH_3) emissions, which originate predominantly from agricultural activities, will hardly change.

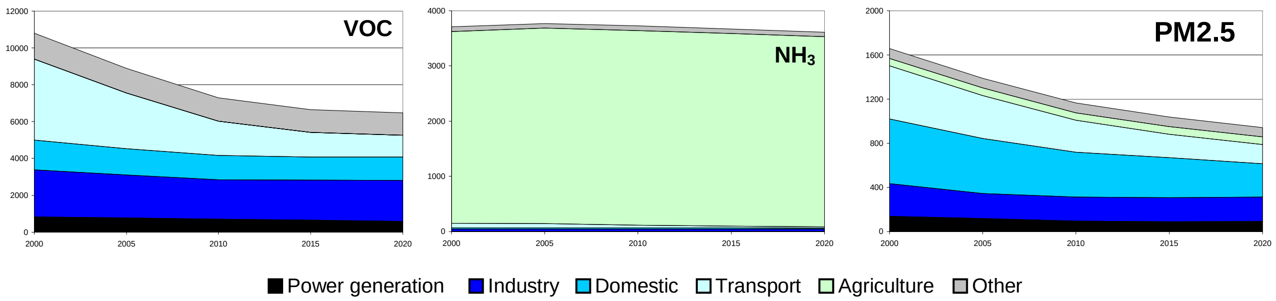


For the pollutants that were in the focus of EU legislation for a long time, i.e., sulfur dioxide, nitrogen oxides (NO_x) and volatile organic compounds (VOC), the contributions from the traditionally dominating source sectors will significantly decrease. Thus, in the future, other sectors, for which there is currently less strict legislation, will cause the majority of emissions.



Although there is no specific legislation to control fine particles (PM2.5), which are now recognized as a major health threat, PM2.5 emissions are expected to decline as a side impact of regulations targeted at other pollutants.

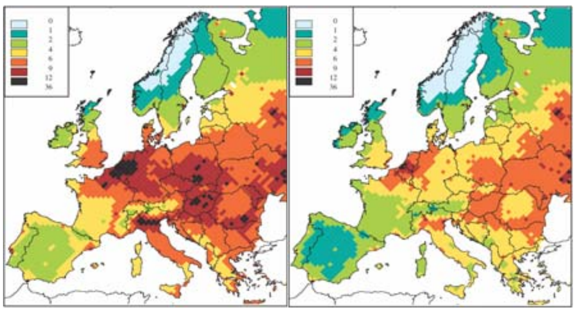
Particularly large reductions of all emissions are foreseen in the New Member States following full implementation of EU air quality legislation.



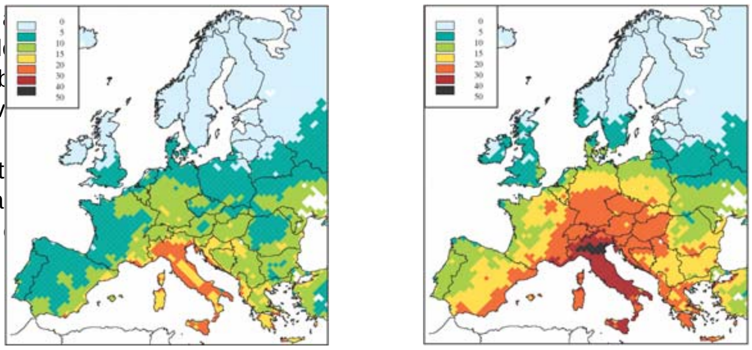
Projected baseline development of emissions in the EU-25

… air quality will improve, but risks remain.

The anticipated decline in emissions will improve … throughout Europe and alleviate major air pollution probl… increase the livelihood of European citizens (see chart b… reduce present risks to terrestrial and aquatic env… However, emissions will not decline sufficiently much … eliminate harmful impacts of air pollution. Significant t… remain for human health with life shortening attributa… exposure to fine particulate matter and ground-level … reaching six months on average.



Estimated losses in life expectancy (in months) attributable to exposure to fine particulate matter (PM2.5) from man-made emissions. Left panel: 2000, right panel: 2020.



Excess ozone concentrations harmful to forest trees (AOT40 above the critical level of 5 ppm.hours). Left panel: 2000, right panel: 2020.

Risks also remain for vegetation and aquatic ecosystems. 150,000 km^2 of forests will continue to receive unsustainable amounts of acid deposition from the atmosphere and many Scandinavian lakes will not be able to recover from past acidification. Biodiversity will remain endangered at more than 650.000 km^2 (45 percent of European ecosystems) due to excessive nitrogen deposition.

More information: www.iiasa.ac.at/rains

Particulate matter and ozone remain future challenges

Present legislation on air pollution will not be sufficient to reach the environmental objectives established by the EU Sixth Environmental Action Programme. Especially fine particles and ozone will remain serious risk factors for human health and the environment. Effective reductions of these problems will need to address the following sources with priority:

For particulate matter pollution:

- Traffic emissions including diesel engines
- Small combustion sources burning coal and wood
- Further reductions in precursor emissions of PM, i.e., SO_2, NO_x NH_3 and VOC.

For ground-level ozone:

- Further VOC controls to reduce ozone in cities
- Further NO_x reductions from traffic and stationary combustion sources to reduce regional scale ozone
- Control of NO_x emissions from ships
- Methane (CH_4) reductions to decrease the hemispheric background level of ozone.

For acid deposition and eutrophication:

- NH_3 emissions from agricultural sources
- Further NO_x control from mobile and stationary sources.
- Control of SO_2 and NO_x emissions from ships

Many of the traditionally important emission sources will have implemented costly control measures. Proposals for further improvements must carefully analyze the cost-effectiveness of additional measures at these sources while considering the role of other sectors that will gain increasing importance.

In designing effective control strategies, it is important to recognize that the different air quality problems are not uniform over Europe. Many pollution problems coincide with high population and industrial densities and thus show large variations over Europe. Acidification is most relevant in central and northern Europe, while ozone is a serious problem in southern and central Europe.

It will be a challenge to design emission control legislation that leads to effective improvements of the most pressing air pollution problems while not jeopardizing further economic development. The CAFE programme aims at a comprehensive assessment of the remaining emission control potentials from all sectors to facilitate a balance of measures that will reach the environmental targets in the most cost-effective way. To take full account of the interactions between pollutants, CAFE will apply a multi-pollutant/multi-effect concept.

	SO_2	NO_x	NH_3	VOC	Primary PM
Health impacts from fine particles	√	√	√	√	
	(via secondary aerosols)				√
Acidification	√	√	√		
Eutrophication		√	√		
Ground-level ozone (health + vegetation)		√		√	

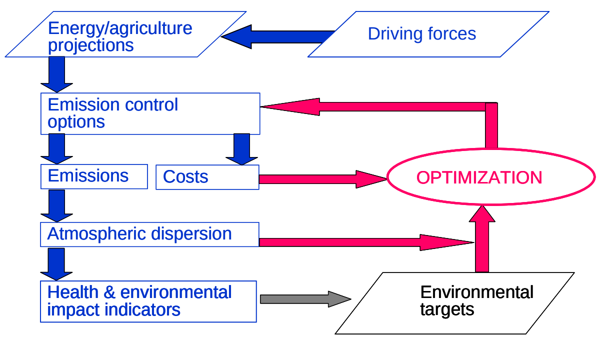
The multi-pollutant/multi-effect concept used for the CAFE assessment

State-of-the-art tools are used for the analysis

To assist the cost-effectiveness analysis of policy proposals for revised air quality legislation, the Clean Air For Europe programme is now preparing a toolset for policy analysis by combining state-of-the-art scientific models dealing with the various relevant aspects with validated databases representing the situations of all Member States and economic sectors:

- The RAINS integrated assessment model for air pollution and greenhouse gases (www.iiasa.ac.at/rain)
- The PRIMES model of the energy sectors in the EU Member States (www.e3mlab.ntua.gr)
- The TREMOVE transport model (www.tremove.org)
- The CAFE cost-benefit analysis (**http://europa.eu.int/comm/environment/air/cafe/index.htm**)

These assessment tools will be applied to search for cost-effective packages of measures that will move Europe closer to its environmental objectives.



The analysis cycle of CAFE

With close involvement of the stakeholders, CAFE will explore balanced policy packages to reach Europe's environmental policy targets and assess their effectiveness as well as their distributional implications for different Member States and economic sectors.

More information: http://europa.eu.int/comm/environment/air/cafe/index.htm

Acknowledgements

The authors want to thank all their colleagues that have contributed to the development of the CAFE baseline scenarios. In particular, we acknowledge the contributions of the PRIMES energy modelling team at the National Technical University of Athens, led by Leonidas Mantzos, the EMEP/MSC-W team providing atmospheric dispersion calculations under the leadership of Leonor Tarrason at the Norwegian Meteorological Institute, Jürgen Schneider from the WHO Office Bonn, and the staff of the Coordination Centre for Effects at RIVM, Netherlands, guided by Jean-Paul Hettelingh, for their contributions to the impact assessment.

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Glossary of Terms used in this report

AOT60	Accumulated excess ozone over a threshold of 60 ppb
BC	Black carbon
CAFE	Clean Air For Europe Programme
CAP	Common Agricultural Policy
CH_4	Methane
CLE	Current legislation
CO_2	Carbon dioxide
EGTEI	Expert Group on Techno-Economic Issues
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
NMS	New Member States
NO_x	Nitrogen oxides
O_3	Ozone
PJ	Petajoule
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
SO_2	Sulphur dioxide
SOA	Secondary organic aerosols
SOMO35	Sum of excess of daily maximum 8-h means over the cut-off of 35 ppb calculated for all days in a year
TPES	Total primary energy equivalent
TREMOVE	Transport Model
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds
WHO	World Health Organisation

1 Introduction

In its Clean Air For Europe (CAFE) programme, 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 impacts of the presently decided legislation on emission controls.

This report presents the 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 key findings of the analysis conducted for the baseline projection under lot 1 of the contract with the European Commission. While all calculations are carried out at a national and sectoral level, this report restricts itself to the presentation of aggregated results. 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/. Future work will refine the analysis (e.g., to include a more accurate representation of urban air quality) and conduct a range of uncertainty analyses to establish the robustness of the baseline projections.

The remainder of the report is organized as follows: Section 2 provides a brief introduction of the concept and modelling tools that have been used for the development of the CAFE baseline scenario. The assumptions on the main alternative driving forces of emissions, e.g., of energy and transport development, are summarized in Section 3. Emission baseline projections are presented in Section 4, and Section 5 discusses the resulting changes in air quality and impacts. Conclusions are drawn in Section 6.

2 Methodology

2.1 The RAINS model

The analysis presented in this report builds on the Regional Air Pollution Information and Simulation (RAINS) model, which describes the pathways of pollution from the 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 (Klaassen *et al.*, 2004).

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			√		√

A detailed description of the RAINS model is provided in Amann *et al*. (2004). On-line access to the model and to all input data is available on the Internet (http://www.iiasa.ac.at/rains).

In 2004, the RAINS model and its scientific basis have been reviewed by a team of experts to judge the scientific credibility of the model approach. The report of the review team is available at http://europa.eu.int/comm/environment/air/cafe/pdf/rains_report_review.pdf.

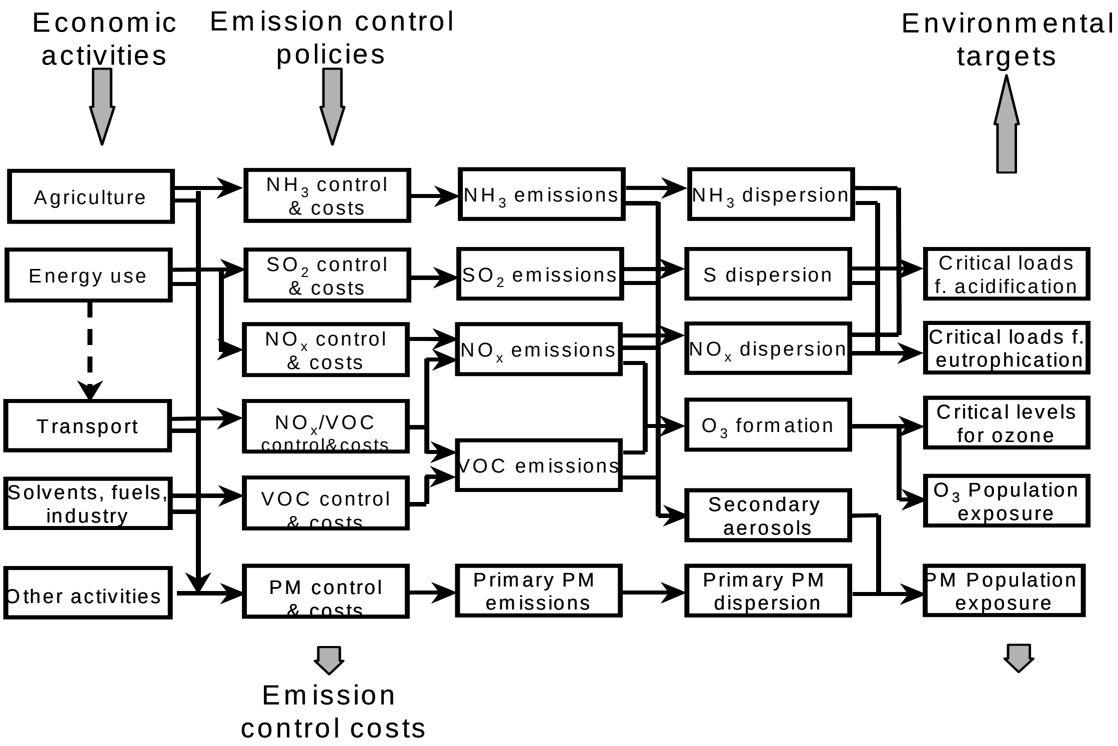


Figure 2.1: Flow of information in the RAINS model

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.

The scenario analysis approach has been applied for the baseline projection the RAINS model to outline the likely range of future development of emissions and air quality impacts in Europe as it is expected from the present trends in economic development taking into account the effects of tightened emission control legislation. For the policy analysis in CAFE, the RAINS optimisation approach will be used to identify sets of emission control measures that would efficiently lead to further improvements of European air quality.

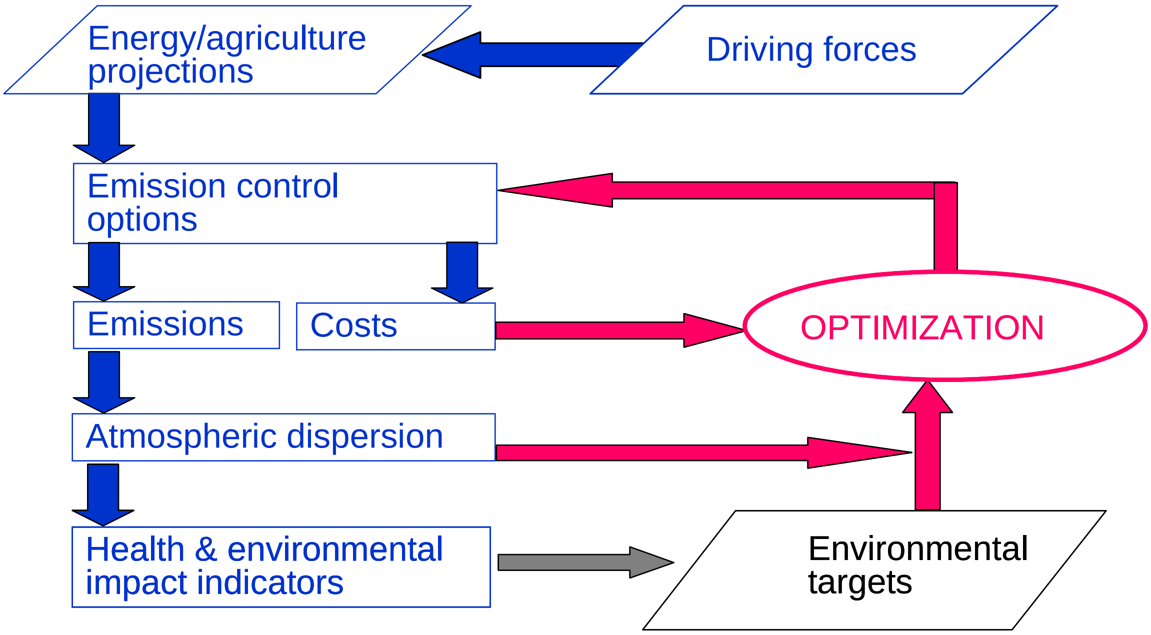


Figure 2.2: The iterative concept of the RAINS optimisation.

2.3 Preparation and review of the RAINS databases

2.3.1 Bilateral consultations with the CAFE stakeholders

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.).

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.

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	-	Y	-	-
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	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	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**

The minutes of these consultations have been made available to the stakeholders to aid the understanding of the construction of the baseline scenario. 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 while maintaining international consistency and comparability of the assessment.

However, a number of discrepancies between national data and the Europe-wide RAINS estimates could not be clarified to a satisfactory extent:

- For some countries, emissions reported in their national emission inventories are still burdened with high uncertainties. This applies in particular to some of the earlier estimates, which have not been not updated with more recent information. The RAINS estimates attempt to match the most recent estimates that have been communicated by national experts during the consultations, even if they have not yet been provided to EMEP through the official channels.
- While in most cases there is a good match between national inventories and RAINS estimates achieved for national total emissions, certain discrepancies occur between the estimates of sectoral emissions. Often this is caused by different sectoral groupings applied in national emission inventories, while the RAINS model applies a common sectoral structure for all countries. For instance, the RAINS model includes industrial power production and district heating plants in the power generation sector, while some national systems use the ownership of the plant as aggregation criterion. In addition, the definition of industrial process emissions is often a source of potential differences at least at the sectoral level (RAINS "process emissions" account only for the additional emissions that add to the fuel-related emissions).
- The recently adopted UNECE nomenclature for reporting (NFR), while establishing consistency with the UNFCCC reporting format for greenhouse gases, bears certain ambiguity on details of air pollutants (e.g., on non-road mobile sources in industry, construction, agriculture and the residential/commercial sector, and on emissions from industrial processes).

Based on the information collected during the bilateral consultations, two draft baseline scenarios have been developed, employing two alternative energy projections produced with the PRIMES model. On April 30, 2004, these scenarios have been presented to the CAFE stakeholders. Comments have led to a revised energy projection with the PRIMES model and to improvements in the RAINS emission calculations. In addition, national energy and agricultural projections to the extent they were available in May 2004 have been implemented in the RAINS model so that by now three sets of CAFE baseline scenarios are available.

On September 27, 2004 a public information workshop was held in Brussels to to present the outcomes of the scenario work to a wider audience.

2.3.2 Improvements made for the final CAFE baseline scenarios

After the presentation of the draft CAFE baseline scenarios, stakeholders provided further information to the RAINS modelling team, which has been incorporated into the final CAFE baseline projections presented in this report:

- The PRIMES energy model has been used to produce a revised energy projection with climate measures that reflects as far as possible the comments on the draft projections received by the Member States.

- For 10 countries (Table 2.2), national energy projections have been implemented as an alternative view on the energy development.
- National projections of agricultural activities have been implemented into RAINS for 10 countries (Table 2.2).
- All comments from stakeholders related to emission estimates have been incorporated into RAINS to the extent they did not cause inconsistencies across countries and did not require changes in the RAINS model structure. In some cases (e.g., Spain, Portugal) this has led to significant revisions of the emission estimates.
- RAINS data for the transport sector have been revised taking into account recent information from the TREMOVE (www.tremove.org) and COPERT-3 models. Thus, the new RAINS calculations apply emission removal efficiencies of control measures provided by COPERT-3, while the earlier data relied on Auto/Oil-II and COPERT-2 results. The effects of electronic controls on exhaust emissions of EURO-2 and EURO-3 controlled heavy duty vehicles are considered, based on findings of the ARTEMIS project. If available, pre-control emission factors were taken from the national inventories. Otherwise, COPERT-3 estimates have been applied.
- Another important revision refers to the inclusion of emissions from international shipping (sea regions within the EMEP area). The assessment is based on the study by ENTEC (2002) and additional data from the TREMOVE model (2004). The ENTEC study was used to define fuel consumption and emission factors from shipping for the year 2000. The future development of fuel consumption used is based on projections developed by the TREMOVE transport model (TREMOVE, 2004), suggesting an annual increase in transport volume of 2.6 percent up to 2020. The RAINS emission projection assumes the implementation of the political agreement on the sulphur content of marine fuels (EC, 2004). As a provisional estimate, future emissions of NO_x have been calculated assuming the base year emission factors. In principle, the "current legislation" projection should include the emissions standards for new ships according to Annex VI of the MARPOL Protocol (MARPOL, 1978). However, this would require much more detailed information about the composition of the ship fleet than presently available in RAINS. In addition, the Annex VI emission standards refer only to new engines and are on average only less than 10 percent lower than the actual emission factors from the currently operating ships. Thus the effects of the implementation of the new standards will be rather limited, especially within the next 10 – 15 years (see also EGTEI, 2003). An in-depth analysis of the effects of the above standards is envisaged from the forthcoming TREMOVE assessment by the end of this year.

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 incorporates a variety 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.

Along these lines, three baseline projections have been compiled for CAFE:

- A Europe-wide consistent view of energy development with certain assumptions on climate policies (as produced by the PRIMES energy model). A draft version of this projection has been presented with the draft CAFE baseline scenario. Since then, comments from Member States have been incorporated into the final version presented in this report.
- As a variant, a Europe-wide consistent view of energy development without climate policies. For this purpose, CAFE employs the baseline projection of the "European energy and transport. Trends to 2030" study of the DG Transport and Energy (CEC, 2003).
- 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 is 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.). Within the available time, 10 countries have provided national projections.

For agriculture, two baseline projections have been implemented:

- A set of Europe-wide consistent projections of agricultural activities without CAP reform, and
- a compilation of national projections of activities supplied by 10 Member States.

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 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)

		PRIMES with climate measures			*PRIMES without further climate measures*			*National projections(***)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	1733	800	544	366	1571	1325	1439	797	537	360
Hard coal	6472	4417	3645	3402	4748	4493	5437	5283	4890	4725
Other solids	2387	2992	3409	3782	2925	3049	3093	3211	3485	3757
Heavy fuel oil	4760	3200	3172	3093	3703	3531	3288	3211	3062	2833
Middle distillates	9753	10276	10826	11278	10758	11310	11760	11490	11904	12232
Gasoline (*)	9640	9611	9561	9696	9906	9883	9992	10071	9891	9842
Natural gas	15961	20138	22164	24417	20791	22611	23878	19155	21397	23613
Hydrogen	0	3	8	19	3	8	19	1	4	10
Renewable	229	944	1133	1353	784	924	1042	1104	1493	1702
Hydropower	1158	1178	1225	1250	1177	1211	1236	1232	1264	1270
Nuclear	9328	9541	9007	7781	9642	9398	8318	9450	8760	7703
Electricity (**)	154	136	108	113	139	138	137	241	188	84
Total	61575	63236	64802	66550	66148	67883	69638	65246	66875	68129

(*) with LPG

(**) net imports

(***) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

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

		PRIMES with climate measures			*PRIMES without further climate measures*			*National projections(***)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	1313	1106	834	698	1125	861	807	1263	1023	932
Hard coal	2280	1591	1578	1453	1945	2118	2140	1543	1558	1447
Other solids	271	490	493	477	318	338	327	591	603	615
Heavy fuel oil	570	565	536	539	548	545	533	568	545	548
Middle distillates	681	828	905	979	841	917	976	904	980	1044
Gasoline (*)	749	926	1025	1117	928	1031	1126	881	956	1036
Natural gas	1771	2309	2723	3268	2284	2652	3008	2276	2671	3145
Hydrogen	0	0	1	1	0	1	1	0	1	1
Renewable	2	39	74	104	36	65	99	43	73	99
Hydropower	57	90	92	90	84	88	89	74	77	79
Nuclear	620	594	595	542	626	622	621	588	586	546
Electricity (**)	-61	-56	-25	-30	-68	-69	-70	-52	-56	-61
Total	8252	8481	8831	9239	8666	9168	9659	8678	9017	9431

(*) with LPG

(**) net imports

(***) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

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

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projections(*)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	12788	11749	11433	10932	12579	12370	12129	12333	12086	11421
Industry	15616	15764	16277	16929	16261	16829	17337	16114	16752	17371
Households	15292	16171	16820	17458	17043	17676	18251	17059	17528	17984
Transport	13897	15352	15902	16723	15945	16541	17384	15540	16239	17047
Non-energy use	3982	4202	4373	4512	4322	4470	4542	4202	4272	4307
Total	61575	63239	64806	66554	66151	67886	69642	65248	66877	68131

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

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

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projection(*)s*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	1951	1913	1795	1693	1993	2000	2015	2043	1910	1832
Industry	2544	2288	2350	2442	2321	2382	2452	2366	2444	2542
Households	2211	2426	2622	2843	2511	2739	2954	2420	2621	2833
Transport	1109	1396	1555	1705	1382	1542	1697	1390	1534	1671
Non-energy use	437	457	509	556	460	505	541	458	508	553
Total	8252	8482	8831	9239	8666	9168	9659	8678	9018	9431

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

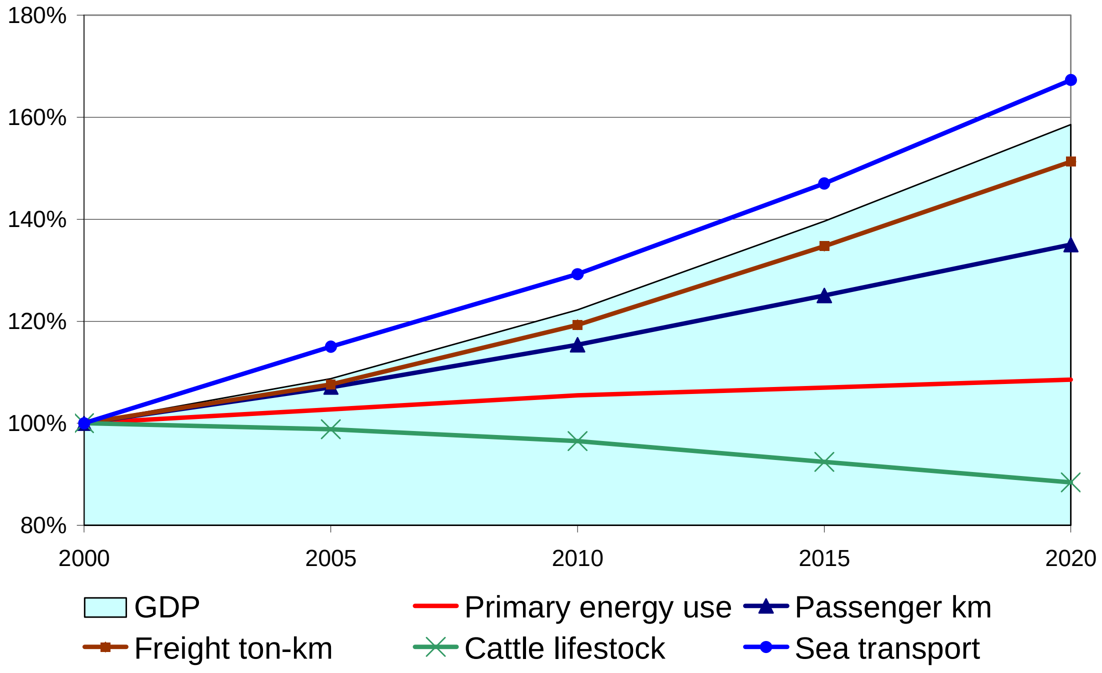


Figure 3.1: Development of main driving forces assumed for the PRIMES energy projections "with climate measures" for the EU-25, relative to 2000

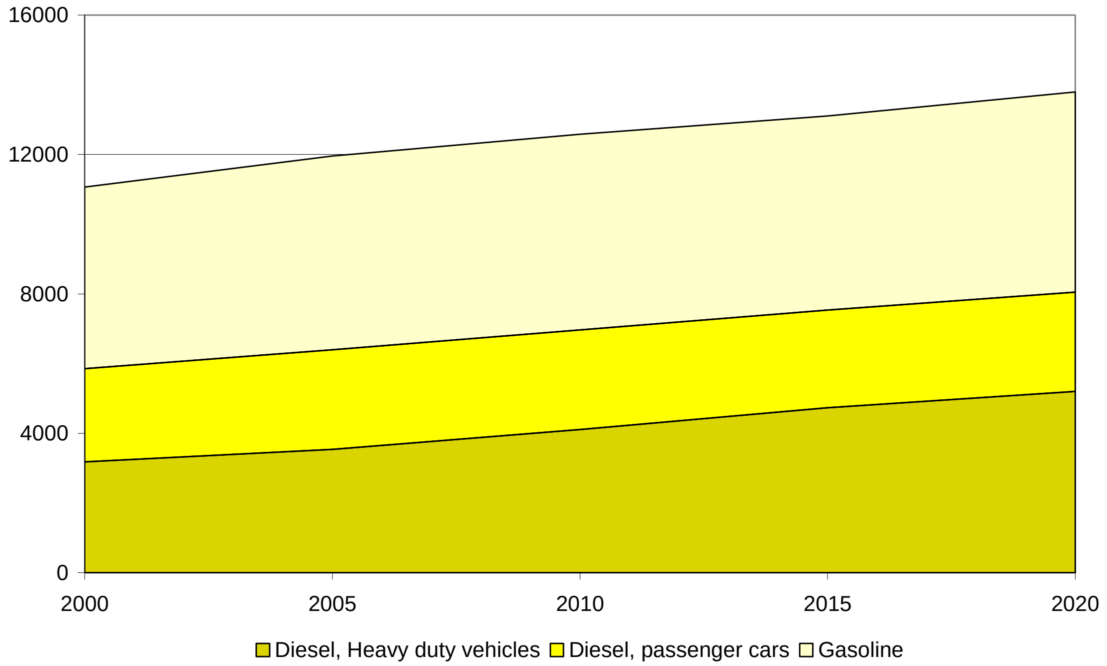


Figure 3.2: Fuel consumption for EU-25 road transport in the PRIMES "with climate measures" energy projection (in PJ)

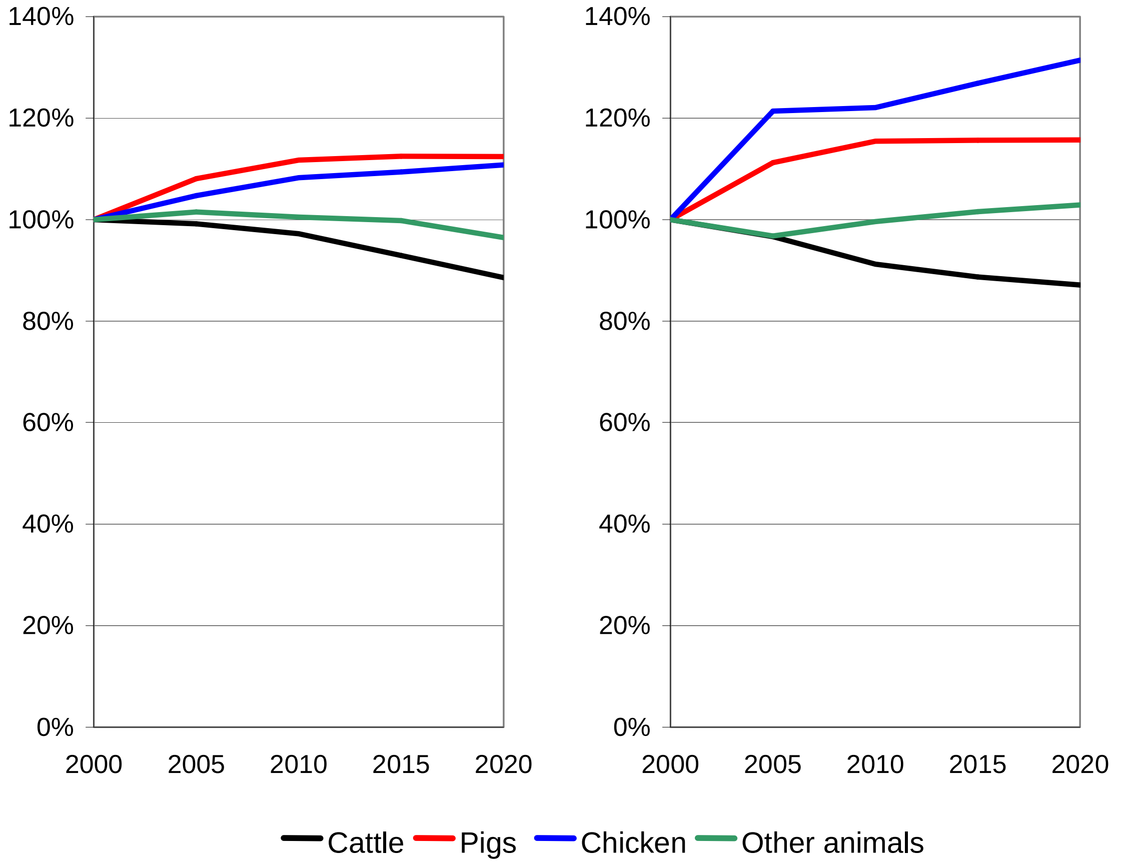


Figure 3.3: Development of animal numbers for EU-15 (left panel) and New Member States (right panel) relative to the year 2000, pre-CAP reform scenario

Table 3.5: Total primary energy consumption (on TPES basis, PJ/year) of the CAFE baseline scenarios for land-based sources and sea-going ships

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projections*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	1201	1360	1423	1495	1325	1375	1446			
Belgium	2421	2431	2465	2545	2557	2636	2660	2660	2651	2708
Denmark	835	839	847	878	828	842	870	991	962	984
Finland	1387	1559	1620	1664	1563	1576	1593	1482	1523	1559
France	11068	11814	12284	12624	12326	12801	13222	12508	12904	13280
Germany	14202	13405	13041	12826	14562	14433	14331			
Greece	1205	1462	1520	1584	1523	1615	1681			
Ireland	597	728	764	806	750	784	822			
Italy	7527	7304	7668	7921	7785	7942	8105	8209	8697	8928
Luxembourg	152	180	190	208	198	205	215			
Netherlands	3171	3045	3266	3537	3372	3464	3581			
Portugal	1068	1094	1245	1398	1248	1362	1484	1278	1357	1415
Spain	5055	5960	6294	6632	6009	6447	6776			
Sweden	2136	2286	2219	2135	2383	2404	2420	2276	2337	2378
UK	9550	9771	9957	10300	9720	9997	10435	9702	9944	9791
Total EU-15	61575	63239	64806	66553	66151	67886	69642			
Cyprus	99	116	126	136	120	130	140			
Czech Republic	1679	1669	1657	1661	1679	1713	1757	1854	1843	1845
Estonia	190	201	193	188	201	203	196			
Hungary	1049	1115	1102	1095	1122	1155	1181			
Latvia	135	168	173	177	162	176	187			
Lithuania	302	297	318	335	281	318	351			
Malta	36	40	46	46	48	52	53			
Poland	3800	3872	4119	4408	4012	4312	4614			
Slovakia	696	716	798	896	736	801	862			
Slovenia	267	287	298	297	304	309	317	299	298	305
Total NMS	8252	8482	8831	9239	8666	9168	9659			
Total EU-25	69828	71720	73637	75793	74817	77054	79301			
Atlantic Ocean	311				401	455	517			
Baltic Sea	192				248	282	321			
Black Sea	65				84	95	108			
Mediterranean	997				1293	1474	1680			
North Sea	363				467	530	602			
Sea regions	1929				2493	2836	3227			

Table 3.6: Total national CO_2 emissions for the CAFE baseline scenarios. RAINS calculations include 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 combustion–related CO_2 emissions calculated by the PRIMES model.

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	60	64	66	69	63	64	69			
Belgium	120	110	118	121	119	123	131	126	133	135
Denmark	52	50	47	46	46	45	44	64	61	63
Finland	63	55	57	61	57	59	61	63	65	67
France	392	392	412	431	423	433	464	436	447	478
Germany	836	738	719	734	847	845	896			
Greece	93	104	103	106	110	113	116			
Ireland	42	45	46	47	47	47	49			
Italy	455	410	427	439	454	460	469	474	497	508
Luxembourg	9	10	11	12	12	12	13			
Netherlands	169	157	167	180	176	180	185			
Portugal	66	65	72	80	75	80	87	77	81	83
Spain	290	307	312	324	310	329	344			
Sweden	60	61	58	63	66	69	81	60	61	63
UK	533	516	505	515	509	517	549	515	530	516
Total EU-15	3239	3084	3120	3228	3312	3377	3558			
Cyprus	7	8	8	9	8	9	9			
Czech Republic	125	103	94	90	103	101	102	114	109	106
Estonia	15	14	13	12	14	14	13			
Hungary	59	62	58	59	63	64	66			
Latvia	7	8	9	9	8	9	11			
Lithuania	12	18	19	19	17	20	22			
Malta	2	2	3	3	3	3	3			
Poland	312	283	293	305	312	325	341			
Slovakia	36	40	45	49	41	44	48			
Slovenia	15	14	15	15	17	17	18	16	16	17
Total NMS	588	553	555	570	587	607	632			
Total EU-25	3828	3636	3675	3799	3899	3984	4189			

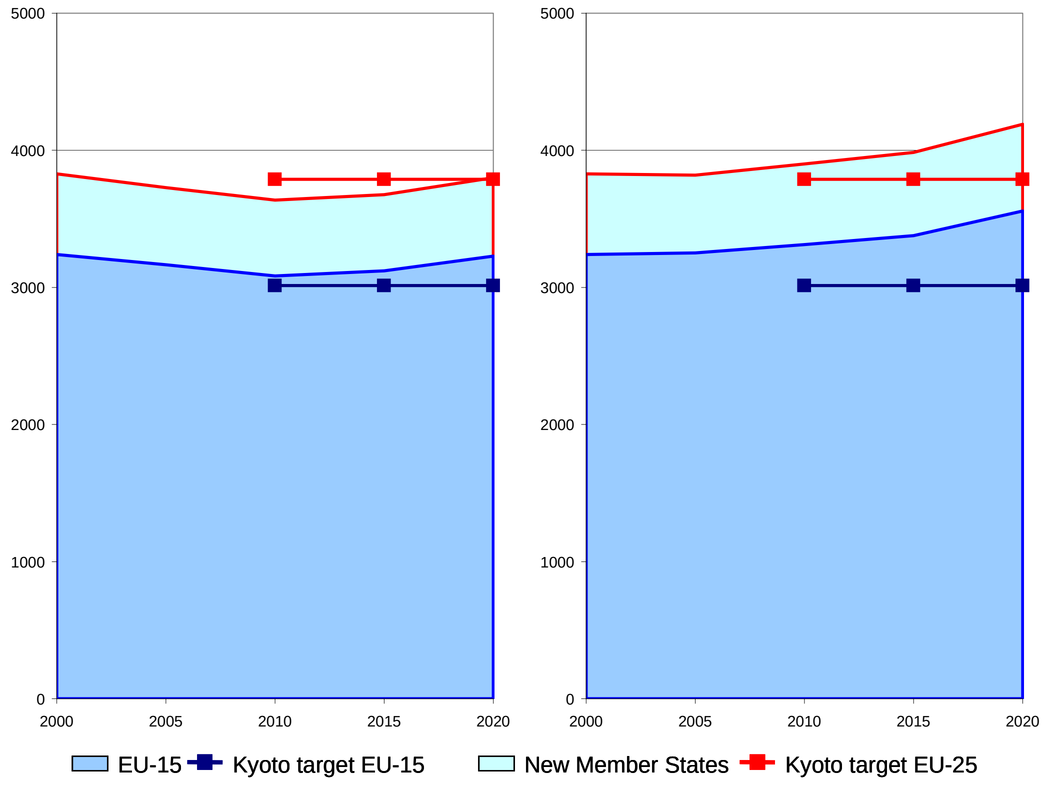


Figure 3.4: CO_2 emissions of the two PRIMES energy projections (Mt). Left panel: “with additional climate measures” projection, right panel: “no further climate measures” projection. The indicated “Kyoto target” assumes for CO_2 the same reduction as for the other greenhouse gases and refers to the Marrakech accords allowing for carbon sinks (-5.5%).

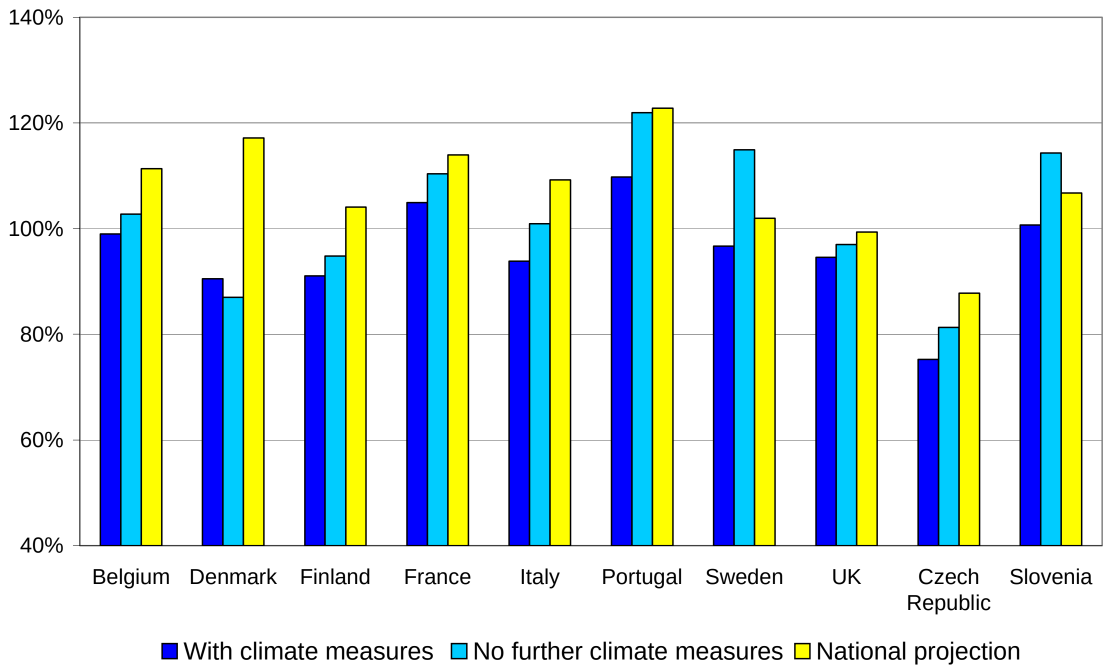


Figure 3.5: CO_2 emissions of the national energy projections (yellow bars) compared to the PRIMES projections with and without further climate measures, relative to the year 2000

4 Emission projections

4.1 Sulphur dioxide (SO_2)

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. Aggregated RAINS emissions for EU-15 and for the New Member States differ from the sum of nationally reported emissions by less than 0.2 percent. For most countries differences are well below five percent. An important discrepancy remains only for Luxembourg, where the RAINS model estimates higher emissions than the national inventory. This difference is explained by 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.

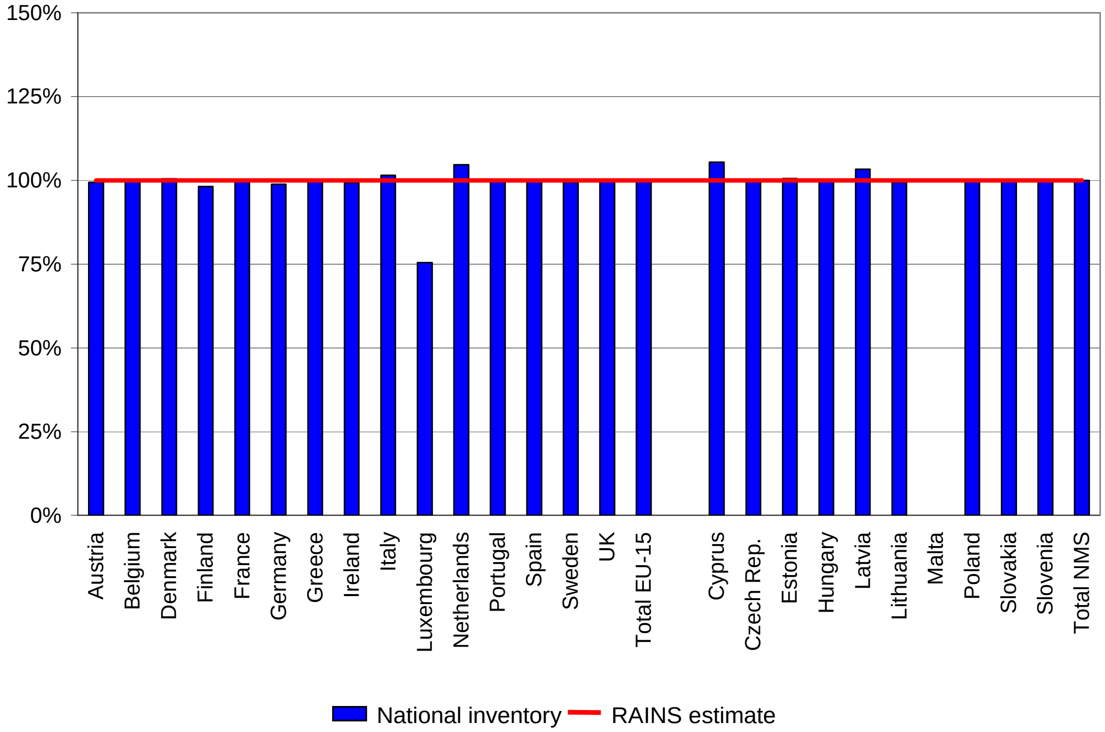


Figure 4.1: Comparison of national emission inventories for SO_2 with the RAINS estimates (for the year 2000)

4.1.2 Future development

Starting from 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 energy projections) and the penetration of emission control legislation. For SO_2, the CAFE baseline scenario assumes full implementation of all source-related emission legislation of the European Union as 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. Thus, further measures that could possibly be under consideration in individual countries in order to meet the national emission ceilings, but which are not yet laid down in legislation, are excluded from this analysis.

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

Large combustion plant directive
Directive on the sulfur content in liquid fuels
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 (Table 4.2 to (*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.5). Compared to the year 2000, SO_2 emissions in the EU-15 are expected to decline between 54 and 60 percent in 2010 and by 63 to 67 percent in 2020. Largest emission reductions result for coal combustion, partly due to the decline in coal consumption (for 2020, coal consumption decreases by 54 percent in the “no further climate measures” scenario and by 32 percent in the scenario “with further climate measures” 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 71 percent in 2020 for the climate case.

Table 4.2: SO_2 emissions by fuel type for the EU-15 from land-based sources (kt SO_2)

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projections(*)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	716	102	78	43	162	139	116	121	90	48
Hard coal	2080	587	367	216	610	451	313	761	741	422
Other solids	113	137	158	174	133	139	140	168	181	189
Heavy fuel oil	1860	632	625	587	759	702	622	695	635	554
Middle distillates	370	169	171	171	175	177	177	205	198	188
Gasoline	30	19	19	20	20	20	21	18	18	19
Natural gas	19	17	17	19	18	18	18	16	19	21
Ind. processes	853	759	757	784	780	780	802	770	765	788
Total	6040	2422	2192	2013	2656	2426	2208	2754	2646	2229

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.3: SO_2 emissions by fuel type for the New Member States from land-based sources (kt SO_2)

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projections(*)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	1036	462	229	156	499	312	221	511	269	185
Hard coal	1059	645	445	312	769	588	461	627	436	307
Other solids	12	22	22	22	14	16	15	25	26	27
Heavy fuel oil	332	179	154	129	179	161	130	175	155	131
Middle distillates	78	11	10	11	11	11	11	13	12	13
Gasoline	11	1	1	1	1	1	1	1	1	1
Natural gas	0	0	0	0	0	0	0	0	0	0
Ind. processes	168	149	154	162	149	153	157	149	154	162
Total	2696	1468	1016	793	1622	1241	997	1502	1053	825

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

Table 4.4: SO_2 emissions by sector for the EU-15 from land-based sources (kt SO_2)

		PRIMES with further climate measures			*PRIMES without further climate measures*			*National projections(*)*		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	3234	655	482	298	829	643	442	899	772	372
Industry	1235	621	586	574	653	629	600	649	676	652
Households	389	177	155	143	186	164	152	225	209	199
Transport	329	210	212	214	208	210	212	210	223	217
Agriculture	0	0	0	0	0	0	0	0	0	0
Process emissions	853	759	757	784	780	780	802	770	765	788
Total	6040	2422	2192	2013	2656	2426	2208	2754	2646	2229

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

Table 4.5: SO_2 emissions by sector for the New Member States from land-based sources (kt SO_2)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	1781	926	507	309	1057	704	493	943	524	330
Industry	402	261	265	261	276	283	278	259	265	265
Households	276	129	87	58	137	98	65	147	107	65
Transport	69	4	3	3	4	3	3	4	3	3
Agriculture	0	0	0	0	0	0	0	0	0	0
Process emissions	168	149	154	162	149	153	157	149	154	162
Total	2696	1468	1016	793	1622	1241	997	1502	1053	825

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

The SO_2 emission projections for 2010 are in many cases lower than the ceilings laid down in the national emission ceilings directive (Figure 4.2). For the EU-15, total SO_2 emissions are computed to under-run the collective ceiling between 31 and 37 percent. A need for stricter control measures seems to emerge only for the Netherlands in case of the PRIMES energy projections, for France for the projection without climate measures, and for the national energy projection of Belgium. 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.

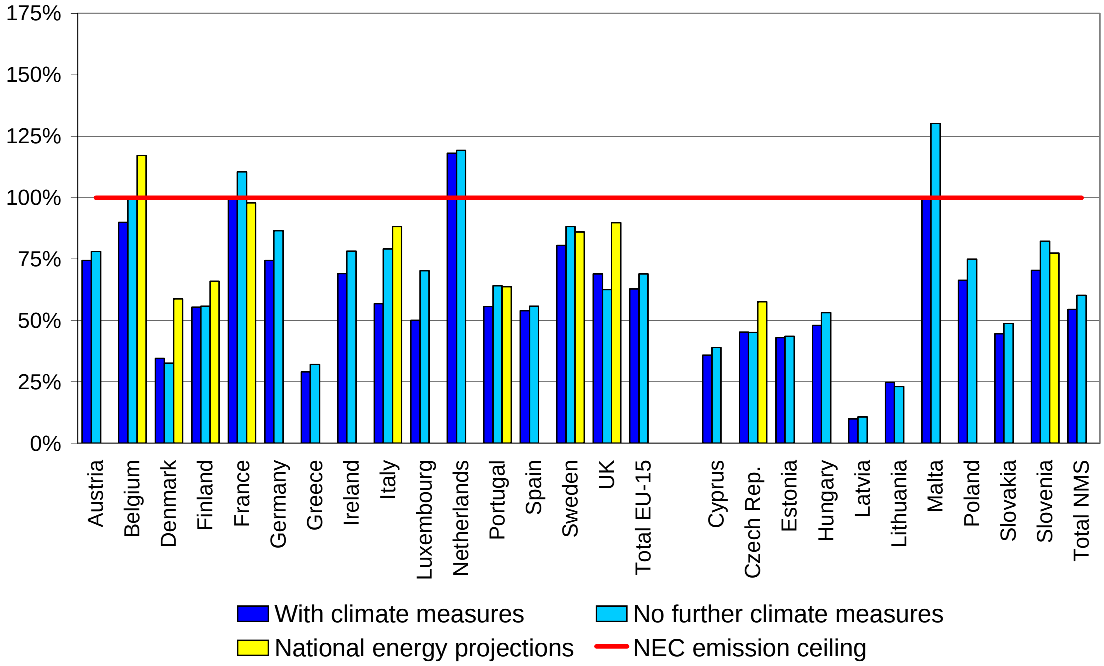


Figure 4.2: Estimated SO_2 emissions for 2010 compared with the emission ceilings for SO_2

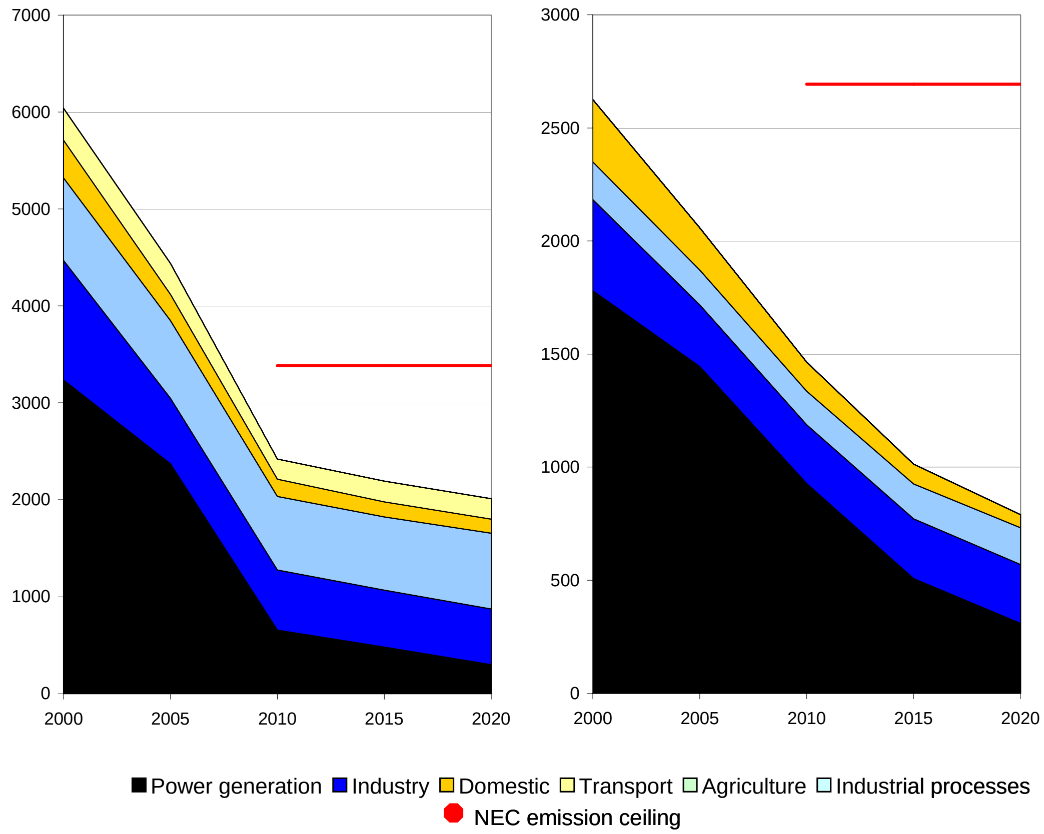


Figure 4.3: SO_2 emissions (kt) by sector for the EU-15 (left panel) and the New Member States (right panel) for the "with climate policies scenario

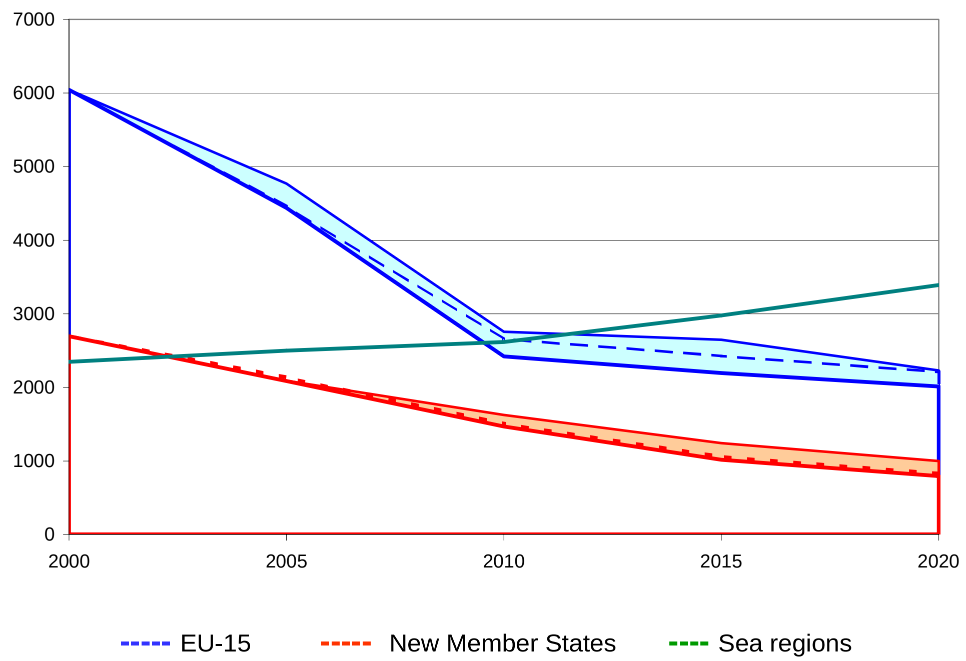


Figure 4.4: Range of SO_2 projections for the "with climate measures" projection (thick solid line), the "no further climate measures projection (thin solid line) and the national energy projections (dashed line), in kt.

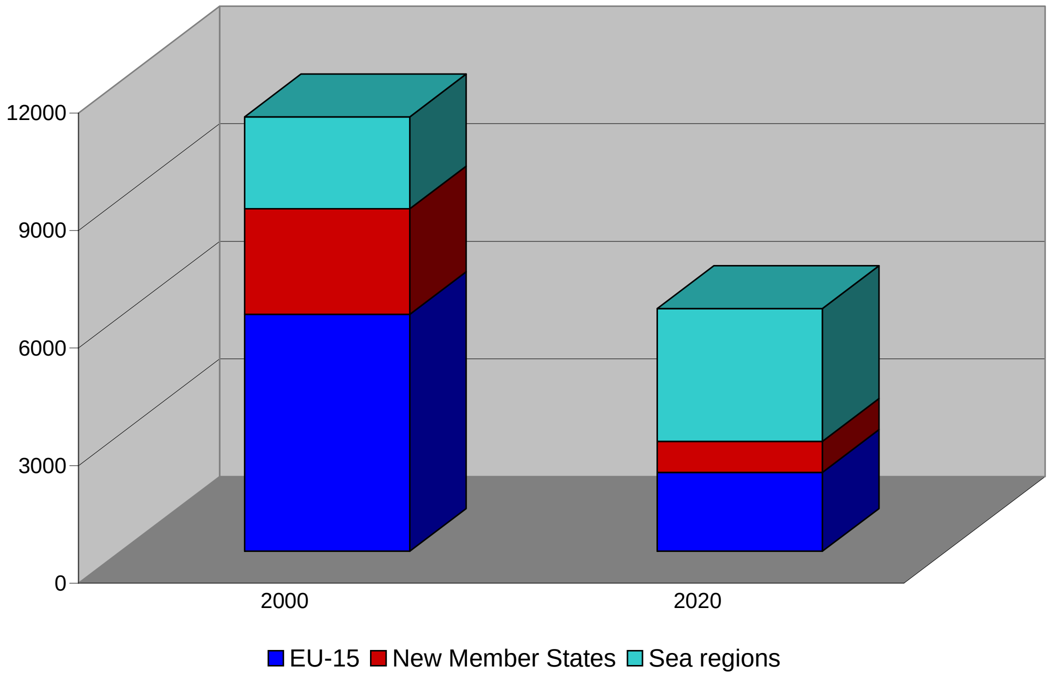


Figure 4.5: SO_2 emissions from land-based sources in the EU-25 and from sea regions, 2000 and for the “with climate measures” projection for 2020 (kt SO_2)

Table 4.6: Total SO_2 emissions (kt) for the CAFE baseline scenarios from land-based sources and sea going ships

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	38	29	28	26	30	29	28			
Belgium	187	89	85	83	99	93	91	116	110	109
Denmark	28	19	16	13	18	16	14	32	29	30
Finland	77	61	60	62	61	61	60	73	72	76
France	654	375	356	345	414	379	363	367	385	362
Germany	643	387	349	332	450	411	426			
Greece	481	152	134	110	168	165	113			
Ireland	132	29	24	19	33	26	19			
Italy	747	270	301	281	376	357	308	419	405	346
Luxembourg	4	2	2	2	3	2	2			
Netherlands	85	59	62	65	60	61	62			
Portugal	230	89	84	81	103	93	87	102	90	80
Spain	1489	403	368	335	416	397	350			
Sweden	58	54	52	50	59	58	60	58	60	62
UK	1186	403	271	209	366	278	225	525	529	275
Total EU-15	6040	2422	2192	2013	2656	2426	2208			
Cyprus	46	14	15	8	15	16	8			
Czech Republic	250	120	68	53	120	74	63	153	107	84
Estonia	91	43	13	10	44	18	11			
Hungary	487	240	103	88	266	129	96			
Latvia	16	10	9	8	11	10	9			
Lithuania	43	36	26	22	33	32	25			
Malta	26	9	10	2	12	12	3			
Poland	1515	927	714	554	1046	883	723			
Slovakia	124	49	38	33	54	46	38			
Slovenia	97	19	19	16	22	21	19	21	17	17
Total NMS	2696	1468	1016	793	1622	1241	997			
Total EU-25	8736	3890	3208	2806	4278	3667	3205			
Atlantic Ocean	397				510	578	657			
Baltic Sea	243				174	198	225			
Black Sea	84				107	122	138			
Mediterranean	1244				1602	1826	2082			
North Sea	461				329	373	424			
Sea regions	2430				2722	3097	3526			

Table 4.7: SO_2 emission estimates for 2000 and for 2010 (kt) from land-based sources

	2000		2010			
	RAINS	*National estimate*	*NEC emission ceiling*	*RAINS, with further climate measures*	*RAINS, no further climate measures*	*RAINS, national energy projections*
Austria	38	38	39	29	30	
Belgium	187	187	99	89	99	116
Denmark	28	29	55	19	18	32
Finland	77	76	110	61	61	73
France	654	654	375	375	414	367
Germany	643	636	520	387	450	
Greece	481	483	523	152	168	
Ireland	132	131	42	29	33	
Italy	747	758	475	270	376	419
Luxembourg	4	3	4	2	3	
Netherlands	85	89	50	59	60	
Portugal	230	231	160	89	103	102
Spain	1489	1491	746	403	416	
Sweden	58	57	67	54	59	58
UK	1186	1189	585	403	366	525
Total EU-15	6040	6052	3850	2421	2656	
Cyprus	46	48	39	14	15	
Czech Rep.	250	251	265	120	120	153
Estonia	91	92	100	43	44	
Hungary	487	486	500	240	266	
Latvia	16	17	101	10	11	
Lithuania	43	43	145	36	33	
Malta	26		9	9	12	
Poland	1515	1511	1397	927	1046	
Slovakia	124	124	110	49	54	
Slovenia	97	96	27	19	22	21
Total NMS	2696	2694	2693	1467	1622	
Total EU-25	8736	8746	6543	3888	4278	

4.2 Nitrogen oxides (NO_x)

4.2.1 Base year emissions

Also for emission of nitrogen oxides the RAINS databases allow rather accurate reconstruction of the nationally reported inventories for the year 2000. Aggregated emissions nearly perfectly match the sums of emissions reported by individual countries (Figure 4.6). For the majority of countries the differences remain below two percent (Table 4.14 and Figure 4.6). Larger differences occur only for Luxembourg and Cyprus. For Luxembourg, the discrepancy is explained by the fact that the RAINS estimates refer to fuel sales statistics (which is consistent with the definition of national emissions for the needs of the National Emission Ceilings (NEC) Directive), whereas the national emission inventory reports only emissions from vehicles driving within the country. For Cyprus, large uncertainties in the assessment of emissions remain, in particular for the road and non-road transport sectors. While RAINS reproduces for most countries total national emissions quite accurately, there remain certain discrepancies with national estimates at the sectoral level due to different source classification.

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 programme uses information about removal efficiencies of control technologies and pre-control emission factors from the COPERT-3 model. Where available, country-specific emission factors for vehicles as provided by national experts have been used, under the condition that sufficient supplementary documentation on the methodologies applied by countries was supplied, so that international consistency is maintained.

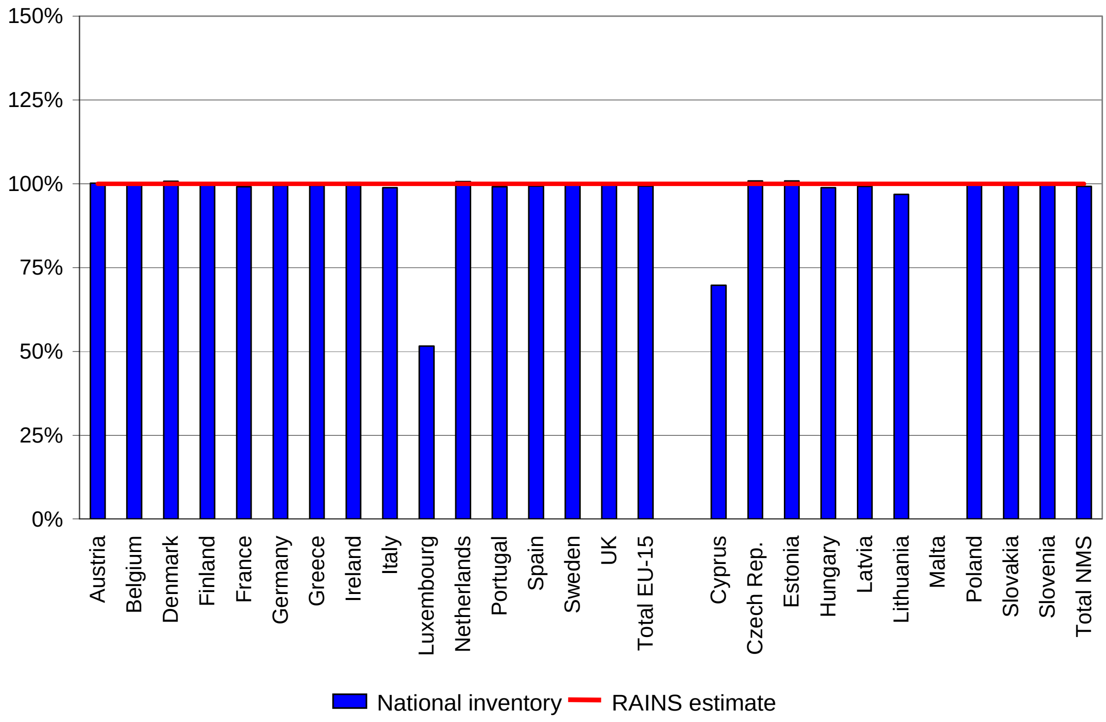


Figure 4.6: Comparison of national emission inventories for NO_x with the RAINS estimates (for the year 2000)

4.2.2 Future development

As for SO_2, the RAINS calculations of future NO_x emissions consider projected volumes of emission generating activities as provided by the energy projections, country-specific emission factors that capture the composition and technical characteristics 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
Emission standards for motorcycles and mopeds
Legislation on non-road mobile machinery
Implementation failure of EURO-II and Euro-III for heavy duty vehicles
IPPC legislation for industrial processes
National legislation and national practices (if stricter)

For the PRIMES energy projection with climate measures, NO_x emissions from the EU-15 are expected to decline by 31 percent in 2010 and by 48 percent in 2020 compared to the year 2000 (Table 4.9 to Table 4.14). Largest decreases will result from the measures in the power generation sector (-44 percent in 2010) and for mobile sources (-35 percent in 2010). For the New Member States, NO_x emissions are computed to decline by 33 percent in 2010 and by 57 percent in 2020. The scenario with no climate measures yields slightly lower reductions (-46 percent for EU-15 and -54 percent for the New Member States till 2020).

The projections indicate a significant shift in the contributions made by the individual source categories to total NO_x emissions (Figure 4.8, Figure 4.9). Due to strict emission controls for vehicles, the share of NO_x emissions caused by mobile sources will decline from 60 percent in 2000 to less than 50 percent in 2020. Especially efficient are the reductions in the controls of gasoline engines, so that their contribution to total NO_x emissions will shrink from 17 percent in 2000 to only four percent in 2020. For 2020, 18 percent of NO_x emissions are calculated to emerge from diesel heavy duty engines, while the share from off-road mobile sources will increase to 19 percent.

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 for 2010 in the emission ceilings directive, while essentially all New Member States would stay well below the preliminary ceilings (Figure 4.12 and Table 4.14). In total, the EU-15 would exceed the ceilings between five to ten percent in 2010, while the NO_x emissions from the New Member States would remain 35 to 38 percent below the ceilings. In 2015, however, progressing implementation of the stricter EURO-IV/V emission limit values for mobile sources would push NO_x emissions from the EU-15 between 6 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 from land-based sources (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	151	47	22	16	81	59	60	47	22	16
Hard coal	1016	490	315	172	507	389	275	621	518	276
Other solids	251	276	305	323	272	282	277	319	340	352
Heavy fuel oil	495	298	284	268	333	306	276	323	297	269
Middle distillates	4629	3671	2944	2500	3856	3062	2583	3793	3078	2625
Gasoline	1836	534	352	312	545	363	323	525	351	307
Natural gas	978	954	995	1037	991	1018	1029	919	967	1018
Ind. processes	558	532	529	536	561	561	565	546	542	547
Total	9913	6802	5747	5165	7145	6039	5388	7094	6115	5410

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.10: NO_x emissions by fuel for the New Member States from land-based sources (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Brown coal	216	141	93	53	153	109	63	164	116	75
Hard coal	384	228	198	116	278	272	164	221	193	113
Other solids	27	41	41	39	30	31	29	48	49	49
Heavy fuel oil	48	35	28	25	35	30	26	36	31	28
Middle distillates	506	398	303	234	404	307	237	428	331	260
Gasoline	238	72	37	34	72	38	35	68	35	31
Natural gas	135	113	122	136	113	121	132	117	126	139
Ind. processes	116	84	84	87	86	85	87	85	84	87
Total	1670	1113	907	724	1171	993	774	1167	966	783

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.11: NO_x emissions by sector for the EU-15 from land-based sources (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	1502	846	717	620	927	805	689	996	863	630
Industry	947	753	743	739	775	769	755	812	831	837
Households	541	522	518	511	549	546	537	551	549	548
Transport	6365	4148	3240	2760	4333	3358	2843	4188	3329	2848
Agriculture	0	0	0	0	0	0	0	0	0	0
Process emissions	558	532	529	536	561	561	565	546	542	547
Total	9913	6802	5747	5165	7145	6039	5388	7094	6115	5410

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.12: NO_x emissions by sector for the New Member States from land-based sources (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	563	364	293	181	407	364	218	389	323	212
Industry	163	119	117	117	123	121	121	122	121	122
Households	96	90	87	85	94	93	91	92	90	87
Transport	732	457	326	254	462	330	257	479	349	274
Agriculture	0	0	0	0	0	0	0	0	0	0
Process emissions	116	84	84	87	86	85	87	85	84	87
Total	1670	1113	907	724	1171	993	774	1167	966	783

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

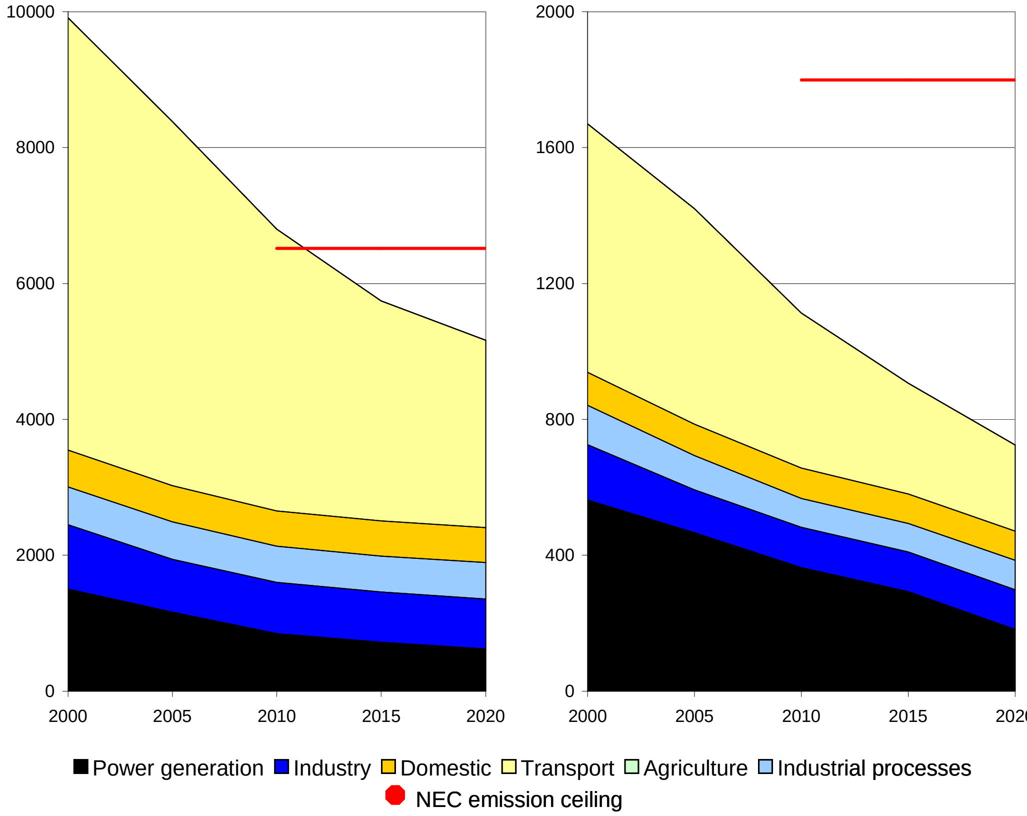


Figure 4.7: NO_x emissions (kt) by sector for the EU-15 (left panel) and the New Member States (right panel) for the "with climate policies scenario

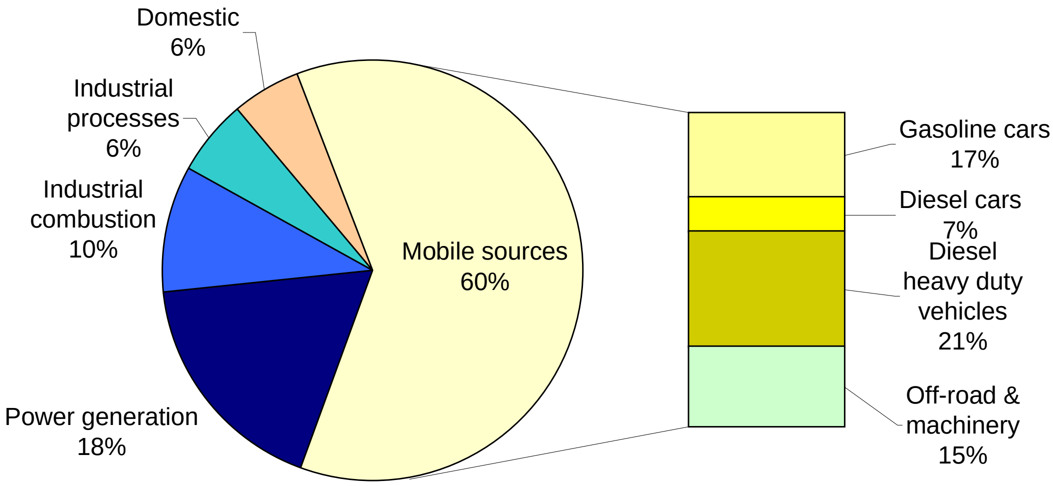


Figure 4.8: Contributions to NO_x emissions in the EU-25 in 2000

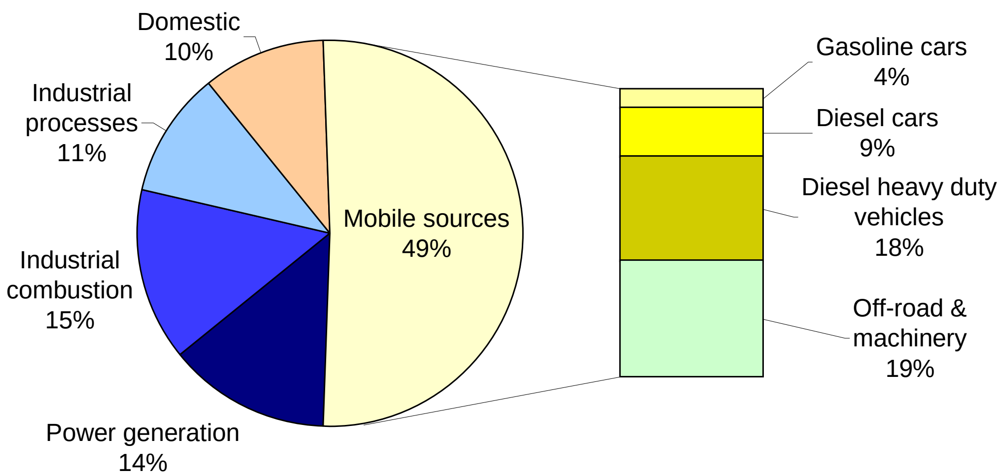


Figure 4.9: Contributions to NO_x emissions in the EU-25 in the 2020 “with further climate measures” projection

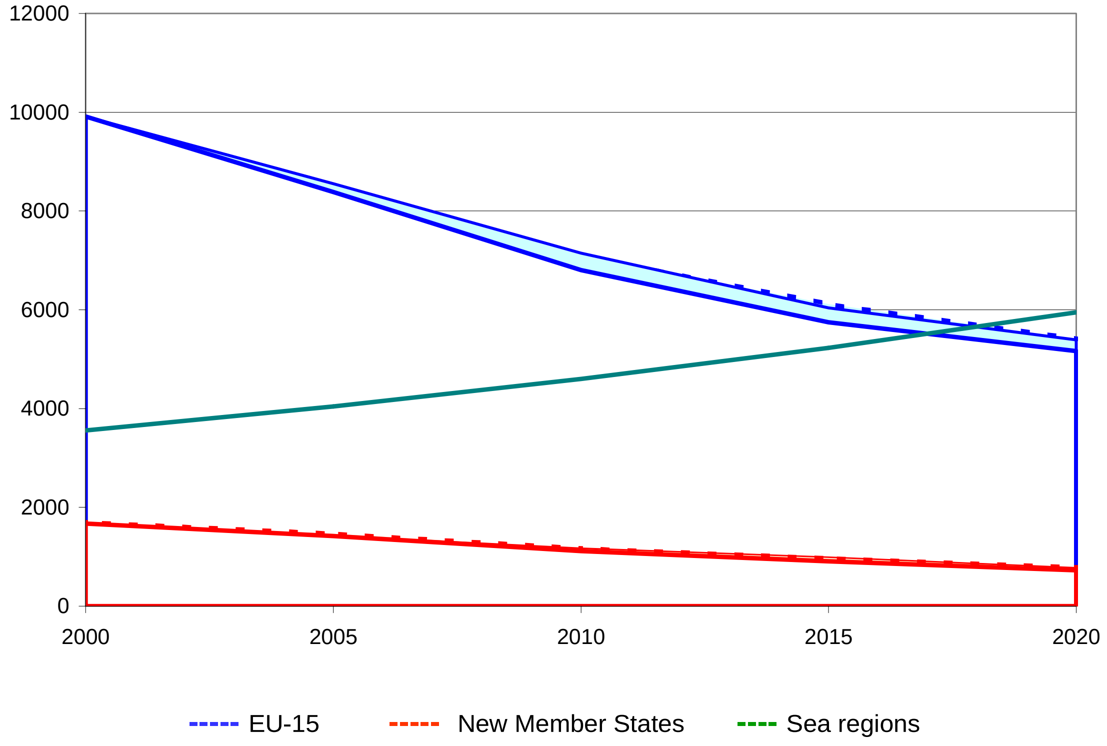


Figure 4.10: Range of NO_x projections for the “with climate measures” projection (thick solid line), the “no further climate measures projection (thin solid line) and the national energy projections (dashed line), in kt.

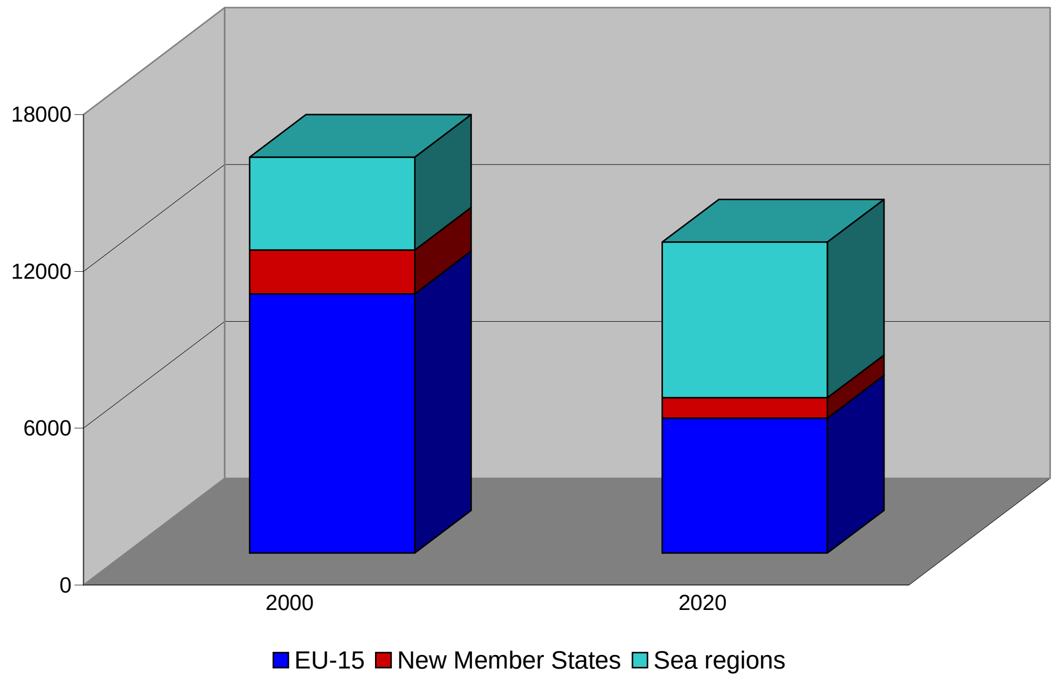


Figure 4.11: NO_x emissions from land-based sources in the EU-25 and from sea regions, 2000 and for the “with climate measures” projection for 2020 (kt SO_2)

Table 4.13: Total NO_x emissions for the two PRIMES scenarios from land-based sources (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	192	157	137	127	160	137	127			
Belgium	333	216	209	190	232	221	202	251	236	213
Denmark	207	151	124	105	147	125	105	175	145	122
Finland	212	150	132	117	151	129	112	152	137	124
France	1447	1028	868	819	1089	905	847	1092	948	902
Germany	1645	1071	861	808	1182	967	909			
Greece	322	257	229	209	266	245	215			
Ireland	129	94	76	63	99	80	65			
Italy	1389	922	804	663	1006	854	692	1031	915	755
Luxembourg	33	25	19	18	28	20	18			
Netherlands	402	283	247	241	314	261	243			
Portugal	263	188	177	156	214	192	165	226	194	164
Spain	1335	964	815	681	970	837	697			
Sweden	251	192	163	150	200	173	161	182	161	152
UK	1753	1105	886	817	1085	893	829	1133	995	831
Total EU-15	9913	6802	5747	5165	7145	6039	5388			
Cyprus	26	20	18	18	20	19	19			
Czech Republic	318	184	141	113	185	150	124	227	193	162
Estonia	37	28	19	15	28	20	16			
Hungary	188	131	99	83	135	107	91			
Latvia	35	31	21	15	29	21	17			
Lithuania	49	44	34	27	41	34	29			
Malta	9	5	4	4	6	4	4			
Poland	843	567	480	364	616	542	390			
Slovakia	106	70	63	60	72	65	58			
Slovenia	58	34	28	24	39	31	28	44	36	34
Total NMS	1670	1113	907	724	1171	993	774			
Total EU-25	11583	7915	6654	5889	8316	7032	6162			
Atlantic Ocean	575	740	840	954						
Baltic Sea	354	458	520	592						
Black Sea	120	155	176	199						
Mediterranean	1837	2383	2715	3095						
North Sea	670	862	979	1111						
Sea regions	3557	4598	5230	5951						

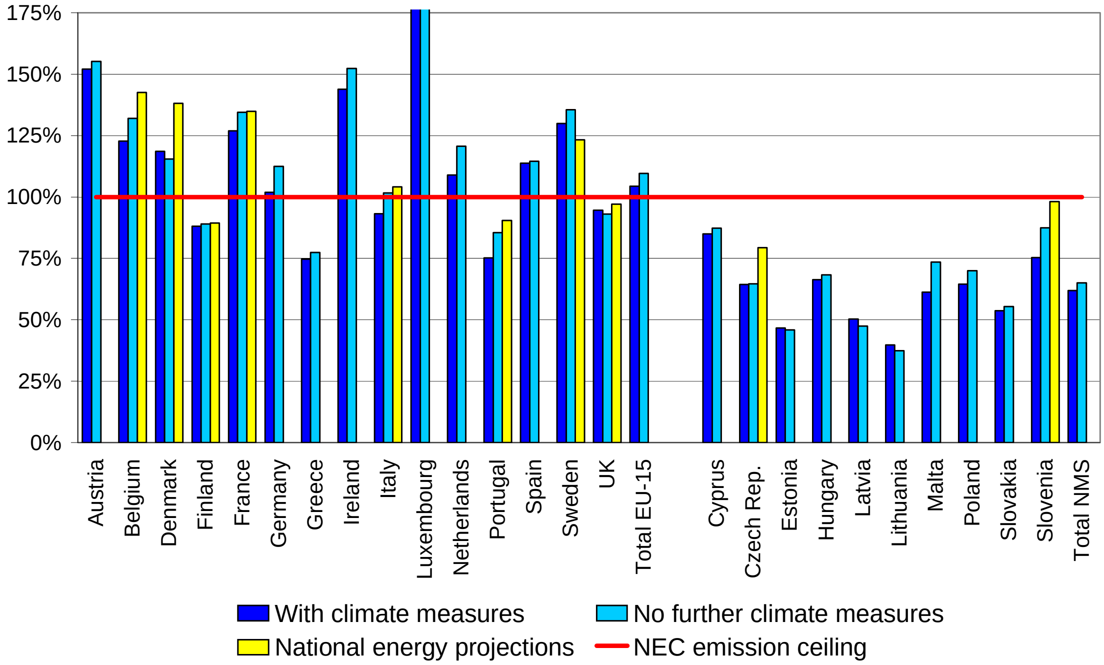


Figure 4.12: Projected NO_x emissions for the year 2010 compared with the national emission ceilings

Table 4.14: NO_x emissions (kt) estimates for 2000 and for 2010 from land-based sources

	2000		2010			
	RAINS	*National estimate*	*NEC emission ceiling*	*RAINS, with further climate measures*	*RAINS, no further climate measures*	*RAINS, national energy projections*
Austria	192	192	103	157	160	
Belgium	333	333	176	216	232	251
Denmark	207	208	127	151	147	175
Finland	212	212	170	150	151	152
France	1447	1435	810	1028	1089	1092
Germany	1645	1637	1051	1071	1182	
Greece	322	320	344	257	266	
Ireland	129	130	65	94	99	
Italy	1389	1372	990	922	1006	1031
Luxembourg	33	17	11	25	28	
Netherlands	402	404	260	283	314	
Portugal	263	260	250	188	214	226
Spain	1335	1326	847	964	970	
Sweden	251	251	148	192	200	182
UK	1753	1749	1167	1105	1085	1133
Total EU-15	9913	9847	6519	6802	7145	
Cyprus	26	18	23	20	20	
Czech Rep.	318	321	286	184	185	227
Estonia	37	38	60	28	28	
Hungary	188	185	198	131	135	
Latvia	35	35	61	31	29	
Lithuania	49	48	110	44	41	
Malta	9		8	5	6	
Poland	843	840	879	567	616	
Slovakia	106	106	130	70	72	
Slovenia	58	58	45	34	39	44
Total NMS	1670	1658	1800	1113	1171	
Total EU-25	11583	11505	8319	7915	8316	

4.3 Volatile Organic Compounds (VOC)

4.3.1 Base year emissions

With the in-depth information from the bilateral consultations the RAINS model can reproduce for most countries national VOC emissions rather well (Figure 4.13, Table 4.19). For 17 of the 25 Member States, the differences are less than five percent. Major discrepancies remain only for Latvia (25 percent) and Slovenia (34 percent). Most of the discrepancies relate to the following factors:

- Some national emission inventories use different biomass consumption data than the PRIMES energy scenario and/or apply different emission factors for biomass burning.
- Use of different emission factors for domestic use of solvents (other than paints); RAINS relies on more recent detailed studies (BIPRO, 2002), which are not always consistent with national inventory numbers.
- Differences in the assessment of evaporative emissions from cars.
- Difficulty in the assessment of emissions from sources with two-stroke gasoline engines used for off-road mobile machinery.

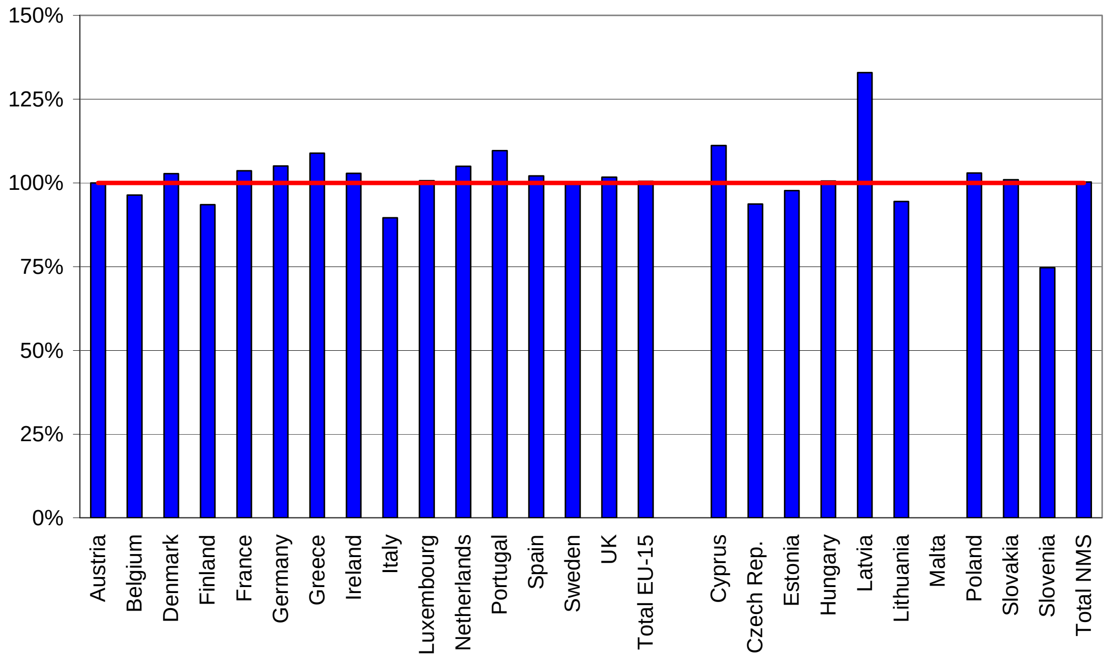


Figure 4.13: Comparison of national emission inventories for VOC with the RAINS estimates (for the year 2000)

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 small 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 4.14).

While this provisional 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) for the "with further climate measures" projection

	2000	*2010*	*2015*	*2020*
SNAP 1: Combustion in energy industries	68	59	61	64
SNAP 2: Non-industrial combustion plants	587	525	487	428
SNAP 3: Combustion in manufacturing industry	40	33	34	35
SNAP 4: Production processes	937	917	908	910
SNAP 5: Extraction and distribution	660	521	516	517
SNAP 6: Solvent use	3207	2384	2226	2155
SNAP 7: Road transport	2932	957	702	627
SNAP 8: Other mobile sources and machinery	767	571	398	319
SNAP 9: Waste treatment	122	123	123	123
SNAP 10: Agriculture	25	25	25	25
Total	9346	6115	5480	5204

Table 4.17: VOC emissions by SNAP sectors for the New Member States (kt) for the "with further climate measures" projection

	2000	*2010*	*2015*	*2020*
SNAP 1: Combustion in energy industries	32	26	19	15
SNAP 2: Non-industrial combustion plants	165	120	96	74
SNAP 3: Combustion in manufacturing industry	9	7	7	7
SNAP 4: Production processes	152	155	158	160
SNAP 5: Extraction and distribution	75	61	51	50
SNAP 6: Solvent use	403	338	318	286
SNAP 7: Road transport	370	112	66	64
SNAP 8: Other mobile sources and machinery	74	50	33	25
SNAP 9: Waste treatment	2	2	2	2
SNAP 10: Agriculture	32	32	32	32
Total	1315	903	782	714

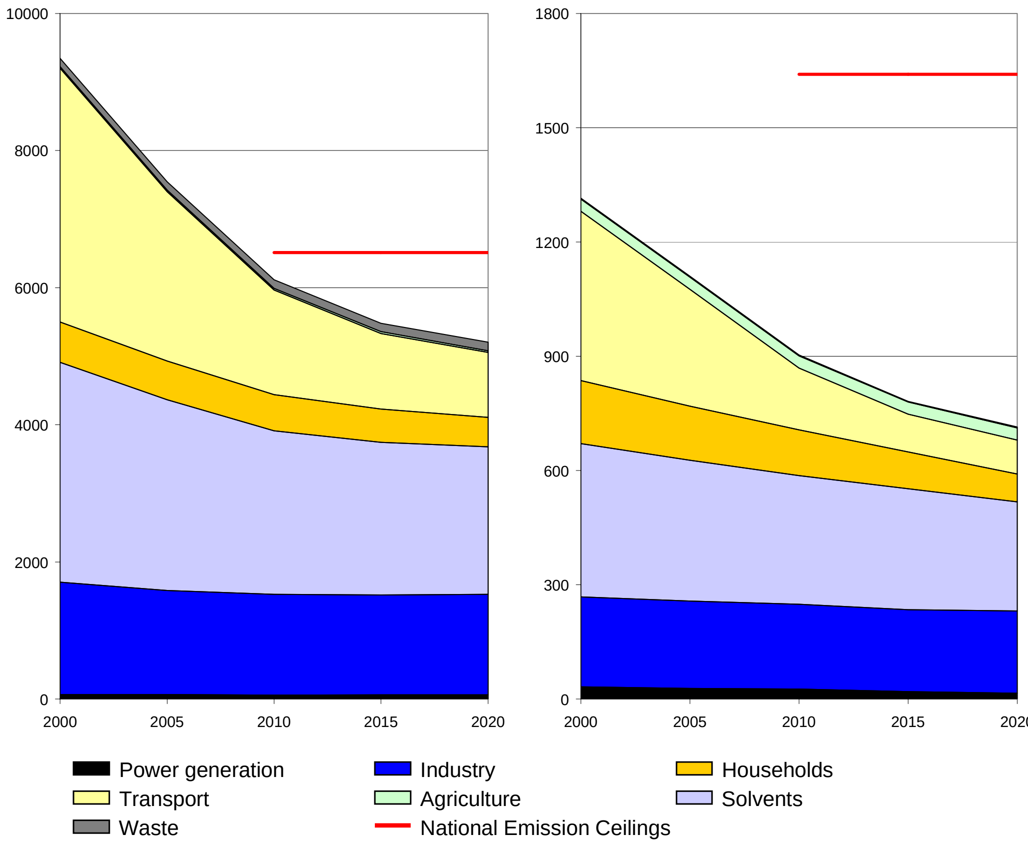


Figure 4.14: VOC emissions for the "with further climate measures" scenario (kt) for the EU-15 (left panel) and the New Member States (right panel)

Table 4.18: Total VOC emissions (kt) for the CAFE baseline scenarios

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	190	152	144	139	152	143	138			
Belgium	242	149	148	147	150	149	148	155	153	152
Denmark	128	74	63	58	73	62	58	76	65	61
Finland	171	125	109	97	124	108	95	106	90	80
France	1542	1010	935	924	1012	935	921	1055	982	973
Germany	1528	1049	864	777	1057	873	783			
Greece	280	167	150	144	168	152	146			
Ireland	88	54	49	47	55	49	46			
Italy	1738	985	824	735	995	830	739	1012	858	770
Luxembourg	13	8	8	8	8	8	8			
Netherlands	265	211	205	204	213	206	203			
Portugal	260	170	161	164	177	164	165	179	160	156
Spain	1121	793	733	702	790	730	697			
Sweden	305	220	195	179	220	198	182	225	205	192
UK	1474	947	892	880	935	883	870	926	870	851
Total EU-15	9346	6115	5480	5204	6130	5489	5199			
Cyprus	13	6	6	6	6	6	6			
Czech Republic	242	146	128	120	147	128	120	163	146	132
Estonia	34	25	19	17	25	19	17			
Hungary	169	111	100	91	111	101	92			
Latvia	52	41	32	28	41	32	28			
Lithuania	75	57	48	44	55	48	43			
Malta	5	2	2	2	2	2	2			
Poland	582	418	359	321	418	363	324			
Slovakia	88	67	64	65	67	64	64			
Slovenia	54	29	23	21	29	23	21	28	24	22
Total NMS	1315	903	782	714	902	787	718			
Total EU-25	10661	7018	6262	5918	7032	6275	5917			

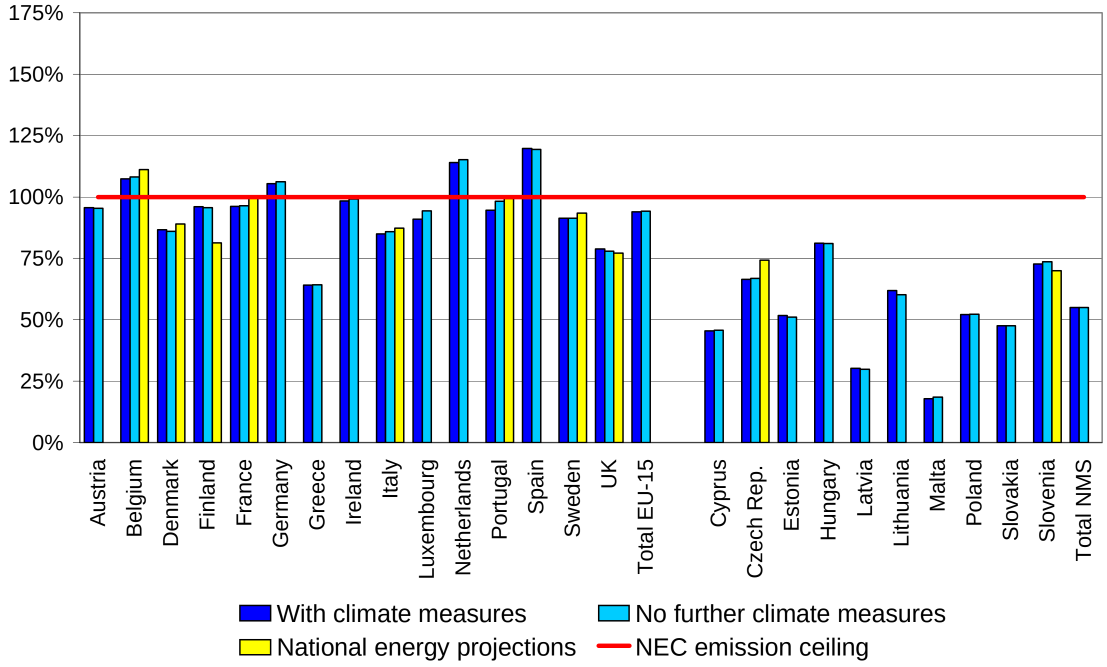


Figure 4.15: Projected VOC emissions for the year 2010 compared with the national emission ceilings

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

	2000		2010			
	RAINS	*National estimate*	*NEC emission ceiling*	*RAINS, with further climate measures*	*RAINS, no further climate measures*	*RAINS, national energy projections*
Austria	190	190	159	152	152	
Belgium	242	233	139	149	150	155
Denmark	128	132	85	74	73	76
Finland	171	160	130	125	124	106
France	1542	1726	1050	1010	1012	1055
Germany	1528	1605	995	1049	1057	
Greece	280	305	261	167	168	
Ireland	88	90	55	54	55	
Italy	1738	1512	1159	985	995	1012
Luxembourg	13	15	9	8	8	
Netherlands	265	278	185	211	213	
Portugal	260	285	180	170	177	179
Spain	1121	1144	662	793	790	
Sweden	305	304	241	220	220	225
UK	1474	1498	1200	947	935	926
Total EU-15	9346	9478	6510	6115	6130	
Cyprus	13	14	14	6	6	
Czech Rep.	242	220	220	146	147	163
Estonia	34	34	49	25	25	
Hungary	169	172	137	111	111	
Latvia	52	69	136	41	41	
Lithuania	75	71	92	57	55	
Malta	5		12	2	2	
Poland	582	599	800	418	418	
Slovakia	88	89	140	67	67	
Slovenia	54	40	40	29	29	28
Total NMS	1315	1315	1640	903	902	
Total EU-25	10661	10792	8150	7018	7032	

4.4 Ammonia (NH_3)

4.4.1 Base year emissions

With the responses to a questionnaire received from nearly 20 countries and the additional information from the bilateral consultations, RAINS can now closely reproduce the national emission inventories for many Member States (Table 4.24, Figure 4.16). For 15 countries the differences to national inventories are smaller than five percent. Only for Portugal, Greece and Cyprus large discrepancies remain.

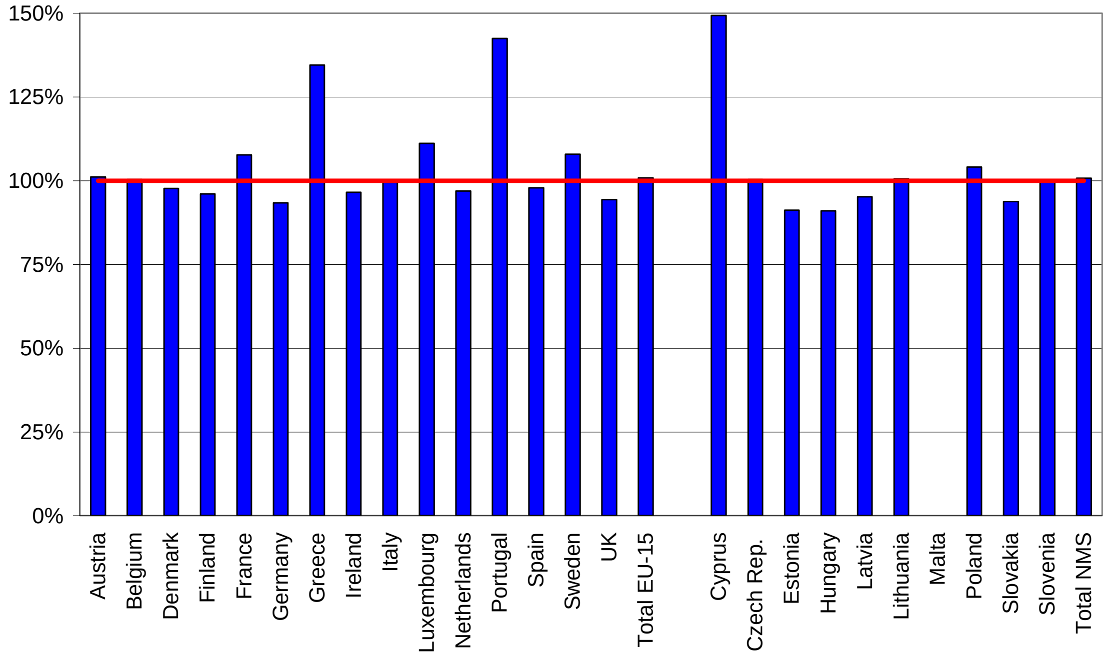


Figure 4.16: Comparison of national emission inventories for NH_3 with the RAINS estimates (for the year 2000)

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

With the changes in animal numbers as presented in Figure 3.3, only small changes in the amount of ammonia emissions are calculated for the future (Figure 4.17). In 2010 the total ammonia emissions of the EU-15 countries should be slightly above the total emission ceiling. Compliance of some countries (Belgium, Denmark, Finland, Germany, Netherlands, Spain and the UK) with the ceiling would require additional emission control measures, if the agricultural projections of the pre-CAP reform scenario materialize (Figure 4.18).

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

		Europe-wide pre-CAP reform projection			National agricultural projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Cattle	1330	1257	1216	1168	1237	1210	1185
Other animals	1083	1173	1179	1179	1153	1198	1239
Fertilizer use	533	505	497	488	504	497	488
Stationary combustion	40	36	37	41	40	40	48
Transport	72	43	24	19	41	24	19
Other	177	166	163	162	166	163	162
TOTAL	3234	3180	3117	3057	3139	3132	3141

(*) National projections from 5 countries. For the other countries, the Europe-wide scenario is assumed in this table.

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

		Europe-wide pre-CAP reform projection			National agricultural projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Cattle	177	158	155	152	159	156	154
Other animals	215	252	255	257	250	253	255
Fertilizer use	142	160	166	172	160	166	172
Stationary combustion	5	5	6	8	6	6	9
Transport	5	6	3	2	6	3	2
Other	45	37	37	37	37	37	37
TOTAL	590	619	622	629	617	621	629

(*) National projections from 3 countries. For the other countries, the Europe-wide scenario is assumed in this table.

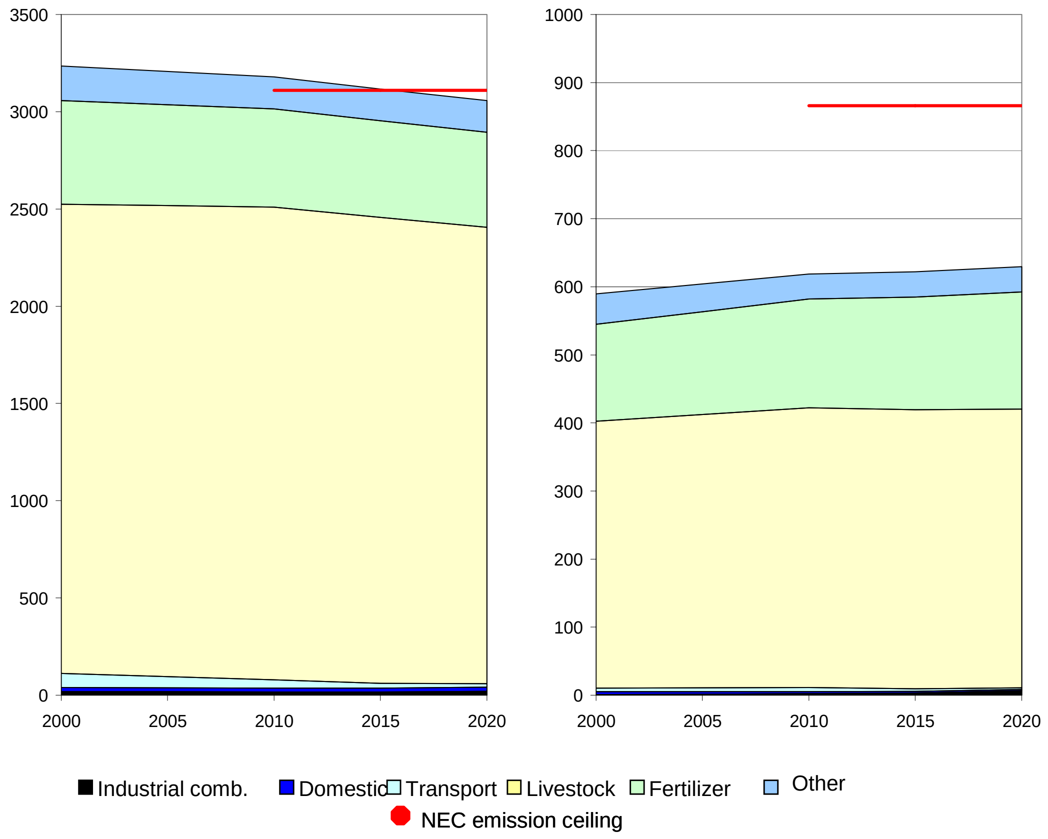


Figure 4.17: NH_3 projections for the pre-CAP reform scenario for the EU-15 (left panel) and the New Member States (right panel), in kt

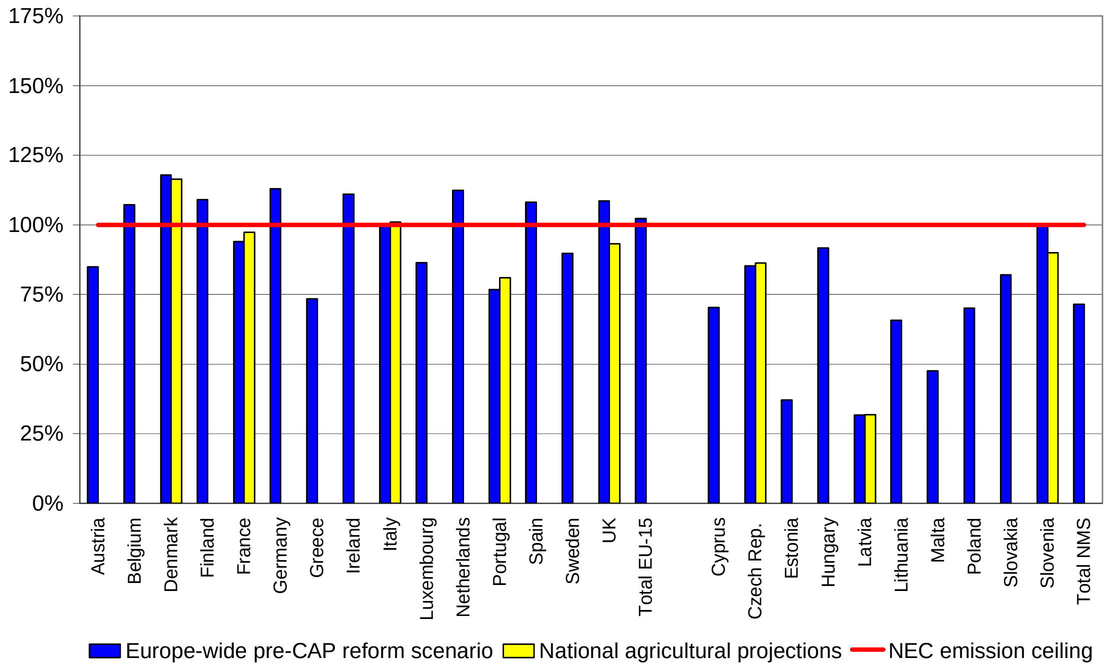


Figure 4.18: Projected NH_3 emissions for the year 2010 compared with the national emission ceilings

Table 4.23: Total NH_3 emissions (kt)

		Europe-wide pre-CAP reform scenario			National agricultural projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	54	56	55	54	55	53	52
Belgium	81	79	78	76			
Denmark	91	81	79	78	80	78	77
Finland	35	34	33	32			
France	728	733	717	702	759	786	817
Germany	638	621	612	603			
Greece	55	54	52	52			
Ireland	127	129	125	121	117	114	113
Italy	432	418	408	399	423	422	422
Luxembourg	7	6	6	6			
Netherlands	157	144	142	140	127	126	125
Portugal	68	69	68	67	73	72	72
Spain	394	382	376	370			
Sweden	53	51	50	49			
UK	315	323	316	310	277	274	275
Total EU-15	3234	3180	3117	3057			
Cyprus	6	6	6	6			
Czech Republic	74	68	67	65	69	67	66
Estonia	10	11	12	12			
Hungary	78	83	84	85			
Latvia	12	14	15	16	14	15	16
Lithuania	50	55	56	57			
Malta	1	1	1	1			
Poland	309	328	329	333			
Slovakia	32	32	32	33			
Slovenia	18	20	20	20	18	19	19
Total NMS	590	619	622	629			
Total EU-25	3824	3798	3739	3686			

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

	2000		2010		
	RAINS	*National estimate*	*NEC emission ceiling*	*Europe-wide pre-CAP reform scenario*	*National agricultural projections*
Austria	54	54	66	56	55
Belgium	81	81	74	79	
Denmark	91	89	69	81	80
Finland	35	33	31	34	
France	728	784	780	733	759
Germany	638	596	550	621	
Greece	55	74	73	54	
Ireland	127	122	116	129	117
Italy	432	429	419	418	423
Luxembourg	7	7	7	6	
Netherlands	157	152	128	144	127
Portugal	68	97	90	69	73
Spain	394	386	353	382	
Sweden	53	58	57	51	
UK	315	297	297	323	277
Total EU-15	3234	3261	3110	3180	
Cyprus	6	9	9	6	69
Czech Rep.	74	77	80	68	
Estonia	10	9	29	11	
Hungary	78	71	90	83	
Latvia	12	12	44	14	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	18
Total NMS	590	597	866	619	
Total EU-25	3824	3857	3976	3798	

4.5 Fine particulate matter

4.5.1 Base year emissions

While the RAINS model applies a uniform and reviewed methodology with country-specific emission factors to compute primary emissions of fine particles (Klimont *et al.*, 2002), 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 4.19, Figure 4.20). 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.

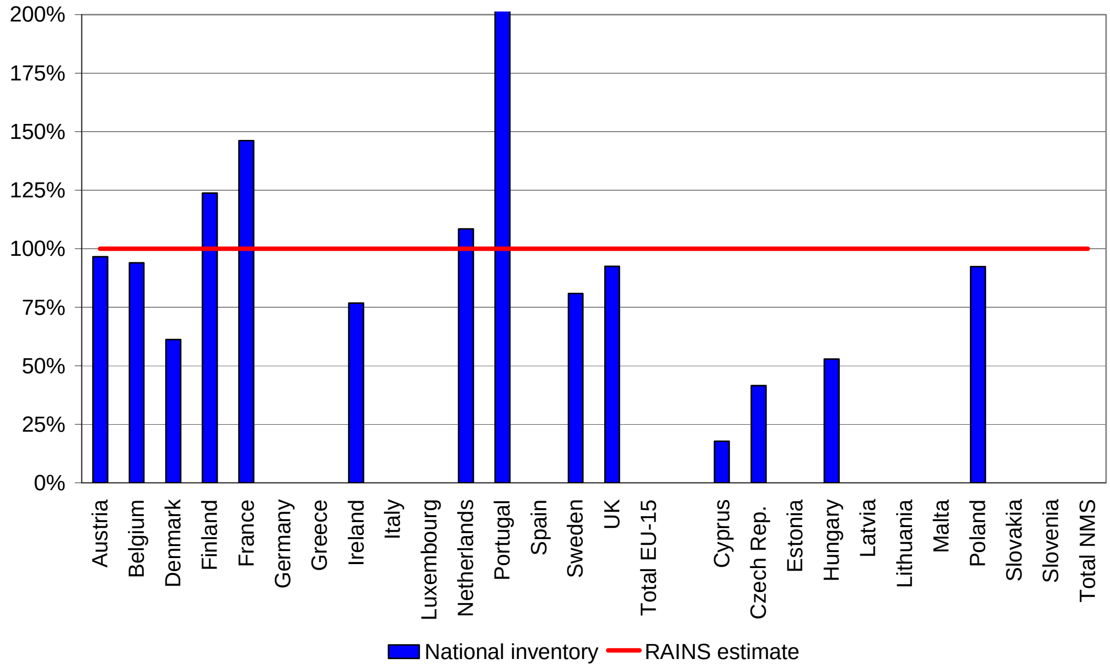


Figure 4.19: Comparison of national emission inventories for PM10 with the RAINS estimates (for the year 2000)

For the year 2000, RAINS estimates that in the EU-15 about one third of the primary PM10 emissions (637 kt) originated from industrial processes and other non-combustion sources (e.g., in agriculture). The transport sector contributes another 521 kt (including non-exhaust emissions), while combustion in the domestic/households sector (mainly fuel wood use in small stoves) is calculated to emit 360 kt. Details on contribution of individual sources to PM2.5 emissions in the EU-15 are shown in Figure 4.22. In the New Member States, the largest share of primary PM10 emissions was caused by the combustion of coal, mainly in the domestic sector.

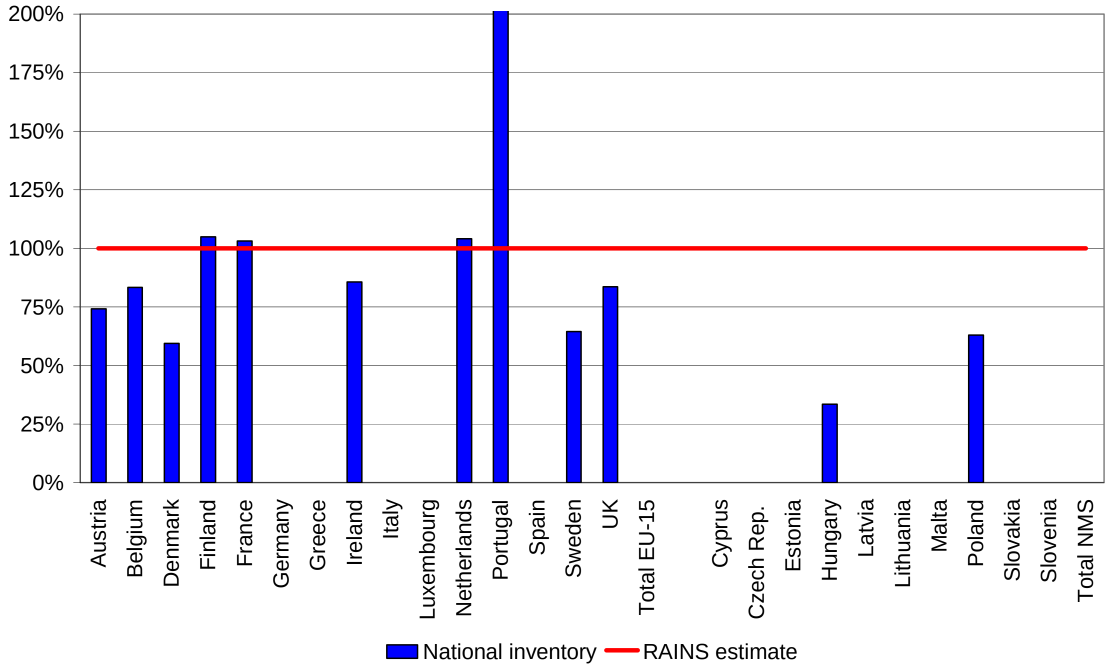


Figure 4.20: Comparison of national emission inventories for PM2.5 with the RAINS estimates (for the year 2000)

4.5.2 Future development

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

Large combustion plant directive
Auto/Oil EURO standards for vehicles
Emission standards for motorcycles and mopeds
Legislation on non-road mobile machinery
IPPC legislation on process sources
National legislation and national practices (if stricter)

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 scenario with climate measures from 2000 to 2010 by approximately 24 percent in the EU15 and by more than 40 percent in the New Member States. For 2020, total primary PM10 emissions would be 34 percent lower in the EU-15 and 55 percent in the New Member States.

Table 4.26: PM10 emissions by sector for the EU-15 (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	111	54	49	43	72	68	86	65	70	49
Industry	38	22	21	20	23	22	21	21	25	24
Households	516	369	341	308	367	339	305	445	424	393
Transport	521	346	286	263	355	293	269	357	298	274
Agriculture	226	223	221	222	228	226	227	224	226	232
Process emissions	411	338	340	348	350	352	357	329	330	335
Total	1823	1352	1258	1204	1396	1301	1265	1442	1373	1307

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.27: PM10 emissions by sector for the New Member States (kt)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	137	59	48	42	64	60	60	66	54	51
Industry	26	8	8	8	9	9	9	9	9	10
Households	241	156	125	93	157	131	96	176	147	104
Transport	58	36	28	26	37	29	26	39	30	27
Agriculture	64	63	63	62	61	59	59	62	62	61
Process emissions	97	51	50	51	52	51	51	51	50	50
Total	622	374	323	282	380	339	301	404	353	303

(*) National projections from 10 countries. For the other countries, the “with climate measures” scenario is assumed.

Table 4.28: Total primary emissions of PM10 (kt) for the CAFE baseline scenarios

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	49	43	41	39	43	41	39			
Belgium	70	44	42	41	50	48	46	57	54	53
Denmark	33	27	25	23	27	25	23	28	26	25
Finland	44	38	36	34	38	36	33	27	25	24
France	373	276	263	245	285	268	265	329	311	302
Germany	260	208	195	191	224	212	211			
Greece	66	64	59	57	68	64	62			
Ireland	22	18	16	16	18	16	16			
Italy	273	179	161	151	184	163	151	216	209	197
Luxembourg	4	3	3	3	4	3	4			
Netherlands	58	50	49	49	51	50	49			
Portugal	59	45	46	48	49	48	49	42	39	36
Spain	234	164	150	141	163	152	145			
Sweden	79	58	53	50	58	55	52			
UK	202	136	119	116	133	119	120			
Total EU-15	1823	1352	1258	1204	1396	1301	1265			
Cyprus	3	3	3	3	3	3	3			
Czech Republic	104	47	38	32	47	39	35	72	65	49
Estonia	42	18	11	9	19	12	10			
Hungary	87	38	35	33	38	39	38			
Latvia	10	8	7	6	8	7	7			
Lithuania	21	19	18	15	19	18	16			
Malta	1	1	1	1	1	1	1			
Poland	305	207	179	153	210	185	159			
Slovakia	29	22	22	22	23	22	22			
Slovenia	21	11	11	8	14	13	11	16	15	14
Total NMS	622	374	323	282	380	339	301			
Total EU-25	2445	1726	1581	1485	1775	1640	1566			

Table 4.29: PM10 emission (kt) estimates for 2000 and 2010

	2000		2010		
	RAINS	*National estimate*	*RAINS, with further climate measures*	*RAINS, no further climate measures*	*RAINS, national energy projections*
Austria	49	47	43	43	
Belgium	70	65	44	50	57
Denmark	33	20	27	27	28
Finland	44	54	38	38	27
France	373	545	276	285	329
Germany	260		208	224	
Greece	66		64	68	
Ireland	22	17	18	18	
Italy	273		179	184	216
Luxembourg	4		3	4	
Netherlands	58	62	50	51	
Portugal	59	438	45	49	42
Spain	234		164	163	
Sweden	79	64	58	58	
UK	202	187	136	133	
Total EU-15	1823		1352	1396	
Cyprus	3	1	3	3	
Czech Rep.	104	43	47	47	72
Estonia	42		18	19	
Hungary	87	46	38	38	
Latvia	10		8	8	
Lithuania	21		19	19	
Malta	1		1	1	
Poland	305	282	207	210	
Slovakia	29		22	23	
Slovenia	21		11	14	16
Total NMS	622		374	380	
Total EU-25	2445		1726	1775	

For the fine fraction of PM, i.e., for PM2.5, calculations suggest a stronger decline than for PM10. For the EU-15, primary emissions of PM2.5 would be - under the assumptions of the baseline scenario – 30 percent below the year 2000 levels, and 41 percent in 2020. For the New Member States PM2.5 is calculated to decline by 38 and 56 percent, respectively (Table 4.30 to Table 4.33).

Table 4.30: PM2.5 emissions by sector for the EU-15 (kt PM2.5)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	70	36	31	27	48	44	51	43	45	33
Industry	23	15	14	14	15	15	14	14	15	15
Households	474	351	327	297	349	325	294	417	398	371
Transport	453	269	208	180	275	212	183	280	220	191
Agriculture	47	48	47	47	49	48	48	48	49	50
Process emissions	257	212	213	218	218	219	222	204	204	208
Total	1324	930	841	784	955	864	812	1007	933	868

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

Table 4.31: PM2.5 emissions by sector for the New Member States (kt PM2.5)

		PRIMES with further climate measures			PRIMES without further climate measures			National projections(*)		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Power generation	78	39	32	28	42	39	38	43	36	34
Industry	10	5	5	4	5	5	5	5	5	5
Households	202	137	112	84	137	117	86	152	129	93
Transport	52	29	20	17	29	20	17	32	22	18
Agriculture	22	22	22	22	22	22	22	22	22	22
Process emissions	61	32	32	32	32	32	32	31	31	32
Total	425	263	222	187	267	234	200	286	246	205

(*) National projections from 10 countries. For the other countries, the "with climate measures" scenario is assumed.

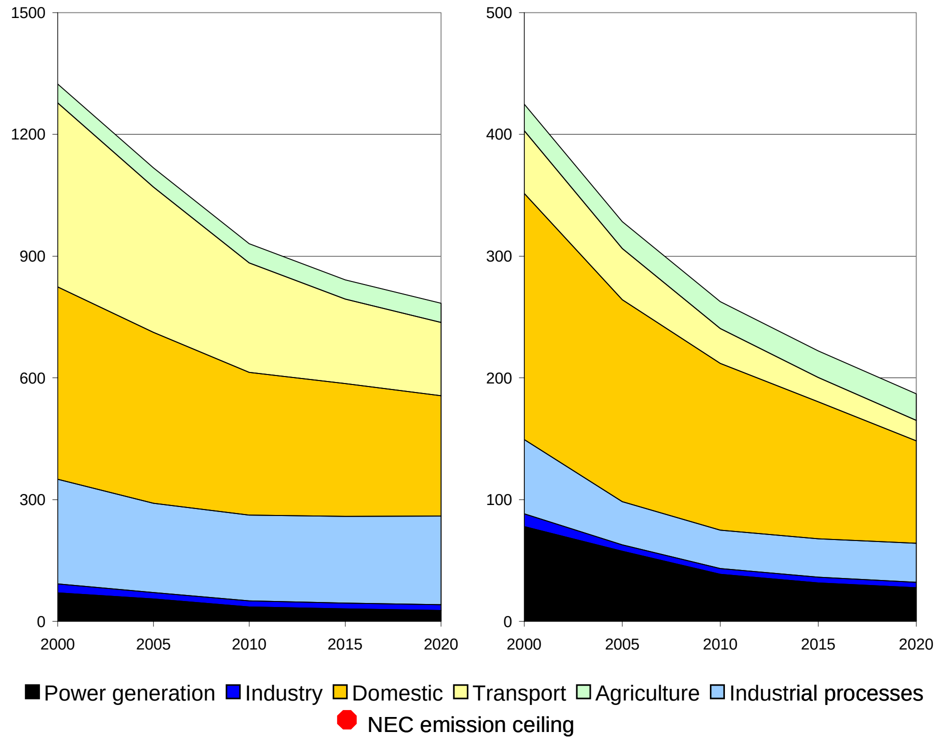


Figure 4.21: PM2.5 emissions by sector (in kt) for the EU-15 (left panel) and the New Member States (right panel) for the "with climate policies scenario

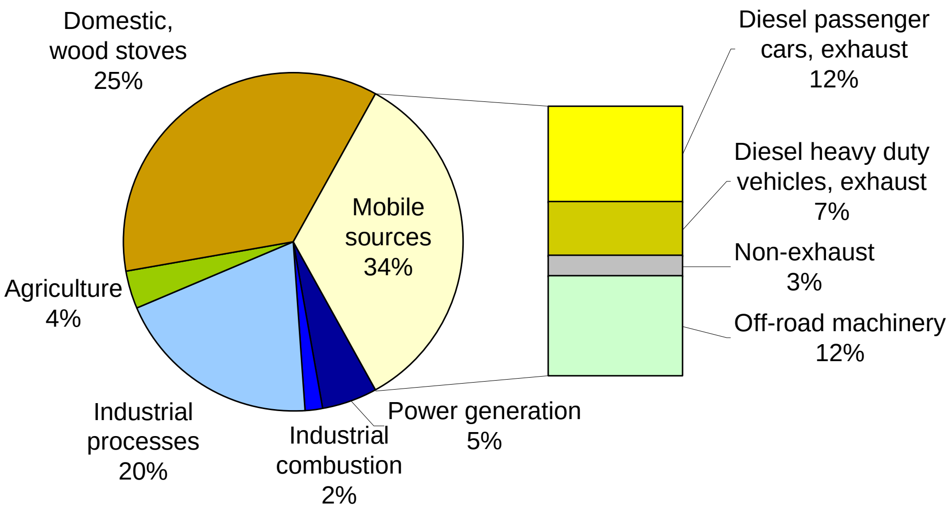


Figure 4.22: Contribution to primary PM2.5 emissions in the EU-15, year 2000

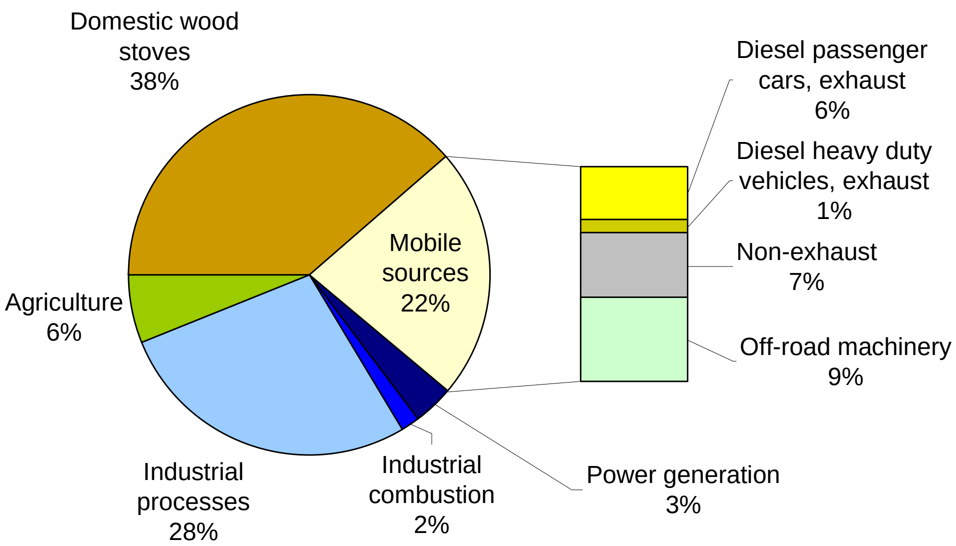


Figure 4.23: Contribution to primary PM2.5 emissions in the EU-15, year 2020

Progressing implementation of emission control technologies and continuing changes in the composition of emission source categories will alter the contributions of the various emission source sectors to total PM2.5 emissions (Figure 4.22, Figure 4.23). Overall, the share of mobile sources will decline from one third to slightly more than 20 percent. Implementation of Euro-V for diesel heavy duty vehicles will reduce the contribution of exhaust emissions from this category from 7 percent in 2000 to one percent in 2020. The share of exhaust emissions from diesel passenger cars is calculated to decline from 12 percent to 6 percent in 2020, while off-road mobile sources will increase their contribution to 9 percent. Overall, the largest sources of primary PM2.5 emissions will be wood combustion in domestic stoves (38 percent) and industrial processes (28 percent).

While the relative contributions from the individual source categories to total primary emissions is enlightening, it does neither provide full information on the largest contributors to population exposure, nor on the sources of the most harmful (toxic) emissions nor on the most cost-effective means for improving human health. Such an analysis must consider, in addition to the sources of primary particle emissions, the contribution to ambient PM made by secondary organic and inorganic aerosols as well as potential differences in the toxicity of emissions from the various sources. As an example, Figure 4.24 presents the development emissions of black carbon associated with the “with climate measures” scenario. In contrast to total PM2.5 emissions, the bulk of black carbon emissions originate from wood combustion and diesel exhaust.

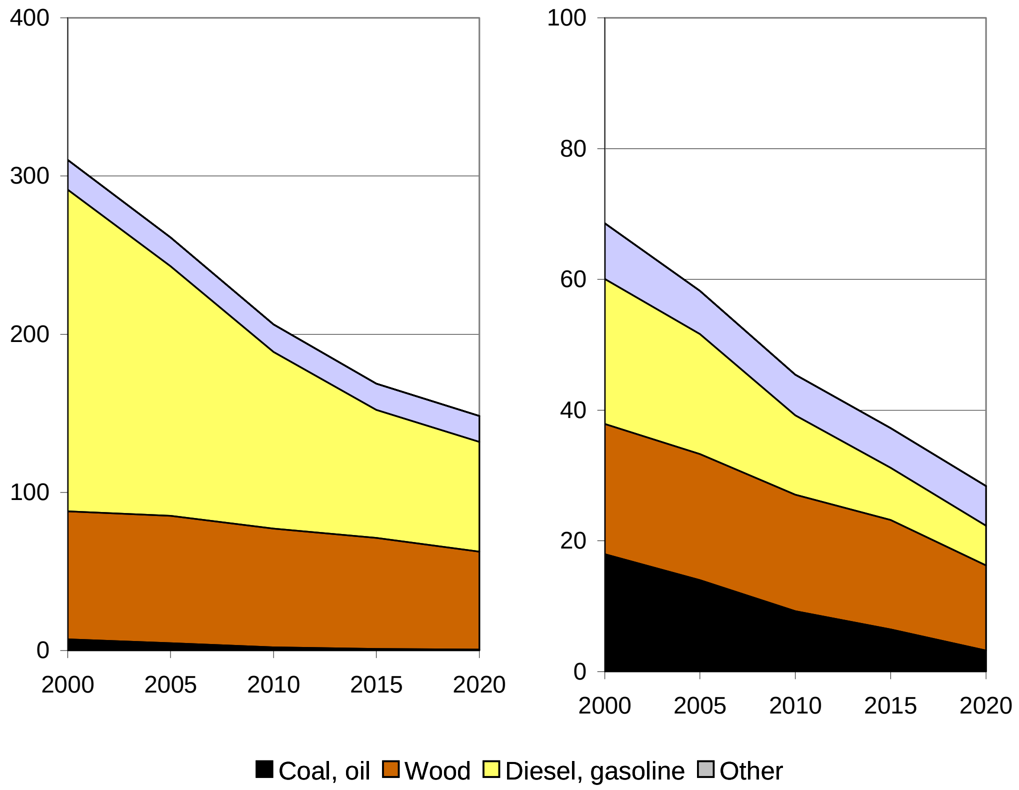


Figure 4.24: Black carbon emissions for the EU-15 (left panel) and the New Member States (right panel) for the “with climate measures” scenario, in kt

Table 4.32: Total primary emissions of PM2.5 (kt) for the two PRIMES scenarios

		PRIMES with further climate measures			PRIMES without further climate measures			National projections		
	2000	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*	*2010*	*2015*	*2020*
Austria	37	31	29	27	31	29	27			
Belgium	43	27	25	24	29	28	26	34	32	31
Denmark	22	17	15	13	17	15	13	17	15	14
Finland	36	32	29	27	31	29	27	21	19	17
France	290	201	184	167	205	186	174	247	227	215
Germany	171	127	116	111	137	127	123			
Greece	49	47	43	41	50	46	44			
Ireland	14	12	10	9	12	10	9			
Italy	209	129	111	100	132	112	100	163	154	141
Luxembourg	3	2	2	2	3	2	2			
Netherlands	36	28	26	26	28	27	26			
Portugal	46	35	36	37	39	38	38	32	29	26
Spain	169	113	100	91	112	101	92			
Sweden	67	47	43	40	48	44	42	50	48	47
UK	129	82	71	68	80	71	69	84	85	71
Total EU-15	1324	930	841	784	955	864	812			
Cyprus	2	2	2	2	2	2	2			
Czech Republic	66	29	22	18	30	24	21	49	44	32
Estonia	22	13	8	6	13	9	7			
Hungary	60	26	24	22	27	26	25			
Latvia	7	6	5	4	6	5	5			
Lithuania	17	16	14	12	15	14	12			
Malta	1	0	0	0	0	0	0			
Poland	215	148	124	102	149	130	107			
Slovakia	18	14	14	14	14	14	14			
Slovenia	15	8	8	6	10	9	7	12	11	10
Total NMS	425	263	222	187	267	234	200			
Total EU-25	1749	1193	1064	971	1222	1098	1013			

Table 4.33: Estimates of primary PM2.5 emissions

	2000		2010		
	RAINS	*National estimate*	*RAINS, with further climate measures*	*RAINS, no further climate measures*	*RAINS, national energy projections*
Austria	37	27	31	31	
Belgium	43	36	27	29	34
Denmark	22	13	17	17	17
Finland	36	38	32	31	21
France	290	299	201	205	247
Germany	171		127	137	
Greece	49		47	50	
Ireland	14	12	12	12	
Italy	209		129	132	163
Luxembourg	3		2	3	
Netherlands	36	38	28	28	
Portugal	46	371	35	39	32
Spain	169		113	112	
Sweden	67	43	47	48	50
UK	129	108	82	80	84
Total EU-15	1324		930	955	
Cyprus	2		2	2	
Czech Rep.	66		29	30	49
Estonia	22		13	13	
Hungary	60	20	26	27	
Latvia	7		6	6	
Lithuania	17		16	15	
Malta	1		0	0	
Poland	215	135	148	149	
Slovakia	18		14	14	
Slovenia	15		8	10	12
Total NMS	425		263	267	
Total EU-25	1749		1193	1222	

5 Air quality and impacts

5.1 PM2.5

The EMEP Eulerian 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, and 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 reviewed state-of-the-art models) as sufficiently accurate and robust for policy analysis. Thus, one should not base an integrated assessment on estimates of total PM mass concentrations (http://www.unece.org/env/documents/2004/eb/ge1/eb.air.ge.1.2004.6.e.pdf). The largest deficiencies have been identified in the quantification of the contribution from natural sources (e.g., mineral dust, organic carbon, etc.) and water. Equally, 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, in order 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.

Based on these arguments, the present modelling capabilities allow quantification of the dispersion of (most of) the fine particles (smaller than 2.5 µm) of anthropogenic origin. This permits calculating changes in PM2.5 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 PM2.5 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 5.2 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 1997, 1999, 2000 and 2003. The graphs reveal a substantial influence of the inter-annual meteorological variability on annual mean PM2.5 concentrations. Without prejudging further decisions of CAFE stakeholders on how to address this inter-annual meteorological variability, the scenario analysis presented in this report is based on the average results obtained from four calculations conducted for the four meteorological conditions. For the future analysis it will be important to thoroughly analyse the impacts of this variability, keeping in mind that some impacts can be caused by short-term episodes and that climate change might lead to more frequent occurrence of extreme weather conditions in the coming decades.

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 (Figure 5.1). 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 declining 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 5.2.

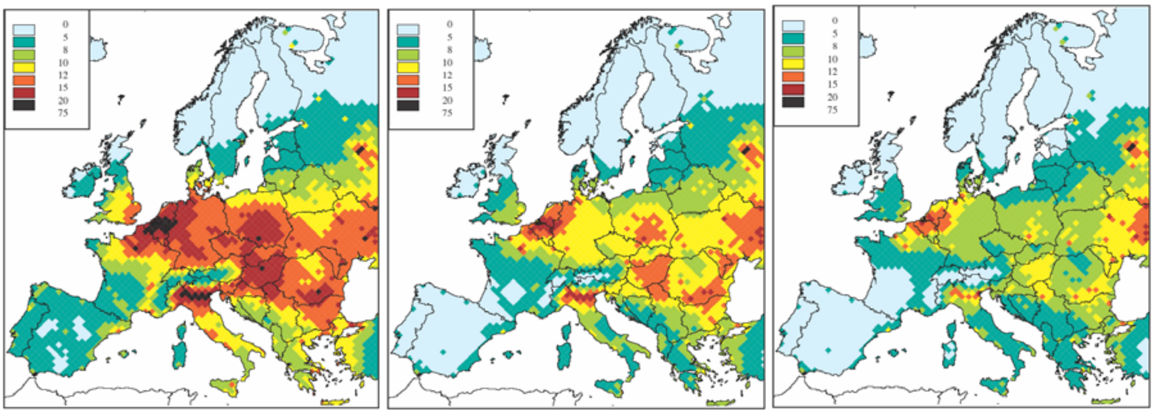
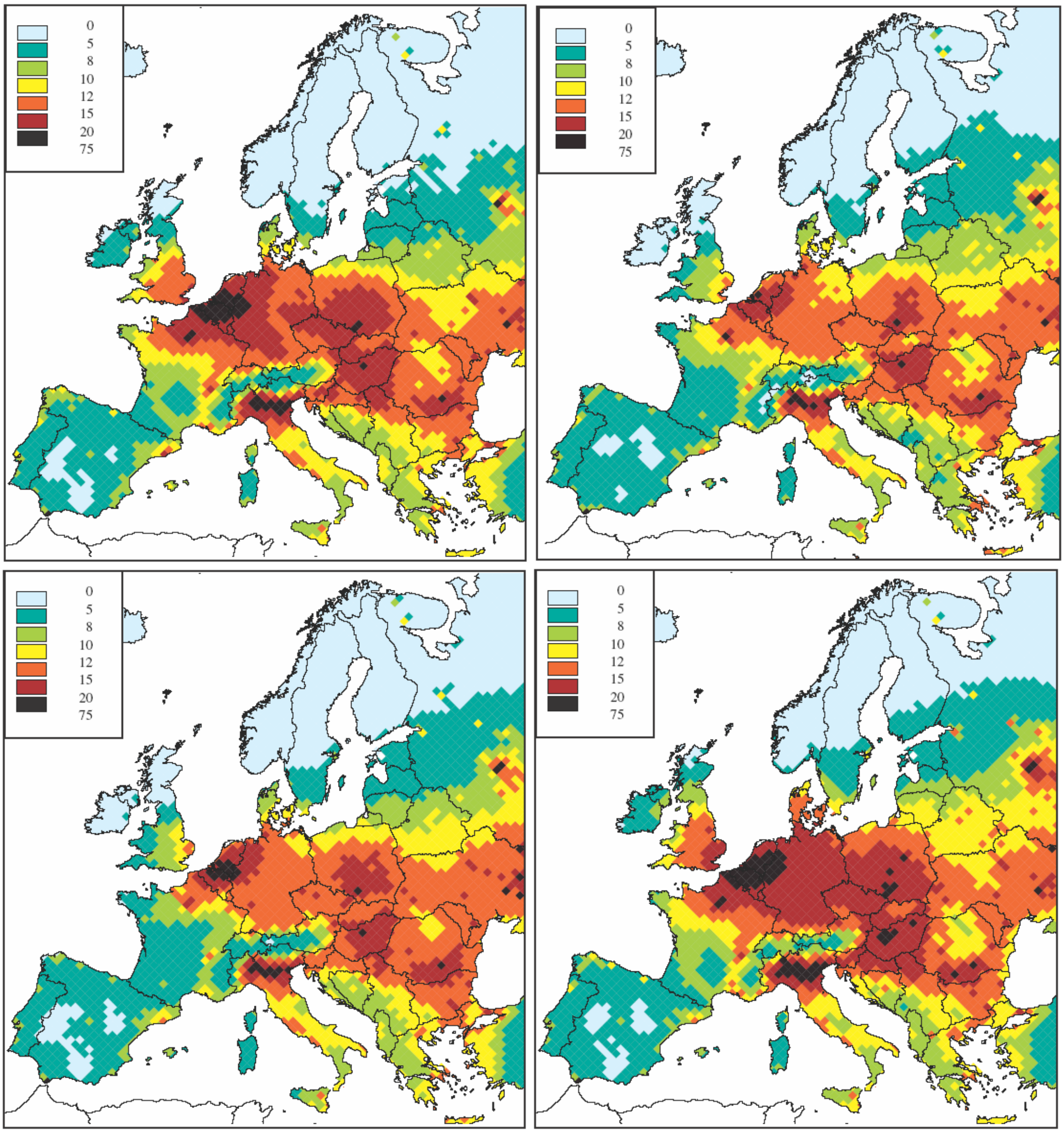


Figure 5.1: Identified anthropogenic contribution to modelled rural PM2.5 concentrations (annual mean, µg/m^3) for the baseline emissions of the year 2000 (left panel), the year 2010 (centre panel) and for 2020 (right panel). Average of calculation results for four meteorological years (1997, 1999, 2000, 2003).



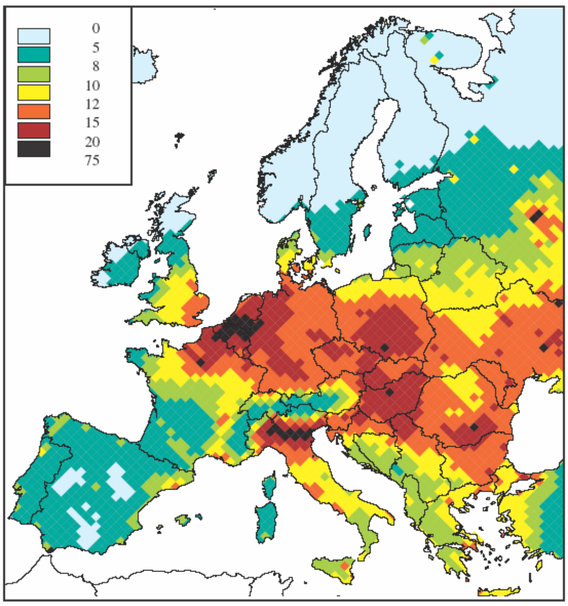


Figure 5.2: Identified anthropogenic contribution to rural concentrations of PM2.5 (annual mean concentrations, µg/m^3), for the emissions of the year 2000 calculated for the meteorological conditions of 1997 (left top panel), of 1999 (right top panel), 2000 (centre left panel) and 2003 (centre right panel). The bottom panel shows PM2.5 concentrations averaged over these four meteorological years, which is used for the scenario analysis in this report. The calculations do not reproduce the total observed mass of PM2.5, because contributions from natural sources and secondary organic aerosols are excluded.

5.2 Loss in life expectancy attributable to anthropogenic PM2.5

With the methodology described in Amann *et al.* (2004), the RAINS model estimates 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. Following the advice of the joint World Health Organization/UNECE Task Force on Health (http://www.unece.org/env/documents/2004/eb/wg1/eb.air.wg1.2004.11.e.pdf), 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 from 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 and thus underestimates overall effects. Awaiting results from the City-Delta project, the provisional estimates presented in this report assume PM2.5 concentrations originating 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 (based on the average of four-year calculations). 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 are calculated to exceed six months. Obviously, these calculations are sensitive towards the meteorological conditions assumed in the analysis (Figure 5.4). While per definition these calculations address long-term exposure to PM, there is uncertainty about the meteorological conditions that are most representative for present and future climates.

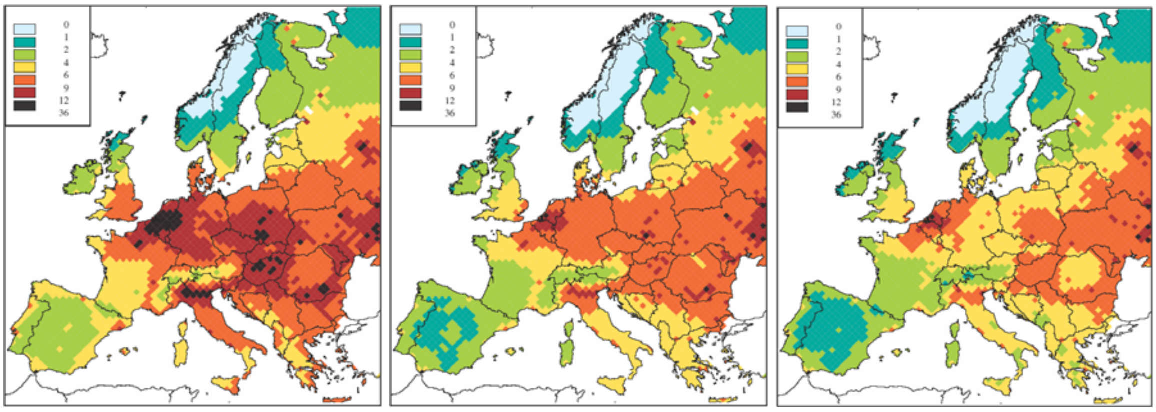


Figure 5.3: Loss in statistical life expectancy that can be attributed to the identified anthropogenic contributions to PM2.5 (in months), for the emissions of the year 2000 (left panel) and the emissions of the "without further climate policies scenario for 2010 (centre panel) and for 2020 (right panel). Average of calculations for four meteorological years (1997, 1999, 2000, 2003).

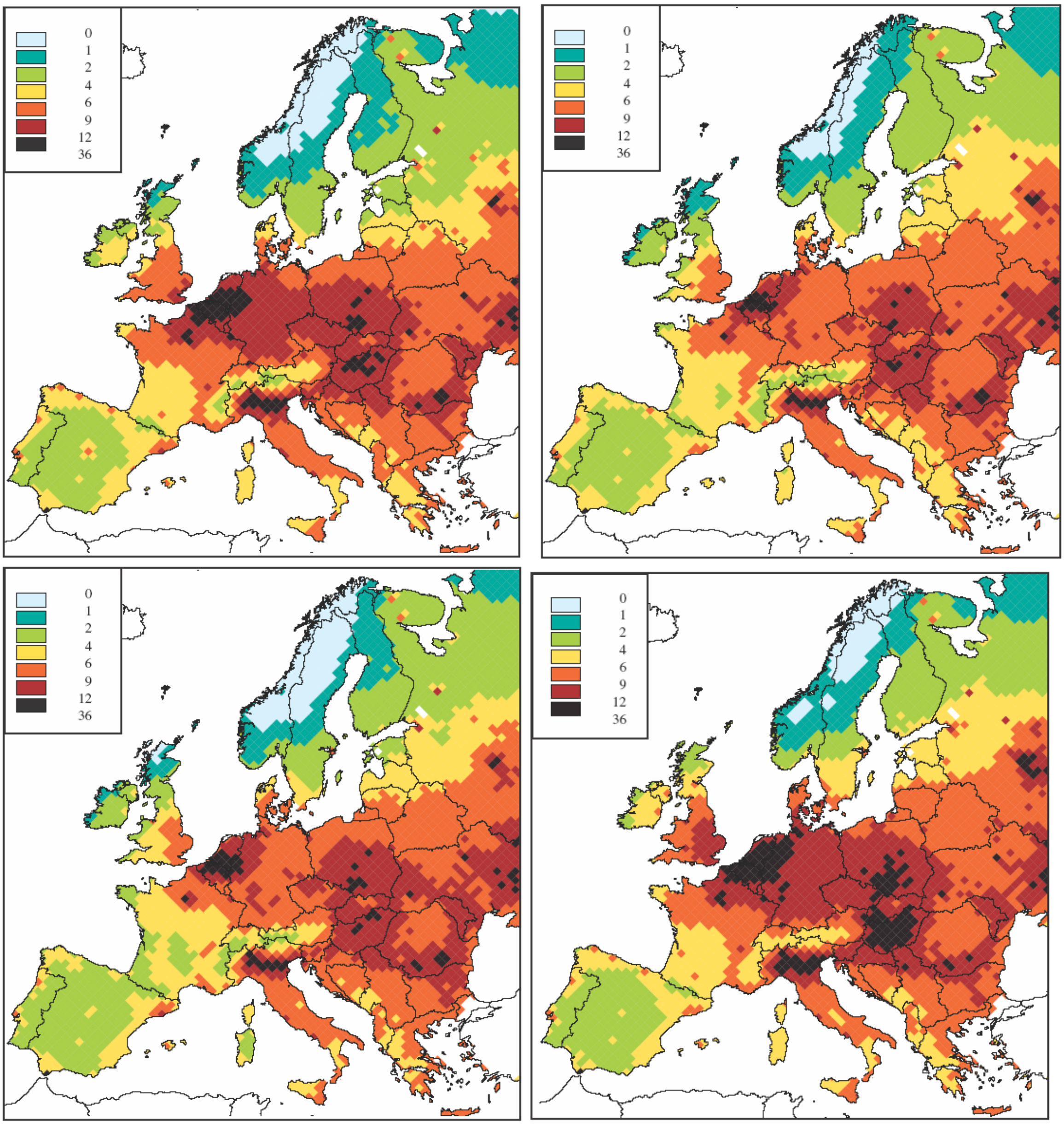


Figure 5.4: Loss in statistical life expectancy that can be attributed to the identified anthropogenic contributions to PM2.5 for the emissions of the year 2000 (in months). The calculation for the meteorological conditions of 1997 is shown in left top panel, for 1999 in the right top panel, for 2000 in the left bottom panel and for 2003 in the right bottom panel.

Table 5.1: Provisional estimates of loss in statistical life expectancy that can be attributed to the identified anthropogenic contributions to PM2.5 (in months) for the emissions of 2000 and the "no further climate measures" scenario for 2010 and 2020. The central estimates present average of four calculations for four meteorological years (1997, 1999, 2000, 2003), while the range indicates the variation across individual meteorological conditions. Provisional calculations with generic assumptions on urban concentrations, to be revised with City-Delta results.

	2000			2010			2020		
	Central estimate	*Range*		*Central estimate*	*Range*		*Central estimate*	*Range*	
Austria	8.0	7.4	9.0	5.9	5.5	6.8	4.8	4.5	5.5
Belgium	13.6	11.7	15.4	9.9	8.5	11.3	8.8	7.6	10.0
Denmark	7.3	6.6	8.7	5.8	5.2	7.0	5.3	4.8	6.4
Finland	3.1	2.6	3.7	2.7	2.2	3.2	2.4	2.0	2.9
France	8.2	7.0	9.3	5.9	4.9	6.7	5.1	4.3	5.8
Germany	10.2	8.9	11.6	7.5	6.5	8.6	6.4	5.6	7.3
Greece	7.1	7.0	7.3	5.8	5.7	5.9	5.2	5.1	5.3
Ireland	3.9	2.9	5.1	3.0	2.2	4.0	2.7	2.0	3.6
Italy	9.0	8.5	9.6	6.6	6.2	7.1	5.6	5.3	6.0
Luxembourg	9.7	8.0	11.2	7.1	5.6	8.2	6.0	4.8	7.1
Netherlands	12.7	10.9	14.6	9.7	8.2	11.2	9.0	7.6	10.2
Portugal	5.2	4.9	5.4	3.4	3.2	3.6	3.2	3.0	3.4
Spain	5.1	5.0	5.4	3.5	3.4	3.7	3.2	3.1	3.3
Sweden	4.3	3.9	5.2	3.4	3.1	4.2	3.2	2.9	3.8
UK	6.9	5.5	8.7	4.9	3.8	6.4	4.5	3.5	5.7
Total EU-15	8.2	7.4	9.3	6.0	5.4	6.8	5.3	4.7	5.9
Czech Rep.	10.1	9.2	11.2	7.2	6.5	8.1	5.7	5.1	6.4
Estonia	4.4	3.7	5.2	3.8	3.2	4.6	3.4	2.9	4.2
Hungary	12.4	11.6	13.6	8.9	8.3	9.8	7.1	6.6	7.9
Latvia	5.1	4.4	6.1	4.4	3.7	5.3	3.9	3.3	4.7
Lithuania	6.9	6.2	8.1	5.9	5.3	7.0	5.2	4.6	6.0
Malta	7.7	7.4	8.0	6.8	6.5	7.1	7.4	7.0	7.8
Poland	10.7	9.9	11.8	8.1	7.4	9.0	6.4	5.9	7.2
Slovakia	10.4	9.6	11.4	7.7	7.1	8.6	6.2	5.7	6.9
Slovenia	9.3	8.7	10.3	6.9	6.4	7.7	5.7	5.3	6.3
Total NMS	10.3	9.5	11.4	7.7	7.1	8.6	6.2	5.7	6.9
Total EU-25	8.6	7.7	9.6	6.3	5.6	7.1	5.4	4.9	6.1

5.3 Ozone

5.3.1 Health impacts

Methodology

For long time, human exposure to ground-level ozone has been found to impair human health and a range of morbidity endpoints have been associated with increased exposure to ozone. Thus, back in 1999, policy analysis with RAINS for the NEC Directive and the Gothenburg Protocol relied on the health guidelines of the World Health Organization for Europe, which specify a guideline value of 60 ppb as an eight hour average (WHO, 2000). At that time, the guideline value was considered as a threshold, below which only minor health effects could be expected, but no quantification of the effects of higher concentrations was available. Consequently, the RAINS model used an AOT60 (i.e., the accumulated excess concentrations over a threshold of 60 ppb) as a proxy for quantifying exceedances of the guideline value as a measure on the way towards the no-effect level (Amann and Lutz, 2000). With this approach, no judgement was assumed on the relative importance of a large one-time excess of the 60 ppb threshold compared to repeated small violations.

In 2003, the WHO systematic review of health aspects of air quality in Europe confirmed the health relevance of exposure to ozone. It was also found that since the time the WHO Air Quality Guidelines were agreed (WHO, 2000), sufficient new evidence was established to justify their reconsideration.

The review found that recent epidemiological studies have strengthened the evidence that effects of ozone observed in short-term studies on pulmonary function, lung inflammation, respiratory symptoms, morbidity and mortality are independent of those from other pollutants, in particular in the summer season. It is also stated that controlled human exposure studies confirmed the potential of ozone to cause adverse effects. Some studies also suggest that long-term exposure to ozone reduces lung function growth in children. However, there is little evidence for an independent long-term O_3 effect on lung cancer or total mortality. The review provided convincing evidence that the level of 120 µg/m^3 does not provide protection against a number of severe health outcomes (WHO, 2003). This review concluded that '*there is little evidence from short-term effect epidemiological studies to suggest a threshold at the population level. It should be noted that many studies have not investigated this issue. Long-term studies on lung function do not indicate a threshold either. However, there may well be different concentration-response curves for individuals in the population, since in controlled human exposure and panel studies there is considerable individual variation in response to O_3 exposure.*' This question was re-assessed when WHO reviewed additional questions from CAFE and the results were basically confirmed (WHO, 2004). The uncertainties were investigated in greater detail, and it was concluded: '*… in some studies associations with outcomes ranging from mortality to respiratory symptoms have been reported from locations where ozone never exceeds 120 to 160 µg/m^3 as 8-hour average values. Some panel studies suggest small effects on lung function above around 60 to 80 µg/m^3 1-hour average. Our confidence in the existence of associations with health outcomes decreases at concentrations well below these levels as problems with negative correlations with other pollutants and lack of correlation with personal exposure increase but we do not have the evidence to rule them out*.'

The review also concluded that '… *time-series studies find linear or near-linear relationships between day-to-day variations in peak ozone levels and health endpoints down to low levels of exposure. As there are usually many more days with mildly elevated concentrations than days with very high concentrations, the largest burden on public health may be expected with the many days with mildly elevated concentrations, and not with the few days with very high concentrations*.'

Based on these findings from WHO, the UNECE-WHO Task Force on Health "*noted that the AOT60 concept used previously within the RAINS model might no longer be appropriate to account for the effects of ozone on human health in the light of the findings of the review published by the WHO/ECEH Bonn Office. In particular, the WHO review had concluded that effects might occur at levels below 60 ppb, which was the threshold level used to calculate AOT60, and a possible threshold, if any, might be close to background levels and not determinable. This review had also indicated that the effects of ozone on mortality and some morbidity outcomes were independent of those of PM*" (TFH, 2003).

Based on these considerations, the joint WHO/UNECE Task Force at its 7th Meeting developed specific recommendations concerning the inclusion of ozone-related mortality into RAINS. Key points of these recommendations are summarised below:

- The relevant health endpoint is mortality, even though several effects of ozone on morbidity are also well documented and causality established; however, available input data (e.g., on base rates) to calculate the latter on a European scale are often either lacking or not comparable.
- The relative risk for all-cause mortality is taken from the recent meta-analysis of European time-series studies, which was commissioned by WHO and performed by a group of experts of St. George's Hospital in London, UK (WHO, 2004). The relative risk taken from this study is 1.003 for a 10 $\mu g/m^3$ increase in the daily maximum 8-hour mean (CI 1.001 and 1.004).
- In agreement with the recent findings of the WHO Systematic Review, a linear concentration-response function is applied.
- The effects of ozone on mortality are calculated from the daily maximum 8-hour mean. This is in line with the health studies used to derive the summary estimate used for the meta-analysis mentioned above.
- Even though current evidence was insufficient to derive a level below which ozone has no effect on mortality, a cut-off at 35 ppb, considered as a daily maximum 8-hour mean ozone concentration, is used. This means that for days with ozone concentration above 35 ppb as maximum 8-hour mean, only the increment exceeding 35 ppb is used to calculate effects. No effects of ozone on health are calculated on days below 35 ppb as maximum 8-hour mean. This exposure parameter is called SOMO35 (sum of means over 35) and is the sum of excess of daily maximum 8-h means over the cut-off of 35 ppb calculated for all days in a year. This is illustrated in the following figure.

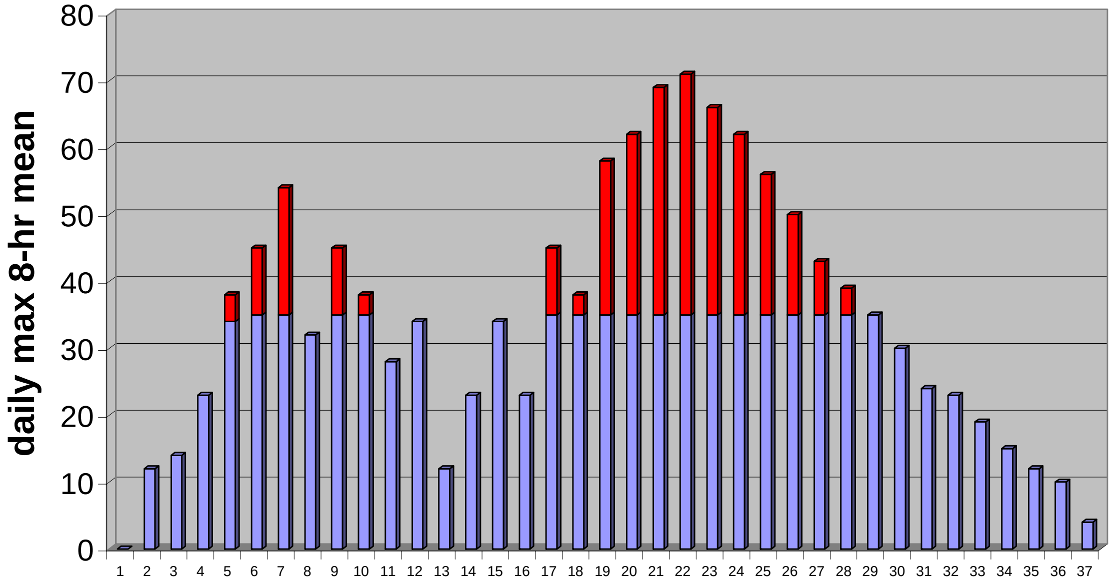


Figure 5.5: SOMO 35: Only the excess of daily maximum eight hour means above 35 ppb (red colour) is included in this indicator. The x-axis indicate subsequent days.

This indicator is based on the application of a very conservative approach to integrated assessment modelling and takes account of the uncertainties in the shape of concentration-response function at very low ozone concentrations. It also reflects the seasonal cycle and geographical distribution of background ozone concentrations, as well as the range of concentrations for which models provided reliable estimates.

However, the Task Force noted that it was highly likely that the overall effects of ozone on mortality are underestimated by this approach. Morbidity is not included at this stage.

For assessing ozone exposure in urban areas, urban background concentrations are used in most of the evidential health studies. Therefore, it is regarded as sufficient to use one average ozone concentration per city.

SOMO35

The Eulerian EMEP model has been used to calculate the SOMO35 exposure indicator referred to above for the baseline emission projections. Obviously, as all other metrics of ozone concentrations, the SOMO35 measure is significantly influenced by inter-annual meteorological variability (Figure 5.6).

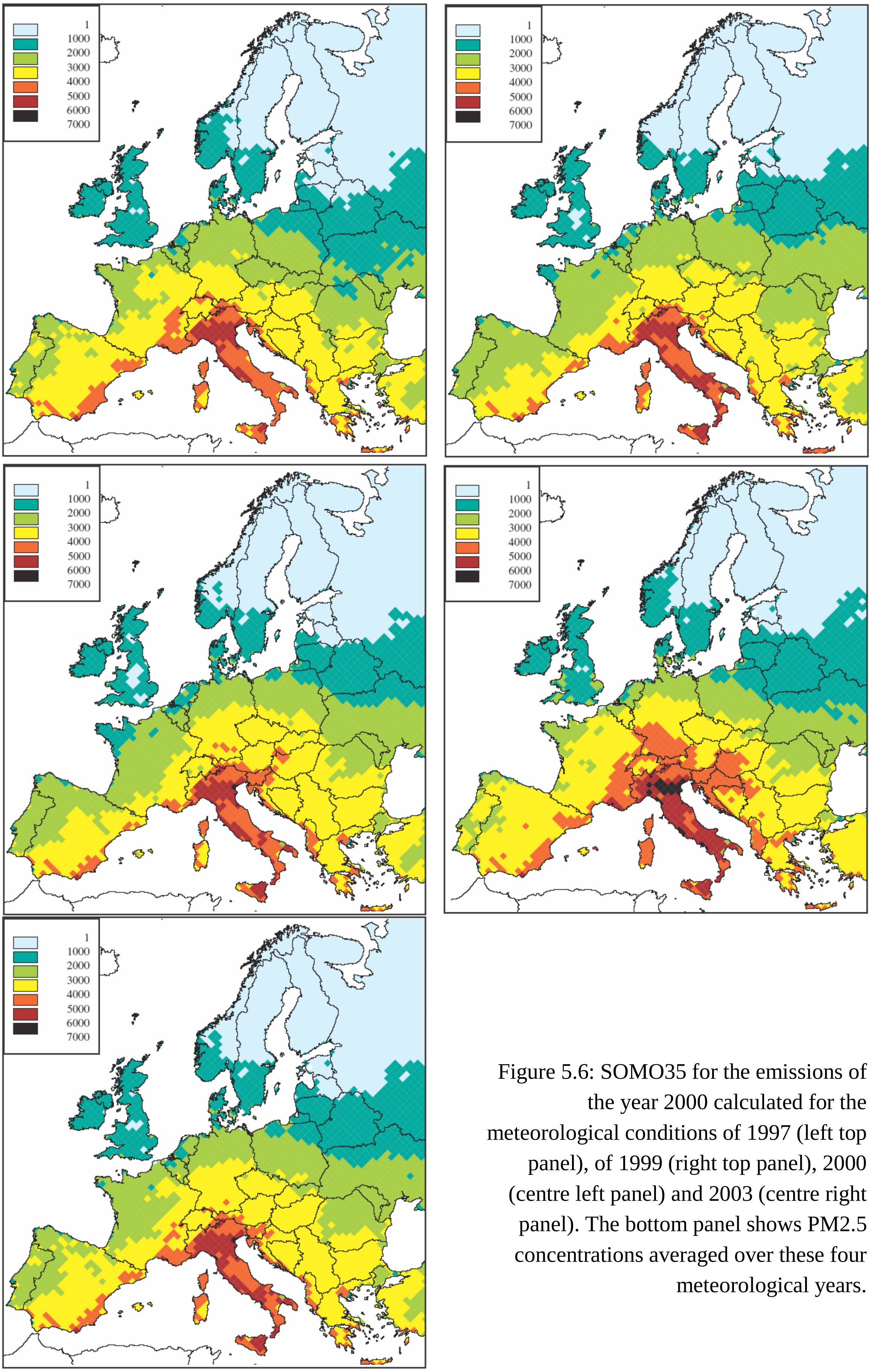


Figure 5.6: SOMO35 for the emissions of the year 2000 calculated for the meteorological conditions of 1997 (left top panel), of 1999 (right top panel), 2000 (centre left panel) and 2003 (centre right panel). The bottom panel shows PM2.5 concentrations averaged over these four meteorological years.

The temporal evolution of the SOMO35 measure for the emissions of the “without further climate measures” scenario is presented in Figure 5.7.

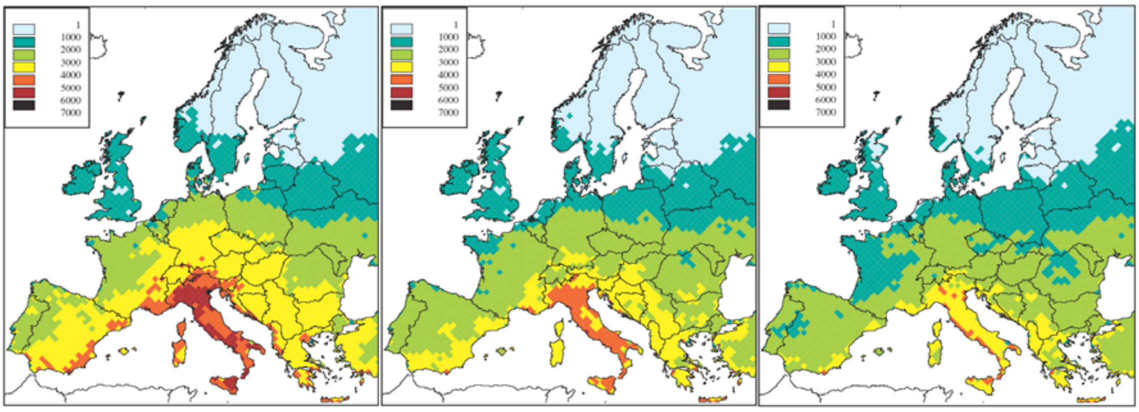


Figure 5.7: Rural ozone concentrations expressed as SOMO35 for the year 2000 (left panel) and for the “no further climate measures” emission projection for the years 2010 (center panel) and 2020 (right panel). Average of calculations for four meteorological years (1997, 1999, 2000, 2003).

Premature mortality attributable to ozone

With the methodology and assumptions outlined above, the changes in premature mortality that are attributable to the projected reductions in ozone precursor emissions have been estimated. Overall, for the average meteorological conditions, the expected decline in ground-level ozone is calculated to reduce premature mortality between 2000 and 2020 by approximately 5,500 cases per year, compared to approximately 22,000 cases computed for the year 2000 (Figure 5.8, Table 5.2). These estimates are loaded with considerable uncertainties of different types, and further analysis is necessary to explore the robustness of these figures. In particular, these numbers are derived from time series studies assessing the impacts of daily changes in ozone levels on daily mortality rates. By their nature, such studies cannot provide any indication on how much the deaths have been brought forward, and some of these deaths are considered as “harvesting effects” followed by reduced mortality few days later. At present it is not possible to quantify the importance of this effect for these estimates. Also the influence of the selected cut-off value (35 ppb) on the outcome needs to be further explored in the future.

Table 5.2: Provisional estimates of premature mortality attributable to ozone (number of premature deaths) for the emissions of the year 2000 for four meteorological years. These calculations are based on regional scale ozone calculations (50*50 km) and average over the meteorological conditions of four years (1997, 1999, 2000, 2003). A cut-off value of 35 ppb has been applied to the impact assessment. No estimates have been performed for Cyprus and Malta.

	Meteorological conditions				
	1997	1999	2000	2003	Average
Austria	422	453	486	503	466
Belgium	381	361	362	458	390
Denmark	179	174	171	184	177
Finland	58	59	48	57	56
France	2663	2296	2206	2896	2515
Germany	4258	4091	4338	5032	4430
Greece	627	647	642	663	645
Ireland	74	62	68	71	69
Italy	4507	4676	4602	5097	4720
Luxembourg	31	29	30	38	32
Netherlands	416	387	374	482	415
Portugal	450	400	405	476	433
Spain	2002	1828	1833	2040	1926
Sweden	197	192	186	205	195
UK	1423	1294	1206	1551	1369
Total EU-15	18110	17339	17329	20169	18279
Czech Rep.	535	579	641	639	599
Estonia	21	25	19	24	22
Hungary	748	829	884	922	846
Latvia	65	85	74	84	77
Lithuania	66	85	82	81	78
Poland	1399	1617	1755	1627	1599
Slovakia	239	269	301	293	275
Slovenia	112	120	128	136	124
Total NMS	3215	3640	3931	3830	3654
Total EU	21429	21002	21242	24080	21938

Table 5.3: Provisional estimates of premature mortality attributable to ozone for the "no further climate measures" CAFE baseline scenario (cases of premature deaths per year). These calculations are based on regional scale ozone calculations (50*50 km) and average over the meteorological conditions of four years (1997, 1999, 2000, 2003). No estimates have been performed for Cyprus and Malta.

	2000	2010	2020
Austria	466	369	311
Belgium	390	318	307
Denmark	177	142	127
Finland	56	45	40
France	2515	2054	1841
Germany	4430	3551	3125
Greece	645	571	534
Ireland	69	59	59
Italy	4720	3896	3475
Luxembourg	32	26	23
Netherlands	415	323	312
Portugal	433	382	369
Spain	1926	1655	1468
Sweden	195	157	141
UK	1369	1277	1311
Total EU-15	18237	15153	13719
Czech Rep.	599	469	388
Estonia	22	18	16
Hungary	846	695	594
Latvia	77	64	57
Lithuania	78	65	58
Poland	1599	1287	1101
Slovakia	275	218	182
Slovenia	124	99	85
Total NMS	3654	2940	2502
Total EU	21938	18145	16291

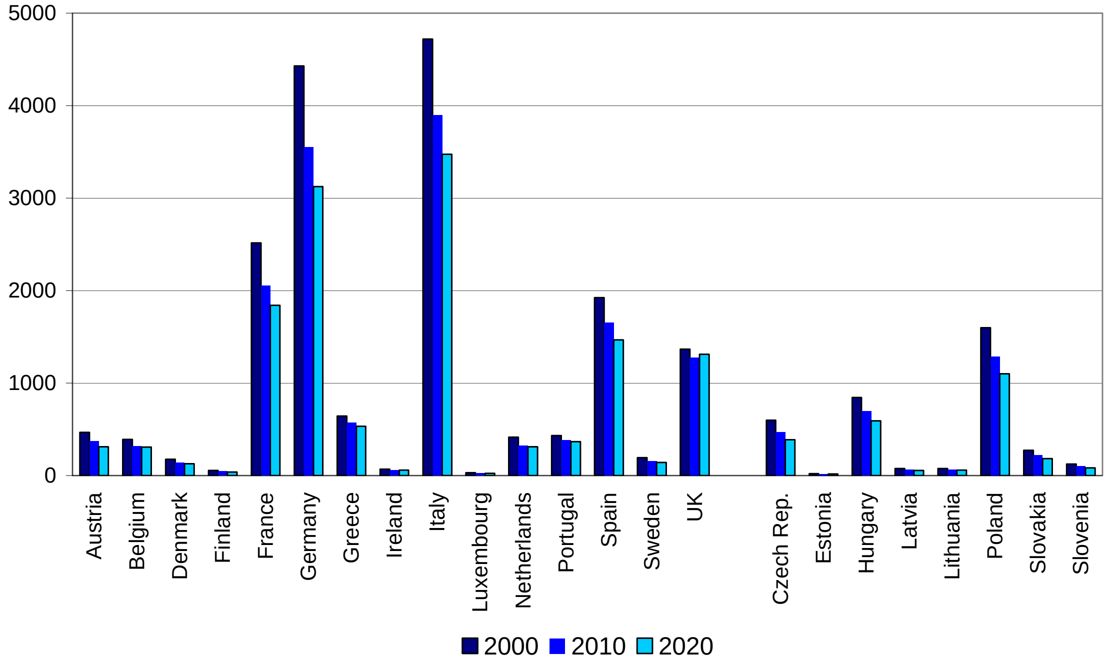


Figure 5.8: Provisional estimates of premature mortality attributable to ozone for the "no further climate measures" CAFE baseline scenario (cases of premature deaths). These calculations are based on regional scale ozone calculations (50*50 km) and average over the meteorological conditions of four years (1997, 1999, 2000, 2003). No estimates have been performed for Cyprus and Malta.

5.3.2 *Vegetation impacts*

The RAINS model applies the concept of critical levels to quantify progress towards the environmental long-term target of full protection of vegetation from ozone damage. At the UNECE workshop in Gothenburg in November 2002 (Karlsson *et al.*, 2003) it was concluded that the effective ozone dose, based on the flux of ozone into the leaves through the stomatal pores, represents the most appropriate approach for setting future ozone critical levels for forest trees. However, uncertainties in the development and application of flux-based approaches to setting critical levels for forest trees are at present too large to justify their application as a standard risk assessment method at a European scale.

Consequently, the UNECE Working Group on Effects retains in its Mapping Manual the AOT40 (accumulated ozone over a threshold of 40 ppb) approach as the recommended method for integrated risk assessment for forest trees, until the ozone flux approach will be sufficiently refined. However, such AOT40 measures are not considered suitable for quantifying vegetation damage, but can only be used as indicators for quantifying progress towards the environmental long-term targets.

The Mapping Manual defines critical levels for crops, forests and semi-natural vegetation in terms of different levels of AOT40, measured over different time spans. From earlier analysis of ozone time series for various parts of Europe, the critical level for forest trees (5 ppm.hours over

the full vegetation period, April 1- September 30 is recommended as default) appears as the most stringent constraint. For most parts of Europe, the other critical levels will be automatically achieved if the 5 ppm.hours over six months condition is satisfied. Thus, if used for setting environmental targets for emission reduction strategies, the critical levels for forest trees would imply protection of the other receptors.

Figure 5.9 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 (UNECE, 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.

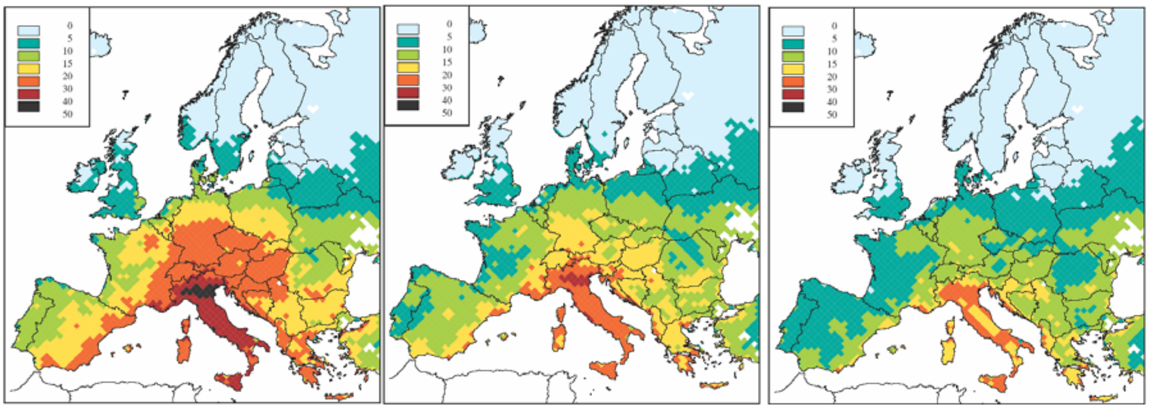


Figure 5.9: Rural AOT40 for forests (in ppm.hours) calculated for the baseline scenario for the with climate measures scenario, average of calculations for the meteorological conditions of 1997, 1999, 2000 and 2003. The critical level for forest trees indicating a no-effect threshold is set at 5 ppm.hours.

5.4 Acid deposition

RAINS used the concept of critical loads as a quantitative indicator for sustainable levels of sulphur and nitrogen deposition. The analysis using is based on the critical loads databases compiled by the Coordination Centre on Effects under the UNECE Working Group on Effects. This database combines quality-controlled critical loads estimates of the national focal centres for more than 1.6 million ecosystems (Posch *et al*., 2004). National focal centres have selected a variety of ecosystem types as receptors for calculating and mapping critical loads. For most ecosystem types (e.g., forests), critical loads are calculated for both acidity and eutrophication. Other receptor types, such as streams and lakes, have only critical loads for acidity, on the assumption that eutrophication does not occur in these ecosystems. The RAINS analysis groups ecosystems into three classes (forests, semi-natural vegetation such as nature protection areas and freshwater bodies) and performs separate analyses for each class. The RAINS analysis compares for a given emission scenario the resulting deposition to these ecosystems with the critical loads and thus provides an indication to what extent the various types of ecosystems are still at risk of acidification. This indicator cannot be directly interpreted as the actual damage occurring at such ecosystems. To derive damage estimates, the historic rate of acid deposition as well as dynamic

chemical processes in soils and lakes need to be considered, which can lead to substantial delays in the occurrence of acidification as well as in the recovery from acidification.

5.4.1 Forest ecosystems

Figure 5.10 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.

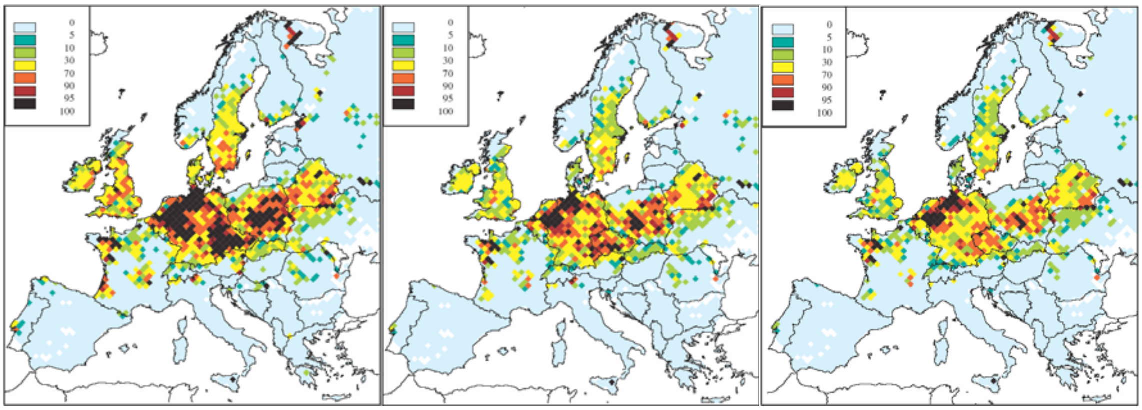


Figure 5.10: Percentage of forest area receiving acid deposition above the critical loads for the baseline emissions for 2000, 2010 and 2020. Results averaged from the calculations for 1997, 1999, 2000 and 2003 meteorological conditions, using ecosystem-specific deposition for forests. Critical loads data base of 2004.

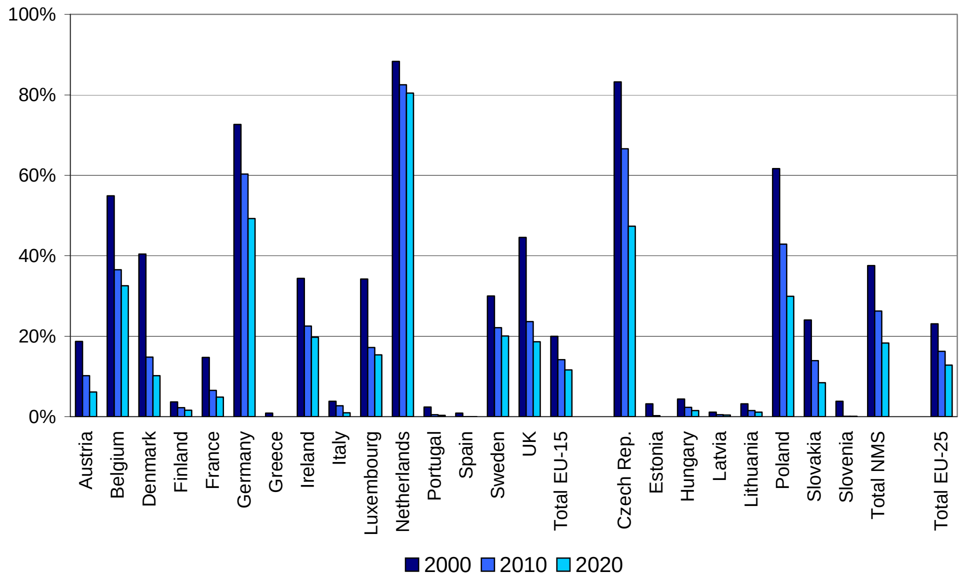


Figure 5.11: Percent of forest area with acid deposition above critical loads (in km^2) for the “no further climate measures” scenario.

Table 5.4: Forest area with acid deposition above critical loads (in km^2) for the "no further climate measures" scenario. The analysis reflects average meteorological conditions of 1997, 1999, 2000 and 2003.

	Percent of forest area			Forest area with acid deposition above critical loads		
	2000	*2010*	*2020*	*2000*	*2010*	*2020*
Austria	19.2%	10.8%	6.9%	7225	4046	2577
Belgium	50.3%	28.5%	24.1%	3287	1860	1577
Denmark	41.1%	15.2%	10.6%	1246	459	321
Finland	3.7%	2.2%	1.6%	8742	5293	3904
France	14.3%	6.3%	4.7%	24455	10820	8055
Germany	73.8%	61.3%	50.1%	74518	61861	50536
Greece	1.5%	0.0%	0.0%	179	0	0
Ireland	34.4%	22.3%	19.5%	1462	949	830
Italy	3.7%	2.4%	1.0%	3288	2144	919
Netherlands	88.7%	84.3%	82.7%	5134	4876	4783
Portugal	2.6%	0.5%	0.4%	260	52	37
Spain	0.9%	0.0%	0.0%	767	34	26
Sweden	29.8%	22.1%	20.0%	52646	38933	35244
UK	44.6%	23.7%	18.7%	8795	4675	3690
Total EU-15	20.0%	14.1%	11.7%	192047	135953	112476
Cyprus	0.0%	0.0%	0.0%	0	0	0
Czech Rep.	84.5%	66.8%	47.8%	15436	12211	8740
Estonia	0.0%	0.0%	0.0%	0	0	0
Hungary	2.7%	1.4%	1.0%	282	147	100
Latvia	1.2%	0.5%	0.5%	297	132	129
Lithuania	2.4%	1.0%	0.6%	280	110	67
Poland	61.2%	42.9%	30.0%	54116	37934	26532
Slovakia	24.2%	14.0%	8.4%	4660	2690	1617
Slovenia	0.0%	0.0%	0.0%	0	0	0
Total NMS	37.6%	26.6%	18.6%	75063	53219	37192
Total EU-25	23.0%	16.3%	12.9%	267029	189175	149666

5.4.2 Semi-natural ecosystems

A number of countries have provided estimates of critical loads for so-called “semi-natural” ecosystems. This group typically contains nature and landscape protection areas, many of them designated as “Natura2000” areas of the EU Habitat directive. While this group of ecosystems includes open land and forest areas, RAINS uses as a conservative estimate grid-average deposition rates for the comparison with critical loads, which systematically underestimates deposition for forested land.

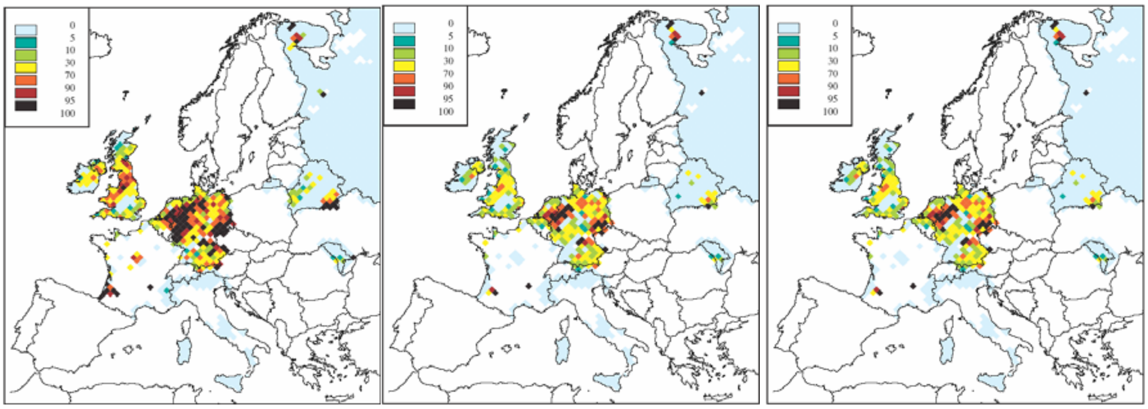


Figure 5.12: Percentage of the area of semi-natural ecosystems receiving acid deposition above the critical loads, for the baseline emissions for 2000, 2010 and 2020. Results averaged from the calculations for 1999 and 2003 meteorological conditions, using ecosystem-specific deposition for forests. Critical loads data base of 2003.

Table 5.5: Area with semi-natural ecosystems with acid deposition above critical loads (in km^2) for the “no further climate measures” scenario. The analysis reflects average meteorological conditions of 1997, 1999, 2000 and 2003.

	Percent of semi-natural ecosystems area			Semi-natural ecosystems area with acid deposition above critical loads		
	2000	*2010*	*2020*	*2000*	*2010*	*2020*
France	33.0%	20.2%	13.4%	3544	2168	1437
Germany	77.7%	67.5%	59.5%	2884	2506	2211
Ireland	23.2%	12.1%	9.6%	1084	564	449
Italy	8.1%	6.1%	1.1%	1995	1516	272
Netherlands	79.5%	70.9%	69.0%	1329	1184	1153
UK	27.0%	11.4%	8.1%	13146	5549	3949
Total EU-25	23.2%	13.2%	9.3%	23982	13488	9471

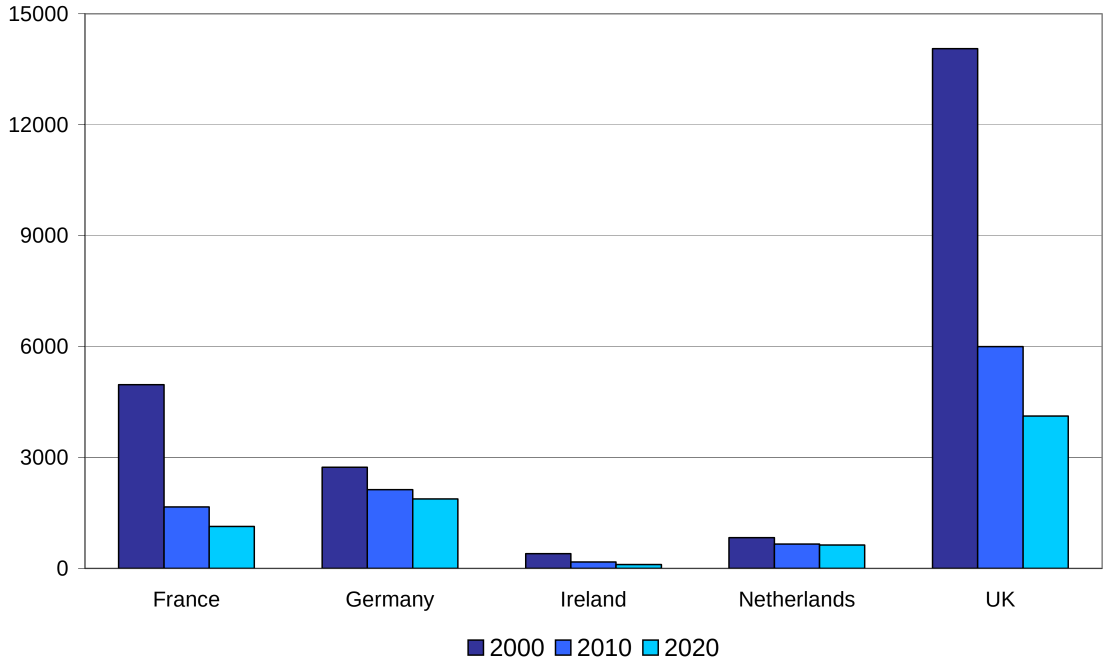


Figure 5.13: Area with semi-natural ecosystems with acid deposition above critical loads (in km^2) for the "no further climate measures" scenario.

5.4.3 Freshwater bodies

In a number of countries critical loads have been estimated for the catchments areas of freshwater bodies (lakes and streams), which in the past experienced significant acidification (Figure 5.14, Table 5.6). The baseline emission projections suggest a significant decline of acid deposition at many of these catchments areas, in many cases even below their critical loads. As indicated above, recovery from acidification requires acid deposition to stay some time below the critical loads.

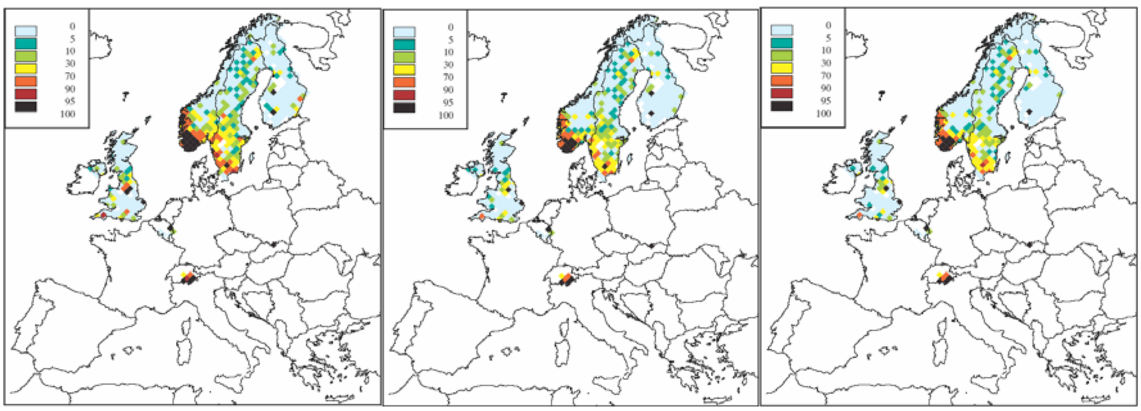


Figure 5.14: Percentage of freshwater ecosystems area receiving acid deposition above the critical loads for the baseline emissions for 2000, 2010 and 2020. Results averaged from the calculations for 1997, 1999 2000 and 2003 meteorological conditions, using grid-average deposition.

Table 5.6: Catchments area with acid deposition above critical loads (km^2) for the "no further climate measures" scenario. The analysis reflects average meteorological conditions of 1997, 1999, 2000 and 2003.

	Percent of catchments area			Catchments area with acid deposition above critical loads		
	2000	*2010*	*2020*	*2000*	*2010*	*2020*
Finland	3.9%	2.7%	1.3%	1210	840	398
Sweden	27.9%	20.3%	18.3%	52094	37849	34083
UK	29.6%	10.4%	7.4%	2291	806	573
Total EU-25	24.7%	17.5%	15.6%	55595	39496	35054

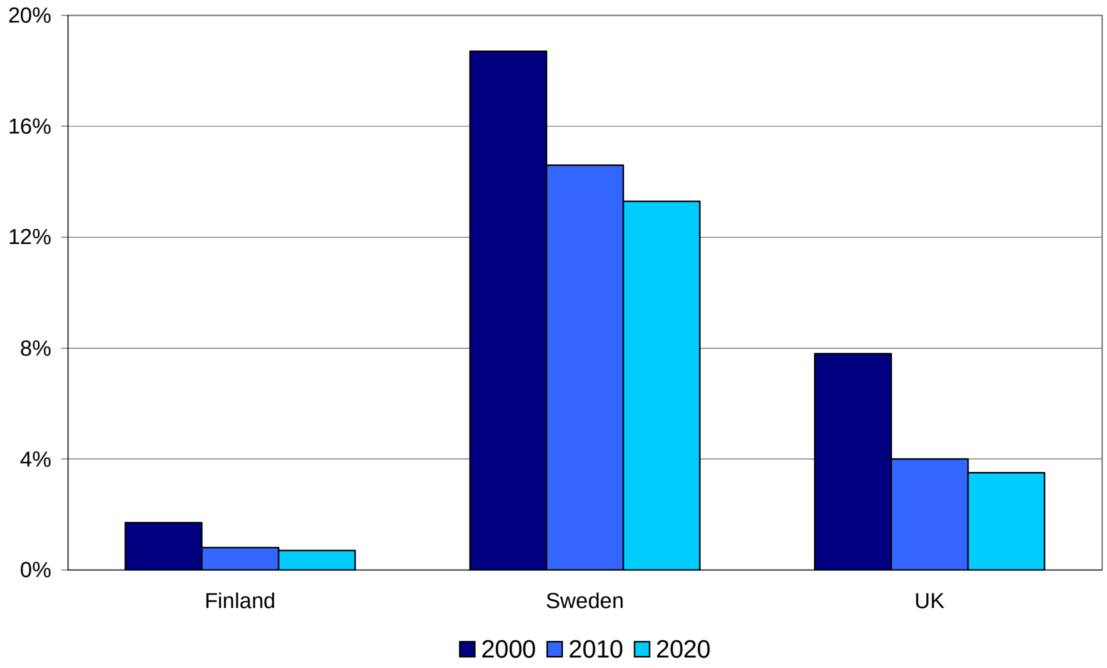


Figure 5.15: Percent of catchments area with acid deposition above critical loads (km^2) for the "no further climate measures" scenario.

5.4.4 Eutrophication

Excess nitrogen deposition poses a threat to a wide range of ecosystems endangering their biodiversities through changes in the plant communities. Critical loads indicating the maximum level of nitrogen deposition that can be absorbed by ecosystems without eutrophication have been estimated throughout Europe.

While many of the precursor emissions are declining over time in the baseline emission projection, the protection of ecosystems from acidification is expected to only gradually improve (Figure 5.16), mainly caused by the maintained level of ammonia emissions.

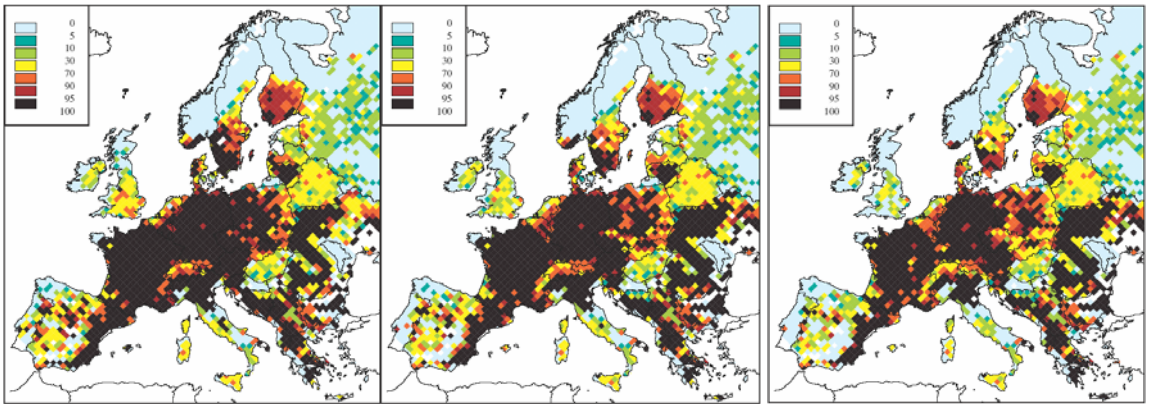


Figure 5.16: Percentage of total ecosystems area receiving nitrogen deposition above the critical loads for eutrophication for the “no further climate measures” emission projection for 2000, 2010 and 2020. Results averaged from the calculations for 1997, 1999 2000 and 2003 meteorological conditions, using grid-average deposition. Critical loads data base of 2003.

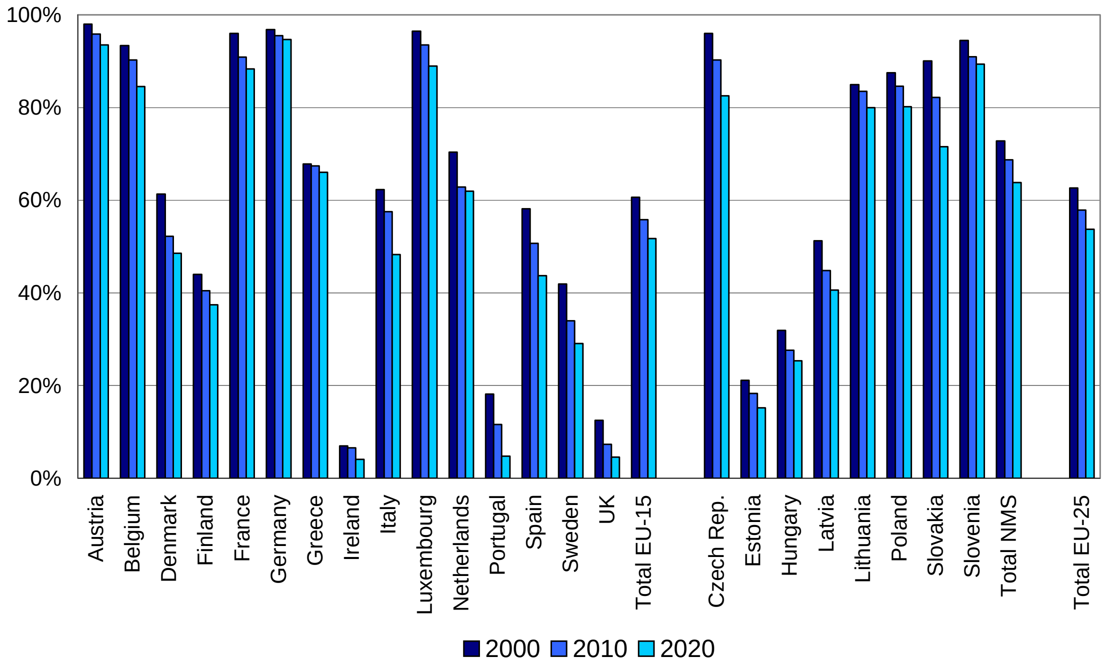


Figure 5.17: Percent of ecosystems area with nitrogen deposition above the critical loads for eutrophication for the “no further climate measures” emission projection

Table 5.7: Ecosystems area (km^2) with nitrogen deposition above the critical loads for eutrophication for the "no further climate measures" emission projection for 2000, 2010 and 2020. Results averaged from the calculations for 1997, 1999 2000 and 2003 meteorological conditions, using grid-average deposition. Critical loads data base of 2003.

	Percent of ecosystems area			Ecosystems area with nitrogen deposition above critical loads for eutrophication		
	2000	*2010*	*2020*	*2000*	*2010*	*2020*
Austria	98.0%	96.3%	94.4%	36277	35651	34966
Belgium	90.7%	87.5%	81.7%	6603	6369	5950
Denmark	61.7%	52.9%	49.3%	1937	1661	1547
Finland	43.9%	40.5%	37.4%	105120	96881	89671
France	96.0%	91.0%	88.5%	172915	163874	159425
Germany	96.9%	95.6%	94.8%	102459	101117	100207
Greece	67.7%	67.3%	66.0%	8264	8204	8048
Ireland	6.6%	6.2%	4.0%	591	557	356
Italy	62.0%	57.2%	47.9%	74085	68302	57249
Netherlands	75.2%	68.5%	67.8%	3478	3166	3135
Portugal	18.8%	11.6%	4.4%	1913	1177	444
Spain	57.6%	50.3%	43.3%	49069	42817	36855
Sweden	42.3%	34.3%	29.4%	77050	62529	53565
UK	12.6%	7.4%	4.6%	9243	5443	3351
Total EU-15	60.7%	55.9%	51.9%	649030	597707	554830
Cyprus	49.3%	50.4%	51.7%	2188	2236	2294
Czech Rep.	96.1%	90.6%	83.1%	17567	16556	15190
Estonia	19.4%	16.4%	13.0%	4346	3679	2918
Hungary	30.6%	26.5%	24.1%	3192	2769	2515
Latvia	52.8%	45.5%	40.9%	13639	11763	10552
Lithuania	94.8%	92.8%	89.3%	10875	10646	10245
Poland	90.2%	87.2%	82.6%	79686	77088	73013
Slovakia	90.3%	82.4%	71.6%	17383	15862	13794
Slovenia	97.9%	96.9%	95.6%	2934	2906	2865
Total NMS	74.6%	70.5%	65.6%	151809	143508	133375
Total EU-25	62.9%	58.2%	54.1%	800791	741228	688156

6 Conclusions

This report presents a first perspective on the likely range of development of European air pollution emissions and air quality up to 2020, as it emerges from an extensive process of data collection and consultation with national experts. While this work under Lot 1 of this contract has focused on compiling up-to-date information from a wide range of sources and applying it in latest state-of-the-art assessment tools, it did not address uncertainties of these projections in a systematic way. Thus, the conclusions drawn in this section should be considered as qualitative and need further confirmation through systematic uncertainty and robustness analysis, which will be the subject of the following lots of work of this contract.

Bringing together information on envisaged economic development, the associated changes in the energy, transport, industrial and agricultural systems, the structure of emission sources in Europe and the impacts of already adopted emission control legislation suggests for the coming decades a radical change in European air pollution. Despite the projected increase in gross domestic product between 2000 and 2020 of almost 60 percent, emissions of many traditional air pollutants will significantly decline up to 2030. The CAFE baseline projections propose for the EU-25 a reduction of SO_2 emissions by approximately 60 to 70 percent between 2000 and 2020, NO_x emissions to drop approximately by half and VOC and PM emissions by some 40 to 50 percent. At the same time, only minor changes can be expected for agricultural emissions and for emissions of greenhouse gases.

As a consequence, air quality will significantly improve, and impacts on human health and vegetation attributable to air pollution will diminish. It is estimated that the anticipated reductions in European emissions will extend statistical life expectancy in Europe by approximately three months and reduce premature mortality attributable to ground-level ozone by more than 5,000 cases per year. Acid deposition will fall below harmful levels at additional 120,000 km^2 of European forests and enable sustainable ecological conditions at many nature protection areas in the EU-25.

Despite this significant progress, air quality problems will not completely disappear. Even for the year 2020, exposure to fine particulate matter from anthropogenic sources is estimated to shorten life of European population by five to six months in average. Ground-level ozone will still cause several thousand cases of premature death every year. 150,000 km^2 of forests will continue to receive unsustainable amounts of acid deposition from the atmosphere and many Scandinavian lakes will not be able to recover from past acidification. Biodiversity will remain endangered at more than 650.000 km^2 (45 percent of European ecosystems) due to excessive nitrogen deposition.

The CAFE baseline projections clearly indicate for the future a change in the relevance of the different sources of pollution. Traditionally large polluting sectors, due to the implementation of stringent control measures, will drastically reduce their shares in total emissions, and other sources, which have received less attention in the past, will turn into dominating contributors. In 2020, the major contributions to SO_2 emissions will come from maritime activities, industrial processes and small combustion sources. NO_x emissions will predominantly originate from sea-going ships, diesel heavy duty vehicles and off-road machinery. Solvents will become the major source of VOC emissions, and wood burning and industrial processes will be responsible for the majority of emissions of fine particulate matter.

Further work, including the assessment of the available emission control potentials from technical and non-technical measures as well as the impacts made by individual sources on harmful population and vegetation exposure, will be necessary to determine cost-effective approaches for further improving air quality in Europe.

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