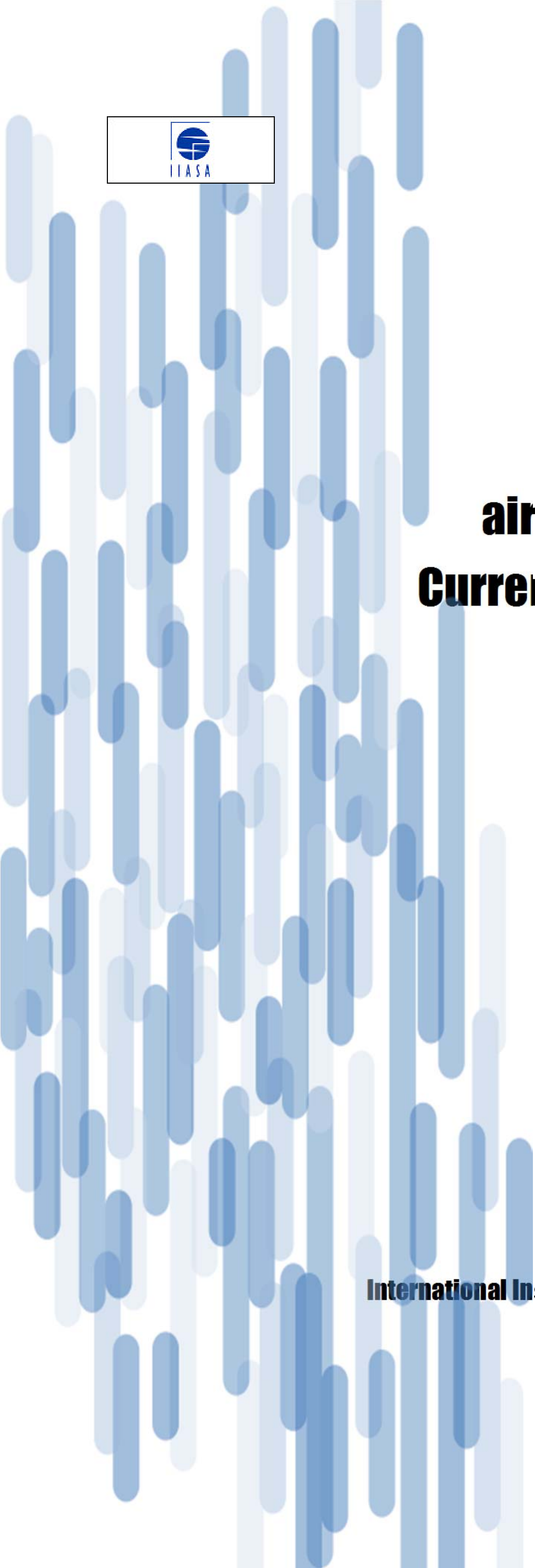

Service Contract on
Monitoring and Assessment
of Sectorial Implementation Actions
(ENV.C.3/SER/2011/0009)

Future emissions of air pollutants in Europe – Current legislation baseline and the scope for further reductions

TSAP Report #1
Version 1.0

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Disclaimer

The orientation and content of this report cannot be taken as indicating the position of the European Commission or its services.

Executive Summary

This report presents an outlook into the likely development of emissions and resulting air quality impacts that emerges from the latest expectations on economic development and the implementation of recent policies on energy, transport, agriculture and climate change. The baseline assumes full implementation of existing air pollution control legislation of the European Union. This TSAP-2012 baseline employs assumptions on future economic development that have been used for other recent policy analyses of the European Commission, in particular the 'Energy trends up to 2030', the 'Roadmap for moving to a competitive low-carbon economy in 2050' (CEC, 2011a), and the White Paper on Transport (CEC, 2011b).

Despite a doubling in economic activity, the baseline scenario suggests a stabilization of energy consumption, as energy efficiency policies will successfully reduce energy demand in households and industry.

As a consequence of the structural changes in the energy and transport sectors and the progressing implementation of emission control legislation, SO_2 emissions will fall drastically. Largest reductions are foreseen for the power sector, which will cut its emissions by almost 90%. NO_x emissions may drop by more than 65% in the coming years if the EURO 6 limit values are effectively implemented. Legislation directed at other pollutants will decrease PM2.5 emissions by about 40%. In contrast to the other air pollutants, only minor changes are expected for NH_3 emissions. VOC emissions will decline by 40% in the EU-27, and converge on a per-capita basis across Member States.

On top of current legislation, technical measures are on the market that could reduce SO_2 emissions by another 35%. Advanced controls to all new sources could reduce NO_x by 80% in 2050 relative to 2005, and primary emissions of PM2.5 by up to 40%. Available measures could cut NH_3 and VOC emissions by about 30% beyond current legislation.

An illustrative decarbonisation scenario of an 80% GHG reduction in the EU in 2050 would offer similar reductions of SO_2, NO_x and PM emissions as from the full implementation of remaining air pollution control measures. Instead of employing end-of-pipe technologies to reduce air pollutant emissions, the decarbonisation scenario would achieve lower emissions through enhanced energy efficiency improvements, the current plans for nuclear energy and the electrification of the transport sector.

A 'Maximum Control Efforts' scenario explores the scope ultimate scope for emission reductions that could be achieved through rapid decarbonisation, application of all available air pollution control technologies, and a change of the agricultural system to produce more healthy diets for the European population. In the long run, such measures would cut SO_2 emissions in the EU-27 by more than 90% compared to today's levels, NO_x by 85%, PM2.5 by more than 75%, NH_3 by about 40% and VOC by 70%.

Obviously, the implementation of such measures requires financial resources. Calculated from a social planner's perspective, air pollution control costs for implementing the current air quality legislation in the EU-27 will increase to 0.6% of the GDP in 2020. Thereafter, however, costs will decline in relation to GDP to 0.4% in 2050. Full implementation of all available technical emission control measures would increase costs by 50%. However, in a decarbonising world additional air pollution control costs that are required to comply with current air quality legislation are up to 20% lower than in the baseline case due to the lower levels of polluting activities.

More information on the Internet

More information about the GAINS methodology and interactive access to input data and results is available at the Internet at http://gains.iiasa.ac.at/TSAP.

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List of acronyms

BAT	Best available technology
bbl	barrel of oil
boe	barrel of oil equivalent
CAFE	Clean Air For Europe Programme of the European Commission
CAPRI	Agricultural model developed by the University of Bonn
CH_4	Methane
CLRTAP	Convention on Long-range Transboundary Air Pollution
CO_2	Carbon dioxide
CCS	Carbon Capture and Storage
EC4MACS	European Consortium for Modelling Air Pollution and Climate Strategies
EMEP	European Monitoring and Evaluation Programme
ETS	Emission Trading System of the European Union for CO_2 emissions
EU	European Union
GAINS	Greenhouse gas - Air pollution Interactions and Synergies model
GDP	Gross domestic product
GHG	Greenhouse gases
IED	Industrial Emissions Directive
IIASA	International Institute for Applied Systems Analysis
IPPC	Integrated Pollution Prevention and Control (directive)
kt	kilotons = 10^3 tons
LCP	Large Combustion Plants (directive)
N_2O	Nitrous oxide
NEC	National Emission Ceilings
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
N_2O	Nitrous oxides
O_3	Ozone
PJ	Petajoule = 10^{15} joule
PM10	Fine particles with an aerodynamic diameter of less than 10 µm
PM2.5	Fine particles with an aerodynamic diameter of less than 2.5 µm
PRIMES	Energy Systems Model of the National Technical University of Athens
SNAP	Selected Nomenclature for Air Pollutants; Sector aggregation used in the CORINAIR emission inventory system
SO_2	Sulphur dioxide
TSAP	Thematic Strategy on Air Pollution
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile organic compounds

1 Introduction

In its 2005 Thematic Strategy on Air Pollution (TSAP), the European Commission outlined a road map to attain 'levels of air quality that do not give rise to significant negative impacts on, and risks to human health and environment' (CEC, 2005). It established health and environmental objectives and emission reduction targets for the main pollutants.

In 2011, the European Commission has launched a comprehensive review and revision of its air policy, in particular of the 2005 Thematic Strategy on Air Pollution and its related legal instruments. To support the European Commission in the review, this report presents a draft baseline scenario that outlines the likely evolution of air pollutant emissions, air quality and resulting impacts.

A benchmark for the TSAP revision

This report presents an outlook into the likely development of emissions and resulting air quality impacts that can be envisaged from the latest expectations on economic development and the implementation of recent policies on energy, transport, agriculture and climate change. The baseline assumes full implementation of existing air pollution control legislation of the European Union. Thereby, it provides a quantitative benchmark for the analysis of the effectiveness of current policies and measures in terms of emission reductions, and a reference against which the potential for additional measures to achieve 'levels of air quality that do not give rise to significant negative impacts on, and risks to human health and environment' could be compared.

Coherence with other EU policy analyses

The baseline employs assumptions on future economic development that have been used for other recent policy analyses of the European Commission, in particular the 'Energy trends up to 2030', the 'Roadmap for moving to a competitive low-carbon economy in 2050' (CEC, 2011a), the White Paper on Transport (CEC, 2011b). Thereby, the TSAP analysis is fully coherent with other policy initiatives, as recent policies in the fields of energy, transport, agriculture and climate change are incorporated.

Building on the EC4MACS model toolbox

The baseline has been developed with the model toolbox of the European Consortium for Modelling of Air pollution and Climate Strategies (EC4MACS), a project funded under the EU LIFE programme (www.ec4macs.eu). As a preparatory action for policy development, EC4MACS has created a network of well-established modelling tools that enables a comprehensive integrated assessment of the policy effectiveness of emission control strategies for air pollutants and greenhouse gases. EC4MACS connects activity projections developed with the PRIMES energy model, the CAPRI agricultural model, the TREMOVE and COPERT transport models as an input to the GAINS integrated assessment model for air pollutant and greenhouse gases. The impacts of emission control strategies are then evaluated by the EMEP and CHIMERE atmospheric dispersion models, the CCE ecosystems impact assessment, the ALPHA-2 to quantify monetary benefits, and the GEM-E3 macro-economic feedback model.

An in-depth assessment up to 2030 embedded into a long-term perspective

For projections to 2030, the baseline builds on the final scenario developed under EC4MACS, which assumes the economic development and energy trajectories of the PRIMES 2010 Reference scenario. Key figures on the assumed energy use, transport activities, agricultural production, as well as the resulting emissions of six air pollutants are presented in this report for individual countries as well as for the whole EU-27.

In order to embed the analysis of potential measures for 2030 into the envisaged long-term development, the report also provides results up to 2050, however only at the aggregated level for the EU-27. For this purpose, the TSAP baseline employs the reference energy and agricultural projections developed for the 2050 Roadmap for the years beyond 2030.

A draft baseline for consultation with Member States

The most recent set of emission control legislation has been defined in close contact with the Commission Services. Emission inventories for 2005 and projections have been harmonized with submissions of Member States to EMEP in 2011. However, owing the lack of comprehensive documentation, recent updates of national inventories that have been reported to EMEP in 2012, as well as national emission projections that have been communicated by Member States to the European Commission in the course of the negotiations of the revised Gothenburg Protocol, are not included. Thereby, the draft baseline serves as a starting point for the bilateral consultations between Member States and IIASA, with the aim to arrive at a shared and fully documented baseline projection for the TSAP revision in December 2012.

The future is uncertain

Obviously, future development is associated with a variety of uncertainties, with important impacts on policy conclusions. Some uncertainties can be handled with statistical and other methods or can be reduced through further research. They result from incomplete scientific understanding of the various processes. However, some uncertainties are inherent and cannot be reduced. They are caused by processes that operate on space/time scales that are not or cannot be captured by the models.

The following uncertainties have been found most critical for projections of future emissions: the future economic development, the effectiveness of energy, transport and agricultural policies assumed in the baseline, possible changes in meteorological conditions due to climate change, the impacts of pollution on human health and the environment, and the effectiveness and costs of abatement options.

Most of these uncertainties are irreducible. In order to establish robustness of policy conclusions, this report develops a 'central baseline' with explicit assumptions on key factors. In a second step, the sensitivity of model outcomes against changes in these assumptions is examined.

Following the recommendations of an EC4MACS workshop on uncertainty treatment, sensitivity analyses have been carried out for

- baselines with time horizons extending beyond 2020,
- including cases with more ambitious climate policies,
- different real life emissions of vehicles, and
- new information on the potentials and costs for ammonia abatement.

Structure of the report

Part 1 of this report presents a set of baseline emission scenarios for different assumptions on energy, climate and air pollution policies. Part 2 outlines resulting impacts on air quality and their effects on human health and vegetation. Part 2 will be released after completion of the atmospheric dispersion calculations with the EMEP Eulerian model.

Part 1 of the report is organized as follows: The methodology is summarized in Section 2. Section 3 reviews key assumptions on the future development of key drivers of emissions and on policies that will influence these drivers. It presents the implications on the evolution of the main emission generating activities, and the resulting emissions under the assumption that current emission control legislation will be fully implemented. Section 5 discusses the scope for further emission reductions that could be achieved with technologies that are currently on the market. Section 6 explores how the current legislation emission trajectory would change if the energy system followed an ambitious decarbonisation path. A 'Maximum Control Efforts' scenario that combines aggressive structural changes in the energy and agricultural systems with full application of available end-of-pipe emission control measures is presented in Section 7. Section 8 compares costs for the implementation of current legislation and the maximum technically feasible reductions. Conclusions are drawn in Section 9.

2 Methodology

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

The EC4MACS toolbox brings together sectoral perspectives on future development

EC4MACS has developed a network of well-established modelling tools that enables a comprehensive integrated assessment of the policy effectiveness of emission control strategies for air pollutants and greenhouse gases (Box 1).

Box 1: Objectives of the EC4MACS project

Clean air and climate change are central fields of EU environmental policy. New scientific findings demonstrate important interactions and potentially large economic synergies between air pollution control and greenhouse gas mitigation. Model analyses, based on latest scientific findings and validated data, can provide valuable information for cost-effective policy strategies. The key objectives of EC4MACS are:

- Provide scientific and economic analyses for the revision of the EU Thematic Strategy on Air Pollution and the European Climate Change Programme (ECCP)
- Improve existing models by including recent scientific findings
- Update of input data
- Achieve acceptance of modelling tools and input data by stakeholders
- Make modelling tools available to the public over the Internet

The EC4MACS approach assumes cause-effect relationships between interacting components of social, economic, and environmental systems. These include

- driving forces of environmental change (e.g., industrial production),
- pressures on the environment (e.g., discharges of pollutants to the atmosphere),
- state of the environment (e.g., air quality in different regions in Europe),
- impacts on population, economy, ecosystems (e.g., reduced life expectancy from the exposure to air pollution),
- response of society (e.g., emission control policies).

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

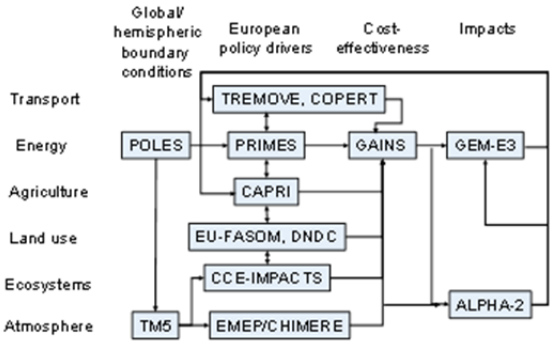

Figure 2.1: The EC4MACS model suite that describes the full range of driving forces and impacts at the local, European and global scale.

The GAINS integrated assessment model for air pollutants and greenhouse gases

The GAINS (Greenhouse gas – Air pollutant Interactions and Synergies) model is an integrated assessment model that brings together information on the sources and impacts of air pollutant and greenhouse gas emissions and their interactions. GAINS is an extension of the earlier RAINS (Regional Air Pollution Information and Simulation) model, which addressed air pollution aspects only. GAINS brings together data on economic development, the structure, control potential and costs of emission sources, the formation and dispersion of pollutants in the atmosphere and an assessment of environmental impacts of pollution.

GAINS addresses air pollution impacts on human health from fine particulate matter and ground-level ozone, vegetation damage caused by ground-level ozone, the acidification of terrestrial and aquatic ecosystems and excess nitrogen deposition) of soils, in addition to the mitigation of greenhouse gas emissions.

GAINS describes the inter-relations between these multiple effects and the range of pollutants (SO_2, NO_x, PM, NMVOC, NH_3, CO_2, CH_4, N_2O, F-gases) that contribute to these effects at the European scale.

GAINS assesses, for each of the 43 countries in Europe, more than 1000 measures to control the emissions to the atmosphere. It computes the atmospheric dispersion of pollutants and analyses the costs and environmental impacts of pollution control strategies. In its optimization mode, GAINS identifies the least-cost balance of emission control measures across pollutants, economic sectors and countries that meet user-specified air quality and climate targets.

3 A baseline projection of emission generating activities

In response to a recent set of exogenous assumptions of the European Commission on population, economic growth and energy prices, a coherent quantification of future human activity patterns has been developed with a suite of economic, energy and agricultural models.

For projections up to 2030, the baseline assumes the economic development and energy trajectories of the PRIMES 2010 Reference scenario (CEC, 2010b) and the corresponding forecast of agricultural activities developed with the CAPRI model.

Key figures on future energy use, transport activities, agricultural production, as well as the resulting emissions of six air pollutants are presented in this report for individual countries as well as for the whole EU-27.

The TSAP baseline follows the assumptions of the 2050 Roadmap report

In order to embed the analysis of potential measures for 2030 into the envisaged long-term development, the report also provides results up to 2050, however only at the aggregated level for the EU-27. For this purpose, the TSAP baseline employs for the years beyond 2030 the Reference energy and agricultural projections developed for the 'Roadmap for moving to a competitive low carbon economy in 2050' (CEC, 2011a).

3.1 Drivers

Types, volumes and locations of human activities are significant drivers of atmospheric pollution. While all these aspects are dynamically changing over time, the future development path is not unique and depends on many factors, which are genuinely uncertain. The baseline scenario comprises numerical projections of population, GDP (volume), households' income, and sectoral activities for 22 sectors in each EU Member State.

3.1.1 Population

Following the population projections of the EUROPOP2008 convergence scenario from EUROSTAT (Giannakouris, 2010), the baseline scenario assumes total EU population to grow by 6% in 2030 relative to 2005.

Continued immigration will let European population grow by six percent up to 2030, mainly in the old Member States

The increase occurs mainly the old Member States (+9%) due to continued immigration, while in the new Member States population will shrink by 4%. Thereafter, it is assumed that population would stabilize in the old Member States, while the decline would accelerate in the new Member States (-9% by 2050 relative to 2030; see Figure 3.1 and Figure 3.2).

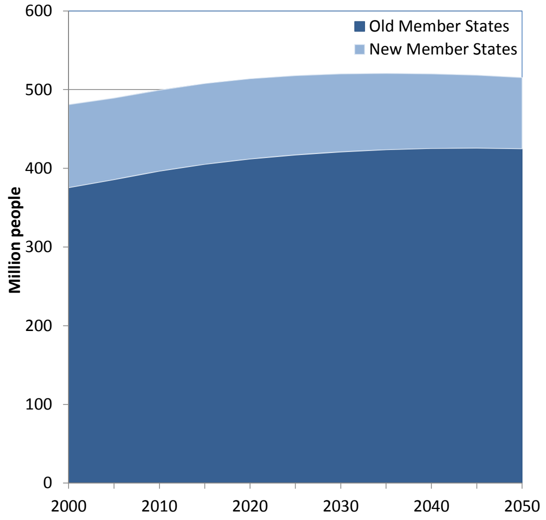

Figure 3.1: Baseline trends in total population in the old and new Member States

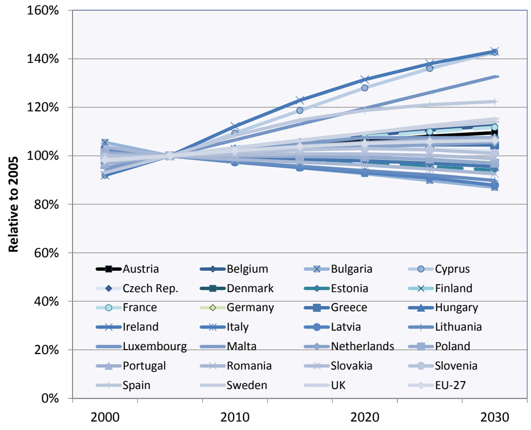

Figure 3.2: Population trends for Member States up to 2030

3.1.2 Economic growth

The Draft TSAP-2012 baseline assumes sustained economic recovery after the downturn in 2008/2009, along the 2009 Ageing Report (European Economy, April 2009) and the intermediate ‘Scenario 2 "Sluggish Recovery" presented by the European Commission in the “Europe 2020” strategy (Box 1). Compared to pre-crisis projections (e.g., the assumptions for the CAFE baseline), the economic recovery will compensate for some of the loss in GDP during the recent recession, but will not reach the earlier growth projections.

After the economic crisis, the baseline scenario assumes GDP to grow by 50% until 2030

A more recent perspective, which takes into account the actual development up to 2011/12, however, would suggest lower growth rates that what has been assumed for the TSAP baseline. For instance, for 2030 GDP would now be only 40% higher than in 2005, compared to the 50% growth assumed in the TSAP baseline.

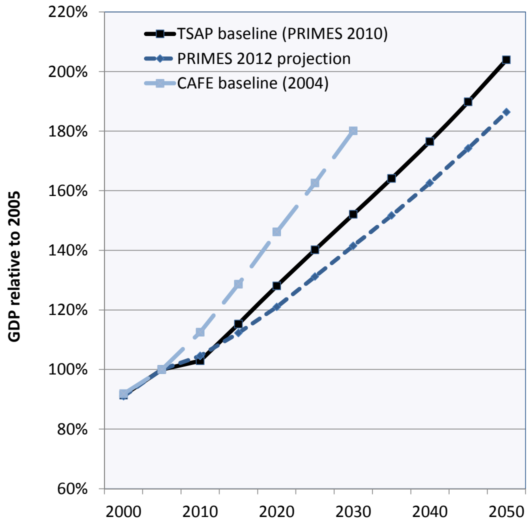

Figure 3.3: Projections of GDP growth: TSAP baseline (based on PRIMES 2010), the CAFE baseline of 2004, and the proposed assumption for the PRIMES 2012 scenario

Growth patterns differ across the EU. Old Member States in northern and central Europe suffer more from the recession (Figure 3.4). They will recover more slowly, but stay on a significant and positive growth path over the long term.

Box 1: Key rationales of the macro-economic assumptions

The economic prospects for the EU are divided in three periods: the recession (2008-2014), recovery (2015-2022), and a low but stable growth period (beyond 2022).

The financial crisis induced a marked deterioration of global economic prospects in the final quarter of 2008. The causes of a vicious recession spiral were the loss of financial assets, the reduction in business confidence accompanied with increased uncertainty, and the resulting reduction in bank lending (credit freeze). The credit rationing practice synchronized worldwide had a detrimental effect for emerging economies through reduction in global trade (credit facilitation to trade was dramatically decreased). Thus, exports of the EU were seriously affected downwards.

Credit rationing together with increased uncertainty resulted in a slowdown of private investment in all sectors and lowered households’ expenditures in durable goods and new houses. The rate of private savings increased, exerting further depressive effects on consumption. Altogether, drop of exports, lower consumption and investment explain recession in GDP terms for the EU economies.

To alleviate the effects of the crisis, the governments put in place extraordinary measures, including reduction of basic interest rates, expansion of money supply and facilitation of credit availability. These measures removed the effects of credit rationing and reduced the “shadow” interest rate, and so encouraged investments and spending in durable goods and houses. The low levels of oil and commodity prices facilitate economic growth as costs of domestically produced goods fall. As these measures expand worldwide, global trade is facilitated again by increased credit availability. Thus, demand is progressively re-established in the EU, concerning both exports and domestic consumption and investment. These trends characterize the recovery period, which may last until 2015.

The recovery process is accompanied by efficiency and productivity gains in many sectors. As a result, growth prospects of the EU are in percentage terms somehow larger than before the crisis, albeit for a limited time period. Based on this logic, the projection displays higher growth rates for the period 2015-2020 compared to a similar projection carried out before the crisis. Despite this, a permanent loss of GDP and welfare is encountered when considering the entire period from 2008 to 2030.

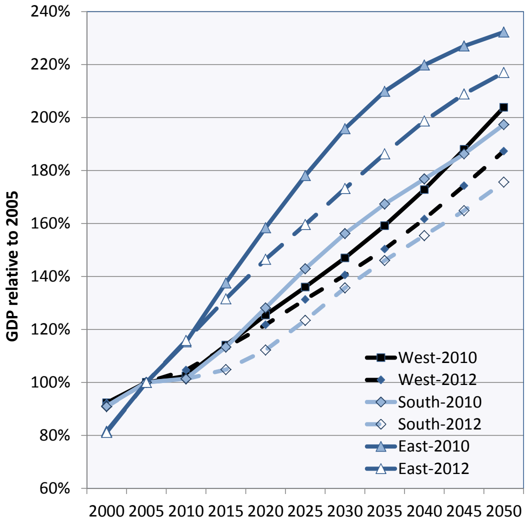

Figure 3.4: Projections of GDP growth for three country groups in the EU, TSAP baseline (2010) compared to the 2012 perspective

Growth patterns differ across the EU

While the new Member States have undergone an important depression too, it is assumed that their recovery will be more pronounced than the EU average. Slower growth rates are assumed in the longer run as these countries approach the performance of the old Member States.

For southern countries, similar growth patterns are assumed, however with somewhat lower long-term prospects than those of the new Member States. Although current differences between old and new Member States will decline over time, full convergence is not assumed until 2030.

3.1.3 Household income and lifestyles

As a consequence of the demographic and macro-economic assumptions, per-capita income will increase at an average rate of about 2% per year. However, differences in per-capita income, notably between the old and the new Member States, will remain even in the long term, with a widening gap after 2030 (Figure 3.5).

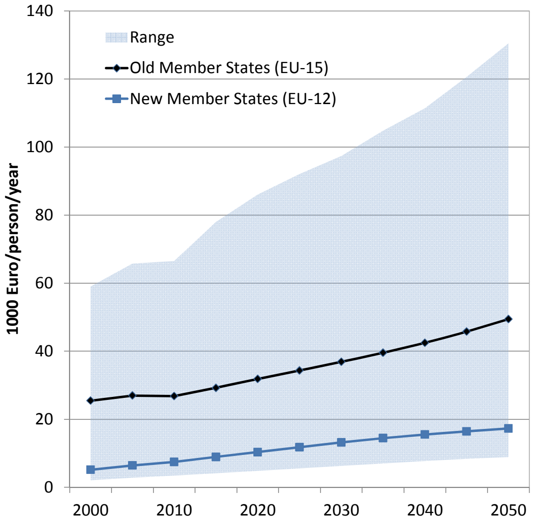

Figure 3.5: Evolution of income levels (GDP/capita) in the old and new Member States

The anticipated increase in personal wealth will have profound impacts on personal lifestyles, and thereby on activities that cause pollution to the atmosphere.

Car use will slowly saturate, but new EU Member States will catch up fast

In the past, travelled mileage and car use have steadily increased with growing income. This trend is expected to slow down in the coming decade in the old Member States. However, the anticipated economic convergence of the new Member States will let travel demand grow fast during the entire projection period (Figure 3.6).

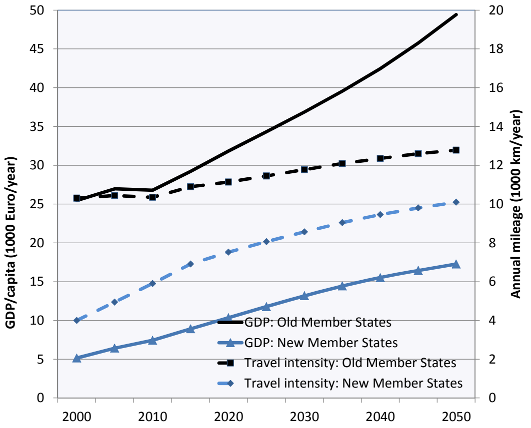

Figure 3.6: Assumed evolution of passenger travel demand in the old and new Member States (solid lines: GDP/capita, dashed lines: travel demand)

Meat consumption will increase further, but demand for milk products will fall

As a consequence of higher incomes, also dietary habits are expected to change. Together with increased population, this should lead to a 25% higher consumption of meat and cereals in Europe until 2030. In contrast, demand for milk products would decline (Figure 3.7). However, in the long run, cereals and meet production will decline.

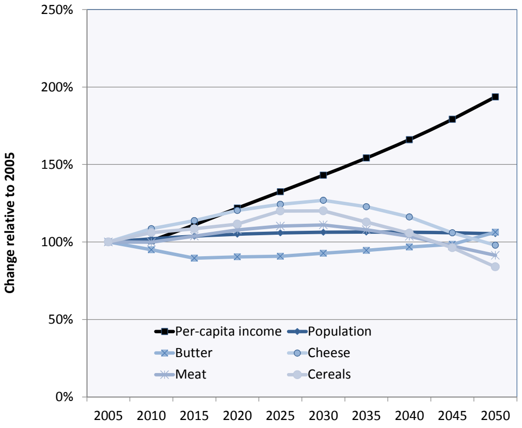

Figure 3.7: Evolution of total population, income and the demand for agricultural products

3.1.4 World energy prices

The TSAP baseline assumes higher energy prices compared with previous projections. Price trajectories for gas and coal are derived from the PROMETHEUS model based on conventional wisdom of the world energy system.

In absence of climate policies, world energy prices are expected to rise

International fuel prices are projected to grow over the projection period with oil prices reaching 88 $/bbl (73 €/bbl; in 2008 $/€) in 2020, 106 $/bbl (91 €/bbl) in 2030 and 130 $/bbl in 2050 (Figure 3.8). Gas prices follow a trajectory similar to oil prices reaching 62 $/boe (51 €/boe) in 2020 and 77 $/boe (66 €/boe) in 2030, while coal prices increase during the economic recovery period and reach almost 26 $/boe (21 €/boe) in 2020; afterwards they would stabilize around 29 $/boe (25 €/boe). In contrast, it is estimated that a stringent global climate policy would lead to significantly lower energy prices.

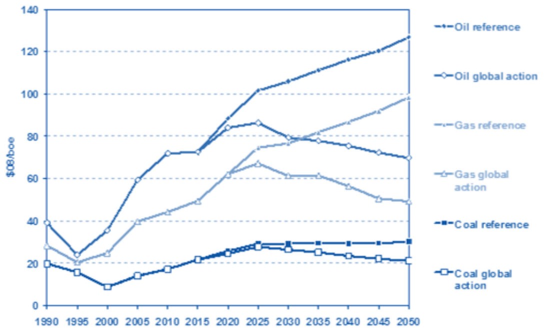

Figure 3.8: Assumed energy prices (in constant US-$ 2008)

3.1.5 Sectoral economic development

As a result of modified consumption patterns and the economic restructuring process, the sectoral composition of future economic activities is likely to change in the future. The GEM E-3 model has been used to develop an internally coherent picture of sectoral economic activities in the 27 Member States that is consistent with the overall macro-economic assumptions.

The service sector and non energy-intensive industries will grow faster than others

The service sectors, which generated in 2005 about 72% of the EU's gross value added, will increase their share to approximately 75% by 2030 (Figure 3.9). Non energy-intensive industries are expected to maintain their current share in total value added of about 13.5%. Within this group, engineering industries producing equipment goods and pharmaceutical and cosmetics industries will grow faster than the average.

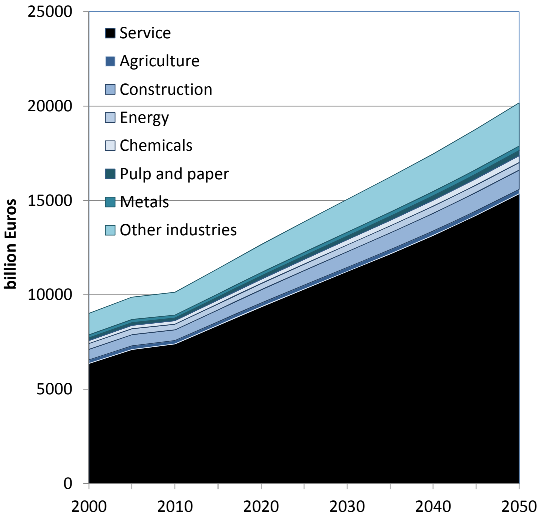

Figure 3.9: Development of GDP by sector, EU-27

3.2 Energy

The Draft TSAP-2012 baseline employs the reference energy projection that has been developed for the 2009 update of the 'EU energy trends to 2030' report of DG-Energy (CEC, 2010b). For the outlook to 2050, the Draft TSAP-2012 baseline relies on the reference case of the 2050 'Roadmap for moving to a competitive low carbon economy' of DG-CLIMA (CEC, 2011a).

Both energy projections have been developed with the PRIMES model, which quantified the implications of the economic development in the various sectors on energy demand and supply in the 27 Member States of the EU. The 2050 scenario is an extension of the 2030 projection (i.e., the 'PRIMES 2010' scenario), with minor corrections of the development up to 2030 for a few Member States.

3.2.1 Energy policy measures assumed in the baseline

In addition to the assumptions on the macro-economic drivers that are discussed in the preceding section, these energy scenarios incorporate the energy and climate measures that are already implemented EU and national policies. They also consider policies agreed in the Energy and Climate package for which national measures have not yet been fully implemented. These include the legally binding targets for renewables to achieve a 20% overall share and a 10% share in transport. Furthermore, they assume achievement of the legally binding targets for non-ETS greenhouse gas emissions, and the ETS target to achieve a 20% reduction in 2020 compared to 2005 (Box 2). However, current policies, including the attainment of the legally binding renewables and greenhouse gas targets, do not fully achieve the 20% energy savings target by 2020.

Box 2: Energy policy measures assumed in the baseline and how they are reflected in the PRIMES model

	Measure	*How the measure is reflected in the PRIMES model*
	Regulatory measures on energy efficiency	
	Eco-design implementing measures	
1	Eco-design Framework Directive 2005/32/EC	Adaptation of modelling parameters for different product groups. As requirements concern only new products, the effect will be gradual (marginal in 2010; rather small in 2015 and up to full effect by 2030). The potential envisaged in the Eco-design supporting studies and the relationship between cost and efficiency improvements in the model's database were cross-checked.
2	Stand-by regulations 2008/1275/EC	
3	Simple Set-to boxes regulation 2009/107/EC	
4	Offices/street lighting regulation 2009/245/EC	
5	Household lighting regulation 2009/244/EC	
6	External power supplies regulation 2009/278/EC	
	Other energy efficiency regulations	
7	Labelling Directive 2003/66/EC	Enhancing the price mechanism mirrored in the model
8	Cogeneration Directive 2004/8/EC	National measures supporting cogeneration are reflected
9	Directive 2006/32/EC on end-use energy efficiency and energy services	National implementation measures are reflected
10	Buildings Directive 2002/91/EC	National measures e.g. on strengthening of building codes and integration of RES are reflected
11	Energy Star Program (voluntary labelling program)	Enhancing the price mechanism mirrored in the model
	Regulator measures for energy markets and power generation	
12	Completion of the internal energy market (including provisions of the 3rd package)	The model reflects the full implementation of the Second Internal market Package by 2010 and Third Internal Market Package by 2015. It simulates liberalised market regime for electricity and gas (decrease of mark-ups of power generation operators; third party access; regulated tariffs for infrastructure use; producers and suppliers are considered as separate companies) with optimal use of interconnectors.

3.2.2 Energy consumption

With the assumptions on economic development, international fuel prices and energy policies that are described above, the PRIMES model estimates that after the economic crisis energy consumption in the EU-27 would return to the 2005 level in 2015 and remain at this level despite the 100% increase in GDP (Figure 3.10).

Despite a doubling in economic activity, the baseline scenario indicates a stabilization of energy consumption

The decoupling between GDP growth and primary energy consumption in the baseline scenario emerges as a direct consequence of the economic restructuring towards less energy-intensive sectors, autonomous technological progress and dedicated energy policies that promote energy efficiency improvements.

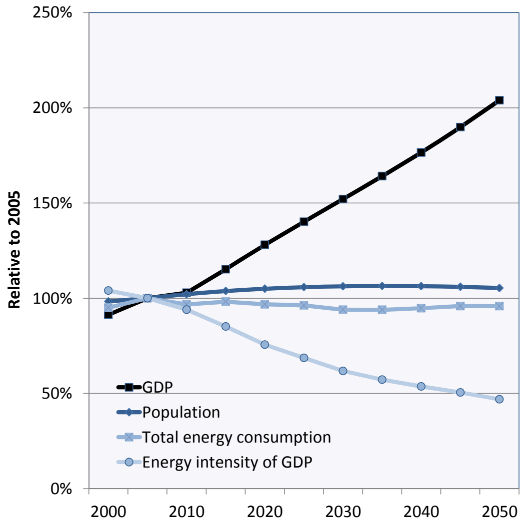

Figure 3.10: Baseline trends in energy consumption, its key drivers (GDP and population) and energy intensities

While the total volume of energy consumption is suggested to remain at today's level, the structural composition of fuels and energy sources is anticipated to change (Figure 3.11). Most importantly, current policies for renewable energy sources are expected to increase biomass use by two thirds in 2030 compared to 2005, and to triple energy from other renewable sources (e.g., wind, solar). In contrast, coal consumption is expected to decline by 18% by 2030, and oil consumption is calculated to be 13% lower than in 2005.

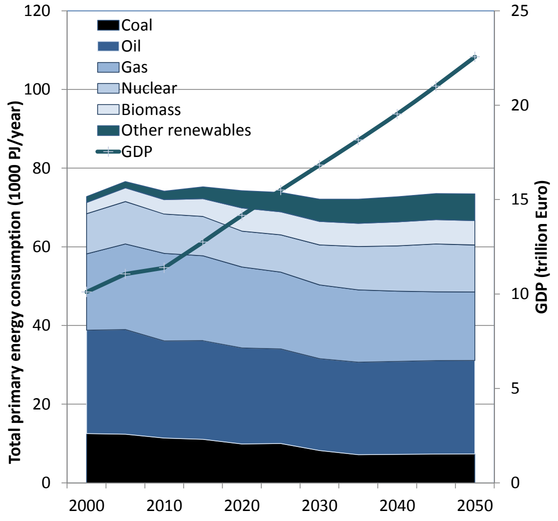

Figure 3.11: Baseline energy consumption by fuel in the EU-27

After economic recovery, energy efficiency policies will reduce energy demand in households and industry

Different trends are expected for different economic sectors. Until economic recovery will be achieved, energy demand in the transport sector is expected to increase by 9% up to 2020 (relative to 2005), and by 3% for households and industry. After that time, progressive implementation of energy efficiency measures will show full effect, especially in the domestic and transport sectors where lower energy consumption is calculated for 2030 than for 2020. Fuel input to the power sector will remain at the current level (Figure 3.12).

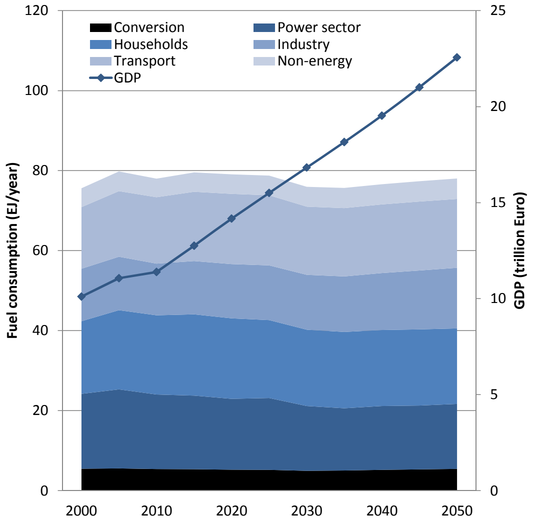

Figure 3.12: Baseline energy consumption by sector in the EU-27

Table 3.1: Baseline energy consumption by fuel in the EU-27 (1000 PJ)

	2000	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Coal	12.5	12.4	11.4	11.0	9.9	10.0	8.2	7.2	7.2	7.3	7.4
Oil	26.3	26.6	24.7	25.1	24.4	24.0	23.4	23.5	23.6	23.8	23.7
Gas	19.4	21.8	22.2	21.6	20.6	19.5	18.8	18.4	17.9	17.5	17.4
Nuclear	10.2	10.8	10.0	10.0	9.1	9.5	10.2	11.0	11.5	12.2	11.9
Biomass	2.9	3.5	3.7	4.5	5.9	5.9	6.0	5.9	6.1	6.2	6.2
Other renewables	1.5	1.6	2.1	3.0	4.4	4.9	5.7	6.1	6.4	6.6	6.8
Total	72.9	76.6	74.1	75.2	74.2	73.7	72.0	72.0	72.7	73.5	73.4

Table 3.2: Baseline energy consumption by sector in the EU-27 (1000 PJ)

	2000	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Conversion	5.5	5.6	5.4	5.4	5.3	5.2	5.0	5.0	5.2	5.3	5.4
Power sector	16.0	16.6	14.8	14.1	12.8	13.0	12.3	11.9	12.0	12.1	11.6
Households	18.2	19.8	19.8	20.3	20.1	19.5	19.1	19.1	19.0	19.1	18.9
Industry	13.1	13.4	12.9	13.3	13.6	13.7	13.7	13.9	14.2	14.7	15.1
Transport	15.4	16.4	16.6	17.3	17.5	17.5	17.0	17.1	17.2	17.2	17.2
Non-energy	4.7	4.9	4.7	4.8	4.9	4.9	5.0	5.0	5.0	5.1	5.1
Total	72.9	76.6	74.1	75.2	74.2	73.7	72.0	72.0	72.7	73.5	73.4

Although energy intensities of Member States are anticipated to converge, significant differences will prevail

The PRIMES model provides country-specific projections of baseline energy consumption for all EU Member States. As an overall feature, energy intensity improvements of GDP will occur in all countries over time, and the large discrepancies between countries that prevail in 2005 are gradually converging (Figure 3.14). It is noteworthy that per-capita consumption is expected to increase in some of the new Member States. However, even for 2030 significant differences in energy intensities are expected to remain. On a per-capita basis, energy consumption levels are more similar (Figure 3.13,).

Table 3.3: Baseline energy consumption by country (Petajoules)

	2000	2005	2010	2015	2020	2025	2030
Austria	1227	1431	1425	1424	1425	1415	1400
Belgium	2654	2644	2490	2575	2586	2425	2303
Bulgaria	798	852	802	831	866	907	894
Cyprus	100	111	121	123	129	134	135
Czech Rep.	1671	1889	1873	1930	1962	1988	1983
Denmark	836	849	814	810	799	784	773
Estonia	192	209	204	229	225	223	226
Finland	1378	1433	1457	1512	1535	1516	1459
France	11201	11664	11388	11450	11393	11319	11289
Germany	14354	14431	13784	13341	12585	11871	11260
Greece	1215	1341	1304	1370	1390	1425	1454
Hungary	1046	1168	1187	1256	1266	1264	1258
Ireland	610	680	652	701	711	738	752
Italy	7440	8032	7723	7958	8230	8472	8734
Latvia	162	193	200	216	222	218	214
Lithuania	301	360	311	338	387	429	428
Luxembourg	152	198	201	218	220	221	217
Malta	32	40	38	35	34	34	34
Netherlands	3251	3463	3319	3361	3291	3229	3156
Poland	3806	3891	4243	4507	4617	4655	4596
Portugal	1057	1136	1051	1063	1036	1043	1050
Romania	1531	1644	1649	1729	1786	1809	1770
Slovakia	719	788	784	884	908	933	926
Slovenia	272	306	332	370	392	396	389
Spain	5129	5966	5877	6279	6617	6861	6956
Sweden	2067	2217	2109	2131	2090	2061	2018
UK	9764	9824	9137	8972	8566	8471	8415
EU-27	72966	76758	74472	75613	75269	74842	74092

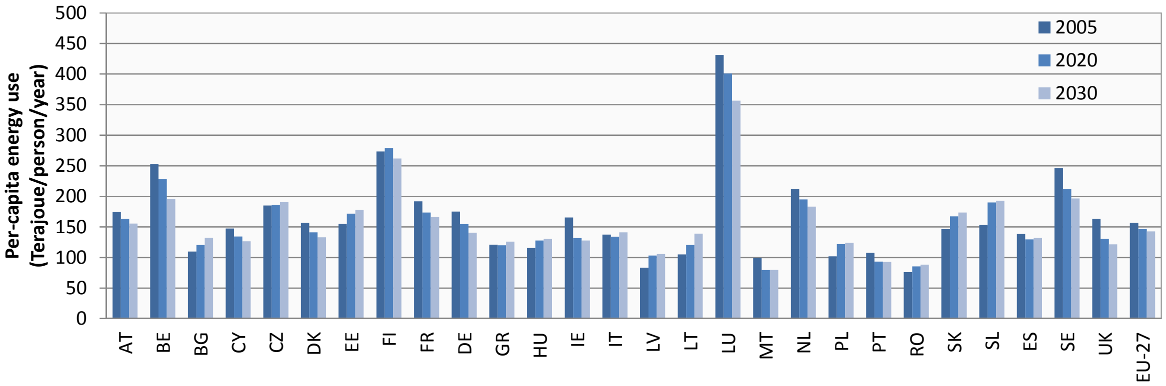

Figure 3.13: Per-capita energy consumption by Member State, 2005, 2020, 2030

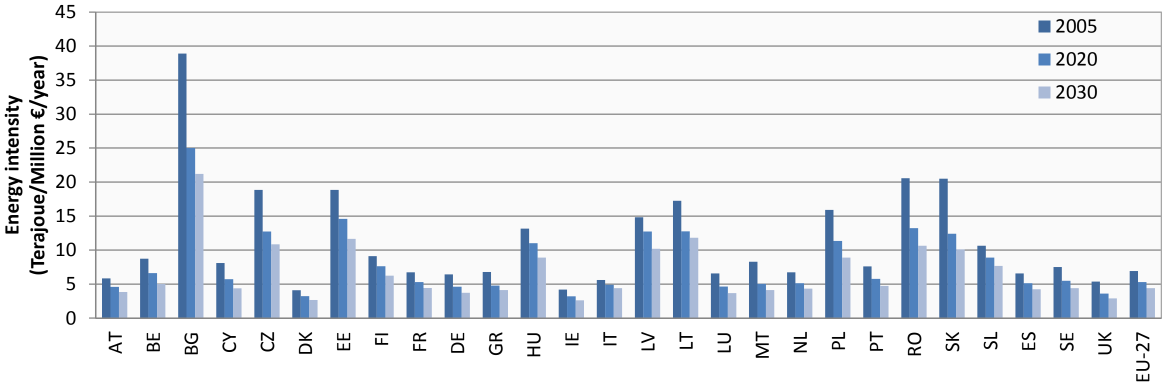

Figure 3.14: Energy intensities of GDP in the Member States, 2005, 2020 and 2030

3.3 Transport

Mobile sources make substantial contributions to emissions of atmospheric pollutants. While the stringent technological standards that have been introduced in the past have substantially lowered emissions from individual vehicles, their positive effect was counteracted by a general increase in the volume of transport activities. Thus, emissions in the future will be determined by the development of the overall vehicle stock, its fuel consumption, and its structural composition.

The TSAP baseline projection employs the TREMOVE, COPERT and FLEETS models to add structural detail (e.g., on fleet composition, vintage structures, etc.) to the overall trends in transport activities and fuel consumption calculated by PRIMES.

3.3.1 Baseline trends in the transport sector

In the baseline, demand for passenger travel and freight transport will continue to grow.

It is estimated that total passenger mileage would increase by more than one third between 2005 and 2030, with a doubling of the air transport mileage (Figure 3.15).

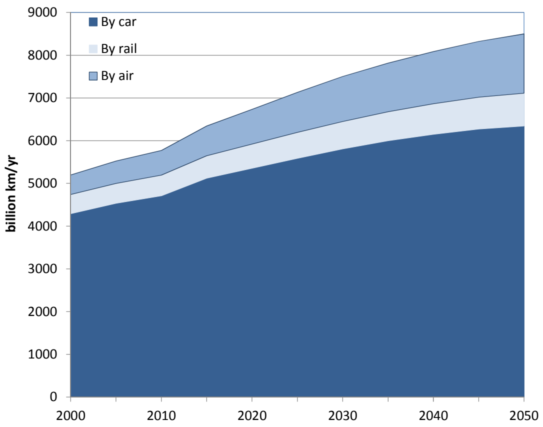

Figure 3.15: Total passenger mileage by transport modes

3.3.2 Transport policy measures assumed in the baseline

The European Union has issued comprehensive legislation on energy efficiency and emission controls that will have profound impacts on the future vehicle fleet (Box 3). The baseline assumes that this legislation will be implemented according to schedule and deliver the envisaged results.

Box 3: Transport policy measures assumed in the baseline

Regulation on CO_2 from cars 2009/443/EC	Limits on emissions from new cars: 135 g CO_2/km in 2015, 115 in 2020, 95 in 2025 – in test cycle. The 2015 target should be achieved gradually with a compliance of 65% of the fleet in 2012, 75% in 2013, 80% in 2014 and 100% in 2015. Penalties for non-compliance are dependent on the number of grams until 2018; starting in 2019 the maximum penalty is charged from the first gram.
Regulation EURO 5 and 6 2007/715/EC	Emission limits for new cars and light commercial vehicles
Fuel Quality Directive 2009/30/EC	Modelling parameters reflect the Directive, taking into account the uncertainty related to the scope of the Directive addressing also parts of the energy chain outside the area of PRIMES model (e.g., oil production outside EU).
Directive 2009/28/EC on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC	This directive establishes 10% mandatory renewables targets in transport by 2020 (including electricity).
Labeling regulation for tires 2009/1222/EC	Decrease of perceived costs by consumers for labeling (which reflects transparency and the effectiveness of price signals for consumer decisions).
Regulation EURO VI for heavy duty vehicles 2009/595/EC	Emissions limits introduced for new heavy duty vehicles.

Vehicle mileage will grow faster than the demand for personal mobility

Higher car ownership facilitated by higher income levels will reduce the average occupancy, so that vehicle mileage will grow by 50%, i.e., even more than passenger mileage.

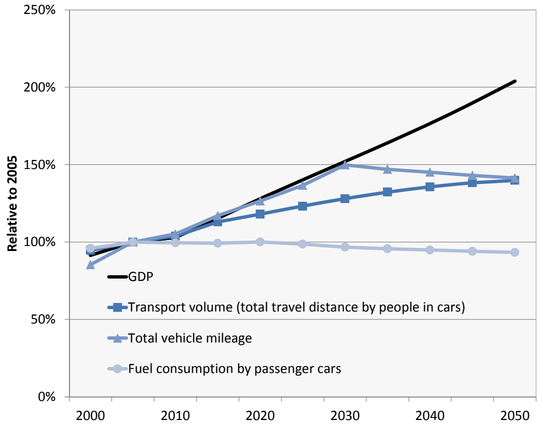

Figure 3.16: Passenger transport demand, vehicle mileage and fuel consumption by passenger cars

The share of diesel passenger cars is likely to remain at the 2010 level

For vehicles, it is estimated that new fuel efficiency requirements would off-set the impacts of the growth in vehicle mileage on energy consumption and thereby decouple total fuel consumption from travel growth (Figure 3.16).

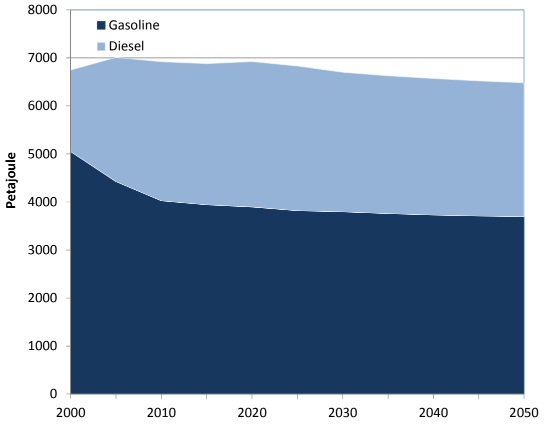

Figure 3.17: Diesel and gasoline consumption for light duty (passenger) vehicles

While the market share of diesel (light duty) cars increased significantly over the last years, the baseline scenario assumes no further change beyond 2010 (Figure 3.17).

Freight transport intensity of the European economy will not change significantly up to 2030

Despite continuing harmonization and expansion of the common European market, no significant changes in freight transport intensities are foreseen up to 2030, (Figure 3.18). Only in the long run when GDP will shift more to the service sector stabilization of transport-intensities is anticipated.

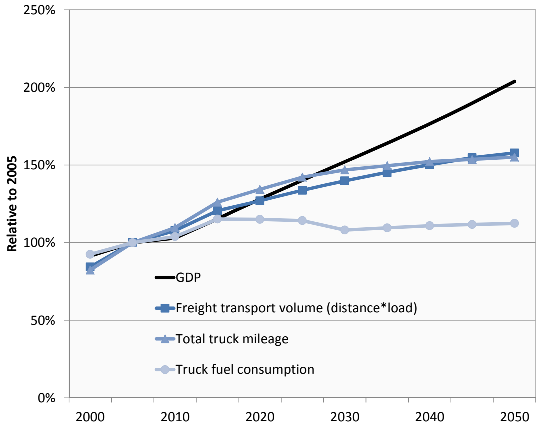

Figure 3.18: Assumed development of GDP, freight transport intensity (freight volumes times transport distance per GDP), truck mileage and fuel consumption in the EU-27

However, there are significant structural differences between countries. The baseline assumes a sharp decline in the shares of rail and waterway transport in the new Member States.

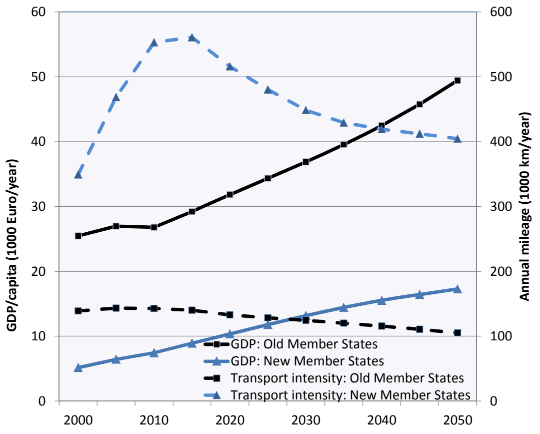

Figure 3.19: GDP and, freight transport intensities (freight volumes times transport distance per GDP) for the old and new Member States

As a consequence, road transport volumes in the new Member States will increase at a faster rate than GDP in the coming years; after 2015, however, growth trends (relative to GDP) should converge to those of the old Member States (Figure 3.19). In total, freight transport volumes will increase steadily, with the majority transported by trucks on road (**Figure 3.20**).

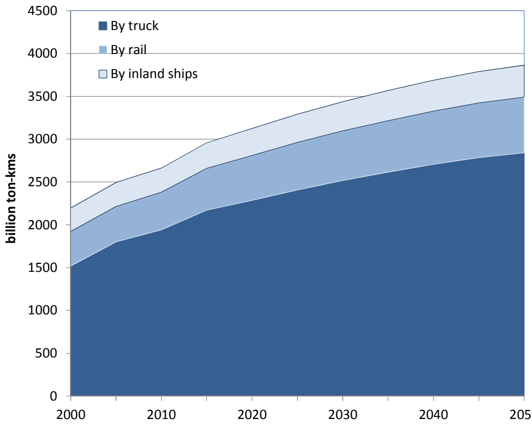

Figure 3.20: Development of freight volumes (ton-kilometres) by different transport modes

New legislation on fuel efficiency should stabilize the growth in fuel demand for total road transport despite the expected increases in travel distance and freight volumes. There are significant variations in fuel consumption for road transport across Member States (Figure 3.21). In most countries, fuel use is expected to decline up to 2030, but there are few exceptions among the new Member States.

Air transport volume doubling until 2030, rail's share stagnates

The transport volume for air travel will double between 2005 and 2030, while overall passenger transport demand grows by one third over the same period in EU27. Rail travel grows at the same rate and thereby maintains it current 8% modal share Car travel will remain the dominant mode with about 70% share in total travel volume.

Freight transport volume is projected to grow by 38% until 2030, slightly more than passenger transport volume. No major structural shifts are expected, so that road remains about 73%, and rail and inland vessels carry 17% and 10%, respectively.

Efficiency improvements and higher load factors for aircrafts compensate to some extent the volume growth; by 2030 fuel demand for air is projected one third higher than in 2005. The complete electrification of rail traction leads to a reduction of the energy intensity of both passenger and freight traction by about one third until 2030. As a consequence, total energy demand for passenger rail will stay constant up t o2030 and decrease by more than 10% thereafter.

Fuel demand for agricultural and forestry machinery is coupled to the overall activity in the agricultural sector. It is projected to decrease by 4% until 2030. Likewise, fuel demand for construction and industry mobile machinery is assumed to follow the overall fuel demand in the industry sector. Fuel consumption from mobile machinery is projected to decrease by 10% until 2030, and then rebound to the 2005 level.

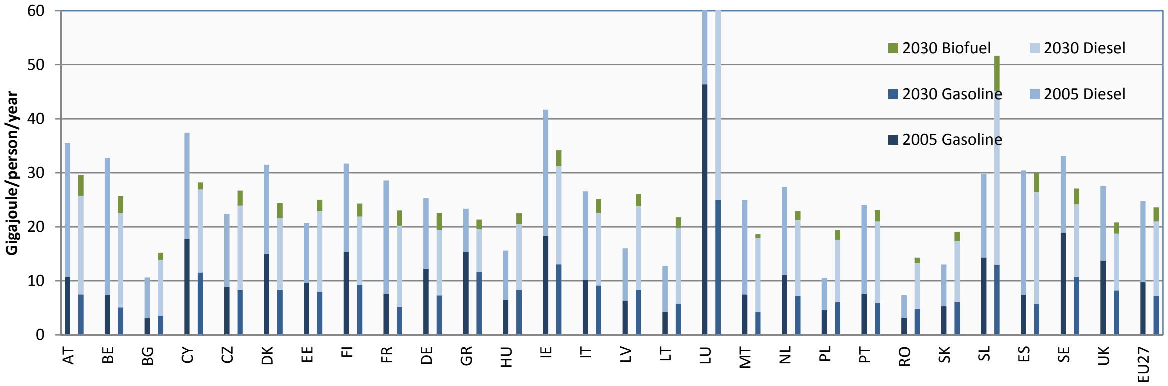

Figure 3.21: Fuel consumption for road transport on a per-capita basis

3.4 Land use and agricultural activities

Agricultural activities and land use are important sources of harmful emissions to the atmosphere. The production of agricultural commodities (food, feed, fibre, bio-fuels) requires land area. Production capacities are limited by the amount of land required for other purposes, by the market prices of the respective products, and by biophysical constraints. Cost-effective policy responses aiming at the protection of the atmosphere must consider all these factors, including the implications of initiatives in other policy areas.

The TSAP baseline considers the implications of a range of recent policy initiatives that have impacts on land use and agricultural activities (Box 4).

3.4.1 Baseline trends in land use

Population growth and economic development increases the demand for built-up land, and at the same time for forest and agricultural products. On top of these factors, climate policies that enhance reforestation and biofuel production will put additional pressure on European land resources.

Box 4: Agricultural policies included in the baseline

- The ‘Health Check’ of the Common Agricultural Policy (CAP)
- Abolition of the ‘Set aside’ (regulation 73/2009) and milk quota regulations
- Agricultural premiums are largely decoupled from production levels
- The World Trade Organization (WTO) December 2008 Falconer proposal
- The biofuel targets of the EU Energy and Climate package as modelled by PRIMES
- The Nitrates directive

Increasing demand for built-up land will reduce land available for agriculture, forestry and biofuel production

Overall, economic development will convert more land into built-up area, so that the overall area for forests, crops and grassland is estimated to shrink by 3% up to 2030. Forest area and crop land are more or less stable, inter alia due to climate policies that promote carbon storage in forests and biofuel production. In contrast, a 9% decline is anticipated for pasture (Figure 3.22).

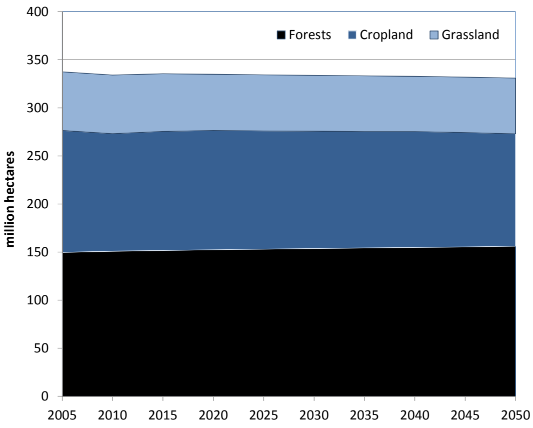

Figure 3.22: Land use for forests, crops and grassland

Higher productivity for food crops will free up land for biofuel production

Increasing agricultural productivity will supply the crop demand for food and fodder on 10% less area. The freed-up land, together with gains from smaller set-aside areas, will be used for biofuel production (Figure 3.23).

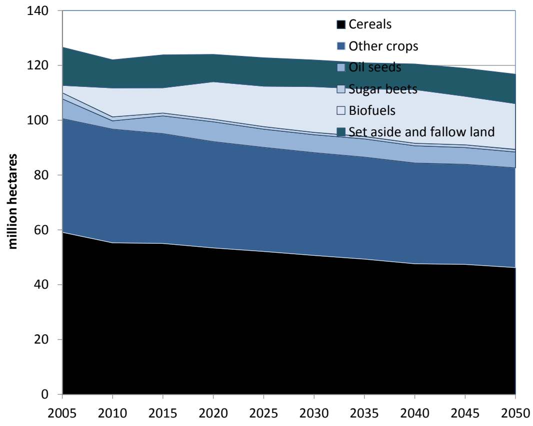

Figure 3.23: Use of arable land for different purposes

3.4.2 Baseline trends in agricultural activities

Crop production will recover to the 2005 levels, but decline in the long run

Up to 2030, the total volume of staple crop production is likely to recover back to the 2005 level after the recent decline in sugar beet production (Figure 3.24). While sugar beets are expected to remain at the lower level, the loss in volume will be compensated by higher crops of wheat and other grains. After 2030, a general decline in agricultural production is foreseen.

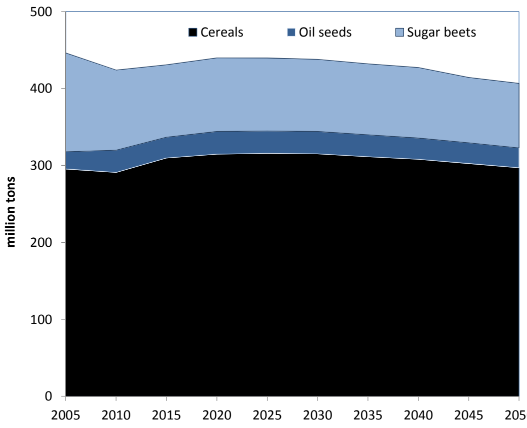

Figure 3.24: Baseline trend in the production agricultural stale crops for non-fodder purposes

Biofuel production in the EU will increase by a factor of 10

The renewable energy targets of the EU Energy and Climate package will lead to a significant increase of total biofuel production. In the short run, biofuel production will shift from oil seeds to cereals, while in the long-run new energy crops are expected to supply the majority of input (Figure 3.25).

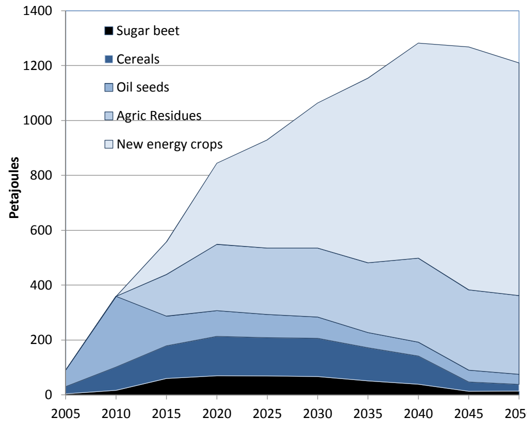

Figure 3.25: Baseline projection of biofuel production

Fertilizer use will rise again

Fertilizer use has declined between 2000 and 2010 due to increased efficiency of fertilizer application and changes in crop types (e.g., reduced sugar beet production). However, for the coming decades the baseline scenario anticipates a return to the 2000 levels due to the intensification of agricultural production, inter alia, due to increased bio-fuel production (Figure 3.26). In the long run, however, fertilizer use is expected to decline.

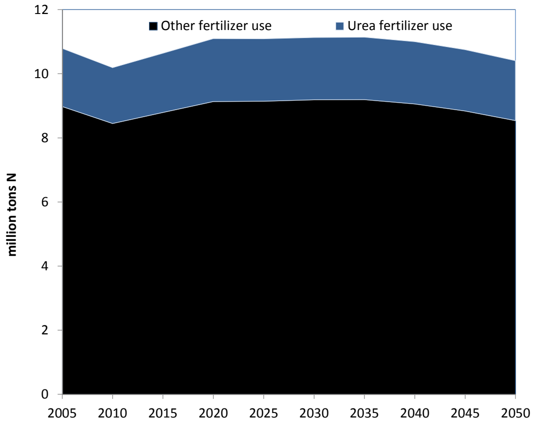

Figure 3.26: Baseline trend in fertilizer use in the EU-27

Cattle numbers will decrease, but there will be more pigs and chicken

Significant changes are expected in the livestock sector as a consequence of the EU agricultural policy reform. Despite – or because of – the abolition of the milk quota regime under the Health Check, dairy cow numbers in the EU will decline up to 2015, compensated by higher productivity. This has implications on other cattle, which will decline too, but at a lower rate. Pig and poultry numbers, which are not strongly influenced by new policies, are expected to continue their increase, although their further growth might be limited by local environmental constraints (Figure 3.27).

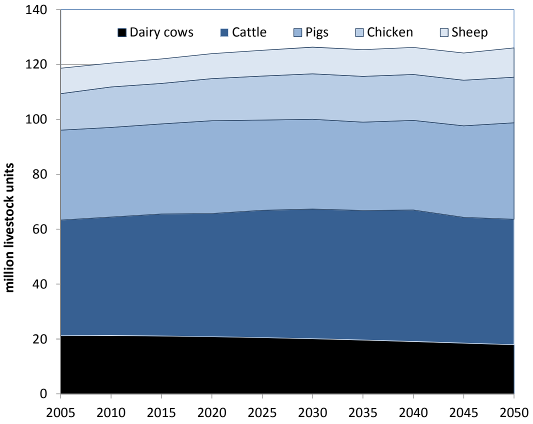

Figure 3.27: Baseline trend in livestock numbers in the EU-27

4 Baseline emissions

4.1 Emission control legislation considered in the baseline

In addition to the energy, climate and agricultural policies that influence future activity levels (see Box 2 to Box 4), the TSAP baseline considers a detailed inventory of national emission control legislation (including the transposition of EU-wide legislation). It assumes that these regulations will be fully complied with in all Member States according to the foreseen time schedule. For CO_2, regulations are included in the PRIMES calculations as they affect the structure and volumes of energy consumption (Box 6). For non-CO_2 greenhouse gases and air pollutants, EU and Member States have issued a wide body of legislation that limits emissions from specific sources, or have indirect impacts on emissions through affecting activity rates (Box 6).

Box 5: Policies and regulations affecting CO_2 emissions that are considered in the baseline

- EU directives and regulations aiming at efficiency improvements, e.g., for energy services, buildings, labelling, lighting, boilers
- Regulation on new cars (involving a penalty for car manufacturers if the average new car fleet exceeds 135 g CO_2/km in 2015, 115 g CO_2/km in 2020, 95 g CO_2/km in 2025 – in test cycle) (DIR 443/2009/EC)
- Provisions for reducing the GHG intensity of fuels for road and non-road use (DIR 30/2009/EC)
- Biofuels directive
- National policies with regard to nuclear power
- Strong national policies supporting use of renewable energy; however compliance with the 20% target share of renewable energy is not mandatory
- Co-generation directive
- Carbon Capture and Storage (CCS) demonstration plants
- Harmonisation of excise taxes on energy
- The Emission Trading Scheme (ETS) directive, including aviation

For air pollutants, the baseline assumes the regulations described in Box 7 to Box 11. However, the analysis does not consider the impacts of other legislation for which the actual impacts on future activity levels cannot yet be quantified. This includes compliance with the air quality limit values for PM, NO_2 and ozone established by the Air Quality directive, which could require, inter alia, traffic restrictions in urban areas and thereby modifications of the traffic volumes assumed in the baseline projection. Although some other relevant directives such as the Nitrates directive are part of current legislation, there are some uncertainties as to how the measures can be represented in the framework of integrated assessment modelling.

Box 6: Legislation considered for non-CO_2 GHG emissions

- Landfill directive
- Waste directive, EU waste treatment hierarchy
- Nitrates directive
- Common Agricultural Policy (CAP) reform and CAP health check
- F-gas directive
- Motor vehicles directive
- The European Emission Trading System (ETS)
- Other relevant legislation:
- Regulation on using specific F-gases in mobile air conditioning systems (DIR 40/2006/EC)

Box 7: Legislation considered for SO_2 emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs are considered according to the information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive.
- Directive on the sulphur content in liquid fuels
- Fuel Quality directive 2009/30/EC regarding quality Directives on quality of petrol and diesel fuels, as well as the implications of the mandatory requirements for renewable fuels/energy in the transport sector
- MARPOL Annex VI revisions from MECP57 regarding sulphur content of marine fuels
- National legislation and national practices (if stricter)

Box 8: Legislation considered for NO_x emissions

- Directive on Industrial Emissions for large combustion plants (derogations and opt-outs included according to information provided by national experts)
- BAT requirements for industrial processes according to the provisions of the Industrial Emissions directive
- For light duty vehicles: All EURO-standards, including adopted EURO 5 and EURO 6, becoming mandatory for all new registrations from 2011 and 2015 onwards, respectively (DIR 692/2008/EC)
- For heavy duty vehicles: All EURO-standards, including adopted EURO V and EURO VI, becoming mandatory for all new registrations from 2009 and 2014 respectively (DIR 595/2009/EC).
- For motorcycles and mopeds: All EURO standards for motorcycles and mopeds up to EURO 3, mandatory for all new registrations from 2007 (DIR 2003/77/EC, 2005/30/EC, 2006/27/EC). Proposals for EURO 4/5/6 not yet legislated.
- For non-road mobile machinery: All EU emission controls up to Stages IIIA, IIIB and IV, with introduction dates by 2006, 2011, and 2014 (DIR 2004/26/EC).
- MARPOL Annex VI revisions from MECP57 regarding emission NO_x limit values for ships
- National legislation and national practices (if stricter)

Box 9: Legislation considered for PM10/PM2.5 emissions

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

Box 10: Legislation considered for NH_3 emissions

- IPPC directive for pigs and poultry production as interpreted in national legislation
- National legislation including elements of EU law, i.e., Nitrates and Water Framework Directives
- Current practice including the Code of Good Agricultural Practice

For heavy duty vehicles: EURO VI emission limits, becoming mandatory for all new registrations from 2014 (DIR 595/2009/EC).

Box 11: Legislation considered for VOC emissions

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

The baseline assumes full implementation of this legislation according to the foreseen schedule. Derogations under the IPPC, LCP and IED directives granted by national authorities to individual plants are considered to the extent that these have been communicated by national experts to IIASA. The precise implications of existing derogations, together with a solid documentation, will be subject of the bilateral consultations for the preparation of the final TSAP scenario.

New legislation will gradually penetrate the market

Most source-oriented emission control legislation involves a clear schedule for its introduction, and applies in many cases only to new sources. The baseline scenario considers the natural turnover of existing capital stock and applies, where appropriate, new legislation only to new sources. Thus, sources with lower emissions will only gradually penetrate the market.

For vehicles, the analysis considers that new vehicles have usually higher annual mileage than older vehicles, so that their share in total mileage will be even larger than their share in the vehicle stock. As an example, Figure 4.1 and Figure 4.2 present the estimated shares of different European exhaust emission standards in the total mileage of the European fleet.

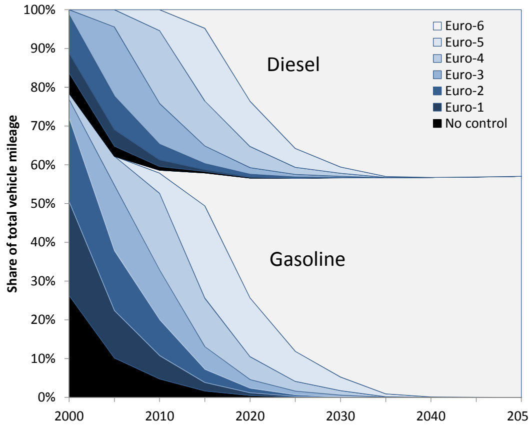

Figure 4.1: Penetration of EURO-standards for passenger cars in the EU-27

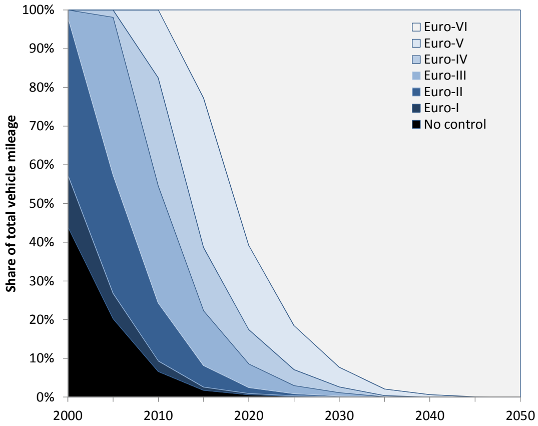

Figure 4.2: Penetration of EURO-standards for heavy duty road vehicles in the EU-27

The draft baseline assumes compliance with EURO 6 limit values under real life conditions

Although in the past EU legislation imposed increasingly stringent emission limit values for vehicles, NO_x emissions from diesel cars were found much higher under real world driving conditions than the limit values for the test cycle. In fact, real-world NO_x emissions have not decreased for EURO 2 to EURO 5 standards.

For EURO 6 light duty diesel vehicles, this draft baseline assumes that from 2015 onwards real-world emission factors will actually come close to the legislative limit value. To account for allowed deterioration and for the difference between real-world driving and legislative test cycle, the TSAP-2012 baseline assumes a value of about 120 mg NO_x/km for real-world driving conditions, compared to the limit value of 80 mg/km. It is assumed that specific actions will ensure that this value is achieved throughout the fleet by 2015.

4.2 Sulphur dioxide (SO_2) emissions

Most of sulphur dioxide (SO_2) emissions from human activities originate from the combustion of sulphur-containing fuels such as coal and oil. Thus, the volumes of such fuels that are burned as well as the application and efficiency of dedicated emission control technologies are key determinants of total emissions. In 2005, more than two-thirds of the EU-27 SO_2 emissions were generated in the power sector and 21% by industrial sources.

SO_2 emissions will fall drastically

The significant changes in fuel consumption levels and patterns that are expected in the baseline projection, together with progressing implementation of emission control measures, will lead to a reduction of about 70% in SO_2 emissions in the coming decades. Most of the decline will emerge from coal use, while only minor changes are foreseen for the emissions from other fuels (Figure 4.3).

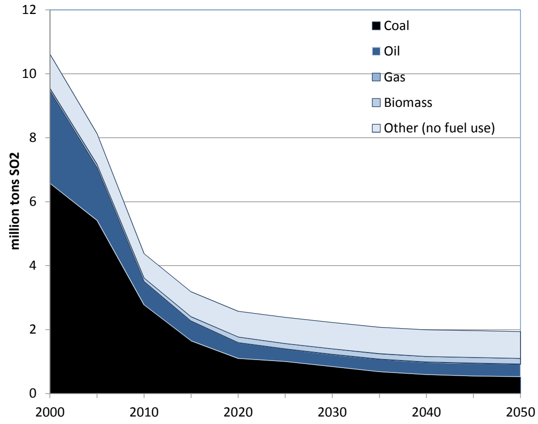

Figure 4.3: SO_2 emissions of the EU-27 by fuel

Most of the SO_2 decline will emerge until 2020, for which emissions are estimated to be 68% below their 2005 levels. In the following decade, emissions would then fall to 72% below the 2005 level; by 2050, SO_2 emissions would be 76% lower.

The power sector will cut its emissions by almost 90%

More than 80% of the drop will come from the power sector, which will reduce its emissions by almost 90% compared to 2005. This is a direct consequence of the decarbonisation in response to the EU climate targets, as well as of the progressing implementation of the LCP, IED and IPPC directives. The domestic sector will decrease its SO_2 emissions by about 50%, while industrial emissions are expected to fall by 40% (Figure 4.5).

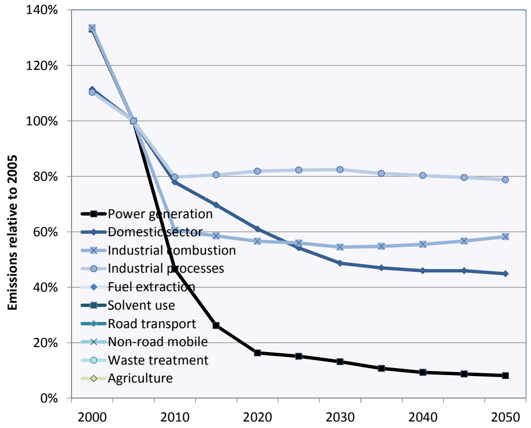

Figure 4.4: Sectoral trends in baseline emissions of SO_2 in the EU-27

As a consequence of these changes, the power sector will lose its dominating role, and the majority of the remaining emissions will emerge from industrial (combustion and process) sources (Figure 4.4, Figure 4.5, Table 4.1).

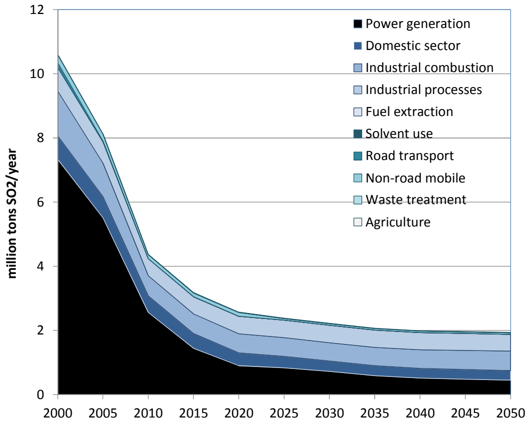

Figure 4.5: SO_2 emissions of the EU-27 by SNAP sector

All countries will reduce SO_2 emissions, with up to 90% decrease in some new Member States

Legislation and changes in the energy structures will lead to declining SO_2 emissions in all Member States (Table 4.2). However, particularly large drops are anticipated for some of the new Member States (e.g., Bulgaria, Estonia, Romania, etc.), where emissions will fall by 80 to 90%. These countries exhibited extraordinary high per-capita levels of SO_2 emissions in 2005 (Figure 4.6), and current legislation will bring them down close to the EU-27 average level.

Table 4.1: SO_2 emissions by SNAP sector, EU-27

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Power generation	7335	5511	2564	1444	902	833	725	591	515	481	450
Domestic sector	736	661	515	461	404	358	322	311	304	304	297
Industrial combust.	1397	1046	633	612	592	585	570	573	581	593	609
Industrial processes	730	662	528	533	542	545	546	537	532	527	521
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0
Road transport	150	33	6	6	6	6	6	6	6	6	6
Non-road mobile	249	206	117	112	114	42	42	42	42	43	43
Waste treatment	2	2	2	1	1	1	1	1	1	1	1
Agriculture	13	12	12	12	12	12	12	12	12	12	12
Sum	10613	8133	4376	3182	2572	2383	2224	2073	1993	1967	1939

Table 4.2: Baseline emissions of SO_2 by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*		*2020*		*2030*	
	[kt]	[kt]	[kt]	*Change*	[kt]	*Change*	[kt]	*Change*
Austria	32	27	20	*-26%*	19	*-31%*	16	*-40%*
Belgium	168	137	102	*-26%*	79	*-43%*	80	*-41%*
Bulgaria	940	901	569	*-37%*	115	*-87%*	91	*-90%*
Cyprus	48	39	24	*-39%*	5	*-88%*	5	*-88%*
Czech Rep.	277	199	168	*-16%*	93	*-53%*	81	*-59%*
Denmark	27	18	11	*-37%*	11	*-39%*	11	*-39%*
Estonia	85	77	14	*-82%*	15	*-81%*	14	*-82%*
Finland	77	72	48	*-33%*	34	*-53%*	34	*-53%*
France	635	469	297	*-37%*	191	*-59%*	173	*-63%*
Germany	619	512	365	*-29%*	315	*-38%*	283	*-45%*
Greece	551	541	291	*-46%*	117	*-78%*	83	*-85%*
Hungary	487	128	79	*-39%*	61	*-52%*	58	*-55%*
Ireland	136	78	34	*-56%*	30	*-62%*	23	*-71%*
Italy	756	381	226	*-41%*	213	*-44%*	167	*-56%*
Latvia	10	5	6	*20%*	5	*-4%*	4	*-21%*
Lithuania	53	46	15	*-67%*	15	*-68%*	15	*-68%*
Luxembourg	2	2	1	*-41%*	1	*-35%*	1	*-39%*
Malta	24	13	11	*-10%*	3	*-78%*	1	*-89%*
Netherlands	75	66	45	*-32%*	45	*-31%*	48	*-27%*
Poland	1518	1263	744	*-41%*	427	*-66%*	387	*-69%*
Portugal	292	224	81	*-64%*	60	*-73%*	56	*-75%*
Romania	777	822	388	*-53%*	140	*-83%*	127	*-85%*
Slovakia	121	90	41	*-55%*	39	*-56%*	38	*-58%*
Slovenia	101	40	14	*-65%*	16	*-61%*	10	*-75%*
Spain	1547	1259	368	*-71%*	277	*-78%*	248	*-80%*
Sweden	44	35	30	*-16%*	26	*-25%*	26	*-27%*
UK	1211	689	384	*-44%*	222	*-68%*	145	*-79%*
EU-27	10613	8133	4376	*-46%*	2572	*-68%*	2224	*-73%*

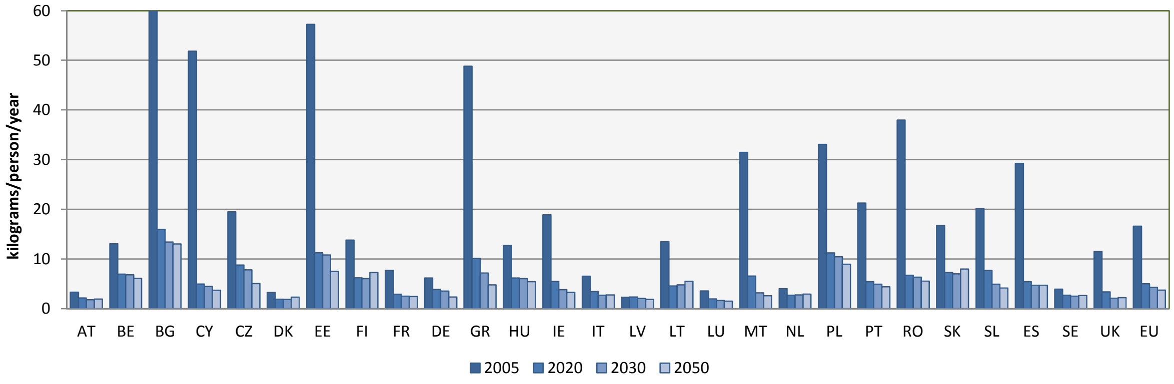

Figure 4.6: Per-capita emissions of SO_2 (kg/person/year). The scale is cut at a value of 60 kg, the actual value of Bulgaria in 2005 is 116 kg/person/year.

4.3 Nitrogen oxides (NO_x) emissions

In 2005, mobile sources were the largest source of NO_x emissions in the EU-27. Road transport contributed 44% to total emissions, and non-road mobile machinery 15%. 22% of NO_x originated in the power sector, 13% in industry, and 6% in households.

NO_x emissions may drop by more than 65%

These emissions and the sector contributions will change significantly in the future as a consequence of recent EU legislation. Overall, NO_x emissions are expected to decline by more than 65% until 2030. This decline will happen gradually as a consequence of the staged introduction of more stringent emission controls to new vehicles and plants; in 2020, NO_x emissions should already be 50% below the 2005 levels.

Largest reductions should occur in the transport sector

Assuming that EURO 6 would deliver the envisaged reduction in NO_x emissions from light duty diesel vehicles (i.e., real life emissions will stay below 150% of the test cycle type approval value), NO_x emissions from road vehicles should drop by 65% in 2020, and by 90% in the long run.

Emissions from power generation are expected to decrease by 60-70%. For the industrial and domestic sectors, smaller changes are anticipated. However, since road transport constitutes currently the major source of total emissions in the EU-27, the overall decline in NO_x emissions will strongly depend on the implementation success of new regulation for mobile sources (**Figure 4.8**).

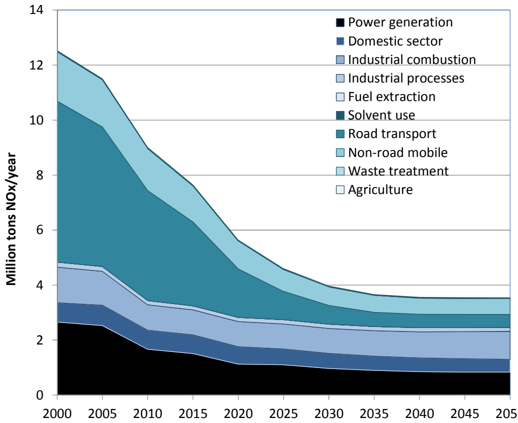

Figure 4.7: NO_x emissions of the EU-27 by SNAP sector

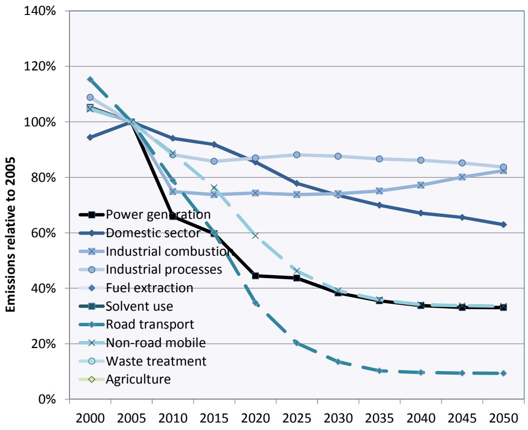

Figure 4.8: Sectoral trends in baseline emissions of NO_x in the EU-27

Table 4.3: NO_x emissions by SNAP sector, EU-27 (kilotons)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Power generation	2658	2526	1664	1508	1124	1103	968	897	853	836	835
Domestic sector	699	741	697	680	634	577	545	518	497	486	466
Industrial combust.	1291	1231	921	908	915	908	912	924	950	986	1014
Industrial processes	190	175	154	150	152	154	153	152	151	149	146
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0
Road transport	5852	5074	4003	3049	1764	1029	684	519	489	478	473
Non-road mobile	1795	1717	1522	1309	1013	793	672	615	585	579	576
Waste treatment	11	10	9	7	6	6	6	6	6	6	6
Agriculture	30	27	27	27	27	27	27	27	27	27	27
Sum	12527	11501	8998	7639	5635	4598	3966	3659	3558	3547	3544

The level of the real-life EURO 6 emission factor for light duty diesel vehicles and its timing are varied in sensitivity analyses. A full compliance with the type approval value could reduce emissions in the EU-27 by 50 kt and 85 kt in 2020 and 2030, respectively. Full compliance from 2018 onwards might cause 300 kt higher emissions in 2020. If however, real-world emissions of EURO 6 vehicles would follow the reduction rate in type approval values relative to real-life EURO 5 emissions, NO_x emissions might be by 270 kt and 470 kt above the baseline in 2020 and 2030, respectively, and total NO_x emissions would increase by 5% and 13%, respectively.

In contrast to other pollutants, national trends differ less for NO_x emissions than for other pollutants. Largest reductions are expected for countries in which transport has a comparably high share in total emissions, where NO_x would drop by up to 82% in 2030. Smallest declines range between 50% and 60% (Table 4.4).

There are large differences in per-capita emissions across countries, owing to different transport habits and, inter alia, the sales of fuels to international customers (**Figure 4.9**).

Table 4.4: Baseline emissions of NO_x by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*		*2020*		*2030*	
	[kt]	[kt]	[kt]	*Change*	[kt]	*Change*	[kt]	*Change*
Austria	182	201	166	*-17%*	96	*-52%*	64	*-68%*
Belgium	340	303	241	*-20%*	167	*-45%*	143	*-53%*
Bulgaria	168	181	105	*-42%*	74	*-59%*	59	*-68%*
Cyprus	22	21	19	*-8%*	13	*-38%*	9	*-57%*
Czech Rep.	302	295	220	*-25%*	158	*-47%*	110	*-63%*
Denmark	218	186	126	*-32%*	84	*-55%*	61	*-67%*
Estonia	38	39	29	*-26%*	22	*-42%*	16	*-58%*
Finland	223	197	162	*-18%*	116	*-41%*	89	*-55%*
France	1583	1383	1015	*-27%*	597	*-57%*	400	*-71%*
Germany	1748	1453	1195	*-18%*	708	*-51%*	487	*-66%*
Greece	329	321	281	*-12%*	255	*-21%*	187	*-42%*
Hungary	177	166	141	*-15%*	86	*-49%*	59	*-65%*
Ireland	142	137	94	*-31%*	76	*-45%*	45	*-67%*
Italy	1465	1347	1083	*-20%*	676	*-50%*	491	*-64%*
Latvia	37	36	35	*-4%*	27	*-26%*	16	*-57%*
Lithuania	55	60	48	*-20%*	31	*-48%*	22	*-64%*
Luxembourg	39	49	40	*-17%*	19	*-62%*	9	*-82%*
Malta	9	11	8	*-23%*	4	*-62%*	2	*-79%*
Netherlands	402	371	276	*-26%*	180	*-52%*	130	*-65%*
Poland	825	778	713	*-8%*	453	*-42%*	337	*-57%*
Portugal	296	262	191	*-27%*	128	*-51%*	75	*-71%*
Romania	283	307	250	*-18%*	170	*-45%*	126	*-59%*
Slovakia	101	98	81	*-17%*	58	*-40%*	46	*-53%*
Slovenia	55	55	47	*-14%*	27	*-50%*	14	*-75%*
Spain	1492	1530	1080	*-29%*	680	*-56%*	451	*-71%*
Sweden	258	210	157	*-25%*	92	*-56%*	70	*-67%*
UK	1740	1508	1193	*-21%*	640	*-58%*	448	*-70%*
EU-27	12527	11501	8998	*-22%*	5635	*-51%*	3966	*-66%*

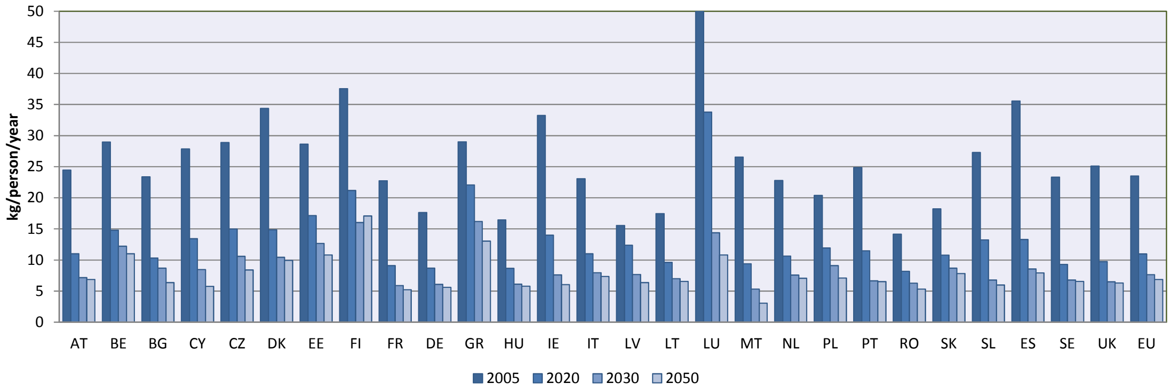

Figure 4.9: Per-capita emissions of NO_x (kg/person/year). The scale is cut at a value of 50 kg, the actual value for Luxembourg in 2005 is 105 kg/person/year.

4.4 Fine particulate matter (PM2.5) emissions

In 2005, small sources in the domestic and service sectors contributed about 30% of total PM2.5 emissions in the EU-27, followed by mobile sources (road transport 15%, non-road mobile machinery 9%), industry (23%) and the power sector (9%).

Legislation directed at other pollutants will decrease PM2.5 emissions by about 40%

Current legislation that is often directed towards other pollutants will also have an impact on PM2.5 emissions. Overall, baseline PM2.5 emissions are expected to decrease by 40% between 2005 and 2030, with a 30% cut in 2020 (Figure 4.10). Stricter standards for diesel vehicles will contribute most to the decline, while no major changes in the emissions from biomass combustion are expected. Non-combustion emissions (e.g., road abrasion, brake and tyre wear, etc.) are likely to increase.

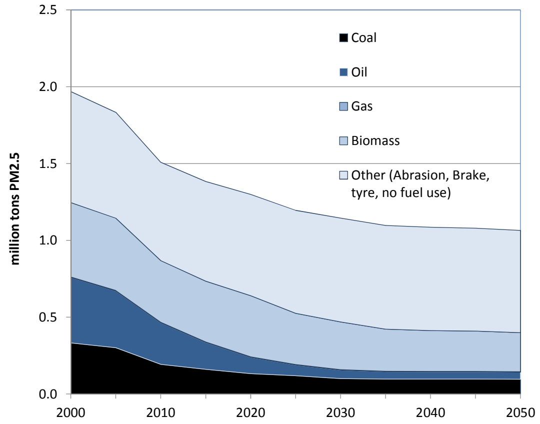

Figure 4.10: PM2.5 emissions of the EU-27 by fuel

As a side-effect of regulations for PM10 emissions, PM2.5 from mobile sources is expected to decrease by about 75% in 2030.

The power sector would cut its emissions to a similar extent, partly due to the switch away from coal. Even without dedicated PM regulations, emissions from the domestic sector would drop by 40-50% due to phase-out of coal. In contrast, industrial emissions are expected to decline by 20% only (Figure 4.11). The domestic sector will remain the largest source, but industrial emissions will gain higher relative shares as other sectors implement more ambitious control measures (Figure 4.12, Table 4.5).

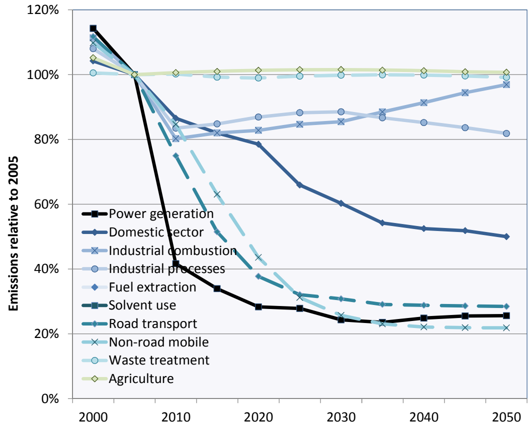

Figure 4.11: Sectoral trends in baseline emissions of PM2.5 in the EU-27

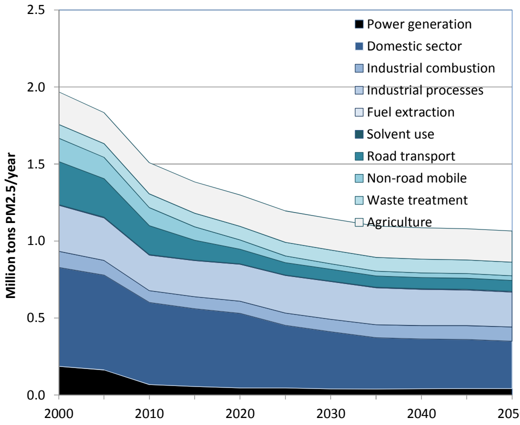

Figure 4.12: PM2.5 emissions of the EU-27 by SNAP sector

Table 4.5: PM2.5 emissions by SNAP sector, EU-27 (kilotons)

	2000	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Power generation	186	163	68	55	46	45	39	38	40	41	42
Domestic sector	642	616	533	505	484	406	371	334	323	319	308
Industrial combust.	106	95	76	78	79	80	81	84	87	90	92
Industrial processes	299	277	231	235	241	244	245	240	236	231	227
Fuel extraction	4	5	4	4	3	3	3	4	4	5	5
Solvent use	0	0	0	0	0	0	0	0	0	0	0
Road transport	279	250	187	129	94	80	77	73	72	71	71
Non-road mobile	152	138	117	87	60	43	36	32	31	30	30
Waste treatment	90	89	89	88	88	89	89	89	89	89	88
Agriculture	211	201	202	203	204	204	204	204	203	203	202
Sum	1969	1833	1508	1383	1299	1195	1145	1097	1085	1080	1065

PM2.5 emissions in Member States decline between 30 and 70%

Depending on the structure of the emission sources, PM2.5 will decline to different extents in the Member States (Table 4.6). While in 2030 cuts are larger than 30% everywhere, they reach up to 70% in countries where diesel makes large contributions to total national emissions (e.g., Malta, Cyprus, Luxembourg). Also, outliers in per-capita emissions (e.g., Estonia, Portugal) would see largest improvements (Figure 4.13).

Table 4.6: Baseline emissions of PM2.5 by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*		*2020*		*2030*	
	[kt]	[kt]	[kt]	*Change*	[kt]	*Change*	[kt]	*Change*
Austria	22	23	18	*-18%*	14	*-36%*	13	*-44%*
Belgium	33	28	24	*-16%*	21	*-25%*	20	*-29%*
Bulgaria	47	53	38	*-28%*	35	*-34%*	30	*-44%*
Cyprus	3	3	2	*-20%*	1	*-50%*	1	*-63%*
Czech Rep.	42	46	43	*-6%*	37	*-19%*	33	*-28%*
Denmark	30	35	31	*-12%*	23	*-33%*	20	*-44%*
Estonia	21	20	10	*-50%*	8	*-59%*	7	*-66%*
Finland	35	32	25	*-23%*	22	*-31%*	19	*-40%*
France	399	344	282	*-18%*	240	*-30%*	212	*-38%*
Germany	157	141	123	*-13%*	105	*-26%*	99	*-30%*
Greece	58	57	46	*-19%*	36	*-37%*	30	*-46%*
Hungary	46	28	26	*-8%*	24	*-16%*	20	*-30%*
Ireland	15	14	11	*-22%*	9	*-37%*	7	*-48%*
Italy	163	143	124	*-13%*	102	*-29%*	94	*-34%*
Latvia	17	19	17	*-6%*	15	*-20%*	12	*-38%*
Lithuania	14	14	12	*-13%*	11	*-20%*	9	*-32%*
Luxembourg	3	3	3	*-17%*	2	*-42%*	2	*-48%*
Malta	1	1	1	*-17%*	0	*-55%*	0	*-65%*
Netherlands	27	27	22	*-19%*	17	*-37%*	17	*-39%*
Poland	231	233	205	*-12%*	192	*-18%*	154	*-34%*
Portugal	105	104	73	*-30%*	65	*-38%*	59	*-43%*
Romania	143	155	115	*-26%*	111	*-28%*	94	*-39%*
Slovakia	25	21	11	*-50%*	11	*-46%*	11	*-48%*
Slovenia	9	9	6	*-31%*	6	*-31%*	5	*-52%*
Spain	167	152	131	*-14%*	105	*-31%*	97	*-36%*
Sweden	35	32	26	*-18%*	21	*-33%*	21	*-32%*
UK	120	97	83	*-14%*	64	*-34%*	59	*-39%*
EU-27	1969	1833	1508	*-18%*	1299	*-29%*	1145	*-38%*

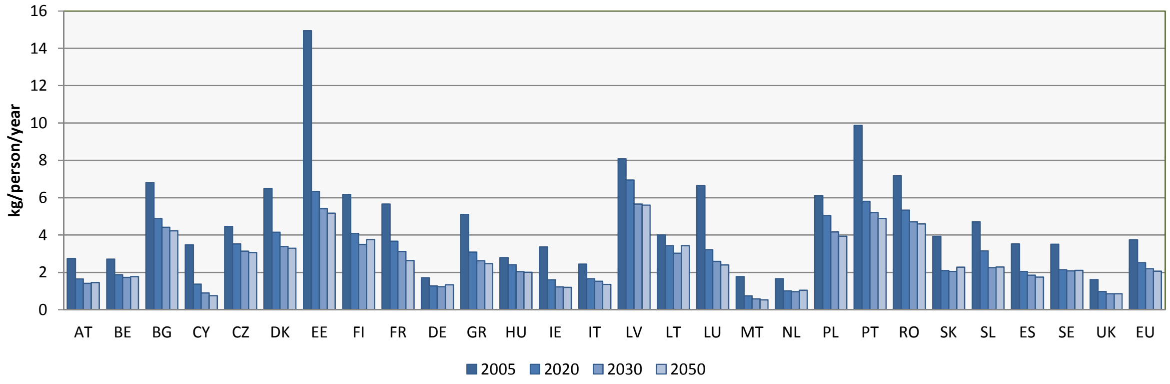

Figure 4.13: Per-capita emissions of PM2.5 (kg/person/year)

4.5 Ammonia (NH_3) emissions

Agriculture is the dominating sources of NH_3 emissions in Europe. In 2005, more than 90% of the NH_3 emissions in the EU originated from this sector. 44% of agricultural emissions were caused by cattle farming, 20% originated from pigs, and 20% from the use and production of fertilizer.

In contrast to the other air pollutants, only minor changes are expected for NH_3 emissions

Although NH_3 emissions are subject to targeted controls in the agricultural sector, and will be affected as a side impact of emission legislation for road transport (i.e., by improved catalytic converters), only slight changes in total emissions in the EU-27 are expected in the long run (Figure 4.14). While emissions declined between 2000 and 2010, they are expected to return to the 2005 level by 2030.

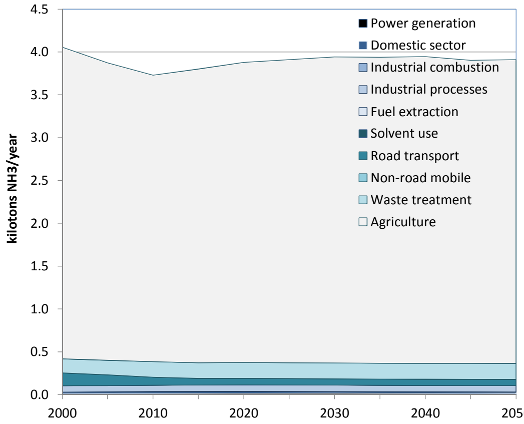

Figure 4.14: NH_3 emissions of the EU-27 by SNAP sector

Emissions from cattle farming remain constant

Although some legislation on NH_3 emissions has been established for the agricultural sector in the EU, this will not lead to substantial changes in total agricultural emissions. Emissions from fertilizer use are expected to increase by about 10%; emissions from pigs and chicken would recover to the 2005 levels, while only minor changes are anticipated for the largest source category, i.e., for cattle farming.

In this context, the 50% decline in emissions from road transport will not have large impacts for national total emissions, as they contributed only three percent in 2005 (Figure 4.15).

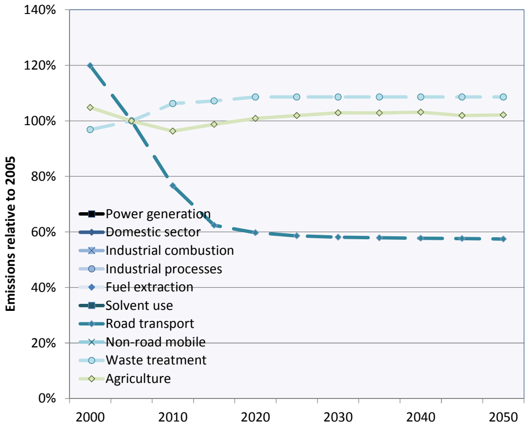

Figure 4.15: Sectoral trends in baseline emissions of NH_3 in the EU-27

Table 4.7: NH_3 emissions by SNAP sector, EU-27 (kilotons)

	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Power generation	9	10	13	14	17	18	16	14	13	12	12
Domestic sector	18	19	19	19	19	18	17	16	16	16	15
Industrial combust.	3	3	4	4	5	4	4	4	5	5	6
Industrial processes	74	74	73	75	74	74	74	74	74	74	74
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0
Road transport	149	124	95	78	74	73	72	72	72	72	71
Non-road mobile	1	1	1	1	1	1	1	1	1	1	1
Waste treatment	164	170	180	182	184	184	184	184	184	184	184
Agriculture	3639	3472	3344	3429	3504	3538	3573	3572	3581	3539	3546
Sum	4057	3873	3729	3801	3879	3911	3943	3938	3946	3903	3910

In some Member States, implementation of advanced emission control legislation will lead to substantially lower NH_3 emissions

There are large differences in the projected evolution of NH_3 emissions across Member States; these are explained, in addition to the on-going shifts in production, by differences in the stringency of national emission control legislation. For instance, in Denmark where strict regulations are in place, emissions are expected to decline by 23%. For comparison, increases of more than 20% are anticipated for Poland, Latvia and Lithuania (Table 4.8).

On a per-capita basis, there are large disparities across Member States

There are also large differences in the per-capita emissions across the EU due to different structures of the agricultural sector. For instance, per-capita emissions of Ireland were 3.5 times above the EU average in 2005 (Figure 4.16).

Table 4.8: Baseline emissions of NH_3 by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*		*2020*		*2030*	
	[kt]	[kt]	[kt]	*Change*	[kt]	*Change*	[kt]	*Change*
Austria	62	61	63	*3%*	67	*10%*	70	*15%*
Belgium	85	74	75	*1%*	79	*6%*	82	*10%*
Bulgaria	69	64	68	*6%*	66	*3%*	67	*5%*
Cyprus	6	6	6	*-9%*	6	*-11%*	6	*-7%*
Czech Rep.	87	81	72	*-11%*	75	*-7%*	76	*-6%*
Denmark	94	74	62	*-16%*	57	*-22%*	58	*-21%*
Estonia	10	12	13	*12%*	13	*8%*	14	*19%*
Finland	37	34	33	*-4%*	33	*-4%*	33	*-3%*
France	713	657	625	*-5%*	641	*-2%*	653	*-1%*
Germany	596	590	585	*-1%*	636	*8%*	652	*11%*
Greece	57	57	56	*-2%*	57	*1%*	57	*1%*
Hungary	77	77	68	*-12%*	80	*4%*	74	*-4%*
Ireland	127	115	115	*0%*	120	*4%*	116	*1%*
Italy	431	409	356	*-13%*	389	*-5%*	396	*-3%*
Latvia	13	13	15	*17%*	16	*22%*	18	*37%*
Lithuania	38	44	49	*10%*	51	*15%*	52	*17%*
Luxembourg	7	6	6	*3%*	7	*9%*	7	*9%*
Malta	2	3	2	*-3%*	3	*6%*	3	*4%*
Netherlands	151	134	134	*0%*	129	*-4%*	130	*-3%*
Poland	311	343	354	*3%*	338	*-1%*	363	*6%*
Portugal	73	73	68	*-6%*	71	*-2%*	74	*2%*
Romania	170	161	151	*-6%*	142	*-11%*	127	*-21%*
Slovakia	30	28	39	*39%*	43	*53%*	44	*56%*
Slovenia	20	19	19	*0%*	20	*4%*	20	*3%*
Spain	383	365	335	*-8%*	375	*3%*	380	*4%*
Sweden	57	54	50	*-7%*	52	*-4%*	53	*-2%*
UK	350	320	310	*-3%*	314	*-2%*	319	*0%*
EU-27	4057	3873	3729	*-4%*	3879	*0%*	3943	*2%*

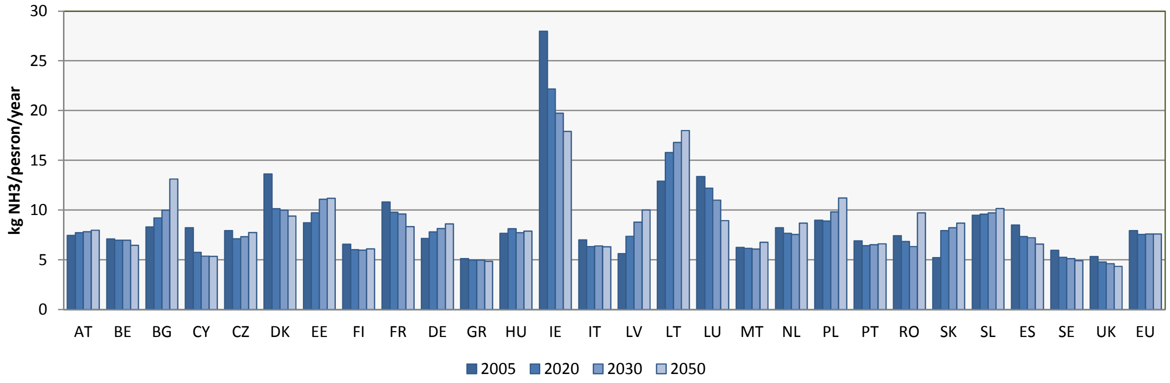

Figure 4.16: Per-capita emissions of NH_3 (kg/person/year)

4.6 Volatile organic compounds (VOC) emissions

In 2005, solvent use was responsible for 37% of total VOC emissions. Road vehicles and non-road mobile sources contributed 23% and 9%, respectively, and industrial sources 16%.

VOC emissions will decline by 40%

EU legislation will cut baseline VOC emission by about 40% up to 2030, with the largest decline before 2020 (Figure 4.17).

Emission laws for vehicles will cut VOC emissions from this sector in the long run by more than 80% and thereby deliver 50% of the total emission reduction in the EU-27. In contrast to NO_x, no major implementation failure of current emission legislation for mobile sources is observed for VOC.

Legislation for solvents should reduce emissions from this activity by about 20%, while no significant changes are expected for emissions from industrial sources (Figure 4.18). As a consequence of the tight regulations on emissions from mobile sources, about 50% of the remaining emissions will come from solvent use (Table 4.9).

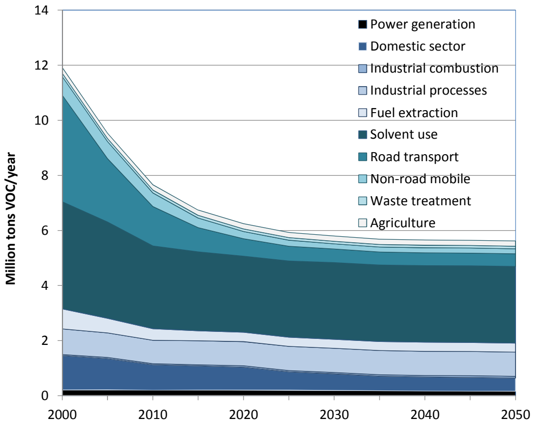

Figure 4.17: VOC emissions of the EU-27 by SNAP sector

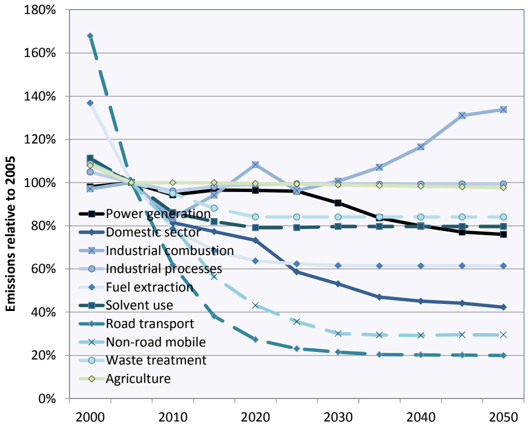

Figure 4.18: Sectoral trends in baseline emissions of VOC in the EU-27

Table 4.9: VOC emissions by SNAP sector, EU-27 (kilotons)

	2000	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*	*2040*	*2045*	*2050*
Power generation	207	211	199	204	204	203	191	177	169	163	161
Domestic sector	1244	1134	925	876	831	665	602	532	511	500	480
Industrial combust.	45	47	39	44	51	45	47	50	54	61	63
Industrial processes	928	885	850	868	877	880	879	878	878	879	879
Fuel extraction	728	532	418	364	339	332	327	327	327	327	327
Solvent use	3892	3496	3010	2865	2767	2768	2785	2785	2785	2785	2785
Road transport	3875	2308	1428	880	630	533	497	470	466	464	459
Non-road mobile	676	619	494	349	267	221	186	182	181	183	183
Waste treatment	121	111	105	98	93	93	93	93	93	93	93
Agriculture	207	192	192	192	191	191	190	189	189	188	187
Sum	11923	9535	7661	6741	6250	5930	5797	5683	5654	5643	5617

On a per-capita basis, VOC emissions will converge in Europe

By 2030, countries with highest per-capita emissions in 2005 will enjoy the largest emission reductions (up to 60%). In other countries where per-capita emissions are lower, VOC will decline by only 20% (Table 4.10). This will lead to convergence of per-capita emissions within the EU-27 towards a level that is below the lowest country level in 2005 (Figure 4.19).

Table 4.10: Baseline emissions of VOC by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*		*2020*		*2030*	
	[kt]	[kt]	[kt]	*Change*	[kt]	*Change*	[kt]	*Change*
Austria	183	171	139	*-19%*	113	*-34%*	108	*-37%*
Belgium	229	184	142	*-23%*	130	*-29%*	130	*-29%*
Bulgaria	147	138	115	*-16%*	84	*-39%*	79	*-43%*
Cyprus	12	9	8	*-21%*	5	*-47%*	5	*-52%*
Czech Rep.	273	271	237	*-12%*	173	*-36%*	157	*-42%*
Denmark	152	135	103	*-24%*	77	*-43%*	68	*-50%*
Estonia	45	37	29	*-21%*	22	*-41%*	18	*-50%*
Finland	182	153	119	*-22%*	96	*-37%*	85	*-44%*
France	1835	1322	915	*-31%*	768	*-42%*	685	*-48%*
Germany	1609	1333	1132	*-15%*	958	*-28%*	901	*-32%*
Greece	348	300	241	*-20%*	165	*-45%*	138	*-54%*
Hungary	175	156	134	*-14%*	110	*-30%*	96	*-39%*
Ireland	89	70	56	*-20%*	53	*-25%*	50	*-29%*
Italy	1705	1267	981	*-23%*	734	*-42%*	699	*-45%*
Latvia	73	69	63	*-10%*	48	*-31%*	40	*-43%*
Lithuania	78	75	65	*-13%*	55	*-26%*	50	*-34%*
Luxembourg	21	15	10	*-33%*	6	*-58%*	6	*-61%*
Malta	5	4	3	*-18%*	3	*-27%*	3	*-25%*
Netherlands	296	228	175	*-23%*	161	*-29%*	161	*-29%*
Poland	746	629	564	*-10%*	471	*-25%*	405	*-36%*
Portugal	289	236	193	*-18%*	169	*-28%*	160	*-32%*
Romania	436	455	396	*-13%*	307	*-33%*	259	*-43%*
Slovakia	73	68	65	*-6%*	57	*-16%*	55	*-20%*
Slovenia	60	44	34	*-24%*	32	*-27%*	25	*-43%*
Spain	1092	943	749	*-21%*	627	*-33%*	615	*-35%*
Sweden	269	205	156	*-24%*	119	*-42%*	115	*-44%*
UK	1502	1017	838	*-18%*	706	*-31%*	686	*-32%*
EU-27	11923	9535	7661	*-20%*	6250	*-34%*	5797	*-39%*

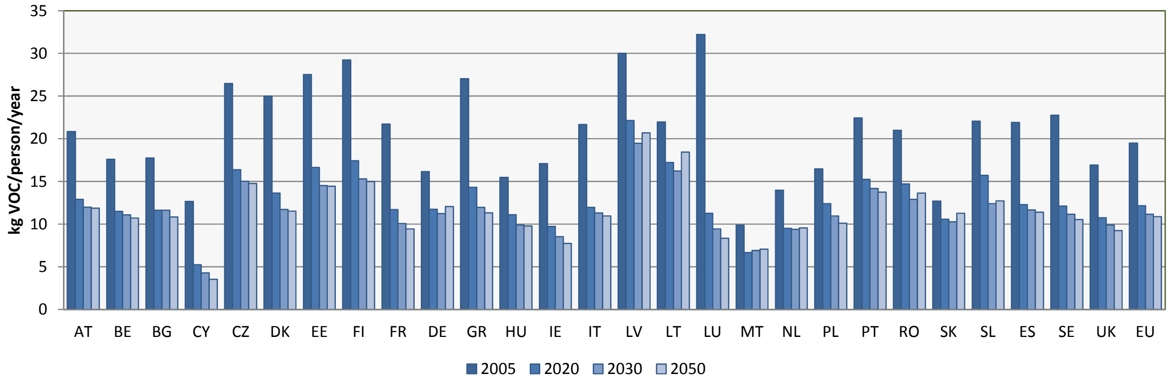

Figure 4.19: Per-capita emissions of VOC (kg/person/year)

5 The scope for further emission reductions

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

The 'Maximum Technically Feasible Reduction' (MTFR) scenario explores to what extent emissions of the various substances could be further reduced beyond what is required by current legislation, through full application of the available technical measures, without changes in the energy structures and without behavioral changes of consumers. However, the MTFR scenario does not assume premature scrapping of existing capital stock; new and cleaner devices are only allowed to enter the market when old equipment is retiring.

5.1 The mitigation potential for SO_2

If all currently available emission control measures were fully applied (with the constraints discussed above), by 2030 SO_2 emissions in the EU-27 could be 35% lower than what is expected for the implementation of current legislation (Figure 5.1). This would enable an 80% reduction of total SO_2 emissions relative to 2005. The potential increases over time slightly.

On top of current legislation, technical measures are available that could reduce SO_2 emissions by another 35%

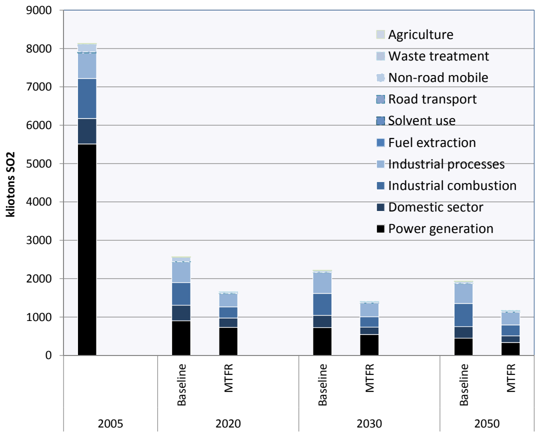

Figure 5.1: SO_2 emissions in, for the current legislation baseline and the maximum technically feasible reduction (MTFR) cases, EU-27

Overall, the largest mitigation potentials are estimated for emissions from heavy industry (Figure 5.2 to Figure 5.4).

There are large variations in the potentials for further SO_2 reductions across Member States, depending on the structures of energy systems and the stringency of existing emission legislation. For instance, for 2030 additional technical measures could reduce SO_2 emissions in Malta by more than 80%, while for Sweden only a negligible additional potential emerges.

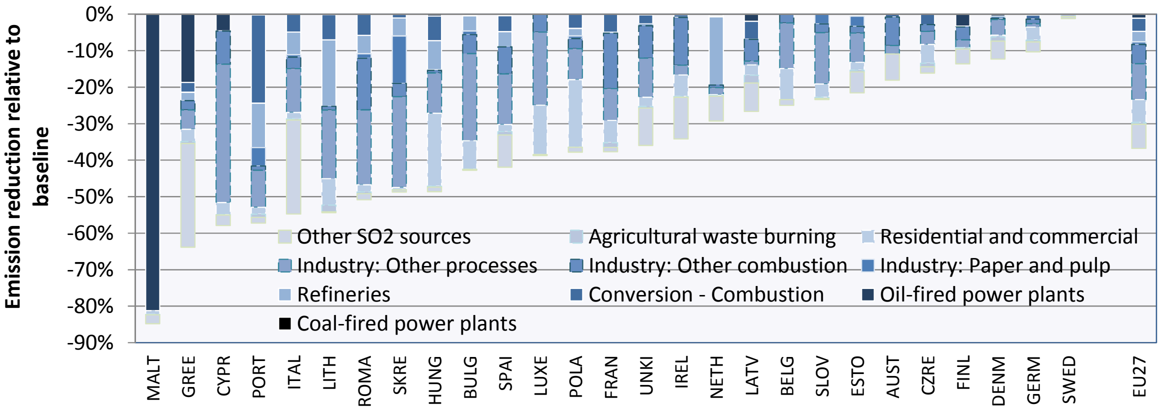

Figure 5.2: Mitigation potentials for SO_2 emissions in 2020 on top of current legislation

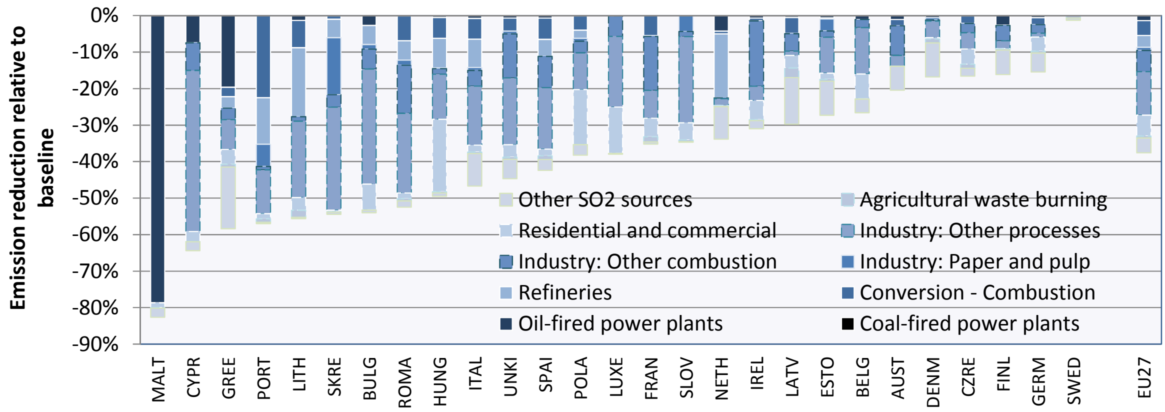

Figure 5.3: Mitigation potentials for SO_2 emissions in 2030 on top of current legislation

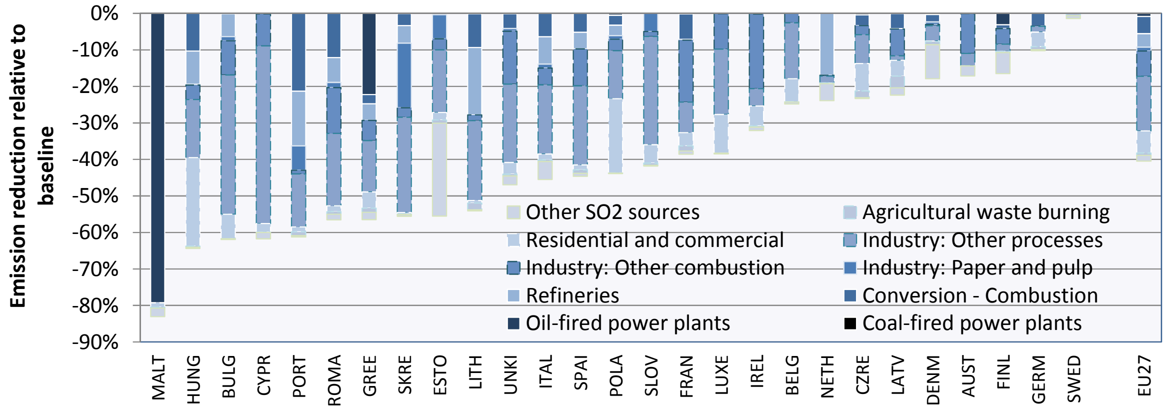

Figure 5.4: Mitigation potentials for SO_2 emissions in 2050 on top of current legislation

5.2 The mitigation potential for NO_x

For NO_x, there is scope for further reductions of combustion- and process-related emissions in some industrial sectors (e.g., glass production) as well as for transport sources. For 2020, the largest potential exists in the industrial sector and for power generation, and total NO_x emissions in the EU could be 15-20% lower than the baseline.

NO_x emissions could be further reduced below the baseline level by 15-20% in 2020

The turnover of capital stock and the associated possibility to apply advanced control measures to new sources increases this potential over time. By 2030, total NO_x emissions could be approximately one third lower than the baseline, essentially due further end-of-pipe measures in the transport sector (assuming tightened emission standards to be achieved through enhanced catalytic reduction devices – EURO 7).

However, under the assumptions for EURO 6, the additional mitigation potential from hypothetical EURO 7/VII standards after 2020 are rather small, i.e., -13% or -93 kt in 2030 and -24% or -113 kt in 2050 (Figure 5.5).

Advanced controls to all new sources could reduce NO_x by 80% in 2050 relative to 2005

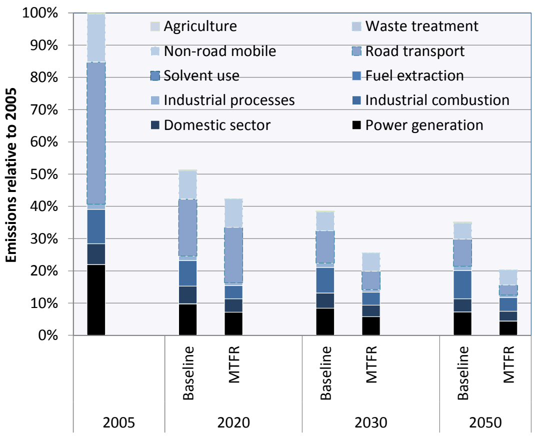

Figure 5.5: NO_x emissions for the current legislation baseline and the maximum technically feasible reduction (MTFR) cases, EU-27

The full turnover of the stationary and mobile sources in 2050 would allow NO_x emissions to be 40% below the baseline, or 80% below the 2005 level.

There are significant structural differences across countries that lead to a wide spread in the available potential for further reductions. In particular, the existing vintage structure combined with current derogations for stationary sources leads to inhomogeneous temporal trends across Member States (Figure 5.6). By 2030 the potential increases in the old Member States as new plants enter the field. By 2050, the scope for further measures ranges between 30 and 60% (Figure 5.8).

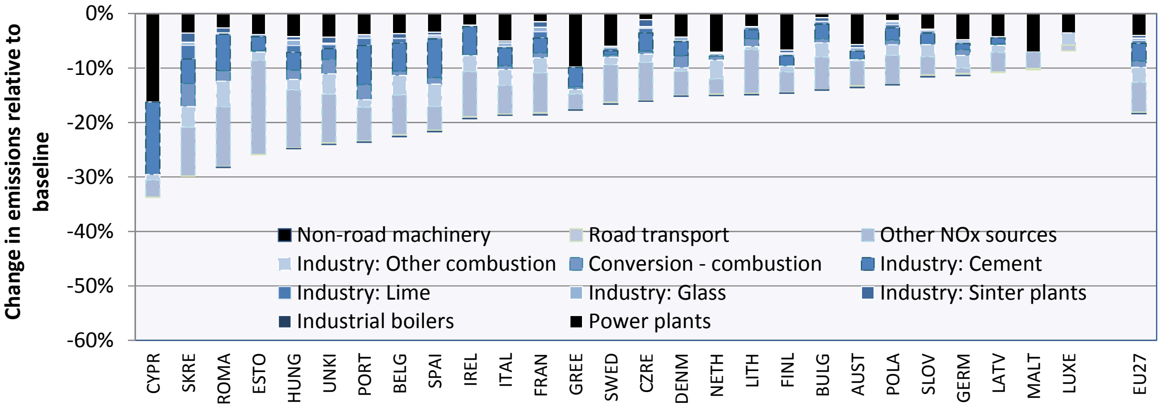

Figure 5.6: Mitigation potentials for NO_x emissions in 2020 on top of current legislation

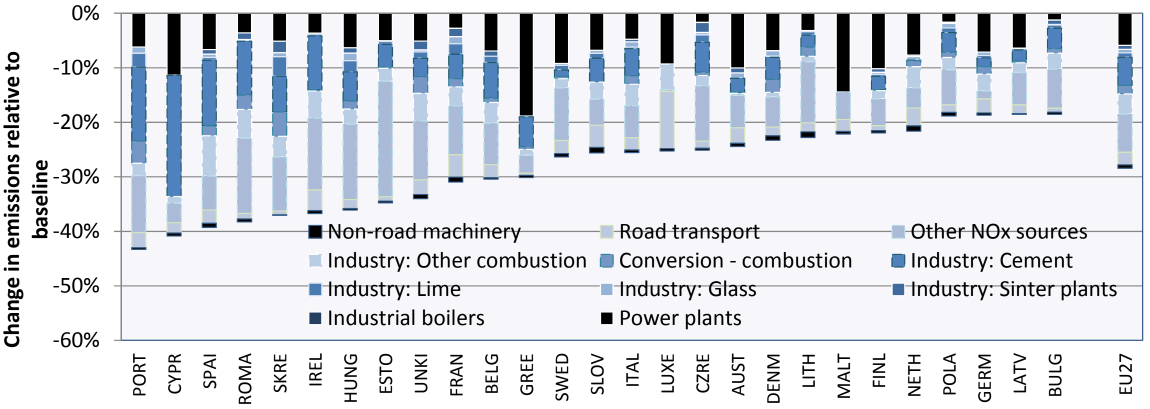

Figure 5.7: Mitigation potentials for NO_x emissions in 2030 on top of current legislation

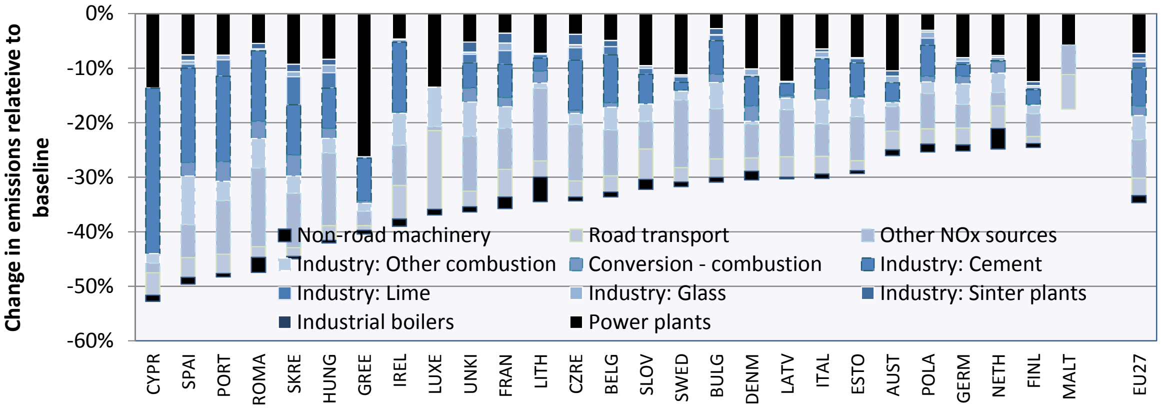

Figure 5.8: Mitigation potentials for NO_x emissions in 2050 on top of current legislation

5.3 The mitigation potential for PM2.5

Technologies that are currently on the market could cut PM2.5 emissions by 40% to 60% below the baseline level (Figure 5.9). Thereby, PM2.5 emissions could be up to 70% lower than in 2005. Largest additional reductions are offered in the residential sector through introduction of clean burning (pellet) stoves for biomass.

Primary emissions of PM2.5 could be further reduced by up to 40%

The potential differs greatly over the Member States, essentially due to the different relative contributions from small heating devices in the domestic sector to total PM2.5 emissions.

Introduction of clean stoves (pellets) could reduce PM2.5 emissions by more than 80% in the new Member States (Figure 5.10 to Figure 5.12).

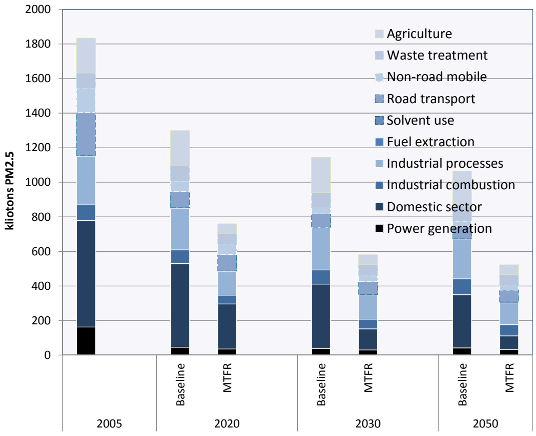

Figure 5.9: PM2.5 emissions in, for the current legislation baseline and the maximum technically feasible reduction (MTFR) cases, EU-27

However, countries where emissions from the residential sector are less prominent face less potential for further reductions.

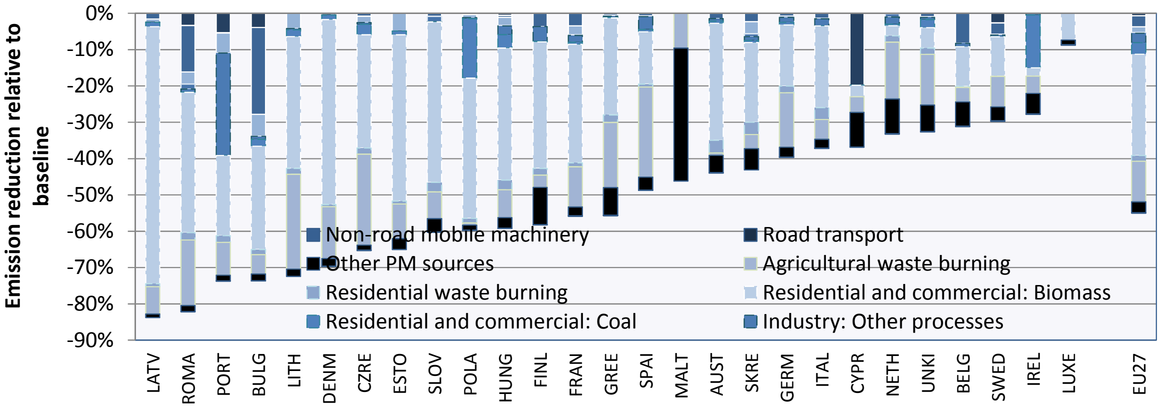

Figure 5.10 Mitigation potentials for PM2.5 emissions in 2020 on top of current legislation

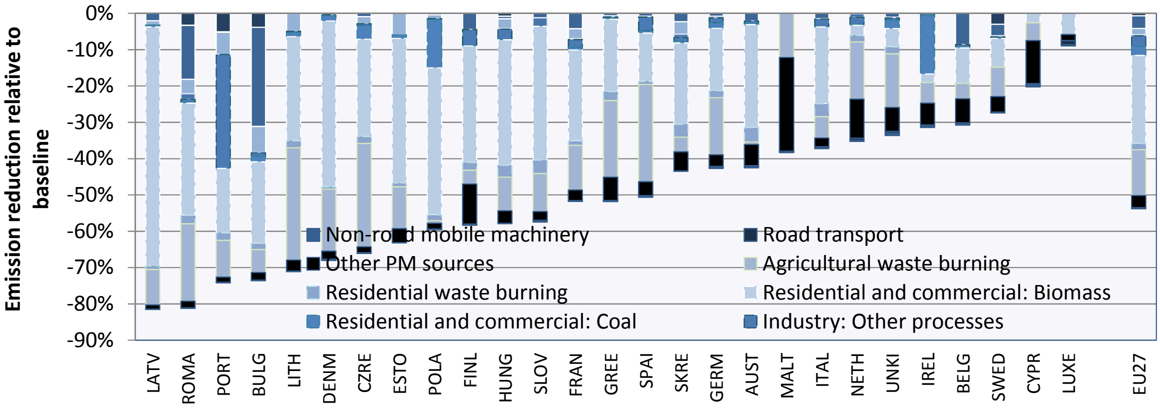

Figure 5.11: Mitigation potentials for PM2.5 emissions in 2030 on top of current legislation

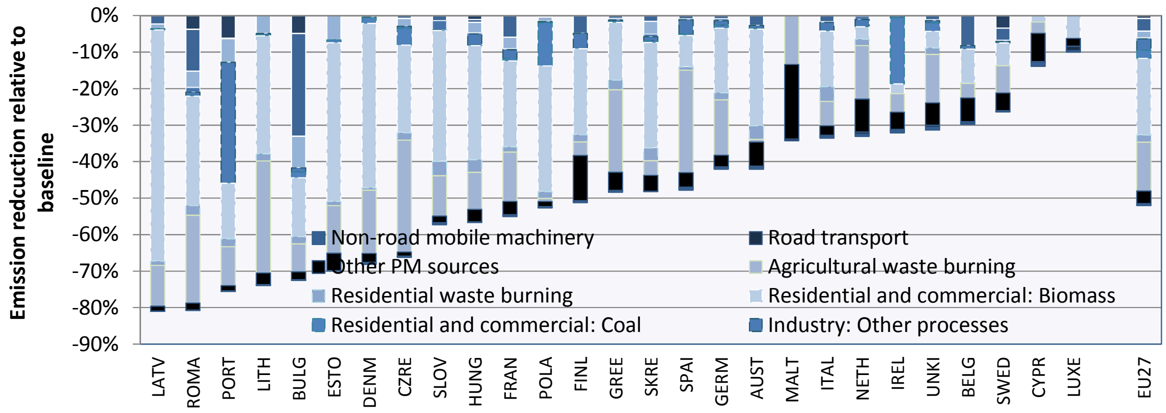

Figure 5.12: Mitigation potentials for PM2.5 emissions in 2050 on top of current legislation

5.4 The mitigation potential for NH_3

Compared to other pollutants, there is less scope for reductions of NH_3 emission in Europe. The measures that are considered in the GAINS model could cut total European emissions by about one third (Figure 5.13); variations across countries are caused by different stringencies of already existing legislation (Figure 5.14 to Figure 5.16).

Although there is less scope for reducing NH_3 emissions, available measures could cut emissions in the EU by about 30% beyond current legislation

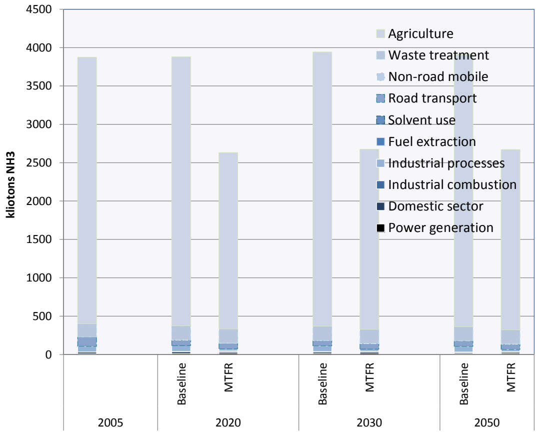

Figure 5.13: NH_3 emissions in, for the current legislation baseline and the maximum technically feasible reduction (MTFR) cases, EU-27

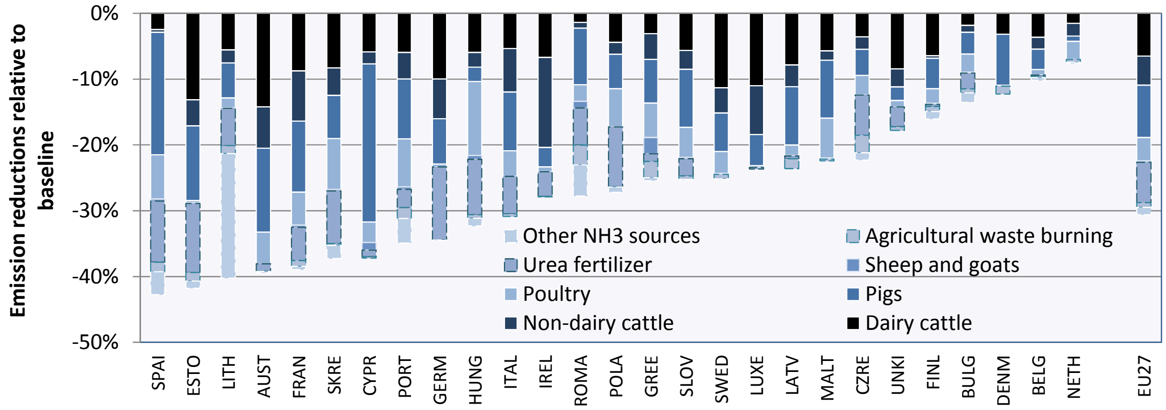

Figure 5.14: Mitigation potentials for NH_3 emissions in 2020 on top of current legislation

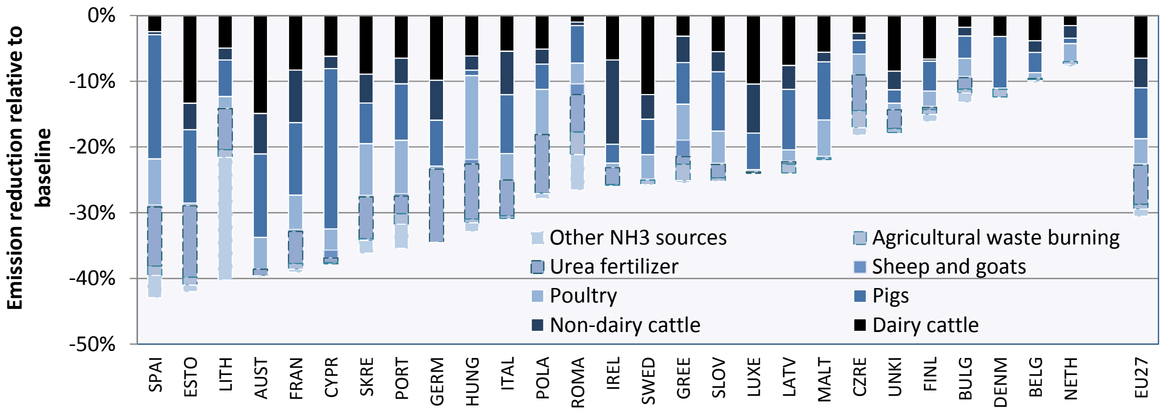

Figure 5.15: Mitigation potentials for NH_3 emissions in 2030 on top of current legislation

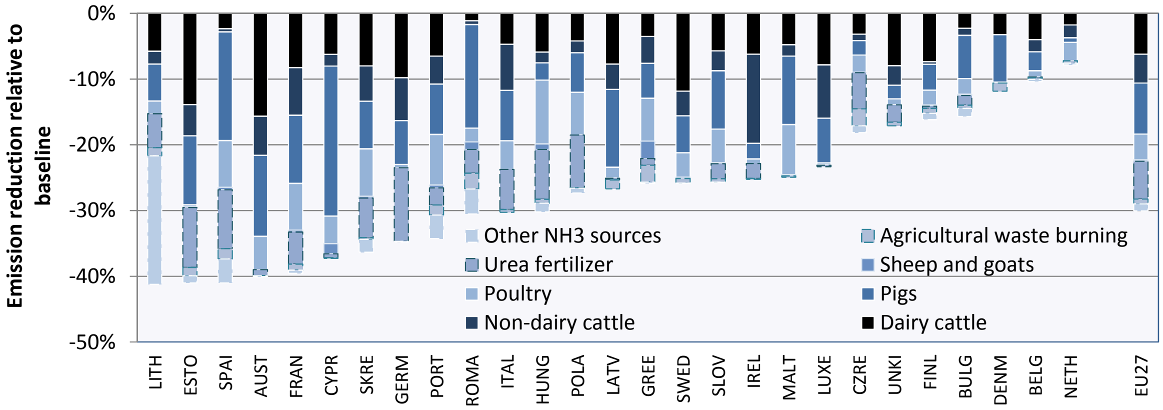

Figure 5.16: Mitigation potentials for NH_3 emissions in 2050 on top of current legislation

5.5 The mitigation potential for VOC

The GAINS model considers practical measures that could, if fully implemented, decrease VOC emissions in Europe by another 35% below the current legislation baseline projection (Figure 5.17).

VOC could be reduced by another 35%

About two thirds of the potential emerges from solvent use, and this potential is rather uniformly distributed across Member States (Figure 5.18 to Figure 5.20).

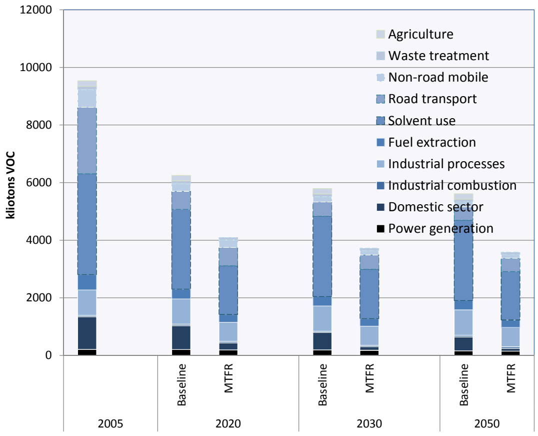

Figure 5.17: VOC emissions in the , for the current legislation baseline and the maximum technically feasible reduction (MTFR) cases, EU-27

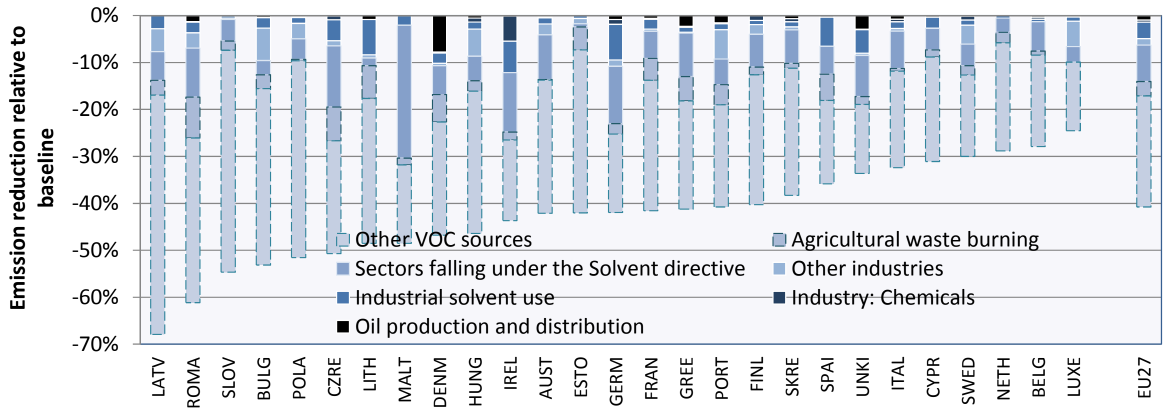

Figure 5.18: Mitigation potentials for VOC emissions in 2020 on top of current legislation

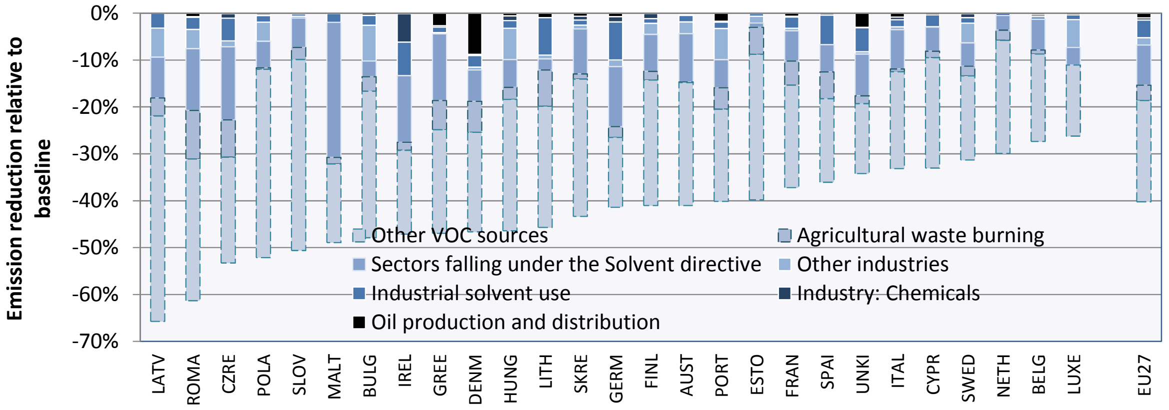

Figure 5.19: Mitigation potentials for VOC emissions in 2030 on top of current legislation

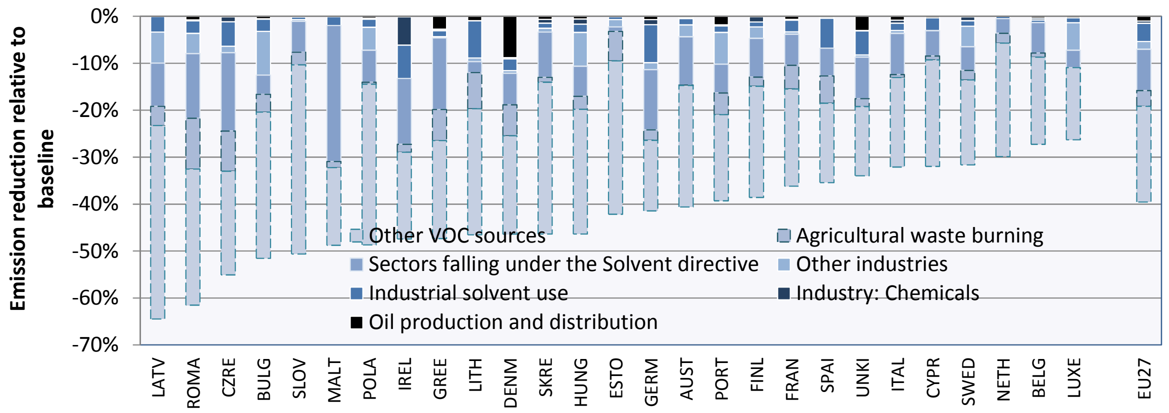

Figure 5.20: Mitigation potentials for VOC emissions in 205 on top of current legislation

6 A decarbonisation scenario

While the preceding section estimated the mitigation potential for air pollutant emission from full application of currently available end-of-pipe control measures, emissions could also be reduced through changes in activity levels that decrease the most pollutant activities.

An illustrative decarbonisation scenario of a 80% GHG reduction in the EU in 2050

As an illustrative example for the mitigation potential from such measures, this section presents the implications of a stringent decarbonisation strategy on the emissions of air pollutants in the EU-27. It employs the 'Global Action with Effective and Widely accepted Technology' scenario that has been developed with the PRIMES model for the communication of the European Commission on a 'A roadmap for moving to a competitive low carbon economy in 2050' (CEC, 2011a).

This particular scenario is used as an illustration of the potential implications of greenhouse gas mitigation strategies on the emissions of air pollutants and not foreseen to be used for quantitative policy analyses. Thus, results are only presented at the aggregated level for the EU-27. For the final TSAP policy analyses, it is planned to employ the scenario that has been presented by DG-CLIMA for the '25% domestic GHG reduction in 2020 and 40% in 2030, which is available at CEC, 2010a.

6.1 The 'Effective and widely accepted technology' scenario

The decarbonisation scenario, which is described in detail in CEC, 2011, aims at a reduction of GHG emissions in the EU-27 by around 80% in 2050. To reach this target, carbon values are applied to all (i.e., the ETS and non-ETS sectors) and all greenhouse gas emissions. Global climate action in line with the two degree target will have a decreasing effect on world energy prices, so that the scenario assumes significantly lower world energy prices than the reference scenario.

The decarbonisation scenario assumes a policy environment that enables all mayor low carbon technologies, such as energy efficiency and renewables, carbon capture and storage (CCS), nuclear and electrification of transport. This is reflected by the following additional but realistic assumptions compared to current policies:

- All renewable technologies are facilitated to a larger extent (e.g., by planning and infrastructures, expressed in higher renewable values). The extent of cost saving technological progress in solar technologies is assumed to be larger.
- Energy intensity improvements are brought about in the context of high ETS prices and demand side policies mirrored through high carbon values; in addition greater renewables penetration increases conversion efficiency and hence improves energy intensity.
- It is assumed that carbon capture and storage (CCS) is successfully demonstrated and is commercially available after 2020, benefiting from cost improvements driven by carbon prices; it also assumed that there is public acceptance for the technology
- It is assumed that current national nuclear policies are implemented as planned. Nuclear energy is assumed to be enabled by increased public acceptance and higher safety of nuclear waste operations. However, no new nuclear will be built in countries which continue to exclude this.
- Electrification of transport is enabled by research and development and other policies promoting progress in battery-driven vehicles. A decrease of battery costs (per kWh) by a factor of four in 30 years as well as lighter batteries, faster charging and higher power densities are assumed. An infrastructure enabling full electrification including smart grids is built up so that from 2030 a transition to electric cars can take place. Constraints to electrification only remain in certain parts of non-urban long-distance road travelling, especially for trucks and buses.

In this enabling context, equalisation of carbon prices across sectors works as key driver for a cost-effective decarbonisation including the selection of technologies and fostering of demand-side energy efficiency. Also additional renewables incentives are assumed, but no further specific energy efficiency policies are assumed beyond those driven by the pricing signal.

These modified constraints reduce energy consumption in the year 2050 by about 18% compared to the reference case (Figure 6.1). Demand for coal fuels decreases by 40% after 2030, and for oil by more than 50% in 2050 (due to the switch to non-fossil fuels in the transport sector).

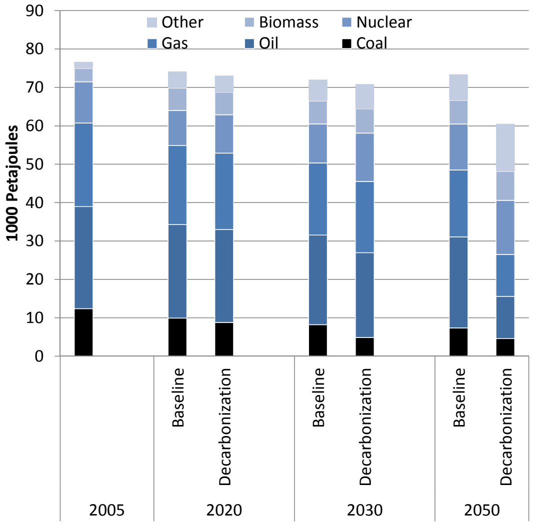

Figure 6.1: Fuel consumption of the baseline and decarbonisation scenarios, EU-27

6.2 Emissions

For the revision of the Thematic Strategy, the degree at which emissions of air pollutants would change as a mere side effect of a decarbonisation strategy is of high interest. For this purpose, an illustrative scenario has been developed that applies the current legislation on air pollution controls (Boxes 6 to 11) to the activity levels of the 'Effective Technology' decarbonisation scenario (Figure 6.1). The resulting trends in sectoral emissions are then compared against the TSAP-2012 baseline and MTFR cases.

It turns out that a decarbonisation strategy has significant impacts on SO_2 and NO_x emissions, while PM2.5, VOC and NH_3 are less affected (to Figure 6.6).

In the long run, a decarbonisation strategy would reduce SO_2 to the same level resulting from of the maximum technical emission controls

Most importantly, the chosen decarbonisation scenario (without any additional measures on SO_2 controls beyond what is in current legislation) would achieve by 2050 the same emission level as the MTFR case, i.e., if all currently available end-of-pipe emission controls were applied to the baseline activity levels (Figure 6.2). Obviously, the (co-)benefits of the decarbonisation strategy emerge over time, in parallel to the phase-in of low carbon measures. It is interesting to note that lower emissions occur in the power plant, domestic and industrial sectors at similar rates.

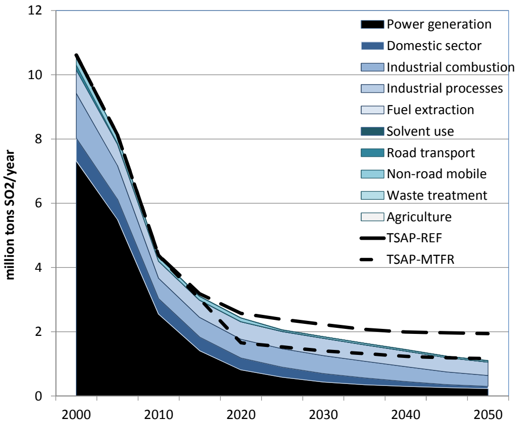

Figure 6.2: SO_2 emissions of the decarbonisation scenario with current legislation on air pollution.

Decarbonisation measures would lead to significant further reductions of NO_x

Also for NO_x, the decarbonisation strategy would deliver in 2050 the same emission reductions that could be achieved through full application of end-of-pipe emission control measures (Figure 6.3). The largest difference emerges from the electrification of the transport sector.

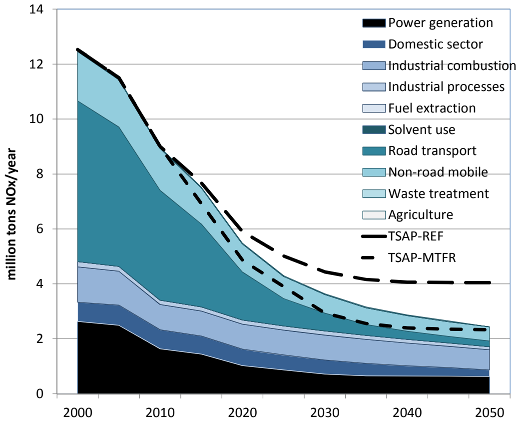

Figure 6.3: NO_x emissions of the decarbonisation scenario with current legislation on air pollution

PM emissions depend on the choice of climate measures

PM2.5 in a decarbonisation pathway depends on the chosen strategy. Particle emissions are critically determined by the assumptions on the use of wood biomass in the residential sector. If a climate policy would favour wood combustion in small stoves without extremely strict regulations on emission characteristics of these stoves, PM emissions could even be higher than in a reference case that assumes heating with ‘clean’ fossil fuels. In the specific case of the ‘Effective Technology’ decarbonisation scenario, total PM2.5 are slightly lower than in the baseline, but significantly above the level that could be achieved by advanced end-of-pipe air pollution controls (Figure 6.4).

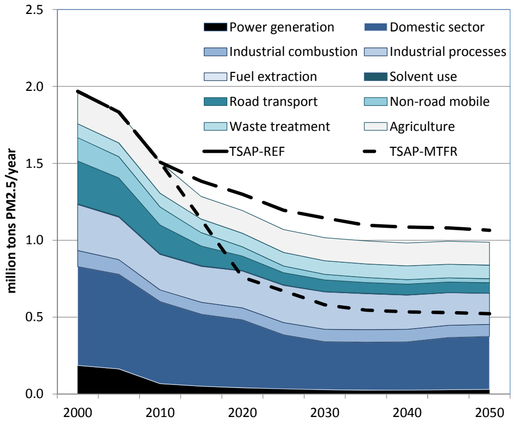

Figure 6.4: PM2.5 emissions of the decarbonisation scenario with current legislation on air pollution

Impacts of the decarbonisation strategy on NH_3 and VOC emissions are small

A decarbonisation strategy has only small impacts on NH_3 and VOC emissions (Figure 6.5, Figure 6.6)

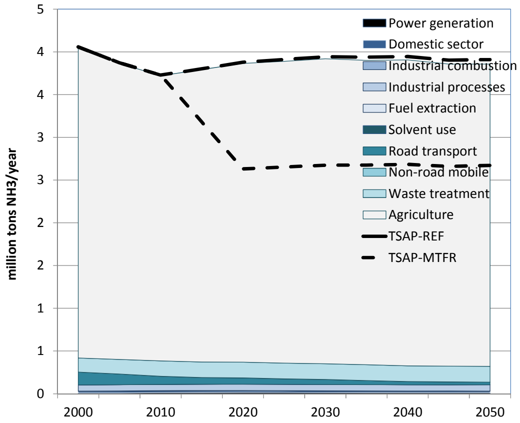

Figure 6.5: NH_3 emissions of the decarbonisation scenario with current legislation on air pollution

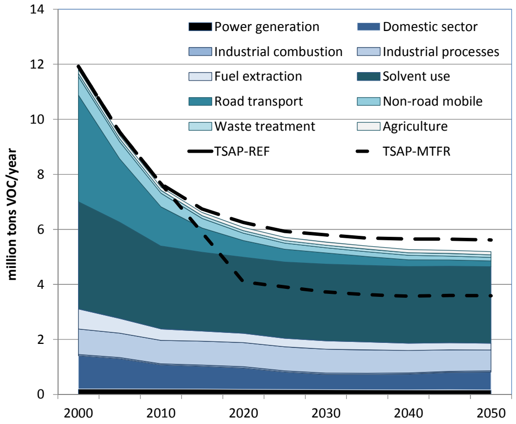

Figure 6.6: VOC emissions of the decarbonisation scenario with current legislation on air pollution

7 A ‘Maximum Control Efforts’ (MCE) scenario

A further scenario explores the scope for emission reductions from the application of the most effective emission control technologies that are currently on the market to all relevant sources in the context of an aggressive decarbonisation strategy, combined with an agricultural development that reduces meat production because consumers change to more healthy diets.

The MCE scenario assumes rapid improvements in energy efficiencies, CCS, current plans for nuclear energy and electrification of transport

For the energy and transport systems, the scenario employs the assumptions of the decarbonisation scenario that is discussed in Section 6. This decarbonisation scenario simulates a strong and rapid move to increased energy efficiency at all stages as well as a switch to less carbon-intensive fuels, even if this involved premature scrapping of existing capital stock. Inter alia, the scenario foresees significant roles for carbon capture and storage (CCS) at the large scale, continuation of current nuclear policies in the Member States, and the electrification of transport.

Despite drastic lower meat consumption in a ‘healthy diet’ scenario, livestock numbers decline to a lesser extent

For agricultural activities, a ‘healthy-diet‘ scenario has been developed that starts from the assumption of a drastic reduction of meat consumption down to levels that are recommended as part of healthy diets. Compared to today, the scenario reduces meat demand in the EU by 75%. Meat will be substituted by more cereals and vegetables, while the demand for milk and milk products is assumed to remain unaffected. However, for this modified food demand, the CAPRI agricultural model suggests smaller changes in livestock numbers, due to the strong coupling between milk and beef production of the agricultural systems. Lower meat prices would also increase the competitiveness on the world market and promote exports. As a consequence, cattle numbers decline in this scenario by only 10%, chicken by 25% and pigs by 75%. In total, meat production would shrink by 33% due to larger meat exports. As cattle breeding is the dominating source of agricultural emissions, NH_3 from this sector would decline by 17% and CH_4 by 9%.

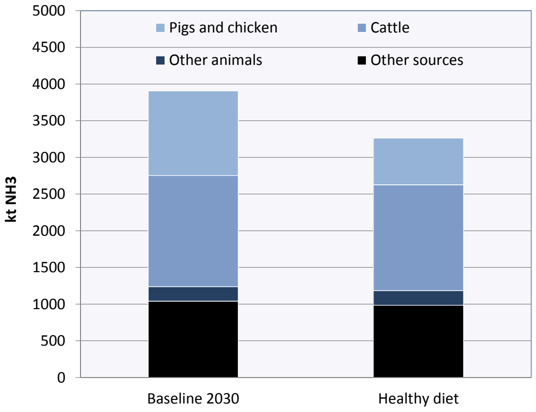

Figure 7.1: NH_3 emissions from the ‘healthy diet’ scenario compared to the baseline in 2030

The MCE scenario assumes early retirement of existing infrastructure to provide scope for full application of best control technologies to all sources

For the control of the emissions of air pollutants, the MCE scenario assumes full implementation of the best technologies discussed in Section 5. In contrast to the MTFR scenario, this scenario allows immediate replacement of existing capital stock with cleaner technologies, even before the end of the regular life time of the infrastructure. Such a premature scrapping has large impacts on emissions in the near future, but the effect declines over time.

7.1 Emissions

In the long run, the fuel mix changes in the decarbonisation scenario will bring SO_2 emissions down to the MTFR level of the baseline case, without applying any additional SO_2 controls beyond current legislation. Thus, implementation of these measures in a decarbonisation environment would offer substantial further cuts of SO_2 emissions; in 2050, SO_2 in the EU-27 would be cut by half compared to the level of the MTFR scenario (Figure 7.2). The largest remaining source would be industrial processes, while all energy-related emissions will diminish (Figure 7.3).

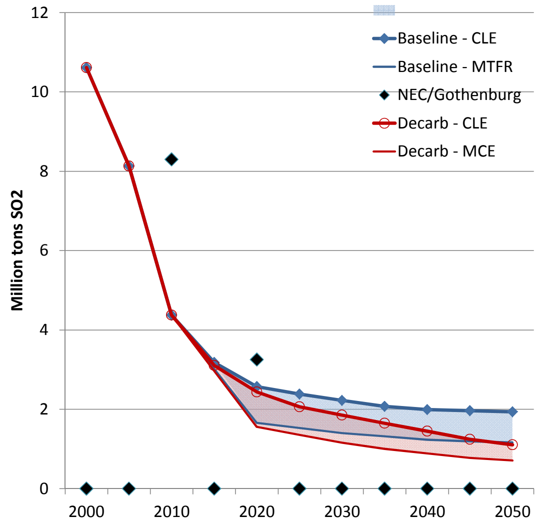

Figure 7.2: Time evolution of SO_2 emissions for the different scenarios for the EU-27

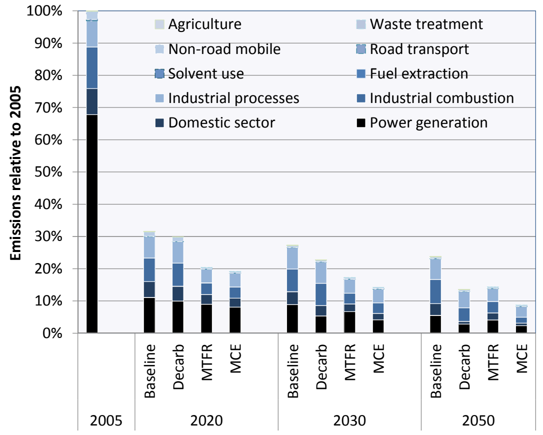

Figure 7.3: SO_2 emissions by SNAP sector, EU-27

A similar situation occurs for NO_x, where in the long run the decarbonisation scenario, without additional air pollution controls, will approach the levels that would result from the application of best technology in the baseline case (Figure 7.4). For the decarbonisation scenario, the scope for further emission reductions through technical measures is smaller (due to the lower activity rates), but nevertheless the MCE scenario brings emissions 30% below the MTFR case level (Figure 7.4). Compared to the decarbonisation case, further end-of-pipe measures would make largest differences to emissions from industrial processes and the power sector, while the impact for the transport sector is small due to the assumed electrification. In contrast, compared to the MTFR case, impacts of the MCE scenario are largest for the transport sector (due to the electrification in the decarbonisation scenario), followed by changes in the power and industrial sectors (due to lower fuel consumption (Figure 7.5).

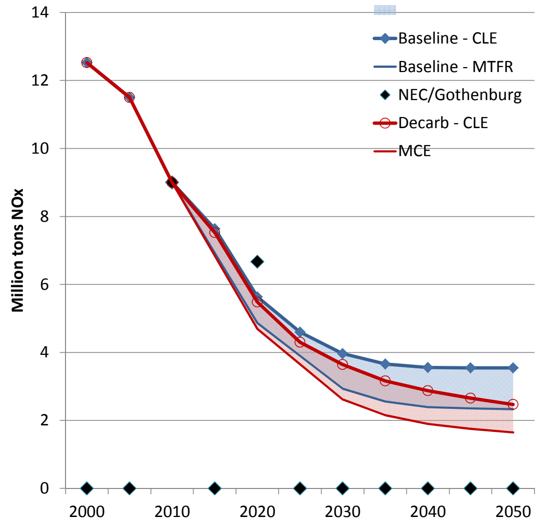

Figure 7.4: Time evolution of NO_x emissions for the different scenarios for the EU-27

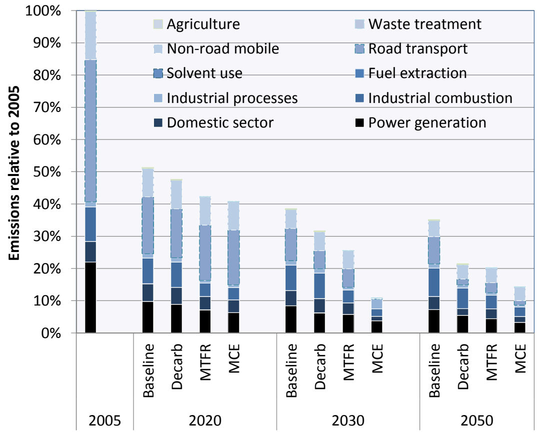

Figure 7.5: NO_x emissions by SNAP sector, EU-27

For PM emissions, there is only little difference between the baseline and the decarbonisation scenario, as more combustion of solid biomass compensates the emission reductions from the transport sector. Subsequently, the additional emission reductions of the MCE scenario (compared to the MTFR case) are smaller than for SO_2 and NO_x (Figure 7.6). Compared to the MTFR case, largest improvements of the MCE scenario occurs for the power sector. In relation to the decarbonisation scenario, significant higher cuts occur also in the agricultural sector, as this sector is unaffected by the decarbonisation strategy (Figure 7.7).

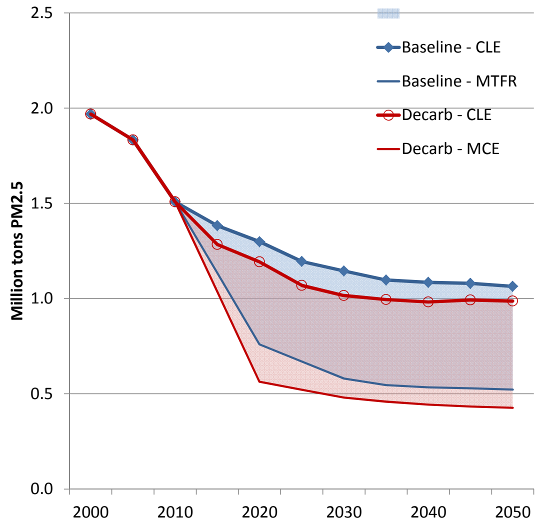

Figure 7.6: Time evolution of PM2.5 emissions for the different scenarios for the EU-27

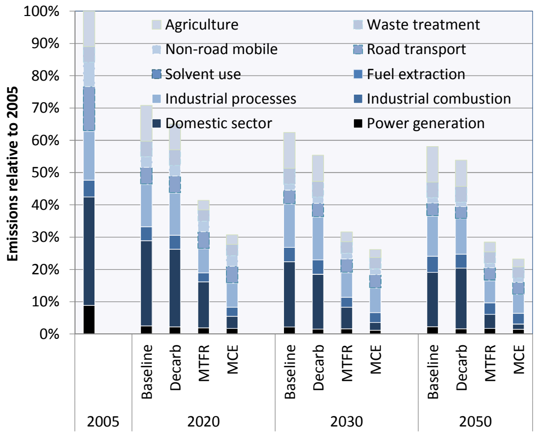

Figure 7.7: PM2.5 emissions by SNAP sector, EU-27

For NH_3, the main difference to the MTFR scenario relates to lower livestock numbers due to the assumption on healthy diets (Figure 7.9).

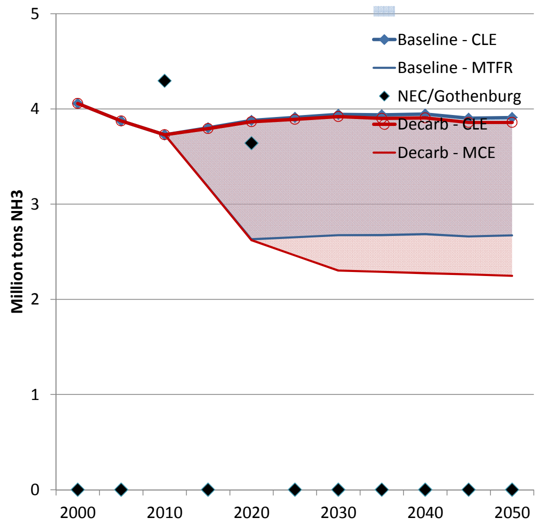

Figure 7.8: Time evolution of NH_3. emissions for the different scenarios for the EU-27

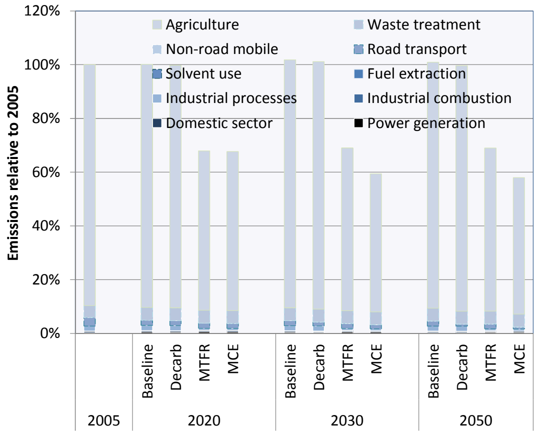

Figure 7.9: NH_3 emissions by SNAP sector, EU-27

The MCE scenario would reduce VOC emissions by another 20% on top of the MTFR case, and by 45% in relation to the decarbonisation case. The largest impact would occur for the solvent sector (Figure 7.10, Figure 7.11).

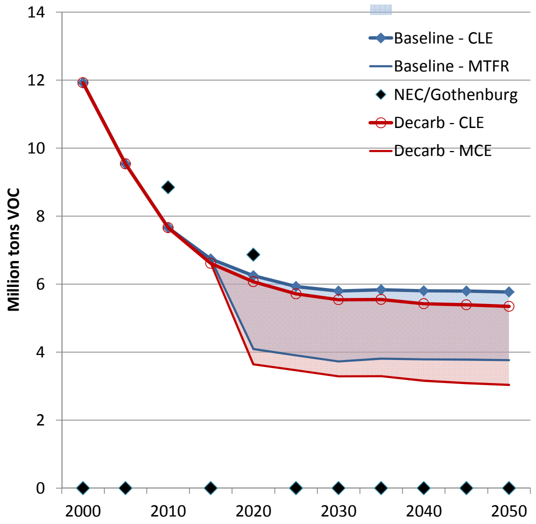

Figure 7.10: Time evolution of PM2.5 emissions for the different scenarios for the EU-27

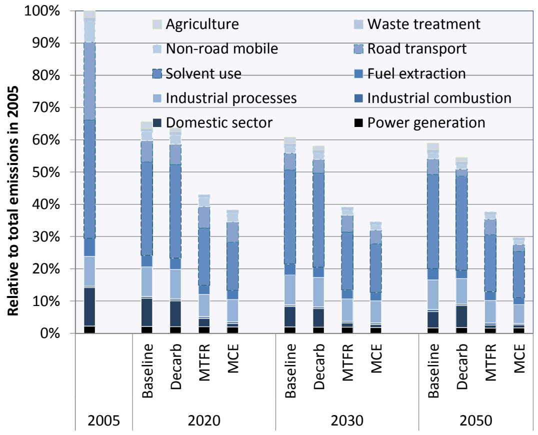

Figure 7.11: VOC emissions by SNAP sector, EU-27

8 Emission control costs

The GAINS model estimates for the various scenarios costs of the dedicated emission control measures. These estimates are based on international experience in technology costs, and consider country-specific circumstances that justify differences in costs across countries for objective reasons. However, the GAINS model does not quantify the full costs of systems changes (e.g., of a decarbonisation strategy) that imply important (macro-economic) feedbacks and potential changes in international competitiveness. Also, the GAINS model does not quantify costs of behavioural changes, as it does not assess welfare costs and consumer utilities.

Thus, cost figures estimated with GAINS refer to the costs of implementing dedicated emission control measures. They do not include benefits from lower emissions that lead to cleaner air, such as improved health conditions, crop productivity, and undisturbed ecosystems. Such benefit estimates will be conducted for Part 2 of this report by the ALPHA-2 model.

The GAINS model estimates costs of emission controls from a social planners perspective

The GAINS model estimates costs of societal resources diverted for the purposes of emission reductions. These estimates do not include transfer payments (e.g., taxes, profits, subsidies), as these do not represent net costs to the society. Up-front investments are annualized over the technical lifetime of the equipment, using a discount rate of 4% that is appropriate for social planning purposes. Obviously, private actors that need to consider profits, taxes and other cost components will apply different discount rates.

8.1 Emission control costs of the scenarios

On this basis, costs of the current legislation air pollution control measures are estimated to increase from 0.4% of the GDP in 2005 to 0.6% in 2010 (Figure 8.1). More than 55% of these costs relate to the implementation of the EURO emission standards for road vehicles, and 12% to measures in the power sector. Beyond 2020, air pollution control costs in the baseline, however, are expected to decline back to 0.4% of GDP in 2050. This is partly caused by the anticipated growth in GDP; however, costs shrink also in absolute terms after 2030 with the phase-out of the most polluting activities.

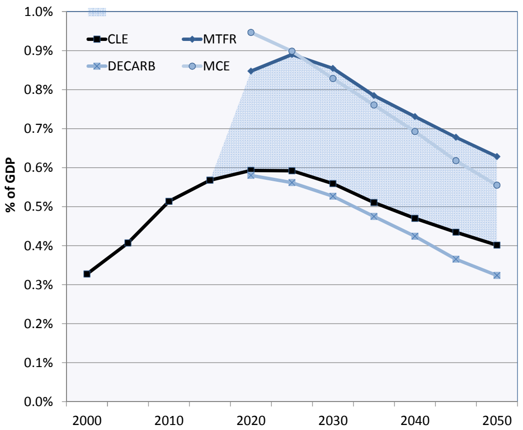

Figure 8.1: Emission control costs in the EU-27 as a percentage of GDP

Full implementation of all MTFR measures would increase total costs by about 50%, with highest additional costs occurring in the domestic sector (Figure 8.2).

It should be noted that these estimates are conservative as cost figures refer to current technologies and neglect a likely decrease in costs due to technological development and the learning effect.

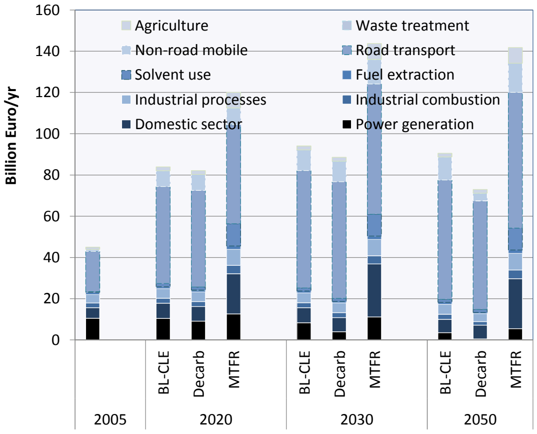

Figure 8.2: Emission control costs per SNAP sector

The GAINS model does not estimate the costs for transforming the energy and transport sectors to low carbon systems in the decarbonisation scenario. However, additional air pollution control costs that are required to comply with current air quality legislation are clearly lower in the decarbonisation case than for the baseline scenario. Up to 2050, these cost savings increase to 20% due to the lower levels of polluting activities (Table 8.1).

Table 8.1: Emission control costs for the scenarios (in billion Euro/yr)

	2005	*2020*			*2030*			*2050*		
		Baseline	Decarb	MTFR	Baseline	Decarb	MTFR	Baseline	Decarb	MTFR
Power generation	10.5	10.4	9.1	12.6	8.4	4.0	11.2	3.6	0.6	5.5
Domestic sector	5.1	7.4	7.1	19.5	7.3	6.9	25.7	6.4	6.6	24.2
Industrial combustion	2.3	2.4	2.4	4.0	2.4	2.4	4.0	2.5	1.7	4.2
Industrial processes	4.2	4.7	4.7	7.8	4.7	4.7	7.9	4.8	3.9	8.1
Fuel extraction	1.1	1.0	0.9	1.7	0.9	0.8	1.6	0.9	0.5	1.6
Solvent use	0.3	1.5	1.5	10.8	1.5	1.5	10.6	1.5	1.5	10.6
Road transport	19.6	47.0	46.9	48.1	56.9	56.5	63.2	57.8	52.6	65.8
Non-road mobile	0.9	7.8	7.8	8.0	10.0	10.0	11.9	11.2	3.8	14.1
Waste treatment	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Agriculture	1.1	1.9	1.9	7.5	1.9	1.9	7.7	1.8	1.8	7.6
Sum	45.0	84.0	82.1	120.0	94.1	88.6	143.7	90.5	73.0	141.8
% of GDP	*0.4%*	*0.6%*	*0.6%*	*0.8%*	*0.6%*	*0.5%*	*0.9%*	*0.4%*	*0.3%*	*0.6%*

As in 2050 air pollution control costs of the decarbonisation scenario (per GDP) return to the level of the year 2020, emissions in 2050 will be significantly lower. SO_2 will be 55% below the 2005 level, NO_x 58% and PM 25% lower than in 2005. In addition, emissions will be substantially lower than in the baseline

9 Conclusions

This report presents an outlook into the likely development of emissions and resulting air quality impacts that emerge from the latest expectations on economic development and the implementation of recent policies on energy, transport, agriculture and climate change. The baseline assumes full implementation of existing air pollution control legislation of the European Union. Thereby, it provides a quantitative benchmark for the analysis of the effectiveness of current policies and measures in terms of emission reductions, and a reference against which the potential for additional measures to achieve 'levels of air quality that do not give rise to significant negative impacts on, and risks to human health and environment' could be compared.

The baseline employs assumptions on future economic development that have been used for other recent policy analyses of the European Commission, in particular the 'Energy trends up to 2030', the 'Roadmap for moving to a competitive low-carbon economy in 2050' (CEC, 2011a), and the White Paper on Transport (CEC, 2011b). Thereby, the TSAP analysis is fully coherent with these other policy initiatives.

The Draft TSAP-2012 baseline assumes sustained economic recovery after the downturn in 2008/2009, along the 2009 Ageing Report (European Economy, April 2009). E.g., for 2030 it envisages for the EU-27 a 50% higher GDP than in 2005. This growth appears as somewhat optimistic in view of recent projections of DG-ECFIN, which suggest for 2030 a GDP increase of 40%. Thus, the draft TSAP-2012 baseline relies on an optimistic economic projection, which provides ample space for a more rapid increase in economic activities (Figure 9.1).

Despite the steep increase in economic activity, the baseline scenario indicates a stabilization of energy consumption, as energy efficiency policies will successfully reduce energy demand in households and industry. Although energy intensities of Member States are anticipated to converge, significant differences will prevail in the future.

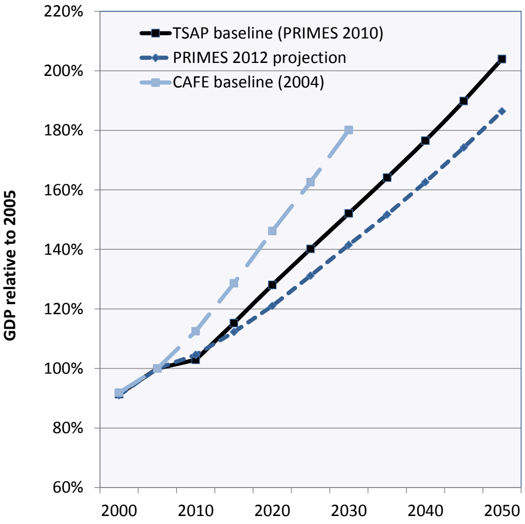

Figure 9.1: Projections of GDP growth: TSAP baseline (based on PRIMES 2010), the CAFE baseline of 2004, and the proposed assumption for the PRIMES 2012 scenario

The baseline scenario assumes that vehicle mileage will grow faster than the demand for personal mobility, and that the share of diesel passenger cars is likely to remain at the 2010 level. Freight transport intensity of the European economy will not change significantly, so that freight volumes will follow the GDP trend.

Increasing demand for built-up land will reduce land available for agriculture, forestry and biofuel production. However, higher productivity for food crops will free up land for biofuel production, which is anticipated in the baseline to increase by a factor of 10. Cattle numbers will decrease, but there will be more pigs and chicken.

The TSAP-2012 baseline assumes that the presently decided legislation on air pollution controls will successfully penetrate the market according to the agreed time tables. It assumes compliance with EURO 6 limit values under real life conditions.

As a consequence of the structural changes in energy system and the progressing implementation of emission control legislation, SO_2 emissions will fall drastically. Largest reductions are foreseen for the power sector, which will cut its emissions by almost 90%. All countries will reduce their SO_2 emissions, with up to 90% decreases in some new Member States. NO_x emissions may drop by more than 65% in the coming years if the EURO 6 limit values are effectively implemented. Largest emission cuts should then occur in the transport sector. Legislation directed at other pollutants will decrease PM2.5 emissions by about 40%. Only minor changes are expected for NH_3 emissions, especially as emissions from cattle farming remain constant. However, NH_3 emissions will decline in countries who have adopted advanced emission control legislation. VOC emissions will decline by 40% in the EU-27, and converge on a per-capita basis across Member States.

On top of current legislation, technical measures are on the market that could reduce SO_2 emissions by another 35%. Application to all new sources could reduce NO_x by 80% in 2050 relative to 2005, and emissions of PM2.5 by up to 40%. Measures are available that would cut NH_3 and VOC emissions by about 30% beyond current legislation.

An illustrative decarbonisation scenario aiming at an 80% GHG reduction in the EU in 2050 would offer similar reductions of SO_2, NO_x and PM emissions as would emerge from a full implementation of all remaining air pollution control technologies. Instead of employing end-of-pipe technologies to reduce air pollutant emissions, the decarbonisation scenario would achieve lower emissions through enhanced energy efficiency improvements and the electrification of the transport sector.

A 'Maximum Control Efforts' scenario explores the ultimate scope for emission reductions that could be achieved through rapid decarbonisation, application of all available air pollution control technologies, and a change of the agricultural system to produce more healthy diets for the European population. In the long run, such measures would cut SO_2 emissions in the EU-27 by more than 90% compared to today's levels, NO_x by 85%, PM2.5 by more than 75%, NH_3 by about 40% and VOC by 70%.

Obviously, the implementation of such measures requires financial resources. Calculated from a social planner's perspective, air pollution control costs for implementing the current air quality legislation in the EU-27 will increase to 0.6% of the GDP in 2020. Thereafter, however, costs will decline in relation to GDP to 0.4% in 2050. Full implementation of all available technical emission control measures would increase costs by 50%. In a decarbonising world, additional air pollution control costs that are required to comply with current air quality legislation are up to 20% lower than in the baseline case due to the lower levels of polluting activities. In addition, such a development would also in up to 20% lower emissions and therefore less harmful impacts on human health and vegetation.

Annex

Annex 1: Emission by sector for the EU-27

Table 1.1: Summary of SO_2 emissions by SNAP sector

	2005	2020			2030				2050			
		BL	Decarb	MTFR	BL	Decarb	MTFR	MCE	BL	Decarb	MTFR	MCE
Power generation	5511	902	811	733	725	436	543	337	450	231	334	190
Domestic sector	661	404	372	242	322	264	195	163	297	69	179	64
Industrial combustion	1046	592	584	293	570	559	270	268	609	341	285	149
Industrial processes	662	542	540	345	546	538	352	347	521	413	326	268
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0	0
Road transport	33	6	6	6	6	5	6	5	6	2	6	2
Non-road mobile	206	114	114	36	42	42	36	36	43	41	37	35
Waste treatment	2	1	1	0	1	1	0	0	1	1	0	0
Agriculture	12	12	7	0	12	7	0	0	12	7	0	0
Sum	8133	2572	2435	1655	2224	1852	1402	1156	1939	1106	1165	708

Table 1.2: Summary of NO_x emissions by SNAP sector

	2005	2020			2030				2050			
		BL	Decarb	MTFR	BL	Decarb	MTFR	MCE	BL	Decarb	MTFR	MCE
Power generation	2526	1124	1022	825	726	968	718	664	434	835	628	509
Domestic sector	741	634	605	479	458	545	509	410	163	466	240	352
Industrial combustion	1231	915	905	476	440	912	911	464	268	1014	736	490
Industrial processes	175	152	152	91	91	153	150	91	347	146	110	84
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0	0
Road transport	5074	2032	1748	1978	1957	1153	648	655	5	972	208	360
Non-road mobile	1717	1013	1018	1010	1016	672	673	648	36	576	515	530
Waste treatment	10	6	6	3	3	6	6	3	0	6	6	3
Agriculture	27	27	27	0	0	27	27	0	0	27	26	0
Sum	11501	5903	5483	4862	4691	4435	3642	2937	0	4043	2468	2329

Table 1.3: Summary of PM2.5 emissions by SNAP sector

	2005	2020			2030				2050			
		BL	Decarb	MTFR	BL	Decarb	MTFR	MCE	BL	Decarb	MTFR	MCE
Power generation	163	46	40	35	31	39	28	30	22	42	30	31
Domestic sector	616	484	442	261	70	371	312	122	43	308	344	80
Industrial combustion	95	79	78	51	51	81	81	56	56	92	80	65
Industrial processes	277	241	240	136	136	245	243	140	139	227	201	125
Fuel extraction	5	3	3	3	3	3	3	3	3	5	1	5
Solvent use	0	0	0	0	0	0	0	0	0	0	0	0
Road transport	250	94	94	94	94	77	76	75	74	71	68	69
Non-road mobile	138	60	61	60	60	36	36	33	33	30	26	26
Waste treatment	89	88	88	64	64	89	89	65	65	88	88	64
Agriculture	201	204	148	55	55	204	149	56	45	202	149	56
Sum	1833	1299	1193	759	563	1145	1016	580	480	1065	987	522

Table 1.4: Summary of NH_3 emissions by SNAP sector

	2005	2020			2030				2050			
		BL	Decarb	MTFR	BL	Decarb	MTFR	MCE	BL	Decarb	MTFR	MCE
Power generation	10	17	16	21	20	16	13	20	17	12	12	16
Domestic sector	19	19	19	18	18	17	16	16	15	15	16	14
Industrial combustion	3	5	4	6	6	4	4	6	6	6	4	7
Industrial processes	74	74	74	28	28	74	74	28	28	74	74	28
Fuel extraction	0	0	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0	0	0
Road transport	124	74	71	74	71	72	58	72	58	71	29	71
Non-road mobile	1	1	1	1	1	1	1	1	1	1	1	1
Waste treatment	170	184	184	184	184	184	184	184	184	184	184	184
Agriculture	3472	3504	3496	2297	2292	3573	3569	2345	1992	3546	3537	2349
Sum	3873	3879	3865	2631	2621	3943	0	2674	0	3910	3857	2672

Table 1.5: Summary of VOC emissions by SNAP sector

	2005	2020			2030				2050			
		BL	Decarb	MTFR	BL	Decarb	MTFR	MCE	BL	Decarb	MTFR	MCE
Power generation	211	204	193	194	185	191	177	182	169	161	168	150
Domestic sector	1134	831	770	243	104	602	554	124	90	480	649	91
Industrial combustion	47	51	50	51	50	47	48	47	48	63	42	63
Industrial processes	885	877	876	664	662	879	869	665	655	879	757	666
Fuel extraction	532	339	333	271	267	327	302	261	244	327	246	261
Solvent use	3496	2767	2767	1693	1423	2785	2785	1714	1440	2785	2785	1686
Road transport	2308	630	605	630	605	497	407	497	408	459	207	459
Non-road mobile	619	267	268	264	265	186	187	154	154	183	131	130
Waste treatment	111	93	93	82	82	93	93	82	82	93	93	82
Agriculture	192	191	115	0	0	190	115	0	0	187	115	0
Sum	9535	6250	6070	4091	3642	5797	0	3726	0	5617	5193	3587

Annex 2: Assumptions on population and GDP by Member States

Table 1.6: Projections of population (million people) and GDP (billion Euro2005) by Member State

	Population			*GDP*		
	2005	2020	2030	2005	2020	2030
Austria	8.2	8.7	9.0	244	310	363
Belgium	10.5	11.3	11.8	302	390	459
Bulgaria	7.8	7.2	6.8	22	35	42
Cyprus	0.8	1.0	1.1	14	23	31
Czech Rep.	10.2	10.5	10.4	100	154	183
Denmark	5.4	5.7	5.8	207	246	290
Estonia	1.4	1.3	1.3	11	15	19
Finland	5.2	5.5	5.6	157	201	233
France	60.8	65.6	68.0	1726	2144	2550
Germany	82.5	81.5	80.2	2243	2724	3009
Greece	11.1	11.6	11.6	198	291	352
Hungary	10.1	9.9	9.7	89	115	141
Ireland	4.1	5.4	5.9	162	222	286
Italy	58.5	61.4	61.9	1429	1679	1974
Latvia	2.3	2.2	2.0	13	17	21
Lithuania	3.4	3.2	3.1	21	30	36
Luxembourg	0.5	0.6	0.6	30	47	59
Malta	0.4	0.4	0.4	5	7	8
Netherlands	16.3	16.9	17.2	513	638	726
Poland	38.2	38.0	37.0	244	406	516
Portugal	10.5	11.1	11.3	149	180	221
Romania	21.7	20.8	20.1	80	135	166
Slovakia	5.4	5.4	5.3	38	73	92
Slovenia	2.0	2.1	2.0	29	44	51
Spain	43.0	51.1	52.7	909	1285	1636
Sweden	9.0	9.9	10.3	295	380	457
UK	60.1	65.7	69.2	1832	2373	2903
EU-27	489.2	513.8	519.9	11063	14164	16825

Annex 3: Emissions by Member States

The following tables provide the provisional GAINS estimates for the emissions of the TSAP-2012 baseline and the MTFR scenarios, for 2005, 2020 and 2030. Bilateral consultations will be conducted with experts from Member States to update and validate these figures. Note that these data refer to the categories contained in the GAINS model. Some countries report emissions from additional sources (e.g., NO_x and NH_3 from agricultural soils) to EMEP, which are however not included in the GAINS estimates.

Table 1.7: SO_2 emissions for the baseline and the MTFR scenario by Member State (kilotons)

	2005	2020		2030	
		Baseline	MTFR	Baseline	MTFR
Austria	27	19	16	16	14
Belgium	137	79	60	80	59
Bulgaria	901	115	66	91	42
Cyprus	39	5	2	5	2
Czech Rep.	199	93	78	81	68
Denmark	18	11	9	11	9
Estonia	77	15	12	14	10
Finland	72	34	30	34	29
France	469	191	125	173	115
Germany	512	315	282	283	240
Greece	541	117	43	83	35
Hungary	128	61	32	58	30
Ireland	78	30	20	23	16
Italy	381	213	98	167	91
Latvia	5	5	4	4	3
Lithuania	46	15	7	15	7
Luxembourg	2	1	1	1	1
Malta	13	3	0	1	0
Netherlands	66	45	33	48	32
Poland	1263	427	267	387	240
Portugal	224	60	31	56	25
Romania	822	140	72	127	62
Slovakia	90	39	20	38	17
Slovenia	40	16	12	10	7
Spain	1259	277	165	248	145
Sweden	35	26	26	26	26
UK	689	222	144	145	81
EU-27	8133	2572	1655	2224	1402

Table 1.8: NO_x emissions for the baseline and the MTFR scenario by Member State (kilotons)

	2005	2020		2030	
		Baseline	MTFR	Baseline	MTFR
Austria	201	101	87	73	50
Belgium	303	181	151	162	110
Bulgaria	181	75	64	61	49
Cyprus	21	13	9	10	6
Czech Rep.	295	161	136	118	85
Denmark	186	87	74	66	48
Estonia	39	23	17	17	11
Finland	197	119	101	93	71
France	1383	646	536	489	294
Germany	1453	748	666	544	407
Greece	321	257	212	191	132
Hungary	166	87	66	62	39
Ireland	137	80	65	55	30
Italy	1347	710	579	553	375
Latvia	36	27	24	17	13
Lithuania	60	31	27	23	17
Luxembourg	49	22	20	13	7
Malta	11	4	4	3	2
Netherlands	371	195	167	155	105
Poland	778	466	406	365	278
Portugal	262	132	102	87	45
Romania	307	172	125	131	79
Slovakia	98	59	42	48	30
Slovenia	55	29	26	16	11
Spain	1530	710	561	509	290
Sweden	210	96	81	76	52
UK	1508	672	518	499	302
EU-27	11501	5903	4862	4435	2937

Table 1.9: PM2.5 emissions for the baseline and the MTFR scenario by Member State (kilotons)

	2005	2020		2030	
		Baseline	MTFR	Baseline	MTFR
Austria	23	14	10	13	8
Belgium	28	21	16	20	14
Bulgaria	53	35	13	30	9
Cyprus	3	1	1	1	1
Czech Rep.	46	37	18	33	13
Denmark	35	23	12	20	8
Estonia	20	8	4	7	3
Finland	32	22	13	19	9
France	344	240	148	212	114
Germany	141	105	74	99	62
Greece	57	36	19	30	15
Hungary	28	24	13	20	9
Ireland	14	9	7	7	5
Italy	143	102	75	94	63
Latvia	19	15	7	12	3
Lithuania	14	11	5	9	3
Luxembourg	3	2	2	2	1
Malta	1	0	0	0	0
Netherlands	27	17	12	17	11
Poland	233	192	119	154	78
Portugal	104	65	20	59	15
Romania	155	111	38	94	22
Slovakia	21	11	7	11	6
Slovenia	9	6	3	5	2
Spain	152	105	62	97	50
Sweden	32	21	16	21	16
UK	97	64	45	59	40
EU-27	1833	1299	759	1145	580

Table 1.10: NH_3 emissions for the baseline and the MTFR scenario by Member State (kilotons)

	2005	2020		2030	
		Baseline	MTFR	Baseline	MTFR
Austria	61	67	40	70	42
Belgium	74	79	70	82	73
Bulgaria	64	66	56	67	57
Cyprus	6	6	3	6	3
Czech Rep.	81	75	56	76	60
Denmark	74	57	50	58	51
Estonia	12	13	7	14	8
Finland	34	33	27	33	28
France	657	641	378	653	383
Germany	590	636	414	652	424
Greece	57	57	40	57	40
Hungary	77	80	47	74	42
Ireland	115	120	86	116	86
Italy	409	389	267	396	271
Latvia	13	16	12	18	13
Lithuania	44	51	30	52	30
Luxembourg	6	7	5	7	5
Malta	3	3	2	3	2
Netherlands	134	129	118	130	119
Poland	343	338	244	363	260
Portugal	73	71	44	74	45
Romania	161	142	98	127	88
Slovakia	28	43	21	44	21
Slovenia	19	20	14	20	14
Spain	365	375	213	380	215
Sweden	54	52	38	53	38
UK	320	314	250	319	254
EU-27	3873	3879	2631	3943	2674

Table 1.11: VOC emissions for the baseline and the MTFR scenario by Member State (kilotons)

	2005	2020		2030	
		Baseline	MTFR	Baseline	MTFR
Austria	171	113	75	108	71
Belgium	184	130	111	130	108
Bulgaria	138	84	44	79	43
Cyprus	9	5	4	5	3
Czech Rep.	271	173	93	157	78
Denmark	135	77	45	68	38
Estonia	37	22	14	18	12
Finland	153	96	64	85	52
France	1322	768	509	685	464
Germany	1333	958	609	901	570
Greece	300	165	105	138	78
Hungary	156	110	67	96	54
Ireland	70	53	32	50	28
Italy	1267	734	548	699	506
Latvia	69	48	19	40	15
Lithuania	75	55	31	50	29
Luxembourg	15	6	5	6	4
Malta	4	3	2	3	2
Netherlands	228	161	125	161	123
Poland	629	471	260	405	205
Portugal	236	169	108	160	102
Romania	455	307	136	259	107
Slovakia	68	57	39	55	34
Slovenia	44	32	16	25	13
Spain	943	627	430	615	413
Sweden	205	119	92	115	87
UK	1017	706	508	686	486
EU-27	9535	6250	4091	5797	3726

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