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TSAP-2012 Baseline: Health and Environmental Impacts

TSAP Report #6

Version 1.0

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Executive Summary

This report examines the health and environmental impacts of the TSAP-2012 baseline emission scenarios that have been presented in the TSAP Report #1 to the Stakeholder Expert Group in June 2012. The baseline suggests for the next decades a steady decline of energy-related emissions from industry, households and transport while no significant changes are foreseen for NH_3 from agricultural activities.

These emission trajectories will lead to significant improvements in air quality. For instance, loss of statistical life expectancy from exposure to fine particulate matter (PM2.5) is expected to decline from 9.6 months in 2000 and 6.9 months in 2010 to 5.5 months in 2020 and 5.0 months in 2030. It is estimated that the number of premature deaths attributable to short-term exposure of ground-level ozone will drop by about 30% by 2020. Ecosystems area where biodiversity is threatened by excess nitrogen deposition will shrink from 1.2 million km^2 in 2000 to 900,000 km^2 in 2030, and acidification will remain an issue at only four percent of the European forest area.

However, by 2020 the baseline improvements for fine particular matter health impacts and eutrophication will fall short of the targets established in the 2005 Thematic Strategy on Air Pollution, while for acidification and ozone these targets will be met. Furthermore, it is unlikely that the baseline development will achieve full compliance with the air quality limit values for PM10 and NO_2 throughout Europe. Equally, the baseline scenario will not provide protection against excess nitrogen deposition at almost 50% of the legally protected Natura2000 areas and other protected zones.

In addition, the magnitude of air pollution impacts and resulting damage remains substantial. It is estimated that for the baseline in 2030, the European population would still suffer a loss of 210 million life-years and experience 18,000 premature deaths because of ozone exposure. Biodiversity will remain threatened by excess nitrogen input at 900,000 km^2 of ecosystems, including 250,000 km^2 which are legally protected, inter alia as Natura2000 areas.

The analysis also highlights the scope for additional measures that could alleviate the remaining damage and move closer to the objectives of the Sixth Environment Action Program. Full application of readily available technical emission reduction measures in the EU could reduce health impacts from PM by 2020 by another 30% and thereby gain more than 55 million life-years in the EU. It could save another 3,000 premature deaths per year because of lower ozone concentrations. Further controls of agricultural emissions could protect biodiversity at another 200,000 km^2 of ecosystems against excess nitrogen deposition, including 50,000 km^2 of Natura2000 areas and other protected zones. It could eliminate almost all likely exceedances of PM10 air quality limit values in the old Member States, while in the urban areas of new Member States additional action to substitute solid fuels in the household sector with cleaner forms of energy would be required. Such Europe-wide emission controls would also eliminate in 2030 all likely cases of non-compliance with EU air quality standards for NO_2 with the exception of a few stations for which additional local measures (e.g., traffic restrictions, low emission zones) would be necessary.

While the general trend appears to be robust, quantification of the remaining effects requires more uncertainty analyses.

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

As an input to the review and revision of the EU air policy in 2013 and in particular of the 2005 Thematic Strategy on Air Pollution, IIASA presented a series of draft emission projections in the TSAP Report #1 in June 2012 (Amann et al., 2012). These scenarios provide an outlook into the likely development of emissions that can be envisaged from the latest expectations on economic development and the implementation of recent policies on energy, transport, agriculture and climate change. However, as numerous improvements in the impact assessment methods were still under way in June 2012, TSAP Report #1 did not explore the health and environmental effects of the emission scenarios. Based on the revised impact assessment methods this TSAP Report #6 presents indicators for health and ecosystems impacts for the emission scenarios that have been presented in June.

It is noteworthy that, due to the timing of the various lines of work, the emission scenarios presented in this report do not incorporate feedbacks received from national experts during the bilateral consultations in fall 2012. These comments, together with updated versions of the energy projections, will flow into the next round of model calculations in early 2013.

1.1 Recent updates of the impact assessment methodologies

In recent months, the impact assessment methodologies of GAINS (Amann, Bertok, Borken-Kleefeld, Cofala, Heyes, Höglund-Isaksson, Klimont, Nguyen, et al., 2011) have been updated along several lines to incorporate recent improvements in atmospheric dispersion modelling and new information on the sensitivity of ecosystems. Furthermore, work is underway to adjust the health impact assessment methodology to new epidemiological findings on the health effects of air pollution. However, pending final advice from the WHO REVIHAAP project, new findings have only been partially introduced into GAINS up to now.

The methodological changes and how the new results compare to earlier estimates are described in detail in the forthcoming companion TSAP Report #8. Here a brief summary of the changes is provided.

- While the chemical transformation and transport of pollutants in the atmosphere has been modelled before for a 50km*50km grid system, the new calculations employ the most recent version of the Eulerian EMEP model (Simpson et al., 2012) with a 28km*28km grid resolution on a longitude/latitude projection. This not only provides more spatial detail, but also avoids interpolation errors when converting meteorological input data. Furthermore, the new version of the EMEP Eulerian model also quantifies the contribution of secondary organic aerosols to PM2.5 that have been ignored previously.

- A new methodology has been developed to downscale ambient concentrations of PM2.5 from a 28*28 km EMEP grid system to a 7*7 km resolution. Based on fine-scale calculations with the CHIMERE model (Bessagnet et al., 2010), this new method replaces the earlier 'City-Delta' approach of GAINS (Cuvelier et al., 2007) and is used for computing population exposure and health impacts from fine particulate matter.

- The assessment of premature mortality from fine particulate matter has been harmonized with the approach used for the benefit assessment. The earlier methodology quantified the life years lost during the remaining lifetime of the population that was older than 30 years in the target year (e.g., in 2020) assuming that a constant PM level prevails for the rest of the life time. In contrast, the new methodology also considers impacts on cohorts born today once they reach the age of 30 years in the future.

- New epidemiological studies suggest some modifications of the health impact methodology used before in GAINS, e.g., to reflect cause-specific mortality and possible non-linearities in the exposure-response functions. However, the WHO project REVIHAAP that is currently reviewing the new evidence has not yet provided definite conclusions. Thus, the current impact assessment presented in this report employs the linear relative risk factors found by Pope et al., 2002 for all-cause mortality that have been used for earlier GAINS work for the TSAP and the revision of the NEC directive. It is planned to adopt the modifications proposed by the REVIHAAP project in the final TSAP scenarios that are planned for early 2013.

- A new methodology has been developed for assessing future compliance with the air quality limit values for PM10 and NO_2 for the AIRBASE monitoring stations that reported exceedances to the EEA.
- In 2012, the Coordination Centre for Effects (CCE) has compiled an updated database on critical loads for acidification and eutrophication, with better defined target ecosystems and improved methodologies (Posch et al., 2011). The critical loads data that have been provided by National Focal Centres for 2.1 million ecosystems in the EU-28 have been allocated to the 28 km*28 km longitude/ latitude grid system that is now used for calculating deposition.
- Furthermore, in the context of the EC4MACS project (www.ec4macs.eu), the CCE has collected from the National Focal Centres critical loads data for ecosystems that are protected by EU legislation (e.g., Birds Directive, Habitat Directive, Natura2000) or national laws. This enables a specific evaluation of the impacts of emission control scenarios on these nature protection areas.
- For calculating future concentrations of ground-level ozone, the co-chairs of the Task Force on Hemispheric Transport Air Pollution (HTAP) advised, based on multi-model/multi-scenario calculations, to assume as a central estimate for the period 2020-2030 a zero ppb change in hemispheric background ozone concentrations compared to the period 2000-2010. Using optimistic and pessimistic assumptions about global emissions, sensitivity cases should explore the implications of changes in background ozone between –1 and +3 ppb. For earlier GAINS analyses an increase of 4.5 ppb between 1990 and 2020 has been recommended before in answers to the 'Urbino questions' provided by the FP6 ACCENT Network of Excellence (Raes & Hjorth, 2006), based on extrapolations of ozone trends measured at the Irish West Coast between 1990 and 2000.

1.2 Structure of the report

Section 2 of this report provides a brief summary of the baseline emission projections, essentially repeating the findings of TSAP Report #1 and discussing changed assumptions on the effectiveness of emission controls for road (i.e., Euro-6) and non-road mobile sources.

Section 3 reviews the environmental impacts of these emission scenarios, and Section 4 draws conclusions from the analysis.

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2 Emissions of the TSAP-2012 scenario

This report examines the environmental impacts that are expected from the future changes of emissions following the TSAP-2012 scenario that has been presented in June 2012 to the Stakeholder Expert Group (see Amann et al., 2012).

The 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). In particular, projections up to 2030 follow the economic development and energy trajectories of the PRIMES 2010 Reference scenario (CEC, 2010) and the corresponding forecast of agricultural activities developed with the CAPRI model.

It should be noted that the TSAP-2012 baseline has been developed by IIASA based on the PRIMES-2010 activity projections, internationally available statistics and information from Member States experts as of spring 2012, and has been presented to the Stakeholder Expert Group in June 2012. Feedbacks received from stakeholders, as well as all information that has been provided by national experts to IIASA in the course of the bilateral consultations in the second half of 2012 are not yet reflected in the TSAP-2012 baseline. This body of new information is currently being incorporated into the GAINS database and will feed into the set of TSAP-2013 scenarios in early 2013.

Despite a doubling in economic activity between 2000 and 2030, the TSAP-2012 baseline scenario suggests a stabilization of energy consumption, as energy efficiency policies will successfully reduce energy demand in households and industry.

While for this report all other factors and assumptions remain unchanged compared to the baseline scenario presented in June 2012 (see the summary on legislation assumed in the baseline in Amann et al., 2012), an adjustment has been made for the assumptions on the implementation schedule and effectiveness of the Euro-6 NO_x emission standards for light duty diesel vehicles, as well as for non-road mobile machinery.

The final TSAP-2012 baseline presented in this report assumes from 2018 onwards real-life NO_x emissions to be 1.5 times higher than the NTE Euro-6 test cycle limit value (i.e., about 120 mg NO_x/km for real-world driving conditions, compared to the limit value of 80 mg/km). Before that, it is assumed that emission factors of new cars would decline to 380 mg NO_x/km from 2014 onwards. Further, inland vessels are now excluded from Stage IIIB or higher emission controls, and railcars and locomotives not subject to Stage IV controls.

As a consequence of the structural changes in the energy and transport sectors and the progressive 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% compared with 2000. NO_x emissions could drop by up to 65% in the coming years if the Euro-6 limit values were effectively implemented. Legislation directed at other pollutants will decrease PM2.5 emissions by up to 40%., and also VOC emissions are expected to decline at a similar rate. In contrast to the other air pollutants, only minor changes are expected for NH_3 emissions.

2.1 Emission control legislation considered in the 'Current legislation' baseline

In addition to the energy, climate and agricultural policies that influence future activity levels, the TSAP-2012 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 1). 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 2).

Box 1: 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

Box 2: 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)

For air pollutants, the baseline assumes the regulations described in Box 3 to Box 7. 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.

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.

Box 3: 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 on the 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 MEPC57 regarding sulphur content of marine fuels
- National legislation and national practices (if stricter)

Box 4: 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 (692/2008/EC), (see also comments above about the assumed implementation schedule of Euro-6).
- 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 (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, DIR 2005/30/EC, DIR 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). Stage IIIB or higher standards do not apply to inland vessels IIIB, and railcars and locomotives are not subject to Stage IV controls.
- MARPOL Annex VI revisions from MEPC57 regarding emission NO_x limit values for ships
- National legislation and national practices (if stricter)

As mentioned above, the final TSAP-2012 baseline presented in this report assumes from 2018 onwards real-life NO_x emissions to be 1.5 times higher than the NTE Euro-6 test cycle limit value (i.e., about 120 mg NO_x/km for real-world driving conditions, compared to the limit value of 80 mg/km). As portable emissions measurement systems (PEMS) will only be introduced gradually, emission factors of new cars are assumed to decline linearly between 2014 and 2018 from the Euro-5 level to the new Euro-6 value. Also, inland vessels are now excluded from Stage IIIB or higher emission controls, and railcars and locomotives not subject to Stage IV controls.

Box 5: 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 6: 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 7: 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 following paragraphs provide a summary of the final TSAP-2012 baseline scenario. Full details are provided in TSAP Report #1 (Amann et al., 2012). As explained there, the TSAP-2012 baseline employs the activity projections of the PRIMES 2010 reference scenario that was developed in 2010. It is planned that for the next round of model analysis, the TSAP-2013 baseline will rely on the forthcoming PRIMES 2012 scenario and incorporate feedbacks on emission calculations received from national experts during the bilateral consultations with IIASA.

2.2 Sulphur dioxide (SO_2) emissions

The significant changes in fuel consumption in the baseline projection, together with progressive implementation of emission control measures, will lead to a reduction of more than 70% in SO_2 emissions in the coming decades. Most of the decline will emerge from coal use, and mainly before 2020, when emissions are estimated to be 68% lower than in 2005. In the following decade, emissions would then fall to 73% below 2005.

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%. Despite the significant reductions in the baseline case, there remains potential for further cuts in emissions from full application of currently available emission control technologies (the MTFR case). In such a case, it is estimated that SO_2 emissions could drop by 80% in 2020 (compared to 68% in the baseline case), and by 83% in 2030 (Figure 2.1).

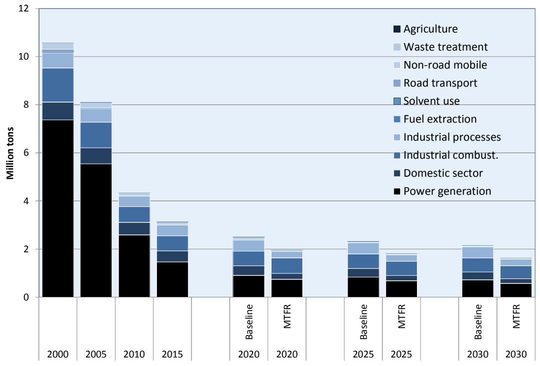

Figure 2.1: SO_2 emissions by sector, EU-28

Table 2.1: SO_2 emissions by SNAP sector, EU-28

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	7369	5542	2590	1465	902	740	833	681	723	566
Domestic sector	745	667	518	462	405	243	360	216	323	196
Industrial combust.	1419	1068	653	625	603	296	597	285	582	272
Industrial processes	735	667	533	539	548	347	551	352	552	353
Fuel extraction	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0
Road transport	155	40	7	6	6	6	6	6	6	6
Non-road mobile	252	209	118	113	114	36	43	36	43	36
Waste treatment	2	2	2	2	2	0	2	0	2	0
Agriculture	13	12	12	12	12	0	12	0	12	0
EU-28	10691	8207	4434	3224	2592	1668	2403	1577	2242	1429
Change to 2005			*-46%*	*-61%*	*-68%*	*-80%*	*-71%*	*-81%*	*-73%*	*-83%*

Table 2.2: Baseline emissions of SO_2 by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	32	27	20	20	19	16	18	15	16	14
Belgium	168	137	102	100	78	59	82	61	80	60
Bulgaria	940	901	569	129	115	66	92	44	91	42
Cyprus	48	39	24	10	5	2	5	2	5	2
Czech Rep.	277	199	168	142	93	78	90	77	81	68
Denmark	27	18	11	10	11	9	11	9	11	9
Estonia	85	77	14	16	15	12	14	11	14	10
Finland	77	72	48	39	34	30	34	29	34	28
France	635	469	297	207	191	125	181	122	173	118
Germany	619	512	365	333	314	285	307	272	281	241
Greece	551	541	291	126	115	44	93	40	82	36
Hungary	487	128	79	62	61	32	59	30	58	30
Ireland	136	78	34	33	29	20	25	18	22	16
Italy	756	381	226	230	213	98	165	93	167	92
Latvia	10	5	6	6	5	4	5	3	4	3
Lithuania	53	46	15	15	15	7	14	7	15	7
Luxembourg	2	2	1	1	1	1	1	1	1	1
Malta	24	13	11	5	3	0	2	0	1	0
Netherlands	75	66	45	47	45	33	46	33	48	33
Poland	1518	1263	744	574	427	267	412	259	387	241
Portugal	292	224	81	78	60	31	58	30	56	29
Romania	777	822	388	238	139	72	139	71	126	64
Slovakia	121	90	41	40	39	20	40	20	37	17
Slovenia	101	40	14	15	16	12	12	8	10	7
Spain	1547	1259	368	358	277	166	276	177	248	150
Sweden	44	35	30	27	26	26	26	26	26	26
UK	1211	689	384	321	222	144	170	108	145	82
EU-27	10613	8133	4376	3182	2567	1661	2377	1569	2218	1422
Croatia	78	74	58	42	24	8	26	8	24	6
EU-28	10691	8207	4434	3224	2592	1668	2403	1577	2242	1429
Change 2005			*-46%*	*-61%*	*-68%*	*-80%*	*-71%*	*-81%*	*-73%*	*-83%*

2.3 Nitrogen oxides (NO_x) emissions

NO_x emissions and their sectorial origin will change significantly in the future as a consequence of recent EU legislation. Overall, NO_x emissions are expected to decline by about 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 level (Figure 2.2).

With the assumptions on the effectiveness and implementation schedule of Euro-6, NO_x emissions from road vehicles should drop by 63% in 2020, and by 86% in the long-run compared to 2005. 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-28, the overall decline in NO_x emissions will strongly depend on the implementation success of new regulation for mobile sources.

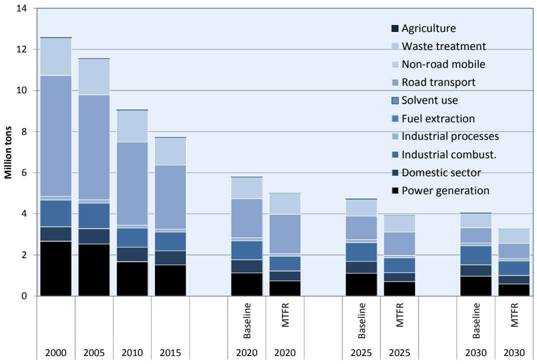

Figure 2.2: NO_x emissions by sector, EU-28

Table 2.3: NO_x emissions by SNAP sector, EU-28

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	2667	2537	1674	1515	1128	738	1108	704	972	591
Domestic sector	703	745	701	684	637	483	581	438	548	412
Industrial combust.	1302	1242	932	917	925	495	918	492	923	493
Industrial processes	197	182	161	157	160	134	162	134	161	134
Fuel extraction	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0
Road transport	5886	5110	4041	3118	1910	1767	1138	979	738	596
Non-road mobile	1809	1730	1535	1320	1027	1020	811	880	689	655
Waste treatment	11	10	9	7	6	3	6	3	6	3
Agriculture	30	28	27	27	27	0	27	0	27	0
EU-28	12603	11582	9080	7746	5820	4639	4751	3630	4066	2883
Change to 2005			*-22%*	*-33%*	*-50%*	*-60%*	*-59%*	*-69%*	*-65%*	*-75%*

Table 2.4: Emissions of NO_x by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	182	201	166	133	98	83	76	60	65	50
Belgium	340	303	241	221	174	140	159	118	146	104
Bulgaria	168	181	105	87	74	61	69	56	59	46
Cyprus	22	21	19	15	13	9	11	7	9	6
Czech Rep.	302	295	220	193	159	123	134	102	111	82
Denmark	218	186	126	107	85	73	70	60	61	47
Estonia	38	39	29	27	23	15	19	11	16	9
Finland	223	197	162	138	118	101	101	83	90	71
France	1583	1383	1015	835	621	503	476	359	412	295
Germany	1748	1453	1195	970	728	591	594	454	495	370
Greece	329	321	281	297	256	208	213	163	188	129
Hungary	177	166	141	119	86	64	69	47	59	38
Ireland	142	137	94	88	78	61	61	43	46	28
Italy	1465	1347	1083	903	693	555	564	482	498	373
Latvia	37	36	35	32	27	23	20	17	16	12
Lithuania	55	60	48	40	31	27	26	21	22	18
Luxembourg	39	49	40	33	20	17	13	10	9	7
Malta	9	11	8	6	4	4	3	3	2	2
Netherlands	402	371	276	243	188	153	154	120	136	103
Poland	825	778	713	602	460	383	392	311	340	260
Portugal	296	262	191	164	130	101	91	61	76	47
Romania	283	307	250	210	172	123	151	101	128	80
Slovakia	101	98	81	74	59	42	53	37	47	31
Slovenia	55	55	47	40	28	24	19	15	14	11
Spain	1492	1530	1080	961	695	544	570	413	457	287
Sweden	258	210	156	125	94	82	76	64	70	57
UK	1740	1508	1193	1015	656	489	527	380	454	299
EU-27	12527	11501	8998	7679	5768	4600	4708	3599	4028	2859
Croatia	77	81	82	67	51	39	43	31	38	24
EU-28	12603	11582	9080	7746	5820	4639	4751	3630	4066	2883
Change 2005			*-22%*	*-33%*	*-50%*	*-60%*	*-59%*	*-69%*	*-65%*	*-75%*

2.4 Fine particulate matter (PM2.5) emissions

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 2.3). 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.

As a side-effect of regulations for TSP and 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. The domestic sector will remain the largest source, but industrial emissions will gain higher relative shares as other sectors implement more ambitious control measures.

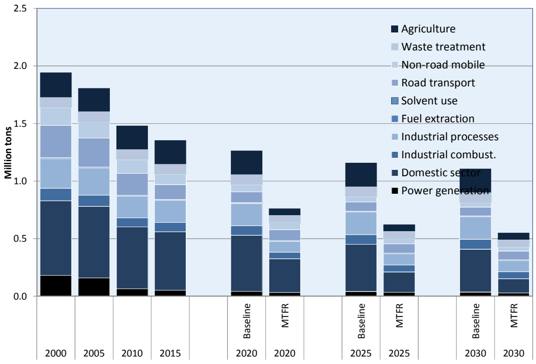

Figure 2.3: PM2.5 emissions by sector, EU-28

With the currently available technical measures, PM2.5 emissions in the EU-28 could be reduced by another 27% in 2020, and by 30% in 2030.

Most of this potential emerges in the domestic sector from small stoves, industrial processes and from a ban on the burning of agricultural waste.

Table 2.5: PM2.5 emissions by SNAP sector, EU-28 (kilotons)

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	182	159	65	52	43	33	42	33	36	28
Domestic sector	648	621	537	508	486	290	408	176	372	122
Industrial combust.	109	98	78	80	80	52	82	55	83	57
Industrial processes	302	279	233	237	237	137	240	139	241	140
Fuel extraction	9	9	8	7	7	7	7	7	6	6
Solvent use	0	0	0	0	0	0	0	0	0	0
Road transport	281	252	190	130	95	95	81	80	77	76
Non-road mobile	153	140	118	88	61	61	44	42	36	34
Waste treatment	91	90	90	89	89	64	90	65	90	65
Agriculture	214	204	205	206	207	55	207	56	207	57
EU-28	1987	1852	1525	1399	1305	794	1201	653	1150	585
Change to 2005			*-18%*	*-24%*	*-30%*	*-57%*	*-35%*	*-65%*	*-38%*	*-68%*

Table 2.6: Emissions of PM2.5 by country (kilotons and change relative to 2005)

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	22	23	18	16	14	11	13	9	13	8
Belgium	33	28	24	22	21	16	21	15	20	14
Bulgaria	47	53	38	37	34	14	31	11	29	9
Cyprus	3	3	2	2	1	1	1	1	1	1
Czech Rep.	42	46	43	40	37	19	36	15	33	13
Denmark	30	35	31	26	23	13	21	9	20	7
Estonia	21	20	10	9	8	5	8	4	7	3
Finland	35	32	25	23	22	14	21	11	19	9
France	399	344	282	255	240	155	216	127	212	114
Germany	157	141	123	111	105	75	101	68	99	62
Greece	58	57	46	41	36	20	32	17	30	15
Hungary	46	28	26	25	24	13	21	10	20	9
Ireland	15	14	11	9	9	7	8	6	7	5
Italy	163	143	124	111	102	76	93	65	94	63
Latvia	17	19	17	16	15	8	13	5	12	3
Lithuania	14	14	12	11	11	5	10	4	9	3
Luxembourg	3	3	3	2	2	2	2	2	2	1
Malta	1	1	1	0	0	0	0	0	0	0
Netherlands	27	27	22	19	17	12	17	11	17	11
Poland	231	233	205	198	192	128	168	95	154	78
Portugal	105	104	73	68	60	21	56	17	54	15
Romania	143	155	115	114	110	41	101	28	93	22
Slovakia	25	21	11	11	11	7	11	7	11	6
Slovenia	9	9	6	7	6	3	5	2	5	2
Spain	167	152	131	116	105	63	101	55	97	51
Sweden	35	32	26	22	21	16	21	16	21	16
UK	120	97	83	72	64	45	60	41	59	40
EU-27	1969	1833	1508	1383	1292	789	1188	649	1138	581
Croatia	19	19	17	15	13	5	12	4	12	4
EU-28	1987	1852	1525	1399	1305	794	1201	653	1150	585
Change 2005			*-18%*	*-24%*	*-30%*	*-57%*	*-35%*	*-65%*	*-38%*	*-68%*

2.5 Ammonia (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-28 are expected in the long run (Figure 2.4). While emissions declined between 2000 and 2010, they are expected to return to the 2005 level by 2030.

Current legislation on NH_3 emissions for the agricultural sector in the EU is not expected to lead to substantial changes in total agricultural emissions. Emissions from fertilizer use would 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.

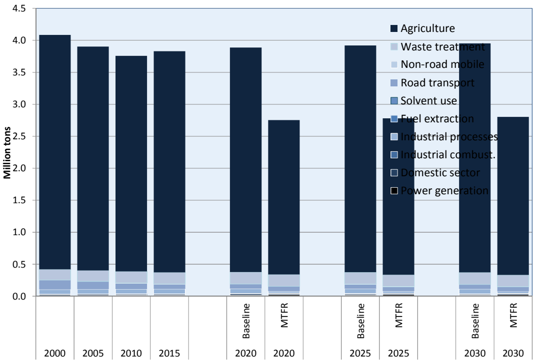

Figure 2.4: NH_3 emissions by sector, EU-28

However, there are technical measures available that could reduce (agricultural) ammonia emissions by up to 30% compared to the baseline projection.

Table 2.7: NH_3 emissions by SNAP sector, EU-28 (kilotons)

	2000	2005	2010	2015	2020		2025		2030	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	9	10	13	14	17	24	18	24	16	22
Domestic sector	18	19	19	19	20	18	18	17	17	16
Industrial combust.	3	3	4	4	5	8	4	7	4	7
Industrial processes	75	75	74	76	75	28	75	29	75	29
Fuel extraction	0	0	0	0	0	0	0	0	0	0
Solvent use	0	0	0	0	0	0	0	0	0	0
Road transport	149	125	96	78	75	75	73	73	73	73
Non-road mobile	1	1	1	1	1	1	1	1	1	1
Waste treatment	165	170	181	182	185	185	185	185	185	185
Agriculture	3665	3499	3370	3456	3511	2405	3545	2433	3580	2461
EU-28	4085	3902	3757	3830	3888	2744	3920	2770	3952	2793
Change to 2005			*-4%*	*-2%*	*0%*	*-30%*	*0%*	*-29%*	*1%*	*-28%*

Table 2.8: Baseline emissions of NH_3 by country (kilotons and change relative to 2005)

	2000	2005	2010	2015	2020		2025		2030	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	62	61	63	65	67	46	69	47	70	48
Belgium	85	74	75	78	78	64	80	66	81	67
Bulgaria	69	64	68	67	66	59	67	60	67	60
Cyprus	6	6	6	6	5	4	6	4	6	4
Czech Rep.	87	81	72	75	72	58	74	60	74	60
Denmark	94	74	62	60	57	43	57	44	57	43
Estonia	10	12	13	13	13	9	14	9	14	9
Finland	37	34	33	33	33	25	33	26	33	26
France	713	657	625	636	641	418	648	422	653	426
Germany	596	590	585	599	632	335	643	339	648	340
Greece	57	57	56	57	57	47	58	47	57	47
Hungary	77	77	68	76	80	57	75	54	74	54
Ireland	127	115	115	119	120	104	118	105	116	104
Italy	431	409	356	377	380	304	382	306	387	310
Latvia	13	13	15	15	16	13	17	14	18	15
Lithuania	38	44	49	49	51	33	51	33	52	33
Luxembourg	7	6	6	7	7	5	7	5	7	5
Malta	2	2	2	3	3	2	3	2	3	2
Netherlands	151	134	134	126	129	119	129	119	129	119
Poland	311	343	354	341	337	231	349	243	362	255
Portugal	73	73	68	70	71	49	73	50	74	51
Romania	170	161	151	145	142	115	129	105	127	102
Slovakia	30	28	39	43	43	32	43	32	44	33
Slovenia	20	19	19	19	19	16	19	16	19	16
Spain	383	365	335	360	372	229	378	232	377	232
Sweden	57	54	50	51	51	41	52	41	52	41
UK	350	320	310	312	314	267	316	270	319	272
EU-27	4057	3873	3729	3801	3859	2726	3889	2751	3921	2774
Croatia	28	29	28	29	29	18	30	19	31	20
EU-28	4085	3902	3757	3830	3888	2744	3920	2770	3952	2793
Change 2005			*-4%*	*-2%*	*0%*	*-30%*	*0%*	*-29%*	*1%*	*-28%*

2.6 Volatile organic compounds (VOC) emissions

EU legislation will cut baseline VOC emissions by about 40% up to 2030, with the largest decline before 2020 (Figure 2.5).

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. As a consequence of the tight regulations on emissions from mobile sources, about 50% of the remaining emissions will come from solvent use.

There are technical measures available that could reduce VOC emissions in Europe by up to 40% compared to the current legislation baseline, mainly from the solvents sector.

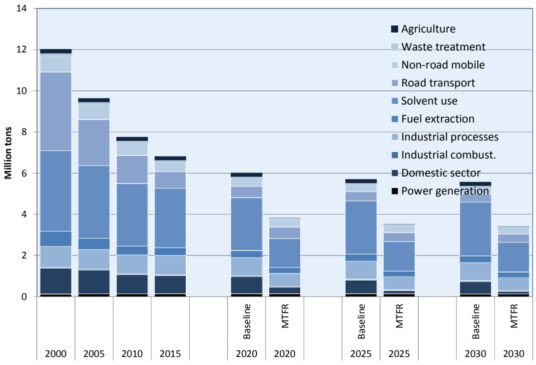

Figure 2.5: VOC emissions by sector, EU-28

Table 2.9: VOC emissions by SNAP sector, EU-28 (kilotons)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	130	144	141	146	145	145	145	145	133	133
Domestic sector	1258	1146	935	884	837	308	669	153	604	124
Industrial combust.	46	47	39	44	51	51	45	45	47	47
Industrial processes	1010	957	914	931	864	622	867	624	866	623
Fuel extraction	738	541	429	377	349	280	340	274	334	269
Solvent use	3909	3529	3044	2890	2569	1402	2588	1414	2607	1427
Road transport	3821	2243	1356	801	547	548	445	445	398	398
Non-road mobile	780	725	601	454	370	367	324	303	296	264
Waste treatment	123	113	107	99	94	83	94	83	94	83
Agriculture	210	195	195	195	194	0	194	0	193	0
EU-28	12026	9641	7761	6821	6020	3806	5710	3487	5574	3368
Change to 2005			*-20%*	*-29%*	*-38%*	*-61%*	*-41%*	*-64%*	*-42%*	*-65%*

Table 2.10: Emissions of VOC by country (kilotons and change relative to 2005)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	183	171	139	122	109	65	106	62	104	61
Belgium	229	184	142	132	124	95	123	90	124	89
Bulgaria	147	138	115	95	77	38	83	44	74	37
Cyprus	12	9	8	6	5	4	5	3	5	3
Czech Rep.	273	271	237	195	164	90	156	77	148	72
Denmark	152	135	103	86	74	44	69	38	65	36
Estonia	45	37	29	26	20	13	19	11	17	10
Finland	182	153	119	103	91	63	85	53	81	48
France	1835	1322	915	810	757	487	686	438	674	424
Germany	1609	1333	1132	1010	891	547	863	519	849	507
Greece	348	300	241	198	151	99	130	76	124	71
Hungary	175	156	134	127	103	58	94	49	88	47
Ireland	89	70	56	54	50	30	48	27	47	26
Italy	1705	1267	981	814	714	506	680	466	678	459
Latvia	73	69	63	55	46	20	42	15	38	14
Lithuania	78	75	65	60	47	25	44	22	41	21
Luxembourg	21	15	10	7	6	5	6	4	6	4
Malta	5	4	3	3	3	1	3	1	3	2
Netherlands	296	228	175	163	151	114	151	113	151	112
Poland	746	629	564	505	448	250	401	200	381	182
Portugal	289	236	193	177	159	96	153	90	150	88
Romania	436	455	396	347	280	122	254	99	239	91
Slovakia	73	68	65	60	52	33	50	30	49	28
Slovenia	60	44	34	33	31	14	26	12	24	11
Spain	1092	943	749	672	599	398	590	386	586	380
Sweden	269	205	156	130	115	82	112	77	110	76
UK	1502	1017	838	751	683	462	671	446	664	437
EU-27	11923	9535	7661	6741	5951	3762	5649	3450	5520	3335
Croatia	102	106	100	81	69	44	61	37	54	33
EU-28	12026	9641	7761	6821	6020	3806	5710	3487	5574	3368
Change 2005			*-20%*	*-29%*	*-38%*	*-61%*	*-41%*	*-64%*	*-42%*	*-65%*

2.7 Emissions of non-EU countries and marine shipping

Due to the long-range transport of air pollutants, air quality within the EU is substantially influenced by emissions outside the territories of EU Member States. While emissions from non-EU countries and marine shipping are not in the focus of this report, the impact calculations for the EU Member States need to consider the likely development of emissions outside the EU and the potential for further emission reductions in these areas.

For the non-EU countries, calculations assume for 2020 the activity projections and current legislation control measures that have been used for the negotiations of the revised Gothenburg protocol (Amann, Bertok, Borken-Kleefeld, Cofala, Heyes, Höglund-Isaksson, Klimont, Rafaj, et al., 2011). Beyond 2020, the energy projections developed within the FP7 EnerGeo project (www.energeo-project.eu) that rely on scenarios developed with the POLES energy model have been employed, together with information on the penetration of already agreed national emission control measures.

For marine shipping activities, this report uses historic and future emissions of air pollutants as provided by their recent report to DG-ENV (Campling et al., 2012). Estimates (Table 2.16 to Table 2.19) cover only the EMEP modelling domain; estimates for 2005, 2020 and 2030 are taken from the report, while data for the year 2025 have been linearly interpolated. For 2000, estimates have been extrapolated based on fuel consumption.

It should be noted that these emissions were taken from the draft report by VITO presented in June 2012. The final baseline will incorporate forthcoming updates that will be provided in the final version of the VITO report

Table 2.11: Emissions of SO_2 by country (kilotons and change relative to 2005), for the baseline and the MCE scenarios

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MCE	Baseline	MCE	Baseline	MCE
Albania	12	19	16	12	14	5	16	5	19	5
Belarus	172	85	81	94	92	38	87	40	90	36
Bosnia-H	193	225	224	212	36	10	47	8	57	7
FYR Macedonia	107	104	117	98	19	6	19	5	17	3
R Moldova	9	7	4	4	3	2	3	2	4	2
Norway	27	26	24	27	28	24	32	25	30	25
Russia	1986	1911	1524	1520	1571	297	1625	281	1683	280
Serbia-M	452	454	437	418	84	35	92	27	99	18
Switzerland	21	20	19	16	14	10	15	10	14	10
Turkey	1805	1462	1868	2025	2087	316	2124	255	2316	224
Ukraine	1349	1063	1115	1162	483	119	412	100	532	108
Non-EU	6131	5377	5430	5587	4431	862	4471	756	4862	718
Change to 2005			*1%*	*4%*	*-18%*	*-83%*	*-17%*	*-86%*	*-10%*	*-87%*

Table 2.12: Emissions of NO_x by country (kilotons and change relative to 2005), for the baseline and the MCE scenarios

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MCE	Baseline			
Albania	16	19	18	19	20	18	21	18	23	18
Belarus	186	178	164	161	165	107	167	100	172	98
Bosnia-H	35	33	32	31	22	15	25	14	27	14
FYR Macedonia	36	35	37	31	22	15	20	12	19	11
R Moldova	22	27	19	17	16	12	16	11	16	10
Norway	184	179	158	171	157	108	148	87	145	78
Russia	3246	3514	2150	1862	1692	1038	1555	920	1573	888
Serbia-M	136	165	148	124	88	61	85	49	82	40
Switzerland	106	85	75	69	56	45	46	34	40	26
Turkey	856	859	982	1020	1066	628	1130	599	1284	586
Ukraine	946	964	649	618	528	347	540	336	596	365
Non-EU	5769	6058	4432	4124	3834	2393	3752	2180	3977	2135
Change to 2005			*-27%*	*-32%*	*-37%*	*-60%*	*-38%*	*-64%*	*-34%*	*-65%*

Table 2.13: Emissions of PM2.5 by country (kilotons and change relative to 2005), for the baseline and the MCE scenarios

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
					Baseline	MCE	Baseline	MCE	Baseline	MCE
Albania	9	9	9	9	8	4	8	3	8	2
Belarus	51	54	50	51	52	21	53	19	54	16
Bosnia-H	15	20	15	14	9	4	9	3	9	2
FYR Macedonia	13	12	12	10	6	2	5	1	5	1
R Moldova	10	10	10	10	10	3	10	2	10	2
Norway	67	53	42	38	38	30	41	26	40	21
Russia	734	756	740	770	766	197	760	188	778	178
Serbia-M	76	71	67	65	48	18	47	12	46	8
Switzerland	10	11	11	9	8	5	8	4	8	4
Turkey	381	350	382	411	423	144	446	127	474	118
Ukraine	365	391	353	355	337	66	351	66	416	74
Non-EU	1731	1739	1689	1743	1706	493	1738	452	1847	427
Change to 2005			-3%	0%	-2%	-72%	0%	-74%	6%	-75%

Table 2.14: Emissions of NH_3 by country (kilotons and change relative to 2005), for the baseline and the MCE scenarios

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
					Baseline	MCE	Baseline	MCE	Baseline	MCE
Albania	18	17	19	21	22	17	21	16	22	20
Belarus	114	117	153	155	157	106	161	109	164	111
Bosnia-H	17	18	19	20	22	16	24	17	25	19
FYR Macedonia	10	9	8	8	8	6	7	5	7	8
R Moldova	17	16	14	15	17	12	18	12	18	13
Norway	25	24	23	23	24	18	25	19	25	17
Russia	553	492	529	543	549	392	562	402	574	412
Serbia-M	66	64	56	56	54	35	49	32	46	32
Switzerland	62	62	64	64	65	58	64	58	64	58
Turkey	424	416	492	477	519	377	547	399	583	436
Ukraine	301	253	251	275	283	187	292	193	302	200
Non-EU	1606	1488	1628	1657	1720	1224	1769	1261	1832	1326
Change to 2005			*9%*	*11%*	*16%*	*-18%*	*19%*	*-15%*	*23%*	*-11%*

Table 2.15: Emissions of VOC by country (kilotons and change relative to 2005), for the baseline and the MCE scenarios

	2000	*2005*	*2010*	*2015*	*2020*		*2025*		*2030*	
					Baseline	MCE	Baseline	MCE	Baseline	MCE
Albania	30	34	32	29	27	10	26	8	25	8
Belarus	211	200	195	173	169	86	152	73	147	69
Bosnia-H	53	44	38	34	30	10	27	9	26	8
FYR Macedonia	29	23	20	17	14	6	12	5	11	4
R Moldova	25	30	28	25	23	10	21	8	20	7
Norway	381	207	141	117	103	63	104	63	105	62
Russia	2816	2674	2204	1895	1692	688	1612	653	1598	648
Serbia-M	136	169	152	132	117	44	105	34	99	30
Switzerland	154	118	93	86	81	49	80	48	80	46
Turkey	864	697	655	617	569	301	550	275	539	270
Ukraine	569	590	471	396	350	148	331	155	320	154
Non-EU	5267	4787	4029	3520	3174	1415	3019	1330	2969	1309
Change to 2005			*-16%*	*-26%*	*-34%*	*-70%*	*-37%*	*-72%*	*-38%*	*-73%*

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Table 2.16: SO_2 emissions from marine shipping (kilotons)

	2000	***2005***	***2020***		***2025***		***2030***	
			Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Atlantic Ocean	284	313	90	19	98	20	106	22
Baltic Sea	118	130	8	8	9	9	9	9
Black Sea	32	35	11	2	12	2	12	3
Mediterranean Sea	621	683	191	42	206	46	222	49
North Sea	281	309	19	19	20	20	22	22
Sum	1336	1469	319	90	345	97	370	105
Change to 2005			*-78%*	*-94%*	*-77%*	*-93%*	*-75%*	*-93%*

Table 2.17: NO_x emissions from marine shipping (kilotons)

	2000	***2005***	***2020***		***2025***		***2030***	
			Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Atlantic Ocean	480	528	602	371	636	289	670	208
Baltic Sea	200	220	234	144	243	111	252	78
Black Sea	55	60	65	40	68	31	71	22
Mediterranean Sea	1051	1156	1283	791	1347	614	1411	437
North Sea	471	518	574	354	600	274	626	194
Sum	2256	2482	2759	1700	2894	1320	3029	939
Change to 2005			*11%*	*-32%*	*17%*	*-47%*	*22%*	*-62%*

Table 2.18: PM2.5 emissions from marine shipping (kilotons)

	2000	***2005***	***2020***		***2025***		***2030***	
			Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Atlantic Ocean	34	38	32	22	35	17	37	12
Baltic Sea	12	13	11	9	12	7	13	5
Black Sea	3	4	3	2	3	2	4	1
Mediterranean Sea	71	78	65	44	70	35	75	25
North Sea	17	19	29	22	31	17	33	12
Sum	137	151	140	99	151	77	162	55
Change to 2005			-7%	-34%	0%	-49%	7%	-63%

Table 2.19: VOC emissions from marine shipping (kilotons)

	2000	***2005***	***2020***		***2025***		***2030***	
			Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Atlantic Ocean	16	17	17	17	18	18	19	19
Baltic Sea	7	8	7	7	7	7	8	8
Black Sea	2	2	2	2	2	2	2	2
Mediterranean Sea	36	39	38	38	39	39	41	41
North Sea	16	17	16	16	17	17	18	18
Sum	76	84	80	80	84	84	87	87
Change to 2005			-4%	-4%	0%	0%	4%	4%

2.8 Long-term emission scenarios

To explore the long-term perspectives for achieving the objectives of the 6th Environment Action Programme of the EU, i.e., to achieve ‘levels of air quality that do not give rise to significant negative impacts on, and risks to human health and environment’, a series of long-term emission scenarios to 2050 has been developed. They include an extension of the baseline projections to 2050 and a decarbonisation scenario assuming no further legislation on air pollution, and variants that explore the scope for further add-on emission controls on these two alternative energy pathways. These scenarios are described in more detail in Amann et al., 2012.

For SO_2 and NOx, the changes in energy use in the decarbonisation scenario without further air pollution controls would reduce emissions to a level that would emerge from the full application of all technically available emission control measures to the baseline energy consumption (ref). In contrast, PM2.5 and VOC emissions are mainly determined by the stringency of pollution control measures, while future NH_3 emissions depend obviously on the level of agricultural activities.

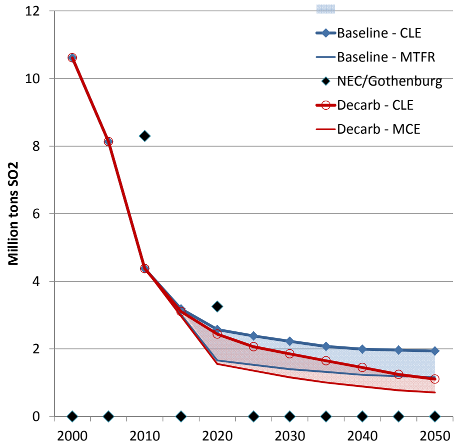


Figure 2.6: **Time evolution of SO_2 emissions for the different scenarios for the EU-27**

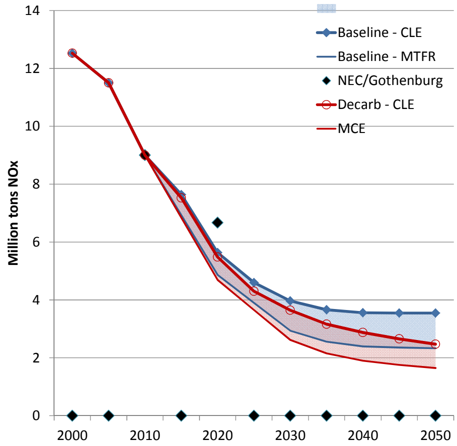


Figure 2.7: Time evolution of NO_x emissions for the different scenarios for the EU-27

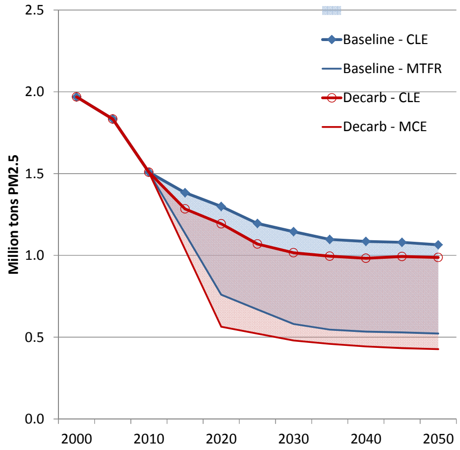


Figure 2.8: Time evolution of PM2.5 emissions for the different scenarios for the EU-27

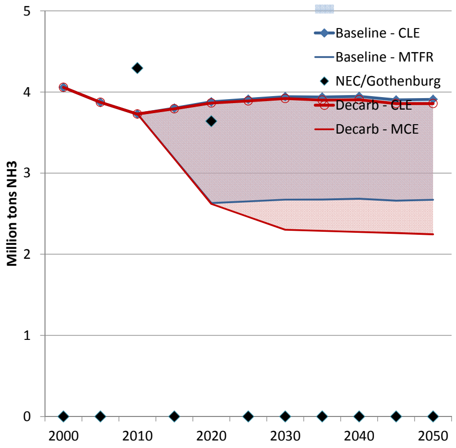


Figure 2.9: Time evolution of NH_3 emissions for the different scenarios for the EU-27

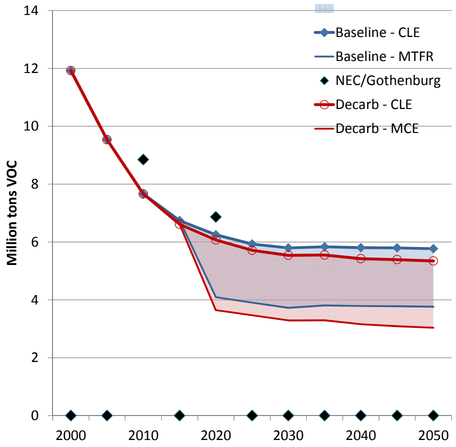


Figure 2.10: Time evolution of VOC emissions for the different scenarios for the EU-27

3 Impact indicators

The following section presents a series of indicators to characterize the effects of future air pollution emission scenarios on human health and ecosystems. Indicators are presented for the current legislation baseline case, as well as for the maximum feasible implementation of currently available technical emission control measures (MTFR). First, a long-term perspective up to 2050 is introduced that outlines the range in which air pollution impacts could develop in Europe as a consequence of the long-term emission scenarios presented in TSAP Report #1. The subsequent section discusses then in more detail the various environmental endpoints up to the year 2030.

3.1 A long-term perspective up to 2050

The envisaged emission reductions of the TSAP-2012 baseline scenario will significantly alleviate the impacts of air pollution on human health and ecosystems. With the exception of ammonia emissions, for which no major changes in their drivers, i.e., agricultural activities, are foreseen in the baseline case, continued structural changes in the energy systems as well as the further penetration of emission control measures will further decrease environmental impacts, even in the long-run. However, analysis shows that the fast improvements that have occurred since 2000 will drastically slow down in the baseline case after 2020 if no further measures are taken.

The future development of economic activities will have a certain impact on air quality; however, its extent depends strongly on the type of impact. This section presents a general perspective on the long-term evolution of air quality impacts in the EU and illustrates the range for future policy interventions via climate/energy policy measures and more stringent requirements for end-of-pipe emission controls. The analysis employs the scenarios presented in TSAP report #1 (Amann et al., 2012), i.e.:

- the TSAP-2012 (in its updated form as presented here),
- the maximum technically feasible emission controls (MTFR) applied to the (PRIMES 2010) baseline energy consumption,
- a decarbonisation (Decarb) scenario with current legislation on air pollution, and
- a maximum control efforts (MCE) scenario that assumes full implementation of available air pollution controls to the decarbonisation pathway, complemented by a an agricultural scenario that responds to a switch to health-diet.

For health impacts from fine particulate matter, the decarbonisation scenario without any further air pollution measures would lead in the long run to approximately 10% less premature mortality than the TSAP-2012 baseline. This improvement is significantly lower than what can be achieved by additional air pollution measures (-28% in 2050). Combined, decarbonisation together with stringent air pollution controls could reduce health impacts up to 40% in 2050 (Figure 3.1).

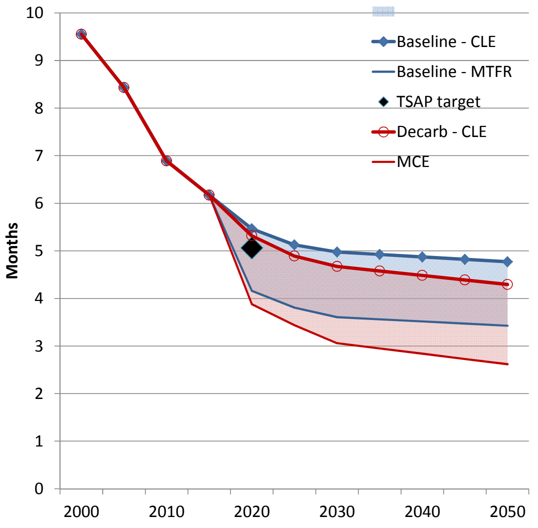


Figure 3.1: Loss in statistical life expectancy attributable to PM2.5

For health impacts from ground-level ozone, the co-benefits of a decarbonisation scenario could achieve almost two-thirds of the potential improvements from a full application of end-of-pipe measures (Figure 3.2). In addition, such a decarbonisation scenario would open the scope for further end-of-pipe measures, so that in 2050 health impacts from ozone could be reduced by 33% below the baseline or by more than 50% compared to 2000.

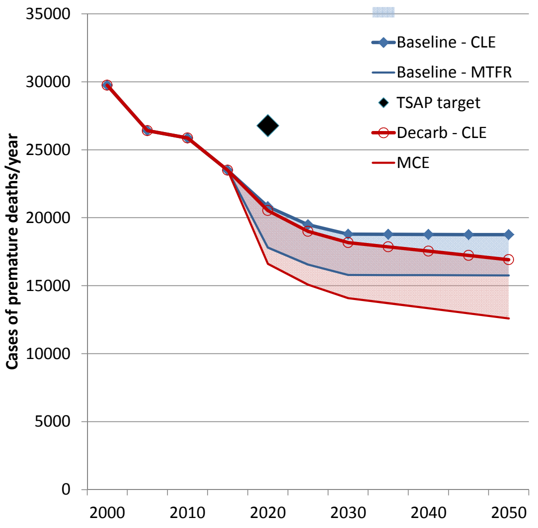


Figure 3.2: Premature deaths attributable to ground-level ozone

In contrast, the fate of future eutrophication of ecosystems is only little influenced by the climate policy of a future energy scenario. However, the scope for environmental improvements widens up by almost a factor of two if agricultural activities were adjusted to meet the food demand for the healthy diet scenario (Figure 3.3).

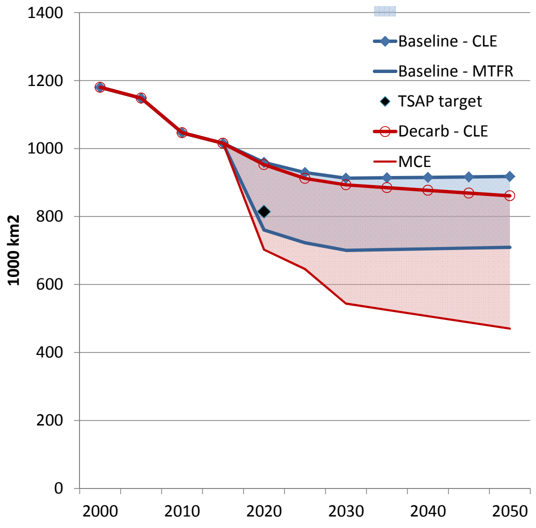


Figure 3.3: Ecosystems area with nitrogen deposition above their critical loads for eutrophication

The baseline development for the acidification of forest soils and freshwater bodies depends strongly on the assumptions about future climate policies (Figure 3.4, Figure 3.5), as these determine the future level of coal use and thereby of SO_2 emissions. In these cases, the decarbonisation scenario without any further air pollution control measures will yield the same benefits for acidification that alternatively could be achieved from a full application of all available end-of-pipe emission control measures.

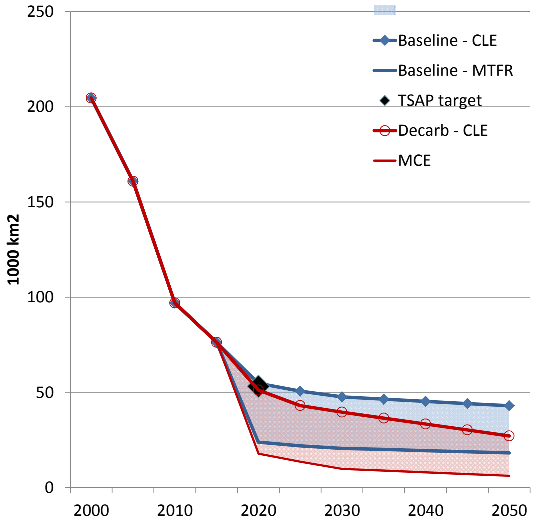


Figure 3.4: Forest area with deposition above their critical loads for acidification

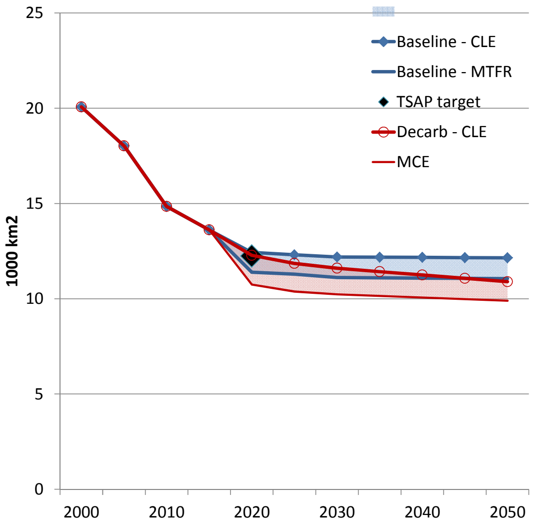


Figure 3.5: Freshwater catchment area with deposition above the critical loads for acidification

3.2 The scope for health and environmental improvements up to 2030

This section provides more detailed results of the air quality impacts of the TSAP-2012 baseline scenario up to 2030 and the scope for further improvements that could be achieved through full implementation of all technically available emission control measures. Due to their preliminary nature, however, this section does not deal with impacts and potential further measures of the decarbonisation and MCE scenarios. It is planned to present such analyses in the final round of model calculations when the PRIMES 2012 scenario will be available.

This section quantifies the improvements in air quality impacts that could be achieved in the future by additional emission control measures in the EU. However, it is clear that sources outside the EU territory, i.e., in non-EU countries and marine shipping, make significant contributions to air quality within the EU, and further measures in these areas could certainly bring additional environmental benefits within the EU. To illustrate the scope for measures outside the EU-territory, impact maps are presented for 2030 assuming the 'Maximum Control Efforts' scenario both for the EU and the non-EU sources.

3.2.1 Health impacts from fine particulate matter

It is estimated that the decrease in the precursor emissions of ambient PM2.5 has reduced the loss of statistical life expectancy in the EU attributable to the exposure to fine particulate matter (PM2.5) from 9.6 months in 2000 to 6.9 months in 2010. The TSAP-2012 baseline projection suggests a further cut to 5.5 months in 2020, and to 5.0 months in 2030.

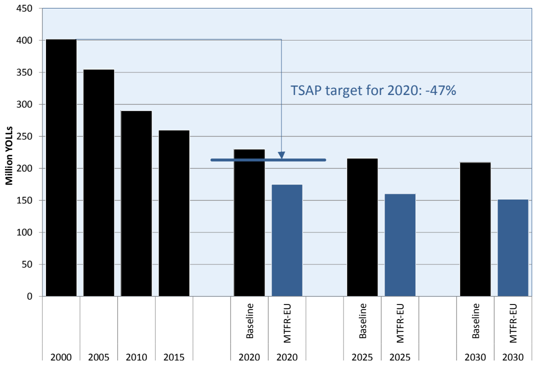


Figure 3.6: Years of life lost (YOLLs) due to exposure to PM2.5 from anthropogenic sources (million YOLLs)

In 2000, life shortening exceeded 12 months in Greece, Italy and Poland. The anticipated changes in emissions would lead to significant improvements throughout Europe, although in Belgium, Poland, the Czech Republic, Hungary and Romania people would still lose more than six months even in 2030 (Table 3.1).

With the additional technical measures that could be implemented within the EU, this life shortening could be further reduced by up to 30% or by 2030 down to about 3.6 months on average. Thereby, these improvements would yield approximately 55 million life years to the European population (Table 3.2).

It should be noted that all these numbers are provisional, subject to change following advice of the WHO REVIHAAP project on an updated health impact methodology that is expected for early 2013.

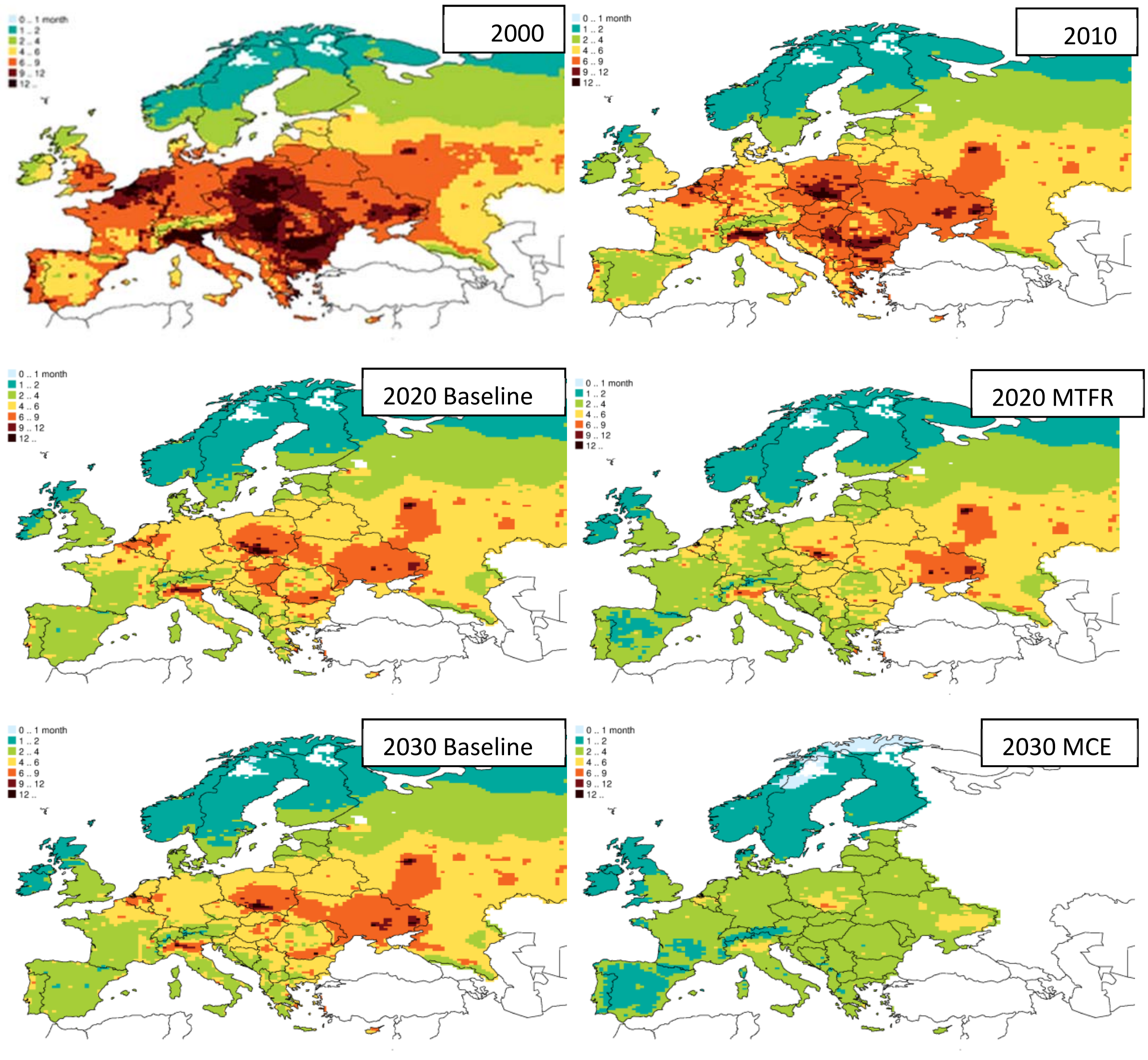


Figure 3.7: Loss of statistical life expectancy from the exposure to fine particulate matter (months)

While the current estimates still apply the relative risk factors for all-cause mortality provided by Pope et al., 2002, they employ improved atmospheric dispersion calculations with the 2012 version of the EMEP model at a spatial resolution of 28 km*28km downscaled to 7*7 km instead of 50*50 km and considering the contribution of secondary organic aerosols. Despite these modifications, relative changes in health impacts between 2000 and the baseline projection of 2020 remain robust. Obviously, the inclusion of secondary organic aerosols (SOA) increases modeled levels of PM2.5, which lead to higher loss in statistical life expectancy. For instance, earlier estimates , e.g., for the revision of the Gothenburg Protocol (Amann, Bertok, Borken-Kleefeld, Cofala, Heyes, Höglund-Isaksson, Klimont, Rafaj, et al., 2011) estimated for the year 2000 a life shortening of 8.1 months, while the current methodology yields 9.6 months.

Larger changes emerge for the number of years of life lost (YOLLs). While the old methodology counted lost life years only for the people that were older than 30 years in 2010, the new methodology considers also the impacts for people who will reach 30 years after 2010 and will equally benefit from lower exposure during their remaining life time. Thus, e.g., for the emissions of the year 2000, the new methodology delivers now 398 million YOLLs, while the former metric resulted in 204 million YOLLs. Note that this increase is a composite result of improved spatial resolution, inclusion of SOA and the consideration of benefits to younger cohorts.

Table 3.1: Loss in statistical life expectancy due to the exposure to PM2.5 from anthropogenic sources (months)

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	8.1	7.3	5.9	5.4	4.7	3.7	4.4	3.4	4.2	3.2
Belgium	11.7	10.1	8.5	7.7	6.9	5.3	6.6	5.1	6.5	4.9
Bulgaria	11.0	11.0	10.1	7.2	6.1	4.7	5.8	4.3	5.6	4.2
Cyprus	7.2	6.3	6.3	6.0	5.8	5.6	5.8	5.6	6.1	5.9
Czech Rep.	9.8	9.0	7.7	7.1	6.3	4.7	6.0	4.3	5.7	4.0
Denmark	6.7	6.3	5.2	4.6	4.0	3.1	3.9	2.9	3.7	2.7
Estonia	5.0	4.7	3.9	3.7	3.4	2.9	3.3	2.8	3.3	2.8
Finland	4.0	3.7	3.1	2.9	2.7	2.4	2.6	2.3	2.6	2.2
France	10.4	8.7	6.9	6.1	5.5	4.1	5.0	3.6	4.9	3.4
Germany	8.9	7.8	6.4	5.9	5.4	4.2	5.2	3.9	5.1	3.7
Greece	12.9	12.2	10.0	8.0	6.8	5.3	6.1	4.7	6.0	4.6
Hungary	11.7	10.0	8.5	7.9	6.8	5.0	6.4	4.6	6.2	4.4
Ireland	4.2	3.6	2.9	2.7	2.4	2.1	2.2	1.9	2.1	1.8
Italy	12.2	10.1	7.9	7.1	6.2	4.7	5.6	4.2	5.5	4.0
Latvia	5.8	5.8	5.2	4.9	4.5	3.6	4.3	3.3	4.2	3.2
Lithuania	6.6	6.3	5.4	5.2	4.7	3.9	4.6	3.7	4.5	3.6
Luxembourg	10.0	9.1	7.5	6.7	6.0	4.7	5.7	4.3	5.5	4.1
Malta	7.7	7.0	5.7	4.9	4.2	3.7	4.1	3.7	4.1	3.7
Netherlands	10.0	8.7	7.1	6.3	5.6	4.4	5.4	4.2	5.3	4.1
Poland	12.0	11.5	10.2	9.4	8.5	6.2	7.9	5.5	7.6	5.2
Portugal	9.9	9.1	6.3	5.8	5.2	3.4	4.8	3.0	4.6	2.8
Romania	11.3	11.2	9.5	8.3	7.0	4.9	6.6	4.4	6.3	4.1
Slovakia	9.7	8.3	7.1	6.7	6.0	4.5	5.8	4.3	5.7	4.2
Slovenia	9.9	8.4	6.7	6.3	5.5	4.0	5.0	3.6	4.8	3.4
Spain	8.0	7.4	5.5	5.0	4.3	3.3	4.2	3.1	4.0	2.9
Sweden	3.7	3.4	2.8	2.6	2.4	2.1	2.3	2.1	2.3	2.1
UK	7.0	5.7	4.8	4.2	3.6	2.9	3.4	2.7	3.2	2.6
EU-27	9.6	8.4	6.9	6.2	5.5	4.2	5.1	3.8	5.0	3.6
Croatia	8.9	8.0	7.0	6.3	4.9	3.7	4.6	3.5	4.5	3.4
EU-28	9.6	8.4	6.9	6.2	5.5	4.2	5.1	3.8	5.0	3.6
Change to 2000		*-12%*	*-28%*	*-35%*	*-43%*	*-56%*	*-46%*	*-60%*	*-48%*	*-62%*

Table 3.2: Years of life lost (YOLLs) due to the exposure to PM2.5 from anthropogenic sources (million YOLLs)

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	5.67	5.13	4.16	3.76	3.31	2.59	3.10	2.35	2.97	2.21
Belgium	10.46	9.03	7.61	6.88	6.12	4.76	5.93	4.52	5.79	4.35
Bulgaria	6.87	6.86	6.29	4.50	3.82	2.94	3.60	2.69	3.50	2.61
Cyprus	0.66	0.58	0.58	0.55	0.53	0.51	0.54	0.52	0.56	0.54
Czech Rep.	8.57	7.84	6.77	6.22	5.50	4.10	5.27	3.78	5.02	3.53
Denmark	3.09	2.92	2.39	2.12	1.87	1.45	1.78	1.33	1.73	1.27
Estonia	0.56	0.53	0.43	0.41	0.38	0.33	0.37	0.32	0.37	0.31
Finland	1.77	1.66	1.39	1.30	1.22	1.08	1.18	1.01	1.16	0.98
France	54.19	45.60	35.95	31.73	28.71	21.44	26.42	18.98	25.67	17.68
Germany	61.06	53.45	44.21	40.43	37.11	28.64	35.85	26.91	34.75	25.48
Greece	12.26	11.55	9.42	7.55	6.46	5.01	5.82	4.49	5.67	4.36
Hungary	9.71	8.34	7.11	6.59	5.62	4.16	5.29	3.82	5.13	3.68
Ireland	1.57	1.33	1.08	0.99	0.89	0.77	0.83	0.71	0.79	0.67
Italy	61.57	50.94	39.76	35.77	31.29	23.78	28.16	21.43	27.81	20.29
Latvia	1.10	1.09	0.97	0.91	0.84	0.68	0.81	0.62	0.78	0.60
Lithuania	1.82	1.74	1.51	1.43	1.31	1.08	1.27	1.02	1.25	1.01
Luxembourg	0.42	0.39	0.32	0.28	0.25	0.20	0.24	0.18	0.23	0.17
Malta	0.27	0.24	0.20	0.17	0.15	0.13	0.14	0.13	0.14	0.13
Netherlands	13.85	12.11	9.84	8.76	7.74	6.16	7.49	5.87	7.32	5.66
Poland	38.18	36.58	32.39	29.86	27.01	19.86	25.31	17.70	24.32	16.51
Portugal	8.78	8.13	5.64	5.20	4.59	3.03	4.27	2.66	4.07	2.50
Romania	20.19	19.99	16.94	14.85	12.59	8.82	11.73	7.80	11.26	7.39
Slovakia	4.40	3.77	3.23	3.04	2.72	2.06	2.63	1.96	2.58	1.90
Slovenia	1.68	1.42	1.13	1.06	0.93	0.67	0.84	0.61	0.80	0.58
Spain	30.77	28.32	21.12	19.12	16.66	12.82	15.98	11.99	15.38	11.23
Sweden	2.88	2.64	2.20	2.02	1.86	1.65	1.83	1.62	1.83	1.61
UK	36.22	29.69	24.67	21.86	18.65	15.02	17.34	13.89	16.76	13.24
EU-27	398.55	351.86	287.30	257.35	228.13	173.69	214.02	158.89	207.62	150.47
Croatia	3.27	2.94	2.57	2.33	1.79	1.36	1.71	1.29	1.66	1.25
EU-28	401.83	354.79	289.86	259.68	229.92	175.05	215.73	160.18	209.28	151.72
Change to 2000		*-12%*	*-28%*	*-35%*	*-43%*	*-56%*	*-46%*	*-60%*	*-48%*	*-62%*

3.2.2 Health impacts from ground-level ozone

It is estimated that the reduction of ozone precursor emissions in Europe between 2000 and 2010 has avoided about 3900 cases of premature deaths per year due to short-term exposure to ozone. For 2020, the TSAP-2012 baseline suggests a further decline by about 5000 cases/year, so that in total the number of premature deaths will be about 30% lower than in the year 2000. By 2030, the TSAP-2012 baseline results in a 37% decline relative to 2000, or 18,800 premature deaths per year in absolute terms.

The target of the 2005 TSAP for 2020, i.e., 10% lower mortality attributable to ground-level ozone, will be safely achieved in the new calculations for 2020, mainly due to more optimistic expectations on the development of hemispheric background ozone levels. Back in the early 2000s, assumptions on future hemispheric background ozone were based on extrapolations of the increasing ozone trends observed in Mace Head at the west coast of Ireland. Based on findings of the LRTAP Task Force on Hemispheric Transport of Air Pollution (HTAP), the current calculations adopt a more optimistic perspective about the future development and assume only little changes in the hemispheric ozone background around Europe for the coming decades.

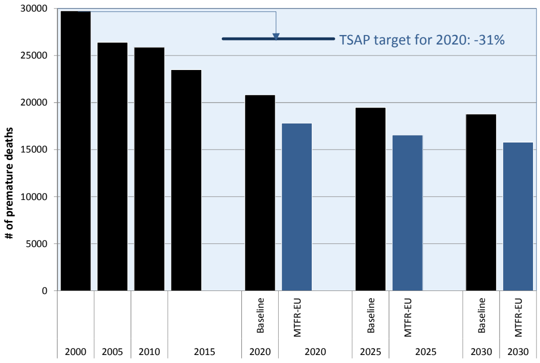


Figure 3.8: Premature deaths attributable to exposure to ground-level ozone (cases/year)

This more optimistic perspective offers also an enlarged scope for further reductions of health impacts from ozone. It is estimated that further technical measures within the EU could reduce premature mortality by 45-50% below the 2000 level (Table 3.3).

However, new research indicates potentially significant impacts on premature mortality from long-term exposure to ozone. As the WHO-REVIHAAP project has not yet provided advice on this issue, this effect is not yet quantified for the TSAP-2012 analyses.

Table 3.3: Cases of premature mortality attributable to exposure to ground-level ozone (cases per year)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	589	521	500	446	385	323	353	292	335	274
Belgium	416	351	388	356	320	270	303	252	294	243
Bulgaria	828	813	740	668	587	512	556	482	531	457
Cyprus	48	46	46	43	41	38	40	37	40	37
Czech Rep.	724	649	621	558	486	405	449	369	428	348
Denmark	214	189	190	175	156	135	148	127	143	123
Estonia	52	47	45	41	36	32	34	30	33	29
Finland	121	110	100	92	82	74	78	69	75	67
France	3051	2630	2469	2245	1984	1698	1835	1558	1762	1479
Germany	4721	4178	4144	3771	3340	2832	3123	2620	3007	2502
Greece	932	876	801	732	655	582	624	552	610	537
Hungary	1043	965	923	822	696	578	636	521	602	486
Ireland	75	68	71	67	63	58	61	56	60	55
Italy	6607	5526	5432	4839	4251	3577	3955	3325	3821	3146
Latvia	107	98	90	82	73	65	69	61	67	59
Lithuania	149	136	126	115	103	91	97	85	94	82
Luxembourg	34	27	30	28	24	21	22	19	21	18
Malta	29	26	25	23	20	18	19	17	19	16
Netherlands	499	420	480	443	399	338	379	319	369	308
Poland	2065	1863	1775	1606	1407	1194	1308	1096	1254	1043
Portugal	662	620	599	566	515	458	489	431	474	415
Romania	1817	1773	1658	1489	1294	1099	1210	1016	1156	964
Slovakia	348	320	306	274	234	194	215	176	204	164
Slovenia	162	143	138	122	103	85	93	75	88	70
Spain	2098	1895	1869	1746	1580	1394	1497	1311	1450	1259
Sweden	295	263	243	223	200	177	188	166	183	160
UK	1642	1470	1686	1595	1503	1331	1458	1284	1434	1259
EU-27	29328	26023	25494	23166	20538	17580	19237	16347	18552	15599
Croatia	422	386	376	330	276	226	250	203	236	187
EU-28	29750	26409	25870	23496	20814	17807	19487	16550	18788	15786
Change to 2000		*-11%*	*-13%*	*-21%*	*-30%*	*-40%*	*-34%*	*-44%*	*-37%*	*-47%*

3.2.3 Excess nitrogen deposition leading to eutrophication of ecosystems

In 2000, almost 1.2 million km^2 of ecosystems in Europe were exposed to nitrogen deposition that exceeded their critical loads for eutrophication (Table 3.3). Thereby, 70% of the total ecosystems area in Europe was at threat of biodiversity losses (Table 3.4).

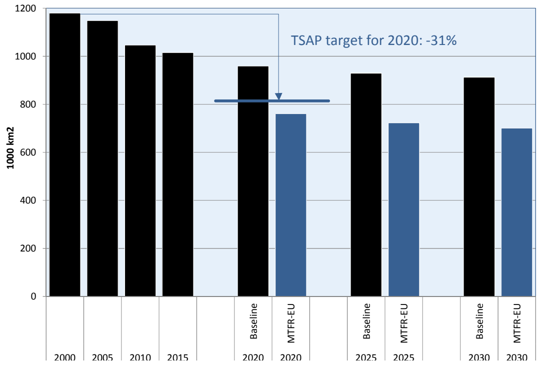


Figure 3.9: Ecosystems area with nitrogen deposition in excess of the critical loads for eutrophication

It is estimated that by 2010 the decline in NO_x emissions has lowered the unprotected area by about 11% or 130,000 km^2. For 2020, a further decline by another 8% or 90,000 km^2 is computed for the TSAP-2012 baseline. However, the cumulative reduction of 19% will fall short of the 31% target established by the 2005 Thematic Strategy on Air Pollution (Figure 3.9), mainly due to the lack of accompanying declines in NH_3 emissions.

This lack of further measures to control ammonia emissions is also the main reason why no significant changes are expected beyond 2020, unless effective NH_3 cuts were implemented. As there are clear potentials for mitigation of NH_3 emissions, additional measures could safely achieve the 2005 TSAP target, and safeguard ecosystems at another 210,000 km^2.

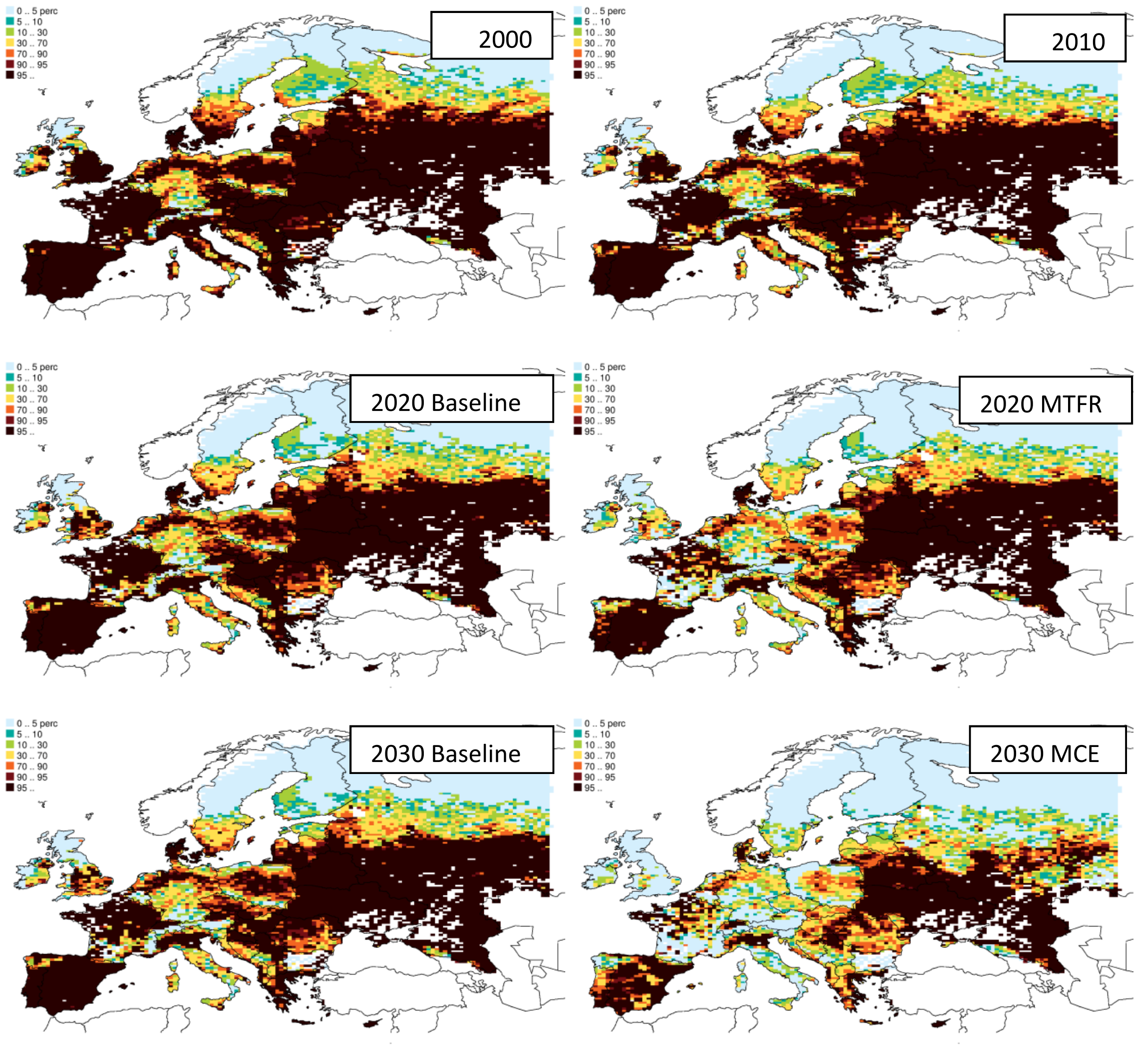


Figure 3.10: Percent of ecosystems area with nitrogen deposition above their critical loads for eutrophication. Note that for 2030 the impacts of the MCE scenario are shown, which assumes maximum measures also in the non-EU countries and for marine shipping.

Table 3.4: Percent of ecosystems area with nitrogen deposition in excess of the critical loads for eutrophication (%)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	81.6	79.6	68.6	63.5	56.0	25.1	51.3	20.7	49.2	18.7
Belgium	13.5	4.6	1.2	1.1	0.9	0.0	0.8	0.0	0.7	0.0
Bulgaria	77.4	75.0	63.1	56.9	44.4	33.4	40.8	30.3	38.2	30.3
Cyprus	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Czech Rep.	96.1	95.1	91.3	89.8	85.7	62.7	83.7	58.2	82.2	54.9
Denmark	100.0	100.0	99.7	99.7	99.5	98.5	99.3	97.1	99.3	96.8
Estonia	43.7	42.3	31.7	26.6	21.2	12.6	19.7	11.6	19.4	11.1
Finland	14.5	12.4	7.3	6.4	4.8	2.2	3.8	1.9	3.5	1.8
France	90.6	89.1	83.1	81.4	76.8	49.1	74.1	44.2	71.4	41.9
Germany	62.2	58.6	53.3	51.5	49.7	32.7	48.6	30.6	47.8	29.5
Greece	99.3	99.3	98.3	98.3	97.8	94.8	97.3	93.8	97.0	93.1
Hungary	100.0	100.0	99.5	97.1	94.3	68.5	88.8	66.9	85.9	66.6
Ireland	38.7	30.8	25.9	27.3	25.1	12.2	22.6	11.5	20.6	10.7
Italy	77.4	74.4	60.5	57.0	48.9	33.7	44.9	30.9	43.2	27.9
Latvia	93.8	93.3	90.9	87.7	82.8	64.7	81.2	62.6	80.5	61.1
Lithuania	98.9	98.9	98.3	97.7	97.3	89.2	97.0	88.3	97.0	88.0
Luxembourg	100.0	100.0	100.0	100.0	99.1	95.7	97.7	94.0	96.8	93.1
Malta										
Netherlands	92.0	90.1	89.4	88.3	88.1	82.9	87.6	81.1	87.3	80.7
Poland	79.0	78.0	73.1	70.4	66.7	48.1	65.7	46.5	65.6	45.9
Portugal	99.9	99.9	99.8	99.7	99.7	93.4	99.6	90.6	99.6	88.9
Romania	98.3	97.9	94.9	93.9	92.7	88.5	91.3	84.6	90.9	82.0
Slovakia	98.9	98.4	97.1	96.3	94.0	86.2	92.0	84.8	90.7	84.5
Slovenia	95.5	89.7	74.4	66.0	50.8	10.3	35.2	6.5	26.9	4.6
Spain	99.4	99.3	97.5	97.5	96.5	90.2	96.2	87.9	95.6	85.9
Sweden	43.1	39.4	29.0	26.6	23.0	14.9	21.5	13.4	20.9	12.5
UK	64.5	56.5	47.5	44.8	38.6	19.7	35.4	16.7	34.1	15.3
EU-27	69.7	67.8	61.7	59.9	56.5	44.7	54.8	42.5	53.8	41.1
Croatia	95.4	94.1	89.2	87.3	83.9	73.7	82.0	71.2	81.0	69.6
EU-28	70.1	68.3	62.2	60.4	57.0	45.2	55.3	43.0	54.3	41.7

Table 3.5: Ecosystems with nitrogen deposition in excess of their critical loads for eutrophication (1000 km^2)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	30.3	29.6	25.5	23.6	20.8	9.3	19.0	7.7	18.3	6.9
Belgium	0.7	0.3	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Bulgaria	33.0	32.0	26.9	24.3	18.9	14.3	17.4	12.9	16.3	12.9
Cyprus	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Czech Rep.	2.1	2.1	2.0	2.0	1.9	1.4	1.8	1.3	1.8	1.2
Denmark	4.3	4.3	4.3	4.3	4.3	4.2	4.2	4.2	4.2	4.1
Estonia	11.2	10.9	8.1	6.8	5.4	3.2	5.1	3.0	5.0	2.9
Finland	35.3	30.0	17.8	15.5	11.6	5.3	9.2	4.6	8.5	4.3
France	159.6	157.0	146.4	143.4	135.4	86.4	130.5	77.9	125.9	73.8
Germany	69.8	65.7	59.8	57.8	55.7	36.6	54.5	34.3	53.6	33.1
Greece	57.9	57.9	57.4	57.3	57.1	55.3	56.8	54.7	56.6	54.3
Hungary	23.8	23.8	23.7	23.2	22.5	16.3	21.2	16.0	20.5	15.9
Ireland	2.0	1.6	1.4	1.4	1.3	0.6	1.2	0.6	1.1	0.6
Italy	102.1	98.1	79.7	75.2	64.5	44.4	59.2	40.7	57.0	36.7
Latvia	32.9	32.7	31.9	30.8	29.0	22.7	28.5	21.9	28.2	21.4
Lithuania	19.3	19.3	19.2	19.1	19.0	17.5	19.0	17.3	19.0	17.2
Luxembourg	1.2	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	4.2	4.1	4.1	4.1	4.0	3.8	4.0	3.7	4.0	3.7
Poland	75.1	74.1	69.5	66.9	63.4	45.7	62.4	44.2	62.3	43.6
Portugal	32.7	32.7	32.7	32.7	32.6	30.6	32.6	29.7	32.6	29.1
Romania	95.2	94.8	91.8	90.9	89.7	85.6	88.3	81.8	88.0	79.4
Slovakia	22.3	22.2	21.9	21.7	21.2	19.4	20.8	19.1	20.5	19.0
Slovenia	10.3	9.7	8.1	7.1	5.5	1.1	3.8	0.7	2.9	0.5
Spain	211.8	211.6	207.8	207.8	205.7	192.2	205.1	187.4	203.8	183.2
Sweden	100.6	91.9	67.7	62.1	53.8	34.9	50.3	31.2	48.8	29.3
UK	10.2	8.9	7.5	7.1	6.1	3.1	5.6	2.6	5.4	2.4
EU-27	1150.6	1119.2	1019.0	988.6	933.3	737.7	904.2	701.1	887.9	679.2
Croatia	29.3	28.9	27.4	26.8	25.8	22.7	25.2	21.9	24.9	21.4
EU-28	1179.9	1148.1	1046.4	1015.4	959.1	760.4	929.4	723.0	912.8	700.6

3.2.4 Excess nitrogen deposition to the Natura2000 and other protected ecosystems areas

As a new element, critical loads data have been collected from the National Focal Centres for areas that are protected under the Birds Directive and the Habitat Directive (i.e., Natura2000 areas).

In addition to fragmentation and climate change, excess nitrogen deposition constitutes a major threat to biodiversity in these protected areas.

For 2010, it is calculated that 72% (or 393,000 km^2) of the protected zones received unsustainable levels of nitrogen deposition that posed a threat to the biodiversity in these areas. By 2030, the expected declines in NO_x emissions would reduce the threatened area to 62% and would leave 345,000 km^2 unprotected. Full application of the available measures to reduce ammonia emissions could safeguard biodiversity against excess nitrogen deposition in another 95,000 km^2 of the nature protection areas (Table 3.6, Table 3.7).

However, it should be noted that not all Member States have provided critical loads for their protected areas.

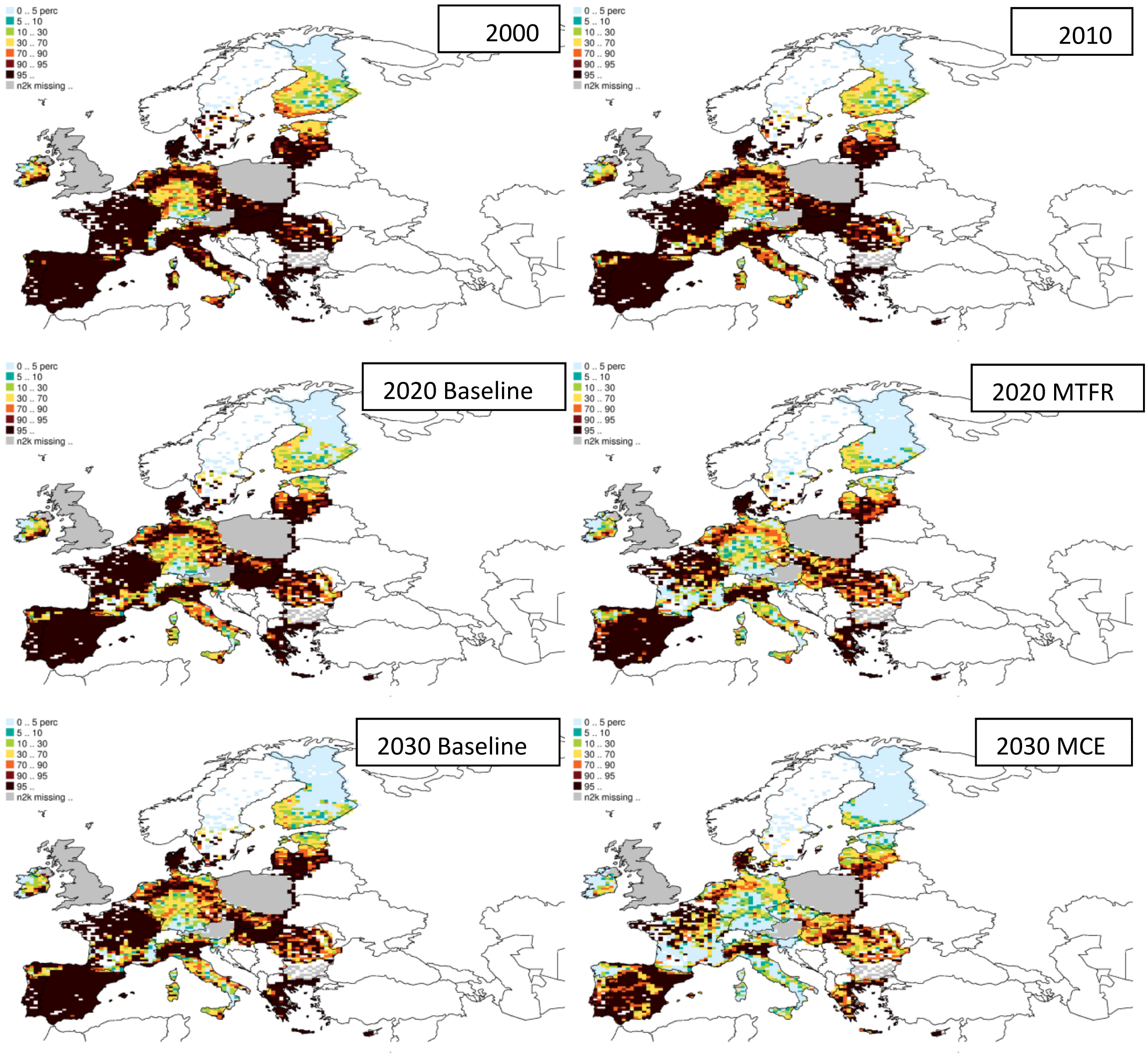


Figure 3.11: Percent of protected ecosystems under the Birds and Habitats Directives with nitrogen deposition above their critical loads for eutrophication. For grey-shaded areas, no critical loads for protected zones have been provided by National Focal Centres.

Table 3.6: Percent of Natura2000 areas with nitrogen deposition in excess of the critical loads for eutrophication (%)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria										
Belgium										
Bulgaria										
Cyprus	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Czech Rep.	93.6	92.3	88.0	86.1	79.3	51.9	76.4	47.4	74.6	44.6
Denmark	100.0	99.9	99.8	99.8	99.6	99.0	99.4	98.3	99.4	97.5
Estonia	51.2	50.1	42.5	36.8	31.5	19.8	30.4	17.8	30.0	16.7
Finland	5.1	4.6	3.6	3.1	2.4	1.3	1.9	1.2	1.7	1.2
France	87.8	86.7	80.3	78.6	73.7	44.9	71.1	39.4	68.1	36.8
Germany	60.8	57.7	53.6	51.6	49.6	31.6	48.4	29.3	47.6	28.1
Greece	99.5	99.4	97.9	97.8	97.6	95.9	97.3	95.1	97.0	94.7
Hungary	100.0	100.0	99.1	97.9	95.9	70.9	90.4	68.7	87.7	68.4
Ireland	37.8	32.1	26.9	28.3	26.2	14.9	24.7	14.1	22.4	13.0
Italy	76.9	73.2	58.5	54.7	45.8	30.0	41.5	27.0	39.7	24.3
Latvia	94.2	94.1	92.4	90.1	84.9	68.4	83.2	66.8	82.4	65.8
Lithuania	97.9	98.2	97.7	96.5	96.0	89.2	95.9	88.7	95.9	88.5
Luxembourg	100.0	100.0	100.0	99.9	99.2	92.6	96.7	88.6	94.0	86.6
Malta										
Netherlands	92.0	90.1	89.4	88.3	88.1	82.9	87.6	81.1	87.3	80.7
Poland										
Portugal	99.9	99.8	99.5	99.5	99.4	93.0	99.4	91.9	99.4	90.3
Romania	95.8	94.9	91.5	90.7	89.9	84.3	87.8	79.0	87.2	76.3
Slovakia	97.2	97.0	95.7	94.3	91.6	82.7	89.6	81.1	87.8	80.5
Slovenia	90.6	82.4	67.1	58.1	43.0	8.3	28.1	5.3	22.5	4.0
Spain	99.8	99.6	98.0	97.9	97.3	91.2	97.0	87.6	96.3	84.7
Sweden	52.4	49.5	38.5	33.5	27.0	19.0	24.9	17.4	24.1	16.3
UK										
EU-27	78.6	77.0	71.6	69.9	66.4	50.8	64.3	47.5	62.8	45.6
Croatia	99.9	98.8	97.6	93.0	87.9	70.4	86.4	66.0	82.7	65.5
EU-28	78.6	77.0	71.6	69.9	66.4	50.8	64.3	47.5	62.8	45.6

Table 3.7: Natura2000 areas with nitrogen deposition in excess of their critical loads for eutrophication (1000 km^2)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria										
Belgium										
Bulgaria										
Cyprus	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Czech Rep.	1.0	0.9	0.9	0.9	0.8	0.5	0.8	0.5	0.8	0.5
Denmark	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Estonia	3.2	3.1	2.6	2.3	1.9	1.2	1.9	1.1	1.8	1.0
Finland	2.0	1.9	1.4	1.2	0.9	0.5	0.8	0.5	0.7	0.5
France	117.4	116.0	107.5	105.1	98.6	60.1	95.1	52.8	91.1	49.3
Germany	55.9	53.0	49.2	47.4	45.6	29.0	44.4	26.9	43.7	25.8
Greece	17.2	17.1	16.9	16.9	16.8	16.6	16.8	16.4	16.7	16.3
Hungary	13.0	13.0	12.9	12.7	12.4	9.2	11.7	8.9	11.4	8.9
Ireland	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.0	0.1	0.0
Italy	61.7	58.8	47.0	44.0	36.8	24.1	33.4	21.7	31.9	19.5
Latvia	5.1	5.1	5.0	4.9	4.6	3.7	4.5	3.6	4.5	3.6
Lithuania	5.5	5.5	5.5	5.4	5.4	5.0	5.4	5.0	5.4	5.0
Luxembourg	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Malta										
Netherlands	4.2	4.1	4.1	4.1	4.0	3.8	4.0	3.7	4.0	3.7
Poland										
Portugal	9.3	9.3	9.3	9.3	9.3	8.7	9.3	8.6	9.2	8.4
Romania	22.1	21.9	21.1	20.9	20.7	19.4	20.2	18.2	20.1	17.6
Slovakia	10.8	10.8	10.6	10.5	10.2	9.2	10.0	9.0	9.8	9.0
Slovenia	6.6	6.0	4.9	4.2	3.1	0.6	2.1	0.4	1.6	0.3
Spain	91.6	91.5	90.0	89.9	89.3	83.7	89.1	80.4	88.4	77.8
Sweden	2.5	2.4	1.9	1.6	1.3	0.9	1.2	0.8	1.2	0.8
UK										
EU-27	432.0	423.2	393.6	384.1	364.7	279.0	353.3	261.2	345.0	250.5
Croatia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU-28	432.0	423.3	393.6	384.1	364.7	279.1	353.3	261.3	345.1	250.5

3.2.5 Acidification of forest soils

With the 2012 data set on critical loads (Posch et al., 2011), it is calculated that the critical loads for acidification have been exceeded in a forest area of more than 200,000 km^2 in the year 2000, i.e., in about 16% of the forests within the EU-28 for which critical loads have been reported. Especially the decline in SO_2 emissions has eliminated the threat from acidification of forest soils in 100,000 km^2 up to 2010, and for the baseline scenario the situation will resolve for another 50,000 km^2 up to 2020 (Table 3.8, Table 3.9). Thereby, the forest area with excess deposition would shrink by 73% between 2000 and 2020, which is close to the 74% established in the 2005 Thematic Strategy on Air Pollution. Additional measures within the EU could lead to further improvements, so that in 2030 more than 98% of forests could be protected. Full implementation of these additional measures could achieve protection also in the former 'black triangle' (i.e., in Poland, Czech Republic and the eastern parts of Germany), while residual problems would remain in the Netherlands due to high ammonia density (Figure 3.13).

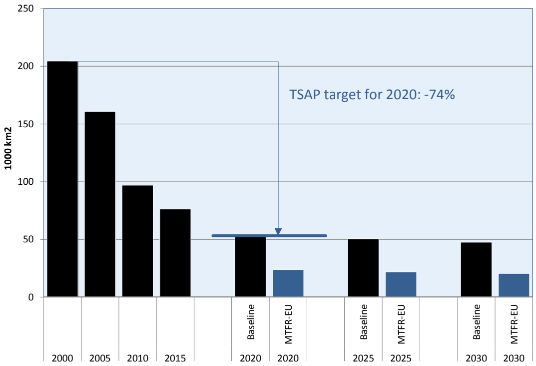


Figure 3.12: Forest area with acid deposition receiving acid deposition in excess of their critical loads

Although the calculations for the revision of the Gothenburg protocol critical loads data have been updated by national Focal Centres (further international harmonization of methodologies and a sharper definition of forest areas) and the resolution of the atmospheric dispersion calculation has been refined, computed relative changes for the baseline scenario remain robust also under the new methodology.

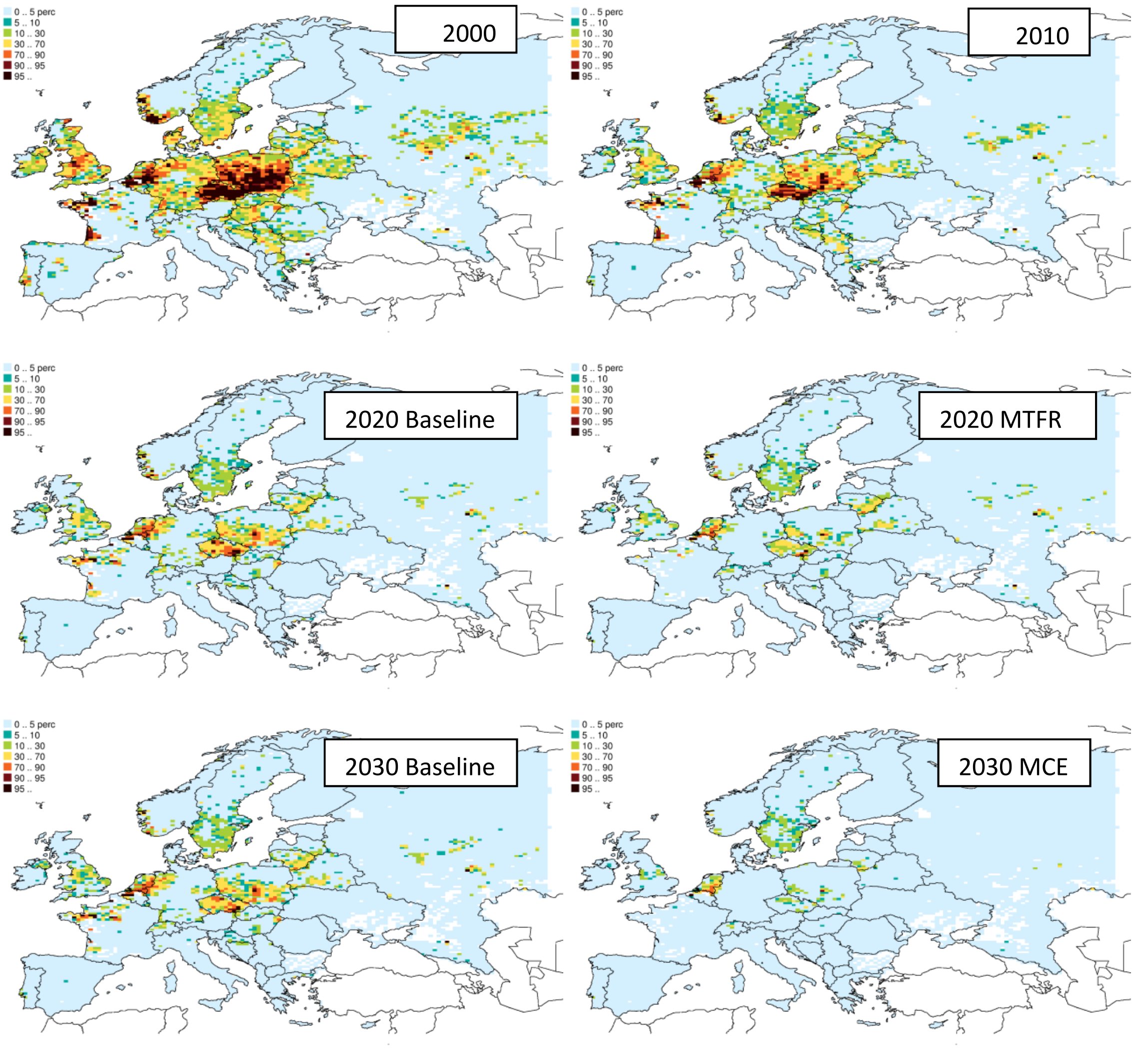


Figure 3.13: Percentage of forest area with acid deposition above critical loads

Table 3.8: Percent of forest area with acid deposition above their critical loads

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	1.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Belgium	19.7	12.2	7.9	6.2	3.1	0.4	2.6	0.4	2.1	0.4
Bulgaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Rep.	91.3	86.3	74.0	67.3	54.4	22.8	49.8	19.3	44.2	15.9
Denmark	72.8	57.3	24.6	14.9	2.2	0.5	2.2	0.4	1.9	0.4
Estonia	1.6	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finland	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	10.8	9.1	7.3	5.2	3.1	0.2	2.5	0.2	2.3	0.1
Germany	40.2	30.1	13.5	9.0	6.4	1.0	5.7	0.8	4.9	0.7
Greece	6.4	6.4	4.3	2.5	1.4	0.4	1.2	0.4	1.2	0.4
Hungary	45.9	22.8	11.1	9.7	8.3	3.8	7.6	3.6	7.6	3.2
Ireland	24.1	13.0	2.2	1.8	0.8	0.1	0.5	0.1	0.3	0.0
Italy	1.9	0.9	0.2	0.1	0.1	0.0	0.1	0.0	0.1	0.0
Latvia	28.1	24.0	12.5	9.2	5.6	2.4	5.1	2.3	4.9	2.3
Lithuania	45.4	45.0	43.1	42.2	39.9	35.2	39.5	34.4	39.3	34.4
Luxembourg	21.5	21.0	19.9	19.0	19.0	11.6	17.7	0.4	17.6	0.4
Malta										
Netherlands	88.3	85.9	81.3	79.3	77.0	65.3	76.1	64.3	75.3	63.3
Poland	64.8	55.8	38.5	30.2	20.4	7.1	19.1	6.3	18.1	5.6
Portugal	12.0	7.6	1.7	1.7	1.2	0.8	1.2	0.7	1.1	0.7
Romania	5.3	4.4	1.1	0.7	0.2	0.0	0.2	0.0	0.1	0.0
Slovakia	15.3	11.6	7.2	6.7	5.4	1.7	4.8	1.0	4.3	0.9
Slovenia	9.2	1.9	0.5	0.3	0.1	0.0	0.1	0.0	0.1	0.0
Spain	4.2	3.3	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.0
Sweden	11.8	8.3	3.8	3.1	2.4	1.7	2.3	1.6	2.2	1.6
UK	27.0	16.8	10.0	8.5	6.3	2.8	5.5	2.2	4.9	1.8
EU-27	15.9	12.5	7.5	5.9	4.3	1.9	3.9	1.7	3.7	1.6
Croatia	8.0	7.7	6.8	6.8	3.3	0.4	3.0	0.3	2.8	0.3
EU-28	15.8	12.5	7.5	5.9	4.2	1.8	3.9	1.7	3.7	1.6

Table 3.9: Forest area with acid deposition in excess of their critical loads for acidification (1000 km^2)

	2000	2005	2010	2015	2020		2025		2030	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Belgium	1.1	0.7	0.4	0.3	0.2	0.0	0.1	0.0	0.1	0.0
Bulgaria	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cyprus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Czech Rep.	2.0	1.9	1.6	1.5	1.2	0.5	1.1	0.4	1.0	0.3
Denmark	1.8	1.4	0.6	0.4	0.1	0.0	0.1	0.0	0.0	0.0
Estonia	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Finland	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
France	18.4	15.4	12.3	8.9	5.3	0.4	4.3	0.3	3.8	0.2
Germany	43.7	32.6	14.7	9.8	7.0	1.1	6.1	0.9	5.3	0.8
Greece	1.2	1.2	0.8	0.5	0.3	0.1	0.2	0.1	0.2	0.1
Hungary	6.7	3.3	1.6	1.4	1.2	0.6	1.1	0.5	1.1	0.5
Ireland	1.3	0.7	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Italy	2.3	1.1	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.0
Latvia	6.2	5.3	2.8	2.0	1.2	0.5	1.1	0.5	1.1	0.5
Lithuania	6.6	6.6	6.3	6.1	5.8	5.1	5.8	5.0	5.7	5.0
Luxembourg	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.0	0.1	0.0
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	4.9	4.8	4.5	4.4	4.3	3.6	4.2	3.6	4.2	3.5
Poland	60.7	52.3	36.1	28.3	19.1	6.6	17.9	5.9	16.9	5.2
Portugal	2.2	1.4	0.3	0.3	0.2	0.1	0.2	0.1	0.2	0.1
Romania	3.5	2.9	0.7	0.5	0.2	0.0	0.1	0.0	0.1	0.0
Slovakia	2.8	2.1	1.3	1.2	1.0	0.3	0.9	0.2	0.8	0.2
Slovenia	1.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Spain	3.3	2.6	0.2	0.2	0.1	0.0	0.1	0.0	0.1	0.0
Sweden	27.6	19.4	8.9	7.2	5.6	4.0	5.3	3.8	5.1	3.7
UK	5.3	3.3	2.0	1.7	1.2	0.5	1.1	0.4	1.0	0.4
EU-27	203.2	159.6	95.8	75.1	54.2	23.8	50.1	21.9	47.1	20.5
Croatia	1.4	1.3	1.2	1.2	0.6	0.1	0.5	0.1	0.5	0.0
EU-28	204.6	160.9	96.9	76.3	54.8	23.8	50.6	21.9	47.6	20.6
Change to 2000		*-21%*	*-53%*	*-63%*	*-73%*	*-88%*	*-75%*	*-89%*	*-77%*	*-90%*

3.2.6 Acidification of freshwater bodies

After the decline of SO_2 emissions before 2000, acidification of freshwater bodies remained to be problematic only in a few countries in the EU, i.e., Ireland, Sweden and the UK (Table 3.10). The 2005 Thematic Strategy on Air Pollution established the target to further reduce the threatened catchment area by 39% between 2000 and 2020.

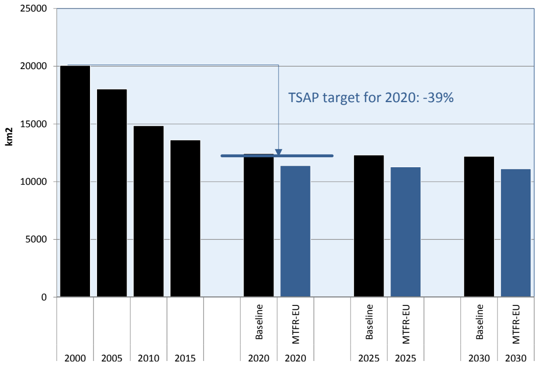


Figure 3.14: Freshwater catchment area receiving deposition in excess of their critical loads for acidification

Table 3.10: Freshwater catchment area with acid deposition in excess of the critical loads for acidification (km^2)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
					Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Ireland	79	31	30	30	29	28	28	28	28	8
Sweden	19316	17550	14489	13331	12186	11217	12079	11142	11967	11017
UK	675	447	327	255	220	147	197	117	197	85
EU-28	20070	18028	14846	13616	12435	11392	12305	11287	12192	11110
Change 2000		*-10%*	*-26%*	*-32%*	*-38%*	*-43%*	*-39%*	*-44%*	*-39%*	*-45%*

3.3 Future compliance with air quality limit values

As a new feature, the GAINS analysis for the TSAP review provides estimates of future compliance with air quality limit values for AIRBASE monitoring stations. A 'hybrid' downscaling methodology has been developed that determines for street canyon and hot spot AIRBASE stations the differences in observed concentrations to the measurements at the nearest background observation sites, and relates them to corresponding quantities that can be derived from available models. This makes it possible to modify the contributions of the different source types for future emission control scenarios.

The methodology will be documented in the forthcoming TSAP Report #8. In short, the approach decomposes observed concentrations into well-defined components, i.e.,

- the contribution from transboundary and long-range transport of anthropogenic emissions,
- urban background increments from local/ urban low-level emission sources,
- the residual to observed urban background concentrations as an unexplained fraction,
- road side increments from near-by sources within the street canyon.

To the extent possible, each of these components is explained with available models (Figure 3.15, Figure 3.16):

- The transboundary and long-range transport of components are modeled with the EMEP source-receptor relationships that are implemented in GAINS with a 28km*28km resolution.
- Resulting concentrations are downscaled to urban background concentrations with a 7km*7km resolution using the fine-scale concentration patterns developed with the CHIMERE model. For future emission control scenarios this downscaling considers changes in urban local low-level emissions from heating and traffic sources.
- The residual to observed concentrations at background stations defines an unexplained fraction, for which assumptions about their possible future evolutions are made depending of the likely nature of these

residuals (e.g., natural sources or model imperfections).

- Furthermore, for each AIRBASE traffic station a simple box model of the $NO/NO_2/O_3$ chemistry is used to determine the characteristic mixing time that emerges from the specific topographic and meteorological conditions, which are not reported in AIRBASE. This box model employs daily monitoring data of these substances for pairs of hot spot and associated background stations and explains the observed differences by the known chemical mechanisms and unknown mixing time and unknown local emissions. Keeping the calculated mixing time constant for the future, this module allows quantifying the response of the street canyon increment to future changes in background NO/NO_2 and O_3 levels and changes in local NO and NO_2 emissions.
- The characteristic mixing time is then used to estimate the non-reactive dispersion of the fine and coarse fractions of street canyon primary PM emissions.

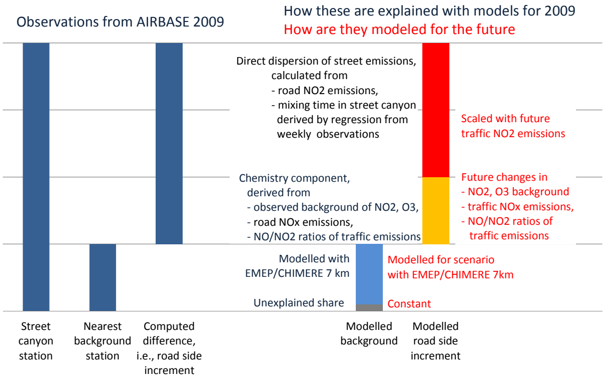


Figure 3.15: Schematic explanation of the different components in NO_2 observations and how they are represented with available models

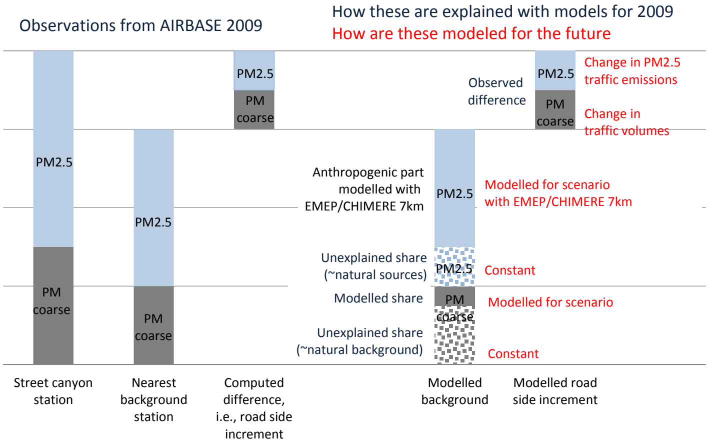


Figure 3.16: Schematic explanation of the different components in PM10 observations and how they are represented with available models

These components are determined for the year 2009 (using observations, emissions and meteorology of this year), and then validated by a back-casting for the years 2000-2008.

Based on the parameterization obtained for 2009, the likely evolution of all components for future scenarios is estimated for each station, and summary statistics about the likelihood of compliance are developed for each country, considering the key uncertainties in future meteorological conditions, the quality of monitoring data, imperfections in current models and uncertainties in the evolution of local emissions (e.g., within the street canyon next to the particular monitoring site, depending on the shares of diesel/gasoline light duty/heavy duty vehicles).

The methodology is described in more detail in a companion paper (Kiesewetter et al., forthcoming). It has been implemented for all AIRBASE stations for which sufficiently representative temporal coverage of all required components was reported and, for NO_2, where in the past annual mean concentrations exceeded 20 µg/m^3. In total, the analysis is carried out for 1843 stations for PM10 and 1174 stations for NO_2. Validations of model results against observations are presented in Figure 3.17 and Figure 3.18.

This approach enables estimating future levels of annual mean NO_2 and PM10 concentrations for each AIRBASE monitoring site. It has been shown before that compliance with the NO_2 annual limit value of 40 µg/m^3 is a more stringent target than meeting the limit value on the number of daily exceedances. For PM10, there exist strong correlations between 35 daily exceedances of 50 µg/m^3/year and an annual mean concentration of 30 µg/m^3, both in observations and model results.

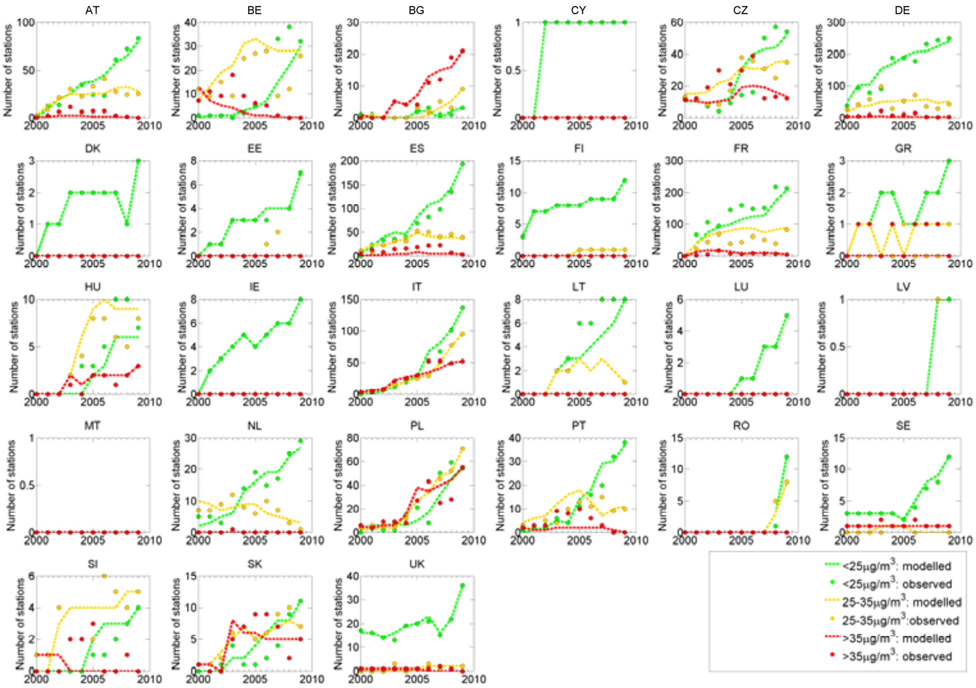


Figure 3.17: Number of stations in three classes of compliance (likely/uncertain/unlikely) with PM10 air quality limit values. Dots represent the observed number of stations in each class, the lines the results of the back-casting with the downscaling methodology.

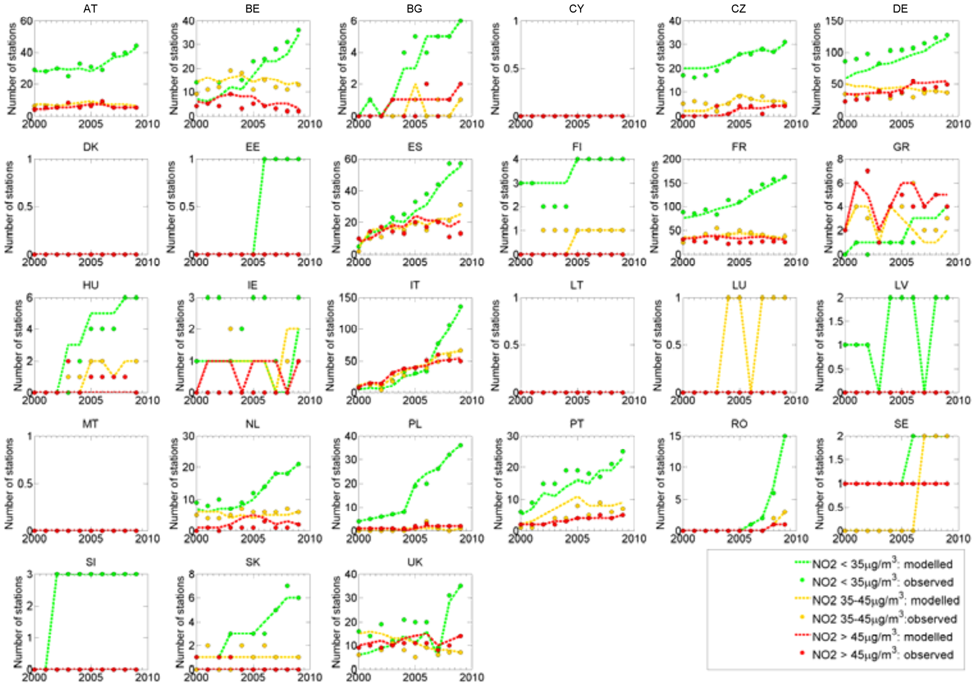


Figure 3.18: Number of stations in three classes of compliance (likely/uncertain/unlikely) with PM10 air quality limit values. Dots represent the observed number of stations in each class, the lines the results of the back-casting with the downscaling methodology.

3.3.1 Compliance with PM10 air quality limit values

It is estimated that in the coming decades, with very few exceptions, the TSAP-2012 baseline development in emissions will lead to a far-reaching elimination of current non-compliance cases in most of the old EU-15 Member States. However, due to the persistence of solid fuel use for home heating in small stoves in some of the new Member States, exceedances of the PM10 limit values are expected to prevail in urban areas in Poland, Slovakia and Bulgaria (Figure 3.20).

Full application of available end-of-pipe technical emission control measures could eliminate almost all likely exceedances in the old Member States already in 2020. However, for urban areas in the new Member States, these end-of-pipe measures will not be sufficient to achieve compliance without dedicated action to substitute solid fuels in the household sector with cleaner forms of energy.

Minor increases in computed concentrations of PM10 between and 2020 and 2030 are caused by the assumptions about constant emission factors of non-exhaust coarse particles from mobile sources; thus, total coarse particle emissions from this source follow the evolution of traffic volumes.

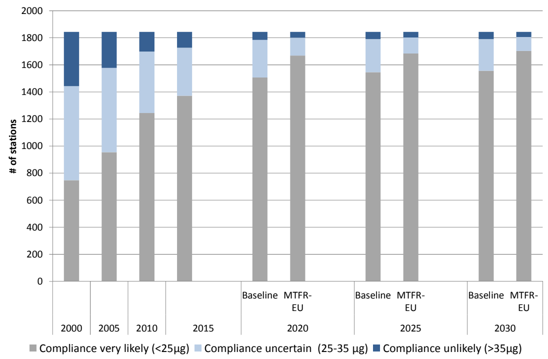


Figure 3.19: Computed compliance with the annual mean PM10 limit value at the 1843 AIRBASE stations

For compliance purposes, the analysis deducts the contributions from natural sources (sea salt, soil dust) as provided by the EMEP model from the computed PM10 concentrations and compares the residual to the nominal limit values.

For 2000, likely compliance, considering the model uncertainty margin, has been estimated for 40% of the stations. The decline in PM precursor emissions has increased this share to more than two thirds in 2010, and it has been estimated that eight percent of the stations were in clear non-compliance. By 2020, more than 80% of stations would be safely in compliance, and likely non-compliance is estimated for three percent of the stations (Figure 3.19). This situation will prevail to 2030.

Implementation of the maximum technically feasible emission control measures could reduce the cases of firm non-compliance to about 40 stations in Europe (i.e., about two percent of all stations). As mentioned above, most of these stations are located in the new Member States, where local heating with solid fuels will still make large contributions to urban PM10 levels (Figure 3.20). To what extent dedicated fuel switching policies that stimulate the substitution of coal and fuel wood by cleaner forms of energy could alleviate the situation needs further analysis.

The analysis has been carried out for 1843 AIRBASE stations in the EU-27 (Croatia is not yet included). Table 3.13 presents for all Member States the number of stations that fall into the three different categories. To this end, the table presents just the number of stations, without paying due attention to what extent stations fall into the same air quality management zone. Thus, the presented number of stations in each class is not necessarily representative for the spatial extension of compliance or non-compliance, as there are large differences in the number of analyzed stations across countries.

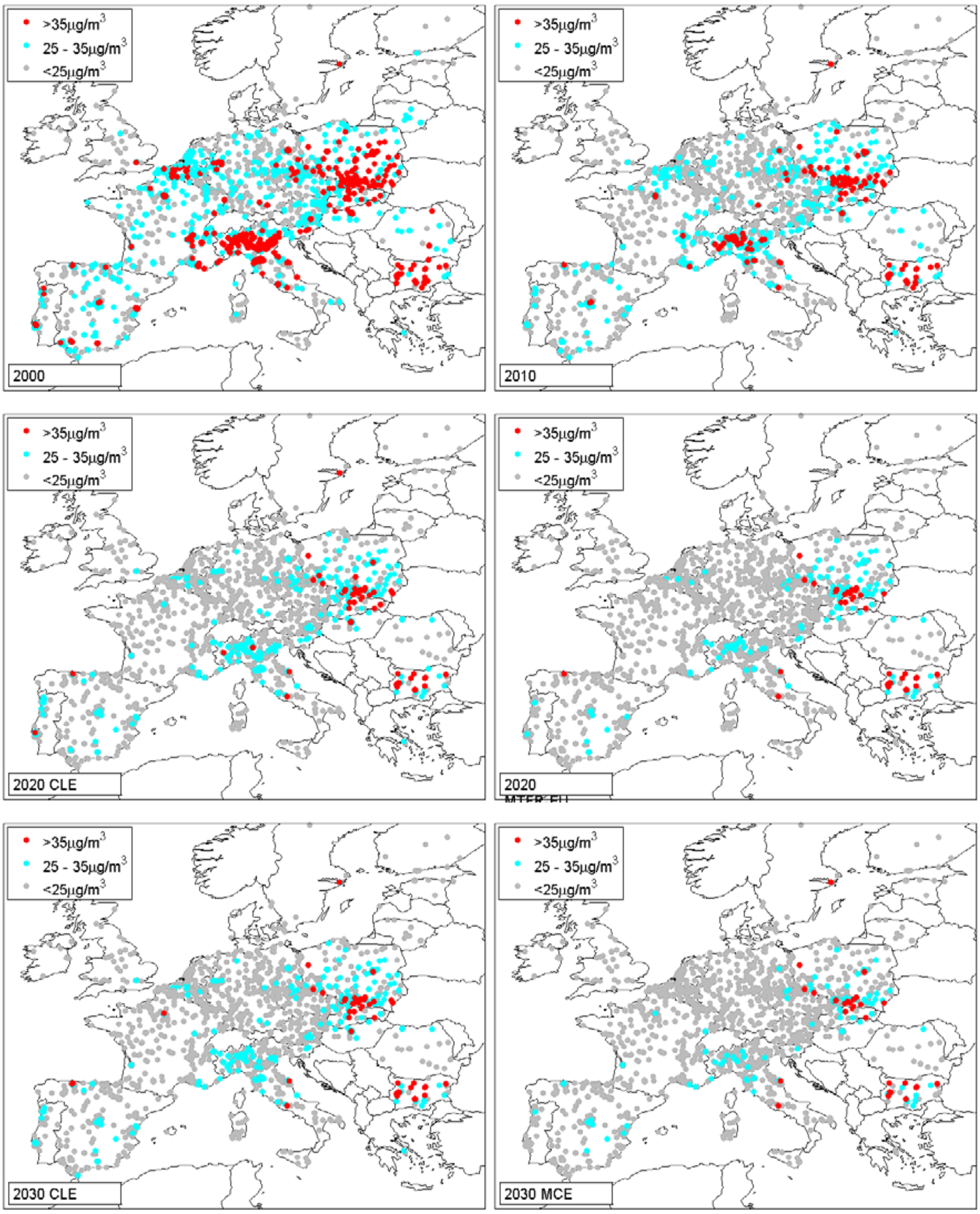


Figure 3.20: Compliance with PM10 limit values. For compliance assessment, deducts the contribution from natural sources are deducted from the measurements and model calculations. It is assumed an annual mean concentration of 30 µg/m^3 corresponds to 30 daily exceedances of the 50 µg/m^3 daily limit value.

grey: <25 µg: compliance with limit values likely
blue: 25-35 µg: compliance uncertain
red: >35 µg: compliance unlikely

Table 3.11: Number of stations with computed annual mean concentrations of PM10 – without contributions from natural sources - (a) below 25µg/m^3, (b) between 25 and 35 µg/m^3, and (c) above 35 µg/m^3, for the **current legislation baseline scenario**

	2010			***2020***			***2025***			***2030***		
	< 25	*25-35*	*> 35*	*<25*	*25-35*	*> 35*	*< 25*	*25-35*	*> 35*	*< 25*	*25-35*	*> 35*
Austria	82	26	0	101	7	0	102	6	0	102	6	0
Belgium	35	23	0	47	11	0	48	10	0	48	10	0
Bulgaria	4	8	21	7	11	15	8	10	15	8	10	15
Cyprus	1	0	0	1	0	0	1	0	0	1	0	0
Czech Rep.	54	35	12	74	22	5	77	20	4	79	18	4
Denmark	3	0	0	3	0	0	3	0	0	3	0	0
Estonia	7	0	0	7	0	0	7	0	0	7	0	0
Finland	13	0	0	13	0	0	13	0	0	13	0	0
France	225	71	5	286	15	0	289	12	0	288	12	1
Germany	244	47	2	272	21	0	275	18	0	277	16	0
Greece	3	1	0	3	1	0	3	1	0	3	1	0
Hungary	6	10	2	8	8	2	8	9	1	8	9	1
Ireland	8	0	0	8	0	0	8	0	0	8	0	0
Italy	145	93	46	203	77	4	222	60	2	225	57	2
Latvia	9	0	0	9	0	0	9	0	0	9	0	0
Lithuania	5	0	0	5	0	0	5	0	0	5	0	0
Luxembourg	1	0	0	1	0	0	1	0	0	1	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	28	2	0	30	0	0	30	0	0	30	0	0
Poland	57	74	49	96	59	25	101	56	23	104	53	23
Portugal	39	9	0	33	14	1	36	12	0	38	10	0
Romania	12	8	0	17	3	0	17	3	0	17	3	0
Slovakia	11	8	4	11	7	5	11	8	4	11	8	4
Slovenia	4	5	0	5	4	0	5	4	0	7	2	0
Spain	200	32	3	218	16	1	218	15	2	218	15	2
Sweden	12	0	1	12	0	1	12	0	1	11	1	1
UK	36	2	0	37	1	0	37	1	0	36	2	0
EU-27	1244	454	145	1507	277	59	1546	245	52	1557	233	53

Table 3.12: Number of stations with computed annual mean concentrations of PM10 – without contributions from natural sources - (a) below 25µg/m^3, (b) between 25 and 35 µg/m^3, and (c) above 35 µg/m^3, for the **maximum technically feasible control** (MTFR) scenario

	2010			***2020***			***2025***			***2030***		
	< 25	*25-35*	*> 35*	*<25*	*25-35*	*> 35*	*< 25*	*25-35*	*> 35*	*< 25*	*25-35*	*> 35*
Austria	82	26	0	106	2	0	108	0	0	108	0	0
Belgium	35	23	0	55	3	0	56	2	0	56	2	0
Bulgaria	4	8	21	8	10	15	9	10	14	9	12	12
Cyprus	1	0	0	1	0	0	1	0	0	1	0	0
Czech Rep.	54	35	12	84	14	3	84	14	3	84	14	3
Denmark	3	0	0	3	0	0	3	0	0	3	0	0
Estonia	7	0	0	7	0	0	7	0	0	7	0	0
Finland	13	0	0	13	0	0	13	0	0	13	0	0
France	225	71	5	296	5	0	297	4	0	297	4	0
Germany	244	47	2	292	1	0	292	1	0	293	0	0
Greece	3	1	0	4	0	0	4	0	0	4	0	0
Hungary	6	10	2	14	4	0	16	2	0	16	2	0
Ireland	8	0	0	8	0	0	8	0	0	8	0	0
Italy	145	93	46	255	27	2	256	26	2	267	15	2
Latvia	9	0	0	9	0	0	9	0	0	9	0	0
Lithuania	5	0	0	5	0	0	5	0	0	5	0	0
Luxembourg	1	0	0	1	0	0	1	0	0	1	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	28	2	0	30	0	0	30	0	0	30	0	0
Poland	57	74	49	119	43	18	123	40	17	128	36	16
Portugal	39	9	0	45	3	0	46	2	0	47	1	0
Romania	12	8	0	18	2	0	18	2	0	18	2	0
Slovakia	11	8	4	12	8	3	12	8	3	12	8	3
Slovenia	4	5	0	7	2	0	8	1	0	8	1	0
Spain	200	32	3	226	8	1	228	6	1	228	6	1
Sweden	12	0	1	13	0	0	13	0	0	13	0	0
UK	36	2	0	38	0	0	38	0	0	38	0	0
EU-27	1244	454	145	1669	132	42	1685	118	40	1703	103	37

3.3.2 Compliance with NO_2 limit values

As a consequence of the assumptions taken in the TSAP-2012 baseline scenario, in particular about the effectiveness of Euro-6 standards, a steep drop in total NO_x emissions from the transport sector is calculated in Europe. Such a rapid decline would have profound impacts on the compliance with NO_2 limit values, as NO_2 concentrations in street canyons are dominated by the contributions from near-by traffic sources.

Owing to the various uncertainties involved (future meteorological conditions, evolution of local emissions, quality of monitoring data), predicted annual mean concentration values are grouped into bands containing stations with likely compliance (< LV – 5ug/m3), stations with uncertain compliance (between LV -5ug/m3 and LV + 5ug/m3), and stations with unlikely compliance (> LV + 5ug/m3). A thorough uncertainty analysis will be conducted in due time.

For the period 2000-2005, likely compliance has been estimated for about 50% of the 1174 AIRBASE stations for which the analysis has been carried out, and likely non-compliance for 25% of these stations. The computed concentrations of the residual 25% of stations fall within an uncertainty margin of ±5 $\mu g/m^3$ around the limit value of 40 $\mu g/m^3$.

Already for 2010, likely compliance is calculated for 66% of all stations, and this share increases to 88% in 2020 and 97% in 2030 (Figure 3.21). Conversely, the share of stations with clear non-compliance falls from 16% in 2010 to 4% in 2020 and 1% in 2030. Implementation of the maximum technically feasible emission control measures (MTFR) could eliminate in 2030 all likely non-compliance cases with the exception of three stations in Europe. It should be noted that the MTFR scenario assumes only Europe-wide technical emission control measures, and does not consider the potential for local measures (e.g., traffic restrictions, low emission zones, etc.).

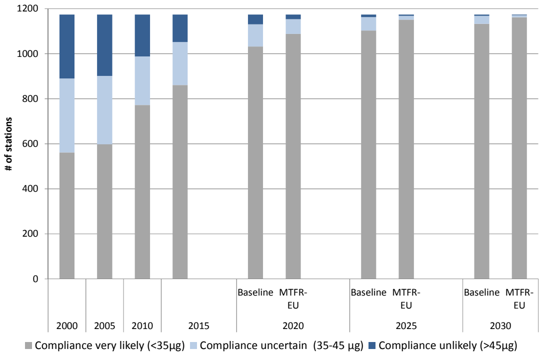
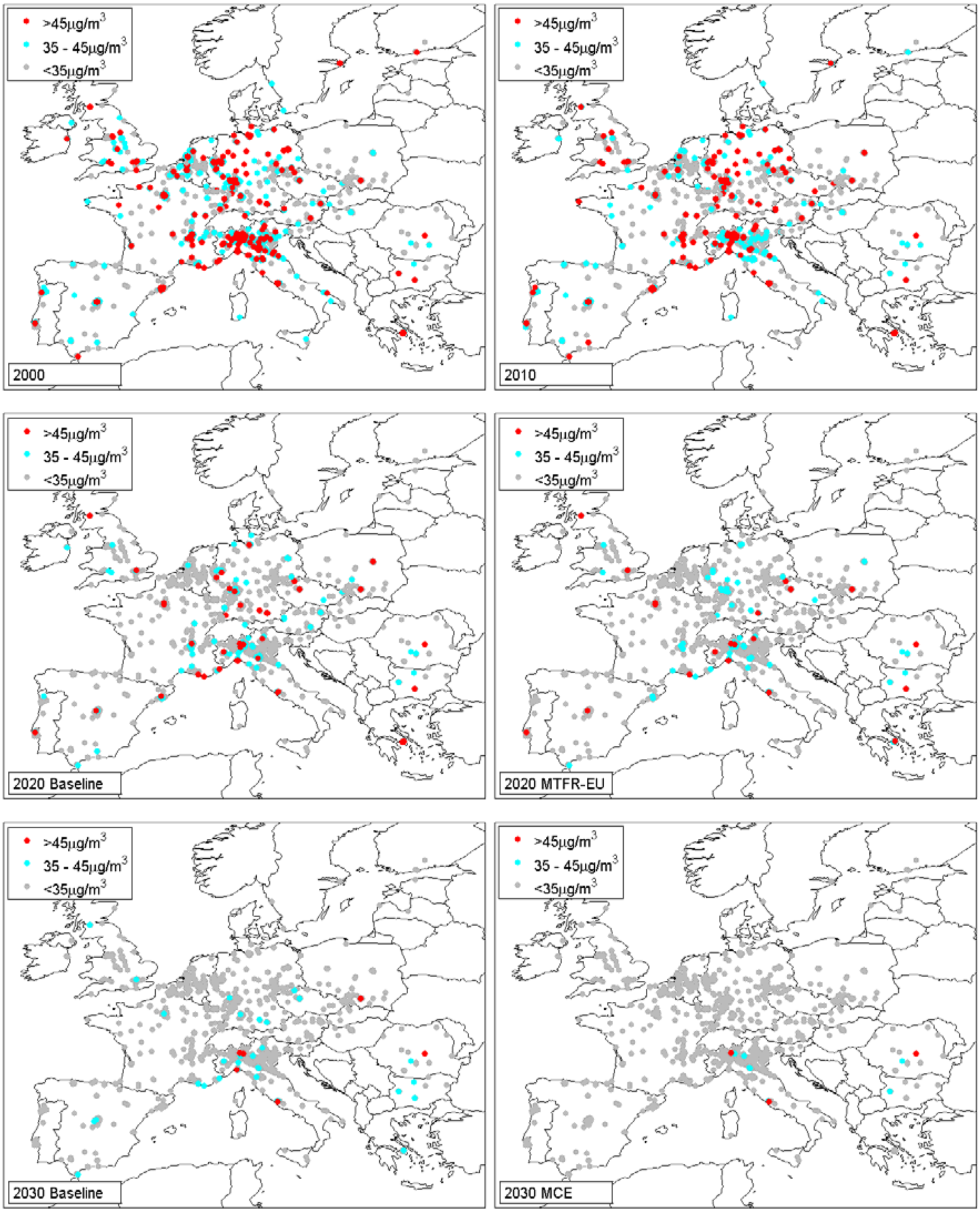


Figure 3.21: Computed compliance with the annual mean NO_2 limit value at the 1174 AIRBASE stations

Obviously, this fast decline in non-compliance stations is a direct consequence of the anticipated sharp cut in NO_x emissions from traffic sources, that has been assumed in the TSAP-2012 baseline, especially from Euro-6 diesel vehicles. The impacts of less optimistic assumptions on the effectiveness of Euro-6 standards on NO_x emissions are discussed in Version 2.0 of TSAP Report # 4 (Borken-Kleefeld & Ntziachristos, 2012). The resulting consequences on the compliance with NO_2 limit values will be analyzed in due course and presented in an addendum to this report.

The analysis has been carried out for 1174 AIRBASE stations in the EU-27 (Croatia is not included). Table 3.13 presents for all Member States the number of stations that fall into the three different categories. To this end, the table presents just the number of stations, without paying due attention to what extent stations fall into the same air quality management zone. Thus, the presented number of stations in each class is not necessarily representative for the spatial extension of compliance or non-compliance, as there are large differences in the number of analyzed stations across countries.

The spatial distribution of complying and non-complying stations for the different years and scenarios is presented in Figure 3.22. The 2030 cases clearly highlight large progress in compliance from the assumed NO_x control scenario. Already in the baseline case, only very few cities would remain in likely non-compliance without additional local measures. There is a scope for additional Europe-wide measures (e.g., in the MTFR scenario) that could alleviate the need for local measures in almost all cities in Europe.


2000

2010

2020 Baseline

2020 MTFR-EU

2030 Baseline

2030 MCE

Figure 3.22: Computed annual mean NO_2 concentrations at AIRBASE monitoring stations:
grey: <35 µg: compliance with annual limit value likely
blue: 35-45 µg: compliance uncertain
red: >45 µg: compliance unlikely

Table 3.13: Number of stations with computed annual mean concentrations of NO_2 (a) below 35µg/m^3, (b) between 35 and 45 µg/m^3, and (c) above 45 µg/m^3, **for the current legislation baseline**

		2000			2010			2020			2025			2030	
	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45
Austria	42	8	4	44	5	5	49	5	0	54	0	0	54	0	0
Belgium	16	25	10	35	14	2	51	0	0	51	0	0	51	0	0
Bulgaria	6	1	2	6	2	1	6	2	1	6	3	0	6	3	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Rep.	31	7	2	30	6	4	36	2	2	38	0	2	38	2	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Finland	4	0	1	4	1	0	5	0	0	5	0	0	5	0	0
France	121	55	51	168	30	29	207	14	6	222	5	0	223	4	0
Germany	74	66	72	126	33	53	184	18	10	198	14	0	208	4	0
Greece	1	4	6	4	2	5	8	0	3	8	2	1	10	1	0
Hungary	6	2	0	6	2	0	8	0	0	8	0	0	8	0	0
Ireland	3	1	1	3	2	0	4	1	0	5	0	0	5	0	0
Italy	81	84	87	142	61	49	203	37	12	223	24	5	233	15	4
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0
Luxembourg	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	13	11	5	21	7	1	28	1	0	29	0	0	29	0	0
Poland	37	1	1	36	1	2	36	1	2	37	1	1	38	0	1
Portugal	23	11	3	26	7	4	34	2	1	36	1	0	37	0	0
Romania	16	2	1	15	3	1	16	2	1	17	1	1	17	1	1
Slovakia	6	1	0	6	1	0	7	0	0	7	0	0	7	0	0
Slovenia	3	0	0	3	0	0	3	0	0	3	0	0	3	0	0
Spain	57	27	17	56	29	16	90	8	3	96	4	1	99	2	0
Sweden	1	2	2	2	2	1	5	0	0	5	0	0	5	0	0
UK	17	20	19	36	7	13	48	6	2	51	5	0	53	3	0
EU-27	561	329	284	772	216	186	1032	99	43	1103	60	11	1133	35	6

Table 3.14: Number of stations with computed annual mean concentrations of NO_2 (a) below 35µg/m^3, (b) between 35 and 45 µg/m^3, and (c) above 45 µg/m^3, **for the maximum technically feasible emission reductions in the EU-28**

		2000			2010			2020			2025			2030	
	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45	< 35	35-45	> 45
Austria	42	8	4	44	5	5	54	0	0	54	0	0	54	0	0
Belgium	16	25	10	35	14	2	51	0	0	51	0	0	51	0	0
Bulgaria	6	1	2	6	2	1	6	2	1	6	3	0	7	2	0
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Rep.	31	7	2	30	6	4	37	1	2	38	2	0	40	0	0
Denmark	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Estonia	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Finland	4	0	1	4	1	0	5	0	0	5	0	0	5	0	0
France	121	55	51	168	30	29	218	6	3	226	1	0	227	0	0
Germany	74	66	72	126	33	53	191	20	1	212	0	0	212	0	0
Greece	1	4	6	4	2	5	8	2	1	10	0	1	11	0	0
Hungary	6	2	0	6	2	0	8	0	0	8	0	0	8	0	0
Ireland	3	1	1	3	2	0	5	0	0	5	0	0	5	0	0
Italy	81	84	87	142	61	49	220	25	7	239	10	3	245	5	2
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	0	1	0	0	1	0	1	0	0	1	0	0	1	0	0
Luxembourg	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	13	11	5	21	7	1	29	0	0	29	0	0	29	0	0
Poland	37	1	1	36	1	2	37	1	1	38	0	1	38	1	0
Portugal	23	11	3	26	7	4	36	0	1	37	0	0	37	0	0
Romania	16	2	1	15	3	1	16	2	1	17	1	1	17	1	1
Slovakia	6	1	0	6	1	0	7	0	0	7	0	0	7	0	0
Slovenia	3	0	0	3	0	0	3	0	0	3	0	0	3	0	0
Spain	57	27	17	56	29	16	97	3	1	101	0	0	101	0	0
Sweden	1	2	2	2	2	1	5	0	0	5	0	0	5	0	0
UK	17	20	19	36	7	13	51	3	2	56	0	0	56	0	0
EU-27	561	329	284	772	216	186	1088	65	21	1151	17	6	1162	9	3

4 Conclusions

This report examines the health and environmental impacts of the TSAP-2012 baseline emission scenarios that have been presented in the TSAP Report #1 to the Stakeholder Expert Group in June 2012.

These baseline projections in the TSAP Report #a suggest for the next decades a steady decline of energy-related emissions: Without further measures, SO_2 emissions should decline in the EU-28 by about 70%, NO_x by 65%, and PM2.5 and VOC by about 40% until 2030 compared to 2005. A key assumption for these projections relates to the timing and effectiveness of Euro-6 emission standards for diesel light-duty vehicles. Most of these emission reductions are expected to emerge before 2020 as a consequence of progressive implementation of the recently agreed emission control legislation. Beyond 2020, the decline will slow down unless new legislation will be introduced.

The swift decline in NO_x emissions in the baseline will only occur if Euro-6 reduces real-driving emission factors of new diesel vehicles below 380 mg/km from 2015 onwards and to 120 mg/km (i.e., 1.5 times of the test cycle value) in 2018.

In contrast to energy-related emissions, no significant changes are foreseen for NH_3, which results mainly from agricultural activities.

These emission trajectories will lead to significant improvements in air quality. For instance, loss of statistical life expectancy from exposure to fine particulate matter (PM2.5) is expected to decline from 9.6 months in 2000 and 6.9 months in 2010 to 5.5 months in 2020 and 5.0 months in 2030. However, the 43% reduction in 2020 falls short of the -47% target of the 2005 Thematic Strategy on Air Pollution. By 2030, the expected levels of ambient PM2.5 would still cost about 210 million years to European citizens. Full application of additional and readily available emission reduction measures in the EU could reduce these health impacts by another 30%, and gain more than 55 million life years in the EU.

It is estimated that ground-level ozone caused about 30,000 cases of premature deaths in the EU in 2000. For 2020, recent estimates suggest for the TSAP-2012 baseline scenario a 30% improvement, however still leading to about 21,000 cases/year. For 2030, a further reduction of about 2,000 cases/year is estimated. Full implementation of all technically available emission control measures in the EU could save another 3,000 premature deaths per year.

Especially for 2020, these new calculations are more optimistic than the estimates conducted for the 2005 Thematic Strategy on Air Pollution, and the reduction in premature deaths (-30%) will exceed the TSAP target of -10%. This optimistic perspective is mainly a result of modified assumptions on the future development of hemispheric background ozone. The recent estimates assume as a central case no further increase in ozone background between 2000 and 2020/2030, based on findings of the LRTAP Task Force on Hemispheric Air Pollution. In contrast, earlier calculations employed an assumed increase of 4.5 ppb between 1990 and 2020, based on extrapolations of monitoring data from the 1990s at the West coast in Ireland. Further sensitivity analyses will be necessary to explore the robustness of the recent estimates within the uncertainty range (-1 to +3 ppb) that has been suggested for future changes in ozone background levels.

For vegetation impacts of ozone, a new methodology employing the ozone flux concept is currently under development. However, its implementation into the GAINS model could not be completed in time for this report, and results will be reported later.

Following the on-going decline in energy related precursor emissions, the acidification problem in Europe will further diminish in the coming decades. However, lacking progress on agricultural emissions will enhance the urgency of the eutrophication problem, which constitutes a serious threat to the biodiversity of European ecosystems.

Based on the most recent estimates of critical loads, it is now calculated that in 2000 excess deposition threatened biodiversity at 1.2 million km^2 of European ecosystems. Since then, slow progress reduced this number to 1.05 million km^2 in 2010. Until 2030, the anticipated reductions in NO_x emissions should bring this number to down to 912,000 km^2, which however will still constitute 54% of the European ecosystems. Further measures, mainly for NH_3 emissions, could protect another 200,000 km^2.

Due to lacking progress in the control of NH_3 emissions, the 2005 TSAP target for eutrophication, i.e., a 31% reduction of areas with excess nitrogen deposition between 2000 and 2020, will not be achieved with 11% improvement that is foreseen in the TSAP-2012 baseline.

Of particular importance is the situation for areas that receive specific protection under the Birds and Habitat Directives or under national law. While not all countries have supplied critical loads data for their protected areas, available data suggest that progress for these zones (including the Natura2000 areas) is slower than for all ecosystems. By 2020, biodiversity in 62% of these protected zones will be threatened by excess nitrogen deposition, in addition to the pressure from fragmentation and climate change.

In contrast, the situation is much brighter for acidification. Especially the sharp fall in SO_2 emissions will reduce the unprotected forest area in the EU from 200,000 km2 in 2000 to less than 50,000 km2 in 2030, which represents about four percent of all forests. There is significant scope for further improvements, both from more stringent technical emission controls and through greenhouse gas mitigation strategies.

As a new element, a methodology has been developed that enables the assessment of compliance with PM10 and NO_2 air quality limit values under future emission scenarios. This methodology has been implemented for all AIRBASE stations for which sufficient monitoring data are available, i.e., for 1483 stations for PM10 and for 1174 stations for NO_2.

For PM10 it is estimated that in the coming decades, with very few exceptions, the TSAP-2012 baseline will lead to a far-reaching elimination of current non-compliance cases in most of the old EU-15 Member States. However, due to the persistence of solid fuel use for home heating in small stoves in some of the new Member States, exceedances of the PM10 limit values are expected to prevail in urban areas in Poland, Slovakia and Bulgaria. Full application of available end-of-pipe technical emission control measures could eliminate almost all likely exceedances in the old Member States already in 2020. However, for urban areas in the new Member States, these end-of-pipe measures will not be sufficient to achieve compliance without dedicated action to substitute solid fuels in the household sector with cleaner forms of energy.

For NO_2, the steep drop in total NO_x emissions from the transport sector as a consequence of the assumed performance of Euro-6 regulations will drop the share of stations that are in clear non-compliance with the annual NO_2 limit value from about 25% in 2000 to 4% in 2020 and 1% in 2030. Implementation of the maximum technically feasible emission control measures (MTFR) could eliminate in 2030 all likely non-compliance cases with the exception of three stations in Europe. It should be noted that the MTFR scenario assumes only Europe-wide technical emission control measures, and does not consider the potential for local measures (e.g., traffic restrictions, low emission zones, etc.).

Obviously, this fast decline in non-compliance stations is a direct consequence of the anticipated sharp cut in NO_x emissions from traffic sources that has been assumed in the TSAP-2012 baseline, especially from Euro-6 diesel vehicles. The impacts of less optimistic assumptions on the effectiveness of Euro-6 standards on NO_x emissions are discussed in Version 2.0 of TSAP Report # 4 (Borken-Kleefeld & Ntziachristos, 2012). The resulting consequences on the compliance with NO_2 limit values will be analyzed in due course and presented in an addendum to this report.

In summary, the TSAP-2012 emission projection will lead to significant improvements in air quality and thereby in the negative impacts on human health and ecosystems as well as for compliance with existing air quality limit values for PM10 and NO_2. While this general trend appears as robust, quantification of the remaining effects requires more uncertainty analyses.

However, while these calculations are performed for the TSAP-2012 baseline relying on the PRIMES-2010 energy scenario, indications are that the forthcoming PRIMES-2012 scenario that incorporates the persistence of the financial and economic crisis from 2010 to 2012 and adopts less optimistic assumptions on the economic recovery will lead to substantially lower emissions than those based on the PRIMES-2010 scenario. Thus, a final TSAP baseline that adopts these more recent expectations as the central estimate will result in an even more optimistic perspective on future air quality impacts.

Despite these anticipated improvements, the baseline still suggests for the future significant damage to human health and ecosystems unless additional measures were to be taken to reduce emissions beyond the current legislation. As mentioned above, full application of readily available technical measures would offer a significant potential for further improvements, and thereby a potentially important step towards the achievement of the objectives of the Sixth Environment Action Programme. Obviously, additional measures will involve additional costs, which need to be balanced against their benefits.

The companion TSAP Report #7 will explore cost-effective scenarios that would go beyond current legislation, achieve significant benefits for human health and ecosystems, improve compliance with existing air quality limit values, and avoid excessive costs to the economy.

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