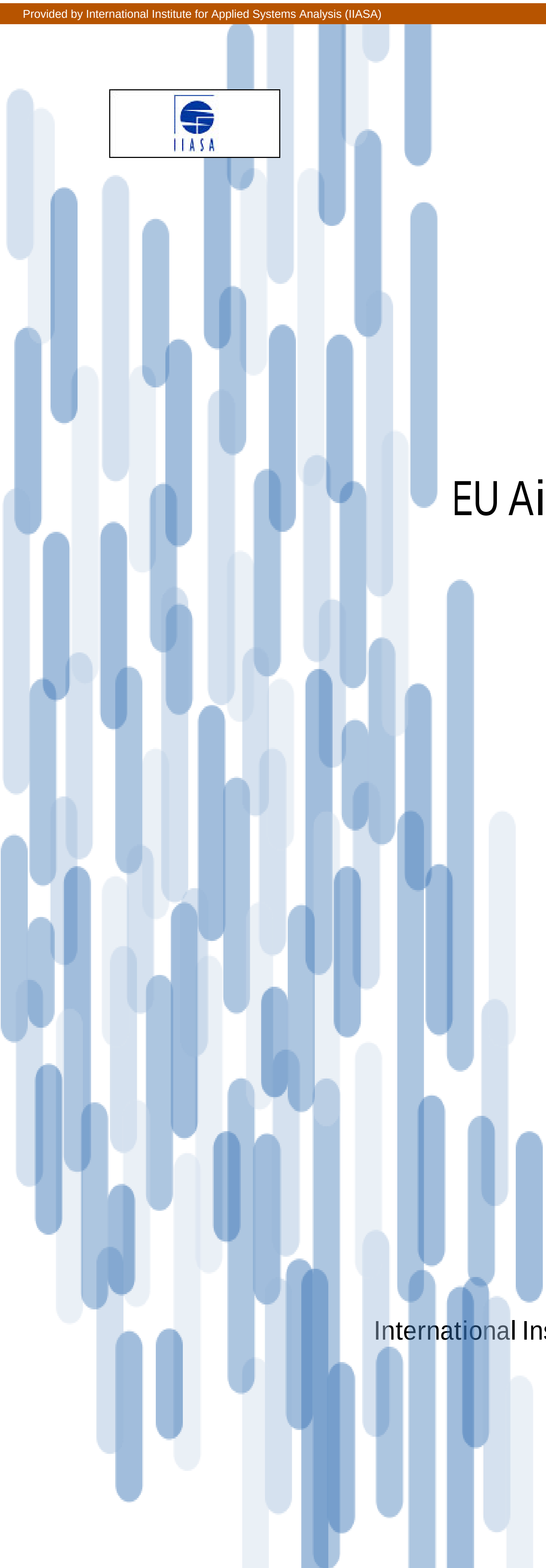

Service Contract on
Monitoring and Assessment
of Sectorial Implementation Actions
(ENV.C.3/SER/2011/0009)

Compliance with EU Air Quality Limit Values - A First Set of Sensitivity and Optimization Analyses

TSAP Report #8
Version 1.0

Editor:
Markus Amann
International Institute for Applied Systems Analysis IIASA

November 2012

The authors

This report was compiled by Markus Amann, Jens Borken-Kleefeld, Gregor Kiesewetter, Peter Rafaj and Fabian Wagner, all working at the International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria.

Acknowledgements

This report was produced under the Service Contract on Monitoring and Assessment of Sectorial Implementation Actions (ENV.C.3/SER/2011/0009) of DG-Environment of the European Commission.

Disclaimer

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

Executive Summary

This report provides additional information to the baseline and optimized scenarios that have been developed for the review and revision of the Thematic Strategy on Air Pollution in TSAP Reports #6 and #7.

The report examines the implications of different assumptions on the implementation of the Euro-6 emission standards for light duty diesel vehicles on compliance with NO_2 air quality limit values in Europe. For the baseline assumptions of the TSAP-2012 baseline scenario, i.e., a decline of real-driving emission in two stages down to 1.5 times the value of test cycle value in 2018, it is estimated that almost all AIRBASE stations that have been modelled in this exercise would achieve the NO_2 limit values by 2030 at the latest.

However, in the least optimistic sensitivity case, i.e., under the assumption of a failure of Euro-6 (no change in real-driving emissions compared to Euro-4), about 100 out of the 1173 AIRBASE monitoring stations would still remain in non-compliance with the limit value in 2030.

A second analysis examines the optimization results presented in TSAP Report #7 in more detail and provides, for each of the optimized scenarios, the sectors in which emission reductions would occur in the cost-optimal cases. These emission reductions will lead to lower background pollution concentrations in Europe, which will affect PM10 levels within cities. It is estimated, e.g., for the high ambition case, that in 2030 the number of stations for which non-compliance is robustly estimated will decline by about 20%. The number of stations for which compliance seems possible but not certain would fall by 30% compared to the baseline. In contrast, the optimized scenarios do not yield significant improvements in the compliance with NO_2 limit values, as the series of scenarios did not consider further measures for road vehicle emissions.

Finally, an initial assessment of current and future emissions of mercury in Europe suggests for the TSAP-2012 baseline a decline of Hg emissions of 22% in 2020 and about 30% in 2030 (relative to 2005), mainly as a consequence of lower coal use in the power sector. Full implementation of the available technical emission controls, especially of certain measures to reduce PM emissions, could eliminate Hg emissions in the EU by another third, so that in 2030 the total release of Hg in the EU could be more than 50% lower than in 2005.

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.

Table of contents

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
Hg	Mercury
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, IIASA analysed for a range of future emission scenarios their impacts on air quality. Baseline emission scenarios and the scope for further emission reductions have been presented in TSAP Report #1 (M. Amann, J. Borken-Kleefeld, et al., 2012). TSAP Report #6 (M. Amann, I. Bertok, et al., 2012) examined the health and environmental impacts of these scenarios, as well as the likely compliance with EU air quality limit values for PM10 and NO_2.

While the TSAP-2012 baseline employs assumptions about the effectiveness and timing of the forthcoming Euro-6 limit values that are considered as most likely, there is considerable uncertainty about these issues. As has been pointed out in version 2 of TSAP Report #5 (Borken-Kleefeld & Ntziachristos, 2012) conceivable different realizations of Euro-6 would have significant impacts on emissions of NO_x from mobile sources, and thus on national total emissions. This report examines the implications of these sensitivity scenarios presented in TSAP Report #6 on the compliance with air quality limit values of NO_2.

Furthermore, TSAP Report #7 (Wagner et al., 2012) explores the scope for cost-effective emission reductions in 2025 and 2030 that go beyond current legislation. While it presents for each year three scenarios with different environmental ambition levels, due to time constraints the report could not include an analysis of such cost-optimized emission controls on compliance with air quality limit values.

This TSAP Report # 8 report presents for the Euro-6 sensitivity cases and the cost-optimized emission reduction scenarios estimates about compliance with air quality limit values for PM10 and NO_2.

The analyses employs the new feature that has been developed for the GAINS model to estimate future compliance with air quality limit values for AIRBASE monitoring stations. This methodology employs a 'hybrid' downscaling approach, which determines for street canyon and hot spot AIRBASE stations the differences in observed concentrations to the measurements at the nearest background observation sites. It relates these differences 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. A brief summary of this methodology is provided in TSAP Report #6 (M. Amann, J. Borken-Kleefeld, et al., 2012), and a full description will appear in a separate forthcoming TSAP Report.

An further section provides first estimates of mercury emissions for the TSAP-2012 baseline and MTFR scenarios.

1.1 Structure of the report

The remainder of this report is organized as follows: Section 2 of this report examines compliance with NO_2 air quality limit values for the series of sensitivity cases on the effectiveness of Euro-6 standards that has been developed in version 2 of the TSAP Report #4. Section 3 provides additional detail on the optimization scenarios of TSAP Report #7; it presents the sectorial composition of optimized emission reductions for all five pollutants, and assesses the implications of these measures on future compliance with PM10 and NO_2 air quality limit values. Mercury emissions of the TSAP-2012 baseline and MTFR scenarios are presented in Section 4, and conclusions are drawn in Section 5.

.

2 Compliance with NO_2 air quality limit values under different assumptions for Euro-6

2.1 Future NO_x emissions under different assumptions on the effectiveness of Euro-6 standards

It has been pointed out in Borken-Kleefeld & Ntziachristos, 2012 that one of the most important uncertainties about the future NO_x development relates to emissions from light duty diesel vehicles under real-world driving conditions. The (revised) TSAP-2012 baseline scenario assumes from 2014 onwards a stepwise decrease of real-driving emissions with the introduction of the Euro-6 emission standard. Second generation EURO 6.b (from 2018 onwards) light duty diesel vehicles are assumed to emit only 120 mg NO_x/km at average real-world driving, given the limit value over the type approval cycle of 80 mg/km. For comparison, Euro-5 vehicles are measured at almost 870 mg NO_x/km under real-world driving Hausberger, 2010. First measurements on premium-class vehicles have confirmed the technical feasibility of the low value with SCR technology under real-world driving Demuynck et al., n.d.; Hausberger, 2012.

2.1.1 Sensitivity cases

As this development is however not certain, sensitivity cases explore how much total NO_x emissions would be affected by different real-driving emissions from light duty diesel vehicles. To span a range of possible developments the following cases are considered:

The baseline scenario

As a most realistic assumption, the TSAP-2012 baseline assumes a stepwise reduction of real-driving emissions, such that a first generation of Euro-6 vehicles (EURO-6.a) would deliver a reduction over Euro-5 proportional to the decline of the emission limit values by 2014, i.e., about 380 mg/km. The second generation vehicles (Euro-6.b) are assumed to emit on average 1.5 times the limit value under real-world driving from 2018 onwards, i.e., 120 mg/km. This reduction may result from the introduction of real-drive emission controls, e.g., by on-board PEMS or random cycle testing.

The legislation case

This case assumes average real-driving NO_x emissions of Euro-6 diesel LDV equal to the test cycle emission limit value of 80 mg/km from 2015 onwards. With current knowledge, this seems a low emission scenario.

The delayed steps case

This case assumes that the introduction of the second step of the baseline case, i.e., the Euro-6.b standards with real-driving emissions of 120 mg/km would only be available from 2020 onwards due to a delayed introduction of real-drive emission controls.

The proportional reductions case

It is assumed that Euro-6 vehicles are introduced in 2015, but they only deliver emission reductions proportional to the ratio of the emission limits over Euro-5, i.e., about 380 mg/km. This is the 'default' approach used by COPERT 4 and the Handbook Emission Factors.

Euro-6 = Euro-4

Here it is assumed that real-driving emissions from Euro-6 diesel LDVs are only 30% lower than those of the previous generation and thus similar to those of Euro-4 vehicles. This pessimistic scenario would correspond to historic experience that new emission limit values did not result in reduced real-driving emissions. It is thus a scenario where the legislation fails.

2.1.2 Impacts on NO_x emissions

As shown earlier, NO_x emissions from all road vehicles in the EU- 27 are projected to decrease further from about 5000 kt in the year 2005.

Under baseline assumptions, they are expected to decline to about 1900 kt in 2020 and 730 kt in the year 2030 (Figure 5.4 – left panel). However, this decline is driven by decreasing unit emissions from gasoline cars and heavy duty vehicles, while emissions from light duty diesel vehicles are expected to increase at least until the year 2015. Light duty diesel vehicles contributed about one quarter to NO$_x$ from all road vehicles in the EU-27 in 2005. By 2015, their share in emissions is projected to grow to 45%, when they will emit 1400 kt. By then, Euro-6 vehicles will enter the market and under baseline assumptions emissions from light duty diesel vehicles will gradually decrease to 1000 kt and 380 kt in year 2020 and 2030, respectively (Figure 5.4 – right panel, Table 2.1).

If real-driving emissions would be as low as the nominal limit value from 2015 onwards (i.e., the “Legislation” case), total NO$_x$ emissions from road vehicles would be 180 kt and 140 kt lower in 2020 and 2030, respectively, i.e., 10% and 18% lower than in the baseline.

A potential delay in the timing of the Euro-6.b emission step to the year 2020 would result in 120 kt and 95 kt higher NO$_x$ emissions in 2020 and 2030, or 6% and 13% more than in the baseline scenario, respectively.

If Euro-6 vehicles would only deliver a proportional reduction on real-driving, NO$_x$ emissions from light duty diesel vehicles would be 130 kt higher in the year 2020; in the year 2030 they would be more than twice as high compared to the baseline projection. As a consequence, NO$_x$ emission from all road vehicles would be higher by 7% and 60% years 2020 and 2030 respectively, though still much lower than in 2005.

If Euro-6 vehicles would bring only small reductions and emit, e.g., the same as Euro-4 vehicles in real-driving, emissions from light duty diesel vehicles would only slightly decline after 2015 to about 1200 kt. In that case, emissions from all road vehicles would be 20% higher than in the baseline scenario in 2020, more than twice as high in 2030 and almost three times higher in 2035, however still down by 70% compared to the year 2005.

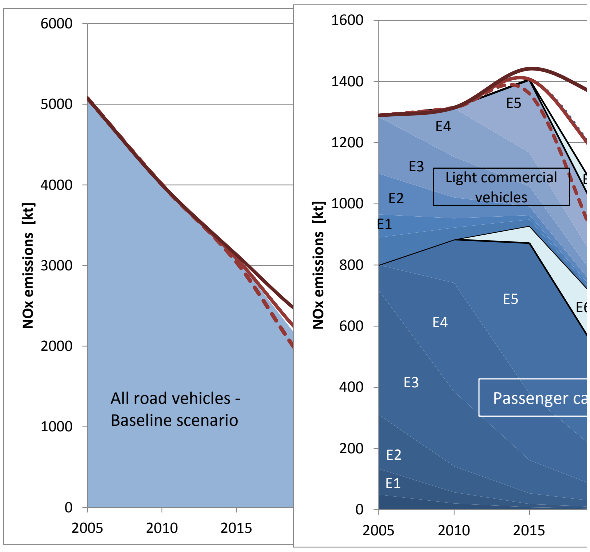

Figure 2.1: Development of NO$_x$ emissions from all road vehicles in the EU-27 (left panel) in the baseline scenario (shaded area) and under the different assumptions for real-driving emissions from light duty diesel vehicles. Right panel: Close-up on NO$_x$ emissions from light duty diesel vehicles under the different scenarios.

Table 2.1: NO$_x$ emissions from light duty vehicles for the sensitivity cases (kt)

Vehicle category	*Scenario*	*2005*	*2010*	*2015*	*2020*	*2025*	*2030*	*2035*
Cars, gasoline	All	861	443	208	121	94	84	79
Trucks & buses, diesel	All	2759	2109	1391	727	391	231	157
All other	All	166	137	83	51	38	32	28
Diesel cars	Baseline	800	883	928	661	395	244	171
	Legislation	800	883	883	532	271	155	103
	Proport. reduct.	800	883	928	756	610	528	494
	Euro6 = Euro4	800	883	959	911	851	796	782
Light trucks, diesel	Baseline	488	431	479	338	215	138	96
	Legislation	488	431	477	283	157	95	61
	Proport. reduct.	488	431	479	377	314	277	263
	Euro6 = Euro4	488	431	480	418	383	356	356

2.2 Compliance with NO_2 limit values

The wide variation in emissions will have substantial impacts on future compliance with NO_2 limit values. Out of the 1174 AIRBASE stations for which the analysis has been carried out, the number of stations for which non-compliance was robustly estimated (i.e., with computed annual mean concentrations above 45 µg/m^3), declines in the baseline case from 186 in 2010 to 43 in 2020, 11 in 2025 and 6 stations in 2030. Theoretically, the strict ‘legislation’ case should eliminate all exceedance stations in 2030 (Figure 2.2).

In contrast, if real-driving emission factors of Euro-6 remained at the Euro-4 levels, non-compliance would prevail throughout Europe; between 2010 and 2020, the number of stations with unlikely compliance would fall from 186 to 112. However, for 2030, clear non-compliance is still estimated for 100 stations (Table 2.3). Thus, the performance of the Euro-6 standards for light duty diesel vehicles emerges as a dominating factor for future compliance with the NO_2 limit values.

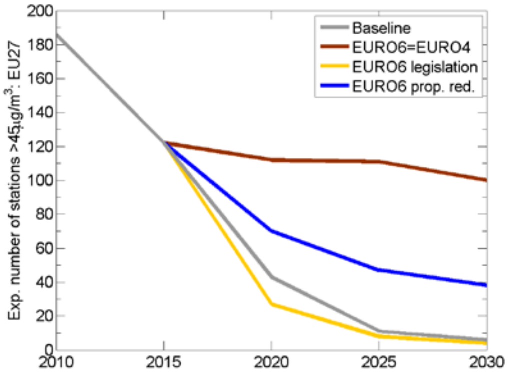

Figure 2.2: Number in the total set of 1174 analysed AIRBASE stations for which robust non-compliance has been estimated for the various sensitivity analyses on the effectiveness of Euro-6

Table 2.2: Number of stations with computed annual mean concentrations of NO_2 (a) below 35µg/m^3 - likely compliance (b) between 35 and 45 µg/m^3, - compliance uncertain, and (c) above 45 µg/m^3 - compliance unlikely, for the TSAP-2012 baseline and the ‘Euro-6=Euro-4 sensitivity case

	2020						*2025*						*2030*					
	Baseline			*Euro-6 = Euro-4*			*Baseline*			*Euro-6 = Euro-4*			*Baseline*			*Euro-6 = Euro-4*		
	< 35	*35-45*	*> 45*	*< 35*	*35-45*	*> 45*	*< 35*	*35-45*	*> 45*				*< 35*	*35-45*	*> 45*	*< 35*	*35-45*	*> 45*
Austria	49	5	0	49	5	0	54	0	0	49	5	0	54	0	0	50	4	0
Belgium	51	0	0	43	7	1	51	0	0	44	6	1	51	0	0	47	4	0
Bulgaria	6	2	1	6	2	1	6	3	0	6	2	1	6	3	0	6	2	1
Cyprus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Czech Rep.	36	2	2	34	3	3	38	0	2	34	3	3	38	2	0	36	2	2
Denmark	0	0	0	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	1	0	0
Finland	5	0	0	5	0	0	5	0	0	5	0	0	5	0	0	5	0	0
France	207	14	6	189	18	20	222	5	0	188	18	21	223	4	0	191	17	19
Germany	184	18	10	145	28	39	198	14	0	145	27	40	208	4	0	149	26	37
Greece	8	0	3	7	1	3	8	2	1	8	1	2	10	1	0	8	2	1
Hungary	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0
Ireland	4	1	0	4	1	0	5	0	0	4	1	0	5	0	0	5	0	0
Italy	203	37	12	185	43	24	223	24	5	194	35	23	233	15	4	198	33	21
Latvia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lithuania	1	0	0	1	0	0	1	0	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	2	0	0
Malta	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	28	1	0	23	5	1	29	0	0	23	5	1	29	0	0	23	5	1
Poland	36	1	2	36	1	2	37	1	1	36	1	2	38	0	1	36	1	2
Portugal	34	2	1	26	9	2	36	1	0	27	8	2	37	0	0	27	8	2
Romania	16	2	1	16	2	1	17	1	1	16	2	1	17	1	1	16	2	1
Slovakia	7	0	0	6	1	0	7	0	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	3	0	0
Spain	90	8	3	69	24	8	96	4	1	71	23	7	99	2	0	71	24	6
Sweden	5	0	0	4	1	0	5	0	0	5	0	0	5	0	0	5	0	0
UK	48	6	2	43	6	7	51	5	0	44	5	7	53	3	0	46	3	7
EU-27	1032	99	43	905	157	112	1103	60	11	921	142	111	1133	35	6	941	133	100

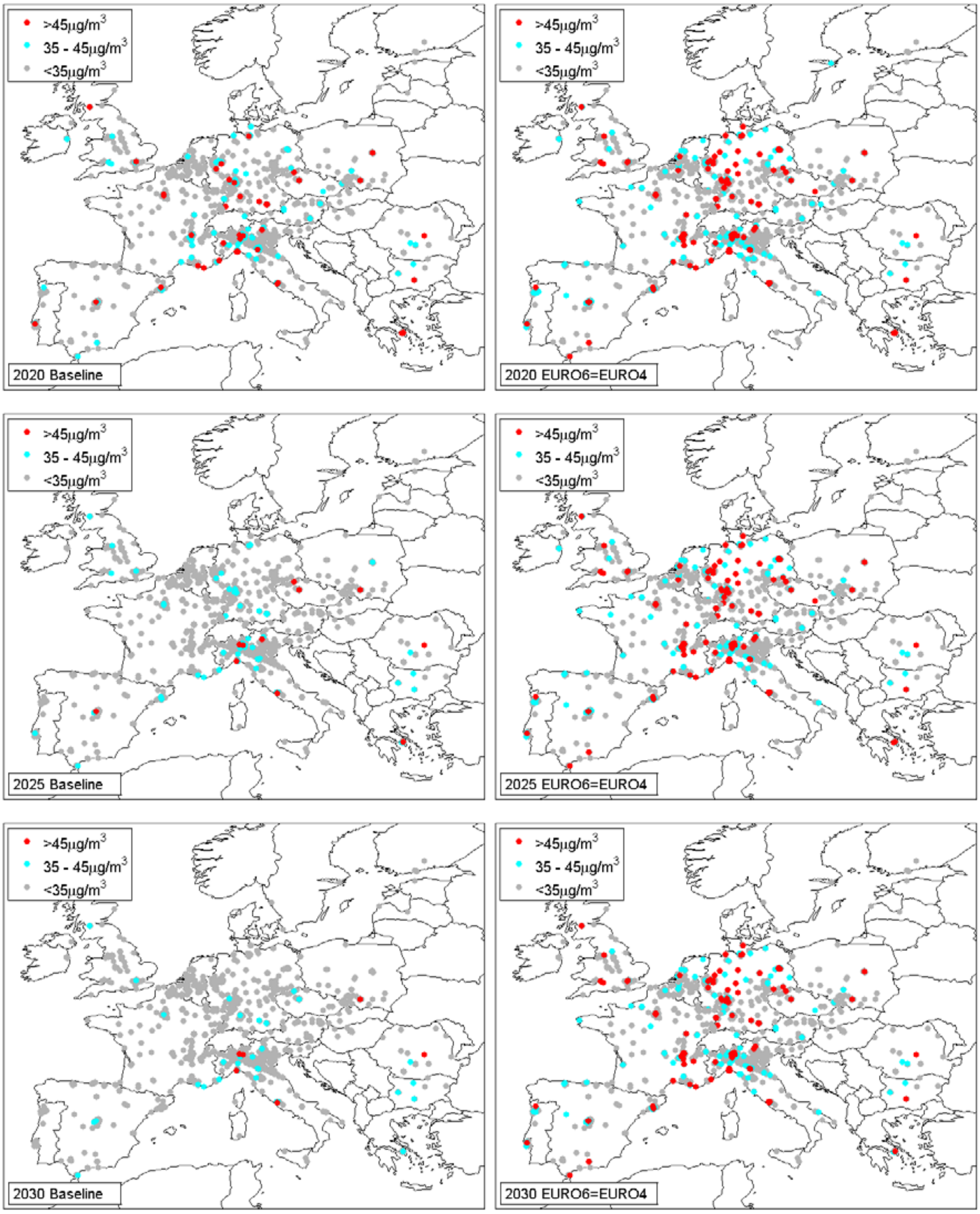

Figure 2.3: Computed annual mean NO_2 concentrations at AIRBASE monitoring stations for the baseline and the Euro6=Euro4 sensitivity case:

grey: <35 µg/m^3: compliance with annual limit value likely
blue: 35-45 µg/m^3: compliance uncertain
red: >45 µg/m^3: compliance unlikely

3 Cost-optimized scenarios: Emission reduction measures and compliance with air quality limit values

TSAP Report #7 (Wagner et al., 2012) presented a series of cost-optimized emission reduction scenarios for progressive 'gap closures' of the four environmental effect indicators between the baseline and maximum feasible reduction cases. Here some further analyses are presented, providing more detail on the measures that have been identified as cost-effective means to meet these environmental targets, and analyzing the implications of these scenarios on compliance with PM10 and NO_2 limit values. For reference, figures on optimized emission reductions as well as their impacts on the other effect indicators are presented in TSAP Report 7.

3.1 Cost-effective portfolios of emission reduction measures

An ex-post analysis has been conducted to retrieve the measures that are taken in the least-cost solution to reduce the emissions of the various precursor substances. The contributions made to total emission reductions by the different sectors are indicated in Figure 3.1 to Figure 3.5.

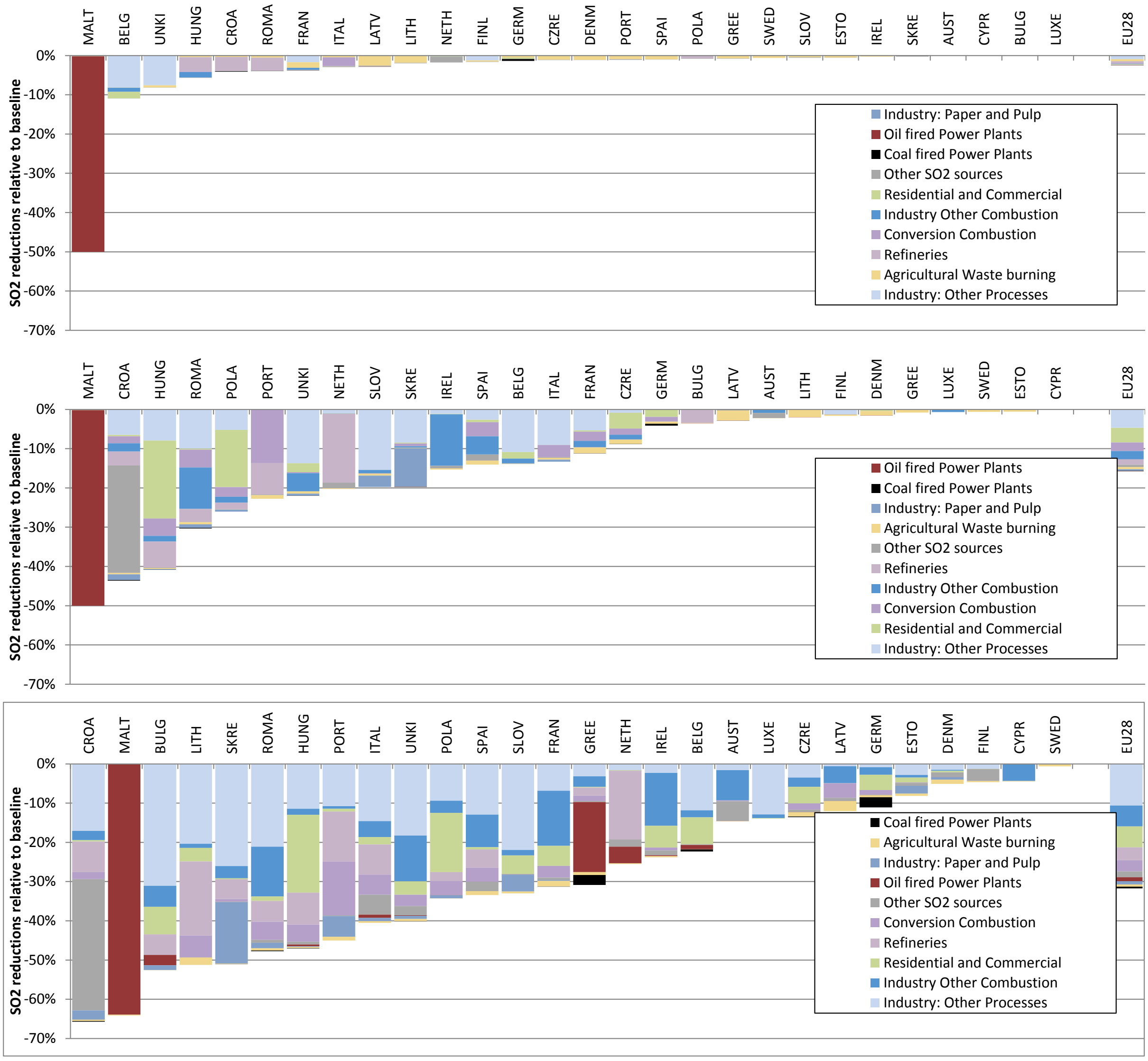

Figure 3.1: Contributions of SO_2 measures in the various sectors to the emission reduction scenarios that have been optimized for 2030 (Top: Low ambition case; Centre: Mid ambition case; Bottom: High ambition case)

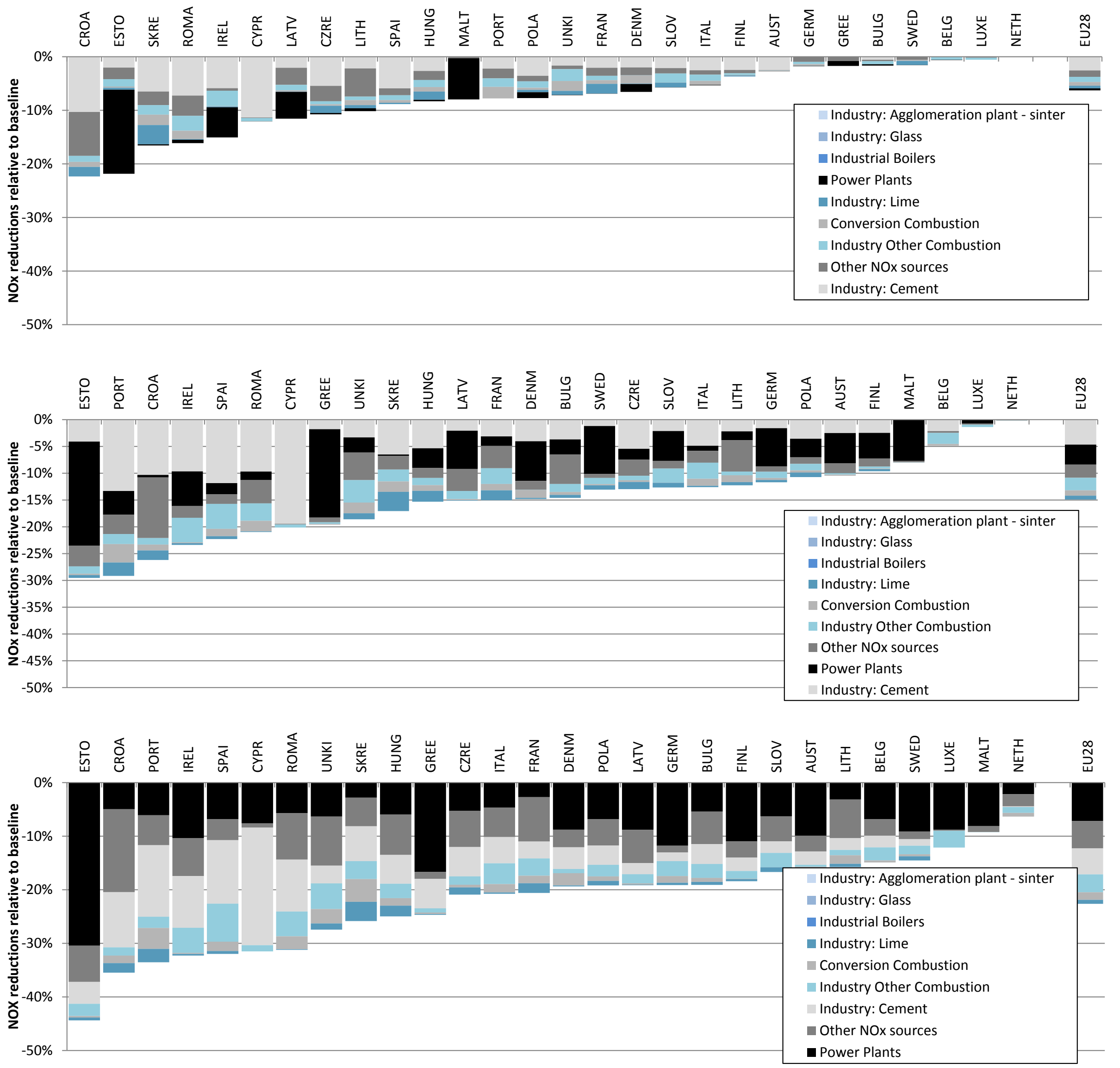

Figure 3.2: Contributions of NO_x measures in the various sectors to the emission reduction scenarios that have been optimized for 2030 (Top: Low ambition case; Centre: Mid ambition case; Bottom: High ambition case)

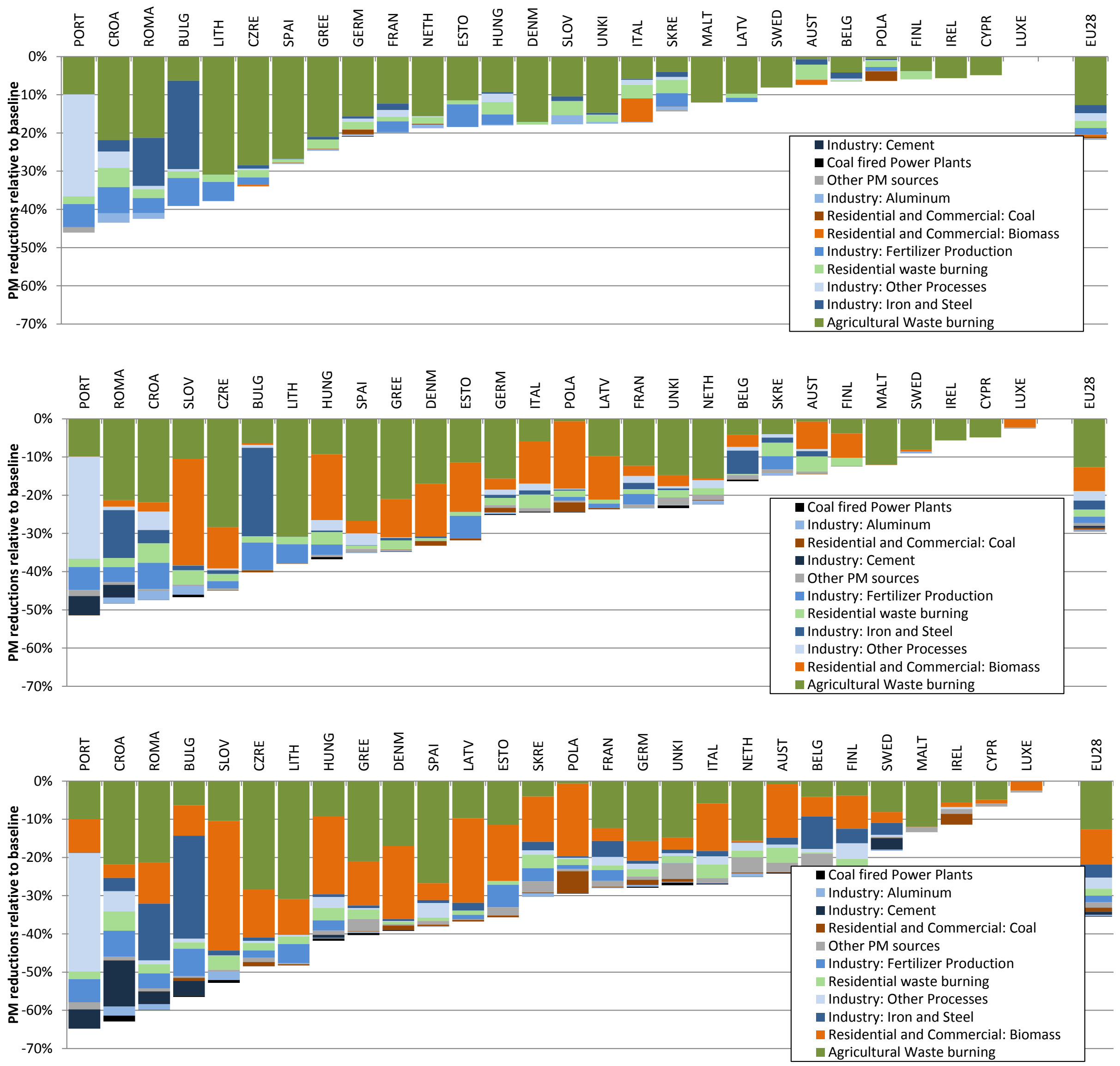

Figure 3.3: Contributions of PM2.5 measures in the various sectors to the emission reduction scenarios that have been optimized for 2030 (Top: Low ambition case; Centre: Mid ambition case; Bottom: High ambition case)

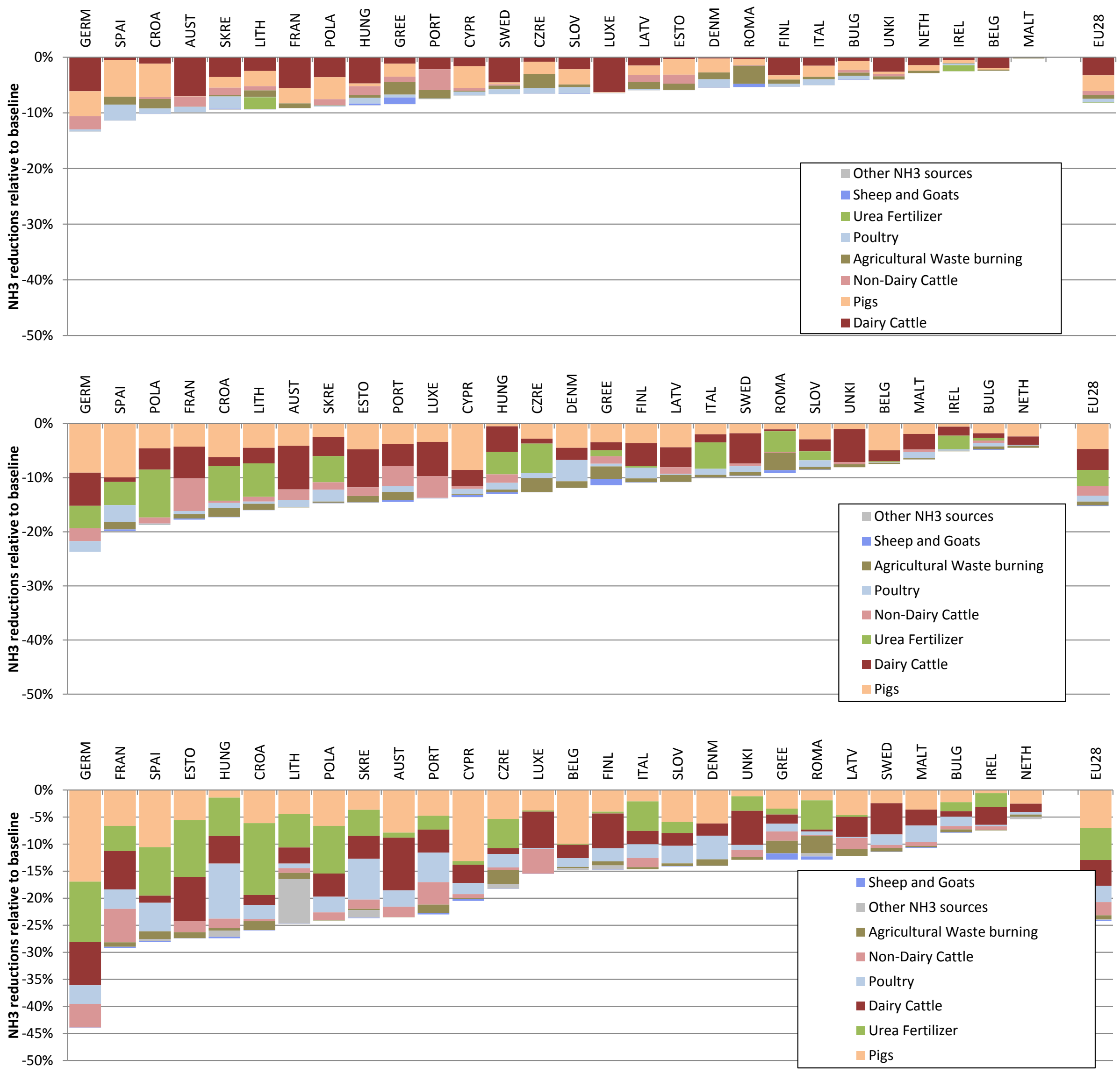

Figure 3.4: Contributions of NH_3 measures in the various sectors to the emission reduction scenarios that have been optimized for 2030 (Top: Low ambition case; Centre: Mid ambition case; Bottom: High ambition case)

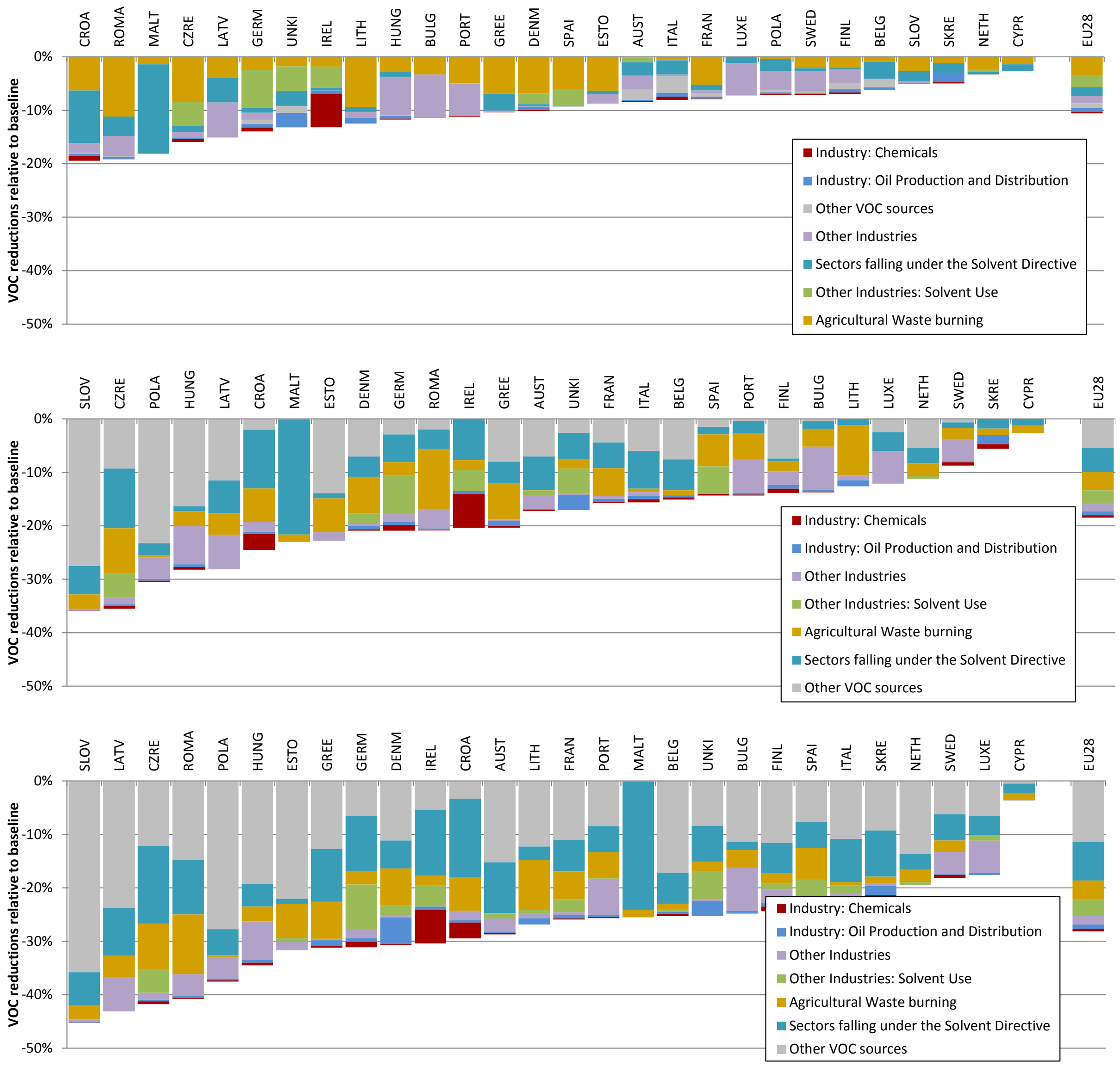

Figure 3.5: Contributions of VOC measures in the various sectors to the emission reduction scenarios that have been optimized for 2030 (Top: Low ambition case; Centre: Mid ambition case; High ambition case)

3.2 Compliance with PM10 and NO_2 limit values

The scenarios in TSAP Report #7 have been optimized to achieve progress in the health and environmental impact indicators. Compliance with air quality limit values was not considered in the target setting for these scenarios. However, the impact of the optimized scenarios on compliance has been estimated in an ex-post analysis following the methodology that is outlined in TSAP Report #6.

Although compliance was not a driver for the optimization, the least-cost portfolios of measures would lead to significant decline of the remaining non-compliance cases for PM10. Especially the PM2.5 health target requires reductions of all precursor emissions of particulate matter, which lead to a large-scale lowering of fine particulate matter levels throughout Europe. This decline in background concentrations will affect also PM10 levels within cities, and thereby increase the chances that local monitoring sites comply with the PM10 limit values. For instance, for the high ambition case in the year 2030, it is estimated that the number of stations for which non-compliance is robustly estimated by about 20%, and the stations for which compliance would be possible but not certain by 30% compared to the baseline (Table 3.1).

Table 3.1: Compliance statistics estimated for the optimized scenarios in 2030 (number of stations)

	PM10			NO2		
Com-pliance	Likely	Uncertain	Unlikely	Likely	Uncertain	Unlikely
Baseline	1557	233	53	1133	35	6
Low case	1582	210	51	1137	31	6
Mid case	1613	183	47	1143	26	5
High case	1640	161	42	1147	22	5
MTFR	1703	103	37	1162	9	3

In contrast, the optimized scenarios do not yield significant improvements in the compliance with NO_2 limit values. This results from the exclusions of further measures for road transport in the initial series of optimizations, owing to the current lack of shared cost estimates for further Euro standards. As NO_2 at road sites is strongly dominated by local emissions within the street canyons, wide-spread improvements in background concentrations will not significantly influence the compliance situation.

Table 3.2: Number of stations with computed annual mean concentrations of PM10 (a) below 25µg/m^3 - likely compliance (b) between 25 and 35 µg/m^3, - compliance uncertain, and (c) above 35 µg/m^3 - compliance unlikely, for the optimized scenarios in 2030

	Baseline			*Low case*			*Mid case*			*High case*			*MTFR*		
	< 25	*25-35*	*>35*	*< 25*	*25-35*	*>35*	*< 25*	*25-35*	*>35*	*< 25*	*25-35*	*>35*	*< 25*	*25-35*	*>35*
Austria	102	6	0	103	5	0	103	5	0	106	2	0	108	0	0
Belgium	48	10	0	49	9	0	54	4	0	55	3	0	56	2	0
Bulgaria	8	10	15	8	10	15	8	10	15	8	11	14	9	12	12
Cyprus	1	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Czech Rep.	79	18	4	80	17	4	82	16	3	82	16	3	84	14	3
Denmark	3	0	0	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	7	0	0
Finland	13	0	0	13	0	0	13	0	0	13	0	0	13	0	0
France	288	12	1	289	11	1	289	12	0	290	11	0	297	4	0
Germany	277	16	0	282	11	0	283	10	0	288	5	0	293	0	0
Greece	3	1	0	4	0	0	4	0	0	4	0	0	4	0	0
Hungary	8	9	1	9	9	0	10	8	0	12	6	0	16	2	0
Ireland	8	0	0	8	0	0	8	0	0	8	0	0	8	0	0
Italy	225	57	2	231	51	2	240	42	2	246	36	2	267	15	2
Latvia	9	0	0	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	5	0	0
Luxembourg	1	0	0	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	0	0	0
Netherlands	30	0	0	30	0	0	30	0	0	30	0	0	30	0	0
Poland	104	53	23	108	50	22	115	45	20	119	43	18	128	36	16
Portugal	38	10	0	39	9	0	43	5	0	44	4	0	47	1	0
Romania	17	3	0	18	2	0	18	2	0	18	2	0	18	2	0
Slovakia	11	8	4	11	8	4	11	8	4	11	9	3	12	8	3
Slovenia	7	2	0	7	2	0	7	2	0	8	1	0	8	1	0
Spain	218	15	2	219	14	2	220	13	2	223	11	1	228	6	1
Sweden	11	1	1	12	0	1	12	0	1	12	0	1	13	0	0
UK	36	2	0	36	2	0	37	1	0	37	1	0	38	0	0
EU-27	1557	233	53	1582	210	51	1613	183	47	1640	161	42	1703	103	37

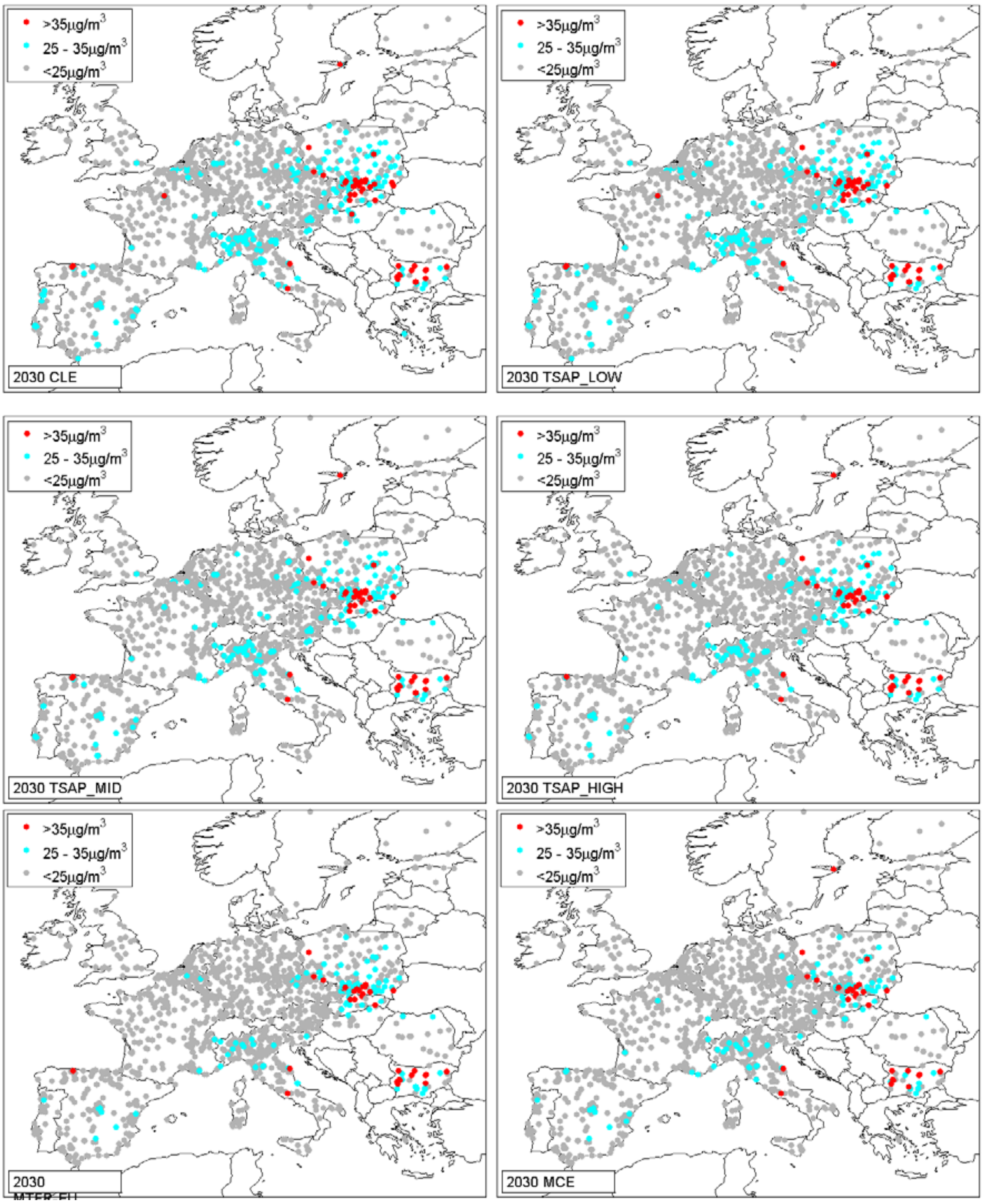

Figure 3.6: Computed annual mean PM10 concentrations in 2030 at AIRBASE monitoring stations for the baseline, the optimized scenarios, the scenario with MTFR in the EU, and the MCE scenario:
grey: <25 µg/m^3: compliance with annual limit value likely
blue: 25-35 µg/m^3: compliance uncertain
red: >35 µg/m^3: compliance unlikely

While the optimized scenarios will improve the situation in the old Member States, especially with regard to stations with computed concentrations around the limit value, exceedances persist in urban areas in the new Member States (Figure 3.3), essentially due the prevailing emissions from solid fuel combustion in small household sources. As the illustrative optimization series did not include substation of coal and wood with cleaner forms of energy, there is only little progress calculated for these regions.

4 Mercury emissions of the TSAP-2012 baseline and MTFR scenarios

Recent work at IIASA introduced the calculation of mercury (Hg) emissions into the GAINS model (Rafaj et al., forthcoming), fully consistent with the estimates of historic and future emissions of the other air pollutants and greenhouse gases. This extension makes it possible to estimate, in addition to the other pollutants, the (side) impacts of different climate and air pollution strategies on Hg emissions.

A first implementation suggests for the EU-28 for the TSAP-2012 baseline a decline of Hg emissions of 22% in 2020 and about 30% in 2030, mainly as a consequence of lower coal use in the power sector (Table 3.4). However, full implementation of the available technical emission control, especially certain measures to reduce PM emissions, could eliminate Hg emissions in the EU by another third, so that in 2030 the total release of Hg in the EU could be more than 50% lower than in 2005.

Table 3.1: Hg emissions by SNAP sector, EU-28 (tons/year)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Power generation	63.5	62.6	53.1	52.4	46.7	31.1	47.9	30.8	39.8	24.0
Domestic sector	4.2	4.0	3.5	3.3	3.2	2.9	2.9	2.6	2.7	2.4
Industrial combust.	3.4	3.4	2.5	2.8	2.7	2.7	2.6	2.5	2.5	2.4
Industrial processes	28.8	27.3	22.6	22.4	21.9	17.4	21.9	18.0	21.9	18.3
Fuel extraction										
Solvent use										
Road transport	0.9	0.8	0.7	0.6	0.6	0.6	0.6	0.6	0.5	0.5
Non-road mobile	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Waste treatment	5.7	5.4	5.4	5.2	5.3	0.2	5.4	0.2	5.6	0.2
Agriculture	0.5	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.5	0.0
EU-28	107.4	104.5	88.7	87.6	81.2	55.2	82.2	55.1	73.8	48.3
Change to 2005			*-15%*	*-16%*	*-22%*	*-47%*	*-21%*	*-47%*	*-29%*	*-54%*

Table 3.2: Emissions of Hg by Member State (t/yr)

	2000	***2005***	***2010***	***2015***	***2020***		***2025***		***2030***	
				Baseline	Baseline	MTFR	Baseline	MTFR	Baseline	MTFR
Austria	1.9	1.1	0.9	0.9	1.0	0.8	1.0	0.8	1.0	0.7
Belgium	2.9	2.4	2.2	1.9	1.6	1.3	2.3	1.3	2.3	1.4
Bulgaria	3.4	3.7	3.2	3.1	2.8	1.7	2.3	1.1	2.2	1.0
Cyprus	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Czech Rep.	5.8	5.2	4.6	4.3	3.6	2.6	3.8	2.8	3.1	2.6
Denmark	0.8	0.9	0.7	0.6	0.6	0.4	0.7	0.3	0.7	0.2
Estonia	0.4	0.4	0.4	0.5	0.4	0.3	0.3	0.3	0.3	0.3
Finland	1.1	1.1	1.2	1.1	1.1	0.8	1.1	0.8	1.1	0.7
France	6.2	5.9	5.2	4.5	4.4	3.0	4.2	3.0	4.1	3.0
Germany	23.1	22.6	20.3	19.8	19.3	12.4	19.1	12.3	15.0	8.8
Greece	2.7	2.8	2.5	2.1	2.0	1.6	1.9	1.6	1.7	1.4
Hungary	4.6	2.6	2.5	2.4	2.3	1.9	2.1	1.8	2.1	1.8
Ireland	0.6	0.6	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.2
Italy	6.2	7.8	6.1	7.1	7.6	3.4	7.7	3.4	7.8	3.4
Latvia	0.2	0.1	0.1	0.2	0.2	0.1	0.2	0.1	0.2	0.1
Lithuania	0.1	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.2	0.1
Luxembourg	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Malta	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Netherlands	1.4	1.4	1.3	1.6	1.6	0.9	1.6	0.9	1.6	0.9
Poland	19.0	18.9	16.0	15.7	13.3	10.7	14.2	11.3	13.8	11.0
Portugal	2.1	2.2	1.8	2.0	1.5	0.5	1.4	0.5	1.5	0.4
Romania	4.5	4.8	3.8	3.8	3.4	2.6	3.4	2.7	3.0	2.3
Slovakia	1.3	1.2	1.0	1.0	1.0	0.8	1.0	0.8	0.8	0.7
Slovenia	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.3	0.3	0.2
Spain	9.8	9.8	6.4	6.5	6.0	4.3	6.4	4.9	5.1	3.9
Sweden	1.2	1.1	1.0	1.0	1.0	0.8	1.0	0.8	1.0	0.8
UK	7.1	6.6	6.1	6.2	5.4	3.1	5.1	2.9	4.3	2.1
EU-27	107.1	104.2	88.4	87.3	80.9	55.1	81.8	54.9	73.5	48.1
Croatia	0.3	0.3	0.3	0.3	0.3	0.1	0.4	0.1	0.4	0.1
EU-28	107.4	104.5	88.7	87.6	81.2	55.2	82.1	55.1	73.8	48.3
Change 2005			*-15%*	*-16%*	*-22%*	*-47%*	*-21%*	*-47%*	*-29%*	*-54%*

5 Conclusions

This report provides additional information to the baseline and optimized scenarios that have been developed for the review and revision of the Thematic Strategy on Air Pollution in TSAP Reports #6 and #7.

The TSAP-2012 baseline scenario assumes implementation of the Euro-6 emission standards for light duty diesel vehicles in two stages, i.e., an interim stage (Euro-6.a) from 2014 onwards, and the final Euro-6.b stage, in which real-driving emissions would amount to 1.5 times the value of test cycle value, from 2018 onwards.

It is shown that this particular assumption on the effectiveness and timing of the Eur-6 introduction will have paramount impact on the compliance situation with the NO_2 air quality limit value. For the baseline case, almost all AIRBASE stations that have been modelled in this exercise would achieve the limit values by 2030 at the latest. However, in the least optimistic sensitivity case, i.e., under the assumption of a complete failure of Euro-6 (assuming no change in real-driving emissions compared to Euro-4), 100 out of the 1173 AIRBASE monitoring stations would still remain in non-compliance with the limit value in 2030.

A second analysis examined the optimization results presented in TSAP Report #7 in more detail and extracted, for each of the optimized scenarios, the sectors in which emission reductions would occur in the cost-optimal case.

These emission reductions will lead to lower background pollution concentrations in Europe, which will affect PM10 levels within cities. It is estimated for the high ambition case in 2030 that the number of stations for which non-compliance is robustly estimated will decline by about 20%. The number of stations for which compliance seems possible but not certain would fall by 30% compared to the baseline.

In contrast, the optimized scenarios do not yield significant improvements in the compliance with NO_2 limit values, as the series of scenarios did not consider further measures for road vehicle emissions.

Finally, an initial assessment of current and future emissions of mercury in Europe suggests 28 for the TSAP-2012 baseline a decline of Hg emissions of 22% in 2020 and about 30% in 2030 (relative to 2005), mainly as a consequence of lower coal use in the power sector. Full implementation of the available technical emission controls, especially of certain measures to reduce PM emissions, could eliminate Hg emissions in the EU by another third, so that in 2030 the total release of Hg in the EU could be more than 50% lower than in 2005.

REFERENCES

Amann, M., Borken-Kleefeld, J., et al., 2012. Future emissions of air pollutants in Europe – Current legislation baseline and the scope for further reductions. TSAP Report #1, Laxenburg, Austria: International Institute for Applied Systems Analysis.

Amann, M., Bertok, I., et al., 2012. TSAP-2012 Baseline: Health and Environmental Impacts. TSAP Report #6, Laxenburg, Austria: International Institute for Applied Systems Analysis.

Borken-Kleefeld, J. & Ntziachristos, L., 2012. The potential for further controls of emissions from mobile sources in Europe. TSAP Report #4, Laxenburg, Austria: International Institute for Applied Systems Analysis (IIASA).

Demuynck, J. et al., Recommendations for the new WLTP cycle based on an analysis of vehicle emission measurements on NEDC and CADC. Energy Policy.

Hausberger, S., 2010. Fuel Consumption and Emissions of Modern Passenger Cars, TU Graz, Institute for Internal Combustion and Thermodynamics.

Hausberger, S., 2012. Overview of the measurement programs on LDV and HDV.

Wagner, F. et al., 2012. Scenarios of Cost-effective Emission Controls after 2020. TSAP Report #7, Laxenburg, Austria: International Institute for Applied Systems Analysis.