PROGRESS TOWARDS THE ACHIEVEMENT OF THE EU'S AIR QUALITY AND EMISSIONS OBJECTIVES

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Editor: Markus Amann
International Institute for Applied Systems Analysis (IIASA)

International Institute for
Applied Systems Analysis
Schlossplatz 1
A-2361 Laxenburg, Austria

Tel: +43 2236 807 342
Fax: +43 2236 71313
E-mail: publications@iiasa.ac.at
Web: www.iiasa.ac.at

Abstract

After completion of the analyses that informed the negotiations on the revised national emission ceilings directive (NECD), important factors have changed. Improved emission inventories, the recent climate and energy policies of the European Union and new source-oriented emission control regulations have profound implications on further actions to meet the emission reduction requirements of the NECD.

Considering the interplay of this new information, this report presents an updated outlook for emissions and air quality in the European Union, and explores the prospects of achieving the WHO guideline values to protect human health and the Union's long-term environmental policy objectives on the protection of ecosystems.

It is found that, broadly speaking, by 2030 the recent legislation will bring the WHO guidelines for PM2.5 within reach for most areas, while further efforts, especially for agricultural ammonia emissions and PM emissions from residential combustion of solid fuels will be required at hot spots.

The authors

This report has been produced by

Markus Amann[1]
Michael Anderl[2]
Jens Borken-Kleefeld[1]
Janusz Cofala[1]
Chris Heyes[1]
Lena Höglund-Isaksson[1]
Gregor Kiesewetter[1]
Zbigniew Klimont[1]
Lorenz Moosmann[2]
Peter Rafaj[1]
Robert Sander[1]
Wolfgang Schöpp[1]
Melanie Tista[2]
Fabian Wagner[1]
Wilfried Winiwarter[1]

Affiliations:

[1] International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria
[2] Umweltbundesamt Vienna, Austria

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Disclaimer

Executive Summary

The policy discussions on the revised directive on national emission ceilings (NECD, 2016/2284/EU) have been informed by systematic cost-effectiveness and cost-benefit analyses conducted around 2013 with the GAINS integrated assessment model. Since the time these analyses have been conducted, a number of important factors have changed. These include, *inter alia*, improved information on emission inventories for historic years, recent proposals for new climate and energy policies of the European Union, new source-oriented regulations for emission controls and, not least, the political agreement on the NEC Directive.

This report provides a revised Outlook up until the year 2030, taking into account the changes listed above, and explores the prospects of achieving the WHO guideline values to protect human health as well as the Union's environmental policy objectives on the protection of ecosystems.

Retrospective changes of inventories for 2005 have direct impact on future emission ceilings and the need for further efforts to meet these ceilings. The 2005 inventories reported by Member States in 2017 have significantly changed compared to the 2014 submissions on which the earlier analyses were based. More than 20% of sectoral figures have altered by more than 10%, and total reported emissions have increased by up to 11% (for PM2.5). This makes the absolute emission ceilings larger in 2030, and affects the need for further measures, although the implied efforts depend on the source sectors for which figures have been changed.

In addition, after 2013 the European Commission released new projections of economic activities, and new source-oriented emission regulations have been agreed, including the Medium Combustion Plants (MCP) Directive, the Eco-design controls for solid fuel stoves and boilers, and for non-road mobile machinery (NRMM).

Considering the interplay of all these changes and especially the legislation since 2013, it is found that, for the EU-28 as a whole, by 2030 SO_2 emissions would decline by 78% relative to 2005, NO_x emissions by 65%, PM2.5 by 51%, NH_3 by 5% and VOC by 42%. As in the previous analysis, for SO_2 and NO_x the pre-2014 legislation delivers most of the NECD emission reduction requirements (ERR). For PM2.5 and VOC, the impact of the additional legislation since 2014 brings those emissions also close to the required levels. Only for NH_3 is there little contribution from source legislation to the achievement of the ERRs. However, the situation for individual countries differs. Additional measures are necessary in sub-sets of Member States, while for others implementation of latest legislation will lead to overshooting of the ERRs. Due to the overshooting, by 2030 the health improvements will be larger than what would result from the ERRs alone. Premature deaths will drop by 54% in relation to 2005, compared to the 52% of the 2013 Commission proposal for the Clean Air Policy package and the 49.6% estimated during Council negotiations.

In total, the additional emission reductions, if implemented in the most cost-effective way, involve emission control costs of 960 million €/yr, assuming the PRIMES 2016 REFERENCE baseline scenario, which implies 1.9€/person/year. With the 12% lower consumption of fossil fuels expected in the CLIMATE AND ENERGY POLICY scenario that reduces the EU's GHG emissions by 40% in 2030 and increases energy efficiency to 30%, additional emission control costs for achieving the ERRs would drop to 540 million €/yr, i.e., by 45% (reaching 1.05€/person/year).

The significant reductions in precursor emissions will reduce ambient PM2.5 levels in the overwhelming majority of countries below the WHO guideline value of 10 μg/m^3. However, two areas in Europe will still face robust exceedances of the WHO guideline value, i.e., Northern Italy and Southern Poland.

Source apportionment analyses for these areas indicate that, after implementation of all measures that are required to meet the ERRs, secondary particles formed in the atmosphere in the presence of ammonia will still contribute about half of the WHO guideline value, despite the forthcoming reductions in NH_3 emissions. Another large fraction consists of primary emissions of particles from the residential combustion of solid fuels, i.e., predominantly wood stoves in Italy, and coal and wood stoves in Poland. However, if all the technical measures that are considered in the 'Maximum Technically Feasible Reductions' scenario are applied, the WHO guideline value could be reached at almost all stations.

Also for NO_2, substantial reductions in the number of stations registering annual average concentrations above 40µg/m^3 are expected. While currently about 20% of the almost 2000 AIRBASE monitoring stations considered in the analysis are robustly or possibly above this level, that figure is almost eliminated with the implementation of the NEC Directive.

For biodiversity, the measures envisaged for reaching compliance with the ERRs will not achieve the improvements that have been suggested in the 2013 Commission proposal for the NEC Directive. In 2030, the measures would reduce the share of Natura2000 nature protection area where biodiversity is threatened by excess nitrogen deposition to 58%, down from 78% in 2005. Additional measures, especially for controlling NH_3 emissions, are available, and their application could further reduce excess nitrogen deposition by 75%, which, however, would still leave 50% of the Natura2000 nature protection areas at risk.

Especially the anticipated further decline in SO_2 emissions that is implied in the ERRs will resolve most of the threat of acidification of forest soils, and full implementation of the additional reduction potentials implies that the critical loads for acidification are met at 99.8% of forest areas.

List of acronyms

CAPRI	Agricultural model developed by the University of Bonn
CH_4	Methane
CLE	Current legislation
CO_2	Carbon dioxide
EC4MACS	European Consortium for Modelling Air Pollution and Climate Strategies
EEA	European Environment Agency
EMEP	European Monitoring and Evaluation Program of the Convention on Long-range Transboundary Air Pollution
ERR	Emission Reduction Requirements of the NEC Directive
EU	European Union
GAINS	Greenhouse gas - Air pollution Interactions and Synergies model
GDP	Gross domestic product
IED	Industrial Emissions Directive
IIASA	International Institute for Applied Systems Analysis
IIR	Informative Inventory Reports
kt	kilotons = 103 tons
MCP	Medium Sized Combustion Plants
MTFR	Maximum technically feasible emission reductions
NEC	National Emission Ceilings
NFR	'Nomenclature For Reporting' of emission inventories to EMEP/EEA
NH_3	Ammonia
NMVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
NO_2	Nitrogen dioxide
NRMM	Non-road Mobile Machinery
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
VOC	Volatile organic compounds

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.

All detailed data of the scenarios presented in this report can be retrieved from the GAINS-online model (http://gains.iiasa.ac.at/gains/EUN/index.login?logout=1). Under the Scenario group 'EU Outlook 2017', the following scenarios can be examined in an interactive mode:

Scenario label in this report	Scenario label in GAINS Online
PRIMES 2016 REFERENCE activities projection	
with the legislation already in place in 2014 (the 'pre-2014' legislation),	REF_pre2014_CLE
with the new legislation adopted after 2014 (the 'post-2014' legislation)	REF_post2014_CLE
with full implementation of the technical emission control measures (MTFR)	REF_MTFR
cost-effective achievement of the emission reduction requirements (ERRs)	REF_ERR_2030
CLIMATE AND ENERGY POLICY activities projection	
with the new legislation adopted after 2014 (the 'post-2014' legislation)	CEP_post2014_CLE
with full implementation of the technical emission control measures (MTFR)	CEP_MTFR
cost-effective achievement of the emission reduction requirements (ERRs)	CEP_ERR_2030

Contents

1 Context

In its Clean Air Programme for Europe (COM(2013)918 final), the European Commission has laid out a comprehensive approach to improve air quality in Europe. It contains provisions for a regular tracking of the progress towards the programme objectives by 2020 and every five years thereafter.

The main legislative instrument to achieve the 2030 objectives of the Clean Air Programme is Directive 2016/2284/EU on the reduction of national emissions of certain atmospheric pollutants, which entered into force on 31 December 2016 (the NEC Directive or NECD). This directive sets national reduction commitments for the five pollutants (sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and fine particulate matter) responsible for acidification, eutrophication and ground-level ozone pollution, which leads to significant negative impacts on human health and the environment. In addition, the revised Directive institutionalizes regular reporting obligations. These include progress towards the reduction commitments as well as towards the health and environmental objectives, additional measures needed to meet the objectives, uptake of funding, examination of the Member States' national air pollution control programmes, and socio-economic impacts.

The Commission proposal for the revised NECD, which was adopted by the European Commission on December 18, 2013, has been informed by extensive cost-effectiveness and cost-benefits analyses with IIASA's GAINS (Greenhouse gas – Air pollution Interactions and Synergies) model (Amann et al. 2011). After that, additional technical analyses were conducted with the GAINS model to support negotiations in the Council and the European Parliament (Amann et al. 2014a); (Amann et al. 2014b) (Amann, M. et al. 2015).

In this context, this report presents an outlook into the future air quality in Europe as it is expected to emerge from the implementation of the revised NEC directive and other recent source-oriented emission legislation. The outlook is developed with the same analytical framework that has been used for the cost-effectiveness and cost-benefits analyses. To reflect the latest developments in the fields of emission inventories, activity projections and emission control legislation, relevant aspects have been updated. In particular, the analysis includes now the PRIMES 2016 REFERENCE scenario, a CLIMATE AND ENERGY POLICY scenario that mimics the final proposals of the European Commission in terms of greenhouse gas reductions of 40% for 2030 and an energy efficiency target of 30%[1], the recently adopted source control measures which affect air pollution, recent improvements and recalculations of reported historic emissions by Member States, and the final political agreement on the NECD.

The remainder of the report is organized as follows: Section 2 summarizes the review of the 2017 submissions of national inventories for 2005 and 2010, especially in view of the changes that occurred compared to the 2014 submissions. Section 3 introduces the recent baseline activity projections, i.e., the PRIMES 2016 REFERENCE and the CLIMATE and ENERGY POLICY scenario for 2030. Section 4 provides updated summaries of emission control legislation, with special emphasis on source-specific regulations that have been passed since 2014. Section 5 presents the implications of all this updated information on baseline emission projections of the five air pollutants for the year 2030, and Section 6 examines the perspectives for meeting the emission reduction requirements that have been laid out in the NEC Directive. Section 7 introduces the resulting air quality impacts on human health and ecosystems, and discusses the prospects for attaining the long-term objectives of EU environmental policy. Section 8 summarizes the key findings and draws conclusions.

[1] https://ec.europa.eu/clima/policies/strategies/2030_en

2 Updated emission inventories

For a number of reasons, after 2014 Member States have reported revised historic emissions data, including for the base years 2005 and 2010. Changes in reported figures emerged, inter alia, from:

- Updates of methods and emission factors following the EMEP/EEA Emission Inventory Guidebooks of 2013 and 2016;
- Changes in national methods and emission factors;
- Updates of activity data;
- Changes in the reporting format from the 'Nomenclature For Reporting' NFR09 to NFR 14. This change in the reporting format does not necessarily result in different national totals, but requires re-allocations of emissions between categories.

Such changes in historic emission inventories could have important repercussions on the projection of future emissions and envisaged compliance with the Emission Reduction Requirements (ERRs) laid out in the NECD. First, as the ERRs percentages are specified in relation to 2005 emissions, obviously any change of 2005 inventories will have immediate impacts on the absolute level of emissions that need to be achieved in 2030. Furthermore, changes in sectoral emissions or emission factors could modify the relative share of a sector in total national emissions, and modify the contribution of a sector towards the total ERR in a country. If new emission estimates for a sector increase due to higher activity data and/or higher emission factors, emission reductions in this sector will play a more important role for meeting the ERRs. This might reduce the overall burden if measures are available that could reduce emissions effectively, as they could be applied to a larger potential. Vice versa, if no easy means for emission reductions are available for such a sector, the achievement of the ERR will be more demanding.

The analysis proceeded in two steps:

- First, the recent inventories for the years 2005 and 2010 submitted by Member States under the National Emissions Ceilings (NEC) Directive 2016/2284/EU (reporting deadline February 15, 2017 with (re-) submissions until 15 March 2017) have been compared with the figures submitted under the Convention on Long-range Transboundary Air Pollution (CLRTAP) in 2014. The largest deviations have been flagged, and explanations for these changes have been extracted from the Informative Inventory Reports (IIRs) or obtained from national experts.
- Second, this information has been incorporated into the GAINS database, with the aim to reproduce the latest reported figures with latest information on emission factors, using the latest activity statistics for 2005 and maintaining coherence across Member States and with the Emission Inventory Guidebook.

2.1 Review of the latest inventory submissions

The comparison was made for the reference years 2005 and 2010 and for the five pollutants covered by the NEC Directive 2016/2284/EU, i.e., NO_X, VOC, SO_2, NH_3 and PM2.5. All 126 NFR categories were compared individually. For 2017, data were submitted in the NFR14 system, while data submitted in 2014 follow the previous NFR system (NFR09). Appropriate conversions have been carried out for this comparison, including changes in the category codes, inclusion of new categories, and lumping of categories.

All categories were flagged where emissions changed by more than 10% between the 2014 and the 2017 submissions. In these cases, the Member States' Informative Inventory Reports (IIRs) were consulted for an explanation of these recalculations. Where no explanation was found in the IIR, Member State inventory experts were contacted and asked for an explanation, except in cases where the difference was very small (< 1% of the overall recalculation difference for a specific pollutant and Member State).

This comparison was conducted for all EU Member States except Greece. As no 2017 submission was available for Greece at the time of this analysis, a comparison with the 2016 submission was carried out. Likewise, no IIR was provided by Greece and therefore no explanations were available for individual categories. Nevertheless, the changes in emissions reported by Greece, compared to the 2014 submission, are included in the discussion below.

Table 2-1 summarizes the number of categories with differences > 10 %, the number of categories where explanations for these differences were found in the IIR, and the number of questions asked and answered.

Table 2-1: Changes in reported emission inventories between 2014 and 2017. Note that the inventory reporting system holds about 3500 entries for each pollutant and year.

	NO_x		VOC		SO_2		NH_3		PM2.5		Total
	2005	2010	2005	2010	2005	2010	2005	2010	2005	2010	
Categories with changes > 10 %	651	693	826	867	403	477	602	631	853	875	**6878**
Explanations found in IIR, or explained by change in NFR system.	573	599	689	716	328	343	503	454	711	710	**5626**
Difference very small	59	91	120	150	69	130	91	523	132	162	**1527**
Questions asked	19	3	17	1	6	4	8	1	10	3	**72**
Questions answered	18	3	13	1	4	4	4	3	9	2	**60**

In many cases, recalculations were explained in the IIR, as the recommended structure for IIRs provides for information on recalculations both in the sectoral chapters and in a dedicated chapter on recalculations. However, there remain a significant number of categories where the information provided by Member States was insufficient to transparently validate the changes in reported emissions (Figure 2-1).

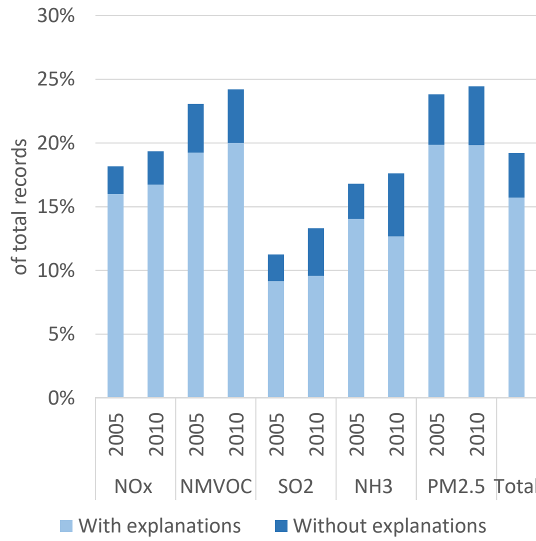


FIGURE 2-1: THE SHARE OF EMISSION REPORTING CATEGORIES WITH CHANGES OF MORE THAN 10% BETWEEN THE 2014 AND 2017 INVENTORY SUBMISSIONS

The largest number of categories with differences > 10 % was found for $PM_{2.5}$, followed by VOC. Member States recalculated $PM_{2.5}$ emissions in a large number of categories, in many cases implementing the recent updates in the EMEP/EEA Guidebook. This can be explained by the fact that there is a shorter reporting history for PM2.5, with less experience and information available. For VOC, many recalculations result from the re-allocations in the NFR14 reporting scheme. In addition, new methods and emission factors were implemented, for instance for emissions from manure management, based on the methods and emission factors provided in the EMEP/EEA Guidebook 2013.

While significant changes occurred for individual Member States (Figure 2-2 to Figure 2-6), it is noteworthy that the recalculations affected also overall emissions of the EU-28[2] (Table 2-2).

TABLE 2-2: CHANGE IN REPORTED EMISSIONS BETWEEN THE 2014 AND THE 2017 SUBMISSIONS (TOTAL EMISSIONS OF ALL MEMBER STATES EXCEPT GREECE).

	NO_x	VOC	SO_x	NH_3	PM2.5
Reference year 2005	+ 3.3 %	+ 3.3 %	- 1.2 %	+ 6.7 %	+ 11.4 %
Reference year 2010	+ 2.9 %	+ 5.2 %	- 2.1 %	+ 5.6 %	+ 13.0 %

With the exception of SO_2, total emission amounts reported in 2017 were higher than those reported in 2014. Largest changes emerged for PM2.5, where many Member States reported higher emissions in the category 'Stationary combustion: residential', due to an update of emission factors in the EMEP/EEA Guidebook. In addition, emissions were estimated for categories for which no emissions had been reported in 2014. This illustrates that in particular for PM2.5 the improvement of completeness of reporting is an on-going process.

[2] For Greece the 2016 CLRTAP submission is used instead of the 2017 NEC submission

Likewise, for VOC, the increase in emissions can be attributed to more complete reporting, in particular to the reporting of emissions from manure management, following the approach provided in the EMEP/EEA Guidebook 2013.

For NH_3, many Member States updated their nitrogen models in the agriculture sector, which resulted in an overall increase of emissions between the 2014 and 2017 submissions. For NO_x, most of the overall increase can be attributed to updated models and emission factors in the transport and agriculture sectors.

In summary, Member States' air pollutant emission inventories have significantly changed in the period from 2014 to 2017, due to updates in activity statistics and models, and new emission factors from the EMEP/EEA Guidebook 2013 and, to a lesser extent, the 2016 version of the EMEP/EEA Guidebook. These updates affected estimates both at the category level and for national total emissions. The largest changes were observed for NH_3 and $PM_{2.5}$, due to updated emission factors and more complete reporting. Many, but not all, Member States' Informative Inventory Reports provide explanations for the re-calculations.

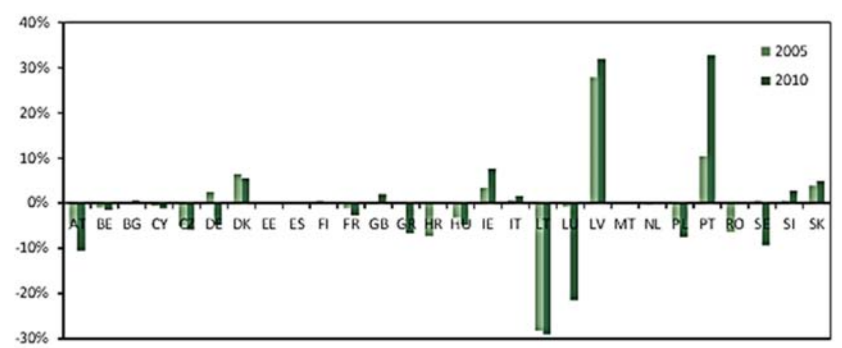


FIGURE 2-2: CHANGES IN REPORTED SO_2 EMISSIONS BETWEEN THE 2014 CLRTAP SUBMISSIONS AND THE 2017 NEC SUBMISSIONS

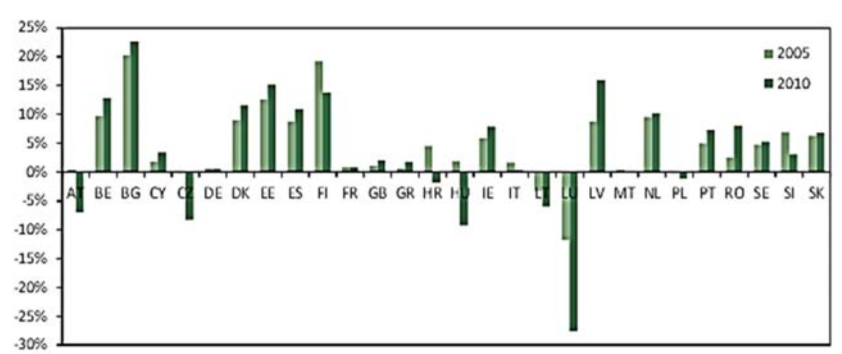


FIGURE 2-3: CHANGES IN REPORTED NO_x EMISSIONS BETWEEN THE 2014 CLRTAP SUBMISSIONS AND THE 2017 NEC SUBMISSIONS

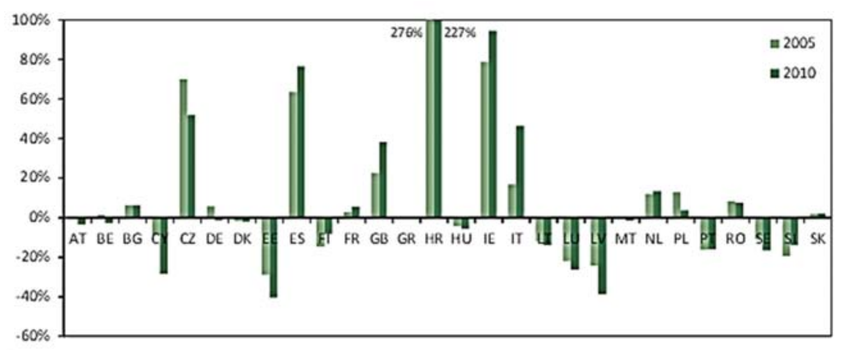


FIGURE 2-4: CHANGES IN REPORTED PM2.5 EMISSIONS BETWEEN THE 2014 CLRTAP SUBMISSIONS AND THE 2017 NEC SUBMISSIONS

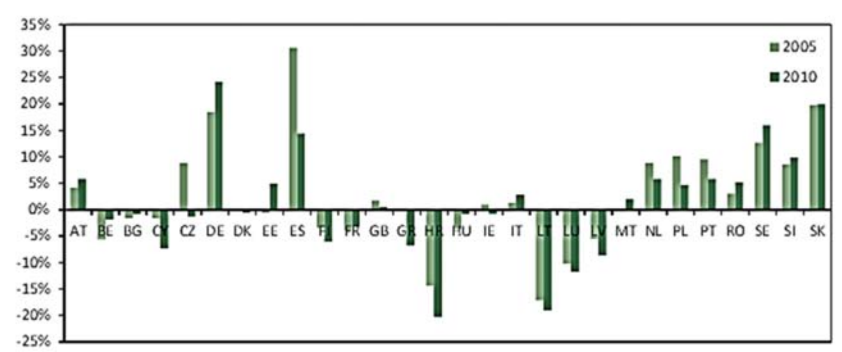


FIGURE 2-5: CHANGES IN REPORTED NH_3 EMISSIONS BETWEEN THE 2014 CLRTAP SUBMISSIONS AND THE 2017 NEC SUBMISSIONS

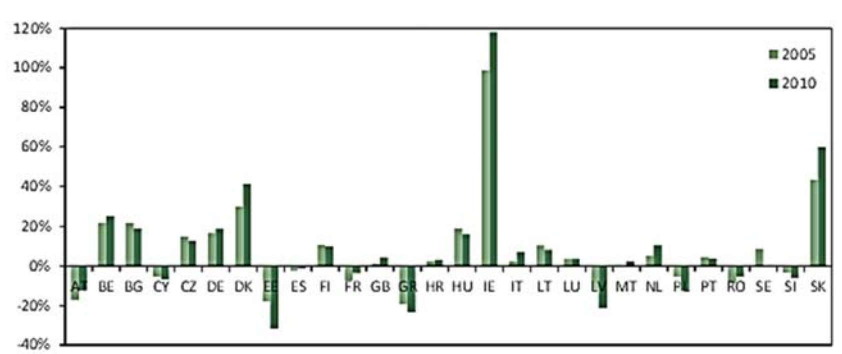


FIGURE 2-6: CHANGES IN REPORTED VOC EMISSIONS BETWEEN THE 2014 CLRTAP SUBMISSIONS AND THE 2017 NEC SUBMISSIONS

2.2 Updates of the GAINS database

This report employs the GAINS model system (see Box 1) developed under the EC4MACS (European Consortium for Modelling of Air pollution and Climate Strategies) project, which was funded under the EU LIFE programme (www.ec4macs.eu). The EC4MACS model toolbox allows simulation of the impacts of policy actions that influence future driving forces (e.g., energy consumption, transport demand, agricultural activities), and of dedicated measures to reduce the release of emissions to the atmosphere, on total emissions, resulting air quality, and a basket of air quality and climate impact indicators.

The central tool, i.e., the Greenhouse gas Air pollution Interactions and Synergies (GAINS) model developed at the International Institute for Applied Systems Analysis (IIASA) explores the costs and multiple benefits of policy interventions on air pollution ((Amann et al. 2011) and allows the development of cost-effective response strategies that meet environmental policy targets at least cost (Wagner et al. 2013).

Box 1: The GAINS model

The GAINS model

The GAINS (Greenhouse gas – Air pollution Interactions and Synergies) model developed at the International Institute for Applied Systems Analysis (IIASA) explores the costs and impacts of policy interventions on air pollution, together with potential co-benefits with greenhouse gas mitigation (Amann et al., 2011).

As a scientific tool for integrated policy assessment, the GAINS model describes the air pollution pathways from atmospheric driving forces to environmental impacts. It brings together information on economic, energy and agricultural development, emission control measures and costs, atmospheric dispersion and source sensitivities. GAINS quantifies the emissions and impacts of 10 air pollutants (SO_2, NO_x, PM2.5, PM10, BC, OC, CO, NH_3, VOCs) and six greenhouse gases (CO_2, CH_4, N_2O, HFCs, PFCs, SF_6), and assesses their impacts on ambient air quality, population exposure, resulting health and vegetation impacts, and various climate metrics.

With this multi-pollutant/multi-effect perspective, GAINS explores the co-control of more than 1500 specific measures on multiple air pollutant and greenhouse gas emissions, and identifies trade-offs and win-win measures,

	PM (BC, OC)	SO_2	NO_x	VOC	NH_3	CO	CO_2	CH_4	N_2O	HFCs PFCs SF_6
Health impacts: PM (Loss in life expectancy)	√	√	√	√	√					
O_3 (Premature mortality)			√	√		√		√		
Vegetation damage: O_3 (AOT40/fluxes)			√	√		√		√		
Acidification (Excess of critical loads)		√	√		√					
Eutrophication (Excess of critical loads)			√		√					
Climate impacts: Long-term (GWP100)	(√)	(√)	(√)	(√)	(√)	(√)	√	√	√	√
Near-term forcing	√	√	√	√	√	√	(√)	√	(√)	(√)
Carbon deposition to the Arctic and glaciers	√									

GAINS is currently implemented for 196 countries/world regions with a global coverage. The GAINS model and databases are accessible over the Internet (http://gains.iiasa.ac.at).

The information on the recent changes in the national emission inventories has been incorporated into the GAINS database, in order to update emission projections and examine the implications for reaching the ERRs. An attempt has been made to reproduce nationally reported figures with internationally available activity statistics and plausible emission factors that are internationally coherent and reflect national circumstances, in particular the uptake of emission control legislation. In general, a reasonable match between the GAINS estimates and nationally reported figures could be achieved. Exceptions include cases where national inventories have been developed on a lower tier methodology, while in general GAINS employs methods that are compatible with Tier 2 as outlined in the EMEP/EEA emission inventory guidebook. For the 2005 inventories, comparisons between the GAINS estimates and the latest national reports are provided in Table 2-3 and Table 2-4.

Table 2-3: Comparison of GAINS estimates of SO_2, NO_x and PM2.5 emissions with the latest national submissions [kilotons]

	SO_2			NO_x			PM2.5		
	National inventory	GAINS	Diff, %	Inventory	GAINS	Diff, %	National inventory	GAINS	Diff, %
Austria	26	26	*2%*	228	229	*0%*	22	21	*-6%*
Belgium	142	143	*0%*	305	304	*0%*	36	38	*4%*
Bulgaria	779	778	*0%*	185	178	*-4%*	28	38	*33%*
Croatia	59	59	*-1%*	81	80	*-2%*	40	42	*4%*
Cyprus	38	38	*0%*	21	22	*2%*	3	3	*-2%*
Czech Republic	208	207	*0%*	277	278	*0%*	35	38	*6%*
Denmark	26	26	*-1%*	186	180	*-3%*	26	27	*2%*
Estonia	76	76	*0%*	40	41	*0%*	14	15	*8%*
Finland	70	69	*-1%*	187	183	*-2%*	35	37	*3%*
France	455	449	*-1%*	1415	1381	*-2%*	252	260	*3%*
Germany	472	471	*0%*	1459	1432	*-2%*	132	126	*-5%*
Greece	541	541	*0%*	417	403	*-3%*	59	59	*0%*
Hungary	42	43	*2%*	157	156	*-1%*	25	42	*66%*
Ireland	74	74	*0%*	137	140	*2%*	19	18	*-7%*
Italy	408	410	*0%*	1208	1192	*-1%*	166	168	*1%*
Latvia	8	9	*6%*	42	41	*-4%*	22	22	*-1%*
Lithuania	31	31	*0%*	53	50	*-5%*	20	20	*-1%*
Luxembourg	2	2	*-1%*	54	56	*4%*	3	3	*-4%*
Malta	11	11	*-1%*	9	9	*-5%*	1	1	*-55%*
Netherlands	64	65	*1%*	366	359	*-2%*	22	23	*5%*
Poland	1164	1170	*1%*	813	784	*-4%*	159	248	*56%*
Portugal	195	178	*-9%*	264	245	*-7%*	58	58	*0%*
Romania	601	609	*1%*	316	333	*5%*	115	136	*19%*
Slovakia	92	93	*0%*	102	88	*-14%*	37	40	*7%*
Slovenia	41	41	*0%*	50	50	*0%*	13	12	*-4%*
Spain	1277	1274	*0%*	1471	1468	*0%*	153	135	*-12%*
Sweden	36	36	*0%*	171	195	*14%*	27	30	*14%*
UK	711	708	*0%*	1608	1541	*-4%*	113	119	*4%*
EU-28	7649	7634	*0%*	11622	11415	-2%	1638	1776	*8%*

Table 2-4: Comparison of GAINS estimates of NH_3 and VOC emissions with the latest national submissions [kilotons]

	NH_3			VOC		
	National inventory	GAINS	Diff, %	National inventory	GAINS	Diff, %
Austria	65	66	*1%*	136	145	*7%*
Belgium	68	69	*2%*	148	145	*-2%*
Bulgaria	48	40	*-15%*	86	128	*50%*
Croatia	38	39	*2%*	95	97	*2%*
Cyprus	6	6	*6%*	12	11	*-3%*
Czech Republic	74	84	*13%*	209	207	*-1%*
Denmark	82	77	*-7%*	112	110	*-2%*
Estonia	10	10	*2%*	28	29	*0%*
Finland	37	39	*6%*	134	126	*-6%*
France	659	753	*14%*	1166	1204	*3%*
Germany	678	671	*-1%*	1109	1157	*4%*
Greece	68	58	*-14%*	220	263	*19%*
Hungary	76	79	*5%*	125	122	*-2%*
Ireland	111	103	*-7%*	70	67	*-4%*
Italy	420	434	*3%*	1232	1206	*-2%*
Latvia	16	17	*3%*	42	48	*12%*
Lithuania	32	33	*2%*	64	69	*7%*
Luxembourg	6	6	*-7%*	11	12	*0%*
Malta	2	2	*6%*	3	4	*17%*
Netherlands	154	152	*-1%*	181	175	*-3%*
Poland	299	314	*5%*	543	587	*8%*
Portugal	55	53	*-4%*	215	197	*-9%*
Romania	204	194	*-5%*	299	347	*16%*
Slovakia	34	32	*-6%*	94	76	*-19%*
Slovenia	21	20	*-3%*	41	43	*6%*
Spain	495	500	*1%*	714	799	*12%*
Sweden	63	64	*1%*	182	202	*11%*
UK	307	314	*2%*	1072	1061	*-1%*
EU-28	**4128**	**4228**	***2%***	**8344**	**8635**	***3%***

3 Baseline activity projections

The European Commission, in the context of the preparation of the 2016 Clean Energy package (COM(2016) 860 final), has come forward with an updated set of baseline activity projections, referred to as the PRIMES 2016 REFERENCE scenario (Capros et al. 2016). This scenario, which includes energy, transport and agricultural projections, has been developed with the PRIMES and the CAPRI models and implemented in the GAINS databases.

Notably, the PRIMES 2016 REFERENCE scenario does not reflect the Climate and Energy Package (CEP) as proposed by the Commission on July 20, 2016. To enable quantification of the co-benefits of the new climate policies, this report examines an additional projection which illustrates one possible outcome of the proposed targets. In particular, the 'EUCO30' variant of the alternative climate policy proposal scenarios ('CLIMATE AND ENERGY POLICY ') resembles at the EU level the final Commission proposal to a large extent, although in reality the specific developments in each country and sector might emerge differently due to the flexibility mechanisms built into the Climate and Energy Package[3]. (Technical details on the EUCO30 scenario can be found in: https://ec.europa.eu/energy/sites/ener/files/documents/20170125_-_technical_report_on_euco_scenarios_primes_corrected.pdf).

TABLE 3-1: ENERGY USE BY FUEL OF THE PRIMES 2016 REFERENCE SCENARIO AND THE CLIMATE AND ENERGY POLICY SCENARIO [1000 PJ]

			PRIMES 2016 REFERENCE				CLIMATE AND ENERGY POLICY	
	2005	2010	2015	2020	2025	2030	2025	2030
Coal	12.4	11.0	10.8	9.9	8.9	7.6	8.4	6.5
Oil	28.8	26.3	25.2	24.0	23.4	22.7	22.4	20.0
Gas	22.7	21.9	18.3	17.8	17.8	17.1	17.2	15.1
Nuclear	10.8	9.9	8.9	7.9	7.3	7.8	7.3	7.5
Biomass	3.7	5.3	5.7	7.2	7.1	7.3	6.8	7.0
Other renew.	1.6	2.3	2.8	3.9	4.3	4.8	4.6	5.6
Total	**80.0**	**76.6**	**71.7**	**70.8**	**68.8**	**67.2**	**66.7**	**61.7**

TABLE 3-2: ENERGY USE BY SECTOR OF THE PRIMES 2016 REFERENCE SCENARIO AND THE CLIMATE AND ENERGY POLICY SCENARIO [1000 PJ]

			PRIMES 2016 REFERENCE				CLIMATE AND ENERGY POLICY	
	2005	2010	2015	2020	2025	2030	2025	2030
Power sector	19.3	17.2	13.8	12.5	11.3	10.8	10.9	9.4
Households	20.2	21.2	20.2	19.9	19.5	19.3	18.6	16.4
Industry	19.0	17.5	17.3	17.9	17.6	16.9	17.4	16.4
Transport	16.6	16.3	16.2	15.8	15.6	15.4	15.0	14.5
Non-energy	4.9	4.4	4.5	4.7	4.8	5.0	4.8	4.9
Total	**80.0**	**76.6**	**71.8**	**70.8**	**68.8**	**67.3**	**66.8**	**61.7**

[3] For details see https://ec.europa.eu/clima/policies/strategies/2030_en and http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016PC0767R%2801%29 for the revision of the 27% to the 30% renewable target

TABLE 3-3: ENERGY USE BY COUNTRY OF THE PRIMES 2016 REFERENCE SCENARIO AND THE CLIMATE AND ENERGY POLICY SCENARIO [1000 PJ]

			PRIMES 2016 REFERENCE				CLIMATE AND ENERGY POLICY	
	2005	2010	2015	2020	2025	2030	2025	2030
Austria	1465	1451	1372	1401	1376	1371	1342	1259
Belgium	2623	2566	2410	2427	2262	2228	2214	2073
Bulgaria	882	788	701	690	669	664	658	615
Croatia	424	414	380	397	396	381	371	344
Cyprus	109	116	90	91	88	87	85	81
Czech Rep.	1944	1885	1759	1747	1771	1762	1768	1722
Denmark	902	892	772	741	717	727	690	654
Estonia	228	233	230	235	234	216	230	180
Finland	1540	1627	1473	1521	1544	1469	1503	1380
France	11865	11466	10944	10573	10319	10100	9951	9193
Germany	14790	14493	13684	13014	12351	11818	12012	10885
Greece	1369	1229	1115	1082	995	920	979	843
Hungary	1275	1195	1044	1080	1115	1188	1105	1079
Ireland	729	666	612	631	623	608	606	553
Italy	8348	7619	6807	6889	6577	6402	6401	5805
Latvia	223	208	187	196	204	202	199	186
Lithuania	420	336	306	298	310	327	293	303
Luxembourg	202	200	202	208	218	222	209	204
Malta	42	39	27	30	30	31	31	30
Netherlands	3937	4074	3870	3877	3825	3673	3775	3472
Poland	3938	4354	4346	4500	4487	4540	4440	4243
Portugal	1192	1055	1001	938	935	882	893	805
Romania	1811	1585	1497	1641	1673	1618	1520	1401
Slovakia	851	784	729	808	823	844	805	805
Slovenia	316	308	292	302	306	300	296	277
Spain	6203	5595	5399	5454	5163	5028	4929	4483
Sweden	2177	2111	2000	1988	1989	2011	1958	1893
UK	10235	9346	8595	8090	7821	7649	7516	6949
Sum	80041	76631	71842	70847	68820	67265	66778	61713

4 Emission control legislation

In addition to the energy, climate and agricultural policies that are included in the energy and agricultural projections, the updated projections consider detailed inventories of national emission control legislation.

4.1 Legislation in place in 2014 – the 'pre-2014' legislation

To facilitate comparisons with the earlier analyses that provided the basis for the negotiations (i.e., up to TSAP report #16; (Amann, M. et al. 2015)), the set of 'pre-2014 legislation' measures reflects all regulations that were in place in May 2014, i.e., at the time when the TSAP16 analyses for the Commission proposal on the NECD were conducted.

It is assumed here 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. 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.

For air pollutants, the baseline assumes the regulations described in Box 2 to Box 6. 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 these measures can be represented in the framework of integrated assessment modelling for air quality.

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 (Amann et al. 2014c).

Box 2: Legislation considered for SO_2 emissions, as of 2014

- Directive on Industrial Emissions for large combustion plants, including the recent LCP BAT Conclusions. (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, i
- 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 3: Legislation considered for NO_x emissions, as of 2014

- Directive on Industrial Emissions for large combustion plants, including the recent LCP BAT Conclusions. (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 below 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).
- 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), depending on machine category and engine size.
- MARPOL Annex VI revisions from MEPC57 regarding NO_x emission limit values for ships
- National legislation and national practices (if stricter)

Box 4: Legislation considered for PM10/PM2.5 emissions, as of 2014

- Directive on Industrial Emissions for large combustion plants, including the recent LCP BAT Conclusions. (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 NOx
- For non-road mobile machinery: All EU emission controls stages as for NOx.
- National legislation and national practices (if stricter)

Box 5: Legislation considered for NH_3 emissions, as of 2014

- 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 6: Legislation considered for VOC emissions, as of 2014

- 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 NOx, 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)

Emission factors for road vehicles

The impact assessment for the Thematic Strategy on Air Pollutants was finalised before many details of the Euro 6 emission regulation for light-duty vehicles had been fixed, and did not include any of the subsequent development.

Based on an assessment by EMISIA, emission factors for road vehicles have now been updated for this report (Table 4-1). In addition, the uptake of new emission standards was adjusted to account for the implementation dates as now defined in the legislation. This leads to slightly higher NO_x emissions from diesel cars in the base year as well as higher emissions in 2030. Most changes, however, affect the period between 2020 and 2025. On the other hand, the widely used COPERT transport emission factor model suggests a reduction by about 40% of the NO_x emission factors for the latest Euro VI trucks. This results in markedly lower emissions from trucks in 2030. In addition, the NO_x emission factors for gasoline cars have been found lower by between 20% and 55% across the different Euro stages.

Furthermore, the timing of tightened emission standards has been adjusted. For NO_x, emission factors for new cars registered between 2014 and 2017 are assumed to be 350 mg NO_x/km. From 2017 onwards, real-driving NO_x emissions are assumed to be 2.1 times higher than the Euro 6 test cycle limit value. This results in about 168 mg NO_x /km for real-world driving conditions, compared to the limit value of 80 mg/km. After 2021, a conformity factor of 1.5 is assumed, corresponding to about 120 mg NO_x/km. It is assumed that the RDE (real-driving) test emissions reflect average on-road emissions. Similar assumptions are taken for light commercial vehicles.

TABLE 4-1: AVERAGE NO_x EMISSION FACTOR BY VEHICLE CATEGORY, THE LATEST COPERT 5 VERSION COMPARED TO COPERT 4 USED FOR THE TSAP IMPACT ASSESSMENT. EXAMPLES FOR FRANCE.

	Fuel	Emission standards	Emission factor in mg NO_x per km	Ratio of new to emission factor compared to the 2013 TSAP assessment
Cars	Diesel	Euro 4	680	1.11
		Euro 5	815	1.16
		Euro 6a,b	540	2.00
		Euro 6d	124	1.11
Cars	Gasoline	Euro 1	355	0.80
		Euro 2	180	0.71
		Euro 3	75	0.67
		Euro 4	40	0.62
		Euro 5	23	0.44
		Euro 6	25	0.52
Heavy duty trucks	Diesel	Euro VI	250	0.61

4.2 Legislation adopted since 2014: The 'post-2014' measures leading to the '2017 legislation'

In parallel with the negotiations of the NEC Directive, the institutions of the European Union have developed a range of source-oriented legislation to reduce emissions from specific source categories in an EU-wide harmonized way (Box 7).

Box 7: Additional legislation decided since 2014

- The Eco-design Directive setting product-related emission standards for small combustion devices for solid fuels;
- The Medium Size Combustion Plant (MCP) Directive, and
- The Non-Road Mobile Machinery (NRMM) Directive. Stage V emission standards phased-in between 2017 and 2021, with an enlarged scope of machine categories.

The Eco-design Directive (2009/125/EC) establishes a framework to set mandatory ecological requirements for energy-related products in the EU. It specifies energy efficiency standards for different combustion devices, as well as emission limit values (ELVs) for small combustion devices using solid fuels. Lot 15 of the Eco-Design Directive covers combustion devices with one or more solid fuel heat generators that provide heat to a water-based central heating system in order to reach and maintain a desired indoor temperature in one or more enclosed spaces. Local room (or space) heating products (lot 20) are defined as appliances that provide heat to indoor spaces by generating heat at the same location as it is needed. These appliances are self-contained heating units, wall-mounted or chimney bound.

The MCP Directive (EU 2015/2193) establishes for medium combustion plants (MCP) emission limit values for solid fuel boilers larger than 1 MW_{th} in the residential, commercial, agriculture (and other) sectors.

The Non-Road Mobile Machinery (NRMM) Directive specifies emission limit values for inland vessels, mobile machines in construction & industry, spark-ignition engines in recreational vessels, military, agricultural and forestry machines, railcars and locomotives, aircraft emissions and pipeline compressors. In particular, the new Stage V for non-road mobile machinery (NRMM) (Regulation (EU) 2016/1628 of September 14, 2016) extends the scope of the regulation including engines >560 kW.

Together with the 'pre-2014' legislation, these measure make up the '2017 legislation' that is referred to in the remainder of this report.

4.3 The scope for further emission reductions beyond current legislation

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

The 'Maximum technically feasible reduction' (MTFR) scenario explores the extent to which emissions could be further reduced through full application of all available technical measures, beyond what is required by current legislation. This scenario excludes changes in the energy structures and does not imply behavioural changes of consumers. Also, with the exception of non-road mobile machinery, the MTFR scenario does not consider premature scrapping of existing capital stock; new and cleaner devices are only allowed to enter the market when old equipment is retired.

Thereby, the MTFR projections provide an indication of the scope for emission reductions from measures that do not require policy changes in other sectors (e.g., energy, transport, climate, agriculture) beyond what is assumed in the respective activity projection (i.e., the PRIMES REFERENCE or CLIMATE AND ENERGY POLICY scenarios). However, a comparison of the emissions between these scenarios highlights the potential for additional emission reduction from policies that modify activity levels.

5 Emission projections

The implications of the new information on emission inventories and activity projections are explored in updated baseline emission projections. These outline the likely evolution of air pollutant emissions assuming effective implementation of the emission control legislation described above according to the foreseen schedule. The following variants are explored in this report:

- For the PRIMES 2016 REFERENCE scenario, emissions resulting from
  - the legislation already in place in 2014 (the 'pre-2014' legislation),
  - the impacts of the new legislation adopted after 2014 (the 'post-2014' legislation),
  - full implementation of the technical emission control measures (MTFR);
- For the PRIMES CLIMATE AND ENERGY POLICY scenario, emissions resulting from
  - the impacts of the new legislation adopted after 2014 (the 'post-2014' legislation),
  - full implementation of the technical emission control measures (MTFR).

As shown in Table 5-1 to Table 5-5 and Figure 6-1, the baseline assumptions on energy policy and emission controls lead to a strong decline in SO_2, NO_x, PM2.5 and VOC emissions, while only small reductions of NH_3 are foreseen.

TABLE 5-1: SO_2 EMISSIONS BY SNAP SECTOR, EU-28 (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CLIMATE AND ENERGY POLICY 2030
		Pre-2014 legislation	With additional post-2014 legislation	With additional post-2014 legislation
Power generation	5333	630	628	563
Domestic sector	572	252	254	190
Industrial combustion	897	405	388	370
Industrial process.	600	345	345	340
Fuel extraction	4	3	3	3
Solvent use				
Road transport	27	5	5	4
Non-road mobile	198	35	35	35
Waste treatment	1	1	1	1
Agriculture	3	3	3	3
Sum	7634	1679	1662	1509

TABLE 5-2: NO_x EMISSIONS BY SNAP SECTOR, EU-28 (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CLIMATE AND ENERGY POLICY 2030
		Pre-2014 legislation	With additional post-2014 legislation	With additional post-2014 legislation
Power generation	2640	948	922	791
Domestic sector	704	528	528	437
Industrial combustion	1291	823	815	813
Industrial process.	233	169	169	168
Fuel extraction	3	1	1	1
Solvent use				
Road transport	4846	1006	1006	906
Non-road mobile	1686	621	556	541
Waste treatment	6	2	2	2
Agriculture	7	7	7	7
Sum	11415	4104	4005	3665

TABLE 5-3: PM2.5 EMISSIONS BY SNAP SECTOR, EU-28 (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CLIMATE AND ENERGY POLICY 2030
		Pre-2014 legislation	With additional post-2014 legislation	With additional post-2014 legislation
Power generation	127	46	44	41
Domestic sector	806	578	355	319
Industrial combustion	78	54	52	52
Industrial process.	182	147	147	148
Fuel extraction	6	3	3	3
Solvent use				
Road transport	265	76	76	71
Non-road mobile	132	30	27	26
Waste treatment	70	68	68	68
Agriculture	110	106	106	106
Sum	1776	1108	877	834

TABLE 5-4: NH_3 EMISSIONS BY SNAP SECTOR, EU-28 (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CLIMATE AND ENERGY POLICY 2030
		Pre-2014 legislation	With additional post-2014 legislation	With additional post-2014 legislation
Power generation	10	15	15	14
Domestic sector	66	69	68	59
Industrial combustion	4	6	6	6
Industrial process.	69	56	56	56
Fuel extraction	0	0	0	0
Solvent use				
Road transport	131	52	52	48
Non-road mobile	2	3	3	3
Waste treatment	159	151	151	151
Agriculture	3786	3664	3664	3664
Sum	4228	4016	4015	4001

TABLE 5-5: VOC EMISSIONS BY SNAP SECTOR, EU-28 (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CLIMATE AND ENERGY POLICY 2030
		Pre-2014 legislation	With additional post-2014 legislation	With additional post-2014 legislation
Power generation	106	80	77	70
Domestic sector	1052	704	410	374
Industrial combustion	56	84	84	87
Industrial process.	823	775	775	761
Fuel extraction	528	299	299	286
Solvent use	3548	2845	2845	2845
Road transport	1864	313	313	305
Non-road mobile	574	206	173	169
Waste treatment	12	3	3	3
Agriculture	71	63	63	63
Sum	8635	5372	5043	4964

6 Additional efforts to achieve the ERRs in 2030

6.1 Emission reduction requirements (ERRs) and national emission ceilings (NECs)

The NEC Directive contains, as an essential element, politically agreed emission reduction requirements (ERRs) that specify the percentage by which, for each Member State and pollutant, national emissions need to be reduced by the year 2030 in relation to the 2005 level. To facilitate a coherent analysis of the efforts that are required to achieve these ERRs, this analysis applies the ERRs to the emissions that are estimated with the GAINS model for the year 2005. Thereby, both the 2005 and 2030 estimates rely on internally consistent time lines of activity projections and emission factors, which avoids artefacts from different calculation methods for historic and future emissions (Table 6-1).

Table 6-1: GAINS estimates of 2005 emissions, the emission reduction requirements (ERRs) of the NEC Directive, and the resulting emission ceilings in 2030 (relative to the GAINS estimates for 2005)

	GAINS estimates for 2005 (kilotons)					Emission reduction requirements (ERRs)					Resulting emission ceilings for 2030 (kilotons)				
	SO_2	NO_x	PM2.5	NH_3	VOC	SO_2	NO_x	PM2.5	NH_3	VOC	SO_2	NO_x	PM2.5	NH_3	VOC
Austria	26	229	21	66	145	41%	69%	46%	12%	36%	16	71	11	58	93
Belgium	143	304	38	69	145	66%	59%	39%	13%	35%	49	125	23	60	94
Bulgaria	778	178	38	40	128	88%	58%	41%	12%	42%	93	75	22	35	74
Croatia	59	79	42	38	97	83%	57%	55%	25%	48%	10	34	19	29	50
Cyprus	38	22	3	6	11	93%	55%	70%	20%	50%	3	10	1	5	6
Czech Rep.	207	278	38	84	207	66%	64%	60%	22%	50%	70	100	15	66	104
Denmark	26	180	27	77	110	59%	68%	55%	24%	37%	11	57	12	58	70
Estonia	76	40	15	10	29	68%	30%	41%	1%	28%	24	28	9	10	21
Finland	69	183	37	39	126	34%	47%	34%	20%	48%	46	97	24	31	66
France	449	1381	260	753	1203	77%	69%	57%	13%	52%	103	428	112	655	578
Germany	471	1431	125	671	1157	58%	65%	43%	29%	28%	198	501	72	477	833
Greece	541	403	59	58	263	88%	55%	50%	10%	62%	65	181	30	52	100
Hungary	42	156	42	79	122	73%	66%	55%	32%	58%	11	53	19	54	51
Ireland	74	139	18	103	67	85%	69%	41%	5%	32%	11	43	11	98	46
Italy	410	1192	168	434	1206	71%	65%	40%	16%	46%	119	417	101	364	651
Latvia	9	41	22	17	48	46%	34%	43%	1%	38%	5	27	13	17	29
Lithuania	31	50	20	33	69	60%	51%	36%	10%	47%	12	25	13	30	37
Luxembourg	2	56	3	6	11	50%	83%	40%	22%	42%	1	10	2	5	7
Malta	11	9	1	2	4	95%	79%	50%	24%	27%	1	2	0	1	3
Netherlands	65	359	23	152	175	53%	61%	45%	21%	15%	30	140	12	120	149
Poland	1170	784	248	314	587	70%	39%	58%	17%	26%	351	478	104	260	434
Portugal	178	245	58	53	197	83%	63%	53%	15%	38%	30	91	27	45	122
Romania	609	333	136	194	347	88%	60%	58%	25%	45%	73	133	57	145	191
Slovakia	92	88	40	32	76	82%	50%	49%	30%	32%	17	44	20	23	51
Slovenia	41	50	12	20	43	92%	65%	60%	15%	53%	3	18	5	17	20
Spain	1274	1468	135	500	799	88%	62%	50%	16%	39%	153	558	68	420	487
Sweden	36	195	30	63	202	22%	66%	19%	17%	36%	28	66	25	53	129
UK	707	1541	119	314	1061	88%	73%	46%	16%	39%	85	416	64	264	647
EU-28	7634	11415	1776	4228	8635	79%	63%	49%	19%	40%	1618	4228	889	3451	5142

6.2 Emission reductions

At the aggregated level for the EU-28, the picture in the original TSAP#16 analysis is broadly borne out. With the PRIMES 2016 REFERENCE projection, the EU would meet the emission reduction requirements (ERRs) for SO_2 and NO_x already with the pre-2014 legislation. The main impact of the post-2014 legislation, including the NECD, comes for the other pollutants. For PM2.5 and VOC, the post-2014 legislation - fully implemented - will on aggregate deliver the emission reductions laid out in the ERRs, although not for every Member State taken individually. For NH_3 there is very limited contribution from the pre-2014 legislation and almost none from the post-2014, which does not focus on ammonia. Thus for NH_3 the major burden of the reduction is driven by the NECD alone, the reduction being however clearly feasible from a technical standpoint.

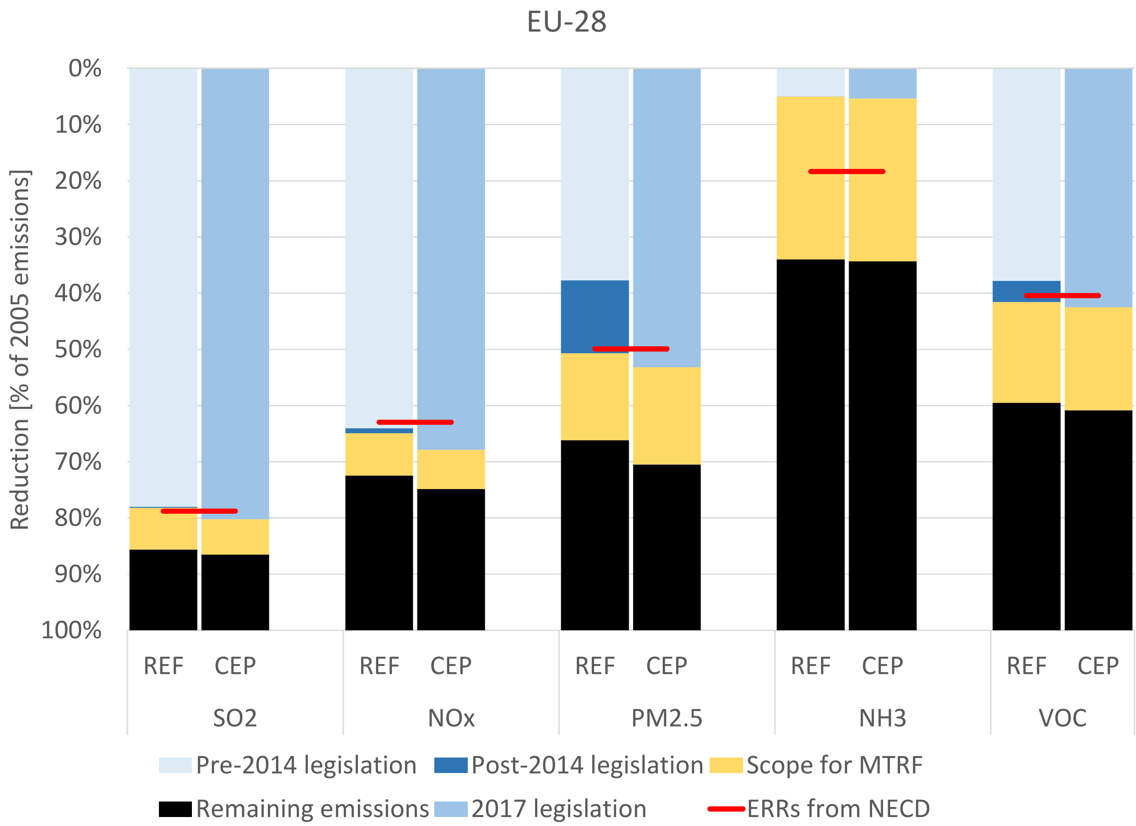


FIGURE 6-1: EMISSION REDUCTIONS IN 2030 RELATIVE TO 2005, FROM (I) IMPLEMENTATION OF THE PRE-2014 LEGISLATION, (II) THE POST-2014 POLICIES, (III) THE FULL IMPLEMENTATION OF ALL TECHNICALLY FEASIBLE MEASURES; FOR THE PRIMES 2016 REFERENCE (REF) AND THE CLIMATE AND ENERGY POLICY SCENARIOS (CEP); EU-28

Table 6-2 to Table 6-6 compare, for individual Member States, the emission ceilings with the baseline emissions for the pre- and post2014 legislations, respectively, for both the PRIMES 2016 REFERENCE and the CLIMATE AND ENERGY POLICY scenarios. As discussed above, only a few Member States will have to take additional measures for SO_2 and NO_x beyond the fully implemented post-2014 legislation. In contrast, the post-2014 legislation will not be sufficient to meet the ceilings for PM2.5 and especially for NH_3. However, there are also cases where the post-2014 legislation will allow the overachievement of the emission ceilings, delivering additional health impact reductions beyond those required by the NECD. Even larger overachievements are computed for the CLIMATE AND ENERGY POLICY scenario, demonstrating the synergies of the policy goals.

Table 6-2: SO_2 baseline emissions, emission ceilings and additional emission reductions to meet the ceilings, for the PRIMES 2016 REFERENCE (REF) and the CLIMATE AND ENERGY POLICY (CEP) scenarios (kilotons)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CEP for 2030	Emission ceilings 2030	2030 projection to meet the ERRs in the optimized scenario		Additional reductions necessary to meet the ERRs for	
		with pre-2014 legislation	with post-2014 legislation	with post-2014 legislation		REF	CEP	REF	CEP
Austria	26	15	15	14	16	15	14	0	0
Belgium	143	52	51	45	49	49	45	3	0
Bulgaria	778	77	76	71	93	76	71	0	0
Croatia	59	18	18	17	10	10	10	8	7
Cyprus	38	2	2	2	3	2	2	0	0
Czech Rep.	207	63	62	61	70	61	60	0	1
Denmark	26	11	10	9	11	10	9	0	0
Estonia	76	28	28	21	24	24	21	4	0
Finland	69	37	36	31	46	36	31	0	0
France	449	135	135	114	103	103	103	32	11
Germany	471	240	240	213	198	198	198	42	16
Greece	541	72	72	64	65	65	64	7	0
Hungary	42	16	15	14	11	11	11	4	2
Ireland	74	12	12	10	11	11	10	1	0
Italy	410	135	135	125	119	119	119	16	6
Latvia	9	3	3	3	5	3	3	0	0
Lithuania	31	14	12	11	12	12	11	0	0
Luxembourg	2	1	1	1	1	1	1	0	0
Malta	11	0	0	0	1	0	0	0	0
Netherlands	65	31	30	29	30	30	29	0	0
Poland	1170	328	324	286	351	324	286	0	0
Portugal	178	39	39	36	30	30	30	8	6
Romania	609	61	60	60	73	60	59	1	1
Slovakia	92	20	20	19	17	17	17	3	2
Slovenia	41	4	4	4	3	3	3	1	0
Spain	1274	123	120	108	153	120	108	0	0
Sweden	36	21	21	20	28	21	20	0	0
UK	707	121	119	120	85	85	85	35	35
EU-28	7634	1679	1662	1509	1618	1498	1422	164	87

TABLE 6-3: NO_x BASELINE EMISSIONS, EMISSION CEILINGS AND ADDITIONAL EMISSION REDUCTIONS TO MEET THE CEILINGS, FOR THE PRIMES 2016 REFERENCE (REF) AND THE CLIMATE AND ENERGY POLICY (CEP) SCENARIOS (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CEP for 2030	Emission ceilings 2030	2030 projection to meet the ERRs in the optimized scenario		Additional reductions necessary to meet the ERRs for	
		with pre-2014 legislation	with post-2014 legislation	with post-2014 legislation		REF	CEP	REF	CEP
Austria	229	67	65	59	71	65	59	0	0
Belgium	304	121	119	108	125	115	105	4	3
Bulgaria	178	58	58	54	75	57	54	0	0
Croatia	79	26	25	23	34	25	22	0	0
Cyprus	22	5	5	5	10	5	5	0	0
Czech Rep.	278	118	118	115	100	100	100	17	14
Denmark	180	57	55	51	57	55	51	0	0
Estonia	40	19	19	15	28	19	15	0	0
Finland	183	92	90	83	97	90	83	0	0
France	1381	465	452	408	428	428	406	24	2
Germany	1431	614	599	540	501	501	501	98	39
Greece	403	129	111	108	181	111	108	0	0
Hungary	156	55	55	51	53	53	50	2	0
Ireland	139	41	41	37	43	41	37	0	0
Italy	1192	428	427	392	417	417	387	9	6
Latvia	41	21	21	19	27	20	19	0	0
Lithuania	50	21	21	19	25	21	19	0	0
Luxembourg	56	11	11	10	10	10	10	2	1
Malta	9	2	2	2	2	2	2	0	0
Netherlands	359	155	145	138	140	140	135	5	2
Poland	784	400	395	360	478	394	359	1	1
Portugal	245	93	92	86	91	91	85	2	1
Romania	333	135	131	125	133	129	123	2	2
Slovakia	88	47	47	46	44	44	44	3	2
Slovenia	50	16	16	15	18	16	15	0	0
Spain	1468	445	439	395	558	439	395	0	0
Sweden	195	57	56	50	66	56	50	0	0
UK	1541	404	390	353	416	389	353	1	1
EU-28	11415	4102	4004	3664	4228	3834	3590	170	74

TABLE 6-4: PM2.5 BASELINE EMISSIONS, EMISSION CEILINGS AND ADDITIONAL EMISSION REDUCTIONS TO MEET THE CEILINGS, FOR THE PRIMES 2016 REFERENCE (REF) AND THE CLIMATE AND ENERGY POLICY (CEP) SCENARIOS (KILOTONS)

	2005	PRIMES 2016 REFERENCE scenario for 2030		CEP for 2030	Emission ceilings 2030	2030 projection to meet the ERRs in the optimized scenario		Additional reductions necessary to meet the ERRs for	
		with pre-2014 legislation	with post-2014 legislation	with post-2014 legislation		REF	CEP	REF	CEP
Austria	21	11	10	10	11	10	10	0	0
Belgium	38	33	32	32	23	23	23	9	9
Bulgaria	38	31	18	16	22	12	11	5	5
Croatia	42	15	13	13	19	10	10	3	3
Cyprus	3	1	1	1	1	1	1	0	0
Czech Rep.	38	22	19	18	15	15	15	4	3
Denmark	27	13	11	10	12	11	10	0	0
Estonia	15	6	5	5	9	5	4	1	1
Finland	37	23	23	19	24	23	19	0	0
France	260	136	117	110	112	112	107	6	3
Germany	125	78	74	73	72	72	72	2	1
Greece	59	27	22	21	30	22	21	0	0
Hungary	42	33	23	22	19	16	16	7	6
Ireland	18	11	8	8	11	8	8	0	0
Italy	168	124	96	93	101	84	84	13	9
Latvia	22	10	8	8	13	8	8	0	0
Lithuania	20	10	6	6	13	6	6	0	0
Luxembourg	3	2	1	1	2	1	1	0	0
Malta	1	0	0	0	0	0	0	0	0
Netherlands	23	16	15	14	12	12	12	2	2
Poland	248	177	128	111	104	104	104	25	7
Portugal	58	33	31	31	27	27	27	4	4
Romania	136	98	57	55	57	38	36	19	19
Slovakia	40	25	17	23	20	17	18	1	5
Slovenia	12	8	6	5	5	4	4	2	1
Spain	135	69	53	50	68	52	49	0	0
Sweden	30	22	20	19	25	20	19	0	0
UK	119	70	58	59	64	57	58	1	1
EU-28	1776	1106	875	832	889	772	753	104	79

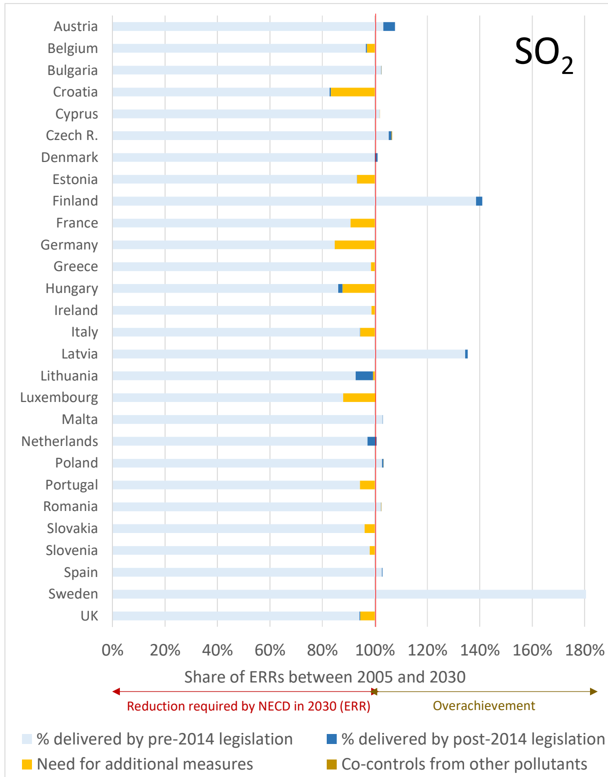
Table 6-5: NH_3 baseline emissions, emission ceilings and additional emission reductions to meet the ceilings, for the PRIMES 2016 REFERENCE (REF) and the CLIMATE AND ENERGY POLICY (CEP) scenarios (kilotons)

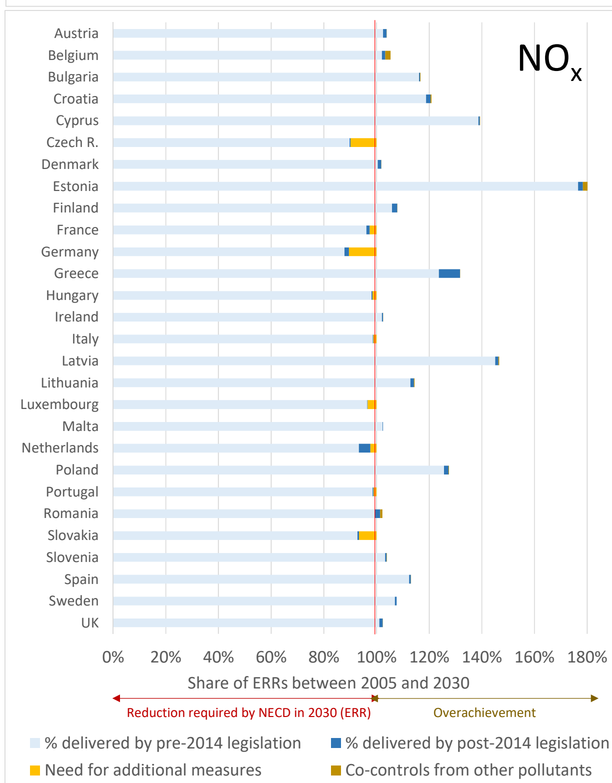
	2005	PRIMES 2016 REFERENCE scenario for 2030		CEP for 2030	Emission ceilings 2030	2030 projection to meet the ERRs in the optimized scenario		Additional reductions necessary to meet the ERRs for	
		with pre-2014 legislation	with post-2014 legislation	with post-2014 legislation		REF	CEP	REF	CEP
Austria	66	74	74	74	58	58	58	16	16
Belgium	69	68	68	68	60	60	60	8	8
Bulgaria	40	41	41	41	35	35	35	6	5
Croatia	38	34	34	34	29	29	29	6	5
Cyprus	6	6	6	6	5	5	5	1	1
Czech Rep.	84	70	70	69	66	66	66	4	3
Denmark	77	62	62	62	58	58	58	4	4
Estonia	10	13	13	13	10	10	10	3	3
Finland	39	34	34	34	31	31	31	4	3
France	753	716	716	714	655	655	655	61	60
Germany	671	673	673	671	477	477	477	196	195
Greece	58	50	50	50	52	48	48	2	2
Hungary	79	65	65	64	54	54	54	11	11
Ireland	103	114	114	114	98	98	98	16	16
Italy	434	413	413	412	364	364	364	48	48
Latvia	17	19	19	18	17	17	17	2	2
Lithuania	33	33	33	33	30	30	30	3	3
Luxembourg	6	6	6	6	5	5	5	1	1
Malta	2	1	1	1	1	1	1	0	0
Netherlands	152	118	118	117	120	117	116	1	1
Poland	314	329	328	325	260	260	260	68	65
Portugal	53	51	51	51	45	45	45	6	6
Romania	194	160	160	159	145	145	145	15	14
Slovakia	32	25	25	26	23	23	23	3	4
Slovenia	20	17	17	17	17	17	16	0	0
Spain	500	476	476	476	420	420	420	56	55
Sweden	63	56	56	56	53	53	53	4	3
UK	314	291	291	291	264	264	264	27	27
EU-28	4228	4016	4015	4001	3451	3444	3442	571	559

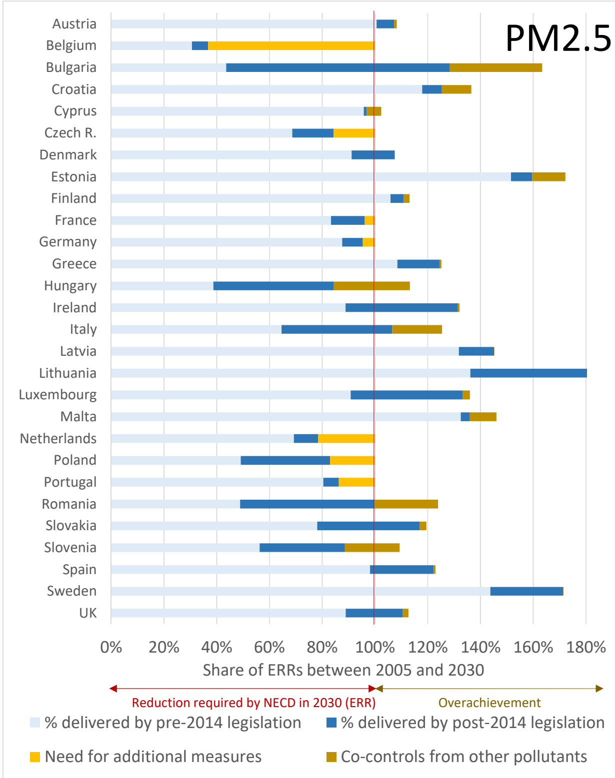
TABLE 6-6: VOC BASELINE EMISSIONS, EMISSION CEILINGS AND ADDITIONAL EMISSION REDUCTIONS TO MEET THE CEILINGS, FOR THE PRIMES 2016 REFERENCE (REF) AND THE CLIMATE AND ENERGY POLICY (CEP) SCENARIOS (KILOTONS)

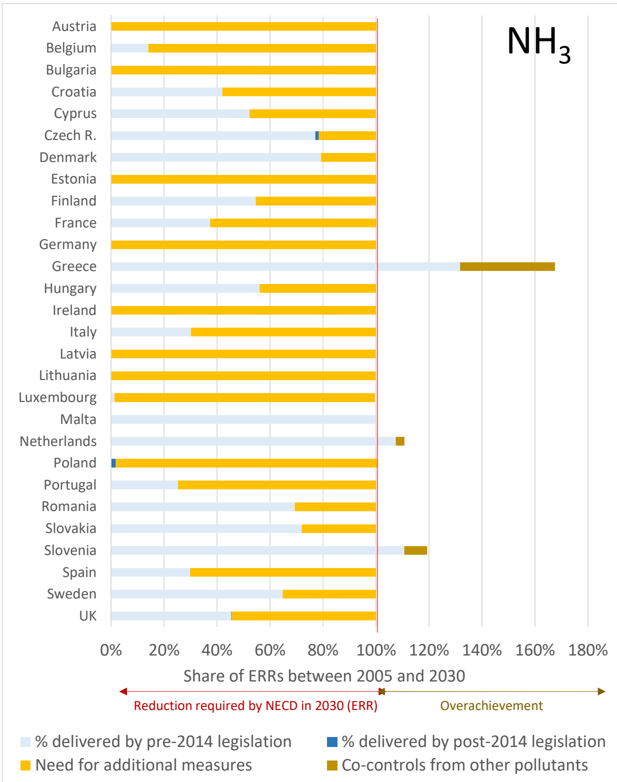
	2005	PRIMES 2016 REFERENCE scenario for 2030		CEP for 2030	Emission ceilings 2030	2030 projection to meet the ERRs in the optimized scenario		Additional reductions necessary to meet the ERRs for	
		with pre-2014 legislation	with post-2014 legislation	with post-2014 legislation		REF	CEP	REF	CEP
Austria	145	97	93	90	93	90	87	3	3
Belgium	145	113	111	109	94	94	94	17	15
Bulgaria	128	76	51	49	74	40	38	11	11
Croatia	97	46	44	44	50	40	39	4	4
Cyprus	11	6	6	6	6	6	6	0	0
Czech Rep.	207	121	114	112	104	104	104	10	8
Denmark	110	59	56	54	70	54	52	2	2
Estonia	29	19	18	18	21	17	16	2	2
Finland	126	63	62	56	66	61	55	1	1
France	1203	605	567	552	578	563	549	5	3
Germany	1157	844	836	827	833	806	797	30	29
Greece	263	128	115	112	100	100	98	15	14
Hungary	122	72	64	62	51	51	51	12	11
Ireland	67	48	43	42	46	40	39	3	3
Italy	1206	750	713	700	651	651	651	61	49
Latvia	48	26	24	24	29	24	24	0	0
Lithuania	69	41	37	36	37	34	34	3	3
Luxembourg	11	8	7	7	7	7	7	1	0
Malta	4	3	3	3	3	3	3	0	0
Netherlands	175	144	142	138	149	140	136	2	2
Poland	587	353	286	287	434	242	256	44	31
Portugal	197	132	129	128	122	118	117	11	11
Romania	347	191	148	145	191	111	108	37	36
Slovakia	76	62	55	59	51	51	51	3	8
Slovenia	43	28	24	23	20	20	20	3	2
Spain	799	529	509	504	487	487	487	22	17
Sweden	202	124	114	112	129	112	110	2	2
UK	1061	684	673	667	647	647	647	26	19
EU-28	**8635**	**5372**	**5043**	**4964**	**5142**	**4712**	**4678**	**330**	**287**

Figure 6-2 quantifies the contributions to the achievement of the ERRs of each Member State of (i) changes in activity levels, energy policies and pre-2014 emission control legislation, (ii) the post-2014 emission control legislation, and (iii) additional efforts. In several cases, MS reduce their emissions more than they are required to (they deliver more than 100% of the ERR – they overshoot the target) by fully implementing existing legislation (including the post-2014 one) and because of co-benefits from actions on other pollutants; they do not need to put in place additional measures. In other cases, co-benefits do not occur and existing legislation (pre- and post-2014), even if fully implemented, does not suffice to reach the ERR. In these cases, MS need to put in place additional measures to reach their ERR (and in this case these measures just allow them to reach exactly the ERR, over-shooting would be too costly). For SO_2 and NO_x, the pre-2014 baseline legislation makes the dominating contribution, as in the original proposal, while for the other pollutants the post-2014 legislation and the NECD deliver important shares. Note that in some cases additional emission controls beyond what would be necessary for attaining the ERRs emerge for some pollutants as a consequence of co-controls of multi-pollutant emission control measures that are taken as a cost-effective means for reach the ERR of another pollutant. For instance, a ban of agricultural waste burning simultaneously reduces PM2.5, VOC and NH_3 emissions. Considered as a low cost measures, it can make a cost-effective contribution to an ERR for NH_3, while at the same time overachieving ERRs for PM2.5 and VOC.






PM2.5
Austria
Belgium
Bulgaria
Croatia
Cyprus
Czech R.
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
Netherlands
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
UK
0% 20% 40% 60% 80% 100% 120% 140% 160% 180%
Share of ERRs between 2005 and 2030
Reduction required by NECD in 2030 (ERR)
Overachievement
% delivered by pre-2014 legislation
% delivered by post-2014 legislation
Need for additional measures
Co-controls from other pollutants


NH3
Austria
Belgium
Bulgaria
Croatia
Cyprus
Czech R.
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
Netherlands
Poland
Portugal
Romania
Slovakia
Slovenia
Spain
Sweden
UK
0% 20% 40% 60% 80% 100% 120% 140% 160% 180%
Share of ERRs between 2005 and 2030
Reduction required by NECD in 2030 (ERR)
Overachievement
% delivered by pre-2014 legislation
% delivered by post-2014 legislation
Need for additional measures
Co-controls from other pollutants

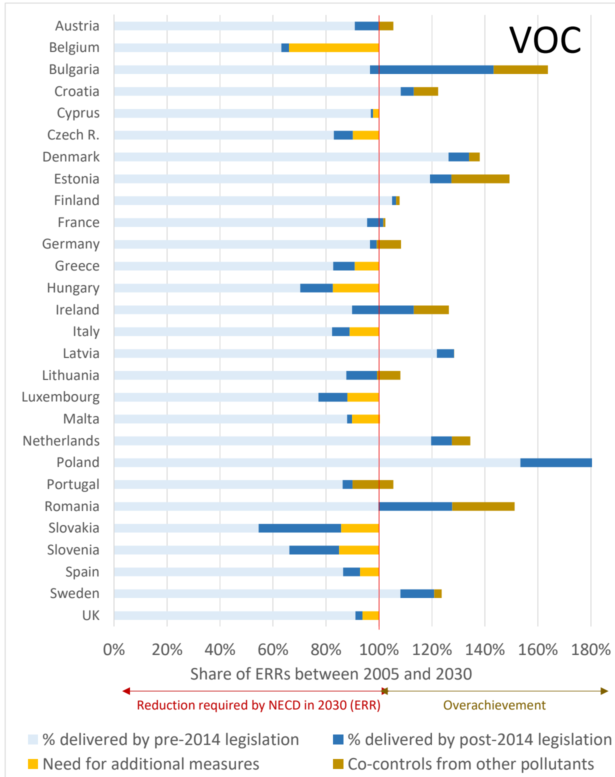


FIGURE 6-2: CONTRIBUTIONS TO THE ERRS DELIVERED BY (I) THE PRE-2014 LEGISLATION BASELINE, (II) THE POST-2014 LEGISLATION MEASURES, (III) FURTHER MEASURES THAT ARE REQUIRED TO MEET THE ERRS, AND (IV) CO-CONTROLS FROM MEASURES TARGETED AT OTHER EMISSIONS.

6.3 Additional measures to meet the ERRs

In addition to the quantification of the further emission reduction volumes that will be necessary to achieve the emission reduction requirements of the political agreement on the NECD, this report explores the distribution of sectors in which further emission control measures would be implemented to meet the ERRs at least cost, both for the activity projections of the PRIMES 2016 REFERENCE scenario as well as for the CEP sensitivity case. For this purpose, the optimization mode of the GAINS model has been used (Wagner et al. 2013).

Figure 6-3 to Figure 6-7 summarize, for each country and pollutant, by how much and in which sector emissions are reduced in a cost-effective approach to meet the ERRs in 2030 for the PRIMES 2016 REFERENCE scenario, on top of the 2017 legislation baseline.

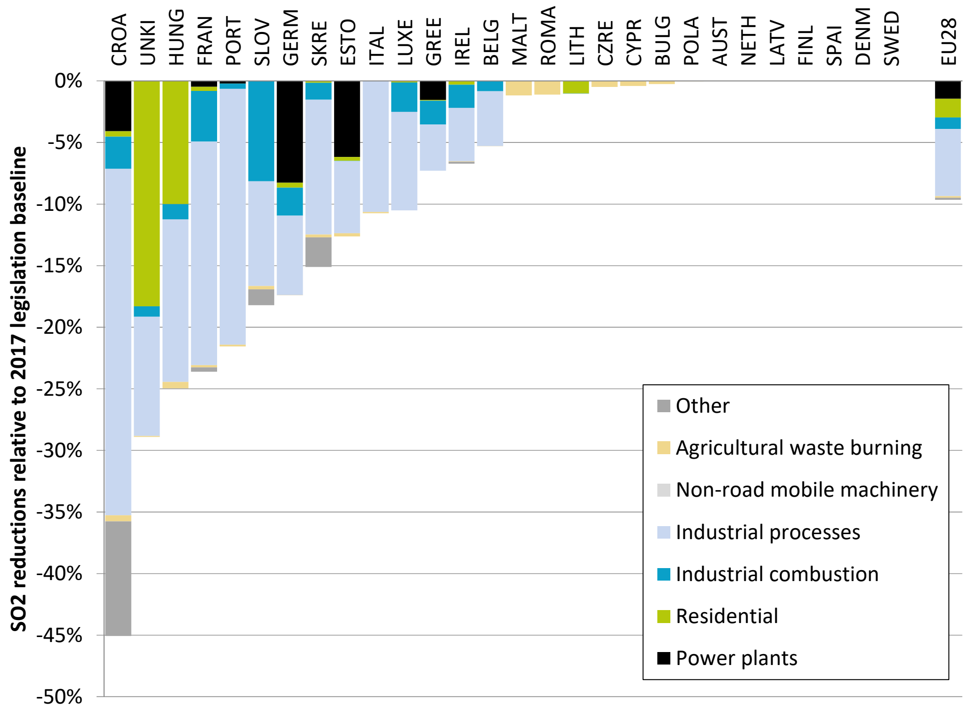


FIGURE 6-3: FURTHER REDUCTIONS OF SO_2 EMISSIONS TO REACH THE ERRS IN 2030, BEYOND THE 2017 LEGISLATION BASELINE, BY SECTOR

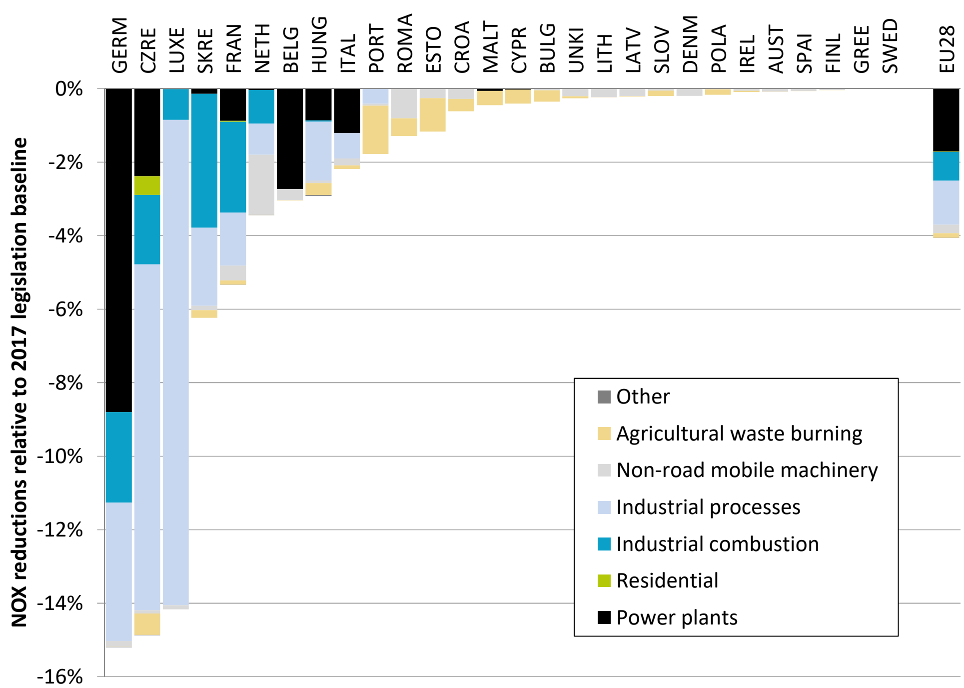


FIGURE 6-4: FURTHER REDUCTIONS OF NO_x EMISSIONS TO REACH THE ERRS IN 2030, BEYOND THE 2017 LEGISLATION BASELINE, BY SECTOR

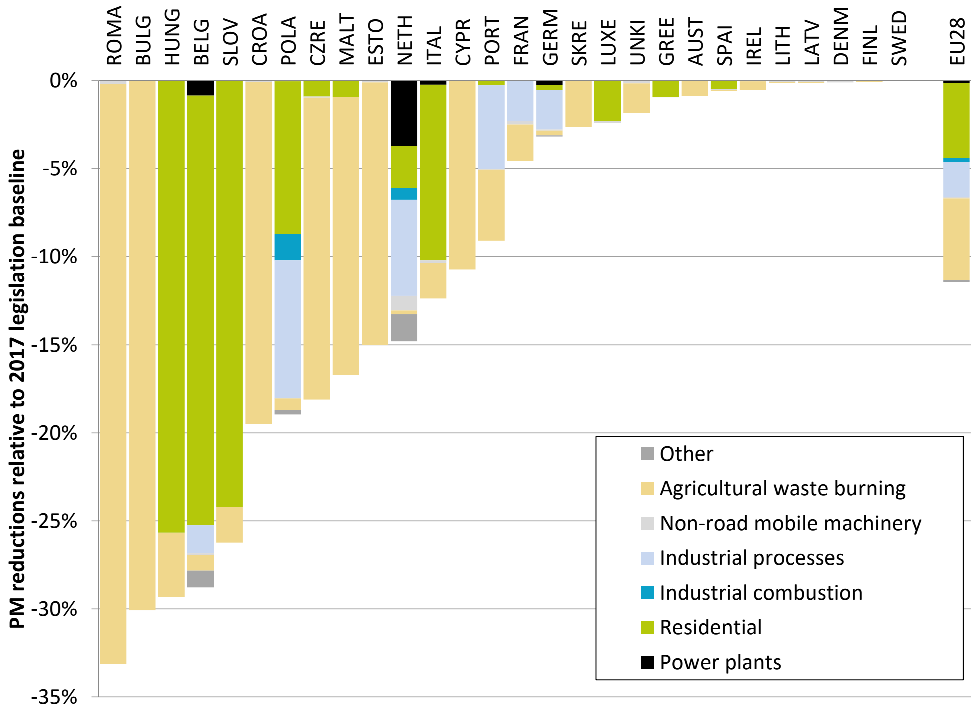


FIGURE 6-5: FURTHER REDUCTIONS OF PM2.5 EMISSIONS TO REACH THE ERRS IN 2030, BEYOND THE 2017 LEGISLATION BASELINE, BY SECTOR

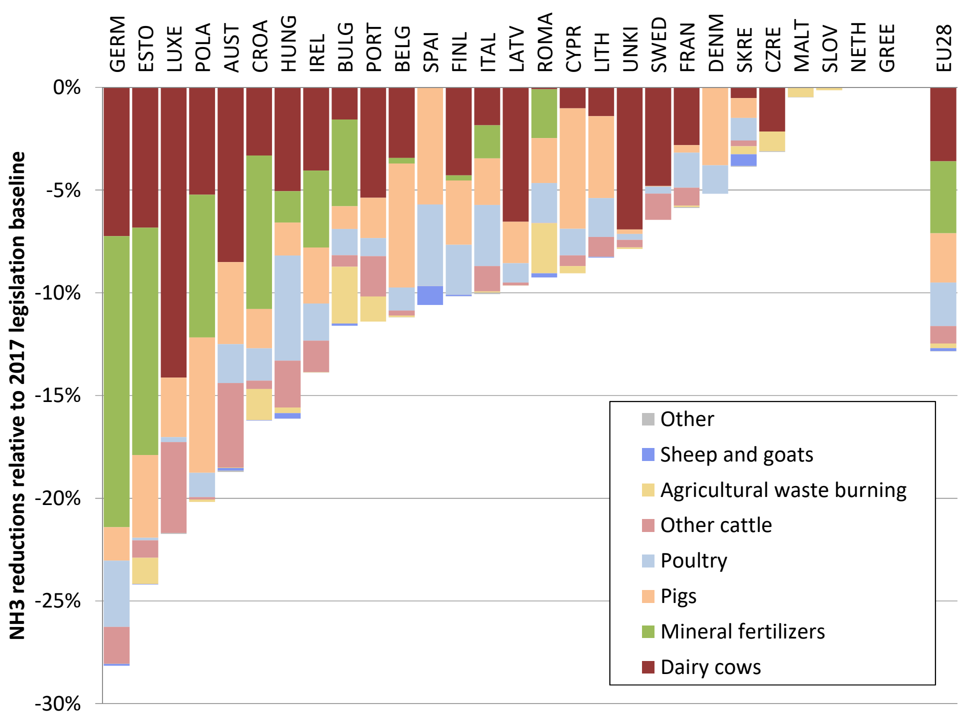


FIGURE 6-6: FURTHER REDUCTIONS OF NH_3 EMISSIONS TO REACH THE ERRS IN 2030, BEYOND THE 2017 LEGISLATION BASELINE, BY SECTOR

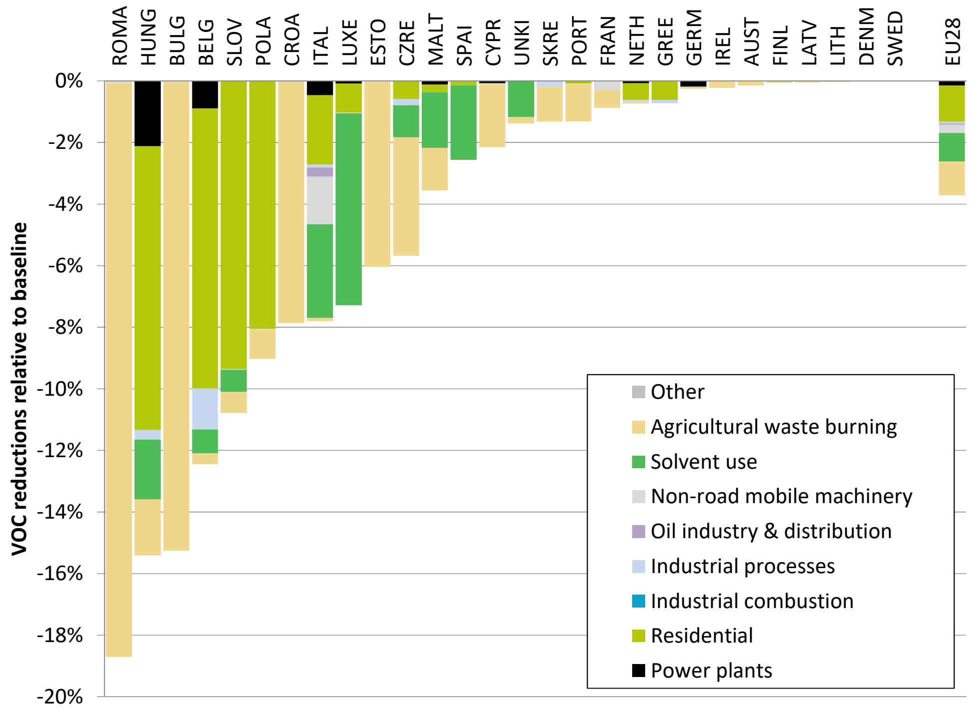


Figure 6-7: Further reductions of VOC emissions to reach the ERRs in 2030, beyond the 2017 legislation baseline, by sector

6.4 Emission control costs

In addition to the portfolios of specific measures that would close the emission gaps between the baseline projections and the ERRs, the cost-effectiveness analysis also provides estimates of emission control costs that are associated with these measures. For the PRIMES 2016 REFERENCE scenario, additional emission control costs amount to 960 million €/yr for the EU-28 as a whole, which corresponds to 1.9 €/person/year. Due to lower consumption of fossil fuels, costs in the CLIMATE AND ENERGY POLICY scenario shrink to about 540 million €/yr, i.e., to 1.05 €/person/year (Table 6-7). Thereby, the proposed climate and energy policy would reduce air pollution control costs by 420 million €/yr in 2030 compared to the PRIMES REFERENCE scenario.

Table 6-7: Emission control costs for the 2017 legislation scenario and the cost-effective achievement of the emission reduction requirements in 2030 (ERR 2030), for the PRIMES 2016 REFERENCE (REF) and the CLIMATE AND ENERGY POLICY (CEP) projections (million €/year)

	PRIMES 2016 REFERENCE			CLIMATE AND ENERGY POLICY		
	2017 legislation	ERR 2030	Additional costs	2017 legislation	ERR 2030	Additional costs
Austria	1725	1730	5	1584	1589	5
Belgium	2365	2379	14	2133	2143	10
Bulgaria	1000	1004	3	905	908	3
Croatia	461	472	11	438	448	10
Cyprus	120	120	0	111	111	0
Czech Rep.	2114	2137	23	2008	2020	12
Denmark	1235	1236	1	1112	1113	0
Estonia	288	293	5	217	220	3
Finland	1214	1218	3	1105	1107	2
France	9924	9997	72	9055	9070	14
Germany	14218	14747	529	12402	12646	244
Greece	1463	1466	3	1338	1338	0
Hungary	939	948	10	868	874	6
Ireland	960	1000	40	877	915	38
Italy	8226	8267	41	7356	7382	26
Latvia	223	224	0	196	197	0
Lithuania	428	429	1	400	401	1
Luxembourg	296	298	2	258	259	1
Malta	41	41	0	39	39	0
Netherlands	3253	3329	76	3121	3185	64
Poland	9131	9181	50	7977	8016	39
Portugal	1155	1161	7	1061	1066	4
Romania	1833	1842	9	1737	1745	7
Slovakia	731	735	3	697	699	3
Slovenia	428	430	1	383	384	0
Spain	6794	6805	12	5935	5946	10
Sweden	1395	1396	1	1203	1204	1
UK	7257	7294	37	6482	6519	37
EU-28	79220	80180	960	71001	71540	539

7 Air quality impacts

This section explores improvements in health- and ecosystems impacts that can be expected from the implementation of the ERRs (the ERR2030 scenario), taking into account the overshoots in emission reductions that might result from the implementation of recent source-oriented EU legislation. For the non-EU countries and for international shipping, latest activity projections have been collected from various sources and recent emission control legislation has been introduced (see Annex 2.)

7.1 Health impacts from PM

The decrease in precursor emissions of ambient PM2.5 in the ERR 2030 scenario results in a decline of the loss in statistical life expectancy attributable to the exposure to fine particulate matter (PM2.5) from nine months in 2005 to 4.1 months in 2030. However, in the Benelux region, Northern Italy, Poland and the Czech Republic people will still lose more than five to six months (Figure 7-1; Table 7-1).

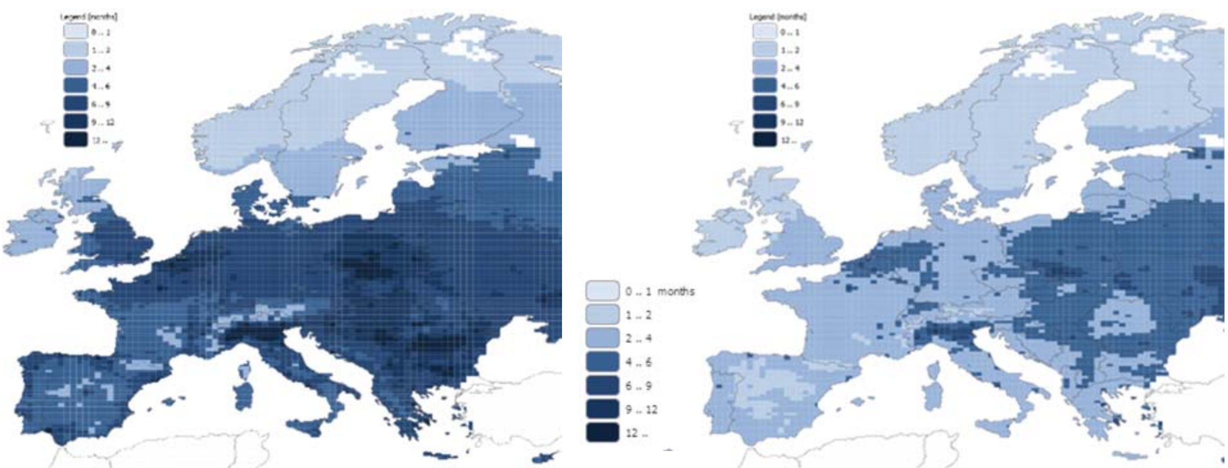


FIGURE 7-1: LOSS OF STATISTICAL LIFE EXPECTANCY FROM EXPOSURE TO PM2.5; LEFT PANEL: 2005, RIGHT PANEL: THE ERR SCENARIO FOR 2030 [IN MONTHS]

The number of premature deaths attributable to PM2.5 will decline from 418,000 cases in 2005 to 194,000 cases in 2030. Note that this 54% reduction is higher than the target figure in the negotiations on the political agreement of the NEC Directive (i.e., 49.6%), which is a direct result of the overachievements of the ERRs in some countries due to the post-2014 source-oriented legislation.

TABLE 7-1: HEALTH IMPACTS FROM PM2.5; LOSS OF STATISTICAL LIFE EXPECTANCY [MONTHS] AND CASES OF PREMATURE DEATHS, FOR 2030 AND THE SCENARIO THAT ACHIEVES THE ERRS IN 2030 (ERR 2030) [4]

	Exposure to PM2.5			
	Loss of statistical life expectancy		Cases of premature deaths	
	2005	ERR 2030	2005	ERR 2030
Austria	7.2	3.6	5267	2647
Belgium	11.3	5.6	10963	5395
Bulgaria	12.3	4.4	12686	4577
Croatia	10.4	4.2	4966	2031
Cyprus	6.5	4.2	461	295
Czech Rep.	9.0	4.5	8676	4317
Denmark	6.1	3.1	3075	1565
Estonia	4.5	3.0	646	422
Finland	4.2	2.9	1943	1351
France	8.4	3.9	42905	19746
Germany	7.8	4.1	63698	33407
Greece	13.6	5.3	14366	5560
Hungary	11.0	5.0	12592	5765
Ireland	4.0	2.0	1071	521
Italy	10.8	5.2	62828	30226
Latvia	6.1	3.6	1659	988
Lithuania	6.8	4.0	2584	1497
Luxembourg	9.2	4.4	333	160
Malta	6.7	3.5	214	113
Netherlands	9.0	4.4	11746	5692
Poland	12.3	6.0	40410	19753
Portugal	8.1	3.2	8258	3301
Romania	12.4	4.9	28101	11079
Slovakia	9.8	4.9	4548	2278
Slovenia	9.4	4.1	1639	714
Spain	8.6	3.3	33575	12765
Sweden	3.4	2.2	3033	1948
UK	6.7	2.9	36246	15407
EU-28	**9.0**	**4.1**	**418492**	**193522**

[4] The calculation of premature deaths assumes constant population figures between 2005 and 2030

7.2 Towards the WHO guideline for PM2.5

For PM2.5, the current Air Quality Directive specifies a target value of 25 µg/m^3 annual mean concentration, which has been transformed into a legally binding limit value as of January 2015. This value is, however, by far higher than the levels considered safe by the World Health Organization (WHO), which specifies a guideline value of 10 µg/m^3 annual mean concentration (World Health Organization 2006). For comparison, in the 2013 review of US air quality legislation, the annual PM2.5 standard in the United States was tightened to 12 µg/m^3 (US-EPA 2013).

As clearly shown by monitoring data, current PM2.5 concentrations exceed the WHO guideline value by a substantial margin in a large area of the EU-28, and it is estimated that in 2005 88% of the population was exposed to higher concentrations. The emission reductions implied by the ERRs will reduce this number to 13% in 2030 (Figure 7-2), and limit exceedances to a few areas in Europe. These include Northern Italy and Southern Poland, due to their high emission densities of sources for which less stringent emission reductions have been politically agreed in the NECD.

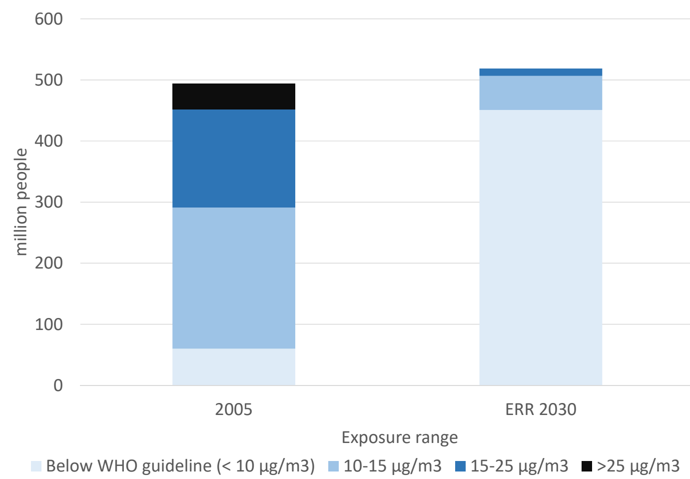


FIGURE 7-2: DISTRIBUTION OF POPULATION EXPOSURE IN THE EU-28 TO PM2.5 LEVELS IN 2005 AND 2030

To shed light on the sources that will be mainly responsible for the remaining exceedances of the WHO guideline value in 2030 after implementation of the NECD, a source attribution has been conducted with the GAINS model (Kiesewetter and Amann 2014; Kiesewetter et al. 2015) for the urban traffic stations that have reported sufficient data to AIRBASE in 2009. Results of this source apportionment, both for 2005 and the ERR 2030 scenario, are provided in the Annex for all Member States for which data availability allowed such analyses.

Focusing on the countries with highest remaining PM2.5 levels, i.e., Italy and Poland (Figure 7-3), the calculations clearly identify secondary particles formed in the atmosphere in the presence of ammonia as major constituents of PM2.5 in ambient air, with contributions of about 5 µg/m^3., which is about half of the WHO guideline value. As the formation of secondary aerosols takes time, the relevant precursor emissions occur mainly at more remote locations outside cities. Especially ammonia from agricultural activities is an indispensable ingredient for the formation of secondary particles. In addition, a substantial part of PM2.5 in ambient air will still come from of primary emissions of particles from the residential combustion of solid fuels, i.e., predominantly wood stoves in Italy, and coal and wood stoves in Poland.

The fact that the major remaining contributions to ambient PM2.5 will originate from NH_3 and primary PM2.5 emissions is not a coincidence. As highlighted above, the ERRs of the NEC Directive haves put highest demand on reductions of these two pollutants, although obviously the political agreement on the actual reductions did not exhaust the full emission reduction potential.

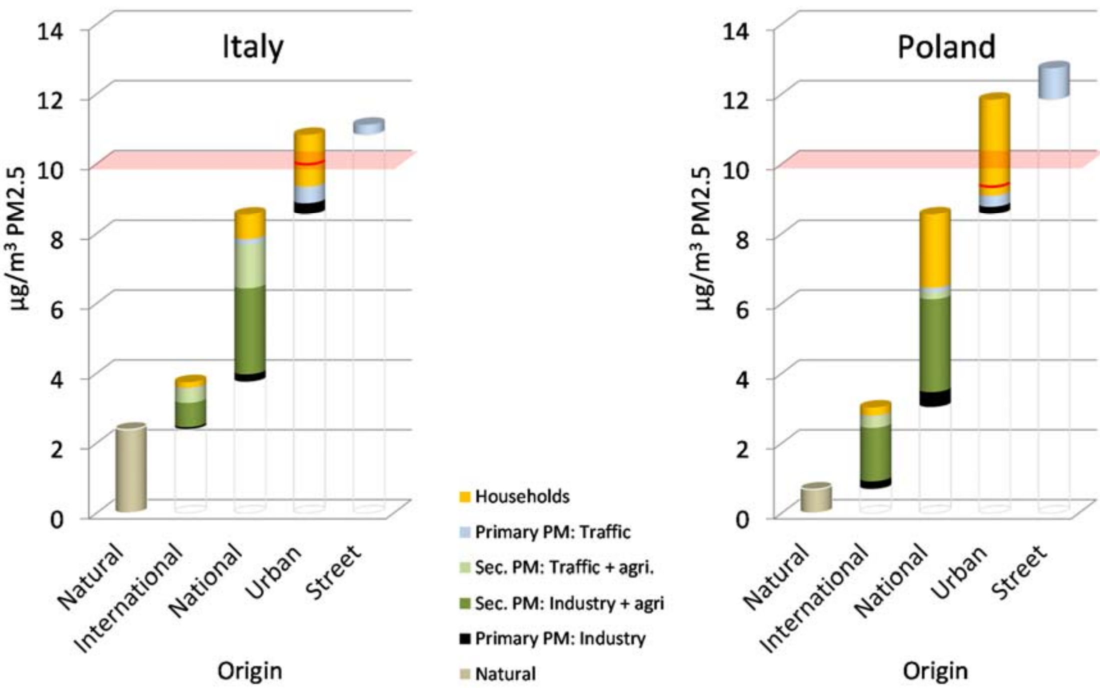


FIGURE 7-3: SOURCES OF PM2.5 AT URBAN TRAFFIC STATIONS IN ITALY AND POLAND, FOR THE ERR 2030 SCENARIO

To explore the feasibility of achieving the WHO guideline values, Figure 7-4 quantifies the remaining contributions to PM2.5 at urban traffic stations in Italy and Poland after implementation of the full emission control potential as outlined in the Maximum Technically Feasible Reductions (MTFR) scenario for 2030 (see also Section 4.3). Note that this scenario excludes premature scrapping of existing capital stock, and that the analysis is conducted for the PRIMES 2016 REFERENCE scenario. Thus, the additional potentials from early replacement of the most polluting equipment and/or changes in energy and agricultural policies are not considered in these graphs. Nevertheless, the graphs clearly indicate that, broadly speaking, the WHO guideline values are within reach even in the areas where highest ambient PM2.5 levels are expected to persist. In addition, it should be noted that the PRIMES 2016 REFERENCE scenario anticipates for 2030 still wide-spread use of coal in Polish households. A switch to cleaner fuel beyond what is assumed in the scenario, if socially and politically acceptable, would bring air quality in Poland closer to the WHO guideline values.

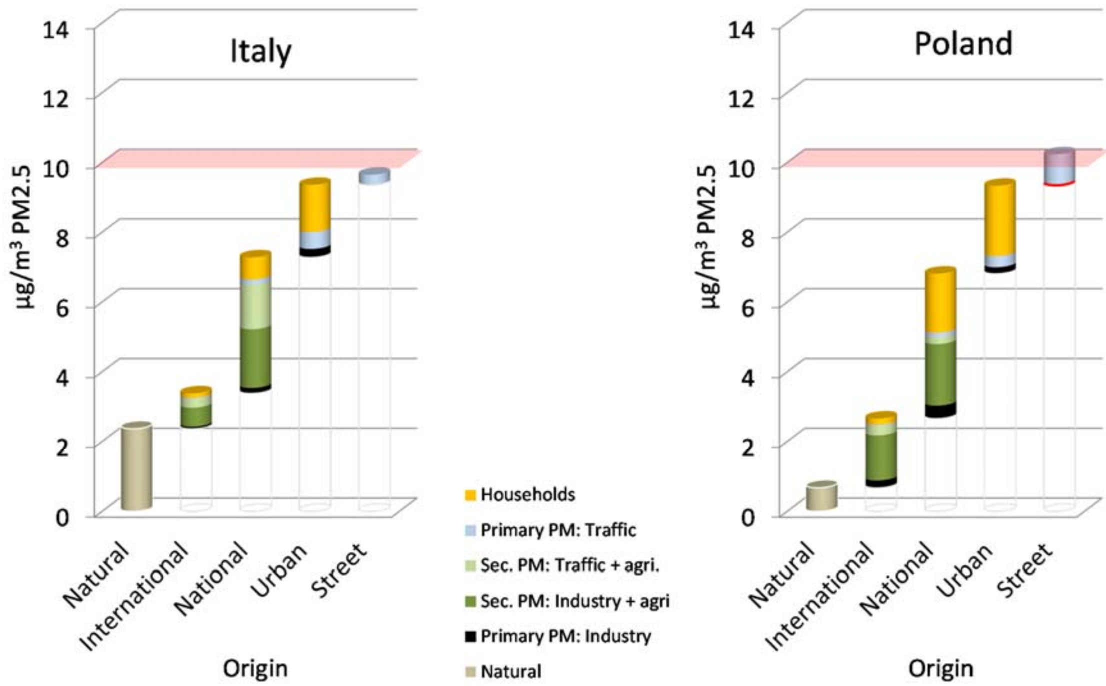


Figure 7-4: Sources of PM2.5 at urban traffic stations in Italy and Poland, for the Maximum Technically Feasible Reductions (MTFR) scenario in 2030

7.3 Compliance with the NO_2 air quality limit value

The measures to reach the ERRs will also benefit compliance with the NO_2 air quality limit values. The GAINS analysis estimates current and future NO_2 concentrations for the 1979 AIRBASE monitoring stations for which sufficient data have been reported for the year 2009 (Kiesewetter et al. 2014). The method takes into account current and future NO_x emissions from the different sources, ozone concentration at the measurement sites and the long-range transport of pollutants in the atmosphere.

To acknowledge the statistical nature of the Europe-wide calculation and of some of the underlying factors (e.g., meteorological variabilities), results are presented on an aggregated bases, but not for individual stations. The relative distributions of stations across different concentration ranges indicate the risk of exceedance of the ambient air quality limit value.

In Figure 7-5 the 1979 monitoring stations are grouped into three categories, i.e.,

- stations with annual mean NO_2 concentrations above 45 µg/m³, indicating a clear risk of exceeding the annual ambient air quality limit value,
- stations with annual mean NO_2 concentrations between 35 and 45 µg/m³, where the accuracy of the Europe-wide method is not sufficient to derive robust results, and
- stations below 35 µg/m³, where the risk for exceedance of the limit value is considered low.

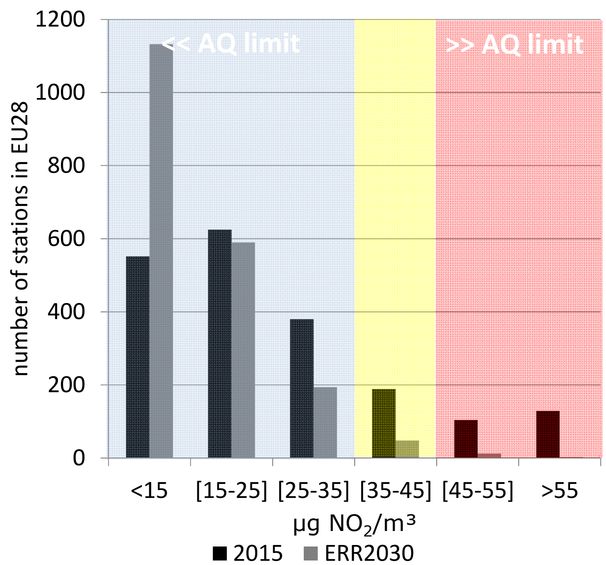


FIGURE 7-5: NUMBER OF AIRBASE MONITORING STATIONS WITH DIFFERENT RANGES OF NO_2 CONCENTRATIONS, FOR 2015 AND THE ERR2030 SCENARIO

In 2015, at about 12% of the monitoring stations annual average NO_2 concentrations clearly exceed 40 µg/m³; for another 10% of the stations there is some probability of exceedance depending, *inter alia*, on actual meteorological conditions. With the emission reductions of the ERR 2030 scenario, less than one percent of the stations fall into the highest category, and for two percent the results are inconclusive.

The average NO_2 (not population-weighted) concentration of these 1979 stations drops from 26 µg/m³ in 2015 to 15 µg/m³ in 2030; for traffic stations the annual average concentration is expected to decline from 47 µg/m³ to 23 µg/m³.

One should note that the calculations are carried out for the 1979 AIRBASE monitoring stations for which sufficient data have been reported in 2009. While this is a large number of stations, their distribution across Member States is rather uneven, with numerous stations in the centre of Europe and only few stations in other areas, especially in the Eastern Member States of the European Union. Thus, despite the positive expectations that can be developed for the regions with high densities of stations, in reality the situation could be less favourable in areas with lower data availability.

7.4 Threat to biodiversity in Natura2000 areas

In addition to fragmentation and climate change, excess nitrogen deposition constitutes an important threat to biodiversity in areas that are protected under the Birds Directive and the Habitat Directive (i.e., Natura2000 areas).

With the same database on critical loads that has been employed for the analyses of the Clean Air Policy package, it is estimated that in 2005 biodiversity was under threat from excess nitrogen deposition in 78% (430,000 km^2) of the protected zones. By 2030, the measures to achieve the ERRs will reduce the threatened area to 58%, and average excess nitrogen deposition will decline by 55%. However, biodiversity will still remain at risk in 58% of the Natura2000 nature protection areas (320,000 km^2) due to excessive nitrogen deposition (Figure 7-6).

Excess nitrogen deposition is caused by deposition of NO_x and NH_3 precursor emissions. While already in 2005 ammonia deposition constituted a considerable share to total nitrogen deposition, the relative importance of NH_3 will grow further, given the fact that the political agreement on the NEC Directive established a 66% reduction requirement for NO_x while for NH_3 emissions a cut by only 19% has been agreed.

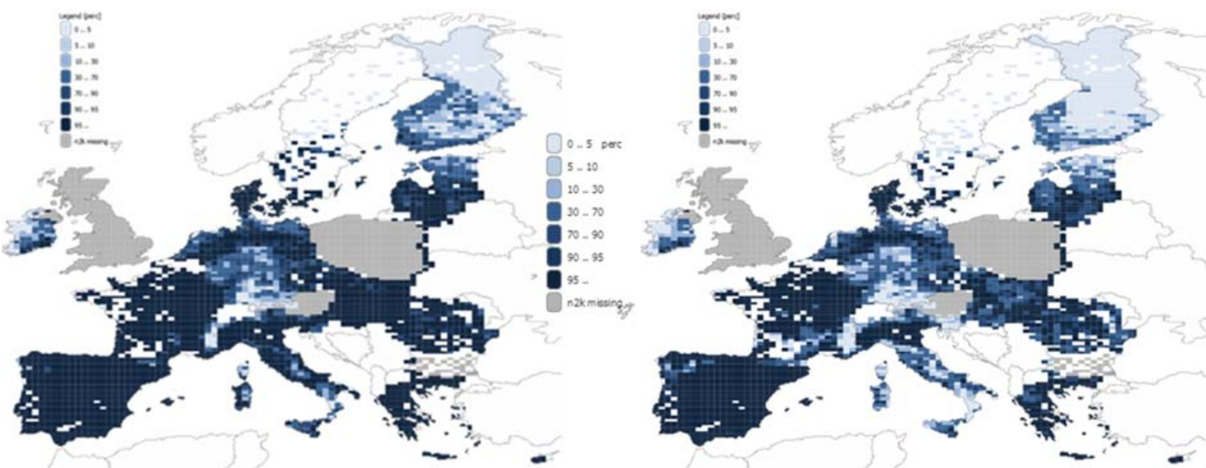


FIGURE 7-6: PERCENTAGE OF NATURA2000 AREAS WITH NITROGEN DEPOSITION ABOVE THEIR CRITICAL LOADS FOR EUTROPHICATION; LEFT PANEL: 2005, RIGHT PANEL: THE ERR 2030 SCENARIO FOR 2030

At the same time, from a technical perspective, there will remain potential for further NH_3 reductions. Assuming full implementation of the technical potential for NO_x and NH_3 emission controls that constitute the MTFR scenario would reduce excess nitrogen deposition by more than 75%, but would still leave about 50% of the Natura2000 areas at risk.

However, additional improvements are conceivable along two lines:

First, the agricultural projection assumes business-as-usual demand trends for agricultural products, notably excluding changes towards healthier diets with lower consumption of meat. Such dietary changes, adopted for health and lifestyle considerations, could reduce livestock numbers and thereby agricultural emissions of NH_3.

Second, ammonia has a much shorter lifetime in the atmosphere than many of the other substances discussed in this report, so that a large share of NH_3 is usually deposited within a few kilometres from the source, unless it is converted into secondary particles. Thus, there exists potential for targeted emission controls at sources (e.g., large industrial farms) that are located in the vicinity of sensitive nature protection areas. Although the current modelling capabilities do not allow such fine-scale analyses at the European level, spatially tailored measures could deliver additional reductions at hot spots in a cost-effective way, as they could substitute for NH_3 emission reductions in a much wider region.

Together, these aspects could offer reductions in NH_3 deposition beyond what is considered in the current modelling approach, which would then bring the policy target for biodiversity targets within reach.

7.5 Threat to biodiversity of all ecosystems

In 2005, more than 1.1 million km^2 (i.e., 67%) of the European ecosystems were exposed to nitrogen deposition that exceeded their critical loads for eutrophication. With the future development mainly influenced by the fate of NH_3 emissions, the ERR 2030 scenario reduces the area under threat to 827,000 km^2, i.e., 49% of all ecosystems. The additional emission reduction measures of the MTFR case could safeguard another 128,000 km^2 in 2030.

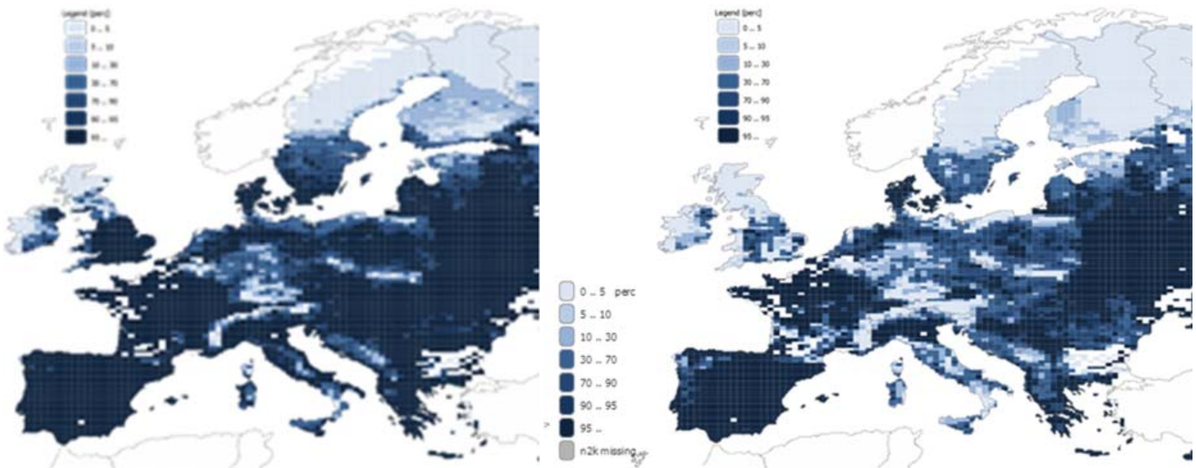


FIGURE 7-7: PERCENTAGE OF ECOSYSTEMS AREAS WITH NITROGEN DEPOSITION ABOVE THEIR CRITICAL LOADS FOR EUTROPHICATION; LEFT PANEL: 2005, RIGHT PANEL: THE ERR 2030 SCENARIO FOR 2030

7.6 Acidification of forest soils

With the 2012 data set on critical loads (Posch et al. 2011), it is calculated that in 2005 critical loads for acidification have been exceeded in a forest area of 156,000 km^2, i.e., in about 12% of the forests within the EU-28 for which critical loads have been reported.

Especially the anticipated further decline in SO_2 emissions that is implied in the ERRs will resolve the threat for another 129,000 km^2 up to 2030. Beyond that, additional measures could provide sustainable conditions for another 13,000 km^2 up to 2030, and leave only 0.2% of European forests threatened by acidification. These measures would especially benefit 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. Similar to eutrophication, NH_3 deposition will account for the dominating share of acid deposition in forests, especially after the reductions of SO_2 and NO_x emissions. As mentioned above, the additional potential for NH_3 reductions from dietary changes and targeted measures to reduce local emissions in the vicinity of sensitive forests could facilitate the achievement of the EU objective of bringing acid deposition below critical loads.

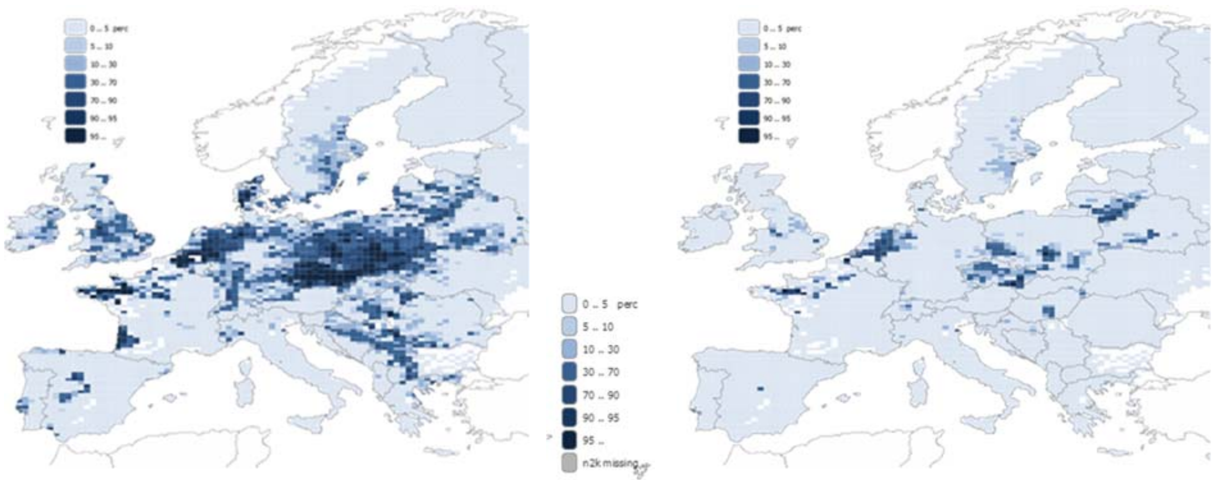


FIGURE 7-8: PERCENTAGE OF FOREST AREA WITH ACID DEPOSITION ABOVE THE CRITICAL LOADS FOR ACIDIFICATION; LEFT PANEL: 2005, RIGHT PANEL: THE ERR 2030 SCENARIO FOR 2030

8 Summary

In 2016, the institutions of the European Union reached political agreement on the revised directive on national emission ceilings (NECD, 2016/2284/EU), which establishes for five pollutants national emission reduction requirements (ERRs) for 2030, relative to the emission levels in the year 2005. The proposal presented by the European Commission in 2013 and the subsequent negotiations of the European Council and Parliament have been informed by systematic cost-effectiveness and cost-benefit analyses conducted with the GAINS integrated assessment model. These assessments built on projections of future air quality resulting from the emission control policies at that time, explored the costs of additional emission reductions, quantified their health and economic benefits, and assessed their distribution across countries and economic sectors. Findings have been presented in a series of 16 reports underpinning the Thematic Strategy on Air Pollution[5].

Since the time these analyses were conducted, a number of important factors have changed. These include, *inter alia*, improved information on emission inventories for historic years, the revised climate and energy policy proposed for the European Union, new source-oriented regulations for emission controls and, not least, the political agreement on the NEC Directive.

This report revisits the Outlook up until the year 2030, taking into account the changes listed above, and explores the prospects of achieving the WHO guideline values to protect human health as well as the Union's environmental policy objectives on the protection of ecosystems.

The new NECD establishes emission ceilings for 2030 in relation to the emission levels for 2005. Thus, retrospective changes of 2005 inventories have direct impact on future emission ceilings and the need for further efforts to meet these ceilings. Most importantly, the 2005 inventories reported by Member States in 2017 have significantly changed compared to the 2014 submissions on which the earlier analyses were based. More than 20% of sectoral figures have altered by more than 10%, most frequently for PM2.5 and VOC. In total for the EU-28, reported emissions of PM2.5 have increased by 11.4%, and by 6.7% for NH_3. This enlarges the absolute emission ceilings in 2030, and affects the need for further measures, although the implied efforts depend on the source sectors for which figures have been changed.

In addition, after 2013 the European Commission has released new projections of economic activities, reflecting the latest economic outlooks as well as recent climate and energy policies. Compared to the earlier projection of 2013, the PRIMES 2016 REFERENCE scenario suggests for 2030 slightly lower total energy consumption.

Furthermore, since 2014 the institutions of the European Union have agreed on a number of new source-oriented emission regulations, including the Medium Combustion Plants (MCP) Directive, the Eco-design controls for solid fuel stoves and boilers, and for non-road mobile machinery (NRMM).

Considering the interplay of all these changes and especially the legislation since 2014, it is found that, for the EU-28 as a whole, by 2030 SO_2 emissions would decline by 78% relative to 2005, NO_x emissions by 65%, PM2.5 by 51%, NH_3 by 5% and VOC by 42%. As in the previous analysis, for SO_2 and NO_x the pre-2014 legislation delivers most of the NECD emission reduction requirements (ERR). For PM2.5 and VOC, the impact of the additional legislation since 2014 brings those emissions also close to the required levels. Only for NH_3 is there little contribution from source legislation to the achievement of the ERRs.

However, the situation for individual countries differs. To meet the ERRs for SO_2, 14 countries have to take additional action. For NO_x, additional action will be required by 13 Member States, for PM2.5 by 15 countries, for VOC by 25 countries, while for NH_3 further efforts are required for almost all (26) Member States (based on the PRIMES 2016 REFERENCE scenario with the 2017 air pollution legislation).

[5] http://www.iiasa.ac.at/web/home/research/researchPrograms/air/policy/TSAP-reports.html

Vice versa, the latest source-oriented legislation will reduce emissions below the respective ERRs in the other Member States, i.e., in 14 countries for SO_2, in 15 countries for NO_x, in 13 countries for PM2.5 and 5 countries for VOC, so that these countries will overshoot the ERRs for these pollutants. These overachievements imply at the EU level larger emission reductions than laid down in the ERRs for 2030; SO_2 is expected to drop 7% below the ERRs, NO_x by 9%, PM2.5 by 13% and VOC by 8%.

As a consequence, by 2030 the improvements in health from better air quality will be larger than what would result from the ERRs. Premature deaths will drop by 54% in relation to 2005, compared to the 52% of the 2013 Commission proposal for the Clean Air Policy package and the 49.6% estimated during Council negotiations.

The significant reductions in precursor emissions will bring down ambient PM2.5 levels throughout Europe, in the overwhelming majority of countries even below the WHO guideline value of 10 $\mu g/m^3$. However, two areas in Europe will still face robust exceedances of the WHO guideline value, i.e., Northern Italy and Southern Poland. Source apportionment analyses for these areas indicate that, after implementation of all measures that are required to meet the ERRs, secondary particles formed in the atmosphere in the presence of ammonia will still contribute about half of the WHO guideline value, despite the forthcoming reductions in NH_3 emissions. Another large fraction of ambient PM2.5 consists of primary emissions of particles from the residential combustion of solid fuels, i.e., predominantly wood stoves in Italy, and coal and wood stoves in Poland. However, with the technical measures that are considered in GAINS, the WHO guideline value could be reached at almost all stations.

Also for NO_2, compliance with the annual limit value should greatly improve. While currently about 20% of the almost 2000 AIRBASE monitoring stations considered in the analysis experience robust or possible exceedance of the limit value, this share is computed to drop to 3% with the implementation of the NECD.

For biodiversity, the measures envisaged for reaching compliance with the ERRs will not achieve the improvements that have been suggested in the 2013 Commission proposal for the NEC Directive. In 2030, the measures would reduce the area of Natura2000 nature protection zones where biodiversity is threatened by excess nitrogen deposition by 58%, down from 78% in 2005. Additional measures, especially for controlling NH_3 emissions, are available, and their application could further reduce excess deposition by 75%, which however would still leave 50% of the Natura2000 areas at risk.

Especially the anticipated further decline in SO_2 emissions that is implied with the ERRs will resolve most of the threat of acidification of forest soils, and full implementation of the additional reduction potentials could provide sustainable conditions for 99.8% of forest areas.

In total, the additional emission reductions, if implemented in the most cost-effective way, involve emission control costs of 960 million €/yr (or 1.9 €/person/year), assuming the PRIMES 2016 REFERENCE baseline scenario. Due to the 12% lower consumption of fossil fuels outlined in the CLIMATE AND ENERGY POLICY scenario, additional emission control costs for achieving the ERRs would drop to 540 million €/yr (or 1.05 €/person/year), i.e., by 45%.

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Annex 1: Sources of PM2.5 at urban traffic stations, for the ERR 2030 scenario

The following graphs present the contributions from different emission sources to ambient PM2.5, for the urban traffic stations that provided for 2009 sufficient data to the AIRBASE database of the European Environment Agency (EEA). The presentations follow the analysis presented in the TSAP Report #12 ((Kiesewetter and Amann 2014)), applying the same methodology ((Kiesewetter et al. 2015)), so that the following graphs are directly comparable with the TSAP Report #12.

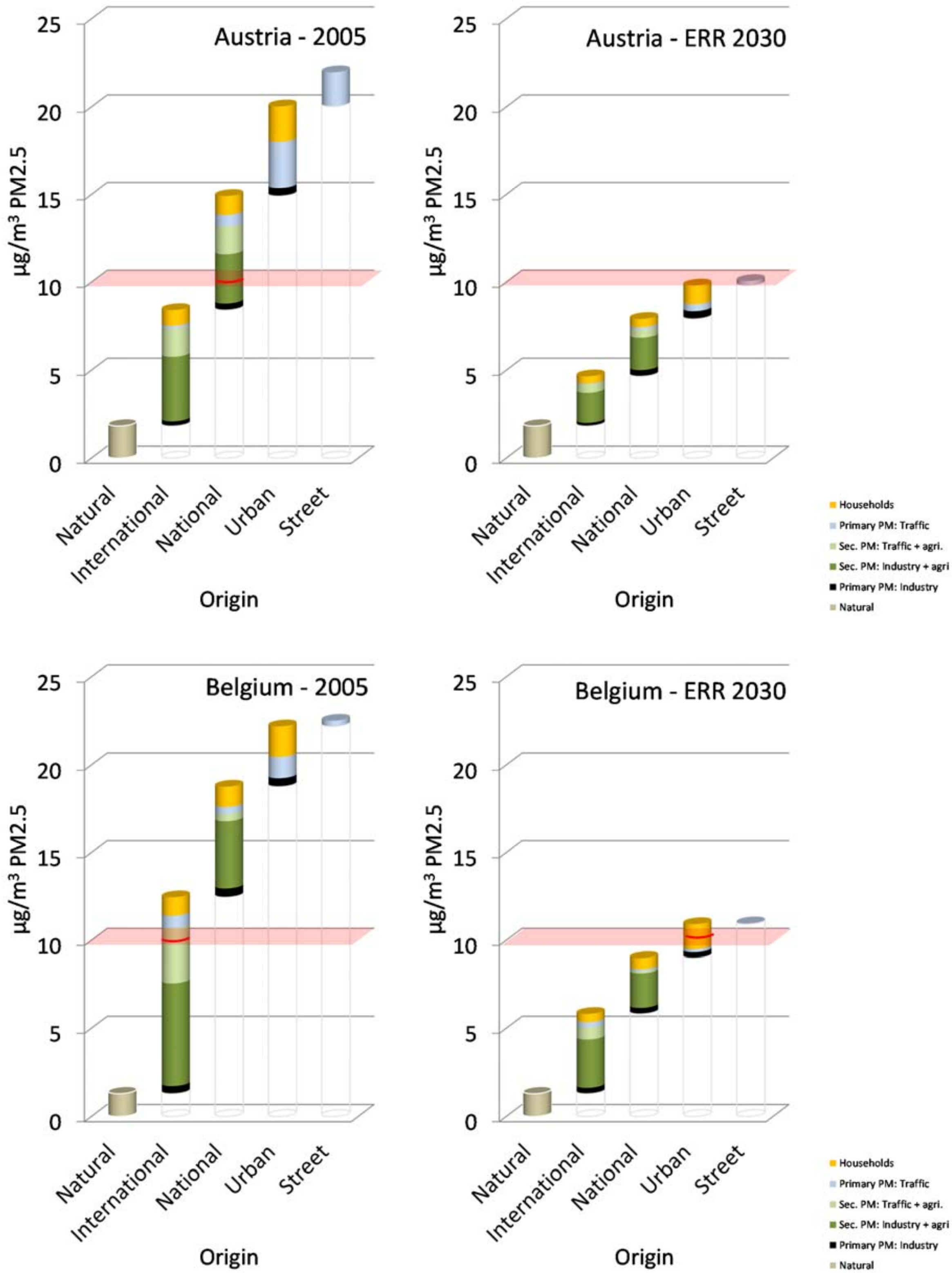
In particular, the graphs distinguish, for each Member State for which the available data allowed such an analysis, the mean contributions to PM2.5 at the urban station from (i) transboundary transport of pollution, (ii) national emission sources (outside a city), (iii) emissions within the city, and (i) sources within the particular street canyon. Furthermore, the graphs quantify the contributions resulting from the emissions of different economic sector. Primary particulate matter (PPM) is explicitly shown from industry (including energy industry, industrial combustion, industrial processes, extraction and distribution of fuels, waste management) and traffic (road and non-road) sources. Secondary aerosol is split into contributions involving industrial (SO_2 and NO_x) emissions and those involving traffic emissions (NO_x). In the atmosphere, both of these components combine with ammonia from the only source agriculture, hence these contributions are attributed to "industrial + agriculture" and "traffic + agriculture" emissions respectively, to indicate the different sectors involved. Contributions from the domestic sector (mainly household heating) are shown as totals, including primary and secondary particles.

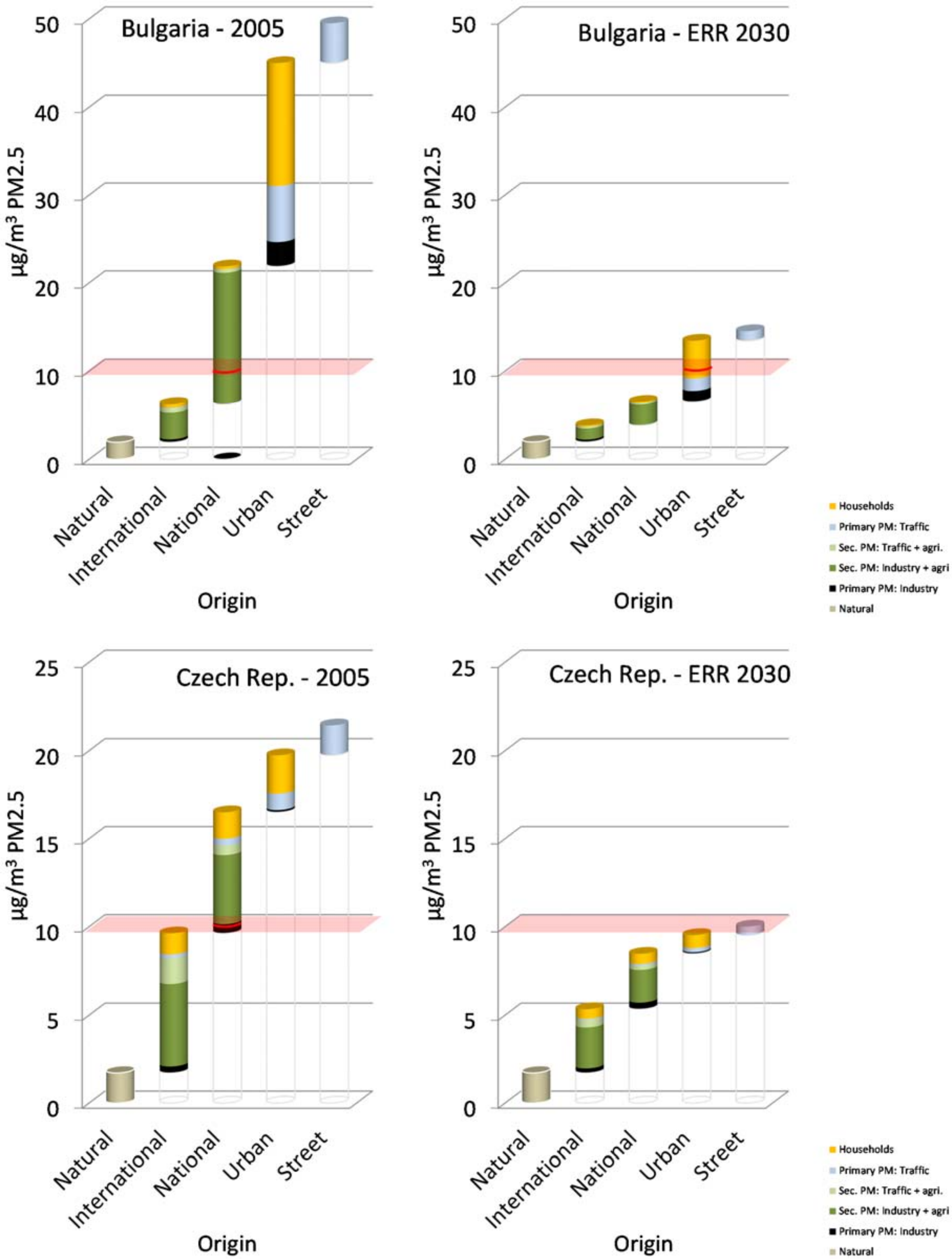
The following colour coding is used for distinguishing the sectoral contributions:

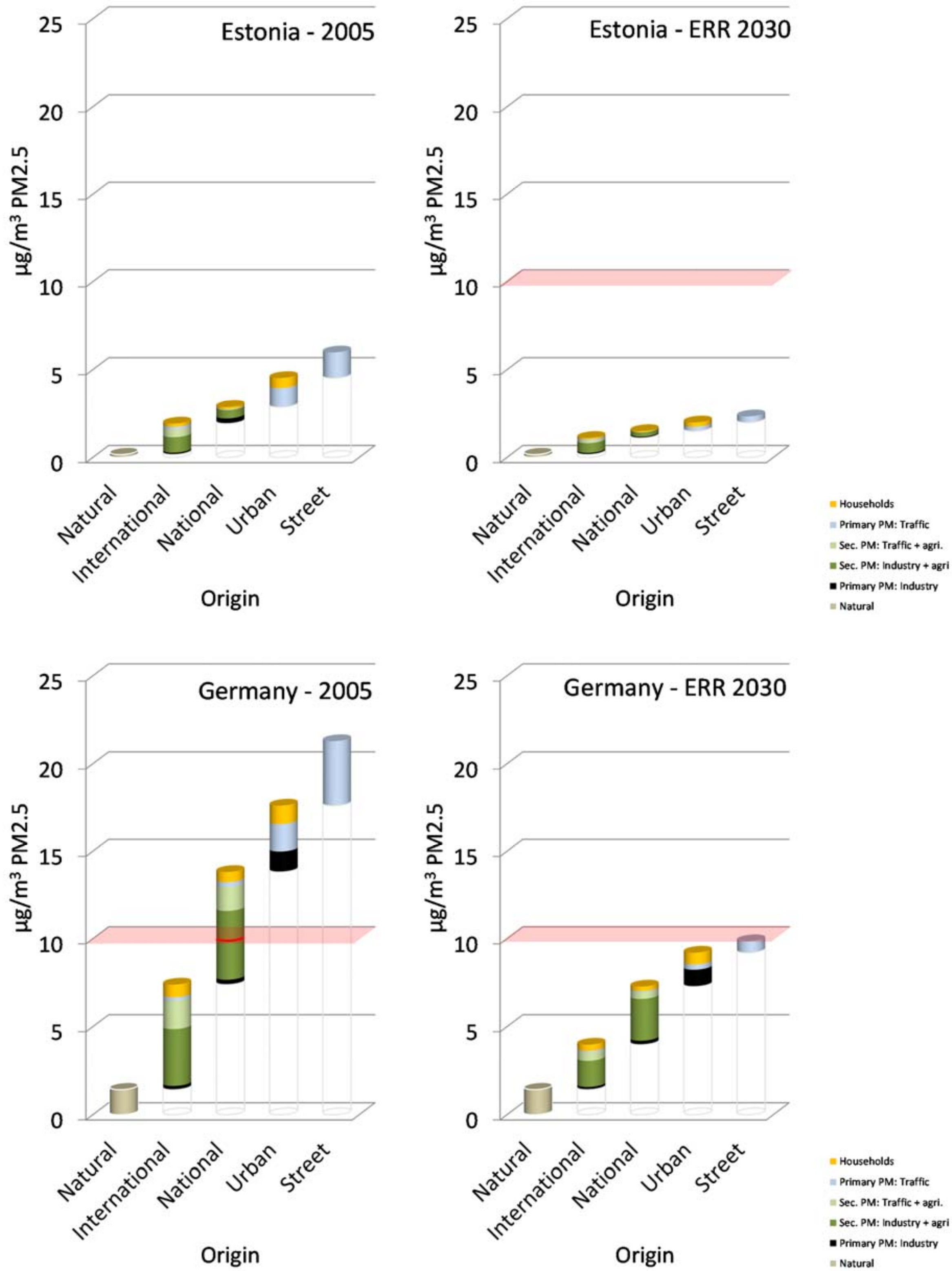
- **Households**
- **Primary PM: Traffic**
- **Sec. PM: Traffic + agri.**
- **Sec. PM: Industry + agri**
- **Primary PM: Industry**
- **Natural**

Furthermore, the graphs indicate the PM2.5 WHO guideline value of 10 µg/m^3.

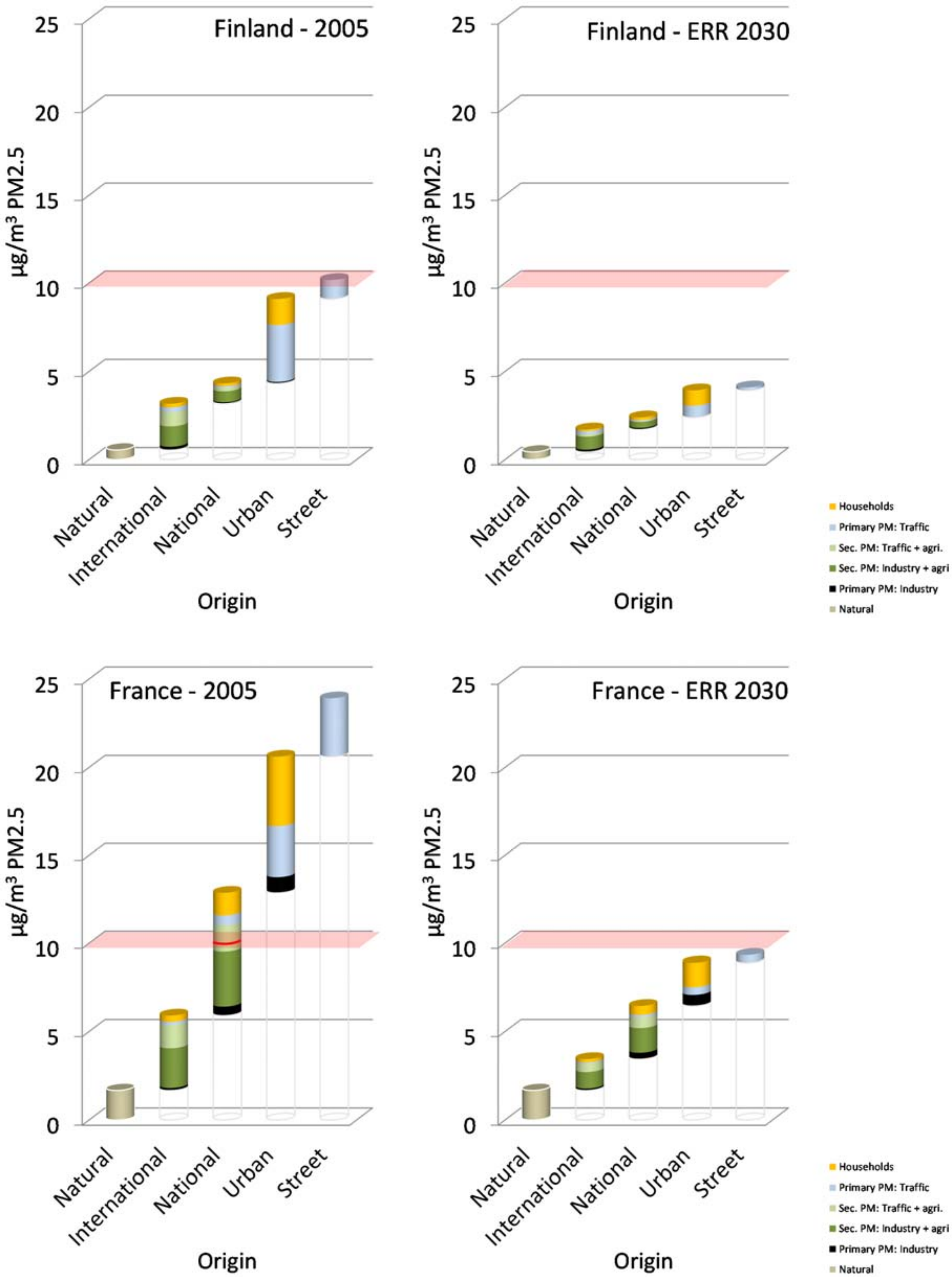
The presentations refer to the 2005 and the ERR 2030 scenario, i.e., the emission pattern that emerges from the achievement of the emission reduction requirements (ERR) laid out in the NEC Directive.

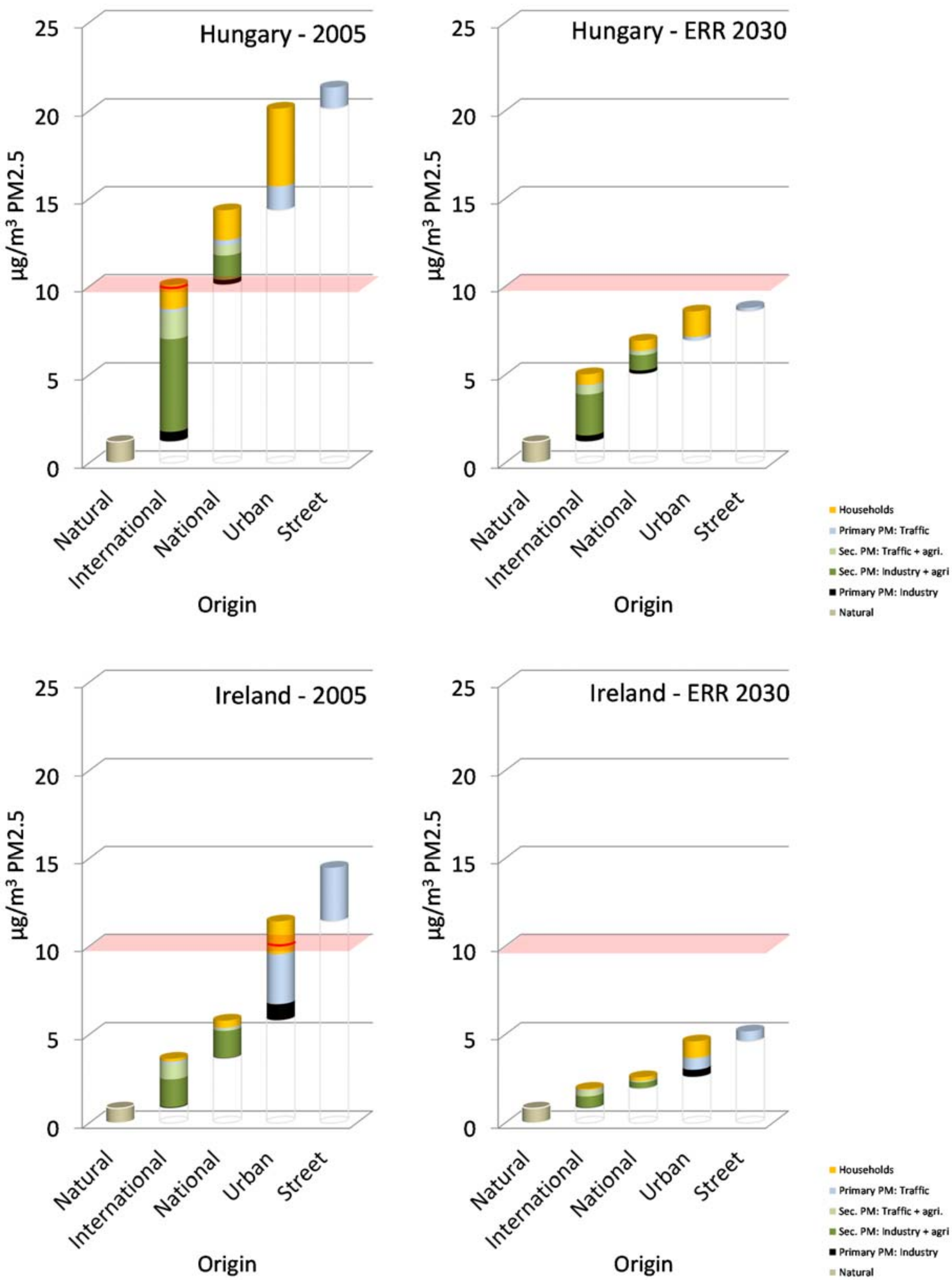

Austria - 2005
Austria - ERR 2030
Belgium - 2005
Belgium - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural


Bulgaria - 2005
Bulgaria - ERR 2030
Czech Rep. - 2005
Czech Rep. - ERR 2030
µg/m3 PM2.5
Origin
Natural
International
National
Urban
Street
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural

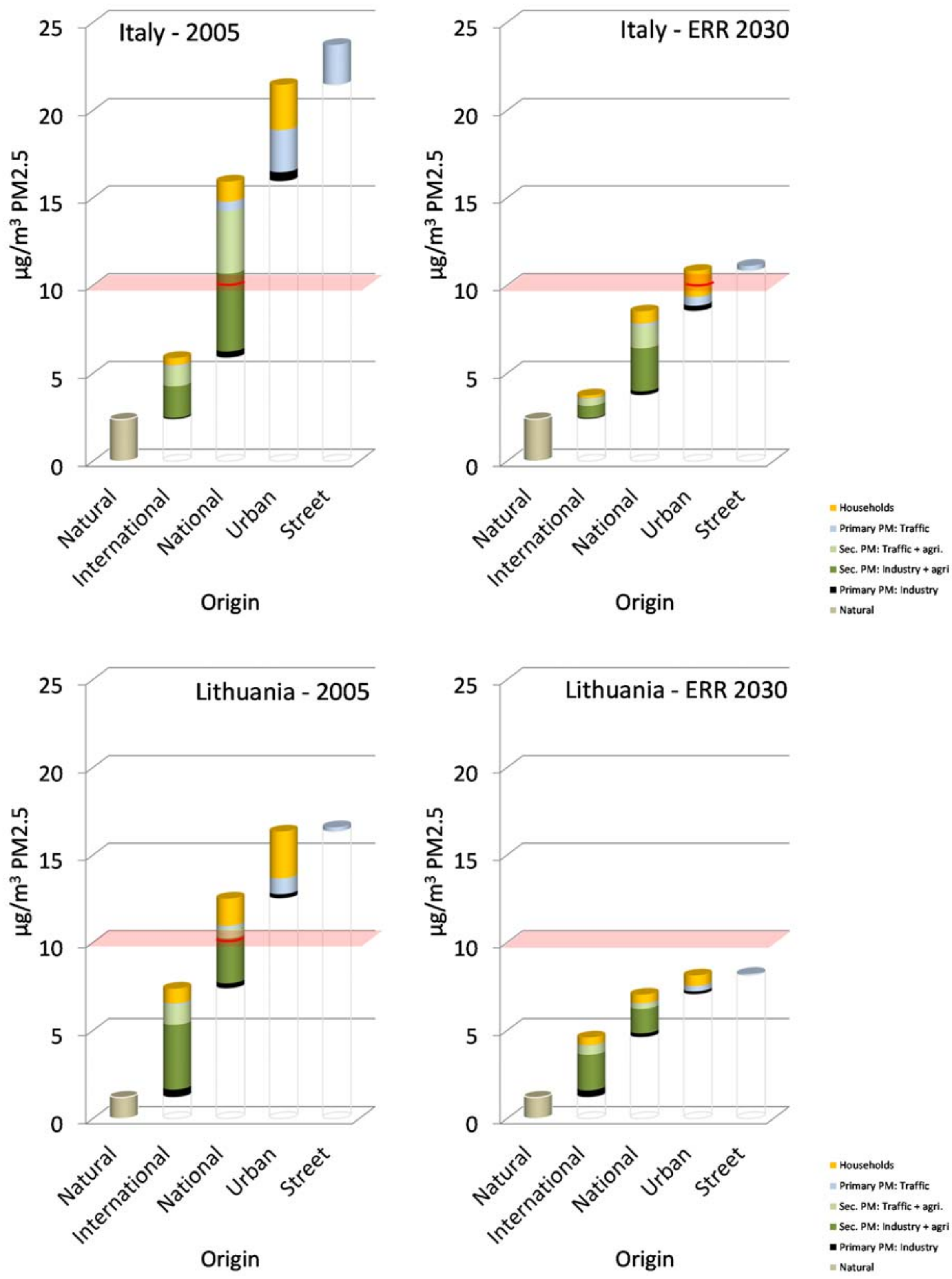


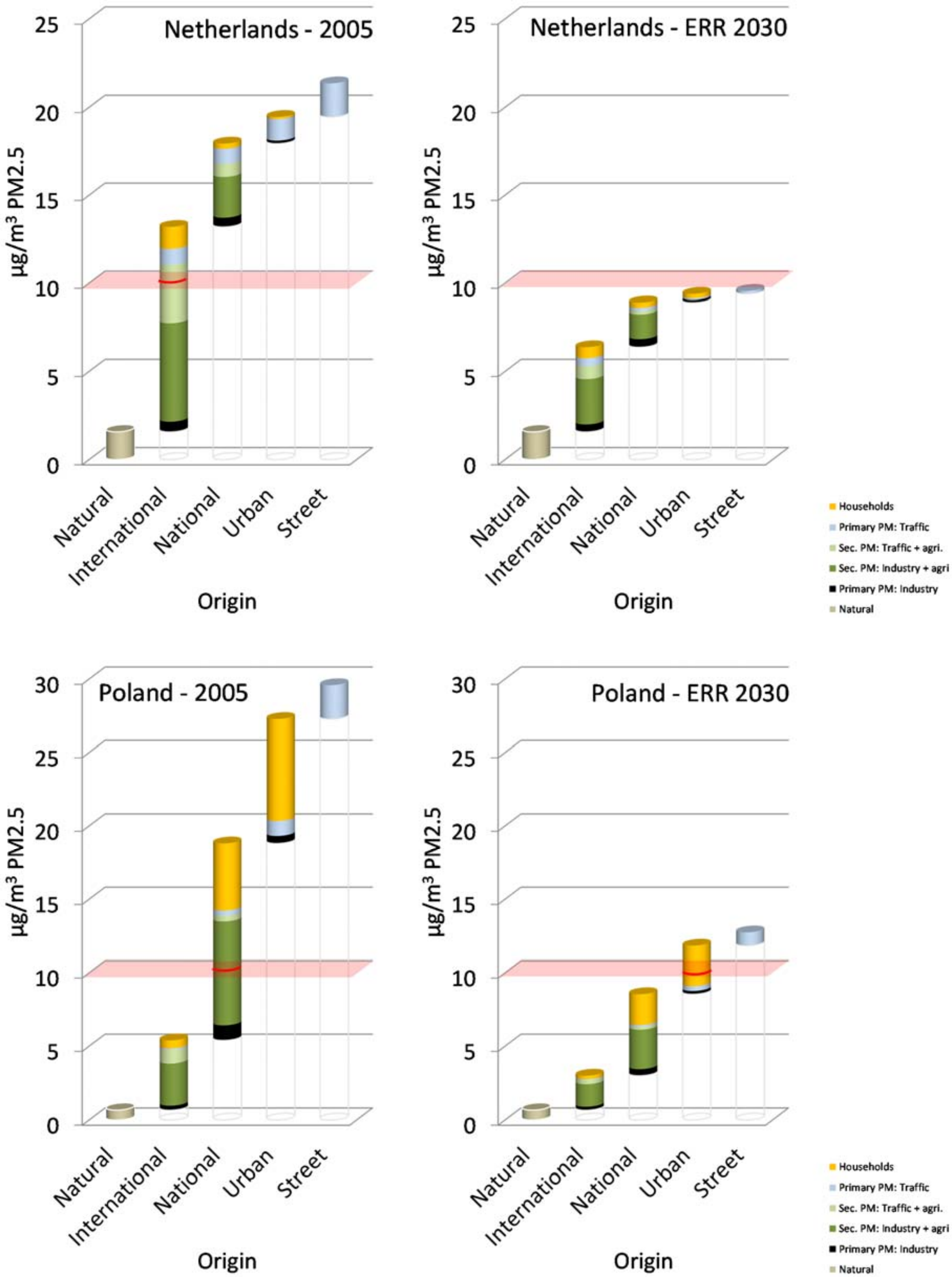
Estonia - 2005
Estonia - ERR 2030
Germany - 2005
Germany - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural


Finland - 2005
Finland - ERR 2030
France - 2005
France - ERR 2030
µg/m³ PM2.5
25
20
15
10
5
0
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural

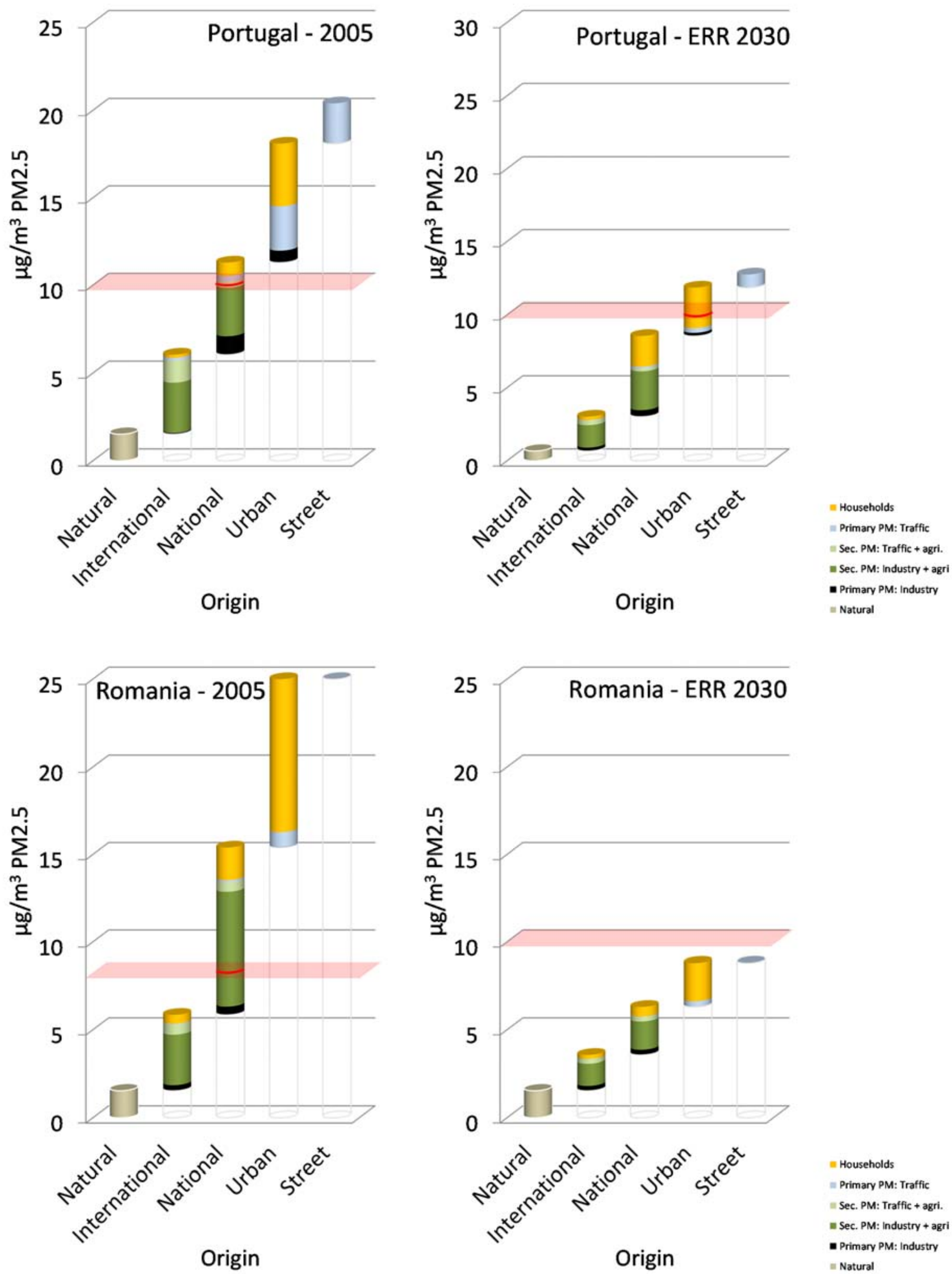


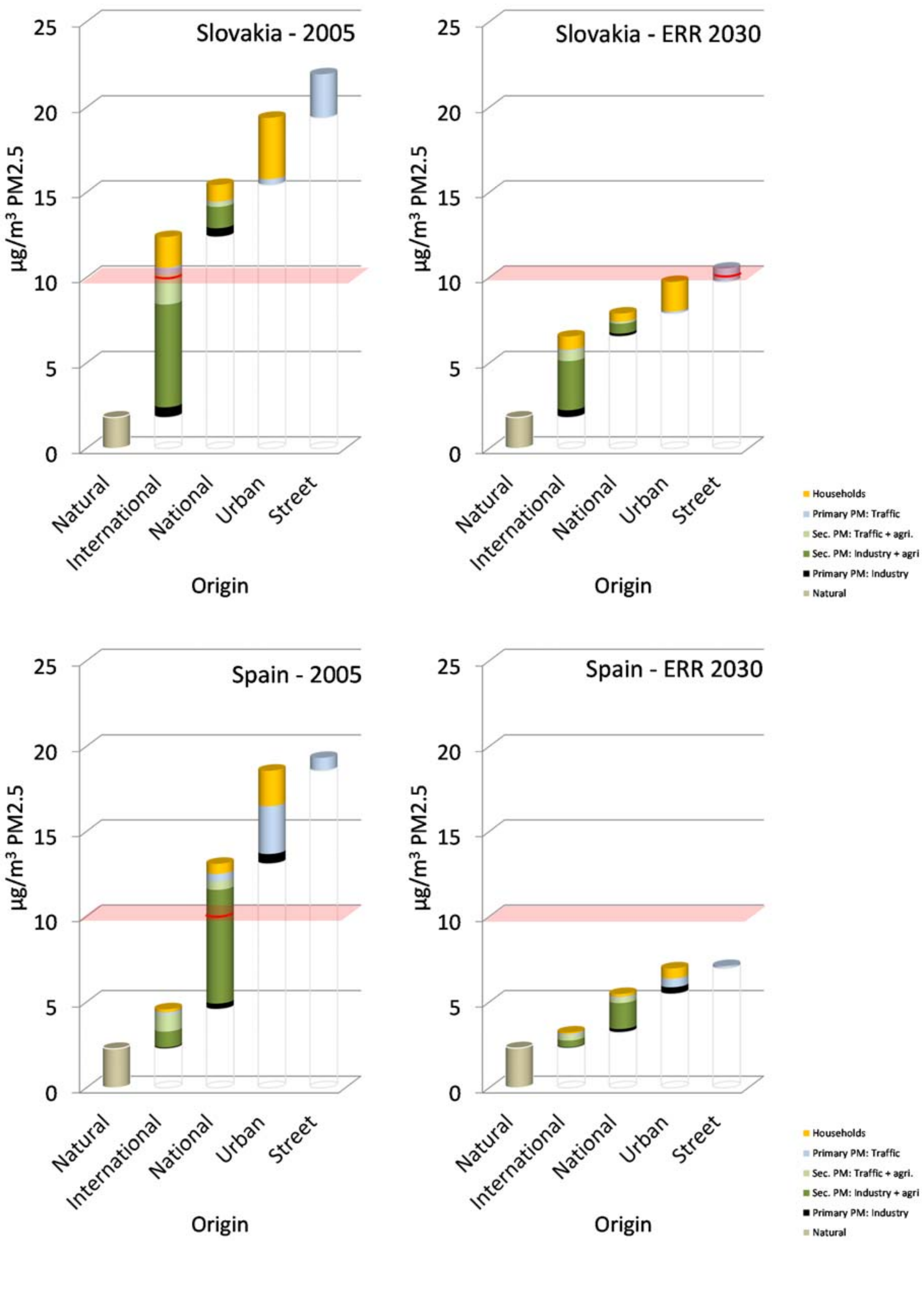
Hungary - 2005
Hungary - ERR 2030
Ireland - 2005
Ireland - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural

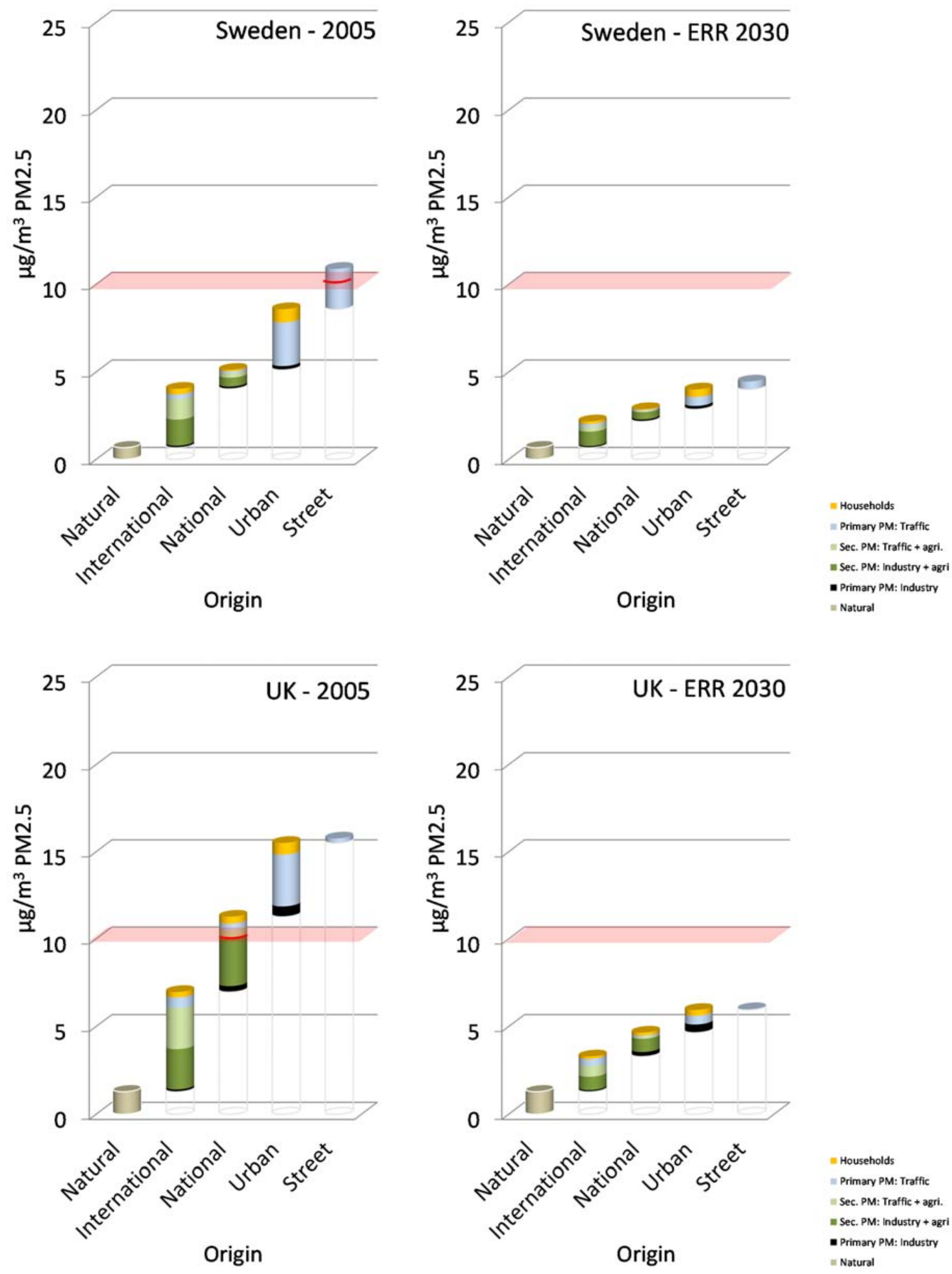

Italy - 2005
Italy - ERR 2030
Lithuania - 2005
Lithuania - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural



Netherlands - 2005
Netherlands - ERR 2030
Poland - 2005
Poland - ERR 2030
µg/m³ PM2.5
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural


Portugal - 2005
Portugal - ERR 2030
Romania - 2005
Romania - ERR 2030
µg/m³ PM2.5
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural


Slovakia - 2005
Slovakia - ERR 2030
Spain - 2005
Spain - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural


Sweden - 2005
Sweden - ERR 2030
UK - 2005
UK - ERR 2030
µg/m³ PM2.5
0
5
10
15
20
25
Natural
International
National
Urban
Street
Origin
Households
Primary PM: Traffic
Sec. PM: Traffic + agri.
Sec. PM: Industry + agri
Primary PM: Industry
Natural

Annex 2: Emissions assumed for the non-EU countries and international shipping

	SO_2		NO_x		PM2.5		NH_3		VOC	
	2005	2030	2005	2030	2005	2030	2005	2030	2005	2030
Albania	12	6	28	28	10	8	16	24	30	20
Belarus	82	64	199	148	61	65	91	117	229	153
Bosnia-H	223	35	58	29	23	16	16	24	40	27
FYR Maced.	117	33	33	21	14	9	8	7	19	17
R Moldova	7	2	31	19	15	14	15	16	33	26
Norway	33	32	198	101	35	21	23	24	201	99
Russia	1721	1512	2796	1767	722	652	510	481	2491	1562
Serbia	422	48	138	65	72	46	57	37	112	78
Montenegro	19	1	8	4	10	6	2	2	16	12
Kosovo	72	10	36	15	11	9	5	4	20	17
Switzerland	15	10	93	41	10	11	60	54	112	73
Turkey	1529	850	883	686	403	448	308	531	648	456
Ukraine	1164	521	895	576	411	354	253	291	610	342
Sum	**5416**	**3124**	**5396**	**3500**	**1798**	**1658**	**1365**	**1611**	**4562**	**2882**
Int. Shipping										