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Emissions of Air Pollutants for the World Energy Outlook 2011 Energy Scenarios

Final Report

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Glossary of terms used in this report

CLRTAP	UN/ECE Convention on Long-Range Transboundary Air Pollution
CO_2	Carbon dioxide
EC4MACS	European Consortium for Modeling Air Pollution and Climate Strategies
GAINS	Greenhouse gas - Air pollution INteractions and Synergies model
IEA	International Energy Agency
IIASA	International Institute for Applied Systems Analysis
IPCC	Intergovernmental Panel on Climate Change
NEC	National Emission Ceilings Directive
NO_x	Nitrogen oxides
PM2.5	Fine particles with an aerodynamic diameter of less than 2.5 µm
RAINS	Regional Air Pollution Information and Simulation model
OECD	Organisation for Economic Co-operation and Development
SNAP	Selected Nomenclature for Air Pollutants; Sector aggregation used in the CORINAIR emission inventory system
SO_2	Sulphur dioxide
UNEP	United Nations Environment Programme
WEM	World Energy Model
WHO	World Health Organization
YOLL	Years of life lost attributable to the PM2.5 exposure from anthropogenic sources

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Abstract

This report examines global emissions of major air pollutants (SO_2, NO_x, PM2.5) resulting from energy scenarios developed for the World Energy Outlook 2011 (OECD/IEA, 2011). Estimates include emissions for 25 regions according to the aggregation used in the IEA World Energy Model (WEM). Emissions have been estimated using the IIASA GAINS model.

The 2011 Outlook discusses three energy pathways for the next 25 years. The New Policies Scenario provides a benchmark to assess achievements and limitations of recent developments of climate and energy policies. It incorporates policy commitments and plans that have been announced by countries around the world to tackle energy insecurity, climate change and local air pollution. These commitments include, inter alia, national pledges to reduce greenhouse-gas emissions communicated officially under the Cancun Agreements and the initiatives taken by G-20 and APEC countries to phase-out fossil-fuel subsidies. The Current Policies Scenario provides a baseline picture of how global energy markets could develop were government policies to remain as they are now. The 450 Scenario sets out an energy pathway consistent with limiting climate change to an increase in average temperature to two degrees Celsius (2 ^{o}C). These pathways were implemented into the GAINS model. Next, emissions of air pollutants were calculated. Calculations take into account the current air pollution control legislation and policies in each country or region as adopted or in the pipeline by mid-2011. Presented in this report estimates do not include emissions from international shipping as well as cruising emissions from aviation. They also do not include emissions from biomass burning (deforestation, savannah burning, and vegetation fires).

In 2009, world emissions of SO_2 from sources covered in this report were about 91 million tons. OECD countries contributed 23 percent of this total. Implementation of pollution controls for the Current Policies Scenario causes an eight percent decrease in world emissions of SO_2 in 2020 compared with 2009. This is a combined result of reducing emissions from OECD countries (by about 30 percent), increase in India, and a decrease in China, Russia, South Africa, and Middle East. After 2020, emissions from many non-OECD countries continue rising, which causes an increase of world emissions by about three million tons until 2035. Particularly remarkable is the increase in SO_2 emissions in India. The corresponding world emissions of NO_x are 82 million tons in 2009 (of which 38 percent originated from the OECD countries), nine percent decrease until 2020 and next increase until 2035 by about 12 million tons. Emissions of PM2.5 (41 million tons in 2009) are dominated by the sources from non-OECD countries – 90 percent of total. Changes in the world emissions until 2035 are rather small, with a 10 percent decrease in the OECD countries and stabilization in the developing world.

The 450 Scenario causes an important reduction in emissions of air pollutants. In 2035, the emissions of SO_2 are nearly 40 percent lower than in the Current Policies case. Emissions of NO_x decrease by 31 percent and those of PM2.5 by nine percent compared with the emissions estimated for the Current Policies scenario. Emissions for the “New Policies” scenario lie between those for the Current Policies and the 450 scenarios.

Costs of air pollution control in 2009 are estimated at more than 200 billion €/a[1]. Until 2035, these costs increase in the Current Policies Scenario by more than a factor of two, which is due to higher activity levels and increasing stringency of controls. In 2035, 60 percent of the total costs are the expenditures on reducing emissions from road transport. The 450 Scenario brings 30 percent cost savings in 2035 compared with the Current Policies case.

The Study also estimated health impacts of air pollution in Europe, China and India in terms of life years lost (YOLL) attributable to the exposure from anthropogenic emissions of PM2.5. PM concentrations as in 2009 cause a loss of about 2.2 billion life-years[2]. This estimate is dominated by impacts in China and India. The Current Policies Scenario implies an increase of the YOLL indicator in 2035 by about 70 percent to 3.2 billion. Decrease of PM concentrations as in the 450 Scenario in 2035 saves about 870 million life-years.

Lower impact indicators and lower air pollution control costs in the scenarios with more active climate policies, and in particular in the 450 Scenario, clearly demonstrate important co-benefits of climate measures for air pollution.

[1] All costs are calculated in € 2005 using international prices of pollution control equipment and four percent real interest rate.

[2] The estimates do not include exposure to indoor air pollution.

1 Introduction

This report describes the work executed by IIASA based on a contract with the International Energy Agency (IEA) to provide a set of emission trends that correspond to the World Energy Model analysis developed by the IEA for the World Energy Outlook 2011 (OECD/IEA, 2011). IIASA calculated emissions of major air pollutants: SO_2, NO_x, and PM2.5 for three energy scenarios, namely:

- The Current Policies Scenario
- The New Policies Scenario and
- The 450 Scenario.

A short characterization of these scenarios is included in section 2. The analysis employs as an analytical tool the IIASA GAINS model. Methodology for air pollution calculations within GAINS is described in Amann, 2004, and Amann *et al.*, 2011. Estimates include emissions for 25 regions according to the aggregation used in the IEA World Energy Model. The national assessment does not cover the emissions from international shipping as well as cruising emissions from aviation. Also emissions from biomass burning (deforestation, savannah burning, and vegetation fires) are not included in national totals.

The remainder of this report is organized as follows: Section 2 summarizes activity scenarios included in the analysis. It also explains assumptions about emission control legislation for individual countries/country groups. Section 3 presents emission projections by country group, economic sector and by fuel. In Section 4, emission control costs are shown. Section 5 discusses health impacts of the scenarios. Since the focus of this year’s Outlook is on Russia, Section 6 provides more details on changes in emissions of air pollutants from that country. Conclusions are drawn in Section 6.

2 Activity projections

The 2011 Outlook discusses three energy pathways for the next 25 years. The New Policies Scenario provides a benchmark to assess achievements and limitations of recent developments of climate and energy policies. It incorporates policy commitments and plans that have been announced by countries around the world to tackle energy insecurity, climate change and local air pollution. These commitments include, inter alia, national pledges to reduce greenhouse-gas emissions communicated officially under the Cancun Agreements and the initiatives taken by G-20 and APEC countries to phase-out fossil-fuel subsidies. The Current Policies Scenario provides a baseline picture of how global energy markets could develop under an assumption that only policies and measures as enacted or adopted by mid-2011 were implemented. The 450 Scenario sets out an energy pathway consistent with limiting climate change to an increase in average temperature to two degrees Celsius (2 ^{o}C). Details about policies adopted in each of the scenarios can be found in the WEO 2011 Report (OECD/IEA (2011).

All three scenarios were developed with the World Energy Model (WEM) and include 25 world regions. Regions are either individual countries or groups of countries with similar policies and emission characteristics. Countries that are major energy consumers (and CO_2 emitters) are treated on an individual basis. Coverage of each region is explained in Appendix 1. Details on energy consumption structure up to 2035 for the scenarios, together with major macroeconomic characteristics (population, GDP and value added by main economic sector), have been provided to IIASA by the IEA. Next, they have been implemented into GAINS using a special interface routine. Missing information has been completed based on scenarios already available in GAINS. In particular, this included development of national energy scenarios for countries that are aggregated into a country group within the WEM, derivation of sector-specific data for transport (vehicle-kilometres, vehicle numbers) and estimation of activities causing process emissions (production of energy-intensive products, agricultural activities, storage and handling of materials, waste treatment, etc.). Projections of activities for process sector have been developed in collaboration with national experts. They remain the same for all three scenarios. This means, that for all countries no changes in production structure of energy-intensive commodities and no shift from OECD countries to the developing world was assumed.

Compared with the assessment for the WEO 2010, the GAINS pattern scenarios, i.e., scenarios used for downscaling to the WEO 2011 energy consumption structures, have been updated. Most important updates depended on: (i) different distribution of fuels among sectors and regions in China; (ii) new projections of development of the transport sector in many countries (structure of road vehicles, assumptions about mileage and fuel economy); (iii) improvement of the coverage of the process sector (new projections of production of products causing process emissions); (iv) revised assumptions about the shares of renewable waste fuels in total biomass used in industry. Updates were done in collaboration with national modelling teams and independent experts collaborating with the IIASA's Mitigation of Air Pollution and Greenhouse Gases (MAG) Program. These updates caused changes in emission and control cost estimates compared with previous assessments.

3 Emission projections

3.1 Assumptions about emission control policies

Calculation of emissions of air pollutants has been performed assuming in each country the current air pollution control policies, i.e., policies that were in force or in the final stage of legislative process as of mid-2011. In particular, for Europe all emission limit values and fuel quality standards have been included, as used in the analysis for the revision of the Gothenburg Protocol to the UN Convention of Long-Range Transboundary Air Pollution (CLRTAP) – compare Amann *et al.*, 2011 For other countries policies have been assessed based on available literature (compare Cofala *et al.*, 2007) and more recent studies (Klimont et al., 2009, Xing et al., 2010). Assumptions about emission controls in the power plant sector have been cross-checked with detailed information from the database on world coal fired power plants (IEA CCC, 2010).

Controlling emissions from mobile sources is essential for air pollution abatement. For Europe, assumptions about emission factors, as well as about timing and penetration of control measures are based on the results of the COPERT 4 model[3]. For other countries information from DieselNet, 2010 and national sources was used. The update of emission factors for diesel cars and trucks takes into account emissions in real operating conditions, which for some vehicle types importantly differ from emission factors derived from test cycles.

IIASA continued its work on the updates of emission estimates for historic years. These updates took place in connection with the review organized for the revision of the Gothenburg Protocol and the revision of the EU National Emission Ceilings Directive[4] (NEC). For other countries, emission factors and control legislation were updated based on literature sources and submissions of national experts who collaborate with IIASA. Updates were also done in result of IIASA's participation in the development of the database on the IPCC Representative Concentration Pathways[5], as well as work on global black and organic carbon assessment for the UNEP. For Europe, IIASA updated the modelling framework within the LIFE EC4MACS Project (Amann et al., 2010). Also new assumptions on adoption of emission limit values for large combustion plants and limits of sulphur content in liquid fuels were adopted for countries that have joined the European Energy Community[6].

Countries - members of the CLRTAP submit annually emission inventories to the Convention authorities. They also revise historic data on a regular basis. Newer submissions for historic years differ in some cases from the old ones even by five to ten percent. This is the reason why historic emissions for some countries differ from the WEO 2010 assessment.

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[3] http://lat.eng.auth.gr/copert/files/COPERT4_v7_1.pdf

[4] http://gains.iiasa.ac.at/index.php/policyapplications/gothenburg-protocol-revision

[5] http://www.iiasa.ac.at/web-apps/tnt/RcpDb/dsd?Action=htmlpage&page=welcome

[6] http://www.energy-community.org/portal/page/portal/ENC_HOME

3.2 Current Policies Scenario

Emissions of SO_2, NO_x and PM2.5 by country group up to 2035 for the Current Policies Scenario are presented in Table 3.1 to Table 3.3. Emissions by SNAP sector, separated by OECD and non-OECD countries, can be found in Table 3.4 to Table 3.6. Values for 2009 have been derived through interpolation.

In 2009, world emissions of SO_2 were about 91 million tons. OECD countries contributed 23 percent to this total. Dominating sources are power plants and industrial emissions. Implementation of air pollution controls and structural changes in energy consumption patterns as in the Current Policies Scenario causes an eight percent decrease in world emissions of SO_2 emissions in 2020 compared with 2009. This is a combined effect of the decrease of emissions from both: the OECD region (minus 31 percent and from the rest of the world (minus one percent). The decrease of emissions in non-OECD countries in the period 2009 – 2020 will occur under a condition of successful enforcement of control measures according to the “current legislation” assumptions, first of all in China. It is characteristic that in India, where strict emission limit values for sulphur from large combustion plants are missing, the emissions increase in the same period by more than four million tons. After 2020 the emissions from the OECD countries further decrease, whereas emissions from non-OECD countries increase and are in 2035 four million tons higher. This is mainly due to higher coal consumption in poorly controlled power plants in India and other developing countries, mainly from Southeast Asia.

According to the GAINS assessment, world emissions of NO_x were about 82 million tons in 2009, of which 38 percent originated from the OECD countries. Road transport was responsible for about 30 percent of NO_x emissions. Until 2020, the emissions decrease by nine percent, which is due to 36 percent decrease of emissions form the OECD countries and an eight percent increase from the rest of the world. It needs to be stressed that majority of non-OECD countries are currently implementing emission standards on road transport sources, which importantly slows down the pace of increase of NO_x emissions. After 2020 the world emissions increase, and are about 11 million tons higher in 2035 than in 2020.

Emissions of PM2.5 (41 million tons in 2009) are dominated by the sources from non-OECD countries – 90 percent of total. On a global scale, the highest contributors are residential and commercial combustion (44 percent) and industrial emissions (29 percent). In 2020 and 2035, the world emissions become slightly (by about one percent) lower. This decrease - in spite of a high increase in total energy consumption - is due to the changes in fuel use patterns and better controls on sources in the power sector, industry, and road transport.

Table 3.7 to Table 3.9 demonstrate emissions by country group and by fuel. Coal was responsible for about 58 percent of world emissions of SO_2 in 2009. Other important contributors were oil use and the process (other sources) sector – about 20 percent each. Whereas in the OECD countries the emissions from coal decrease due to stringent emission limit values, the coal-related SO_2 emissions for the non-OECD countries increase up to 2035 by more than six million tons. In case of NO_x, oil contributed 50 percent to world emissions in 2009, followed by coal (23 percent) and gas (12 percent). In the projection period, the emissions from oil decrease, mainly due to better controls on transport sources. Emissions from other fuels, in particular from coal, increase. PM2.5 emissions are dominated by biomass fuels and process sources. Each sector contributed about 40 percent of world emissions in 2009. In the projection period the emissions from coal increase, which is balanced by a decrease of emissions from other sources.

Table 3.1: Emissions of SO_2 by country group[7] in the Current Policies Scenario, thousand tons/year

WEM region	2005	2009	2010	2015	2020	2025	2030	2035
US	13,810	8,792	7,537	5,498	4,428	3,874	3,754	3,684
Canada	2,188	1,832	1,743	1,550	1,525	1,520	1,511	1,509
Mexico	1,657	971	799	515	502	457	431	410
Chile	534	607	625	730	775	822	847	859
Japan	755	598	559	532	508	499	496	489
Korea	558	549	547	526	520	512	503	491
AUNZ	1,441	1,394	1,382	1,374	1,381	1,398	1,421	1,387
OE5	2,031	1,932	1,907	2,080	2,121	2,209	2,343	2,378
EUG4	2,035	1,389	1,228	1,099	983	878	866	816
EU17	4,194	2,602	2,203	1,732	1,437	1,368	1,317	1,278
EU6	1,825	1,261	1,121	386	265	238	220	214
OETE	2,018	2,252	2,310	2,217	1,431	1,381	1,530	1,602
Russia	6,268	6,019	5,956	5,031	4,317	4,488	4,679	4,858
Caspian	2,427	2,668	2,729	2,897	3,096	3,204	3,286	3,355
China	30,407	33,161	33,849	34,640	33,272	30,253	27,685	28,884
India	5,765	7,502	7,937	9,755	11,939	13,547	15,559	17,779
Indonesia	1,079	989	966	899	970	1,050	1,147	1,260
ASEAN9	1,711	1,474	1,415	1,383	1,548	1,719	1,953	2,186
ODA	1,867	1,999	2,032	2,131	2,545	2,915	3,370	3,545
Brazil	1,069	1,099	1,106	1,181	1,246	1,330	1,402	1,429
OLAM	1,783	1,832	1,844	1,688	1,510	1,590	1,647	1,689
NAFR	1,309	1,149	1,109	968	857	802	818	857
South Africa	2,122	2,017	1,991	1,644	1,378	1,263	1,161	1,165
OAFR	1,713	2,063	2,151	1,733	1,576	1,592	1,599	1,634
ME	4,722	4,906	4,952	4,529	3,957	3,493	3,480	3,573
OECD	29,201	20,665	18,531	15,635	14,181	13,538	13,489	13,302
Non-OECD	66,086	70,392	71,468	71,081	69,907	68,866	69,536	74,028
World	95,287	91,057	90,000	86,716	84,088	82,404	83,025	87,330

[7] Aggregation of countries to the WEO 2010 groups is explained in Appendix 1

Table 3.2: Emissions of NO_x by country group in the Current Policies Scenario, thousand tons/year

WEM region	2005	2009	2010	2015	2020	2025	2030	2035
US	17,549	13,750	12,801	9,631	7,765	6,768	6,433	6,379
Canada	1,590	1,312	1,242	1,066	959	913	932	957
Mexico	1,406	1,288	1,258	1,134	1,086	1,125	1,194	1,240
Chile	318	374	388	427	456	496	539	578
Japan	2,296	1,801	1,678	1,328	1,059	907	860	842
Korea	1,189	1,170	1,166	1,090	988	920	861	831
AUNZ	1,316	1,216	1,191	1,059	979	967	975	962
OE5	1,359	1,359	1,359	1,283	1,254	1,254	1,320	1,346
EUG4	5,458	4,481	4,237	3,438	2,661	2,374	2,266	2,273
EU17	5,149	4,132	3,878	3,216	2,562	2,242	2,088	2,102
EU6	615	473	438	354	288	251	228	227
OETE	1,428	1,307	1,277	1,143	1,009	988	1,047	1,084
Russia	5,047	4,797	4,734	4,187	3,718	3,416	3,454	3,636
Caspian	1,119	1,221	1,247	1,341	1,501	1,632	1,792	1,955
China	15,023	18,680	19,595	21,085	21,475	21,896	22,929	24,444
India	4,227	5,203	5,447	5,477	6,686	8,022	9,808	12,265
Indonesia	1,383	1,506	1,537	1,597	1,628	1,735	1,894	2,054
ASEAN9	2,508	2,408	2,383	2,526	2,677	2,922	3,315	3,722
ODA	1,839	1,781	1,766	2,003	2,205	2,376	2,636	2,910
Brazil	2,158	2,252	2,276	2,355	2,392	2,422	2,613	2,746
OLAM	2,851	2,841	2,839	2,865	2,630	2,739	2,957	3,106
NAFR	1,444	1,516	1,534	1,538	1,585	1,644	1,760	1,826
South Africa	1,247	1,264	1,268	1,191	1,099	1,114	1,152	1,193
OAFR	1,749	1,829	1,848	1,967	2,000	2,078	2,136	2,227
ME	4,034	4,012	4,007	4,055	4,252	4,669	5,198	5,502
OECD	37,628	30,883	29,197	23,672	19,768	17,967	17,470	17,510
Non-OECD	46,673	51,090	52,195	53,685	55,144	57,903	62,921	68,898
World	84,301	81,974	81,392	77,357	74,912	75,870	80,390	86,408

Table 3.3: Emissions of PM2.5 by country group in the Current Policies Scenario, thousand tons/year

WEM region	2005	2009	2010	2015	2020	2025	2030	2035
US	1,150	982	939	864	808	768	759	786
Canada	171	152	148	137	129	123	122	124
Mexico	474	435	426	404	405	412	422	429
Chile	156	163	165	172	177	180	186	192
Japan	216	185	177	164	152	146	143	141
Korea	176	180	181	180	178	175	173	168
AUNZ	182	169	165	161	155	151	152	155
OE5	452	518	535	561	573	597	614	612
EUG4	646	571	552	494	463	443	447	456
EU17	704	621	601	543	511	494	495	525
EU6	236	200	192	185	182	176	169	171
OETE	590	552	542	549	520	536	606	617
Russia	1,332	1,301	1,293	1,340	1,327	1,338	1,361	1,387
Caspian	221	233	236	249	269	282	295	307
China	12,332	13,928	14,328	13,381	12,296	11,496	10,770	10,697
India	5,430	5,839	5,942	6,038	6,196	6,321	6,470	6,701
Indonesia	1,438	1,484	1,495	1,536	1,561	1,576	1,589	1,616
ASEAN9	1,826	1,844	1,849	1,905	1,937	1,934	1,948	2,004
ODA	2,174	2,217	2,228	2,406	2,547	2,714	2,849	2,894
Brazil	867	848	843	860	872	835	788	792
OLAM	1,089	1,075	1,072	1,079	1,064	1,056	1,067	1,073
NAFR	501	527	534	544	549	508	474	480
South Africa	382	432	444	448	447	436	425	421
OAFR	5,340	5,682	5,767	6,110	6,431	6,684	6,877	7,010
ME	692	718	725	764	776	724	685	704
OECD	4,327	3,976	3,889	3,681	3,551	3,488	3,513	3,588
Non-OECD	34,453	36,881	37,488	37,395	36,974	36,616	36,374	36,873
World	38,780	40,857	41,377	41,076	40,525	40,104	39,886	40,461

Table 3.4: Emissions of SO_2 by SNAP sector for the Current Policies Scenario, thousand tons/year

OECD

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	18,221	11,087	9,303	6,639	5,222	4,587	4,489	4,361
2: Domestic	1,381	1,250	1,217	1,139	1,084	1,029	972	951
3: Industrial combust.	4,040	3,390	3,227	3,268	3,268	3,296	3,322	3,292
4: Industrial processes	4,503	4,290	4,237	4,124	4,140	4,236	4,317	4,311
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	297	105	57	39	34	33	32	32
8: Off-road sources	707	491	437	374	381	306	304	303
9: Waste management	24	26	27	25	25	24	23	23
10: Agriculture	27	27	27	28	28	27	29	29
Sum	29,201	20,665	18,531	15,635	14,181	13,538	13,489	13,302

Non-OECD

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	37,974	38,965	39,213	38,737	38,212	36,882	37,202	41,565
2: Domestic	4,420	4,815	4,914	4,971	4,892	4,717	4,445	4,135
3: Industrial combust.	12,456	14,947	15,570	17,151	17,615	17,893	18,320	18,622
4: Industrial processes	8,913	9,804	10,026	8,452	7,381	7,490	7,561	7,560
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	885	499	402	337	325	376	443	512
8: Off-road sources	987	947	937	1,020	1,065	1,091	1,146	1,215
9: Waste management	322	278	267	268	265	260	253	253
10: Agriculture	130	136	138	145	151	158	165	165
Sum	66,086	70,392	71,468	71,081	69,907	68,866	69,536	74,028

World

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	56,194	50,052	48,516	45,376	43,434	41,468	41,691	45,926
2: Domestic	5,801	6,064	6,130	6,110	5,976	5,746	5,417	5,086
3: Industrial combust.	16,496	18,337	18,797	20,419	20,883	21,189	21,643	21,914
4: Industrial processes	13,416	14,094	14,263	12,575	11,521	11,726	11,878	11,871
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	1,182	604	459	376	359	409	476	545
8: Off-road sources	1,694	1,438	1,374	1,394	1,447	1,397	1,450	1,518
9: Waste management	346	304	294	293	290	283	276	276
10: Agriculture	157	163	165	173	179	185	194	194
Sum	95,287	91,057	90,000	86,716	84,088	82,404	83,025	87,330

Table 3.5: Emissions of NO_x by SNAP sector for the Current Policies Scenario, thousand tons/year

OECD

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	9,813	7,742	7,224	5,755	4,840	4,592	4,524	4,517
2: Domestic	2,010	1,949	1,934	1,921	1,948	1,974	2,009	2,052
3: Industrial combust.	4,335	4,157	4,112	4,234	4,265	4,336	4,400	4,400
4: Industrial processes	1,043	999	988	968	959	943	922	922
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	14,903	11,078	10,122	6,378	3,900	2,809	2,602	2,647
8: Off-road sources	5,421	4,852	4,709	4,313	3,756	3,214	2,912	2,871
9: Waste management	41	42	42	40	38	36	35	35
10: Agriculture	64	64	64	64	63	61	65	65
Sum	37,628	30,883	29,197	23,672	19,768	17,967	17,470	17,510

Non-OECD

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	12,683	14,109	14,465	15,501	16,994	18,369	20,429	23,138
2: Domestic	2,980	3,184	3,235	3,341	3,403	3,436	3,439	3,435
3: Industrial combust.	8,602	10,810	11,362	12,463	13,003	13,471	13,961	14,205
4: Industrial processes	1,163	1,179	1,183	1,262	1,331	1,393	1,449	1,448
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	13,543	13,381	13,340	12,139	11,310	11,654	13,069	14,831
8: Off-road sources	7,136	7,892	8,081	8,433	8,548	9,019	10,002	11,270
9: Waste management	366	324	313	315	313	307	300	300
10: Agriculture	199	212	215	230	242	255	272	272
Sum	46,673	51,090	52,195	53,685	55,144	57,903	62,921	68,898

World

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	22,496	21,851	21,689	21,256	21,834	22,962	24,953	27,655
2: Domestic	4,990	5,134	5,169	5,262	5,351	5,410	5,448	5,487
3: Industrial combust.	12,937	14,967	15,475	16,697	17,268	17,807	18,361	18,605
4: Industrial processes	2,206	2,178	2,172	2,229	2,290	2,335	2,372	2,370
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	28,446	24,459	23,462	18,517	15,210	14,463	15,672	17,478
8: Off-road sources	12,557	12,744	12,790	12,746	12,303	12,233	12,914	14,141
9: Waste management	407	366	356	355	351	344	335	335
10: Agriculture	263	275	279	294	306	317	337	337
Sum	84,301	81,974	81,392	77,357	74,912	75,870	80,390	86,408

Table 3.6: Emissions of PM2.5 by SNAP sector for the Current Policies Scenario, thousand tons/year

OECD

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	311	235	217	222	227	234	241	238
2: Domestic	1,178	1,202	1,208	1,178	1,162	1,149	1,155	1,223
3: Industrial combust.	386	337	324	328	324	336	345	358
4: Industrial processes	566	520	508	510	524	537	546	541
5: Fuel extraction	40	39	39	40	39	40	39	38
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	629	479	442	302	232	208	210	211
8: Off-road sources	442	384	369	317	265	219	199	199
9: Waste management	325	330	331	329	326	322	316	316
10: Agriculture	450	451	452	454	453	444	463	463
Sum	4,327	3,976	3,889	3,681	3,551	3,488	3,513	3,588

Non-OECD

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	2,041	2,401	2,491	2,837	3,236	3,528	3,909	4,446
2: Domestic	16,014	16,889	17,108	17,163	16,878	16,469	15,917	15,616
3: Industrial combust.	6,278	6,822	6,958	6,462	5,997	5,708	5,447	5,511
4: Industrial processes	3,431	3,972	4,108	4,079	3,994	3,888	3,816	3,816
5: Fuel extraction	70	95	101	126	141	156	168	168
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	888	844	833	694	600	615	693	784
8: Off-road sources	670	709	719	705	674	701	783	893
9: Waste management	2,123	2,108	2,104	2,141	2,157	2,145	2,124	2,124
10: Agriculture	2,937	3,040	3,066	3,188	3,297	3,407	3,516	3,516
Sum	34,453	36,881	37,488	37,395	36,974	36,616	36,374	36,873

World

SNAP sector	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
1: Power generation	2,352	2,637	2,708	3,059	3,463	3,762	4,150	4,684
2: Domestic	17,192	18,091	18,316	18,341	18,040	17,618	17,071	16,839
3: Industrial combust.	6,665	7,159	7,283	6,790	6,321	6,044	5,793	5,869
4: Industrial processes	3,997	4,492	4,616	4,589	4,518	4,425	4,362	4,357
5: Fuel extraction	110	134	140	166	180	196	207	206
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	1,517	1,323	1,275	996	832	822	903	995
8: Off-road sources	1,112	1,092	1,088	1,023	939	920	981	1,092
9: Waste management	2,448	2,437	2,435	2,470	2,482	2,467	2,440	2,440
10: Agriculture	3,387	3,491	3,517	3,643	3,750	3,850	3,979	3,979
Sum	38,780	40,857	41,377	41,076	40,525	40,104	39,886	40,461

Table 3.7: Emissions of SO_2 by fuel for the Current Policies Scenario, thousand tons/year

OECD

Fuel	2005	2009	2010	2015	2020	2025	2030	2035
Coal	17,291	11,256	9,748	7,456	6,073	5,433	5,265	5,087
Oil	6,476	4,244	3,685	3,120	2,966	2,790	2,737	2,682
Gas	34	37	38	40	41	42	44	46
Biomass	332	328	327	384	432	479	537	577
Other sources	5,068	4,800	4,733	4,636	4,668	4,795	4,907	4,911
Total	29,201	20,665	18,531	15,635	14,181	13,538	13,489	13,302

Non-OECD

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	38,906	41,632	42,314	44,038	44,381	43,422	43,527	47,648
Oil	13,239	13,427	13,474	12,920	12,445	12,015	12,059	12,322
Gas	180	219	229	290	355	415	490	568
Biomass	1,772	1,819	1,831	1,906	1,991	2,149	2,401	2,431
Other sources	11,989	13,294	13,621	11,926	10,735	10,865	11,060	11,059
Total	66,086	70,392	71,468	71,081	69,907	68,866	69,536	74,028

World

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	56,197	52,889	52,062	51,493	50,454	48,856	48,792	52,734
Oil	19,715	17,670	17,159	16,040	15,411	14,805	14,795	15,003
Gas	214	256	267	331	397	456	534	614
Biomass	2,104	2,147	2,158	2,290	2,423	2,628	2,937	3,008
Other sources	17,057	18,094	18,353	16,562	15,403	15,660	15,966	15,970
Total	95,287	91,057	90,000	86,716	84,088	82,404	83,025	87,330

Table 3.8: Emissions of NO_x by fuel for the Current Policies Scenario, thousand tons/year

OECD

Fuel	2005	2009	2010	2015	2020	2025	2030	2035
Coal	7,004	5,214	4,767	3,705	2,958	2,774	2,639	2,496
Oil	22,327	17,555	16,362	12,097	8,955	7,224	6,653	6,589
Gas	4,956	4,916	4,906	4,610	4,477	4,445	4,502	4,629
Biomass	773	792	797	888	966	1,054	1,142	1,241
Other sources	2,568	2,406	2,366	2,372	2,412	2,469	2,534	2,556
Total	37,628	30,883	29,197	23,672	19,768	17,967	17,470	17,510

Non-OECD

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	11,284	13,909	14,566	16,550	18,287	19,588	21,247	23,471
Oil	22,692	23,277	23,424	22,618	21,895	22,646	24,961	27,967
Gas	4,517	4,581	4,596	4,562	4,726	5,004	5,547	6,194
Biomass	2,374	2,524	2,562	2,716	2,856	2,962	3,063	3,166
Other sources	5,806	6,799	7,047	7,239	7,379	7,703	8,101	8,100
Total	46,673	51,090	52,195	53,685	55,144	57,903	62,921	68,898

World

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	18,288	19,123	19,332	20,255	21,246	22,363	23,886	25,967
Oil	45,019	40,832	39,786	34,715	30,851	29,870	31,614	34,556
Gas	9,473	9,497	9,503	9,172	9,203	9,449	10,050	10,822
Biomass	3,147	3,317	3,359	3,604	3,822	4,016	4,205	4,407
Other sources	8,374	9,205	9,412	9,610	9,790	10,172	10,635	10,655
Total	84,301	81,974	81,392	77,357	74,912	75,870	80,390	86,408

Table 3.9: Emissions of PM2.5 by fuel for the Current Policies Scenario, thousand tons/year

OECD

Fuel	2005	2009	2010	2015	2020	2025	2030	2035
Coal	450	479	486	491	486	471	464	456
Oil	994	775	720	513	377	296	268	266
Gas	29	22	20	21	22	24	26	28
Biomass	1,062	987	968	949	947	955	973	1,048
Other sources	1,792	1,714	1,695	1,707	1,720	1,741	1,782	1,789
Total	4,327	3,976	3,889	3,681	3,551	3,488	3,513	3,588

Non-OECD

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	4,239	5,063	5,269	5,782	6,151	6,439	6,751	7,156
Oil	1,569	1,551	1,546	1,374	1,232	1,250	1,382	1,560
Gas	59	65	66	79	94	106	119	133
Biomass	14,751	15,297	15,433	15,469	15,212	14,757	14,219	14,100
Other sources	13,835	14,906	15,173	14,690	14,285	14,064	13,903	13,923
Total	34,453	36,881	37,488	37,395	36,974	36,616	36,374	36,873

World

Fuel	2005	2009	2010	2,015	2,020	2,025	2,030	2,035
Coal	4,689	5,542	5,755	6,274	6,637	6,910	7,215	7,613
Oil	2,564	2,326	2,267	1,888	1,609	1,546	1,650	1,826
Gas	88	87	86	100	116	130	145	161
Biomass	15,813	16,283	16,401	16,418	16,158	15,713	15,193	15,148
Other sources	15,627	16,620	16,868	16,397	16,005	15,805	15,685	15,713
Total	38,780	40,857	41,377	41,076	40,525	40,104	39,886	40,461

3.3 New Policies Scenario

Emissions for the New Policies Scenario by country group are shown in Table 3.10 to Table 3.12. Emissions by SNAP sector are presented in Table 3.13 to Table 3.15. In this scenario, not only energy-related CO_2 emissions are reduced but also emissions of air pollutants decrease. By 2035, the SO_2 emissions are nearly 14 million tons (or 16 percent) lower than in the Current Policies Scenario. Majority of that reduction (12 million tons) occurs in the non-OECD countries. In case of $NO_{x,}$ the emissions are 11 percent lower. In absolute terms, this means 9.6 million tons of NO_x less, of which 8.2 million tons is due to lower emissions from non-OECD countries.

Also, PM2.5 emissions decrease in the New Policies Scenario compared with the Current Policies case. In 2035, they are 1.5 million tons lower than in 2009, which is due to the decrease of emissions from developing countries. Emissions from the OECD region remain constant. Here the reduction of emissions from coal and oil is compensated by the increase of emissions from biomass fuel use in the residential sector.

Table 3.16 to Table 3.18 present the emissions by fuel, separately for the OECD and non-OECD country group. Also in this scenario, dominating sources of PM2.5 are combustion of biomass fuels and process emissions.

Table 3.10: Emissions of SO_2 by country group in the New Policies Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	5,421	4,234	3,628	3,403	3,211
Canada	1,550	1,514	1,495	1,473	1,464
Mexico	497	485	440	417	391
Chile	726	770	801	816	804
Japan	529	502	485	473	458
Korea	522	510	489	470	442
AUNZ	1,347	1,336	1,333	1,316	1,237
OE5	2,001	1,960	1,988	2,037	1,959
EUG4	1,093	949	808	766	726
EU17	1,703	1,371	1,276	1,200	1,152
EU6	382	253	221	209	199
OETE	2,219	1,307	1,219	1,293	1,235
Russia	4,990	4,223	4,309	4,357	4,353
Caspian	2,797	2,985	3,055	3,084	3,097
China	34,233	31,354	27,079	23,810	23,614
India	9,377	10,655	11,659	12,682	13,968
Indonesia	884	949	1,003	1,065	1,130
ASEAN9	1,351	1,413	1,536	1,698	1,844
ODA	2,064	2,371	2,628	2,963	2,992
Brazil	1,171	1,212	1,269	1,319	1,325
OLAM	1,644	1,443	1,496	1,520	1,484
NAFR	948	831	737	707	702
South Africa	1,622	1,355	1,224	1,099	1,066
OAFR	1,720	1,525	1,493	1,463	1,411
ME	4,505	3,885	3,309	3,174	3,169
OECD	15,389	13,631	12,743	12,372	11,844
Non-OECD	69,908	65,760	62,238	60,443	61,591
World	85,298	79,391	74,982	72,815	73,435

Table 3.11: Emissions of NO_x by country group in the New Policies Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	9,596	7,611	6,552	6,160	6,000
Canada	1,066	951	894	902	917
Mexico	1,126	1,069	1,085	1,130	1,155
Chile	424	450	480	510	530
Japan	1,326	1,044	880	817	778
Korea	1,084	970	845	751	656
AUNZ	1,041	943	912	886	829
OE5	1,274	1,229	1,219	1,266	1,275
EUG4	3,434	2,617	2,257	2,096	2,058
EU17	3,195	2,504	2,150	1,965	1,934
EU6	354	283	242	220	215
OETE	1,132	974	944	985	996
Russia	4,159	3,653	3,305	3,268	3,348
Caspian	1,330	1,480	1,606	1,746	1,888
China	20,898	20,538	20,004	20,083	20,478
India	5,289	6,129	7,204	8,554	10,564
Indonesia	1,584	1,604	1,676	1,790	1,886
ASEAN9	2,479	2,535	2,727	3,029	3,338
ODA	1,988	2,145	2,282	2,504	2,740
Brazil	2,360	2,383	2,386	2,559	2,668
OLAM	2,852	2,590	2,635	2,738	2,759
NAFR	1,536	1,576	1,622	1,715	1,757
South Africa	1,177	1,078	1,066	1,064	1,049
OAFR	1,961	1,976	2,031	2,067	2,125
ME	4,012	4,133	4,374	4,688	4,849
OECD	23,564	19,388	17,275	16,483	16,133
Non-OECD	53,109	53,076	54,106	57,011	60,659
World	76,673	72,464	71,381	73,494	76,793

Table 3.12: Emissions of PM2.5 by country group in the New Policies Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	867	808	770	768	802
Canada	138	131	126	127	136
Mexico	405	406	412	421	425
Chile	173	177	180	183	187
Japan	164	151	142	138	135
Korea	178	176	169	164	155
AUNZ	160	155	152	153	155
OE5	558	569	595	613	612
EUG4	495	464	442	450	464
EU17	541	511	500	508	549
EU6	187	185	180	175	178
OETE	548	513	529	599	606
Russia	1,330	1,305	1,301	1,303	1,302
Caspian	250	270	285	300	316
China	13,380	12,169	11,188	10,280	10,016
India	5,982	6,048	6,121	6,176	6,316
Indonesia	1,535	1,561	1,574	1,584	1,606
ASEAN9	1,897	1,907	1,897	1,898	1,938
ODA	2,389	2,506	2,642	2,743	2,749
Brazil	863	875	835	788	800
OLAM	1,081	1,067	1,059	1,069	1,071
NAFR	544	549	509	476	484
South Africa	446	444	431	417	409
OAFR	6,101	6,405	6,640	6,817	6,934
ME	763	772	714	666	681
OECD	3,679	3,548	3,489	3,527	3,620
Non-OECD	37,295	36,575	35,904	35,291	35,406
World	40,974	40,123	39,393	38,817	39,026

Table 3.13: Emissions of SO_2 by SNAP sector for the New Policies Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	6,445	4,793	3,975	3,618	3,216
2: Domestic	1,121	1,060	1,001	938	909
3: Industrial combust.	3,234	3,177	3,153	3,129	3,044
4: Industrial processes	4,124	4,140	4,236	4,317	4,311
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	39	33	32	31	30
8: Off-road sources	373	375	296	288	282
9: Waste management	25	25	24	23	23
10: Agriculture	28	28	27	29	29
Sum	15,389	13,631	12,743	12,372	11,844

Non-OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	37,696	34,577	31,251	29,557	31,019
2: Domestic	4,922	4,761	4,536	4,242	3,902
3: Industrial combust.	17,080	17,264	17,125	17,147	17,064
4: Industrial processes	8,452	7,381	7,490	7,561	7,560
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	334	318	365	425	490
8: Off-road sources	1,011	1,042	1,053	1,092	1,138
9: Waste management	268	265	260	253	253
10: Agriculture	145	151	158	165	165
Sum	69,908	65,760	62,238	60,443	61,591

World

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	44,142	39,371	35,226	33,175	34,235
2: Domestic	6,043	5,821	5,537	5,180	4,810
3: Industrial combust.	20,315	20,441	20,278	20,276	20,109
4: Industrial processes	12,575	11,521	11,726	11,878	11,871
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	373	351	397	456	520
8: Off-road sources	1,385	1,417	1,349	1,380	1,420
9: Waste management	293	290	283	276	276
10: Agriculture	173	179	185	194	194
Sum	85,298	79,391	74,982	72,815	73,435

Table 3.14: Emissions of NO_x by SNAP sector for the New Policies Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	5,675	4,621	4,164	3,900	3,647
2: Domestic	1,918	1,932	1,952	1,978	2,008
3: Industrial combust.	4,229	4,251	4,306	4,351	4,324
4: Industrial processes	968	959	943	922	922
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	6,364	3,832	2,708	2,466	2,460
8: Off-road sources	4,307	3,691	3,104	2,766	2,672
9: Waste management	40	38	36	35	35
10: Agriculture	64	63	61	65	65
Sum	23,564	19,388	17,275	16,483	16,133

Non-OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	15,146	15,588	15,840	16,544	17,649
2: Domestic	3,328	3,368	3,389	3,381	3,361
3: Industrial combust.	12,432	12,842	13,115	13,417	13,473
4: Industrial processes	1,262	1,331	1,393	1,449	1,448
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	12,066	11,089	11,187	12,246	13,730
8: Off-road sources	8,330	8,302	8,619	9,402	10,427
9: Waste management	315	313	307	300	300
10: Agriculture	230	242	255	272	272
Sum	53,109	53,076	54,106	57,011	60,659

World

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	20,822	20,210	20,005	20,444	21,296
2: Domestic	5,246	5,300	5,341	5,359	5,370
3: Industrial combust.	16,661	17,093	17,422	17,768	17,797
4: Industrial processes	2,229	2,290	2,335	2,372	2,370
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	18,430	14,922	13,895	14,712	16,190
8: Off-road sources	12,637	11,993	11,723	12,168	13,098
9: Waste management	355	351	344	335	335
10: Agriculture	294	306	317	337	337
Sum	76,673	72,464	71,381	73,494	76,793

Table 3.15: emissions of PM2.5 by SNAP sector for the New Policies Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	214	206	195	183	158
2: Domestic	1,186	1,186	1,201	1,243	1,358
3: Industrial combust.	329	325	338	347	360
4: Industrial processes	510	524	537	546	541
5: Fuel extraction	40	39	40	39	38
6: Solvents	0	0	0	0	0
7: Road traffic	301	228	200	199	196
8: Off-road sources	317	261	213	190	189
9: Waste management	329	326	322	316	316
10: Agriculture	454	453	444	463	463
Sum	3,679	3,548	3,489	3,527	3,620

Non-OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	2,762	2,917	2,976	3,077	3,282
2: Domestic	17,147	16,835	16,394	15,811	15,513
3: Industrial combust.	6,466	5,994	5,679	5,391	5,434
4: Industrial processes	4,079	3,994	3,888	3,816	3,816
5: Fuel extraction	126	141	156	168	168
6: Solvents	0	0	0	0	0
7: Road traffic	689	588	591	652	728
8: Off-road sources	696	653	668	734	826
9: Waste management	2,141	2,157	2,145	2,124	2,124
10: Agriculture	3,188	3,297	3,407	3,516	3,516
Sum	37,295	36,575	35,904	35,291	35,406

World

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	2,976	3,123	3,172	3,261	3,440
2: Domestic	18,333	18,022	17,595	17,055	16,871
3: Industrial combust.	6,795	6,319	6,017	5,738	5,794
4: Industrial processes	4,589	4,518	4,425	4,362	4,357
5: Fuel extraction	166	180	196	207	206
6: Solvents	0	0	0	0	0
7: Road traffic	991	816	791	851	924
8: Off-road sources	1,013	913	881	924	1,014
9: Waste management	2,470	2,482	2,467	2,440	2,440
10: Agriculture	3,643	3,750	3,850	3,979	3,979
Sum	40,974	40,123	39,393	38,817	39,026

Table 3.16: Emissions of SO_2 by fuel for the New Policies Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	7,238	5,570	4,700	4,223	3,739
Oil	3,083	2,899	2,692	2,610	2,506
Gas	40	41	41	43	44
Biomass	392	454	516	590	643
Other sources	4,636	4,668	4,795	4,907	4,911
Total	15,389	13,631	12,743	12,372	11,844

Non-OECD

Fuel	2015	2020	2025	2030	2035
Coal	43,189	40,803	37,662	35,435	36,313
Oil	12,581	11,839	11,077	10,943	11,037
Gas	291	349	399	456	519
Biomass	1,921	2,033	2,235	2,549	2,664
Other sources	11,926	10,735	10,865	11,060	11,059
Total	69,908	65,760	62,238	60,443	61,591

World

Fuel	2015	2020	2025	2030	2035
Coal	50,427	46,373	42,363	39,658	40,052
Oil	15,664	14,738	13,768	13,553	13,543
Gas	332	390	440	499	563
Biomass	2,313	2,487	2,751	3,139	3,307
Other sources	16,562	15,403	15,660	15,966	15,970
Total	85,298	79,391	74,982	72,815	73,435

Table 3.17: Emissions of NO_X by fuel for the New Policies Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	3,618	2,732	2,335	1,999	1,649
Oil	12,058	8,791	6,964	6,307	6,120
Gas	4,607	4,428	4,353	4,357	4,381
Biomass	911	1,025	1,154	1,286	1,428
Other sources	2,372	2,412	2,469	2,534	2,556
Total	23,564	19,388	17,275	16,483	16,133

Non-OECD

Fuel	2015	2020	2025	2030	2035
Coal	16,213	16,775	16,827	17,040	17,601
Oil	22,386	21,323	21,615	23,316	25,736
Gas	4,534	4,683	4,878	5,286	5,744
Biomass	2,738	2,917	3,083	3,267	3,478
Other sources	7,239	7,379	7,703	8,101	8,100
Total	53,109	53,076	54,106	57,011	60,659

World

Fuel	2015	2020	2025	2030	2035
Coal	19,831	19,506	19,162	19,039	19,251
Oil	34,443	30,114	28,578	29,623	31,855
Gas	9,141	9,111	9,231	9,643	10,125
Biomass	3,648	3,942	4,237	4,553	4,906
Other sources	9,610	9,790	10,172	10,635	10,655
Total	76,673	72,464	71,381	73,494	76,793

Table 3.18: Emissions of PM2.5 by fuel for the New Policies Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	477	458	425	396	363
Oil	511	370	286	254	246
Gas	21	22	24	27	31
Biomass	963	980	1,018	1,076	1,202
Other sources	1,706	1,717	1,735	1,774	1,778
Total	3,679	3,548	3,489	3,527	3,620

Non-OECD

Fuel	2015	2020	2025	2030	2035
Coal	5,657	5,703	5,682	5,651	5,658
Oil	1,357	1,195	1,189	1,290	1,436
Gas	79	94	106	119	132
Biomass	15,512	15,300	14,870	14,340	14,273
Other sources	14,690	14,283	14,058	13,891	13,907
Total	37,295	36,575	35,904	35,291	35,406

World

Fuel	2015	2020	2025	2030	2035
Coal	6,134	6,161	6,107	6,047	6,021
Oil	1,869	1,565	1,475	1,544	1,682
Gas	100	117	130	146	163
Biomass	16,475	16,281	15,888	15,416	15,475
Other sources	16,396	16,000	15,793	15,665	15,685
Total	40,974	40,123	39,393	38,817	39,026

3.4 450 Scenario

Emissions for the 450 Scenario by country group are shown in Table 3.19 to Table 3.21. Emissions by SNAP sector are presented in Table 3.22 to Table 3.23. Changes in fuel consumption volume and structure aimed at a reduction of energy-related CO_2 emissions cause an important reduction of emission of air pollutants. By 2035, the SO_2 emissions are 34 million tons (39 percent) lower than in the Current Policies Scenario. Majority of that reduction (30 million tons) occurs in non-OECD countries. In case of NO_x, the emissions are 31 percent lower, which is largely a result of lower use of coal and lower emissions from mobile sources (road- and non-road vehicles). In absolute terms, this means 27 million tons of NO_x less, of which nearly 23 million tons is due to lower emissions from the non-OECD countries. Emissions of PM2.5 also decrease compared with the Current Policies Scenario. In 2035, they are 3.7 million tons (nine percent) lower. Higher biomass fuels use in the residential sector in the 450 scenario causes an increase of PM2.5 emissions from the OECD country group. Emissions from the non-OECD countries decrease by 3.7 million tons compared with the Current Policies case.

Emissions by fuel for are shown in Table 3.25 to Table 3.27. Major contributor to lower emission levels is the decrease in the use of coal (31 million tons of SO_2, 16.5 million tons of NO_x, and four million tons of PM2.5 less compared with the Current Policies). Corresponding numbers for oil are: minus 3.4 million tons of SO_2, 9.3 million tons of NO_x, and 0.5 million tons of PM2.5. In turn, the emissions from solid biomass used in combustion processes are higher.

Table 3.19: Emissions of SO_2 by country group in the 450 Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	5,368	4,112	3,024	2,455	2,288
Canada	1,539	1,486	1,449	1,416	1,388
Mexico	504	447	379	343	314
Chile	725	757	774	760	720
Japan	523	480	447	420	398
Korea	519	494	458	425	388
AUNZ	1,340	1,266	1,136	1,038	966
OE5	1,932	1,739	1,517	1,366	1,189
EUG4	1,064	884	727	660	628
EU17	1,674	1,303	1,136	1,031	951
EU6	369	247	207	198	190
OETE	2,067	1,205	1,059	1,112	832
Russia	4,926	3,977	3,765	3,625	3,477
Caspian	2,749	2,863	2,895	2,892	2,867
China	33,599	28,845	22,382	17,691	15,706
India	9,118	9,301	8,615	8,669	8,767
Indonesia	862	868	852	845	848
ASEAN9	1,349	1,371	1,387	1,404	1,450
ODA	2,010	2,228	2,327	2,252	2,198
Brazil	1,162	1,175	1,192	1,202	1,182
OLAM	1,628	1,365	1,360	1,324	1,265
NAFR	951	811	672	613	594
South Africa	1,611	1,323	1,087	890	783
OAFR	1,708	1,460	1,395	1,336	1,202
ME	4,495	3,732	3,047	2,790	2,670
OECD	15,189	12,969	11,045	9,915	9,229
Non-OECD	68,602	60,769	52,245	46,842	44,029
World	83,792	73,739	63,290	56,757	53,259

Table 3.20: Emissions of NO_x by country group in the 450 Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	9,487	7,342	5,965	5,251	4,890
Canada	1,055	920	844	826	809
Mexico	1,115	1,034	1,016	1,011	962
Chile	421	439	453	443	423
Japan	1,306	996	797	690	613
Korea	1,072	915	750	618	515
AUNZ	1,033	891	777	690	624
OE5	1,248	1,169	1,117	1,114	1,087
EUG4	3,365	2,501	2,089	1,852	1,745
EU17	3,131	2,389	1,968	1,737	1,658
EU6	346	272	226	203	193
OETE	1,110	937	893	918	879
Russia	4,093	3,442	2,960	2,788	2,732
Caspian	1,302	1,396	1,465	1,511	1,523
China	20,575	19,237	17,129	15,538	14,461
India	5,175	5,648	6,043	6,731	7,635
Indonesia	1,545	1,488	1,452	1,447	1,415
ASEAN9	2,447	2,414	2,464	2,560	2,705
ODA	1,951	2,023	2,086	2,113	2,253
Brazil	2,314	2,269	2,197	2,270	2,266
OLAM	2,770	2,451	2,437	2,457	2,338
NAFR	1,490	1,448	1,400	1,387	1,327
South Africa	1,164	1,042	904	798	670
OAFR	1,931	1,899	1,917	1,905	1,893
ME	3,922	3,902	3,995	4,098	3,820
OECD	23,233	18,596	15,775	14,233	13,328
Non-OECD	52,133	49,867	47,568	46,724	46,109
World	75,366	68,464	63,343	60,957	59,437

Table 3.21: Emissions of PM2.5 by country group in the 450 Scenario, thousand tons/year

WEM region	2015	2020	2025	2030	2035
US	890	877	896	976	1,168
Canada	141	136	137	147	176
Mexico	408	409	415	425	432
Chile	172	175	176	175	175
Japan	163	147	135	129	127
Korea	178	172	163	158	150
AUNZ	161	153	143	142	150
OE5	549	542	536	527	513
EUG4	495	468	450	463	487
EU17	542	516	514	533	580
EU6	186	185	180	175	180
OETE	542	510	525	595	596
Russia	1,324	1,281	1,246	1,228	1,214
Caspian	248	266	281	294	310
China	13,309	11,869	10,535	9,281	8,773
India	5,928	5,839	5,730	5,656	5,616
Indonesia	1,535	1,553	1,557	1,555	1,567
ASEAN9	1,893	1,885	1,845	1,812	1,825
ODA	2,376	2,465	2,571	2,613	2,605
Brazil	860	867	829	785	809
OLAM	1,077	1,061	1,053	1,060	1,058
NAFR	542	544	499	462	467
South Africa	443	436	411	389	372
OAFR	6,090	6,372	6,586	6,740	6,830
ME	760	764	701	648	650
OECD	3,698	3,597	3,565	3,676	3,959
Non-OECD	37,115	35,898	34,548	33,294	32,873
World	40,813	39,495	38,113	36,970	36,832

Table 3.22: Emissions of SO_2 by SNAP sector for the 450 Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	6,335	4,377	2,624	1,635	1,227
2: Domestic	1,088	978	869	766	681
3: Industrial combust.	3,185	3,032	2,966	2,876	2,722
4: Industrial processes	4,124	4,140	4,236	4,317	4,311
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	38	32	30	27	24
8: Off-road sources	366	359	269	242	212
9: Waste management	25	25	24	23	23
10: Agriculture	28	28	27	29	29
Sum	15,189	12,969	11,045	9,915	9,229

Non-OECD

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	36,737	30,483	22,597	17,786	15,685
2: Domestic	4,849	4,554	4,207	3,829	3,464
3: Industrial combust.	16,831	16,645	16,239	15,934	15,574
4: Industrial processes	8,452	7,381	7,490	7,561	7,560
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	326	299	334	366	397
8: Off-road sources	994	991	960	948	931
9: Waste management	268	265	260	253	253
10: Agriculture	145	151	158	165	165
Sum	68,602	60,769	52,245	46,842	44,029

World

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	43,072	34,859	25,221	19,421	16,912
2: Domestic	5,938	5,532	5,076	4,595	4,144
3: Industrial combust.	20,016	19,677	19,206	18,809	18,297
4: Industrial processes	12,575	11,521	11,726	11,878	11,871
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	364	331	364	393	421
8: Off-road sources	1,360	1,350	1,228	1,190	1,144
9: Waste management	293	290	283	276	276
10: Agriculture	173	179	185	194	194
Sum	83,792	73,739	63,290	56,757	53,259

Table 3.23: Emissions of NO_x by SNAP sector for the 450 Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	5,560	4,287	3,322	2,628	2,236
2: Domestic	1,886	1,847	1,814	1,806	1,824
3: Industrial combust.	4,200	4,164	4,194	4,191	4,118
4: Industrial processes	968	959	943	922	922
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	6,283	3,711	2,541	2,170	1,955
8: Off-road sources	4,233	3,527	2,863	2,416	2,172
9: Waste management	40	38	36	35	35
10: Agriculture	64	63	61	65	65
Sum	23,233	18,596	15,775	14,233	13,328

Non-OECD

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	14,790	13,843	11,689	10,094	9,162
2: Domestic	3,296	3,281	3,243	3,184	3,132
3: Industrial combust.	12,306	12,545	12,695	12,816	12,711
4: Industrial processes	1,262	1,331	1,393	1,449	1,448
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	11,729	10,360	10,032	10,337	10,492
8: Off-road sources	8,205	7,952	7,954	8,272	8,593
9: Waste management	315	313	307	300	300
10: Agriculture	230	242	255	272	272
Sum	52,133	49,867	47,568	46,724	46,109

World

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	20,350	18,130	15,011	12,722	11,398
2: Domestic	5,182	5,128	5,057	4,990	4,956
3: Industrial combust.	16,506	16,709	16,889	17,007	16,829
4: Industrial processes	2,229	2,290	2,335	2,372	2,370
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	18,011	14,070	12,573	12,507	12,447
8: Off-road sources	12,439	11,479	10,817	10,688	10,765
9: Waste management	355	351	344	335	335
10: Agriculture	294	306	317	337	337
Sum	75,366	68,464	63,343	60,957	59,437

Table 3.24: emissions of PM2.5 by SNAP sector for the 450 Scenario, thousand tons/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	208	179	122	78	48
2: Domestic	1,220	1,281	1,378	1,537	1,861
3: Industrial combust.	328	323	336	345	357
4: Industrial processes	510	524	537	546	541
5: Fuel extraction	40	39	40	39	38
6: Solvents	0	0	0	0	0
7: Road traffic	297	221	187	175	155
8: Off-road sources	312	251	200	178	180
9: Waste management	329	326	322	316	316
10: Agriculture	454	453	444	463	463
Sum	3,698	3,597	3,565	3,676	3,959

Non-OECD

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	2,691	2,553	2,097	1,726	1,521
2: Domestic	17,079	16,625	16,074	15,416	15,125
3: Industrial combust.	6,452	5,954	5,630	5,326	5,356
4: Industrial processes	4,079	3,994	3,888	3,816	3,816
5: Fuel extraction	126	141	156	168	168
6: Solvents	0	0	0	0	0
7: Road traffic	672	552	533	555	567
8: Off-road sources	686	626	618	647	681
9: Waste management	2,141	2,157	2,145	2,124	2,124
10: Agriculture	3,188	3,297	3,407	3,516	3,516
Sum	37,115	35,898	34,548	33,294	32,873

World

SNAP sector	2,015	2,020	2,025	2,030	2,035
1: Power generation	2,899	2,733	2,219	1,804	1,569
2: Domestic	18,299	17,906	17,451	16,953	16,985
3: Industrial combust.	6,780	6,277	5,966	5,671	5,713
4: Industrial processes	4,589	4,518	4,425	4,362	4,357
5: Fuel extraction	166	180	196	207	206
6: Solvents	0	0	0	0	0
7: Road traffic	969	772	721	730	722
8: Off-road sources	998	877	818	824	861
9: Waste management	2,470	2,482	2,467	2,440	2,440
10: Agriculture	3,643	3,750	3,850	3,979	3,979
Sum	40,813	39,495	38,113	36,970	36,832

Table 3.25: Emissions of SO_2 by fuel for the 450 Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	7,085	5,046	3,182	2,004	1,427
Oil	3,030	2,743	2,473	2,306	2,106
Gas	40	39	39	38	37
Biomass	399	473	556	660	749
Other sources	4,636	4,668	4,795	4,907	4,911
Total	15,189	12,969	11,045	9,915	9,229

Non-OECD

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	42,047	36,401	28,470	22,867	20,046
Oil	12,418	11,229	10,207	9,767	9,533
Gas	285	338	368	403	441
Biomass	1,926	2,067	2,335	2,746	2,950
Other sources	11,926	10,735	10,865	11,060	11,059
Total	68,602	60,769	52,245	46,842	44,029

World

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	49,132	41,447	31,652	24,871	21,473
Oil	15,448	13,972	12,680	12,073	11,639
Gas	325	377	407	441	478
Biomass	2,325	2,540	2,891	3,406	3,699
Other sources	16,562	15,403	15,660	15,966	15,970
Total	83,792	73,739	63,290	56,757	53,259

Table 3.26: Emissions of NO_x by fuel for the 450 Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	3,559	2,498	1,552	840	512
Oil	11,860	8,421	6,444	5,495	4,869
Gas	4,516	4,197	4,053	3,903	3,701
Biomass	926	1,068	1,256	1,462	1,690
Other sources	2,372	2,412	2,469	2,534	2,556
Total	23,233	18,596	15,775	14,233	13,328

Non-OECD

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	15,797	14,940	12,506	10,412	8,962
Oil	21,910	20,156	19,663	20,085	20,395
Gas	4,444	4,445	4,508	4,648	4,854
Biomass	2,743	2,948	3,188	3,477	3,798
Other sources	7,239	7,379	7,703	8,101	8,100
Total	52,133	49,867	47,568	46,724	46,109

World

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	19,357	17,439	14,058	11,252	9,475
Oil	33,770	28,577	26,107	25,580	25,264
Gas	8,960	8,642	8,562	8,551	8,555
Biomass	3,669	4,016	4,444	4,939	5,488
Other sources	9,610	9,790	10,172	10,635	10,655
Total	75,366	68,464	63,343	60,957	59,437

Table 3.27: Emissions of PM2.5 fuel for the 450 Scenario, thousand tons/year

OECD

Fuel	2015	2020	2025	2030	2035
Coal	462	407	314	240	185
Oil	503	354	263	220	197
Gas	21	23	27	36	54
Biomass	1,007	1,100	1,234	1,423	1,775
Other sources	1,705	1,713	1,727	1,756	1,748
Total	3,698	3,597	3,565	3,676	3,959

Non-OECD

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	5,522	5,151	4,512	3,923	3,474
Oil	1,332	1,134	1,088	1,119	1,155
Gas	78	94	105	115	126
Biomass	15,496	15,245	14,801	14,272	14,252
Other sources	14,686	14,274	14,042	13,866	13,866
Total	37,115	35,898	34,548	33,294	32,873

World

Fuel	2,015	2,020	2,025	2,030	2,035
Coal	5,984	5,558	4,826	4,164	3,659
Oil	1,835	1,488	1,351	1,339	1,352
Gas	100	117	131	151	180
Biomass	16,503	16,345	16,035	15,694	16,027
Other sources	16,391	15,987	15,769	15,622	15,613
Total	40,813	39,495	38,113	36,970	36,832

3.5 Comparison of emissions

Figure 3.1 to Figure 3.3 compare the emissions of air pollutants by major countries/country groups for the three scenarios. Aggregation of country groups shown in this section is explained in Appendix 1. Figures clearly demonstrate the prominent role of non-OECD countries in the world emissions of air pollutants. Contributions of China and India are particularly high. The figures also show that important reductions, especially in the developing world, can be achieved through energy system measures.

Figure 3.1: Emissions of SO_2 in the WEO 2010 by country group, million tons

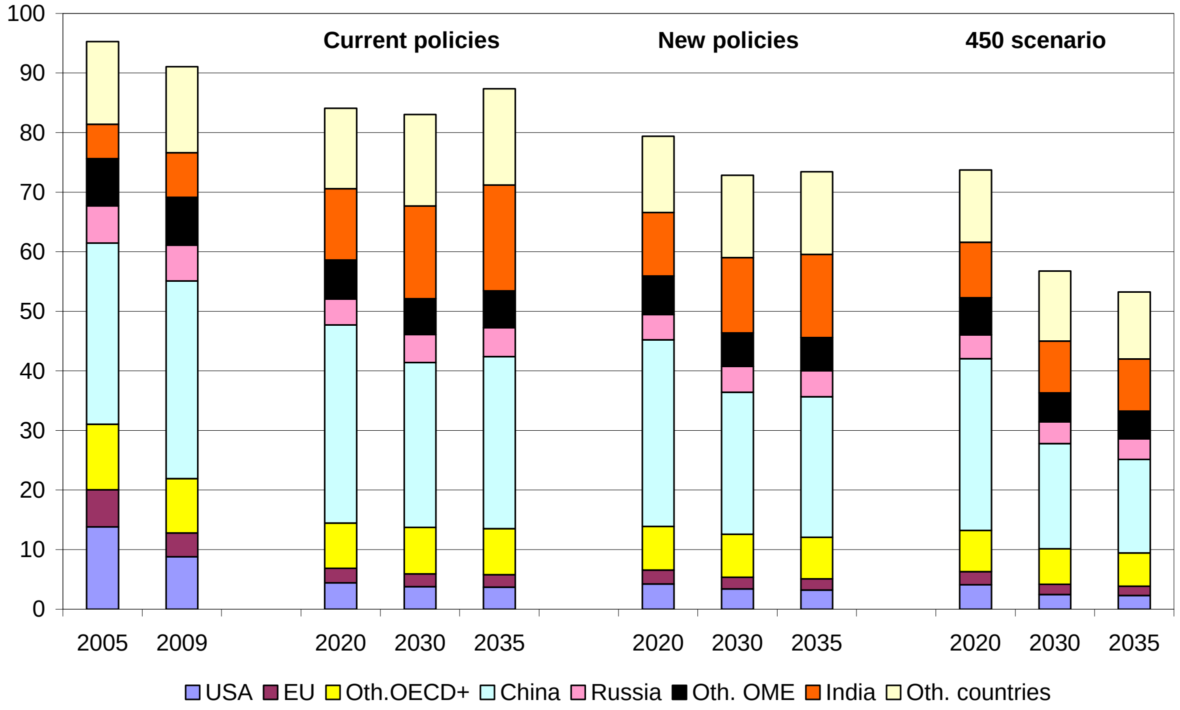


Figure 3.2: Emissions of NO_x in the WEO 2010 by country group, million tons

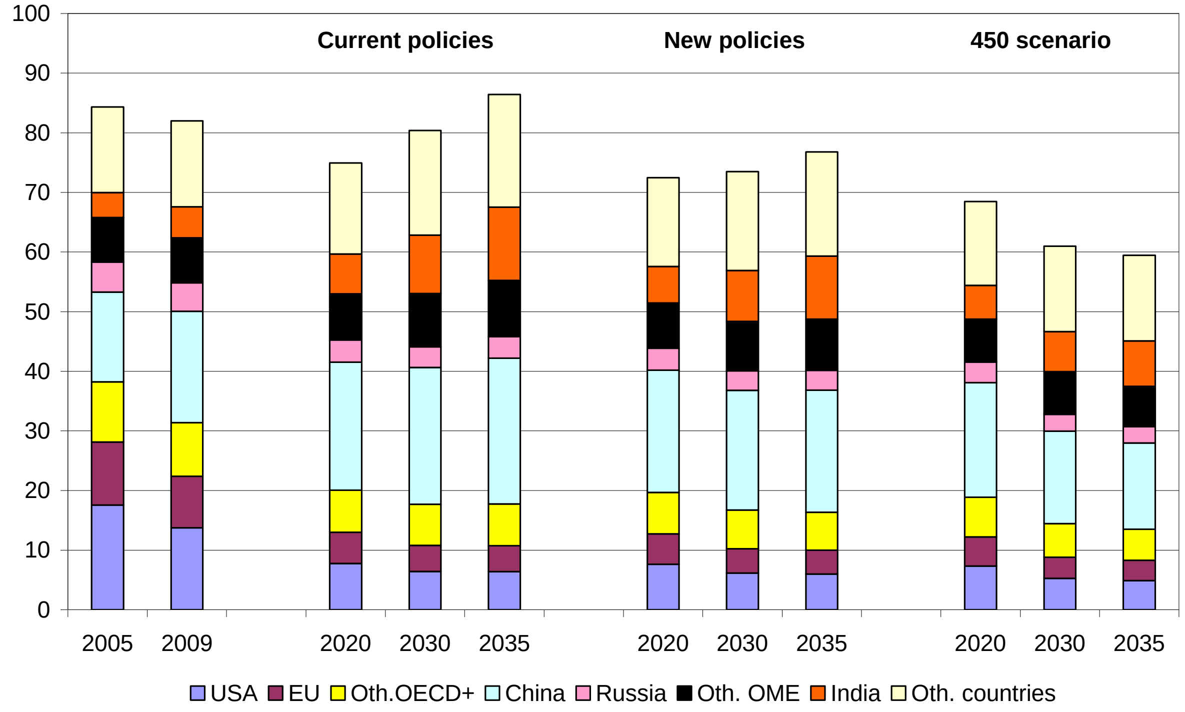
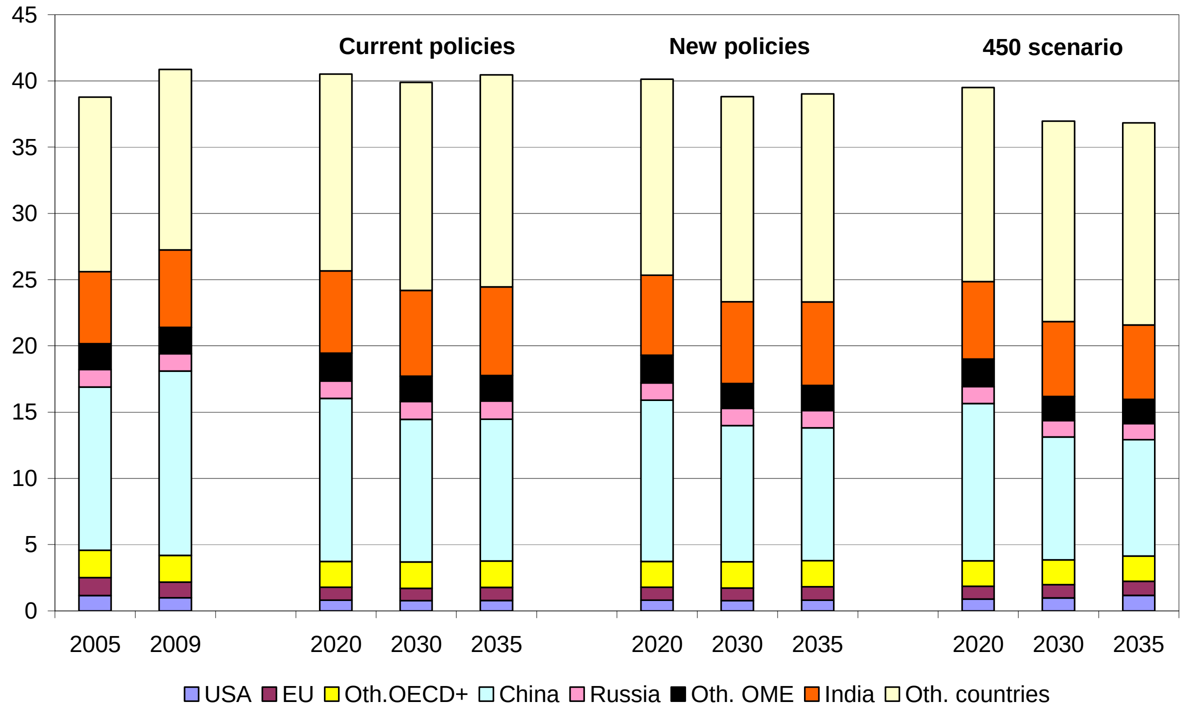


Figure 3.3: Emissions of PM2.5 in the WEO 2010 by country group, million tons



4 Air pollution control costs

This section presents air pollution control costs for the three WEO 2011 scenarios. Calculations include international costs of pollution control equipment and four percent (social) real interest rate. All costs and prices are expressed in constant € 2005 and take into account "current policy" pollution control legislation. Methodology of costs calculations can be found in Amann *et al.*, 2004.

Under such assumptions control costs were about 200 billion €/a in 2009. Until 2035 these costs increase in the Current Policies Scenario by more than a factor of two, which is due to higher activity levels (higher energy consumption, higher car ownership) and increasing stringency of controls. In 2035, 60 percent of the total are costs of reducing emissions from road transport sources.

The New Policies scenario brings cost savings of about 45 billion € compared with the Current Policies scenario. In the 450 case additional cost savings of 92 billion € compared with the New Policies scenario are achieved. Details by country group are presented in Table 4.1 to Table 4.3. Costs by sector (SNAP aggregation) are shown in Table 4.4 to Table 4.6. Figure 4.1 compares the costs by countries/country groups for the three scenarios.

Figure 4.1: Air pollution control costs for the WEO 2010 scenarios by country group, billion €/year

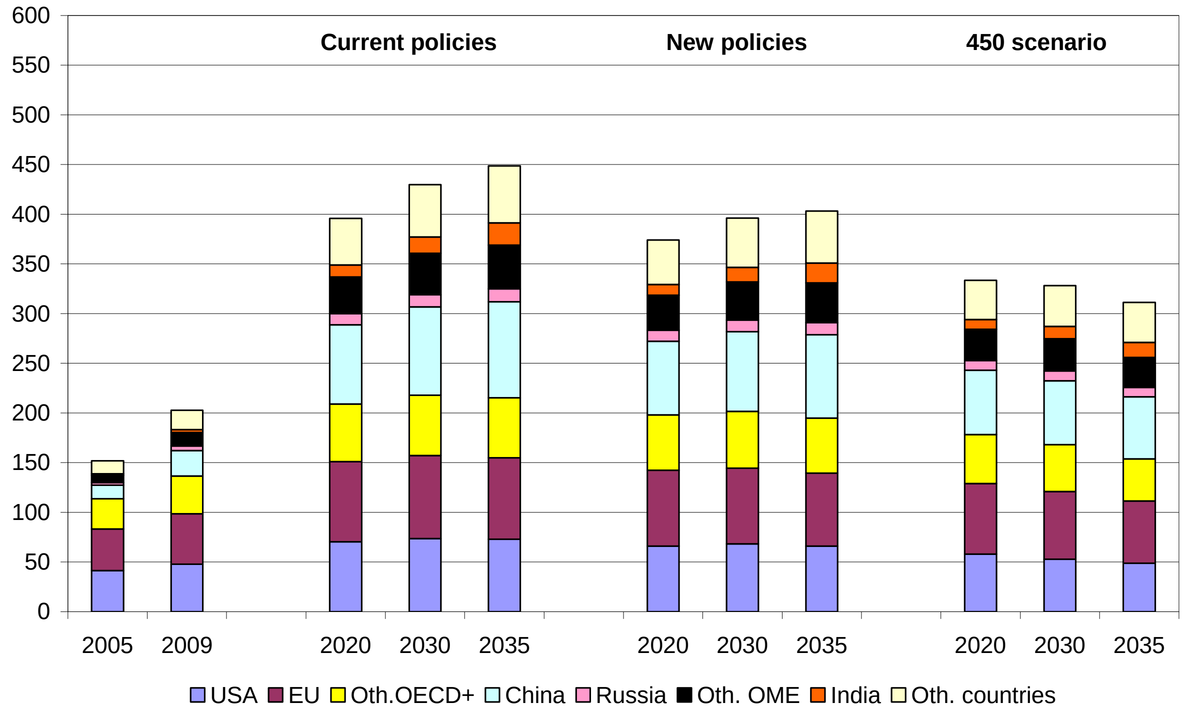


Table 4.1: Air pollution control costs by country group in the Current Policies Scenario, billion €/year

WEM region	2005	2009	2010	2015	2020	2025	2030	2035
US	41.4	47.7	49.3	59.8	65.3	70.3	73.6	72.9
Canada	3.4	4.2	4.4	5.4	6.2	6.9	7.2	7.2
Mexico	2.3	3.3	3.5	4.3	4.8	5.1	5.4	5.6
Chile	0.5	0.7	0.8	1.1	1.4	1.6	1.8	2.0
Japan	12.9	14.5	14.9	16.2	16.9	17.5	17.6	16.8
Korea	3.3	4.2	4.4	5.3	5.8	6.1	6.2	6.0
AUNZ	3.4	3.9	4.0	4.8	5.4	5.6	5.7	5.5
OE5	3.4	4.6	4.9	6.7	8.3	9.7	11.0	11.5
EUG4	24.6	28.8	29.8	34.3	39.9	42.6	43.4	42.1
EU17	17.0	22.0	23.3	29.0	34.9	38.3	40.1	39.7
EU6	1.6	2.6	2.8	4.1	5.0	5.5	5.8	5.8
OETE	1.6	2.0	2.1	2.8	3.9	4.4	5.2	5.4
Russia	2.5	4.8	5.3	7.7	9.5	11.2	12.2	12.9
Caspian	0.5	0.6	0.6	0.6	0.7	0.7	0.7	0.7
China	13.5	25.5	28.6	47.1	65.8	79.7	89.0	96.8
India	1.6	3.0	3.3	6.2	8.7	11.9	16.4	22.4
Indonesia	1.6	2.5	2.7	4.3	6.1	7.2	7.9	8.6
ASEAN9	2.9	4.3	4.6	6.9	9.8	12.1	14.1	16.1
ODA	2.2	2.6	2.7	3.2	3.5	3.7	3.8	4.2
Brazil	2.8	5.4	6.1	9.3	11.4	13.4	14.4	15.4
OLAM	2.2	3.7	4.1	6.4	8.6	9.7	10.8	11.5
NAFR	1.1	2.1	2.3	3.2	3.9	4.4	4.7	4.8
South Africa	1.1	1.6	1.8	2.6	3.4	3.7	4.0	4.2
OAFR	1.2	1.6	1.8	2.7	3.8	4.6	5.6	6.0
ME	3.3	6.4	7.1	11.5	15.2	19.9	23.2	24.4
OECD	112.2	133.9	139.3	167.0	188.9	203.5	211.9	209.3
Non-OECD	39.7	68.7	76.0	118.7	159.2	192.3	217.9	239.2
World	151.9	202.6	215.3	285.7	348.1	395.8	429.8	448.6

Table 4.2: Air pollution control costs by country group in the New Policies Scenario, billion €/year

WEM region	2015	2020	2025	2030	2035
US	59.3	62.8	66.0	68.1	65.9
Canada	5.4	6.2	6.7	7.0	7.0
Mexico	4.3	4.8	4.9	5.1	5.2
Chile	1.1	1.4	1.6	1.7	1.8
Japan	16.1	16.5	16.6	16.1	14.8
Korea	5.3	5.8	5.8	5.6	5.1
AUNZ	4.7	5.2	5.3	5.2	4.8
OE5	6.6	8.1	9.5	10.8	11.3
EUG4	34.2	38.8	39.8	39.0	37.5
EU17	28.8	34.0	36.5	37.3	36.0
EU6	4.2	4.9	5.3	5.6	5.5
OETE	2.8	3.7	4.2	4.9	4.9
Russia	7.6	9.4	10.9	11.7	12.1
Caspian	0.6	0.7	0.7	0.7	0.7
China	46.7	63.4	74.2	80.1	83.9
India	5.9	8.0	10.8	14.7	20.0
Indonesia	4.3	6.0	7.0	7.5	7.9
ASEAN9	6.8	9.2	11.2	12.8	14.4
ODA	3.1	3.3	3.5	3.6	3.8
Brazil	9.4	11.4	13.4	14.4	15.3
OLAM	6.4	8.4	9.3	9.9	10.1
NAFR	3.3	3.9	4.4	4.6	4.7
South Africa	2.6	3.3	3.5	3.7	3.6
OAFR	2.7	3.8	4.6	5.5	5.7
ME	11.5	14.8	18.4	20.3	21.0
OECD	165.9	183.5	192.7	196.0	189.4
Non-OECD	117.7	154.2	181.4	199.9	213.8
World	283.6	337.8	374.1	396.0	403.2

Table 4.3: Air pollution control costs by country group in the 450 Scenario, billion €/year

WEM region	2015	2020	2025	2030	2035
US	59.1	62.1	58.0	52.7	48.8
Canada	5.4	6.0	6.3	6.4	6.2
Mexico	4.3	4.6	4.5	4.4	4.0
Chile	1.1	1.3	1.5	1.5	1.5
Japan	15.9	15.6	14.6	13.0	10.9
Korea	5.2	5.4	5.0	4.3	3.5
AUNZ	4.7	4.9	4.4	3.8	3.4
OE5	6.5	7.6	8.1	8.6	8.3
EUG4	33.6	37.4	37.6	35.3	31.8
EU17	28.4	32.6	33.4	32.9	30.6
EU6	4.0	4.7	4.9	5.1	4.7
OETE	2.8	3.6	4.0	4.5	4.3
Russia	7.5	8.9	9.8	10.0	9.7
Caspian	0.6	0.6	0.7	0.7	0.7
China	45.9	59.6	64.6	64.3	62.4
India	5.9	7.8	9.8	12.3	15.1
Indonesia	4.1	5.5	6.0	6.1	5.9
ASEAN9	6.7	8.6	9.7	10.1	10.7
ODA	3.1	3.1	3.0	2.7	2.8
Brazil	9.1	10.6	11.8	12.1	12.2
OLAM	6.1	7.8	8.5	8.8	8.4
NAFR	3.1	3.4	3.5	3.2	2.9
South Africa	2.5	3.1	2.9	2.5	2.0
OAFR	2.7	3.6	4.2	4.8	4.7
ME	11.2	13.9	16.8	17.8	15.8
OECD	164.1	177.5	173.4	163.0	149.0
Non-OECD	115.2	144.8	160.1	165.1	162.2
World	279.3	322.3	333.6	328.0	311.2

Table 4.4: Air pollution control costs by SNAP sector for the Current Policies Scenario, billion €/year

OECD

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	32.9	35.6	36.2	37.0	37.1	36.9	35.7	33.1
2: Domestic	7.3	9.0	9.4	10.6	12.3	13.2	14.8	15.6
3: Industrial combust.	5.0	5.6	5.7	6.0	6.0	6.1	6.3	6.2
4: Industrial processes	8.2	8.9	9.0	9.6	10.0	10.5	10.7	10.7
5: Fuel extraction	2.6	2.6	2.5	2.6	2.5	2.6	2.5	2.4
6: Solvents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7: Road traffic	54.5	68.9	72.5	92.9	107.5	116.2	121.2	121.5
8: Off-road sources	1.4	3.1	3.5	7.9	13.0	17.7	20.3	19.3
9: Waste management	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Sum	112.2	133.9	139.3	167.0	188.9	203.5	211.9	209.3

Non-OECD

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	9.2	16.5	18.4	24.9	31.4	36.5	41.6	46.6
2: Domestic	2.2	2.9	3.1	3.8	4.5	5.3	6.2	6.2
3: Industrial combust.	5.9	8.2	8.8	10.3	11.0	11.7	12.3	12.3
4: Industrial processes	7.8	9.5	9.9	10.5	10.9	11.3	11.6	11.6
5: Fuel extraction	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.4
6: Solvents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7: Road traffic	13.3	28.9	32.8	63.0	90.4	115.0	134.6	150.8
8: Off-road sources	0.8	2.2	2.6	5.7	10.5	12.0	11.2	11.3
9: Waste management	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Sum	39.7	68.7	76.0	118.7	159.2	192.3	217.9	239.2

World

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	42.1	52.1	54.6	61.9	68.4	73.4	77.3	79.7
2: Domestic	9.5	11.9	12.5	14.4	16.8	18.5	21.0	21.8
3: Industrial combust.	10.9	13.8	14.5	16.3	17.0	17.9	18.5	18.4
4: Industrial processes	16.0	18.3	18.9	20.0	20.9	21.8	22.3	22.3
5: Fuel extraction	3.0	2.9	2.9	3.0	2.9	3.0	2.9	2.9
6: Solvents	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7: Road traffic	67.8	97.8	105.3	156.0	197.9	231.1	255.7	272.3
8: Off-road sources	2.2	5.3	6.1	13.6	23.5	29.6	31.5	30.7
9: Waste management	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Sum	151.9	202.6	215.3	285.7	348.1	395.8	429.8	448.6

Table 4.5: Air pollution control costs by SNAP sector for the New Policies Scenario, billion €/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	36.1	33.7	30.6	26.5	21.9
2: Domestic	10.7	12.5	13.8	16.0	17.6
3: Industrial combust.	6.0	6.0	6.1	6.2	6.1
4: Industrial processes	9.6	10.0	10.5	10.7	10.7
5: Fuel extraction	2.6	2.5	2.6	2.5	2.4
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	92.7	105.5	111.5	114.2	112.1
8: Off-road sources	7.9	12.8	17.2	19.4	18.1
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.4	0.4	0.4	0.4	0.4
Sum	165.9	183.5	192.7	196.0	189.4

Non-OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	24.3	28.4	30.8	32.8	34.1
2: Domestic	3.8	4.5	5.3	6.3	6.4
3: Industrial combust.	10.3	10.9	11.3	11.6	11.4
4: Industrial processes	10.5	10.9	11.3	11.6	11.6
5: Fuel extraction	0.4	0.4	0.4	0.5	0.4
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	62.7	88.8	110.8	126.6	139.3
8: Off-road sources	5.6	10.2	11.4	10.6	10.6
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.1	0.1	0.1	0.1	0.1
Sum	117.7	154.2	181.4	199.9	213.8

World

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	60.4	62.2	61.4	59.2	56.0
2: Domestic	14.5	17.0	19.2	22.3	23.9
3: Industrial combust.	16.3	16.9	17.4	17.8	17.5
4: Industrial processes	20.0	20.9	21.8	22.3	22.3
5: Fuel extraction	3.0	2.9	3.0	2.9	2.9
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	155.4	194.3	222.3	240.8	251.4
8: Off-road sources	13.5	23.0	28.6	30.0	28.7
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.5	0.5	0.5	0.5	0.5
Sum	283.6	337.8	374.1	396.0	403.2

Table 4.6: Air pollution control costs by SNAP sector for the 450 Scenario, billion €/year

OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	35.5	31.1	18.1	6.9	3.6
2: Domestic	10.8	13.3	15.7	19.7	23.7
3: Industrial combust.	5.9	5.9	6.0	6.1	6.0
4: Industrial processes	9.6	10.0	10.5	10.7	10.7
5: Fuel extraction	2.6	2.5	2.6	2.5	2.4
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	91.6	102.1	104.6	100.3	88.1
8: Off-road sources	7.7	12.1	15.5	16.4	14.1
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.4	0.4	0.4	0.4	0.4
Sum	164.1	177.5	173.4	163.0	149.0

Non-OECD

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	23.7	25.2	21.9	18.0	14.8
2: Domestic	3.8	4.5	5.3	6.3	6.4
3: Industrial combust.	10.2	10.5	10.7	10.8	10.4
4: Industrial processes	10.5	10.9	11.3	11.6	11.6
5: Fuel extraction	0.4	0.4	0.4	0.5	0.4
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	61.1	83.5	100.1	108.9	110.0
8: Off-road sources	5.6	9.8	10.3	9.0	8.6
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.1	0.1	0.1	0.1	0.1
Sum	115.2	144.8	160.1	165.1	162.2

World

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	59.2	56.3	40.0	24.9	18.3
2: Domestic	14.6	17.8	21.0	25.9	30.1
3: Industrial combust.	16.1	16.4	16.7	16.9	16.3
4: Industrial processes	20.0	20.9	21.8	22.3	22.3
5: Fuel extraction	3.0	2.9	3.0	2.9	2.9
6: Solvents	0.0	0.0	0.0	0.0	0.0
7: Road traffic	152.6	185.6	204.7	209.1	198.1
8: Off-road sources	13.3	21.9	25.8	25.5	22.7
9: Waste management	0.0	0.0	0.0	0.0	0.0
10: Agriculture	0.5	0.5	0.5	0.5	0.5
Sum	279.3	322.3	333.6	328.0	311.2

5 Health impacts

Comprehensive assessment of all health and ecosystems impacts of energy scenarios analyzed in this report was not possible for all countries due to lack of data. Thus the analysis was limited to the estimates of life years lost (YOLL) attributable to the exposure to PM2.5 in ambient air in Europe, China and India. Countries included cover nearly half of the world population. Ambient PM2.5 concentrations include primary PM2.5 as well as secondary aerosols (sulphates and nitrates).

Methodology of the assessment (Amann, Heyes, Schöpp, and Mechler, 2004) was developed in collaboration with the World Health Organization (WHO) and the Global Burden of Disease Project[8]. Since the YOLL indicator includes long-term health effects of exposure to fine particles, the estimates refer to the population above the age of thirty[9]. The assessment covers only outdoor exposure and does not consider negative health effects of indoor air pollution.

In the countries covered by the GAINS assessment (China, India and Europe) concentrations of fine particles as in 2009 cause a loss of about 2.2 billion of life years - Table 5.1. This estimate is dominated by impacts in China and India, which together contribute 88 percent of YOLL in 2009. The Current Policies Scenario implies an increase of the YOLL indicator until 2035 by 46 percent to 3.2 billion. This is a combined effect of higher emissions of air pollutants and population increase in India and China and a decrease of air pollution in Europe. Reductions of precursor emissions in the 450 scenario compared with the Current Policies case and thus lower concentrations of PM2.5 in 2035 save 870 million life-years, of which 380 million in China and 460 million in India. The New Policies scenario decreases life-years lost in the countries included by about 340 million compared with the Current Policies scenario.

[8] http://www.globalburden.org/index.html

[9] In 2009, the share of population over the age of thirty was 56 percent in China, 45 percent in India and 72 percent in the European Union. These shares increase until 2035 for China to 67 percent and for India to 55 percent.

Table 5.1: Life years lost (YOLL) due to exposure to anthropogenic emissions of PM2.5, million life years

WEM region	2005	2009	2010	Current policies scenario 2015	2020	2025	2030	2035
China	1139	1345	1396	1470	1522	1497	1470	1489
India	458	569	597	724	907	1094	1352	1490
Russia (1)	57	55	55	54	52	51	52	53
EU6	15	13	13	11	9	8	8	8
OE5 (2)	3	2	2	2	2	1	1	1
EUG4	104	87	83	73	65	59	59	59
EU17	73	61	59	52	47	43	43	43
OETE	34	31	30	28	24	23	25	25

WEM region	New Policies scenario 2015	2020	2025	2030	2035
China	1463	1481	1419	1361	1340
India	710	858	1015	1214	1307
Russia (1)	54	51	50	50	50
EU6	11	9	8	8	8
OE5 (2)	2	2	1	1	1
EUG4	73	64	57	56	56
EU17	52	46	42	41	41
OETE	27	23	22	23	23

WEM region	450 scenario 2015	2020	2025	2030	2035
China	1449	1419	1291	1177	1105
India	700	805	885	1009	1028
Russia (1)	53	50	48	47	46
EU6	10	9	8	7	7
OE5 (2)	2	2	1	1	1
EUG4	72	62	54	53	52
EU17	51	45	40	39	39
OETE	27	22	21	22	20

(1) Only European part

(2) Does not include Turkey

6 Effects of the scenarios for Russia

This section discusses the effects of the WEO 2011 energy scenarios on emissions of air pollutants in Russia. Similarly as for other countries, calculations assume implementation of “current legislation” measures to control air emissions from combustion and process sources. Russian air pollution control system is based on a set of ambient air quality standards. In addition, for some sources emission limit values exist. However, degree of enforcement of these standards and limit values is hard to identify. It is also uncertain how the air pollution control system will evolve in the future. After consultations with Russian experts collaborating with IIASA it has been assumed that major large combustion plants will be equipped with moderate (and relatively cheap) control measures like in-furnace control of SO_2 emissions or combustion modification for NO_x. Measures on mobile sources are based on European legislation (Euro standards). Pace of implementation of those measures follows legislation already in force, together with governmental plans to introduce Euro 4/IV before 2015. The “current legislation” also includes improvement in the quality of liquid fuels, which is necessary to meet stricter standards on mobile sources. Controls on process sources from the non-ferrous metals industry, which are important emission sources of SO_2 and dust, have been assumed according to programs presented by major enterprises from this sector. To control emissions of PM from large stationary combustion and process sources, implementation of medium - to high efficiency electrostatic precipitators has been assumed.

Under such assumptions, emissions of SO_2 from the territory of the Russian Federation decrease in the Current Policies scenario from the current six million tons to about 4.9 million tons in 2035 (Table 6.1). Most important contributors to the emissions are sources from the power generation and process sectors. Emissions of NO_x (Table 6.2) decrease from about 4.8 million tons in 2009 to 3.6 million tons. This is mainly due to the decrease from the power generation and mobile sources. In turn, emissions of fine particles (PM2.5 - Table 6.3), which are estimated at 1.3 million tons in 2009, increase by about seven percent, which is a combined effect of higher energy consumption and lack of substantial improvement in stringency of controlling emissions. Expenditures on pollution control (Table 6.10) increase from about 4.8 billion €/a in 2009 to 12.9 billion €/a in 2035.

Implementation of policies to reduce energy consumption and emissions of greenhouse gases bring important benefits for air pollution in Russia – Table 6.4 to Table 6.9. Compared with the Current Policies scenario, the New Policies case causes a reduction in SO_2 emissions in 2035 by more than a half million tons. Corresponding reductions of NO_x and PM2.5 are: 287 and 85 thousand tons. Co-benefits for air pollution of the 450 scenario relative to the New Policies scenario are even higher: about 880 thousand tons of SO_2, 620 thousand tons of NO_x, and 90 thousand tons of fine particles. Expenditures on controlling emissions decrease by 820 million €/a for the New Policies scenario and by further 2.4 billion €/a for the 450 scenario - Table 6.11 and Table 6.12.

Lower emissions improve air quality in Russia and thus reduce negative health impacts - Table 5.1. The number of lifeyears lost in the European part of the country decreases in the 450 scenario and is in 2035 about 13 percent lower than in the Current Policies scenario.

Table 6.1: Emissions of SO_2 by SNAP 1 sector in Russia, Current Policies scenario, kilotons

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	2793	2298	2174	2256	2327	2445	2593	2743
2: Domestic	204	197	195	196	195	195	193	188
3: Industrial combust.	502	613	641	673	694	719	748	779
4: Industrial processes	2326	2667	2752	1732	929	958	976	976
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	186	56	23	1	1	1	1	2
8: Off-road sources	155	110	99	102	102	102	101	104
9: Waste management	95	71	65	64	63	61	60	60
10: Agriculture	7	7	7	7	7	7	7	7
Sum	6268	6019	5956	5031	4317	4489	4679	4858

Table 6.2: Emissions of NO_x by SNAP 1 sector in Russia, Current Policies scenario, kilotons

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	2262	2007	1944	1606	1323	1176	1226	1321
2: Domestic	132	136	137	146	156	165	176	186
3: Industrial combust.	338	392	406	448	474	494	514	531
4: Industrial processes	119	128	130	142	146	147	146	146
5: Fuel extraction	0	0	0	0	0	0	0	0
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	1107	998	970	708	520	358	333	354
8: Off-road sources	988	1058	1076	1067	1030	1008	993	1031
9: Waste management	95	71	65	64	63	61	60	60
10: Agriculture	6	6	6	6	6	6	6	6
Sum	5047	4797	4734	4187	3718	3416	3454	3636

Table 6.3: Emissions of PM2.5 by SNAP 1 sector in Russia, Current Policies scenario, kilotons

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	224	205	201	194	190	196	207	224
2: Domestic	154	140	136	136	132	131	129	133
3: Industrial combust.	77	87	89	100	105	109	112	113
4: Industrial processes	389	410	415	473	485	496	508	508
5: Fuel extraction	5	5	4	5	6	6	7	7
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	55	55	55	42	26	18	18	19
8: Off-road sources	89	91	92	90	87	85	84	88
9: Waste management	147	116	109	107	105	102	101	101
10: Agriculture	192	193	193	193	193	194	194	194
Sum	1332	1301	1293	1340	1327	1338	1361	1387

Table 6.4: Emissions of SO_2 by SNAP 1 sector in Russia, New Policies scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	2223	2252	2303	2331	2324
2: Domestic	188	178	168	155	138
3: Industrial combust.	673	693	711	729	749
4: Industrial processes	1732	929	958	976	976
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	1	1	1	1	2
8: Off-road sources	102	100	99	98	99
9: Waste management	64	63	61	60	60
10: Agriculture	7	7	7	7	7
Sum	4990	4223	4309	4357	4353

Table 6.5: Emissions of NO_x by SNAP 1 sector in Russia, New Policies scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	1588	1282	1104	1095	1111
2: Domestic	145	152	158	162	165
3: Industrial combust.	445	466	481	495	507
4: Industrial processes	142	146	147	146	146
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	707	517	354	326	340
8: Off-road sources	1063	1021	994	978	1014
9: Waste management	64	63	61	60	60
10: Agriculture	6	6	6	6	6
Sum	4159	3653	3305	3268	3348

Table 6.6: Emissions of PM2.5 by SNAP 1 sector in Russia, New Policies scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	190	180	180	178	177
2: Domestic	130	120	112	102	96
3: Industrial combust.	100	105	109	112	113
4: Industrial processes	473	485	496	508	508
5: Fuel extraction	5	6	6	7	7
6: Solvents	0	0	0	0	0
7: Road traffic	42	26	17	18	18
8: Off-road sources	90	86	84	84	88
9: Waste management	107	105	102	101	101
10: Agriculture	193	193	194	194	194
Sum	1330	1305	1301	1303	1302

Table 6.7: Emissions of SO_2 by SNAP 1 sector in Russia, 450 scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	2166	2030	1813	1680	1548
2: Domestic	186	172	156	140	124
3: Industrial combust.	669	680	676	675	677
4: Industrial processes	1732	929	958	976	976
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	1	1	1	1	1
8: Off-road sources	100	96	92	87	84
9: Waste management	64	63	61	60	60
10: Agriculture	7	7	7	7	7
Sum	4926	3977	3765	3625	3477

Table 6.8: Emissions of NO_x by SNAP 1 sector in Russia, 450 scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	1552	1154	887	802	751
2: Domestic	141	141	140	137	135
3: Industrial combust.	443	458	466	472	477
4: Industrial processes	142	146	147	146	146
5: Fuel extraction	0	0	0	0	0
6: Solvents	0	0	0	0	0
7: Road traffic	695	493	328	287	280
8: Off-road sources	1049	981	926	877	878
9: Waste management	64	63	61	60	60
10: Agriculture	6	6	6	6	6
Sum	4093	3442	2960	2788	2732

Table 6.9: Emissions of PM2.5 by SNAP 1 sector in Russia, 450 scenario, kilotons

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	183	156	125	104	87
2: Domestic	133	125	119	113	115
3: Industrial combust.	100	105	108	111	112
4: Industrial processes	473	485	496	508	508
5: Fuel extraction	5	6	6	7	7
6: Solvents	0	0	0	0	0
7: Road traffic	42	24	16	16	15
8: Off-road sources	89	83	79	75	76
9: Waste management	107	105	102	101	101
10: Agriculture	193	193	194	194	194
Sum	1324	1281	1246	1228	1214

Table 6.10: Emission control costs by SNAP 1 sector in Russia, Current Policies scenario, million €/a

SNAP sector	2005	2009	2010	2015	2020	2025	2030	2035
1: Power generation	970	1501	1634	1688	1725	1841	1964	2133
2: Domestic	18	26	28	46	57	70	83	85
3: Industrial combust.	150	175	181	191	198	203	207	209
4: Industrial processes	672	757	778	911	1013	1041	1038	1038
5: Fuel extraction	55	77	82	112	125	140	158	158
6: Solvents	0	0	0	0	0	0	0	0
7: Road traffic	622	2052	2410	4467	6147	7565	8386	8911
8: Off-road sources	21	168	205	234	265	301	337	345
9: Waste management	0	0	0	0	0	0	0	0
10: Agriculture	11	11	11	11	11	11	11	11
Sum	2519	4766	5328	7660	9540	11170	12183	12890

Table 6.11: Emission control costs by SNAP 1 sector in Russia, New Policies scenario, million €/a

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	1647	1640	1690	1692	1698
2: Domestic	45	52	61	67	64
3: Industrial combust.	191	199	203	205	206
4: Industrial processes	911	1013	1041	1038	1038
5: Fuel extraction	112	125	140	158	158
6: Solvents	0	0	0	0	0
7: Road traffic	4462	6122	7479	8211	8570
8: Off-road sources	232	260	292	321	321
9: Waste management	0	0	0	0	0
10: Agriculture	11	11	11	11	11
Sum	7612	9421	10914	11703	12067

Table 6.12: Emission control costs by SNAP 1 sector in Russia, 450 scenario, million €/a

SNAP sector	2015	2020	2025	2030	2035
1: Power generation	1591	1420	1185	1018	894
2: Domestic	46	56	66	77	79
3: Industrial combust.	191	196	193	191	191
4: Industrial processes	911	1013	1041	1038	1038
5: Fuel extraction	112	125	140	158	158
6: Solvents	0	0	0	0	0
7: Road traffic	4387	5832	6920	7234	7043
8: Off-road sources	229	249	271	286	270
9: Waste management	0	0	0	0	0
10: Agriculture	11	11	11	11	11
Sum	7478	8901	9826	10012	9684

7 Summary and conclusions

This report assesses emissions of air pollutants for energy scenarios analyzed in the World Energy Outlook 2011. The assessment has been done with the IIASA GAINS model and covers emissions from 25 regions of the world, consistent with the aggregation of countries in the IEA World Energy Model. Presented here national emissions do not include emissions form international shipping as well as cruising emissions from aviation. Also emissions from biomass burning (deforestation, savannah burning, and vegetation fires) are not included in national totals.

The assessment takes into account the current air pollution control legislation in each country. In the Current Policies Scenario the world emissions of SO_2 (91 million tons in 2009) decrease by eight percent until 2020. In the period 2020 – 2035, the emissions increase by about three million tons. The emissions of NO_x (82 million tons in 2009) decrease until 2020 also by about nine percent and then begin to rise, so that in 2035 they are five percent higher than in 2009. Emissions of PM2.5 (41 million tons in 2009) remain at approximately the same level over the projection period.

The 450 Scenario, with stringent policies to increase energy efficiency and reduce energy-related CO_2 emissions, causes important reductions of emissions of air pollutants compared with the Current Policies case. In 2035, this reduction is 39 % for SO_2, 31 percent for NO_x, and nine percent for PM2.5. Expenditures on air pollution control in the 450 scenario are reduced in 2035 by 137 billion €/a compared with the Current Policy case. In addition, impact of air pollution on human health is much lower for the scenario with stringent climate measures. In 2035, life years lost in Europe, China and India attributable to the exposure from anthropogenic emissions of PM2.5 decrease in the 450 scenario by 27 percent, which means saving of about 870 million life years.

These numbers clearly demonstrate large co-benefits of climate policies for air pollution. Thus, synergies between climate and air pollution control policies need to be taken into account when developing targets and strategies for reducing negative environmental impacts of air pollution.

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Appendix 1

Breakdown of regions in the World Energy Model

COUNTRY GROUPS FOR WORLD ENERGY MODEL

OECD										Eastern Europe/Eurasia			
OECD Americas (OECDAMS)				OECD Asia Oceania (OECDPAC)			OECD Europe (OECDEUR) and Israel			European TE (ETE)		Russia	Caspian
								EU27					
US	Canada	Mexico	Chile	OECD Asia		OECD Oceania	Other OECD Europe	Europe 21		Europe 6	non-EU Eastern Europe/Eurasia		
US	CAN	MEX	CHILE	JPN	KOR	AUNZ	OE5	EUG4	EU17	EU6	OETE	Russia	CASP
United States	Canada	Mexico	Chile	Japan	Korea	Australia	Iceland	France*	Austria*	Bulgaria	Albania	Russia	Armenia
						New Zealand	Israel	Germany*	Belgium*	Cyprus	Belarus		Azerbaijan
							Norway	Italy*	Czech Republic	Latvia	Bosnia and Herzegovina		Georgia
							Switzerland	United Kingdom*	Denmark*	Lithuania	Croatia		Kazakhstan
							Turkey		Estonia	Malta	Gibraltar		Kyrgyzstan
									Finland*	Romania	Republic of Kosovo		Tajikistan
									Greece*		FYR of Macedonia		Turkmenistan
									Hungary		Republic of Moldova		Uzbekistan
									Ireland*		Montenegro		
									Luxembourg*		Serbia		
									Netherlands*		Ukraine		
									Poland				
									Portugal*		data not available yet		
									Slovak Republic				
									Slovenia				
									Spain*				
									Sweden*				
									* part of EU15				

Developing Countries (DC)

Non-OECD Asia (DevAsia)					Latin America (LAM)		Africa			Middle East
China	India	South East Asia (ASEAN)		Rest of Other Developing Asia	Brazil	Other Latin America	North Africa	South Africa	Other Africa	
China	**India**	**INDO**	**ASEAN9**	**ODA**	**Brazil**	**OLAM**	**NAFR**	**SAFR**	**OAFR**	**ME**
People's Republic of China	India	Indonesia	Brunei Darussalam	Bangladesh	Brazil	Argentina	Algeria	South Africa	Angola	Bahrain
Hong Kong			Cambodia	DPR of Korea		Bolivia	Egypt		Benin	Islamic Republic of Iran
			Laos*	Mongolia		Colombia	Libya		Botswana	Iraq
			Malaysia	Nepal		Costa Rica	Morocco		Cameroon	Jordan
			Myanmar	Pakistan		Cuba	Tunisia		Congo	Kuwait
			Philippines	Sri Lanka		Dominican Republic			Democratic Republic of Congo	Lebanon
			Singapore	Chinese Taipei		Ecuador			Côte d'Ivoire	Oman
			Thailand	Other Asia		El Salvador			Eritrea	Qatar
			Viet Nam	Afghanistan		Guatemala			Ethiopia	Saudi Arabia
				Bhutan		Haiti			Gabon	Syria
				Cook Islands		Honduras			Ghana	United Arab Emirates
				East Timor		Jamaica			Kenya	Yemen
				Fiji		Netherlands Antilles			Mozambique	
				French Polynesia		Nicaragua			Namibia	
				Kiribati		Panama			Nigeria	
				Laos		Paraguay			Senegal	
				Macau		Peru			Sudan	
				Maldives		Trinidad and Tobago			United Republic of Tanzania	
				New Caledonia		Uruguay			Togo	
				Papua New Guinea		Venezuela			Zambia	
				Samoa		Other Latin America			Zimbabwe	
				Solomon Islands		Antigua and Barbuda			Other Africa	
				Tonga		Aruba			Burkina Faso	
				Vanuatu		Bahamas			Burundi	
						Barbados			Cape Verde	

Developing Countries (DC)										
Non-OECD Asia (DevAsia)					Latin America (LAM)		Africa			Middle East
China	India	South East Asia (ASEAN)		Rest of Other Developing Asia	Brazil	Other Latin America	North Africa	South Africa	Other Africa	
China	**India**	**INDO**	**ASEAN9**	**ODA**	**Brazil**	**OLAM**	**NAFR**	**SAFR**	**OAFR**	**ME**
People's Republic of China	India	Indonesia	Brunei Darussalam	Bangladesh	Brazil	Argentina	Algeria	South Africa	Angola	Bahrain
Hong Kong			Cambodia	DPR of Korea		Bolivia	Egypt		Benin	Islamic Republic of Iran
			Laos*	Mongolia		Colombia	Libya		Botswana	Iraq
			Malaysia	Nepal		Costa Rica	Morocco		Cameroon	Jordan
			Myanmar	Pakistan		Cuba	Tunisia		Congo	Kuwait
			Philippines	Sri Lanka		Dominican Republic			Democratic Republic of Congo	Lebanon
			Singapore	Chinese Taipei		Ecuador			Côte d'Ivoire	Oman
			Thailand	Other Asia		El Salvador			Eritrea	Qatar
			Viet Nam	Afghanistan		Guatemala			Ethiopia	Saudi Arabia
				Bhutan		Haiti			Gabon	Syria
				Cook Islands		Honduras			Ghana	United Arab Emirates
				East Timor		Jamaica			Kenya	Yemen
				Fiji		Netherlands Antilles			Mozambique	
				French Polynesia		Nicaragua			Namibia	
				Kiribati		Panama			Nigeria	
				Laos		Paraguay			Senegal	
				Macau		Peru			Sudan	
				Maldives		Trinidad and Tobago			United Republic of Tanzania	
				New Caledonia		Uruguay			Togo	
				Papua New Guinea		Venezuela			Zambia	
				Samoa		Other Latin America			Zimbabwe	
				Solomon Islands		Antigua and Barbuda			Other Africa	
				Tonga		Aruba			Burkina Faso	
				Vanuatu		Bahamas			Burundi	
						Barbados			Cape Verde	

Developing Countries (DC)

Non-OECD Asia (DevAsia)					Latin America (LAM)		Africa			Middle East
China	India	South East Asia (ASEAN)		Rest of Other Developing Asia	Brazil	Other Latin America	North Africa	South Africa	Other Africa	
China	India	INDO	ASEAN9	ODA	Brazil	OLAM	NAFR	SAFR	OAFR	ME
						Belize			Central African Republic	
						Bermuda			Chad	
						British Virgin Islands			Comoros	
						Cayman Islands			Djibouti	
						Dominica			Equatorial Guinea	
						Falkland Islands			Gambia	
						French Guyana			Guinea	
						Grenada			Guinea-Bissau	
						Guadeloupe			Lesotho	
						Guyana			Liberia	
						Martinique			Madagascar	
						Montserrat			Malawi	
						St. Kitts and Nevis			Mali	
						Saint Lucia			Mauritania	
						Saint Pierre et Miquelon			Mauritius	
						St. Vincent and the Grenadines			Niger	
						Suriname			Reunion	
						Turks and Caicos Islands			Rwanda	
									Sao Tome and Principe	
									Seychelles	
									Sierra Leone	
									Somalia	
									Swaziland	
									Uganda	

* Laos GDP and population data only

Aggregations

Aggregated WEM region	Coverage
OECD+	OECD countries plus non-OECD EU Member States
OME	Other Major Economies (Brazil, China, Russia, South Africa and countries of the Middle East)
Other countries	All countries not belonging to OECD+ and OME (except India, which is shown on the graphs separately)