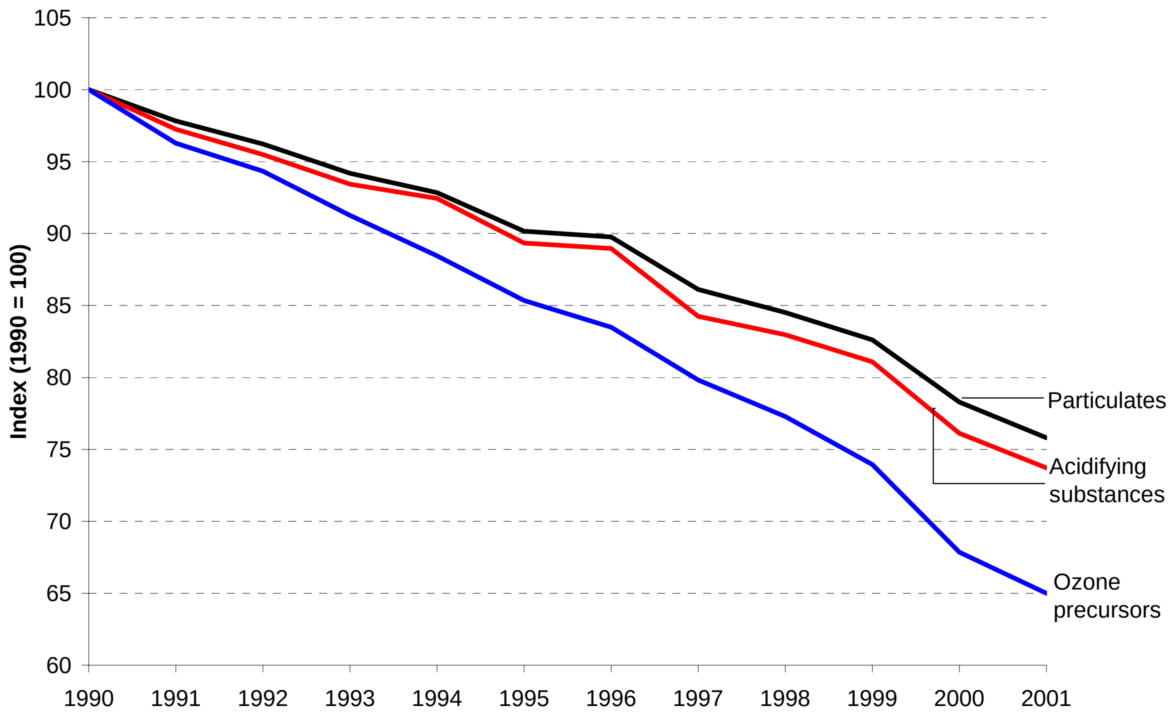
Indicator factsheet

TERM 2003 03 EEA-31 — Transport emissions of air pollutants (CO, NH_3, NO_x, NMVOC, PM_{10}, SO_x) by mode

☺ **Transport emissions of acidifying substances, ozone precursors and particulates decreased by 26, 35 and 24 %, respectively, between 1990 and 2001 in EEA-31. This was mostly a result of emission reductions realised in road transport, which in turn was due to the increased use of catalytic converters, reduced sulphur concentrations in fuels and fleet renewal. However, further reductions for all substances will be required from all sectors in order to achieve the various environmental targets set for 2010. Unlike the steady decline of emissions from EU-15, Iceland, Lichtenstein and Norway, in AC-10 emissions of acidifying substances, ozone precursors and particulates decreased by 16, 16 and 22 % between 1990 and 1993 but then remained largely stable until 1998 before decreasing further in 1999–2001 to 61, 59 and 67 % of the 1990 levels respectively. The initial sharp decline in the early 1990s was mainly due to the economic recession that impacted strongly on traffic volumes. The stabilisation of emissions, despite rising transport volumes in the second half of the 1990s, was a result of fleet renewal. Emissions from CC-3 fluctuated in the same period, ending down by 16, 12 and 18 %.**

Figure 1: Transport emissions of air pollutants for EEA-31 (acidifying substances, ozone precursors and particulates), 1990–2001

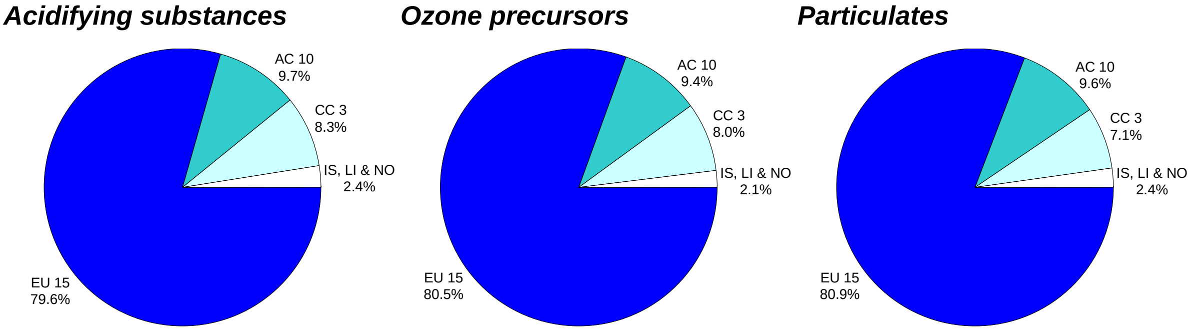


NB: The transport emissions data include all of 'road transport' and 'other transport/mobile sources', less the memo items, which include international aviation (LTO (landing and take-off) and cruise) and international marine (international sea traffic — bunkers). These are reported separately to the EMEP for information.

For explanations of the country groupings (EEA-31, EU-15, AC-10 and CC-3), please refer to the metadata section.

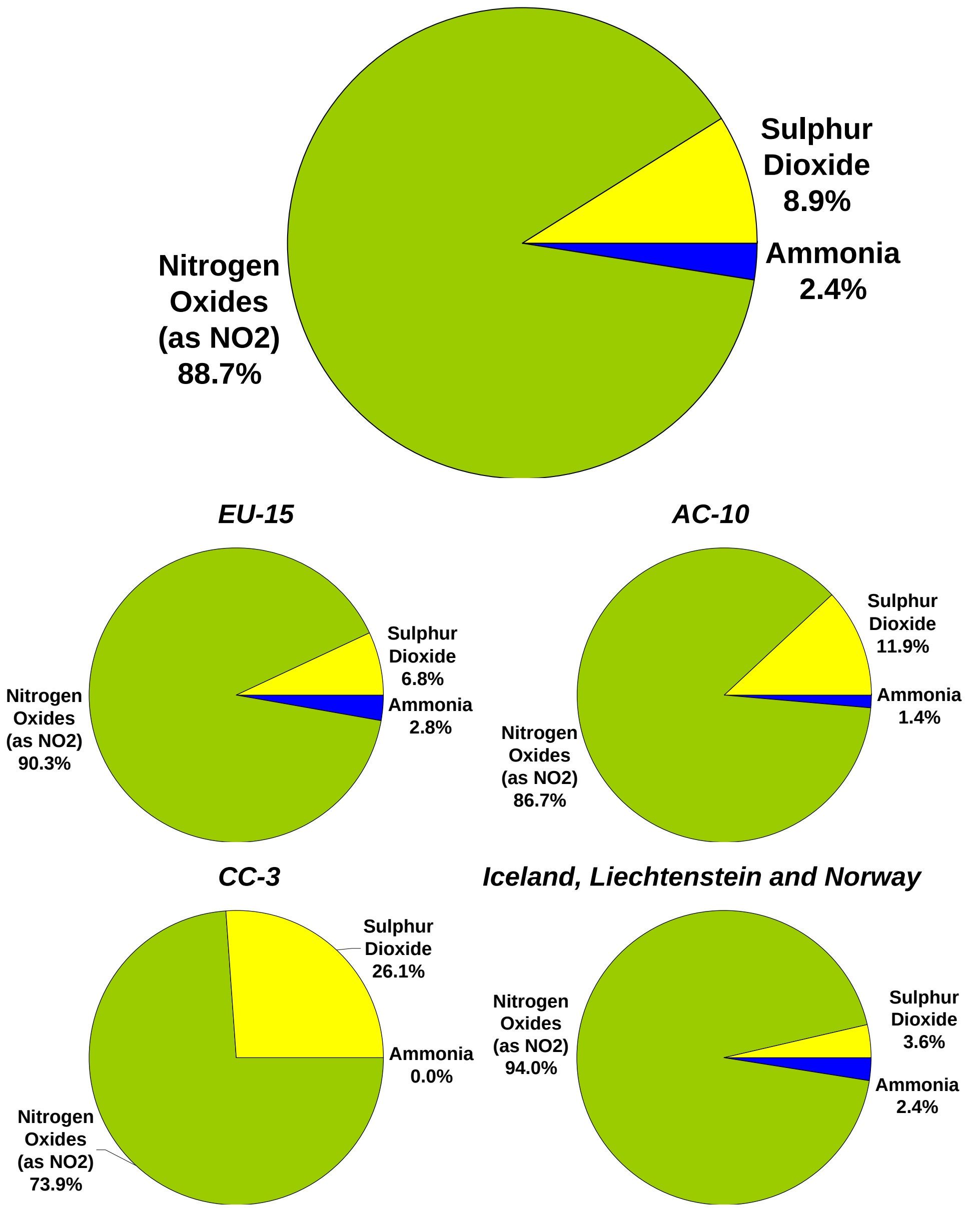
Source: EEA–ETC/ACC, 2003.

Figure 2: Split of transport emissions of air pollutants in 2001 (acidifying substances, ozone precursors and particulates by EEA-31 region (EU-15, AC-10, CC-3 and Iceland, Liechtenstein and Norway)



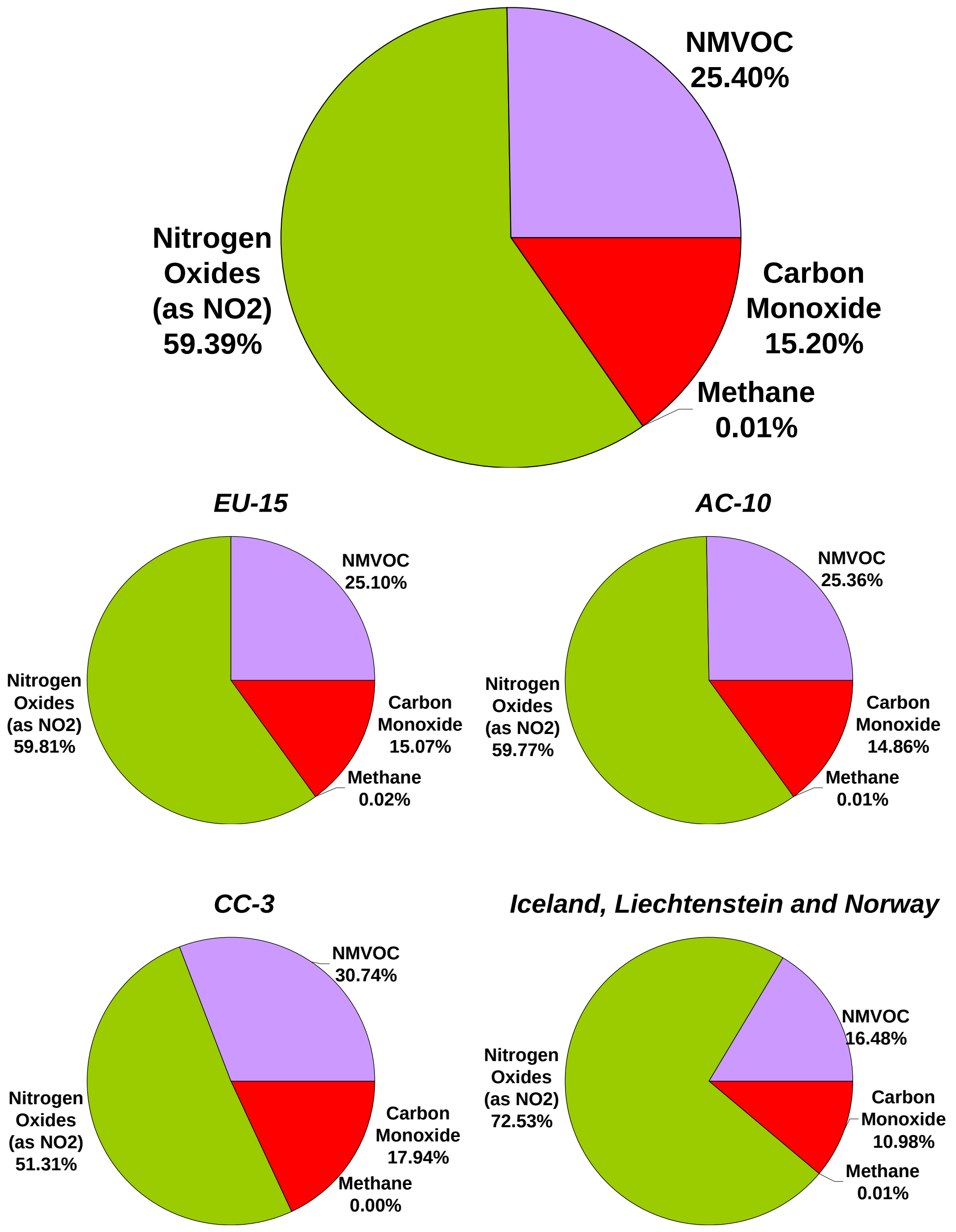
NB: For explanations of the country groupings (EEA-31, EU-15, AC-10 and CC-3), please refer to the metadata section.
Source: EEA–ETC/ACC, 2003.

Figure 3: Pollutant split of EEA-31 transport emissions of acidifying substances, 2001 (%)



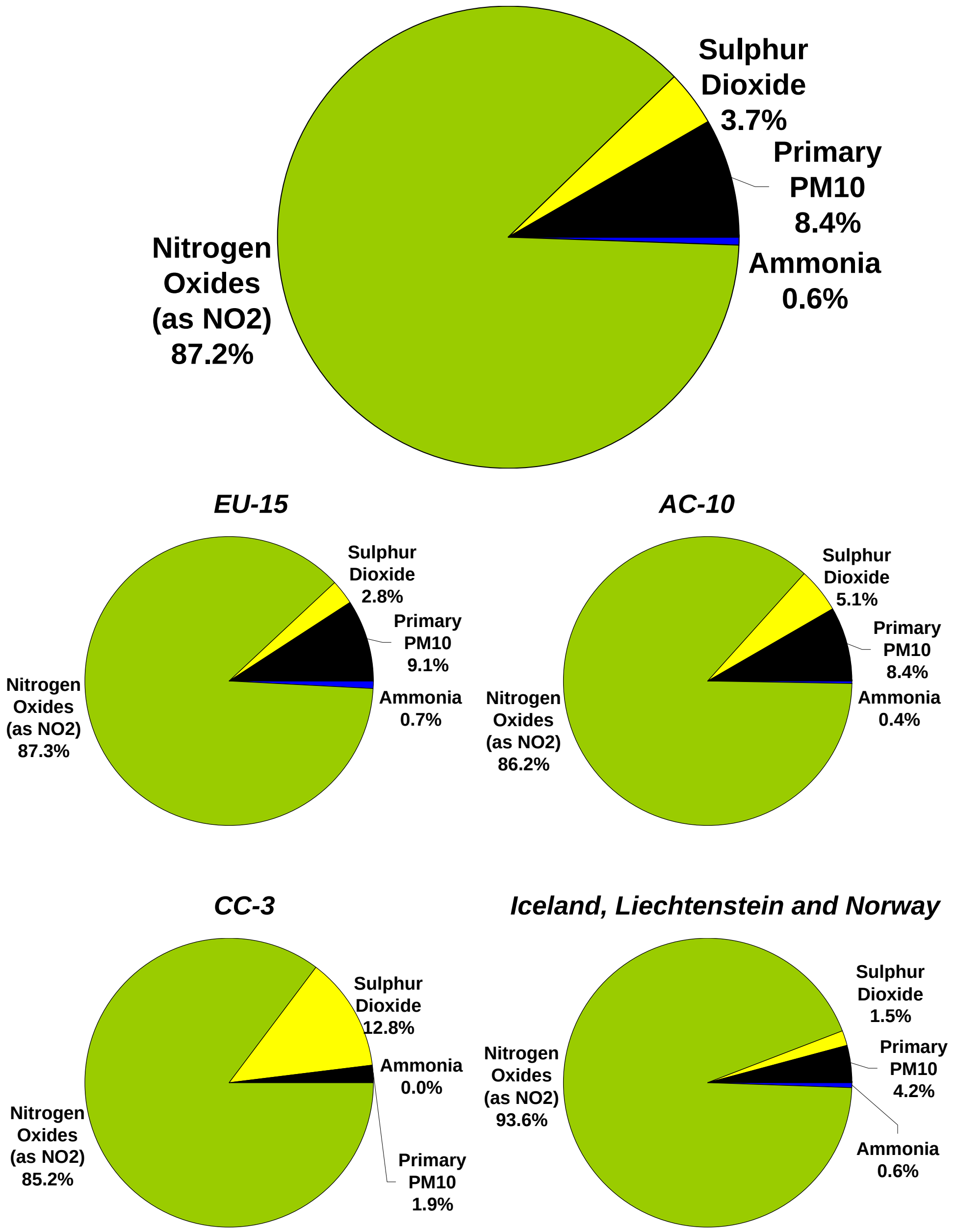
NB: For explanations of the country groupings (EEA-31, EU-15, AC-10 and CC-3), please refer to the metadata section.
Source: EEA–ETC/ACC, 2003.

Figure 4: Pollutant split of EEA-31 transport emissions of ozone precursors, 2001 (%)



NB: For explanations of the country groupings (EEA-31, EU-15, AC-10 and CC-3), please refer to the metadata section.
Source: EEA–ETC/ACC, 2003.

Figure 5: Pollutant split of EEA-31 transport emissions of particulates, 2001 (%)



NB: For explanations of the country groupings (EEA-31, EU-15, AC-10 and CC-3), please refer to the metadata section.
Source: EEA–ETC/ACC, 2003.

Results and assessment

Policy relevance

No specific emission reduction target or objective exists for transport-related emissions of acidifying substances, ozone precursors or particulates. However, environmental targets do exist for total emissions (including all sectors) of acidifying substances, ozone precursors and particulates (see Signals 2002 AP3b, Signals 2002 AP5b and Signals 2002 AP5c, respectively) as well as for air quality. The accession countries must meet emission reduction targets for 2010 as laid down in the accession treaties to comply with the national emission ceilings directive (2001/81/EC). Other countries have to comply with the ceilings provided through the 1999 Gothenburg protocol of the UNECE International Convention on Long-Range Transboundary Air Pollution. The EU Member States all also are signatories to the Gothenburg protocol.

Policy context

The transport sector is one of the main contributors to emissions of acidifying substances, ozone precursors and particulates. It is expected that the share of the transport sector in national total emissions will increase in the coming years. Therefore, without implementation of appropriate emission abatement strategies for transport it will be difficult to meet the Gothenburg protocol reduction targets.

Following the air quality framework directive (96/62/EC ([1])), a number of limit values have been set for the atmospheric concentrations of main pollutants, including sulphur dioxide, nitrogen oxides, air-borne particulate matter (PM_{10}), lead, carbon monoxide, benzene and ozone. Limits have been set at levels that should prevent or reduce harmful effects on health and ecosystems. In some countries national standards also apply.

Meeting these air quality targets for atmospheric concentrations requires reductions in emissions and particularly so in areas with dense traffic. In addition to these standards, the UNECE Convention on Long-Range Transboundary Air Pollution has adopted the long-term objective in reaching the 'Critical loads and levels for air pollution', and such long-term objectives have also been integrated into EU environmental action plans and in separate legislative acts.

The national emission ceilings directive (NECD) (2001/81/EC ([2]))covers the same pollutants as the Gothenburg protocol (sulphur dioxide, nitrogen oxides, non-methane volatile organic compounds and ammonia).

Table 1 and Table 2 summarise the main current and proposed emission targets for EEA-31. There are substantial differences in emission ceilings, and hence emission reduction percentages for different countries, due to the different sensitivities of the affected ecosystems.

Current European legislation that should contribute towards attaining the emission targets for acidifying substances and ozone precursors includes Directive 98/70/EC ([3]) on the quality of petrol and diesel fuels, and the sulphur content of certain liquid fuels (proposal for a directive amending Directive 1999/32/EC ([4])). Directive 94/63/EC ([5]) on the storage and distribution of petrol and solvents aims to limit emissions of volatile organic compounds, the integrated pollution prevention and control directive (1996/61/EC) and the large combustion plant directive (2001/80/EC).

Measures to reduce greenhouse gas emissions may also reduce emissions of acidifying substances and ozone precursors. Such measures can include fuel switching and efficiency improvements.

In the coming years, future development of policies and measures are likely to be performed in parallel between the UNECE/CLRTAP and the EU. For the UNECE/CLRTAP, it will be in the framework of revision of protocols. For the EU, it will be in the context of the European Commission 'Clean air for Europe' programme (CAFE).

Environmental context

Acidification of soils and waters is caused by emissions of sulphur dioxide, nitrogen oxides and ammonia into the atmosphere, and their subsequent chemical reactions and deposition on ecosystems and materials. For the transport sector, nitrogen oxides are the most significant pollutant. Deposition of acidifying substances causes damage to ecosystems, buildings and materials

([1]) OJ L 296, 21.11.1996, pp. 55–63.
([2]) OJ L 309, 27.11.2001, pp. 22–30.
([3]) OJ L 350, 28.12.1998, pp. 58–68.
([4]) OJ C 45 E, 25.2.2003, pp. 277–296.
([5]) OJ L 365, 31.12.1994 pp. 24–33.

(corrosion). The adverse effect associated with each individual pollutant depends on its potential to acidify and the individual properties of the ecosystems and materials.

Emissions of total non-methane volatile organic compounds (NMVOC), nitrogen oxides (NO_x), carbon monoxide (CO) and methane (CH_4) contribute to the formation of ground-level (tropospheric) ozone. Tropospheric ozone has adverse effects on human health and ecosystems. Referred to as ozone precursors, NO_x, NMVOC, CO and CH_4, can be aggregated based on their tropospheric ozone forming potential (TOFP) (de Leeuw, F. A. A. M., 2002) to assess the relative impact of emissions of the different pollutants. Transport contributes significantly to emissions of NO_x, NMVOC and CO.

Air-borne particulate matter (PM) has adverse effects on human health and can be responsible and/or contribute to a number of respiratory problems. In this assessment the particulate matter refers to the sum of primary emissions of PM_{10} and the weighted emissions of precursors leading to the secondary physico-chemical production of particulate matter in the atmosphere (secondary PM_{10}). A large fraction of the urban population is exposed to levels of fine particulate matter in excess of air quality limit values set for the protection of human health. The emissions data for primary PM_{10} are generally not as robust as those for other air pollutants and the factors used in the estimation of the secondary PM_{10} emissions are based on assumptions about the deposition and reactions of the precursor pollutants.

Assessment

Acidifying substances

Emissions of acidifying substances from transport decreased by 26 % between 1990 and 2001 in EEA-31 (and EU-15). The introduction of catalytic converters and reduced sulphur in fuels has contributed substantially to this reduction, offsetting the pressure from increased road traffic in the same period. Decreases were much larger in AC-10 (39 %), but smaller in CC-3 (16 %) and Iceland, Liechtenstein and Norway (15 %). The proportion of emissions emitted from the different country groupings in 2001 was: 79.6 % in EU-15, 9.7 % in AC-10, 8.3 % in CC-3 and 2.4 % in Iceland, Liechtenstein and Norway.

In the transport sector, NO_x (88.7 % in EEA-31) is the most important pollutant contributing to the formation of acidifying substances. Road transport contributed 15 % to the total emissions (i.e. from all sectors) of acidifying substances in 2001 for EEA-31 (17.4 % EU-15, 9.2 % AC-10, 7.5 % CC-3 and 15.5 % Iceland, Liechtenstein and Norway).

Substantial further reductions of emissions of acidifying pollutants are needed to reach the 2010 targets of the national emission ceilings directive.

Ozone precursors

Emissions of ozone precursors from transport decreased by 35 % between 1990 and 2001 in EEA-31. Reduction occurred because of increased penetration of diesel and of catalytic converters for road vehicles. Decreases were similar in the EU (36 %), much larger in AC-10 (41 %), but smaller in CC-3 (12 %) and Iceland, Liechtenstein and Norway (23 %). The proportion of emissions emitted from the different country groupings in 2001 was: 80.5 % in EU-15, 9.4 % in AC-10, 8.0 % in CC-3 and 2.1 % in Iceland, Liechtenstein and Norway.

Emissions of NO_x (59.4 %) and of NMVOC (25.4 %) were the most significant pollutants contributing to the formation of tropospheric ozone in 2001 in EEA-31. Road transport is the dominant source of ozone precursors and contributed 36 % of total ozone precursor emissions in 2001 in EEA-31 (39 % EU-15, 29 % AC-10, 26 % CC-3 and 19 % Iceland, Liechtenstein and Norway).

Total ozone precursor emissions in the transport sector are declining in most countries and in EEA-31 as a whole. They decreased by 28 % in EEA-31 between 1990 and 2001. Road transport has contributed most strongly to this reduction, as its emissions of ozone precursors decreased by 35 % over the same period, emissions from other transport decreased by 11.5 %. The contribution of transport as a whole (road and other) to the total dropped from 51 % in 1990 to 46 % in 2001.

International transport is a further significant source of ozone precursors such as NO_x (see Box 3, 'Emissions of acidifying substances from international ship traffic'). However, this is not included in the EMEP totals reported above.

Emission reductions so far have not led to fewer cases of critical levels (ecosystems) or concentration thresholds (human health). As a result, the 2010 targets will be difficult to achieve. Substantial further reductions of emissions of ozone precursor pollutants from all sectors are required to achieve the Gothenburg Protocol and the national emission ceilings directive 2010 targets. Meeting these targets requires a reduction of about 51 % of emissions of ozone precursors from 1990 levels by 2010.

According to recent studies by BMT and Entec UK for the European Commission (European Commission, 2000b and European Commission, 2002), SO_2 and NO_x from shipping are expected to increase by 2010. This means an associated increase in ozone precursor emissions.

Particulates

Emissions of particulate matter from the transport sector decreased by 24 % between 1990 and 2001 in EEA-31 (and EU-15). EEA-31 emissions of total primary PM_{10} and secondary PM_{10} precursors were reduced by 38 % over the same period. The reduction was largely a result of the continued penetration of catalytic converters and other improvements to vehicle technology, reducing the emissions of secondary particulate precursors. Decreases were much larger in AC-10 (33 %), but smaller in CC-3 (18 %) and Iceland, Lichtenstein and Norway (14 %). The proportion of emissions emitted from the different country groupings in 2001 was: 80.9 % in EU-15, 9.6 % in AC-10, 7.1 % in CC-3 and 2.4 % in Iceland, Liechtenstein and Norway. There are still few data currently available on primary particulate emissions for AC-10 and CC-3.

Emissions of NO_x (87.2 %) was the most significant pollutant contributing to atmospheric PM_{10} in 2001. Road transport is the dominant source of emissions of fine particulates, contributing 24 % to EEA-31 total emission of fine particulates.

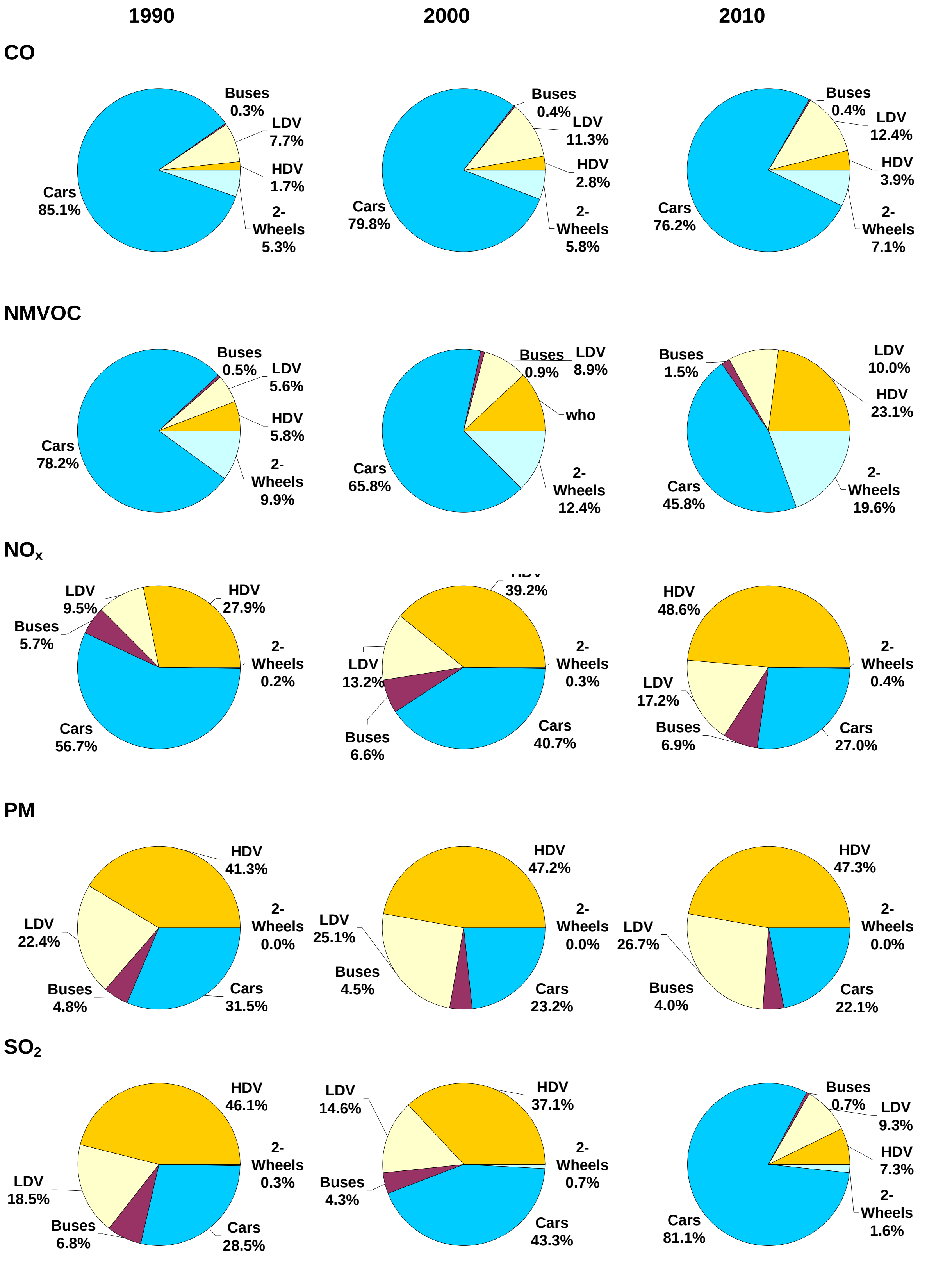
However, emissions from road transport decreased by 29 % between 1990 and 2001, contributing significantly to the overall reduction of particulate emissions. Emissions other than from road transport decreased by only 7 % over the same period.

Emissions of primary PM_{10} and secondary PM_{10} precursors are expected to decrease significantly between 2001 and 2010, as improved vehicle engine technologies are adopted and stationary fuel combustion emissions are controlled through abatement or use of low sulphur fuels such as natural gas. Despite this, it is expected that in the near future in the majority of the urban areas over EU-15 territory, PM_{10} concentrations will still be well above the limit values. Substantial further reductions in all sectors are needed to reach the limit values set in the EU first daughter directive to the framework directive on ambient air quality. Additional measures to reduce the sulphur content of diesel and petrol fuels have been decided upon by the European Commission (European Commission, 2003), which include the availability of sulphur-free (< 10 ppm sulphur or ‘zero sulphur’) fuel from 2005 in Member States, and complete transition to sulphur-free fuel by 2009. These measures should reduce emissions of NO_x and SO_2, as well as primary PM_{10}, from road vehicles in the future.

As mentioned under ‘ozone precursors’, emissions of SO_2 and NO_x from shipping in European waters are expected to increase by 2010 with an associated increase in primary and secondary PM_{10} precursors (European Commission, 2000b).

Sub-indicator: Emission of CO, NMVOC, NO_x, PM and SO_2 from road transport

Figure 6: Mode split in road transport pollutant emission for EU-15 (CO, NMVOC, NO_x, PM and SO_2), 1990, 2000 and 2010



Source: LAT/TÜV/KTI, 2003.

Emissions of CO

Total EU-15 emissions of CO from road transport were reduced by 47 % between 1990 and 2000. Carbon monoxide is mainly emitted from incomplete combustion of fossil fuels. Emission reduction of CO is mainly a result of improved inspection of road vehicles and increased penetration of diesel vehicles.

Emissions of CO from road transport contributed 53 % to total (i.e. all sectors) emissions of CO in 2000. Passenger cars were the largest CO emitters (79.8 %) in road transport in 2000 (the last year for which such data are available).

Projections assuming implementation of existing and agreed policies and measures are for a 63 % decrease in CO emissions from road transport between 1990 and 2010 (EEA/ETC–ACC, 2002b). Emissions from all vehicle categories are projected to decrease with the largest percentage reductions for passenger cars (67 %).

Emissions of NMVOC

Road transport NMVOC emissions decreased by 51 % in the EU Member States between 1990 and 2000. Road transport emissions of NMVOC account for around 28 % of total (i.e. all sectors) emissions of NMVOC.

The introduction of the exhaust catalysts and greater use of diesel in cars have contributed to the reduction of emissions from road transport. Fugitive sources such as petroleum transportation contribute 6 % to the 2000 EU emissions of NMVOC.

Projections assuming implementation of existing and agreed policies and measures are for a 75 % decrease in NMVOC emissions from road transport between 1990 and 2010 (EEA/ETC–ACC, 2002b). Emissions from all vehicle categories are projected to decrease with the largest percentage reductions for passenger cars (85 %).

Emissions of NO_x

Emissions of NO_x from road transport decreased by 25 % in EU Member States between 1990 and 2000. This was mainly due to the introduction of catalysers on new cars (see also Box 1). Increasing road travel has partly offset reductions achieved by emission abatement. Emissions of NO_x from road transport contributed 47 % to total (i.e. all sectors) emissions of NO_x in 2000. Passenger cars were the largest NO_x emitters (40.7 %) in road transport in 2000 (the last year for which such data are available), however HDVs emitted almost as much (39.2 %).

Projections assuming implementation of existing and agreed policies and measures are for a 53 % decrease in NO_x emissions from road transport between 1990 and 2010 (EEA/ETC-ACC, 2002b). Emissions from all vehicle categories are projected to decrease, with the largest percentage reductions for passenger cars (78 %) and buses (48 %).

Emissions of PM

Road transport emissions of fine particles were reduced by 26 % between 1990 and 2000. The emission of fine particles is dominated by emissions of PM_{10} precursors, which contribute 90 % of the total emissions of fine particles. Emissions of NO_x (87 %) and SO_2 (1.5 %) were the most important pollutants in 2000 contributing to secondary particulates. Light and heavy delivery vehicles were the largest fine particle emitters (25.1 and 47.2 %) in road transport in 2000 (the last year for which such data are available).

The emission reductions between 1990 and 2000 were mainly due to abatement measures, including fuel switching as well as increased penetration of catalytic converters for new road vehicles. Road transport emissions of fine particles accounted for around 28 % of total (i.e. all sectors) emissions of fine particles in 2000.

Projections assuming implementation of existing and agreed policies and measures are for a 45 % decrease in fine particles emissions from road transport between 1990 and 2010. Emissions from all vehicle categories are projected to decrease, with the largest percentage reductions for buses (55 %) and light and heavy delivery vehicles (35 and 37 %).

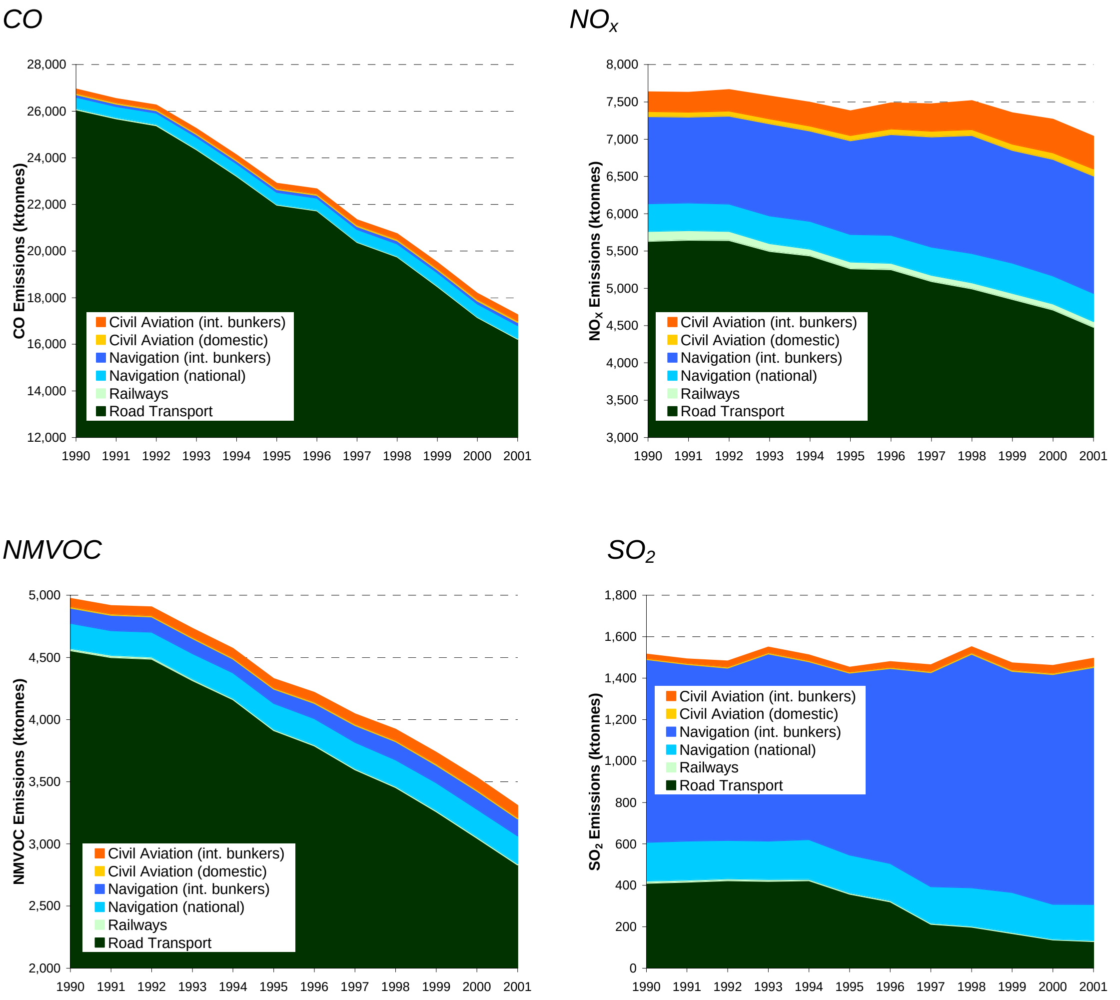
Emissions of SO_2

Road transport SO_2 emissions decreased by 74 % in the EU Member States between 1990 and 2000. Road transport emissions of SO_2 account for around 2 % of total (i.e. all sectors) emissions of SO_2. This is as a result of considerable reductions in the sulphur content of automotive fuels over the period despite increasing traffic (discussed further in Box 2).

Projections assuming implementation of existing and agreed policies and measures are for a 97 % decrease in SO_2 emissions from road transport between 1990 and 2010 (EEA/ETC–ACC, 2002b). Emissions from all vehicle categories are projected to decrease with the largest percentage reductions for buses and coaches (99.7 %).

Sub-indicator: Emissions of CO, NMVOC, NO_x and SO_2 by transport type

Figure 7: Emission trends of air pollutants (CO, NMVOC, NO_x and SO_2) by transport type in EEA-25, 1990–2001



Source: 2003 national CRF submissions to IPCC.

NB: Data from Germany, Luxembourg, Cyprus, Lithuania, Turkey and Lichtenstein are not included. International navigation and aviation figures are for international bunkers and do not take into full account emissions in the EMEP area from non-EEA-31 activities.

Assessment

Emissions of CO

Emissions of CO from transport are dominated by road vehicles, which accounted for 91 % of all carbon monoxide transport emissions and 46 % of total emissions in 2001. Emissions from most other transport modes are increasing, however their proportion of total emissions has only increased from 3.4 to 4.5 % of total emissions between 1990 and 2001. Emissions from rail transport have decreased by over 37 % in the same period (attributable partly due to increased electrification of European railways, but mainly due to direct emissions reductions from diesel powered stock).

Emissions of NMVOC

Whilst NMVOC emissions from road transport and rail are decreasing (38 and 48 % respectively), emissions from navigation (inland waterways and maritime shipping activities) and aircraft have increased between 1990 and 2001. However non-road transport has only increased from 4.2 to 4.7 % of total NMVOC emissions between 1990 and 2001. Road transport accounted for 26 % of all NMVOC emissions in 2001.

Emissions of NO_x

Whilst emissions of NO_x have decreased significantly from transport in general in EEA-31 between 1990 and 2001 (24 %, not including international bunkers), emissions from ships (international) and civil aviation (domestic and international) have increased (by 35, 37 and 69 % respectively). Increases in emissions from civil aviation reflect continued strong growth in air transport and represent an increasing proportion of total emissions. Emissions resulting from international bunkers may not accurately represent changes in emissions in the EMEP area, due to the difficulty of matching fuel bunker purchases to where emissions take place. This is demonstrated in considering a recent study (European Commission, 2002) of shipping emissions, which in the EMEP area estimates growth in NO_x emissions of 29 % (see Box 3 for further information). In this study all shipping movements in the EMEP area were considered and used as a basis to calculate emissions, rather than using a calculation based on international fuel bunkers (fuel sales).

As NO_x emissions from road transport continue to decrease, emissions from shipping are an increasingly significant source of total emissions in the EMEP area.

Emissions of SO_2

Road and rail transport emissions of sulphur dioxide have been reduced by over 69 and 57 % respectively between 1990 and 2001. This is as a result of considerable reductions in the sulphur content of automotive fuels over the period despite increasing traffic (discussed further in Box 2). Emissions from national navigation (inland waterways and shipping) have also decreased by over 7 % due to similar fuel sulphur content restrictions. However, emissions from civil aviation and international shipping activities have increased considerably due to a lack of similar tightening of regulations. Although sulphur dioxide emissions represent only a very small fraction of total sulphur emissions, maritime shipping emissions contribute considerably to totals. Recent estimates (European Commission, 2002) suggest that emissions of sulphur dioxide from international shipping activities in the EMEP area may have contributed to as much as 39 % of all emissions. This is discussed further in Box 3.

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Data

Table 1: NECD emission-reduction targets for the EU and its Member States

	2010 target reduction (on 1990 emissions) (%)			
October 2001 NECD directive	NO_x	SO_2	NMVOC	NH_3
Austria	– 49	– 57	– 56	– 17
Belgium	– 45	– 72	– 54	– 31
Denmark	– 54	– 70	– 50	– 48
Finland	– 43	– 58	– 42	– 24
France	– 57	– 72	– 56	1
Germany	– 61	– 90	– 69	– 28
Greece	6	3	– 22	– 8
Ireland	– 45	– 77	– 50	3
Italy	– 49	– 71	– 48	– 10
Luxembourg	– 53	– 73	– 53	– 7
Netherlands	– 55	– 75	– 63	– 44
Portugal	– 21	– 55	– 53	– 14
Spain	– 34	– 66	– 59	– 25
Sweden	– 58	– 40	– 53	– 23
United Kingdom	– 58	– 84	– 52	– 13
EU-15 target in NECD	***– 56***	***– 78***	***– 62***	***n/a (6)***

Source: EEA/ETC–ACC, 2002.

(6) There is no specific EU-15 target for NH_3 in Annex 2 of the EC national emissions ceilings directive.

Table 2: Gothenburg emission reduction targets for EEA-31 countries

	2010 target reduction (on 1990 emissions) (%)			
	NO_x	NMVOC	SO_2	NH_3
Austria	– 45	– 55	– 57	– 19
Belgium	– 47	– 56	– 72	– 31
Denmark	– 55	– 52	– 70	– 43
Finland	– 43	– 38	– 55	– 11
France	– 54	– 63	– 68	– 4
Germany	– 60	– 69	– 90	– 28
Greece	0	– 30	7	– 9
Ireland	– 43	– 72	– 76	– 8
Italy	– 48	– 48	– 70	– 10
Luxembourg	– 52	– 55	– 73	0
Netherlands	– 54	– 62	– 75	– 43
Portugal	– 25	– 68	– 53	10
Spain	– 24	– 39	– 65	1
Sweden	– 56	– 54	– 44	– 7
United Kingdom	– 56	– 53	– 83	– 11
European Union	***– 49***	***– 57***	***– 75***	***– 15***
Bulgaria	– 26	– 15	– 57	– 25
Czech Republic	– 61	– 49	– 85	– 35
Hungary	– 17	– 33	– 46	– 27
Latvia	– 10	– 11	– 10	0
Lithuania	– 30	– 11	– 35	0
Poland	– 31	– 4	– 56	– 8
Romania	– 20	– 15	– 30	– 30
Slovakia	– 42	– 6	– 80	– 37
Slovenia	– 27	– 5	– 86	– 17
Liechtenstein	– 41	– 45	– 27	0
Norway	– 28	– 37	– 58	0

Source: EEA/ETC–ACC, 2003.

Table 3: Transport emissions of acidifying substances EEA-31, 1990–2001

Unit: ktonnes of acidifying substances

Sulphur dioxide, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change (%) 1990–2001
EU-15	799.9	763.3	738.3	753.2	774.7	681.7	635.6	448.8	466.1	434.7	331.0	330.0	– 58.7
AC-10	213.6	157.7	150.1	102.4	101.4	99.3	108.7	104.1	96.0	92.1	68.6	70.3	– 67.1
CC-3	137.0	138.3	126.9	124.9	121.5	123.5	124.8	122.7	130.8	133.5	127.8	132.1	– 3.6
IS, LI and NO	15.7	14.6	12.6	11.5	8.9	8.7	6.9	5.8	6.1	5.6	5.7	5.3	– 66.4
EEA-31	**1166.2**	**1074.0**	**1028.0**	**992.0**	**1006.6**	**913.2**	**876.1**	**681.4**	**699.1**	**666.0**	**533.1**	**537.7**	**– 53.9**

Source: EEA/ETC–ACC, 2003.

Table 4: Transport emissions of ozone precursors EEA-31, 1990–2001

Units: ktonnes of NMVOC equivalent

TOFP, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change (%) 1990–2001
EU-15	20 035.7	19 530.2	19 293.3	18 426.0	17 663.6	16 993.3	16 492.1	15 609.0	15 017.4	14 238.5	13 289.5	12 784.0	– 36.2
AC-10	2 530.2	2 342.1	2 174.8	2 127.6	2 275.4	2 066.6	2 086.5	2 180.5	2 164.3	2 021.9	1 682.8	1 496.1	– 40.9
CC-3	1 448.3	1 250.7	1 185.8	1 344.0	1 286.4	1 409.1	1 442.4	1 346.0	1 340.6	1 448.0	1 279.8	1 278.7	– 11.7
IS, LI and NO	427.9	409.5	405.5	407.7	394.4	389.8	385.7	371.9	368.7	365.3	334.9	328.9	– 23.1
EEA-31	**24 442.0**	**23 532.6**	**23 059.4**	**22 305.3**	**21 619.8**	**20 858.8**	**20 406.6**	**19 507.4**	**18 891.0**	**18 073.9**	**16 586.9**	**15 887.7**	**– 35.0**

Source: EEA/ETC–ACC, 2002.

Table 5: Transport emissions of particulates EEA, 1990–2001

Unit: ktonnes of PM equivalent

Secondary particulates, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change (%) 1990–2001
EU-15	7 937.1	7 907.6	7 873.9	7 649.9	7 502.7	7 267.2	7 175.6	6 829.7	6 681.0	6 484.3	6 219.7	6 036.9	– 23.9
AC-10	1 117.9	1 014.9	963.1	932.9	992.6	912.6	955.8	991.6	991.5	924.0	824.3	748.4	– 33.1
CC-3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
IS, LI and NO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-
EEA-31	**9 055.0**	**8 922.5**	**8 837.0**	**8 582.8**	**8 495.3**	**8 179.8**	**8 131.3**	**7 821.3**	**7 672.5**	**7 408.3**	**7 044.1**	**6 785.3**	**– 25.1 %**

Primary particulates, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change (%) 1990–2001
EU-15	678.8	678.2	672.3	661.8	652.9	646.1	635.6	619.5	606.4	593.3	575.6	577.5	– 14.9
AC-10	60.7	60.7	60.7	60.7	60.7	60.7	59.4	60.6	64.0	62.4	62.8	62.6	3.2
CC-3	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	10.7	0.0
IS, LI and NO	10.1	9.8	10.2	10.3	9.8	9.7	9.7	9.3	9.0	8.6	7.8	7.7	– 23.5
EEA-31	**760.2**	**759.3**	**753.8**	**743.5**	**734.1**	**727.2**	**715.3**	**700.0**	**690.0**	**674.9**	**656.8**	**658.5**	**– 13.4**

Source: EEA/ETC–ACC, 2002.

Table 6: EU road transport emissions of NO_x, NMVOC, CO, PM and SO_2, 1990, 2000 and 2010

Unit: ktonnes

NO_x

	Two-wheelers	Cars	Buses	LDV	HDV	Total
1990	12 812.74	3 358 130.20	336 556.62	565 013.80	1 655 339.32	5 927 852.68
2000	11 877.53	1 878 732.24	305 105.97	610 898.91	1 808 419.22	4 615 033.87
2010	10 686.87	747 528.11	189 970.54	476 009.84	1 347 965.60	2 772 160.96
change 1990-2000	– 7 %	– 44 %	– 9 %	8 %	9 %	– 22 %
change 2000-2010	– 10 %	– 60 %	– 38 %	– 22 %	– 25 %	– 40 %
change 1990-2010	– 17 %	– 78 %	– 44 %	– 16 %	– 19 %	– 53 %

NMVOC

	Two-wheelers	Cars	Buses	LDV	HDV	Total
1990	601 068.16	4 750 973.97	33 111.77	339 624.18	353 601.68	6 078 379.77
2000	431 580.93	2 282 927.84	31 898.70	308 031.10	416 435.21	3 470 873.77
2010	301 651.21	705 077.75	22 649.75	154 471.58	356 561.31	1 540 411.59
change 1990-2000	– 28 %	– 52 %	– 4 %	– 9 %	18 %	– 43 %
change 2000-2010	– 30 %	– 69 %	– 29 %	– 50 %	– 14 %	– 56 %
change 1990-2010	– 50 %	– 85 %	– 32 %	– 55 %	1 %	– 75 %

PM

	Two-wheelers	Cars	Buses	LDV	HDV	Total
1990	—	102 905.62	15 575.15	73 135.59	134 885.27	326 501.63
2000	—	68 964.90	13 487.61	74 545.88	140 159.03	297 157.42
2010	—	39 510.14	7 072.83	47 731.26	84 630.36	178 944.57
change 1990-2000		– 33 %	– 13 %	2 %	4 %	– 9 %
change 2000-2010		– 43 %	– 48 %	– 36 %	– 40 %	– 40 %
change 1990-2010		– 62 %	– 55 %	– 35 %	– 37 %	– 45 %

CO

	Two-wheelers	Cars	Buses	LDV	HDV	Total
1990	2 091 032.49	33 479 159.99	108 486.91	3 019 258.51	661 460.66	39 359 398.56
2000	1 507 165.86	20 611 657.97	93 673.61	2 907 755.35	723 534.08	25 843 786.87
2010	1 044 258.15	11 153 806.50	57 025.06	1 810 067.45	570 935.96	14 636 093.12
change 1990-2000	– 28 %	– 38 %	– 14 %	– 4 %	9 %	– 34 %
change 2000-2010	– 31 %	– 46 %	– 39 %	– 38 %	– 21 %	– 43 %
change 1990-2010	– 50 %	– 67 %	– 47 %	– 40 %	– 14 %	– 63 %

SO_2

	Two-wheelers	Cars	Buses	LDV	HDV	Total
1990	1 042.05	114 213.41	27 147.02	74 084.09	184 888.36	401 374.93
2000	749.56	44 668.15	4 433.93	15 048.91	38 231.66	103 132.20
2010	215.75	11 113.43	90.13	1 274.07	1 005.60	13 698.98
change 1990-2000	– 28 %	– 61 %	– 84 %	– 80 %	– 79 %	– 74 %
change 2000-2010	– 71 %	– 75 %	– 98 %	– 92 %	– 97 %	– 87 %
change 1990-2010	– 79 %	– 90 %	– 100 %	– 98 %	– 99 %	– 97 %

Source: LAT/TÜV/KTI, 2003.

Table 7: EEA-31 transport emissions of SO_2, NO_x, NMVOC, CO, CH_4, NH_3 and Primary PM_{10}, 1990–2001

Unit: ktonnes

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	% Change
NH_3	15.40	17.66	22.68	29.01	37.64	45.66	55.38	61.33	66.80	72.27	75.97	78.46	409.6 %
CO	40 441.53	38 433.40	37 216.87	35 666.84	33 795.09	32 469.68	31 016.89	29 155.59	28 120.93	26 241.58	23 017.20	21 957.23	– 45.7 %
CH_4	251.00	238.56	235.27	225.69	218.35	214.04	214.70	203.88	194.11	185.51	167.34	160.02	– 36.3 %
NO_x	10 110.65	9 911.68	9 755.65	9 547.58	9 385.26	9 131.49	9 113.24	8 819.16	8 628.35	8 438.66	8 031.40	7 734.95	– 23.5 %
NMVOC	7 658.44	7 212.67	7 063.69	6 733.91	6 452.30	6 146.69	5 876.63	5 540.90	5 271.16	4 892.11	4 256.71	4 035.72	– 47.3 %
SO_2	1 166.15	1 073.97	1 027.99	991.98	1 006.60	913.20	876.06	681.44	699.09	666.04	533.08	537.66	– 53.9 %
Primary PM_{10}	760.23	759.34	753.78	743.52	734.07	727.17	715.32	699.99	689.99	674.93	656.84	658.45	– 13.4 %

Source: EEA/ETC-ACC, 2003.

File: TERM 2003 03 EEA-31-Transport emissions of air pollutants_v0.5xls

Metadata

EEA-31 = EU-15, AC-10, CC-3, Iceland, Lichtenstein and Norway.

EU-15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and United Kingdom.

AC-10 = Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

CC-3 = Bulgaria, Romania and Turkey.

A. On emissions of acidifying substances

Technical information

1 Data source: National total and sectoral emissions officially reported to the UNECE/CLRTAP/ EMEP, update 2003.

2. Description of data: Emissions of combined SO_2, NO_x and NH_3 in 1 000 tonnes of acid equivalents. Combination of data officially reported to CLRTAP/EMEP. Gaps filled by ETC/ACC where necessary using simple interpolation techniques (see 6).

   The transport emissions data include all of SNAP 7 (road transport) and 8 (other transport/mobile sources) less the memo items, which include international aviation (LTO and cruise) and international marine (international sea traffic — bunkers). These are reported separately to the EMEP for information.

3. Spatial coverage: EEA-31.

4. Temporal coverage: 1990–2001. Data before 1990 are available but not presented, as the base year for the NECD and Gothenburg protocol is 1990.

5. Methodology: Annual country data submissions to the UNECE/CLRTAP. Combination of emission measurements and emission estimates based on volume of activities and emission factors. Recommended methodologies for emission data collection are compiled in the joint EMEP/Corinair *Atmospheric emission inventory guidebook*.

6. Methodology of manipulation: Interpolation to derive annual total emission data from one country when data are missing between two different years. If the reported data are missing either at the beginning or at the end of the time-series period, the emission value has been considered to equal the first (or last) reported emission value. Acid equivalents: weighting factors (w) are used for SO_2, NO_x and NH_3, which are multiplied with the emissions (Em, Gg) and the resulting acid equivalent emissions are added (de Leeuw, F. A. A. M., 2002). Thus, total acid equivalent emission =

$w(SO_2) \times Em(SO_2) + w(NO_x) \times Em(NO_x) + w(NH_3) \times Em(NH_3)$ where weight factors are given by $w(SO_2)$ = 2/64 acid eq./g = 31.25 acid eq./kg, w(NOx) = 1/46 acid eq./g = 21.74 acid eq./kg, $w(NH_3)$ = 1/17 acid eq./g = 58.82 acid eq./kg.

Qualitative information

7. Strengths and weaknesses:

Strength: Officially reported data following agreed procedures and emission inventory guidebook, e.g. regarding source sector split.

Weakness: The acidifying coefficients are not agreed and used in all EEA-31 countries.

8. Reliability, accuracy, robustness, uncertainty: The individual uncertainties in the individual pollutants are discussed in the indicator factsheets for the individual substances. The trend is likely to be much more accurate than individual absolute annual values — the annual values are not independent of each other. However, not all countries apply changes to methodologies back to 1990.

9. Overall scoring (1–3, 1 = no major problems, 3 = major reservations): 2

   Relevancy: 1.
   Accuracy: 2 (Acidifying coefficients not agreed and used in all EEA-31 countries).
   Comparability over time: 2.
   Comparability over space: 2.

B. On emissions of ozone precursors

Technical information

1. Source: Emissions of CO, NO_x and NMVOC — national total and sectoral emissions officially reported to the UNECE/CLRTAP/EMEP, update 2003.

CH_4 — national total and sectoral emissions data officially reported to the UNFCCC and EU monitoring mechanism, update 2001 (national annual greenhouse gas inventories).

2. Description: Emissions of TOFP in 1 000 tonnes in terms of NMVOC equivalent. Combination of official data reported to the UNFCCC and CLRTAP with additional data reported to the EEA–ETC/ACC. TOFP is the tropospheric ozone forming potential of each of the air pollutants that contribute to ozone formation in the troposphere.

   The transport emissions data include all of SNAP 7 (road transport) and 8 (other transport/mobile sources), less the memo items, which include international aviation (LTO and cruise) and international marine (international sea traffic — bunkers). These are reported separately to the EMEP for information.

3. Spatial coverage: EEA-31.

4. Temporal coverage: 1990–2001. Data available before 1990, but not presented, as the base year for the NECD and Gothenburg protocol is 1990.

5. Methodology: Annual country data submissions to the CLRTAP or UNFCCC (for methane). Combination of emission measurements and emission estimates based on volume of activities and emission factors. Recommended methodologies for emission data collection are compiled in the joint EMEP/CORINAIR *Atmospheric emission inventory guidebook*.

6. Methodology of manipulation: interpolation to derive annual total emission data from one country when data are missing between two different years. If the reported data are missing either at the beginning or at the end of the time-series period, the emission value has usually been considered to equal the first (or last) reported emission value. TOFP were calculated according to each compound's typical tropospheric ozone-forming potential. Factors are NO_x 1.22, NMVOC 1, CO 0.11 and CH_4 0.014 (de Leeuw, F. A. A. M., 2002). Results are in NMVOC equivalents (1 000 tonnes).

Qualitative information

7. Strengths and weaknesses:

Strength: Officially reported data following agreed procedures and now Strachan, e.g. regarding source sector split.

Weakness: Available data sets do not include full EEA-31 for all years. Reporting to the CLRTAP/EMEP, UNFCCC and EEA–ETC/ACC can be incompatible for some countries. Incomplete reporting and resulting intra- and extrapolation may obscure some trends. The TOFP does not, as yet, have wide support or recognition in the EEA-31 countries.

8. Reliability, accuracy, robustness, uncertainty: The individual uncertainties of the estimates for individual gases are discussed in the factsheets for these gases. The trend is likely to be much more accurate than for individual absolute annual values — the annual values are not independent of each other.

9. Overall scoring (1–3, 1 = no major problems, 3 = major reservations): 2

   Relevancy: 2 (Measures emissions of precursors).
   Accuracy: 2 (See factsheets for individual pollutants).
   Comparability over time: 2.
   Comparability over space: 2.

C. On emissions of particulates

Technical information

1. Source: Primary PM_{10} — Auto-Oil II studies (data for 1990, 1995 and 2000). Secondary PM_{10} precursors (NO_x, SO_2 and NH_3) — national total and sectoral emissions officially reported to the UNECE/CLRTAP/EMEP, update 2002 (EMEP/MSC-W Note 1/01).

2. Description: Emissions of secondary PM_{10} made using aerosol formation factors provided by the ETC/ACC, NO_x = 0.88, SO_2 = 0.54 and NH_3 = 0.64 (de Leeuw, F. A. A. M., 2002).

   The transport emissions data include all of SNAP 7 (road transport) and 8 (other transport/mobile sources), less the memo items, which include international aviation (LTO and cruise) and international marine (international sea traffic — bunkers). These are reported separately to the EMEP for information.

3. Spatial coverage: EEA-31.

4. Temporal coverage: 1990–2001. The best coverage is from 1990 to 2001 for NO_x, SO_2 and NH_3.

5. Methodology: Annual country data submissions to the CLRTAP. Combination of emission measurements and emission estimates based on volume of activities and emission factors. Recommended methodologies for emission data collection are compiled in the joint EMEP/Corinair *Atmospheric emission inventory guidebook*.

6. Methodology of manipulation: interpolation to derive annual total emission data from one country when data are missing between two different years. If the reported data are missing either at the beginning or at the end of the time-series period, the emission value has usually been considered to equal the first (or last) reported emission value. Emissions of secondary PM_{10} are made using aerosol formation factors provided by the ETC/ACC. Factors are NO_x = 0.88, SO_2 = 0.54 and NH_3 = 0.64. Results are in PM_{10} equivalents (1 000 tonnes).

Qualitative information

7. Strengths and weaknesses:

Strength: Officially reported data for SO_2, NO_x and NH_3 following agreed procedures, e.g. regarding source sector split.

Weakness: Primary PM_{10} data are uncertain, have been compiled with input from countries, but not official data sets, and are based on an original 1990 data set compiled by the TNO. Available data sets do not include all years and had to be interpolated. Reporting to the CLRTAP/EMEP, UNFCCC and EEA–ETC/ACC can be incompatible for some countries. Incomplete reporting and resultant extrapolation may obscure some trends. The aerosol formation factors do not, as yet, have wide support or recognition.

8. Reliability, accuracy, robustness, uncertainty: The uncertainties for the emission estimates of individual gases, SO_2, NO_x and NH_3, are discussed in their individual factsheets. The primary PM_{10} data are likely to be very uncertain, but also the aerosol formation factors are uncertain. The trend is likely to be much more accurate than individual absolute annual values.

9. Overall scoring (1–3, 1 = no major problems, 3 = major reservations): 2

Relevancy: 1 (Aggregates used to better connect to environmental problems related to emissions of the listed substances).
Accuracy: 2 (Aggregates do not, as yet, have wide support or recognition in EEA-31 countries; some gaps in the series).
Comparability over time: 1.
Comparability over space: 2 (Aggregates do not, as yet, have wide support or recognition in EEA-31 countries).

Further work required

Countries should improve the completeness of the time-series of their estimates (filling gaps). Further validation and checking is the responsibility of the country and needs, especially, to lead to improved detailed sectoral time-series of emissions. There is also a need for further validation and checking of emission estimates within the framework of CLRTAP/EMEP and EEA–ETC/ACC activities.

The approach of TOFP values needs wider recognition and acceptance.

For the emissions of particulates, each country should report primary PM_{10} on an annual basis. The use of aerosol formation factors needs to be given wider recognition and acceptance.

Box 1: Effectiveness of measures to reduce NO_x emissions from road transport

Nitrogen oxide emissions from road transport in EU-15 countries increased by about 20 % from 1980 to 1990 and then fell, so that by 2000 they essentially returned to the 1980 levels.

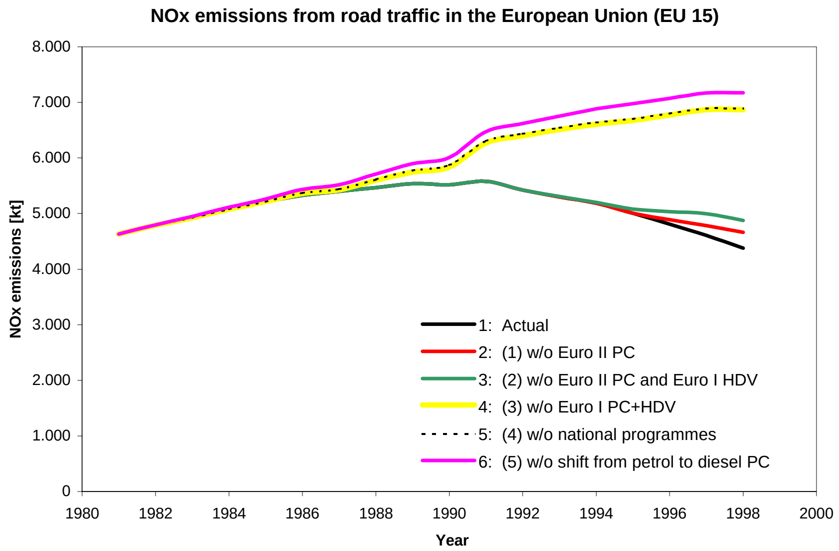
That the emission did not continue to increase in line with traffic growth was mainly due to the introduction of three-way catalyst converters to cars in the late 1980s and early 1990s. Although many Member States had encouraged the penetration of cars with catalyst converters before 1990, Directive 91/441/EEC made it effective in all Member States. Emission standards for heavy-duty vehicles, as demanded by Directive 91/542/EEC, Stage I, also contributed to the emission reduction although to a lesser extent. Without these measures, nitrogen oxide emissions by traffic in the EU would have been 50 % higher in 1998.

After 1995, the effects became apparent with the introduction of stricter emission standards for both heavy-duty vehicles (91/542/EEC, Stage II) and passenger cars (94/12/EC). It is expected that these will lead to further reductions in the near future.

Additional measures at national levels, implemented in the late 1980s, such as the early introduction of oxidation catalysers for petrol cars, did not have any significant effect, but stimulating the use of three-way catalysers was a much more drastic measure.

The gradual increase in sales of diesel passenger cars in some European countries contributed further to a reduction in nitrogen oxide emissions, which was significant in Austria, Belgium, Germany, France and the Netherlands. Increased use of diesel across the EU caused a drop in emissions of 2 to 4 % in the 1990s.

Figure 8: Effectiveness of measures to reduce NO_x emissions from road transport in EU-15



NB: Emission estimates of the ForeMove/Copert model. Disaggregated data are not available for 1999 emissions, EEA, 2000.

Source: EEA–ETC/ACC, 2003a.

Box 2: Sulphur in fuels

The European Commission has completed a consultation process on the need to reduce the sulphur content of petrol and diesel fuels below 50 parts per million (the standard required by 2005). Options being considered for the period post-2005 were a reduction of the sulphur content to either 'lower than 30 ppm' or 'lower than 10 ppm'. The results of this consultation (European Commission, 2000c) indicated that there is overall qualitative agreement that lowering the sulphur content of petrol and diesel can improve the emissions performance of engines and after-treatment devices.

For the present vehicle fleet, lower sulphur fuels will slow the degradation of exhaust catalysers and facilitate a partial restoration of catalyser efficiency, leading to lower emissions of hydrocarbons, carbon monoxide, nitrogen oxides and, for diesel vehicles, particulate material. Submissions on the size of these benefits ranged from suggesting that they are negligible, to indicating that they could deliver worthwhile benefits to air quality in urban areas. Many respondents felt that the benefits resulting from a reduction to a 10 ppm sulphur limit could be significantly greater than a 30 ppm limit.

With future vehicle production, the main benefit identified from adopting lower sulphur fuels was improved fuel economy, though the automotive industry believes that 'lower than 10 ppm' diesel is also essential for HGVs to meet future Euro IV and V emission limits. Quantitative data, mainly from vehicle manufacturers, estimated the fuel economy benefit to be 1 to 5 % relative to fuel with 50 ppm for future petrol vehicles. Smaller fuel economy improvements for diesel vehicles are also expected, but quantification is more uncertain.

The disbenefits of a lower sulphur fuel grade are increases in CO_2 emissions at the refinery, associated to sulphur separation, and additional investment costs. These CO_2 emissions are greater for 'lower than 10 ppm' fuels, although there is significant uncertainty as to the actual increase.

Following this work a Commission proposal has passed Directive 2003/17/EC (European Commission, 2003a) to amend Directive 98/70/EC. The directive mandates the introduction of zero sulphur (< 10 ppm) petrol and diesel fuels by no later than 1 January 2005. This is consistent with the entry into force in 2005 of the new Euro IV vehicle emissions limits and the requirement of some new automotive technologies to use zero sulphur fuels in order to attain these limits. The amending Directive states that zero-sulphur fuel should be made available 'on an appropriately balanced geographical basis' from 1 January 2005 and made mandatory from 2009.

The reasoning behind this amendment is that by 2009 the composition of vehicle fleets able to take full advantage of the lower sulphur content will be sufficient to more than offset any disadvantages due to additional refining of the fuel. The availability of zero-sulphur petrol (< 10 ppm) would lead to an improvement in the fuel economy of future gasoline direct injection cars by 1–5 % compared with similar vehicles using fuel containing a maximum of 50 ppm sulphur. It would also lead to lower emissions of conventional pollutants from the existing fleet of petrol vehicles.

Box 3: Emissions of acidifying substances from international ship traffic

According to a recent study for the European Commission (European Commission, 2002), shipping in European waters was responsible for emitting around 2.6 million tonnes of sulphur dioxide and 3.6 million tonnes of nitrogen oxides in 2000. This equates to 39 % of total SO_2 emissions and 36 % of total NO_x emissions from EU-15 countries as reported under UNECE guidelines. (Total ship emissions of hydrocarbons and for PM in ports only account for around 1.3 and 0.1 % of national totals respectively.) The study also demonstrated that 80 % of the total shipping emissions of NO_x and SO_2 arise from vessels at sea, other than ferries and fishing boats, with the largest proportion of this figure contributed by vessel movements between EU-15 ports (34 %). This is substantially higher than previous estimates of 1.9 mtonnes of sulphur dioxide and 2.3 mtonnes of nitrogen oxides (European Commission, 2000b).

The European Commission 2002 study also concludes that it is clear that the majority of emissions arise from certain key groups of movements including, in order of decreasing priority:

- EU-15 Member States to EU-15 Member States;
- EU-15 Member States to non-member, non-accession candidate country States;
- non-member, non-accession candidate country states to EU-15 Member States.

On the basis of planned reductions, emissions of SO_2 and NO_x in 2010 are still projected to exceed critical loads for ecosystems. Clearly there is scope for international shipping to make a contribution to emissions reduction and help close the gap between the expected results of currently planned actions and the desired position of the elimination of exceeding critical loads and to improving air quality.

EU regional action to tackle ship emissions is legally possible by means of environmentally differentiated incentive schemes and, in some cases, by regulatory instruments, even where these go beyond global international standards, such as those in Marpol, Annex VI.

The European Commission 2000b report concludes that regional regulation of foreign transiting vessels in European territorial seas and beyond is not feasible for NO_x, as it would require the imposition of CDEM (construction, design, equipment and manning) rules and standards higher than generally accepted international CDEM rules or standards.

However, the report believes that such a regulatory approach is feasible for SO_2, since it can be regarded as imposing emission, rather than CDEM, rules and standards. Since there is a direct correlation between fuel sulphur content and emissions, the emission standard can be met simply by burning low sulphur fuel. In-port SO_2 emission regulations would, therefore, not have the effect of imposing permanent requirements on foreign ships.

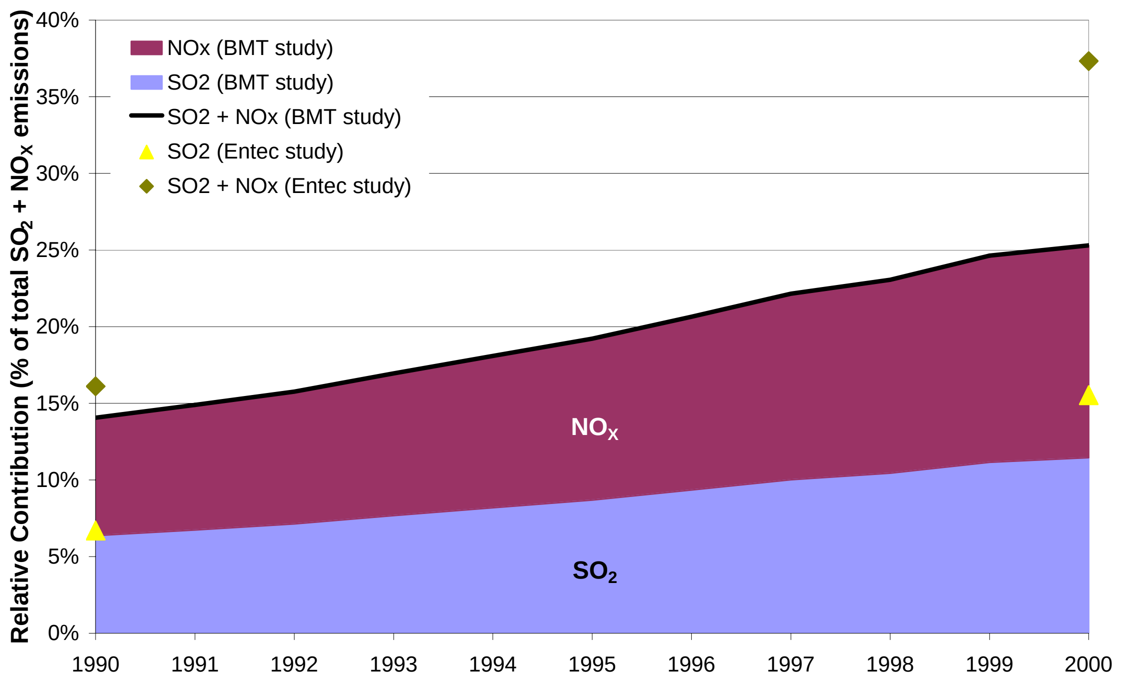
The European Commission 2000b study also examines two alternative regulatory approaches to SO_x emissions, both of which could result in a reduction of 30 to 40 % of total present emissions. It concludes that EC legislation regulating SO_2 emissions by setting limits on the sulphur content of fuel consumed by ships in territorial waters is preferable to regulating limiting sulphur content at the point of sale, as the latter approach would distort the present bunker market. Modelling work suggests that a sulphur limit of 1 % would be most cost-effective and would also tie in with the EC liquid fuels directive, which is primarily aimed at non-marine emitters.

The European Commission 2002 study assessed the feasibility of multiple fuel storage by vessels, and its overall conclusion is that, while there are technical, engineering and cost issues to be addressed, these would not present an insurmountable barrier to duel-fuel usage. According to European Commission 2000b, such a regulation on consumption, with a limit of 1 %, is likely to reduce emissions at a cost of USD 1 000 per tonne of SO_2 emission abated. A 35 % emission reduction achieved in this way would cost shipping an estimated USD 700 million per annum.

With regards to economic incentives, the European Commission 2000b study concludes that for control of both SO_2 and NO_x emissions a nationally operated, but port-administered, levy system is to be preferred to a port-based, port-dues-linked scheme. It suggests that ultimately, an NO_x incentive scheme may be capable of producing emission reductions of up to 50 %. The greatest uncertainty concerns the pace of adoption, and it will undoubtedly take many years to achieve this level. Achievement of NO_x reductions of this order by incentive schemes is estimated to cost between USD 800 and USD 1 200 per tonne of NO_x abated.

Overall, the achievement of substantial emission reductions of the order of 40 % or so would be feasible from a combination of measures reviewed by the study. The likely cost to shipping is estimated to be in the order of USD 3 billion per annum.

Figure 9: Contribution from international shipping in the Baltic, Black, Mediterranean and North Seas and the north-east Atlantic Ocean to total European acidifying emissions



Source: European Commission, 2000b and European Commission, 2002.

NB: Emissions from the European Commission, 2002 study also include the Black Sea, Caspian Sea and in-port emissions.