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Task ID number	Task Title	ETC Task leader	EEA contact person(s)
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Indicator Title

Indicator title:	EEA32 - Transport emissions of air pollutants (CO, NH_3, NO_X, NMVOCs, PM_{10}, SO_X) by mode
ETC/ACC Indicator ID	TERM 2006 03
Sub indicators, ID + title	Emission of CO, NMVOC, NO_X, PM and SO_X from road transport Emissions of CO, NMVOC, NO_X and SO_X by transport type

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Internal ETC/ACC Review (by ETC-members and data source owners)

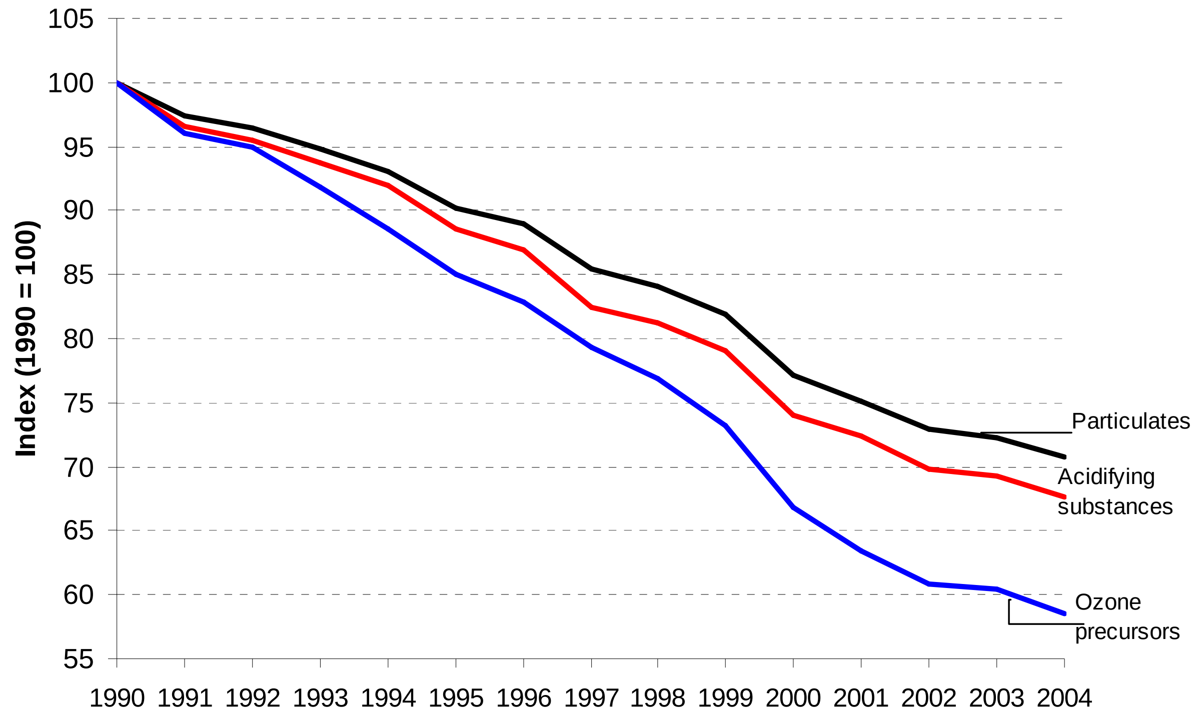
Date	Reviewer/Person	Institution	Modifications / Reason for modification

Indicator fact sheet

TERM 2006 03 — Transport emissions of air pollutants (CO, NH_3, NO_x, NMVOCs, PM_{10}, SO_x) by mode

☺ Transport emissions of acidifying substances, ozone precursors and particulates decreased by 32%, 41% and 29%, respectively, between 1990 and 2004 in the EEA32. 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 of 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 the EU15 and EFTA4, in the EU10 emissions of acidifying substances, ozone precursors and particulates decreased by 22%, 14% and 16% between 1990 and 1993 but then remained largely stable until 1998 before decreasing further in 1999-2004 to 66%, 69% and 75% 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 the AC4 have fluctuated in the same period, with emissions of acidifying substances, ozone precursors and particulates reduced by 13%, 10% and 16% respectively by 2001, but have risen sharply since then to 109%, 126% and 110% of the respective 1990 values by 2004. This rise is almost entirely attributable to significant growth in NO_x emissions from Bulgaria and Turkey.

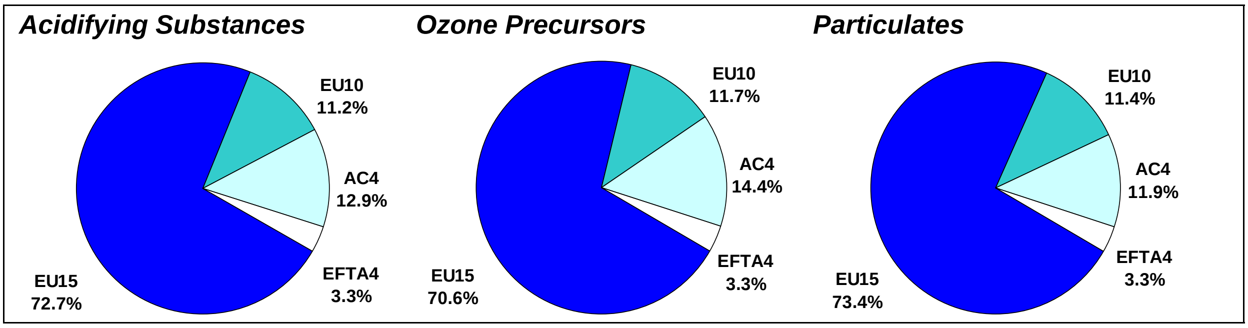
Figure 1: Transport emissions of air pollutants for EEA32 (acidifying substances, ozone precursors and particulates), 1990-2004 (indexed: 1990 = 100)



Notes: 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 EMEP for information.
For explanations of the country groupings (EEA32, EU15, EU10, AC4 and EFTA4), please refer to the meta-data section.

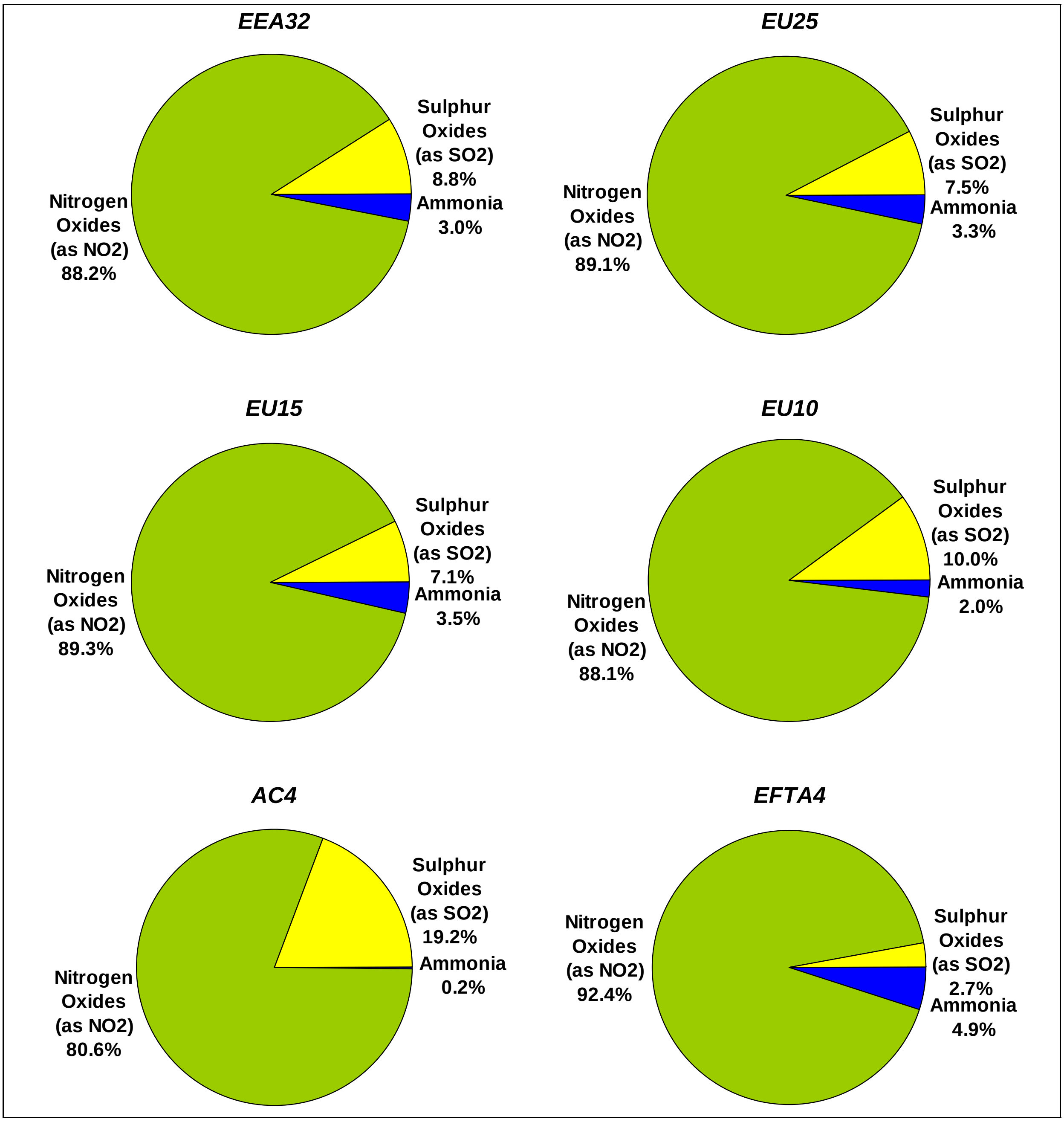
Source: EEA-ETC/ACC, 2006.

Figure 2: 2004 split of transport emissions of air pollutants (acidifying substances, ozone precursors and particulates by EEA32 region & Croatia (EU15, EU10, AC4 and EFTA4)



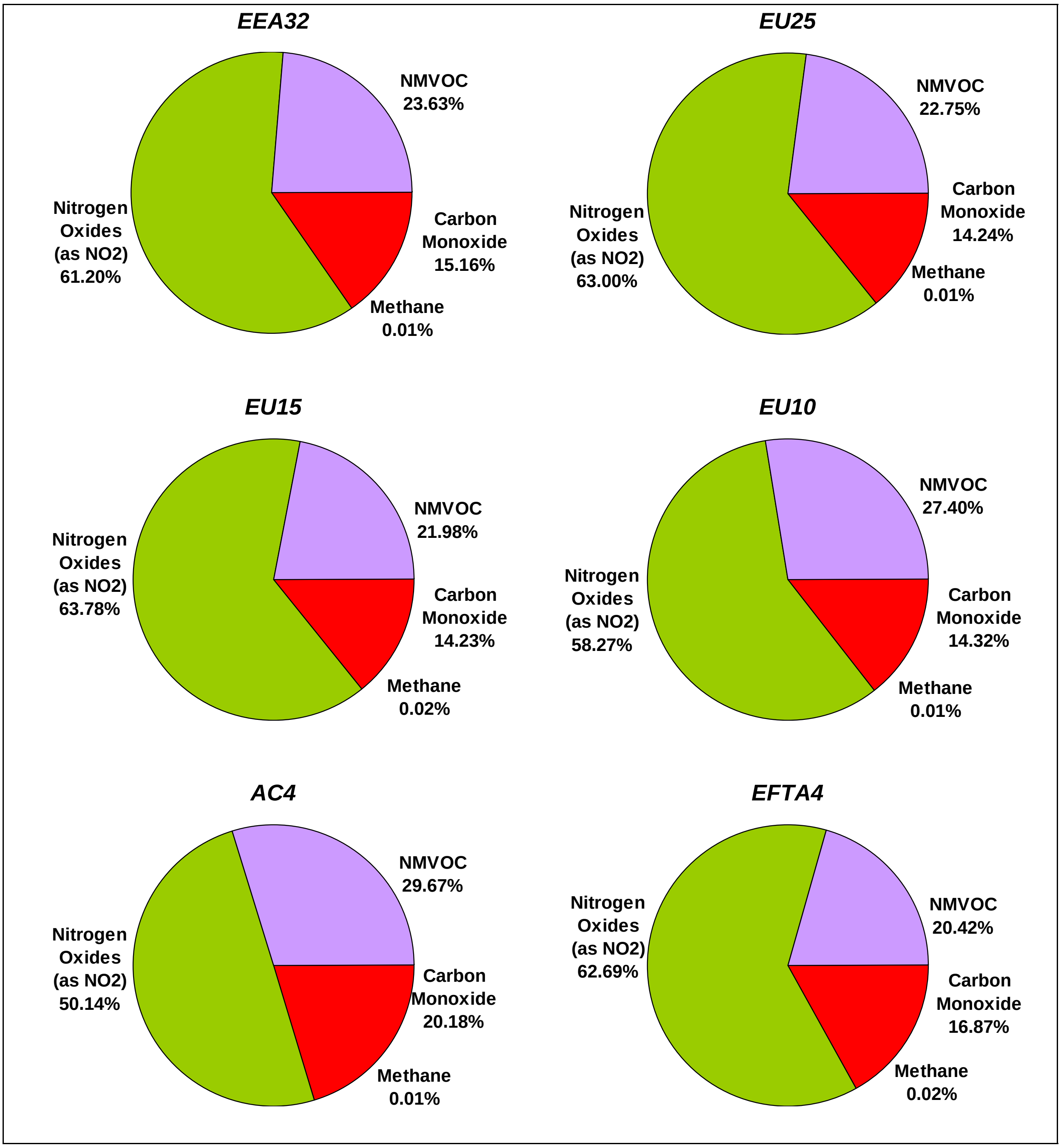
Notes: For explanations of the country groupings (EEA32, EU15, EU10, AC4 and EFTA4), please refer to the meta-data section.
Source: EEA-ETC/ACC, 2006.

Figure 3: Pollutant split of EEA32 transport emissions of acidifying substances, 2004 (%)



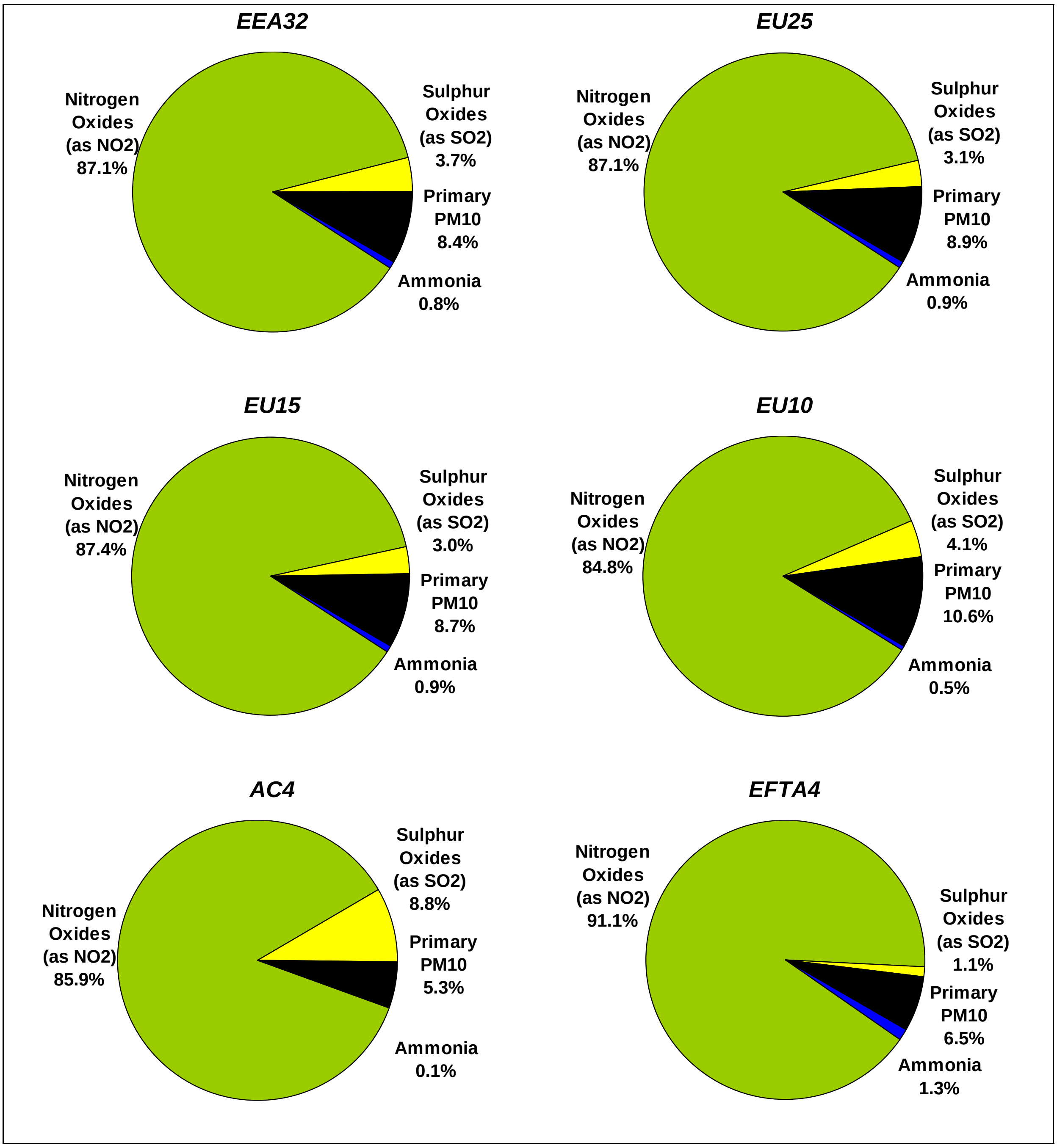
Notes: For explanations of the country groupings (EEA32, EU25, EU15, EU10, AC4 and EFTA4), please refer to the meta-data section. Of the EU10, NH_3 data was not provided by Poland. Of the AC4, Turkey did not provide NH_3 data or SO_X data for other transport. Of the EFTA4, Iceland did not provide NH_3 data.
Source: EEA-ETC/ACC, 2006.

Figure 4: Pollutant split of EEA32 transport emissions of ozone precursors, 2004 (%)



Notes: For explanations of the country groupings (EEA32, EU25, EU15, EU10, AC4 and EFTA4), please refer to the meta-data section.
Source: EEA-ETC/ACC, 2006.

Figure 5: Pollutant split of EEA32 transport emissions of particulates, 2004 (%)



Notes: For explanations of the country groupings (EEA32, EU25, EU15, EU10, AC4 and EFTA4), please refer to the meta-data section. Of the EU10, NH_3 data was not provided by Poland. Of the AC4, NH_3 data was not provided at all by Turkey and neither was SO_X for other transport. Of the EFTA4, Iceland did not report NH_3 or PM_{10} data.
Source: EEA-ETC/ACC, 2006.

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 EEA factsheets: CSI01 'Emissions of acidifying substances', CSI02 'Emissions of ozone precursors' and CSI03 'Emissions of primary particles and secondary particulate precursors', respectively) as well as for air quality. The new EU10 Member States must meet emission reduction targets for 2010 as laid down in the accession treaties (Treaty of Accession to the European Union 2003) to comply with the National Emission Ceilings Directive (2001/81/EC), and which also contains emission ceiling targets for the EU15 Member States. 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 EU15 Member States are also all 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 may also increase in the coming years, due to a greater rate of progress in total emissions reductions from other sectors. Therefore, without implementation of appropriate emission abatement strategies for transport it will be difficult to meet the National Emission Ceilings Directive and Gothenburg Protocol reduction targets. Reductions in these emissions are necessary for improvements in both the environment and public health.

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 limit values for atmospheric concentrations is likely to require 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"; such long term objectives have also been integrated into EU environmental action plans and in separate legislative acts.

Both the National Emission Ceilings Directive (NECD) (2001/81/EC ([2])) and Gothenburg protocol cover the same pollutants as the Gothenburg protocol (sulphur dioxide, nitrogen oxides and non-methane volatile organic compounds and ammonia).

Table 1 and Table 2 summarise the main current and proposed emission targets for the EEA32. There are substantial differences in emission ceilings, and hence emission reduction percentages for different countries, due to the different sensitivities of the affected ecosystems and technical feasibility for reductions.

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). The Thematic Strategy from CAFE is expected in late 2005.

([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 045 E, 25.02.2003, pp. 277–296.
([5]) OJ L 365, 31.12.1994 pp. 24–33.

Environmental context

Acidification of soils and waters is caused by emissions of sulphur oxides, 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 acidifying pollutant. Deposition of acidifying substances causes damages to ecosystems, buildings and materials (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. NO_x, NMVOC, CO and CH_4, (referred to as ozone precursors), can be aggregated based on their tropospheric ozone forming potential (TOFP) (de Leeuw, 2002) to assess the relative impact of emissions of the different pollutants. Transport contributes significantly to emissions of NO_x, NMVOC and CO.

Airborne 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, '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 inorganic particulate matter in the atmosphere (secondary PM_{10}) (de Leeuw, 2002). 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

Emission of acidifying substances from transport decreased by 32.4% between 1990 and 2004 in the EEA32. The introduction of both catalytic converters and reduced sulphur in fuels have contributed substantially to this reduction, offsetting the pressure from increased road traffic in the same period. Decreases between 1990 and 2004 in the different country groupings were: 36% in EU25, 36% in EU15, 34% in EU10, 9% in AC4 and 35% in EFTA4. The proportion of emissions emitted from the different country groupings in 2004 was: 73% in EU15, 11% in EU10, 13% in AC4 and 3% in EFTA4.

In the transport sector, NO_x is the most important pollutant contributing to the formation of acidifying substances, comprising 88% of total transport-related acidifying emissions in the EEA32. Road transport contributed 14% to the total emissions (i.e. from all sectors) of acidifying substances in 2004 for the EEA32 (15% of total emissions in EU25, 17% EU15, 10% EU10, 10% AC4 and 16% EFTA4).

Further reductions of emissions of acidifying pollutants are needed to reach the 2010 targets of the National Emission Ceilings Directive (Targets: -56.9% for EU25, -56.3% for EU15 and –50.6% for EU10).

Ozone precursors

Emissions of ozone precursors from transport decreased by 41% between 1990 and 2004 in the EEA32. Reductions have occurred mainly because of increased penetration catalytic converters for road vehicles as a result of tightening of EU regulations on new vehicle emissions limits. Decreases were slightly larger in the EU15 (48%), less in the EU10 (31%), AC4 (26%) and larger in the EFTA4 (47%). The proportion of emissions emitted from the different country groupings in 2004 was: 35% in EU15, 39% in EU10, 32% in AC4 and 26% in EFTA4.

Emissions of NO_x (61%) and of NMVOC (24%) were the most significant pollutants contributing to the formation of tropospheric ozone in 2004 in the EEA32. Road transport is the dominant source of ozone precursors and contributed 34% of total ozone precursor emissions in 2004 in the EEA32 (35% EU15, 30% EU10, 33% AC4 and 25% EFTA4).

Total ozone precursor emissions are declining in most countries and in the EEA32 as a whole. They decreased by 36% in the EEA32 between 1990 and 2004. Road transport has contributed most strongly to this reduction, as its emissions of ozone precursors decreased by 49% over the same period, with emissions from other transport increasing by 1.5%. The contribution of transport as a whole (road and other) to the total dropped from 50% in 1990 to 46% in 2004.

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 exceedances of critical levels (ecosystems) or concentration thresholds (human health). 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 54.9% of emissions of ozone precursors from 1990 levels by 2010 for the EU25 (-52.9% for EU15 and -26.2% for EU10).

According to recent studies by BMT and Entec UK for the European Commission (European Commission, 2000b and European Commission, 2003), 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 29% between 1990 and 2004 in the EEA32 (and 32% in EU25). EEA32 emissions of total primary PM_{10} and secondary PM_{10} precursors were reduced by 44% over the same period. The reduction from transport has been achieved largely as a result of the continued penetration of catalytic converters and other improvements to vehicle technology, reducing the emissions of secondary particulate precursors. Decreases were similar in the EU15, EU10 and EFTA4 (33%, 25% and 34% respectively), but smaller in AC4 (10%). The proportion of emissions emitted from the different country groupings in 2004 was: 73% in EU15, 11% in EU10, 12% in AC4 and 3% in EFTA4. There is much better data available on primary particulate emissions for EU10 and AC4 compared to previous years.

Emission of NO_X (87%) was the most significant pollutant contributing to atmospheric PM_{10} in 2004. Road transport is the dominant source of emissions of fine particulates, contributing 22% to the EEA32 total emission of fine particulates.

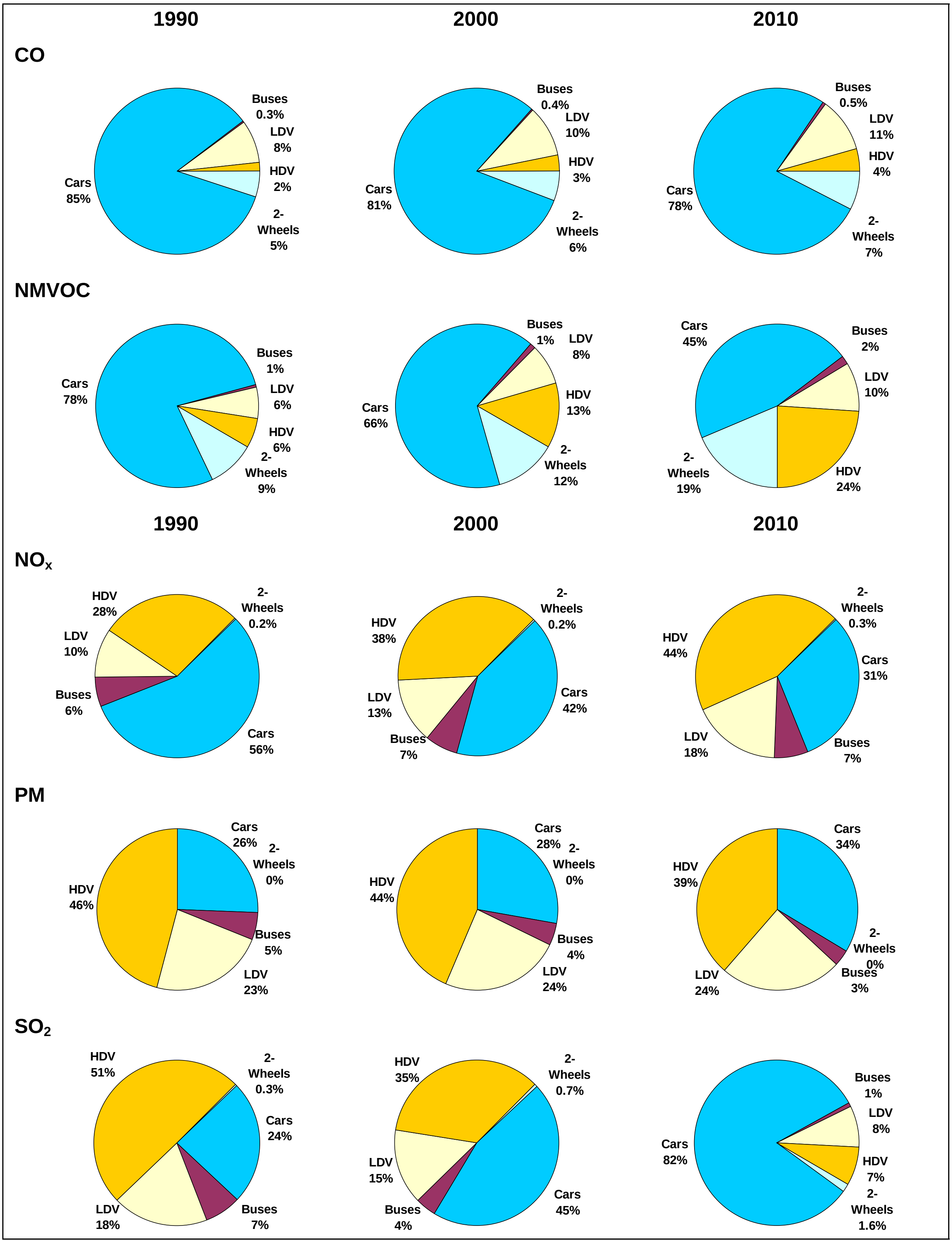
However, emissions from road transport decreased by 36% between 1990 and 2004, contributing significantly to the overall reduction of particulate emissions. Emissions from sources other than road transport decreased by only 8% over the same period.

Emissions of primary PM_{10} and secondary PM_{10} precursors are expected to decrease significantly between 2004 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 EU15 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 included the availability of the 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_X, as well as primary PM_{10}, from road vehicles in the future.

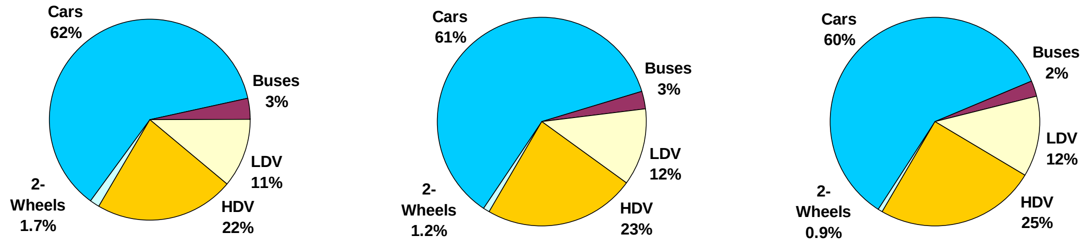
As mentioned under ’ozone precursors’, emissions of SO_2 and NO_X from shipping in European waters are expected to increase by 2010 with an associated increase in primary and secondary PM_{10} precursors (European Commission, 2000b).

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 EU15 (CO, NMVOC, NO_x, PM and SO_2), 1990, 2000 and 2010



Fuel consumption (by volume)



Source: LAT, 2004.

Assessment of emissions from road transport

Emissions of CO from road transport

Total EU15 emissions of CO from road transport were reduced by 64% between 1990 and 2004. 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. CO emissions from road transport contributed 44% to total (i.e. all sectors) emission of CO in 2004. Passenger cars were the largest CO emitters (81%) 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 from road transport

Road transport NMVOC emissions decreased by 69% in the EU Member States between 1990 and 2004. Road transport emissions of NMVOC account for around 22% 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 contributed 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 from road transport

NO_x emissions from road transport decreased by 38% in EU Member States between 1990 and 2004. 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. NO_X emissions from road transport contributed 42% to total (i.e. all sectors) emissions of NO_x in 2004. Passenger cars were the largest NO_x emitters (42%) in road transport in 2000 (the last year for which such data are available), however HDVs emitted almost as much (38%). 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 from road transport

Road transport emissions of fine particles were reduced by 40% between 1990 and 2004. The emission of fine particles is dominated by emissions of PM_{10} precursors, which contribute over 90% of the total emissions of fine particles. Emissions of NO_x (87%) and SO_2 (3.0%) were the most important pollutants in 2004 contributing to secondary particulates in the EU15. Cars/heavy delivery vehicles were the largest fine particle emitters (28%/44%) in road transport in 2000 (the last year for which such data are available), with light delivery vehicles contributing 24%. The emission reductions between 1990 and 2004 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 27% of total (i.e. all sectors) emissions of fine particles in 2004.

Emissions are expected to reduce significantly over the coming years due to both tighter emissions controls under the Euro 4 and proposed Euro 5 standards for cars and LDV (from 2005, est. 2009) and Euro IV (2005) & V (2008) for HDV, plus increasing use of particulate filters. 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/heavy delivery vehicles (35/37%).

Emissions of SO_2

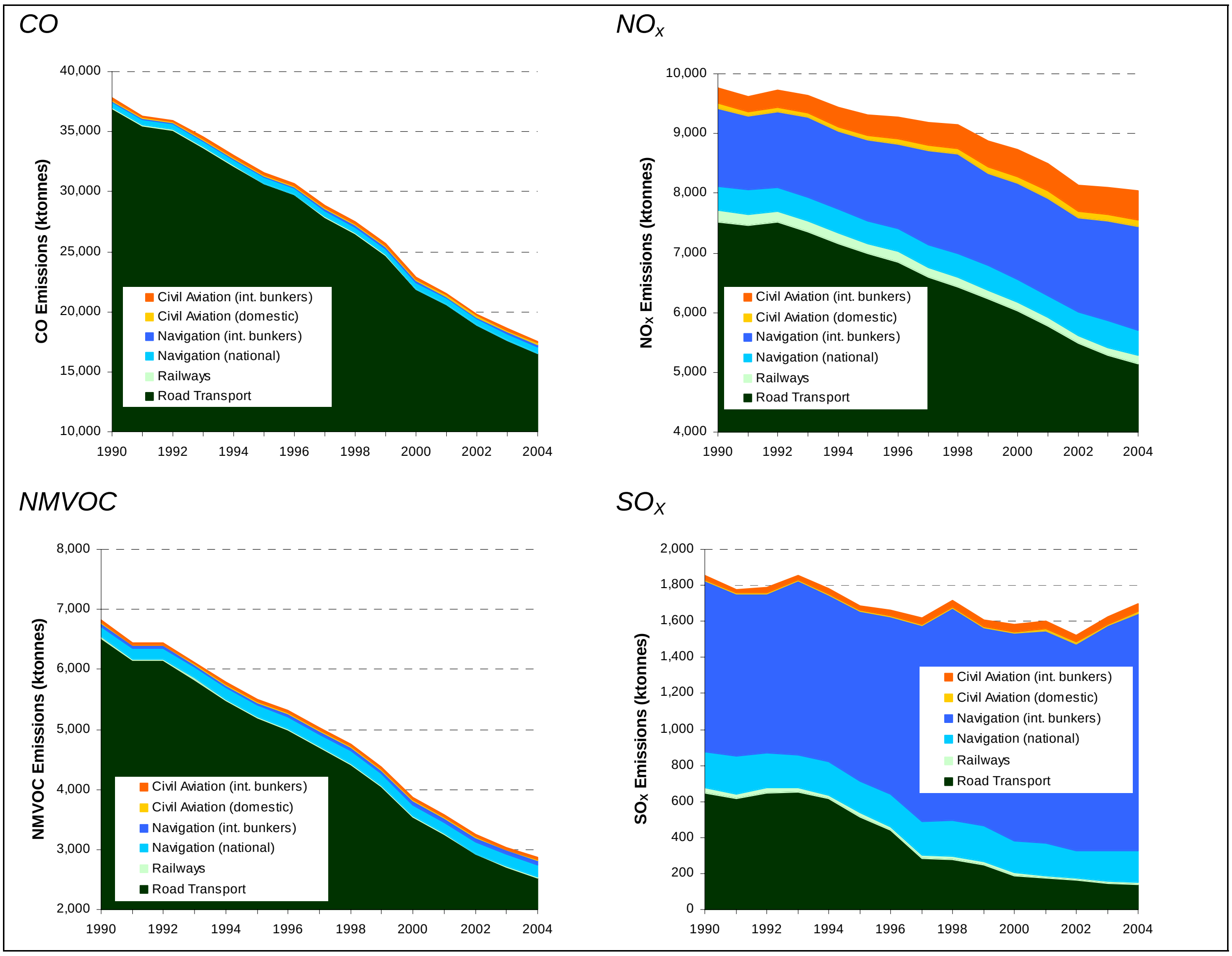
Road transport SO_2 emissions decreased by 88% in the EU Member States between 1990 and 2004. Road transport emissions of SO_2 account for just over 1% of total (i.e. all sectors) emissions of SO_2. This is as a result of considerable reductions in the sulphur content of automotive fuels over the period 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%).

Emissions Relative to Fuel Consumption from road transport

Relative to the volume of fuel consumed, passenger cars (76% petrol in 2000) and two-wheelers emit larger than their relative share of CO and NMVOC (the two-wheeler share of NMVOC is particularly large). Conversely LDV (76% diesel in 2000) and heavy duty vehicles (HDV and buses) emit larger than their share of NOx and PM. This is mostly a result of the differences between petrol and diesel engine technologies, however the proportions of emissions are expected to move towards reducing this imbalance between 2000 and 2010 with the existing policy measures (tailpipe emission limits). Two significant exceptions include the increasing proportion of HDV NOx emissions and the even larger increase of NMVOC emissions from two-wheelers (19% in 2010, relative to 1% total fuel consumed). This can be attributed to the significantly higher type approval tailpipe emission limits for current and future two-wheeler standards relative to petrol vehicles. SO_2 emissions are directly linked to fuel sulphur content and therefore follow fuel consumption more closely. Up until the end of 2004 the sulphur limits for petrol and diesel under Directive 98/70/EC were 150 ppm and 350 ppm respectively, explaining the greater contribution of diesel vehicles to SO_2 emissions. From 2005 the limit values for both petrol and diesel drop to 50 ppm.

Sub-indicator: Emissions of CO, NMVOC, NO_X and SO_X by transport type

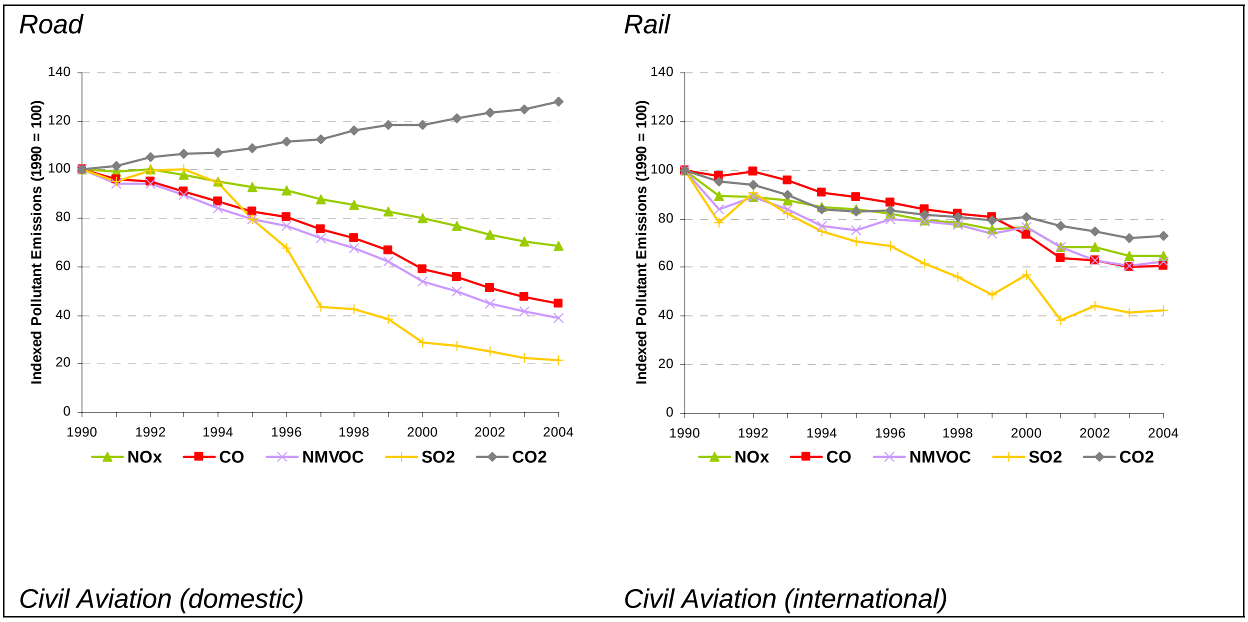
Figure 7: Emission trends of air pollutants (CO, NMVOC, NO_X and SO_X) by transport type in the EEA32, 1990 –2004

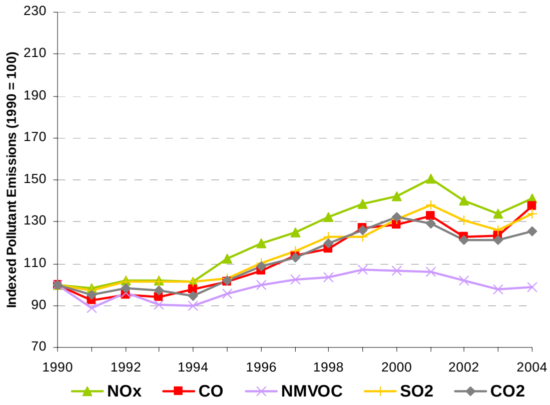


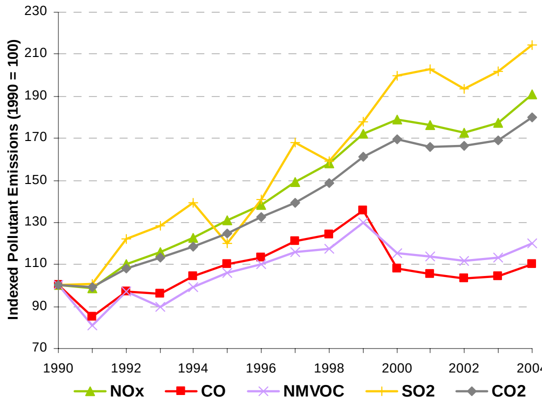
Source: 2006 National CRF submissions to IPCC.

Notes: Data from Liechtenstein was not available. Data from Slovenia was not available for most pollutants and modes. International navigation and aviation figures are for international bunkers and do not take into full account emissions in the EMEP area from non-EEA32 activities.

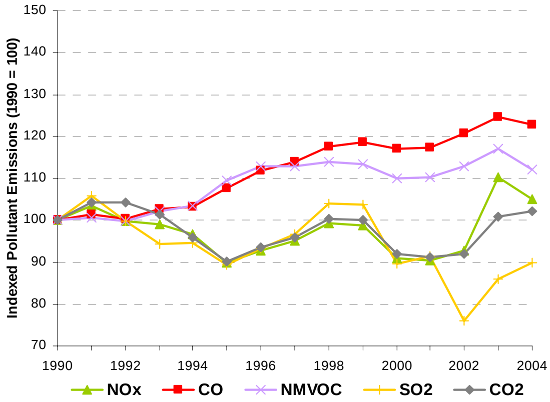
Figure 8: Indexed emission trends of air pollutants (CO, NMVOC, NO_X and SO_X) and CO_2 by transport type in the EEA32, 1990 –2004



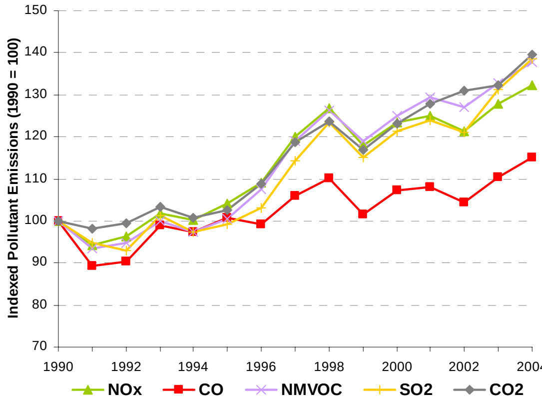




Navigation (national)



Navigation (international)



Source: 2006 National CRF submissions to IPCC.

Notes: Data from Liechtenstein was not available. Data from Slovenia was not available for most pollutants and modes. International navigation and aviation figures are for international bunkers and do not take into full account emissions in the EMEP area from non-EEA32 activities.

Assessment of emissions by transport type

Emissions of CO from transport

Total transport emissions of CO have decreased by 54% between 1990 and 2004 (including international bunkers reported). Emissions of CO from transport are dominated by road vehicles (discussed earlier), which accounted for 94% of all carbon monoxide transport emissions and 46% of total emissions in 2004. Emissions from most of the other transport modes are increasing, however their combined proportion has only increased from 2.5% to 5.8% of total transport emissions between 1990 and 2004.

Emissions of NMVOC from transport

Total transport emissions of NMVOC have decreased by 58% between 1990 and 2004 (including international bunkers reported). Whilst NMVOC emissions from road transport and rail are decreasing (61% and 38% respectively), emissions from navigation (inland waterways and maritime shipping activities) and aircraft have increased between 1990 and 2004. However non-road transport has increased from 3.6% to 11.6% of total NMVOC emissions between 1990 and 2004. Road transport accounted for 88% of all NMVOC emissions in 2004.

Emissions of NO_x from transport

Whilst emissions of NO_x have decreased significantly from transport in general in EEA32 between 1990 and 2004 (26%, including international bunkers), emissions from ships (international) and civil aviation (domestic & international) have increased (by 32%, 41% and 91% 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. In May 2006 the Commission also posted a formal recommendation on the use of shore electric power supply in ports to further reduce emissions in sensitive areas (European Commission, 2006).

Similarly for air transport, where particular concern is mainly in the rapid growth in contributions to global warming. CO_2 emissions from the aviation sector currently contribute about 3% of total human induced emissions (compared to road transport which is over 20%). A significant portion of the global warming impact of aviation in fact comes from emissions of water vapour and of NO_x, which causes ozone formation, especially at high altitudes (EurActiv, 2005). The total global warming impact is estimated at 2-3 times that of the CO_2 emissions alone.

Emissions from rail transport have decreased by 38% in 1990-2004; this is attributable partly to increased electrification of European railways, but is mainly due to direct emissions reductions from diesel-powered stock. In the period 1998-2001, electrification of railway lines (rather than rolling stock) and increased from 48% to 51% (whilst total length of railway lines decreased by 4% in the same period). However, UIC (International Railways Union) emission limits for CO, NMVOC, NO_x and PM from diesel engines have decreased by around 25% since 1993 (and 60% since 1982). Emissions from new diesel rail vehicles are for the first time controlled under the NRMM Directive (European Commission, 2004), with 3A limit values for railcar and locomotive engines applying from 2006 and 2009 respectively (reducing NO_x 30-40% relative to UIC II limits), and further reductions (around 90% PM) in a second stage, 3B, from 2012. The rail industry has undergone its own review for the EC of possible reductions using technical and operational measures from the current fleet, as well as initial indications for the new fleet (under the so called UIC 'Rail Diesel Study'). The study, which completed reporting at the end of 2005, indicated a number of technical and non-technical options for emissions reductions from the current and future fleets (AEAT, 2005).

Emissions of SO_X from transport

Total transport emissions of SO_X have decreased by 60% between 1990 and 2004 (including international bunkers reported). Road and rail transport emissions of sulphur dioxide have been reduced by over 79% and 58% respectively between 1990 and 2004. This is as a result of considerable reductions in the sulphur content of automotive fuels (also in most cases the same as rail diesel fuel) over the period despite increasing traffic (discussed further in Box 2). Emissions from national navigation (inland waterways and shipping) have also decreased by 10% due to similar fuel sulphur content restrictions. However, emissions from civil aviation (domestic and international) and international shipping activities have increased considerably (34%, 114% and 38% respectively). This is partly due to a lack of similar tightening of regulations (kerosene and marine heavy fuel oil respectively), but mainly due to significant growth in these two areas. This is demonstrated in the figures showing indexed emissions for different modes, where it can be seen that for navigation the levels of SO_2 increase at a similar or lower rate than those of CO_2 (a good indicator of fuel consumption). For aviation, the rate of increase in SO_2 emissions outstrips the increase of CO_2 emissions, indicating that there may be a degree of movement of sulphur between automotive fuels and aviation fuel fractions at the refinery.

Although (non-bunker fuel) 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, together with developments in reductions to limits for sulphur in marine fuels under Directive 2005/33/EC (European Commission, 2005).

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Data

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

		2010 Target Reduction % (on 1990 emissions)			
		NO_x %	NMVOC %	SO_2 %	NH_3 %
EU15	Austria	-51%	-44%	-47%	-4%
EU15	Belgium	-54%	-61%	-73%	-34%
EU15	Denmark	-53%	-49%	-69%	-48%
EU15	Finland	-43%	-42%	-58%	-18%
EU15	France	-56%	-57%	-72%	-1%
EU15	Germany	-63%	-72%	-90%	-27%
EU15	Greece	15%	-7%	7%	-8%
EU15	Ireland	-47%	-50%	-77%	3%
EU15	Italy	-49%	-43%	-74%	3%
EU15	Luxembourg	-52%	-53%	-73%	0%
EU15	Netherlands	-53%	-62%	-74%	-49%
EU15	Portugal	3%	-34%	-50%	65%
EU15	Spain	-32%	-42%	-66%	7%
EU15	Sweden	-52%	-46%	-43%	4%
EU15	United Kingdom	-60%	-50%	-84%	-22%
EU10	Cyprus	28%	-3%	-15%	5%
EU10	Czech Republic	-47%	-50%	-86%	-49%
EU10	Estonia	-19%	-30%	-63%	10%
EU10	Hungary	-17%	-33%	-50%	-27%
EU10	Latvia	-12%	37%	4%	-6%
EU10	Lithuania	-30%	-15%	-35%	0%
EU10	Malta				
EU10	Poland	-31%	-4%	-56%	-8%
EU10	Slovakia	-41%	1%	-79%	-40%
EU10	Slovenia	-29%	-9%	-86%	-17%
EU15	***Sum of EU15 targets***	***-51%***	***-54%***	***-77%***	***-13%***
EU10	***Sum of EU10 targets***	***-32%***	***-22%***	***-64%***	***-17%***
EU 25	***Sum of EU25 targets***	***-49%***	***-50%***	***-73%***	***-14%***
EU25	***EU25 target in NECD***	***-53%***	***-57%***	***-74%***	***n/a***[6]

[6] There is no specific EU25 target for NH_3 specified under the National Emissions Ceilings Directive.

Source: Calculated on the basis of 2010 targets (ktonnes) specified in the National Emission Ceilings Directive (2001/81/EC) and amended by the Treaty of Accession to the European Union 2003 and the most recent 1990 reported emissions (EEA/ETC-ACC, 2006).

Notes: Although official, EU10 targets are temporary and "are without prejudice to the review of the NEC Directive…".

The "EU 25 target in NECD" is the target set in the NEC Directive, representing a stretch beyond the sum of the individual Member State targets (and hence is in greater than the "Sum of EU25 targets").

Table 2: Gothenburg Emission reduction targets for EEA32 countries

		2010 Target Reduction % (on 1990 emissions)			
		NO_X %	NMVOC %	SO_2 %	NH_3 %
EU15	Austria	-49%	-44%	-47%	-4%
EU15	Belgium	-53%	-59%	-71%	-34%
EU15	Denmark	-53%	-49%	-69%	-48%
EU15	Finland	-43%	-42%	-55%	-18%
EU15	France	-53%	-54%	-70%	-1%
EU15	Germany	-62%	-72%	-90%	-27%
EU15	Greece	15%	-7%	12%	-8%
EU15	Ireland	-47%	-50%	-77%	3%
EU15	Italy	-49%	-43%	-72%	3%
EU15	Luxembourg	-52%	-53%	-73%	0%
EU15	Netherlands	-52%	-61%	-74%	-49%
EU15	Portugal	7%	-26%	-46%	98%
EU15	Spain	-32%	-41%	-64%	7%
EU15	Sweden	-52%	-46%	-43%	4%
EU15	United Kingdom	-60%	-50%	-83%	-22%
EU10	Czech Republic	-47%	-50%	-85%	-35%
EU10	Hungary	-17%	-33%	-46%	-27%
EU10	Latvia	22%	37%	10%	-6%
EU10	Lithuania	-30%	-15%	-35%	0%
EU10	Poland	-31%	-4%	-56%	-8%
EU10	Slovakia	-41%	1%	-79%	-40%
EU10	Slovenia	-29%	-9%	-86%	-17%
EU15	***Sum of EU15 targets***	***-51%***	***-54%***	***-75%***	***-12%***
EU10	***Sum of EU10 targets***	***-33%***	***-16%***	***-63%***	***-16%***
EU 25	***Sum of EU 25 targets***	***-48%***	***-49%***	***-72%***	***-13%***
AC4	Bulgaria	-26%	-15%	-57%	-25%
AC4	Croatia	-1%	-14%	-61%	-19%
AC4	Romania	-20%	-15%	-30%	-30%
EFTA4	Liechtenstein	-30%	-13%	-3%	-27%
EFTA4	Norway	-30%	-34%	-58%	13%
EFTA4	Switzerland	-49%	-45%	-39%	-7%

Source: Calculated on the basis of 2010 targets (ktonnes) specified in Council Decision 2003/507/EC (European Commission, 2003b) and the most recent 1990 reported emissions (EEA/ETC-ACC, 2006).

Table 3: Transport emissions of acidifying substances EEA32, 1990-2004

Unit: ktonnes of acidifying substances

Acidifying Substances, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	% Change 1990-2004
EU15	201.8	198.5	199.4	195.4	190.5	183.1	177.5	166.7	164.3	159.7	149.9	144.0	135.4	131.6	128.5	-36.3%
EU10	29.7	26.3	25.0	23.4	25.0	22.8	24.2	24.9	24.6	22.9	20.6	20.7	20.8	20.8	19.7	-33.6%
EU25	**231.5**	**224.8**	**224.4**	**218.8**	**215.5**	**205.8**	**201.7**	**191.6**	**188.8**	**182.7**	**170.5**	**164.7**	**156.3**	**152.4**	**148.3**	**-36.0%**
AC4	20.9	18.7	16.5	17.7	16.9	17.9	18.3	16.9	16.7	17.3	16.6	18.2	20.3	22.8	22.8	9.2%
EFTA4	8.8	8.6	8.2	8.1	7.7	7.3	7.2	6.9	6.8	6.7	6.4	6.2	5.9	6.0	5.8	-34.7%
EEA32	**259.7**	**250.9**	**248.2**	**243.5**	**238.9**	**229.9**	**225.9**	**214.1**	**211.0**	**205.3**	**192.1**	**187.8**	**181.3**	**180.0**	**175.7**	**-32.4%**

Source: EEA/ETC-ACC, 2006.
Notes: EEA32 excludes Croatia, which is not an EEA Member.

Table 4: Transport emissions of ozone precursors EEA32, 1990-2004

Units: ktonnes of NMVOC equivalent

TOFP, ktonnes	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	% Change 1990-2004
EU15	19475.7	18929.3	18860.3	18064.2	17207.0	16520.1	15952.6	15116.8	14571.5	13810.7	12662.5	11937.9	11046.5	10537.6	10099.6	-48.1%
EU10	2406.1	2238.4	2151.0	2067.1	2211.8	1989.2	2015.7	2104.3	2082.2	1958.4	1683.2	1573.2	1597.9	1599.1	1672.7	-30.5%
EU25	**21,881.9**	**21,167.7**	**21,011.3**	**20,131.3**	**19,418.8**	**18,509.3**	**17,968.3**	**17,221.1**	**16,653.6**	**15,769.1**	**14,345.7**	**13,511.1**	**12,644.4**	**12,136.6**	**11,772.3**	**-46.2%**
AC4	1630.4	1405.0	1319.9	1477.8	1429.2	1557.4	1599.1	1514.8	1514.5	1547.3	1441.0	1467.9	1739.9	2126.9	2056.8	26.2%
EFTA4	906.7	858.2	815.4	778.7	738.4	688.4	669.4	631.7	602.0	577.3	557.3	514.7	485.6	510.3	477.3	-47.4%
EEA32	**24271.3**	**23312.0**	**23047.1**	**22290.0**	**21478.9**	**20647.5**	**20125.1**	**19248.4**	**18651.0**	**17772.7**	**16218.2**	**15391.3**	**14774.6**	**14678.5**	**14211.1**	**-41.4%**

Source: EEA/ETC-ACC, 2006.
Notes: EEA32 excludes Croatia, which is not an EEA Member.

Table 5: Transport emissions of particulates EEA32, 1990-2004

Unit: ktonnes of PM equivalent

Secondary Particulates, ktonnes	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**% Change 1990-2004**
EU15	7450.5	7374.3	7396.8	7224.6	7037.1	6814.2	6631.4	6317.3	6206.6	6029.5	5698.2	5459.1	5144.6	4983.7	4854.8	-34.8%
EU10	1043.8	945.5	897.4	866.7	930.4	844.0	892.3	926.3	918.9	854.6	771.4	740.5	753.0	751.7	741.1	-29.0%
EU25	**8,494.3**	**8,319.8**	**8,294.2**	**8,091.4**	**7,967.6**	**7,658.2**	**7,523.7**	**7,243.6**	**7,125.5**	**6,884.2**	**6,469.6**	**6,199.6**	**5,897.6**	**5,735.4**	**5,596.0**	**-34.1%**
AC4	735.6	647.6	570.2	620.2	588.6	629.0	644.4	592.5	578.8	609.4	582.0	616.4	715.8	817.7	820.1	11.5%
EFTA4	340.3	328.7	317.2	310.3	297.1	283.2	278.9	266.6	261.3	258.0	246.7	230.9	221.2	227.4	221.7	-34.9%
EEA32	**9519.6**	**9256.6**	**9148.4**	**8986.3**	**8811.4**	**8529.9**	**8403.7**	**8056.3**	**7919.4**	**7705.2**	**7248.4**	**7005.6**	**6794.3**	**6740.2**	**6597.4**	**-30.7%**

Primary Particulates, ktonnes	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**% Change 1990-2004**
EU15	521.4	526.4	533.9	533.5	528.1	526.4	522.0	512.4	504.6	498.1	478.4	483.8	474.0	466.5	460.9	-11.6%
EU10	64.7	64.7	64.2	64.2	64.3	64.2	62.7	63.6	66.6	64.5	64.6	85.3	88.4	87.7	87.6	35.3%
EU25	**586.1**	**591.2**	**598.2**	**597.7**	**592.5**	**590.7**	**584.7**	**575.9**	**571.1**	**562.6**	**543.0**	**569.1**	**562.4**	**554.2**	**548.5**	**-6.4%**
AC4	48.6	47.8	47.0	46.3	45.5	44.7	44.9	45.1	45.2	45.4	45.5	45.5	45.5	45.5	45.5	-6.3%
EFTA4	20.8	20.3	20.2	19.9	19.1	18.6	18.4	17.9	17.5	17.0	16.1	19.2	18.7	15.4	15.3	-26.4%
EEA32	**655.0**	**658.7**	**664.8**	**663.3**	**656.5**	**653.4**	**647.4**	**638.4**	**633.2**	**624.4**	**604.1**	**633.3**	**626.1**	**614.6**	**608.8**	**-7.0%**

Source: EEA/ETC-ACC, 2006.
Notes: EEA32 excludes Croatia, which is not an EEA Member.

Table 6: EU15 road transport emissions of NO_X, NMVOC, CO, PM and SO_2, 1990, 2000 and 2010

Unit: ktonnes

NO_X

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	12382	3322737	348075	571102	1663102	5917398
2000	11231	1918939	316036	614566	1776356	4637128
2010	9883	909585	195005	513159	1291445	2919076
Change 00-90	-9%	-42%	-9%	8%	7%	-22%
Change 10-00	-12%	-53%	-38%	-17%	-27%	-37%
Change 10-90	-20%	-73%	-44%	-10%	-22%	-51%

NMVOC

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	574814	4822637	34236	376112	360861	6168660
2000	400668	2180156	33062	271276	417903	3303065
2010	275090	676208	23362	142678	352390	1469727
Change 00-90	-30%	-55%	-3%	-28%	16%	-46%
Change 10-00	-31%	-69%	-29%	-47%	-16%	-56%
Change 10-90	-52%	-86%	-32%	-62%	-2%	-76%

PM_{10}

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	0	76426	16107	68572	136398	297503
2000	0	88277	13961	77249	139164	318652
2010	0	71400	7220	52099	81968	212687
Change 00-90		16%	-13%	13%	2%	7%
Change 10-00		-19%	-48%	-33%	-41%	-33%
Change 10-90		-7%	-55%	-24%	-40%	-29%

CO

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	2007803	34156212	112263	3325034	673908	40275220
2000	1406625	19311269	97010	2400011	725013	23939928
2010	957017	9973947	58396	1382034	559989	12931383
Change 00-90	-30%	-43%	-14%	-28%	8%	-41%
Change 10-00	-32%	-48%	-40%	-42%	-23%	-46%
Change 10-90	-52%	-71%	-48%	-58%	-17%	-68%

SO_2

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	1000	91189	28132	70088	188588	378995
2000	702	48328	4601	15779	37217	106627
2010	198	9871	111	972	900	12053
Change 00-90	-30%	-47%	-84%	-77%	-80%	-72%
Change 10-00	-72%	-80%	-98%	-94%	-98%	-89%
Change 10-90	-80%	-89%	-100%	-99%	-100%	-97%

Fuel (litres)

	2-Wheels	Cars	Buses	LDV	HDV	Total
1990	4283553638	157195311437	8500415480	28680718194	56669845686	255329844435
2000	3819952204	190815650230	9087405508	37561789116	73505116943	314789914000
2010	3497330179	221842505520	9275381245	46516080472	91892957224	373024254641
Change 00-90	-11%	21%	7%	31%	30%	23%
Change 10-00	-8%	16%	2%	24%	25%	18%
Change 10-90	-18%	41%	9%	62%	62%	46%

Source: LAT/TÜV/KTI, 2004.

Table 7: EEA32 Transport emissions of SO_X, NO_X, NMVOC, CO, CH_4, NH_3 and Primary PM10, 1990-2004

Unit: ktonnes

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	% Change
NH_3	16.47	19.65	24.32	31.93	41.68	52.88	59.59	65.82	72.91	78.73	83.47	90.04	92.42	88.66	89.16	441.3%
CO	41017.82	38941.46	38304.00	36463.27	34278.30	32445.98	31262.30	29404.86	28260.55	26380.68	23288.70	22428.53	21163.46	20942.55	19581.25	-52.3%
CH_4	251.29	238.73	239.31	230.87	224.08	219.89	219.46	208.99	200.46	192.35	174.79	163.15	152.00	5896.34	140.62	-44.0%
NO_X	9988.76	9772.61	9654.31	9497.75	9318.32	9075.28	8967.38	8687.87	8528.02	8300.90	7852.67	7521.61	7328.80	7262.55	7128.89	-28.6%
NMVOC	7569.58	7102.50	7052.01	6688.59	6336.85	6003.57	5743.02	5411.76	5135.37	4741.03	4073.78	3745.51	3503.40	3431.98	3357.95	-55.6%
SO_X	1331.38	1192.91	1179.76	1125.73	1082.56	944.01	878.26	683.06	681.58	648.11	527.14	609.18	529.36	541.57	494.24	-62.9%
Primary PM_{10}	654.99	658.71	664.82	663.28	656.47	653.44	647.41	638.37	633.25	624.42	604.07	633.33	626.09	614.57	608.83	-7.0%

Source: EEA/ETC-ACC, 2006.

File: TERM_2005_03_Transport_emissions_of_air_pollutants_v1.xls

Metadata

EEA32 = EU15, EU10, AC4 – HR (Croatia), EFTA4.

EU15 = Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and UK.

EU10 = Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia.

AC4 = Bulgaria, Croatia, Romania and Turkey.

EFTA4 = Iceland, Liechtenstein, Norway and Switzerland

A. On emissions of acidifying substances

Web presentation information

1. Abstract/description/teaser: Good progress is being made on the implementation of policies to reduce emissions of acidifying substances. Emissions in the EEA32 area have decreased steadily since 1990, with particularly significant decreases in the EU15 and new EU10 countries.
2. Policy issue/question: Are emissions of acidifying substances from transport decreasing?
3. EEA dissemination themes: Acidification, Air Quality & Transport.
4. DPSIR: P

Technical information

5. Data source: National total and sectoral emissions officially reported to the UNECE/CLRTAP/ EMEP, update 2004. Base data is available from http://webdab.emep.int/.
6. Description of data: Emissions of combined SO2, NOx and NH3 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.
7. Geographical coverage: EEA32.
8. Temporal coverage: 1990-2004. Data before 1990 are available but not presented, as the base year for the NECD and Gothenburg Protocol is 1990.
9. Methodology and frequency of data collection: 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.
10. Methodology of manipulation: Acid equivalents: weighting factors (w) are used for SO2, NOx and NH3, 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(SO2) × Em(SO2) + w(NOx) × Em(NOx) + w(NH3) × Em(NH3) where weight factors are given by w(SO2) = 2/64 acid eq./g = 31.25 acid eq./kg, w(NOx) = 1/46 acid eq./g = 21.74 acid eq./kg, w(NH3) = 1/17 acid eq./g = 58.82 acid eq./kg.
    ETC-ACC gap-filling methodology: To allow trend analysis, where countries have not reported data for one, or several years, data has been interpolated to derive annual emission when data is missing between two different years. If the reported data is 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. It is recognised that the use of gap filling can potentially lead to artificial trends, but it is considered unavoidable if a comprehensive and comparable set of emissions data for European countries is required for policy analysis purposes. A list of the data used within this sheet, which has been gap-filled, is available from ETC-ACC upon request.

Qualitative information

11. 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 EEA32 countries.

12. Reliability, accuracy, robustness, and uncertainty: The individual uncertainties in the individual pollutants are discussed in the indicator fact sheets 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.

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

Relevancy: 1
Accuracy: 2 (Acidifying coefficients not agreed and used in all EEA32 countries.)
Comparability over time: 2
Comparability over space: 2

B. On emissions of ozone precursors

Web presentation information

1. Abstract/description/teaser: Good progress is being made on the implementation of policies to reduce emissions of ozone precursors. Emissions in the EEA32 area have decreased steadily since 1990, with particularly significant decreases in the EU15 and new EU10 countries.

2. Policy issue/question: Are emissions of ozone precursors from transport decreasing?

3. EEA dissemination themes: Air Quality & Transport

4. DPSIR: P

Technical information

5. Source: Emissions of CO, NOx and NMVOC — national total and sectoral emissions officially reported to the UNECE/CLRTAP/EMEP, update 2004. Base data is available from http://webdab.emep.int/.

CH4 — national total and sectoral emissions data officially reported to the UNFCCC and EU monitoring mechanism, update 2004 (national annual greenhouse gas inventories).

6. 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.

7. Geographical coverage: EEA32.

8. Temporal coverage: 1990-2004. Data available before 1990, but not presented, as the base year for the NECD and Gothenburg Protocol is 1990.

9. Methodology and frequency of data collection: 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.

10. Methodology of manipulation: TOFPs were calculated according to each compound's typical tropospheric ozone forming potential. Factors are NOx 1.22, NMVOC 1, CO 0.11 and CH4 0.014 (de Leeuw, F.A.A.M. 2002). Results are in NMVOC equivalents (1 000 tonnes). ETC-ACC gap-filling methodology: To allow trend analysis, where countries have not reported data for one, or several years, data has been interpolated to derive annual emission when data is missing between two different years. If the reported data is 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. It is recognised that the use of gap filling can potentially lead to

artificial trends, but it is considered unavoidable if a comprehensive and comparable set of emissions data for European countries is required for policy analysis purposes. A list of the data used within this sheet, which has been gap-filled, is available from ETC-ACC upon request.

Qualitative information

11. Strengths and weaknesses:

Strengths: officially reported data following agreed procedures and Emission Inventory Guidebook, e.g. regarding source sector split.

Weaknesses: available data sets do not include full EEA32 for all years. Reporting to the CLRTAP/EMEP and UNFCCC 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 EEA32 countries.

12. Reliability, accuracy, robustness, and uncertainty: The individual uncertainties of the estimates for individual gases are discussed in the fact sheets 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.

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

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

C. On emissions of particulates

Web presentation information

1. Abstract/description/teaser: Good progress is being made on the implementation of policies to reduce emissions of particulates. Emissions in the EEA32 area have decreased steadily since 1990, with particularly significant decreases in the EU15 and new EU10 countries.

2. Policy issue/question: Are emissions of particulates from transport decreasing?

3. EEA dissemination themes: Air Quality & Transport

4. DPSIR: P

Technical information

5. Source: Primary PM_{10} and Secondary PM_{10} precursors (NO_x, SO_2 and NH_3) — national total and sectoral emissions officially reported to the UNECE/CLRTAP/EMEP, update 2004. Base data is available from http://webdab.emep.int/. Where PM10 data was not reported by countries to EMEP/LRTAP, emission estimates for 1990, 1995 and 2000 were obtained from the RAINS PM10 module, using the BL_CLE_Apr04 baseline scenario. This data can be obtained from http://www.iiasa.ac.at/web-apps/tap/RainsWeb/

6. 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.

7. Geographical coverage: EEA32.

8. Temporal coverage: 1990-2004. The best coverage is from 1990-2004 for NO_x, SO_2 and NH_3.

9. Methodology and frequency of data collection: Annual country data submissions to 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*.

10. Methodology of manipulation: Emissions of secondary PM_{10} are made using aerosol formation factors provided by ETC/ACC. Factors are NO_x = 0.88, SO_2 = 0.54 and NH_3 = 0.64 (de Leeuw 2002). Results are in PM_{10} equivalents (1 000 tonnes). ETC-ACC gap-filling methodology. To allow trend analysis, where countries have not reported data for one, or several years, data has been interpolated to derive annual emission when data is missing between two different years. If the reported data is 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. It is recognised that the use of gap filling can potentially lead to artificial trends, but it is considered unavoidable if a comprehensive and comparable set of emissions data for European countries is required for policy analysis purposes. A list of the data used within this sheet that has been gap-filled is available from ETC-ACC upon request.

Qualitative information

11. 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 and data sets are not always complete necessitating gap filling. Reporting to the CLRTAP/EMEP and UNFCCC 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.

12. Reliability, accuracy, robustness, and uncertainty: The uncertainties for the emission estimates of individual gases, SO_2, NO_x and NH_3, are discussed in their individual fact sheets. 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.

13. 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 (3 for PM10) (Aggregates do, as yet, not have wide support or recognition in EEA32 countries; some gaps in the time series.)
Comparability over time: 1
Comparability over space: 2 (Aggregates do, as yet, not have wide support or recognition in EEA32 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 acidifying, particulate and TOFP coefficients needs wider recognition and acceptance.

The completeness of submissions with respect to NH_3 emissions from certain sectors also needs attention.

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

Nitrogen oxide emissions from road transport in EU15 countries increased by about 20% from 1980 to 1990 and have then reduced, so that by 2000 they essentially returned to the 1980 levels.

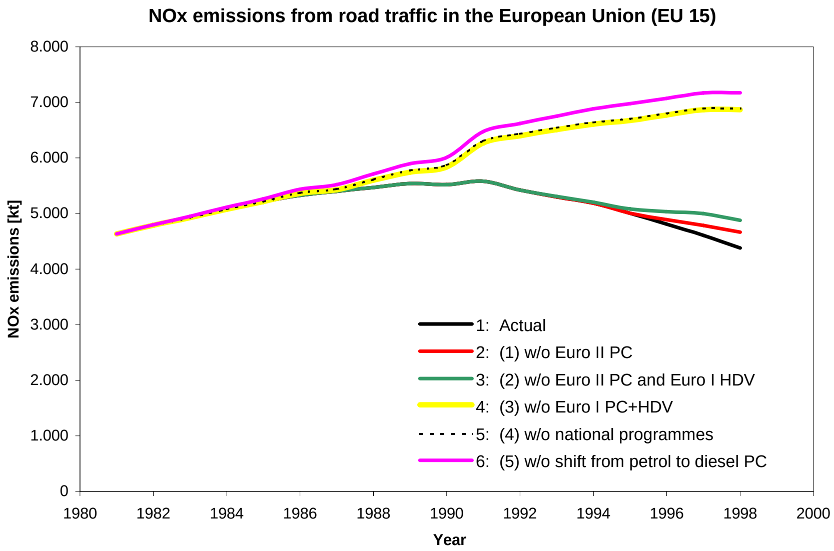
That the emission did not continue to increase in the line with traffic growth was mainly due to the introduction of three-way catalyst converters to cars in the late 1980s and early 1990s. Although many Member States had encouraged the penetration of cars with catalyst converters before 1990, Directive 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 9: Effectiveness of measures to reduce NO_x emissions from road transport in EU-15



Notes: Emission estimates of the ForeMove/Copert model; disaggregated data are not available for 1999 emissions.

Source: EEA–ETC/ACC, 2000.

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 10ppm' diesel is also essential for HDVs (heavy duty vehicles) 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 1st January 2005. This is consistent with the entry into force in 2005 of the new "EURO 4" 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 1st 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 to 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 EU15 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 EU15 ports (34%). This is substantially higher than previous estimates of 1.9 Mt of sulphur dioxide and 2.3 Mt 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:

- EU15 member states to EU15 member states;
- EU15 member states to non-member, non-accession candidate country states;
- Non-member, non-accession candidate country states to EU15 member states.

On the basis of planned reductions, emissions of SO_2 and NO_x in 2010 are still projected to cause exceedances of 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 eliminating exceedances of 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 (Marine Pollution Convention) Annex VI, which came into force in May 2005. 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.

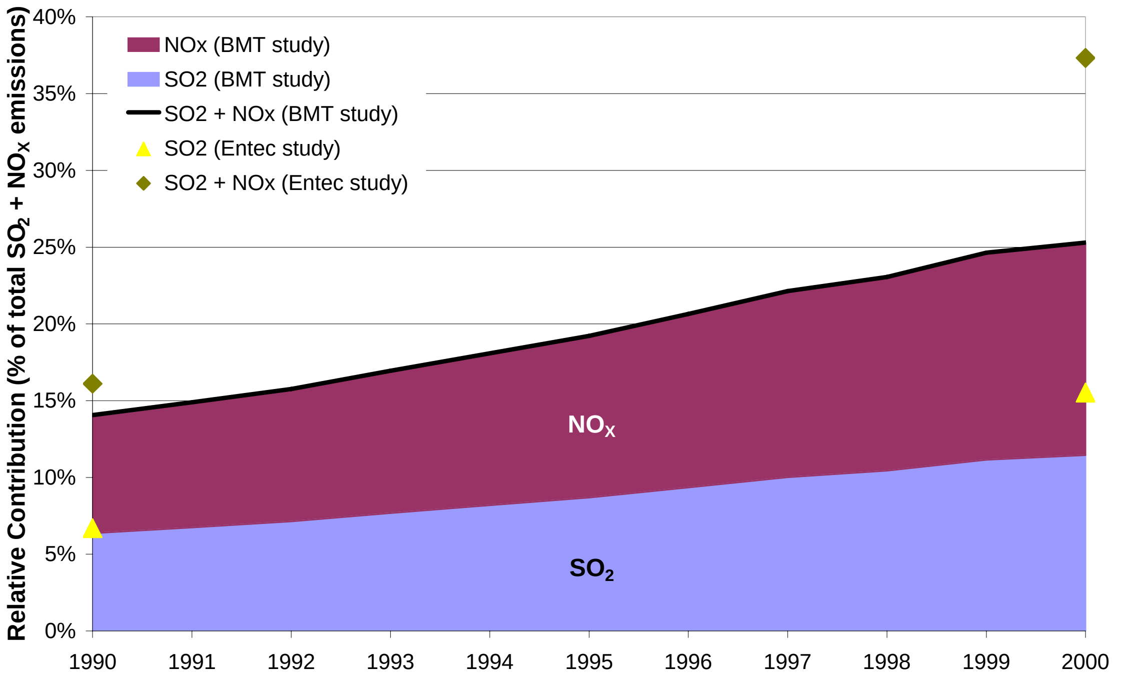
The European Commission 2000b study also examines two alternative regulatory approaches to SO_x emissions, both of which could result in a reduction of 30 to 40% of total present emissions. It concludes that EC legislation regulating SO_2 emissions by setting limits on the sulphur content of fuel consumed 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.

Directive 99/32/EC is the primary regulatory instrument in the EU for control of sulphur content in fuel, prescribing limits on sulphur content in gas oil, heavy fuel oil and marine gas oils. Marine heavy fuel oils were not covered under the Directive previously, however an amending directive incorporating these fuels has entered into force. Its full name is 'Directive 2005/33 of the European Parliament and Council modifying Directive 1999/32 as regards the sulphur content of marine fuel'. This so-called 'marine fuel sulphur directive' entered into force on 11 August 2005. Its first provisions (including the Baltic Sea and passenger vessel 1.5% fuel sulphur limit) will apply from 11 August 2006, for all types of marine fuel used by passenger vessels on regular services throughout the European Union. The amending Directive also replaces the existing marine gas oil provisions with a requirement that any type of marine fuel used by inland vessels and by seagoing ships at berth in EU ports should contain no more than 0.1% sulphur. The Council has agreed an implementation date starting in January 2010.

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 USD1000 per tonne of SO_2 emission abated. A 35% emission reduction achieved in this way would cost shipping an estimated USD700 million per annum.

With regards to economic incentives, the European Commission 2000b study concludes that for control of both SO_2 and NOx 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, a 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 USD800 and USD1200 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 USD3 billion per annum.

Figure 10: 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.

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