EN05 Energy-related emissions of ozone precursors

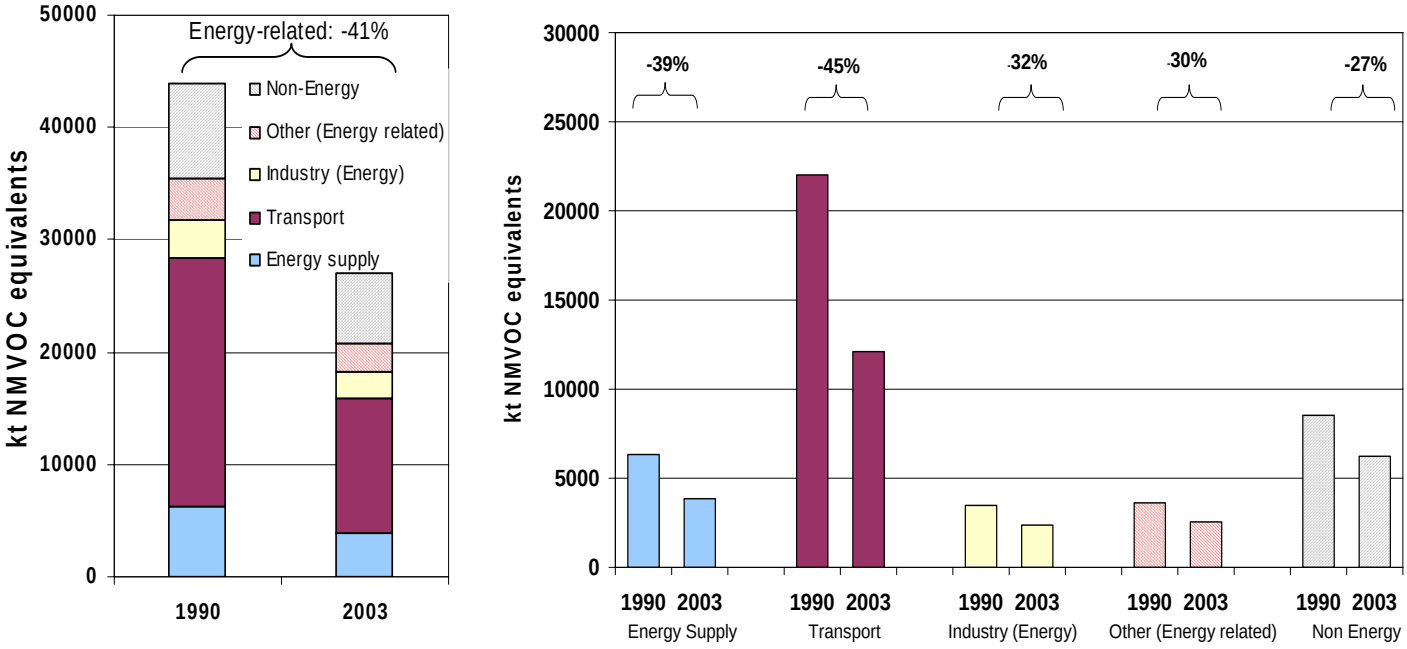
Key message

Emissions of energy-related ozone precursors (CH_4, CO, NMVOC, NO_X) have decreased by 41 % between 1990 and 2003 in the EU-25. The largest reductions (-45 %) in emissions occurred in the transport sector largely as a result of the continued introduction of catalytic converters in new vehicles during this period. However, energy production and use remains a significant source for all these pollutants. Reducing energy-related emissions of ozone precursors therefore remains a key priority for reducing local and transboundary air pollution and in ensuring that countries meet their respective emissions ceiling targets of the National Emissions Ceilings Directive and the UNECE Gothenburg Protocol.

Rationale

Emissions of total non-methane volatile organic compounds, nitrogen oxides, carbon monoxide and methane contribute to the formation of ground level (i.e. tropospheric) ozone. Ozone is a powerful oxidant and can have a range of adverse impacts on both human health and ecosystems.

Fig. 1 Total and sectoral energy-related emissions of tropospheric ozone precursors, EU-25 (weighted by tropospheric ozone formation potential, ktonnes)

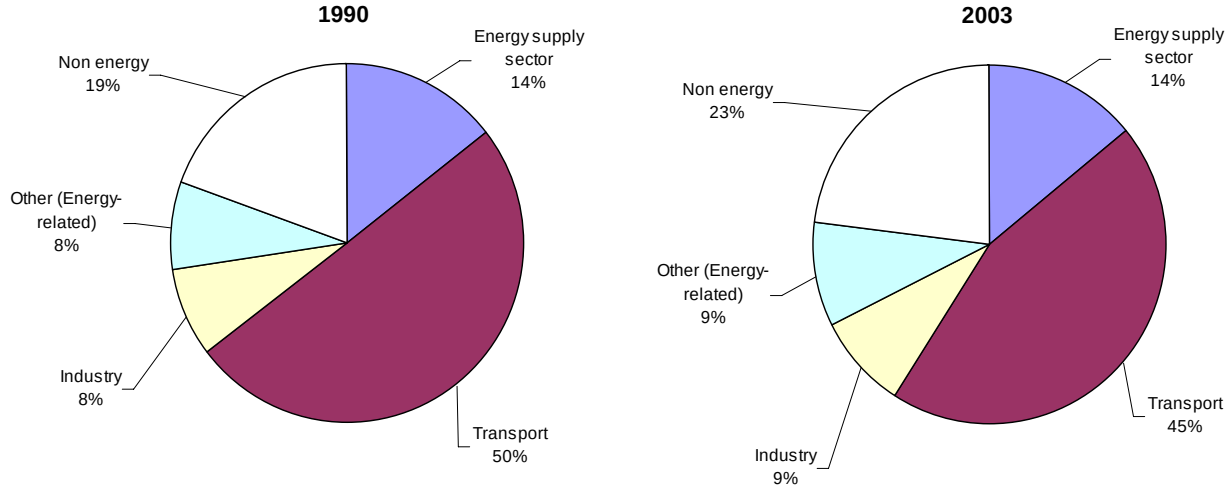


Source: ETC-ACC 2005

Note: The graphs above show the emissions of ozone precursors (methane CH_4; carbon monoxide CO; non-methane volatile organic compounds NMVOCs; and nitrogen oxides NO_x) each weighted by a factor prior to aggregation to represent their respective tropospheric ozone formation potential (TOFP). The TOFP factors are: NO_x 1.22, NMVOC 1, CO 0.11 and CH_4 0.014 (de Leeuw 2002). Results are expressed in NMVOC equivalents (ktonnes). Data not available for Malta (CO, NMVOC and NO_x), or Cyprus (CH_4).

The energy supply sector includes public electricity and heat production (power plants), oil refining, production of solid fuels and fugitive emissions from fuels. The transport sector includes emissions from road and off-road sources (e.g. railways and vehicles used for agriculture and forestry). Industry (energy) relates to emissions from combustion processes used in the manufacturing industry including boilers, gas-turbines and stationary engines. 'Other (energy-related)' covers energy use principally in the services and household sectors.

Fig. 2: Sectoral shares of tropospheric ozone precursors (energy and non-energy components) in total emissions, EU-25



Source: ETC-ACC 2005.

1. Indicator assessment

EU-25 emissions of energy-related ozone precursors (weighted by tropospheric ozone formation potentials) decreased by 41 % between 1990 and 2003. In 2003, the production and use of energy was responsible for over three-quarters of the total emissions of ozone precursors. Of this fraction, NO_x was the most significant pollutant (weighted by tropospheric ozone formation potential) contributing over 60 % of the total energy-related emissions. The changes in the emission intensity of energy-related ozone precursors are thus strongly correlated with the changes observed in NO_x emissions intensity (see EN06-EU-25), as this is the most important energy-related ozone precursor.

In the EU-25, the transport sector is the dominant source of ozone precursors, and contributed 58 % of the energy-related ozone precursor emissions in 2003 (and around half of total ozone precursor emissions). The 'energy supply', 'other' and 'industry energy' sources contributed less than 20 % each of the energy-related emissions, respectively.

The EU-25 transport sector experienced the largest decrease in ozone precursor emissions between 1990 and 2003 both in relative and absolute terms. These emission reductions were mainly due to the continuing increase in the share of passenger cars with a catalytic converter. The energy supply sector also experienced a significant decrease in emissions during this period (-39 %). The decreases in emissions from this sector (primarily NO_x) can be attributed to increased use of abatement technologies and fuel-switching from coal to gas prompted by the liberalisation of the energy market, the requirements of the IPPC and Large Combustion Plant Directives and improved technology efficiencies (see also EN09; EN19 and EN27).

Total energy-related emissions of CO decreased by 52 % during the period 1990-2003 in the EU-25, mainly in the transport sector. Decreases in CO emissions in transport occurred mainly as a result of catalytic converters on road vehicles. The remaining energy-related sectors also all reduced their CO emissions between 1990 and 2003, although in absolute (ktonne) terms, their combined emission reduction was significantly less than the reduction achieved by the transport sector.

Total energy-related NMVOC emissions decreased by 49 % in the region over the same period and accounted for half of the total NMVOC emissions in 2003. The majority of energy-related emissions arose from the road transport sector and petrol evaporation in the energy supply sector. Emissions from the transport sector have decreased by more than half since 1990, primarily due to the introduction of catalytic converters on cars. For the EU-15, emissions of NMVOC in 2003 are significantly higher than the 2010 targets of the NECD for EU Member States (expressed as TOFP) and substantial emission reductions are therefore still required to reach the target. However, the new Member States have made good progress in reducing NMVOC emissions, and energy-related and non-energy related emissions are already below the 2010 emission target.

Methane emissions formed less than 1 % of total ozone precursor emissions in 2003, largely as a result of its low tropospheric ozone formation potential weighting factor relative to the other pollutants. Compared with the other pollutants that contribute to ozone formation, the significance of methane is therefore relatively small. An assessment of NO_x trends is included in the fact-sheet 'EN06: Energy-related emissions of acidifying substances'.

2. Indicator rationale

2.1 Environmental context

Tropospheric (ground level) ozone has adverse effects on human health and ecosystems. NO_x, NMVOC, CO and CH_4 are known as ozone precursors. High concentrations of ground level ozone have been shown to adversely affect the human respiratory system, and there is evidence that long-term exposure to raised ozone concentrations accelerates the decline in lung function with age and may impair the development of lung function. In the environment, high concentrations of ozone are harmful to crops and forests, decreasing yields, causing leaf damage and decreasing disease resistance. Ozone is also capable of causing damage to man made polymeric materials such as plastics and rubbers.

2.2 Policy context

This indicator monitors the trend in emissions of ozone precursors. Emissions of NO_x and NMVOCs are both covered by the EU National Emission Ceilings Directive (NECD; 2001/81/EC) and the Gothenburg protocol under the United Nations Convention on Long-range Transboundary Air Pollution (CLRTAP; UNECE 1999). Both these instruments contain emission ceilings targets that EU Member States and other countries must meet by 2010. Emission reduction targets for the new Member States have been specified in the Treaty of Accession to the European Union 2003[1] in order that they can comply with the National Emission Ceilings Directive. In addition, the Treaty of Accession also includes a new target for the EU-25 region as a whole. Targets for the new Member States are temporary and are without prejudice to the forthcoming review of the NECD. The NECD generally involves slightly stricter emission reduction targets than the Gothenburg Protocol. For example, during the period 1990—2010 the EU-15 has NO_x emission reduction targets of 51 % and 50 % under the NECD and Gothenburg Protocol respectively. For NMVOC, the reduction required under the NECD is 55 %, the Gothenburg reduction target the reduction required is 54 %.

In September 2005 the European Commission released a thematic strategy on air pollution. This strategy sets interim objectives for reducing air pollution impacts across Europe by 2020. Other directives influencing emissions of ozone precursors include:

- The Integrated Pollution Prevention and Control (IPPC) Directive (96/61/EC) aims to prevent or minimise pollution of water, air and soil by industrial effluent and other waste from industrial installations, including energy industries, by defining basic obligations for operating licences or permits and by introducing targets, or benchmarks, for energy efficiency. It also requires the application of Best Available Techniques (BAT) in new installations from now on (and for existing plants over the next 10 years according to national legislation).
- The Large Combustion Plant Directive (2001/80/EC) sets emission limits for licensing of new plants and requires Member States to establish programmes for reducing total emissions. Emissions limits for all plant will be revised in 2007 under the IPPC Directive.
- Emissions from transport are controlled by a number of Directives. These include: emissions from passenger cars and light commercial vehicles (70/220/EEC, as last amended by Directive 2001/100/EC targeting CO, NMVOCs and NOx); quality of petrol and diesel fuels (98/70/EC) as last amended by Directive 2003/17/EC specifying lower sulphur contents of fuels, (but also indirectly targeting emissions of the primary pollutants CO, NMVOCs and NOx; emissions from non-road mobile machinery (97/68/EC) as amended by Directive 2002/88/EC specifying limits for CO, NMVOC and NOx emissions; and for heavy duty vehicles Directive 88/77/EEC as last amended by Directives 1999/96/EC (which provides the Euro 3 (from October 2000), Euro 4 (from October 2005) and Euro 5 (from October 2008) emission standards for CO, NMVOCs and NOx) and Directive 2001/27/EC (adapting to technical progress Directive 88/77/EEC).
- The 1994 VOCs Directive (94/63/EC) applies to the operations, installations, vehicles and vessels used for storage, loading and transport of petrol from one terminal to another or from a terminal to a service station
- There are no specific EU emission targets set for either carbon monoxide (CO) or methane (CH_4). However, there are several Directives and Protocols that affect the emissions of CO and CH_4. Carbon monoxide is covered by the second daughter Directive under the Air Quality Directive. This gives a limit of 10 mg m-3 for ambient air quality to be met by 2005. Methane is included in the basket of six greenhouse gases under the Kyoto protocol.

[1] The Treaty of Accession 2003 of the Czech Republic, Estonia, Cyprus, Latvia, Lithuania, Hungary, Malta, Poland, Slovakia and Slovenia. AA2003/ACT/Annex II/en 2072

Table 1: Energy-related substance emissions 1990-2003 weighted by tropospheric ozone formation potential (TOPF units kt)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	% Change 1990-2003
Austria	531	548	518	500	471	454	480	439	444	420	412	423	423	438	-17 %
Belgium	718	628	647	638	637	675	592	575	620	570	563	532	514	506	-30 %
Denmark	544	610	556	556	552	523	569	499	461	434	406	396	390	396	-27 %
Finland	562	540	524	517	512	482	495	482	468	470	452	443	421	423	-25 %
France	4,661	4,780	4,660	4,417	4,122	3,926	3,806	3,565	3,478	3,294	3,064	2,933	2,728	2,629	-44 %
Germany	6,438	5,610	5,033	4,604	4,171	3,834	3,594	3,385	3,199	3,033	2,808	2,643	2,493	2,364	-63 %
Greece	668	680	679	686	697	697	732	742	773	770	773	790	745	745	11 %
Ireland	264	264	281	257	249	244	255	257	263	235	234	238	219	207	-22 %
Italy	4,352	4,497	4,631	4,476	4,331	4,264	4,139	3,951	3,686	3,442	3,116	3,005	2,731	2,731	-37 %
Luxembourg	67	66	66	65	60	55	54	43	36	32	33	32	32	32	-53 %
Netherlands	1,044	1,002	992	946	913	855	847	774	769	761	681	654	634	637	-39 %
Portugal	529	552	589	576	574	583	564	560	572	567	556	537	540	540	2 %
Spain	2,348	2,434	2,516	2,416	2,454	2,407	2,372	2,384	2,394	2,432	2,406	2,363	2,398	2,377	1 %
Sweden	888	857	837	788	770	750	723	675	647	612	581	562	546	543	-39 %
United Kingdom	5,746	5,555	5,383	5,076	4,918	4,587	4,399	4,113	3,870	3,588	3,295	2,578	2,902	2,756	-52 %
Iceland	26	27	29	30	32	33	28	22	22	22	22	22	22	22	-17 %
Liechtenstein	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-48 %
Norway	588	579	604	632	637	650	659	657	649	659	652	660	603	567	-4 %
Switzerland	354	365	334	301	274	245	261	246	202	188	194	163	160	174	-51 %
Cyprus	47	45	48	48	49	48	50	50	51	51	52	46	47	48	2 %
Czech Republic	1,140	1,123	1,073	912	798	736	766	754	731	682	691	579	538	556	-51 %
Estonia	228	213	132	132	144	146	155	161	163	137	100	92	100	102	-55 %
Hungary	491	422	397	384	384	396	403	405	404	402	379	376	369	382	-22 %
Latvia	216	193	174	131	122	133	137	128	122	116	108	117	112	113	-48 %
Lithuania	333	351	208	167	169	153	163	164	167	149	129	123	125	129	-61 %
Malta	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Poland	3,142	2,992	2,902	2,871	2,512	2,312	2,357	2,306	2,053	2,029	1,635	1,902	1,901	1,901	-40 %
Slovakia	370	333	310	304	290	300	244	235	236	217	215	216	210	200	-46 %
Slovenia	113	104	106	115	121	122	130	129	114	104	103	116	116	108	-5 %
Croatia	602	424	420	431	388	439	400	342	385	354	339	336	372	382	-37 %
Bulgaria	237	194	153	152	163	164	176	184	185	185	189	168	163	163	-31 %
Romania	1,047	881	733	688	681	702	722	739	760	602	668	727	727	727	-31 %
Turkey	1,624	1,622	1,679	1,850	1,810	1,922	2,050	2,067	2,026	2,135	2,026	1,876	2,211	2,547	57 %
EU-10	**6,080**	**5,775**	**5,350**	**5,065**	**4,589**	**4,346**	**4,404**	**4,332**	**4,042**	**3,885**	**3,412**	**3,568**	**3,518**	**3,537**	**-42 %**
EU-15	**29,360**	**28,624**	**27,910**	**26,517**	**25,431**	**24,336**	**23,620**	**22,445**	**21,679**	**20,662**	**19,380**	**18,128**	**17,716**	**17,324**	**-41 %**
EU-25	**35,440**	**34,399**	**33,260**	**31,583**	**30,020**	**28,682**	**28,024**	**26,777**	**25,721**	**24,547**	**22,792**	**21,696**	**21,234**	**20,861**	**-41 %**
EEA	**39,682**	**38,299**	**37,060**	**35,516**	**33,843**	**32,675**	**32,143**	**30,851**	**29,765**	**28,508**	**26,694**	**25,481**	**25,330**	**25,282**	**-36 %**

Source: ETC-ACC 2005.

References

de Leeuw, F.A.A.M. (2002). *A set of emission indicators for long-range transboundary air pollution.* Environmental Science & Policy, 5, 135-145.

UNECE (1999). Protocol to the 1979 Convention on Long-range Transboundary Air Pollution (CLRTAP) to abate acidification, eutrophication and ground-level ozone, Gothenburg, Sweden, 1 December 1999.

EEA (2004): EMEP/CORINAIR Atmospheric Emission Inventory Guidebook 3rd edition; EEA Technical Report No. 30

Further Reading

EEA (2003). Europe's Environment: the third assessment. Environmental Assessment Report No 10, European Environment Agency, Copenhagen, Denmark (http://reports.eea.eu.int/)

EEA (2005) The European Environment - State and Outlook 2005. State of Environment report No 1/2005 European Environment Agency, Copenhagen, Denmark (http://reports.eea.eu.int/)

Meta data

Technical information

1. Data Source: Officially reported national total and sectoral emissions to UNECE/EMEP (United Nations Economic Commission for Europe/Co-operative programme for monitoring and evaluation of the long-range transmissions of air pollutants in Europe) Convention on Long-range Transboundary Air Pollution (CLRTAP), submission 2005. Base data are available on the EMEP the website (http://webdab.emep.int/). CH_4 emissions are from officially reported national total and sectoral emissions, reported to UNFCCC and EU Monitoring Mechanism, submission 2005 (National Annual Greenhouse Gas Inventories). Gross inland energy consumption data from EUROSTAT (Aug 2005 download: http://europa.eu.int/comm/eurostat/). Emissions of ozone precursors is one of the European Environment Agency's core-set indicators. More information can be found at http://themes.eea.eu.int/IMS/CSI

2. Description of data: Emissions of TOFP in ktonnes in terms of NMVOC Equivalent. TOFP is the Tropospheric Ozone Forming Potential of each of the air pollutants that contribute to ozone formation in the troposphere. Gaps in reported data are filled by ETC/ACC where necessary using simple interpolation techniques (see 6).

3. Geographical Coverage: EU-25 for comparison with EU National Emission Ceilings Directive (European Commission 2001). Other analyses include data for EFTA 4 (Iceland, Liechtenstein, Switzerland and Norway) and Bulgaria, Croatia, Romania and Turkey. The EEA country grouping includes EU-25, EFTA4 and Bulgaria, Romania and Turkey.

4. Temporal Coverage: 1990–-2003

5. Methodology and frequency of data collection: Annual country data submissions to UNECE/CLRTAP/EMEP. Recommended methodologies for emission data collection are compiled in the Joint EMEP/CORINAIR Atmospheric Emission Inventory Guidebook 3rd edition EEA Copenhagen EEA (2004).

6. Methodology of data manipulation: 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 emissions. 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. The gap-filled air emissions spreadsheet is available on http://dataservice.eea.eu.int/dataservice/metadetails.asp?id=818 Eurostat energy consumption data for Croatia (1990) was also gap-filled using the above methodology.
The relative impact of the combined contribution of NOx, NMVOC, CO and CH_4 to ozone formation can be assessed based on their tropospheric ozone forming potentials (TOFP): nitrogen oxides 1.22, non-methane volatile organic compounds 1.0, carbon monoxide 0.11 and methane 0.014 (de Leeuw 2002). Results are in NMVOC equivalents (ktonnes), except where specified. These factors are assumed to be representative for Europe as a whole; on the (very) local scale different factors might be estimated; see de Leeuw (2002) for a more extensive discussion on the uncertainties in these factors. Due to the variation in potential TOFP factors that might be determined on a local scale, the use such factors does not always have wide support or recognition in EU Member States. The energy supply sector includes public electricity and heat production, oil refining, production of solid fuels and fugitive emissions from fuels. The transport sector includes emissions from road and off-road sources (e.g. railways and vehicles used for agriculture and forestry). Industry (energy) relates to emissions from combustion processes used in the manufacturing industry including boilers, gas turbines and stationary engines. 'Other (energy-related)' covers energy use principally in the services and household sectors.

Quality information

7. Strengths and weaknesses (at data level):
Strength: officially reported data following agreed procedures and Emission Inventory Guidebook, e.g. regarding source sector split. Weakness: available datasets do not include full time series for all years and/or sectors. Reporting to CLRTAP/EMEP and UNFCCC can be inconsistent for some countries in terms of precise sector definitions, missing data etc. Incomplete reporting and resulting intra- and extrapolation may obscure some trends.

8. Reliability, accuracy, robustness, uncertainty (at data level): The individual uncertainties of the estimates for individual gases are discussed in the respective EEA Air Pollution fact-sheets for these gases. The trend is likely to be much more accurate than to individual absolute annual values - the annual values are not independent of each other.

9. Overall scoring (1 = no major problems, 3 = major reservations):
   Relevancy: 1
   Accuracy: 2
   Comparability over time: 2
   Comparability over space: 2