AP5c - EEA18 Emissions of primary particulates (PM10) and secondary particulate precursors

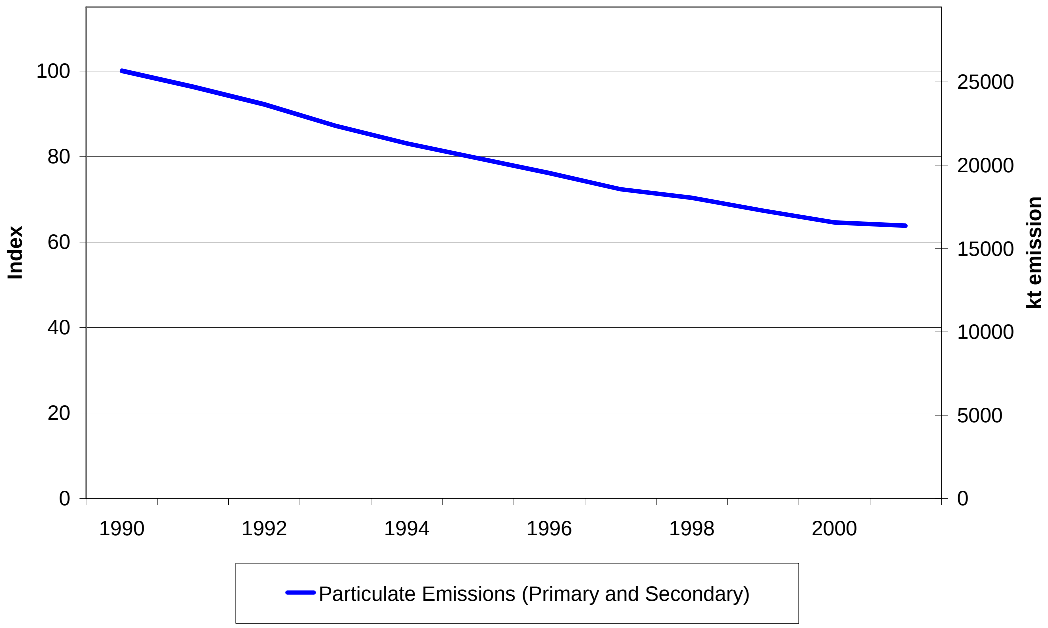
Key messages

☺ **Total EU15 emissions of fine particulates have been reduced by 36% between 1990 and 2001. This is mainly due to reduction in emissions of the secondary particulate precursors SO_2 and NO_x, but also to reductions of primary PM_{10} from energy industries.**

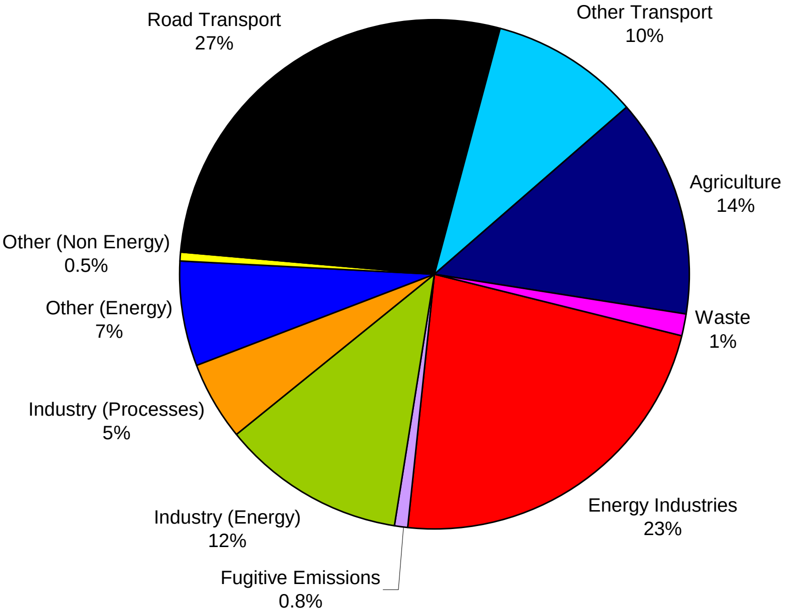
☺ **Nine Member States have reduced their total emissions of fine particulates by more than 25% since 1990.**

☹ **Substantial further reductions are needed to reach the limit values set in the EU First Daughter Directive to the Framework Directive on Ambient Air Quality.**

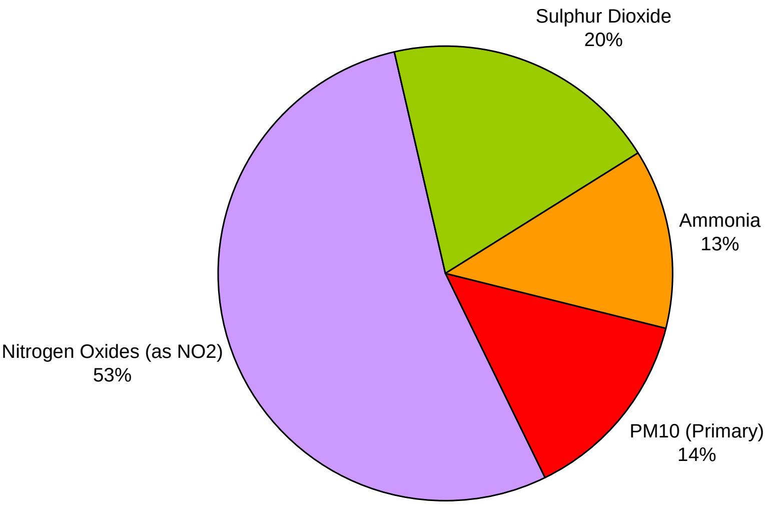
Title: EU15 emissions of primary and secondary fine particulates (ktonnes).



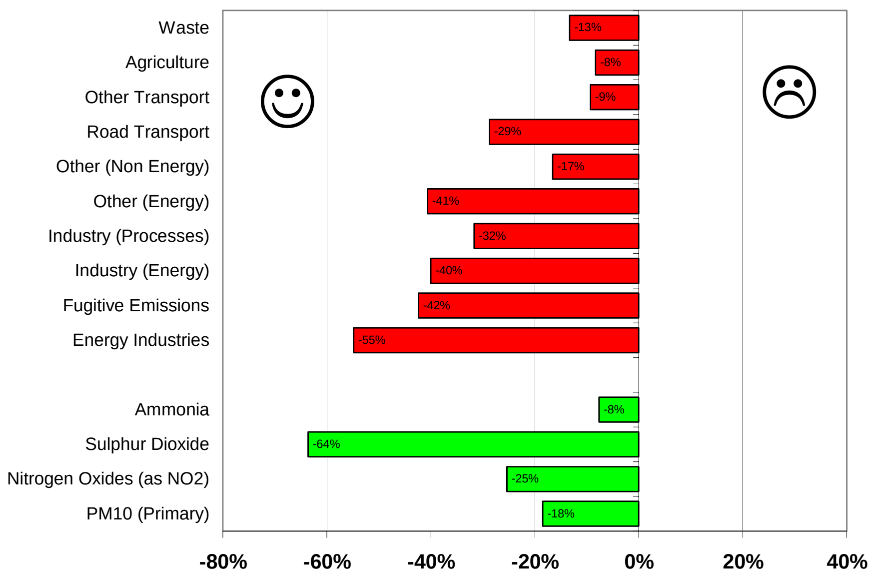
Title: Sector split of EU15 emissions of primary and secondary fine particulates in 2001 (%).



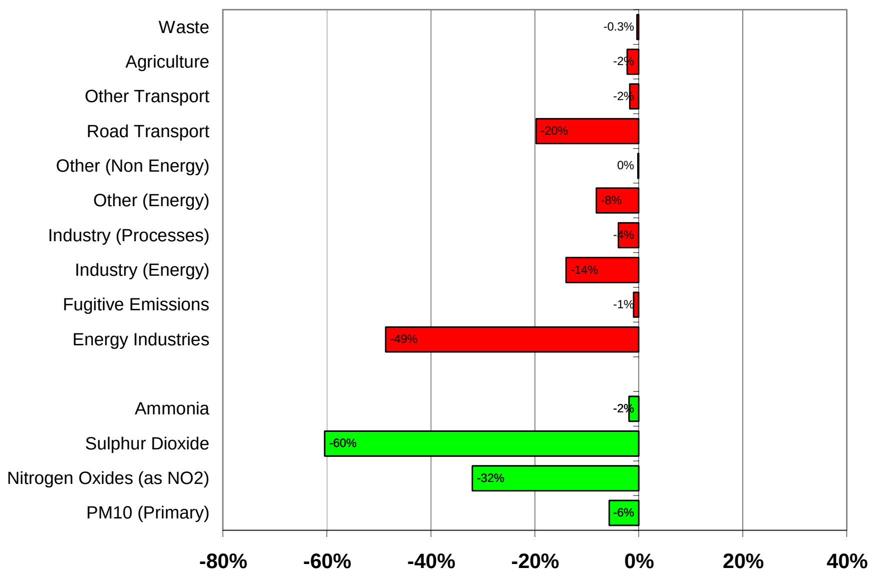
Title: Pollutant split of EU15 emissions of primary and secondary fine particulates in 2001 (%).



Title: Change in emissions of primary and secondary fine particulates (PM10) per sector and per pollutant between 1990 – 2001, (%).



Title: Contribution of the change in emissions of primary and secondary fine particulates (PM10), per sector and per pollutant, relative to the total change in EU15 emissions between 1990 and 2001, (%).



Notes: Emission trend of primary and secondary fine particulates aggregated according to respective particulate formation potentials for each pollutant. Particulate formation factors for SO_2, NO_x and NH_3 were used to assess the emissions of secondary particulates precursors: SO_2=0.54; NO_x=0.88 and NH_3=0.64 (de Leeuw, 2002).

No emission target exists for emissions of primary particles.

The graphs above include EU15 emissions only. Emissions of the other Western Europe countries Norway, Iceland, Liechtenstein and Switzerland are included in the tables at the end of this factsheet

Source: EEA/ETC-ACC (2003)

Results and assessment

Policy relevance

Emissions of fine particles are controlled in the European Union by several different types of regulation including:

- The European Union's National Emission Ceilings Directive (NECD) and Protocols to the United Nations Economic Commission for Europe's Convention on Long Range Transboundary Air Pollution (CLRTAP). With respect to PM_{10}, these measures are currently focused on controlling emissions of the secondary PM_{10} precursors
- Air quality standards for PM_{10} in the First Daughter Directive to the Framework Directive on Ambient Air Quality, and related national legislation in member states.
- Emission standards for specific mobile and stationary sources for primary PM_{10} and secondary PM_{10} precursor emissions.

This indicator constitutes relevant information for the Clean Air For Europe program (CAFE).

Environmental context

Fine particles have adverse effects on human health and can be responsible and/or contribute to a number of respiratory problems. Fine particles in this context refer to the sum of primary PM_{10} and the weighted emissions of secondary PM_{10}-precursor pollutants. Primary PM_{10} refers to fine particles directly emitted into the atmosphere from emission sources while secondary emissions refer to emissions from pollutants which are (partly) transformed to particles by photo-chemical reactions in the atmosphere. A large fraction of the urban population is exposed to levels of fine particulate matter in excess of limit values set for the protection of human health. The emission data for primary PM_{10} is not as robust as that for other air pollutants and the factors used in the estimation of secondary PM_{10-} emission are based on assumptions about the deposition and reactions of the precursor pollutants.

Assessment

EU emissions of fine particles have been reduced by 36% from 1990 to 2001. The total emission reduction between 2000 and 2001 was 1.1%.

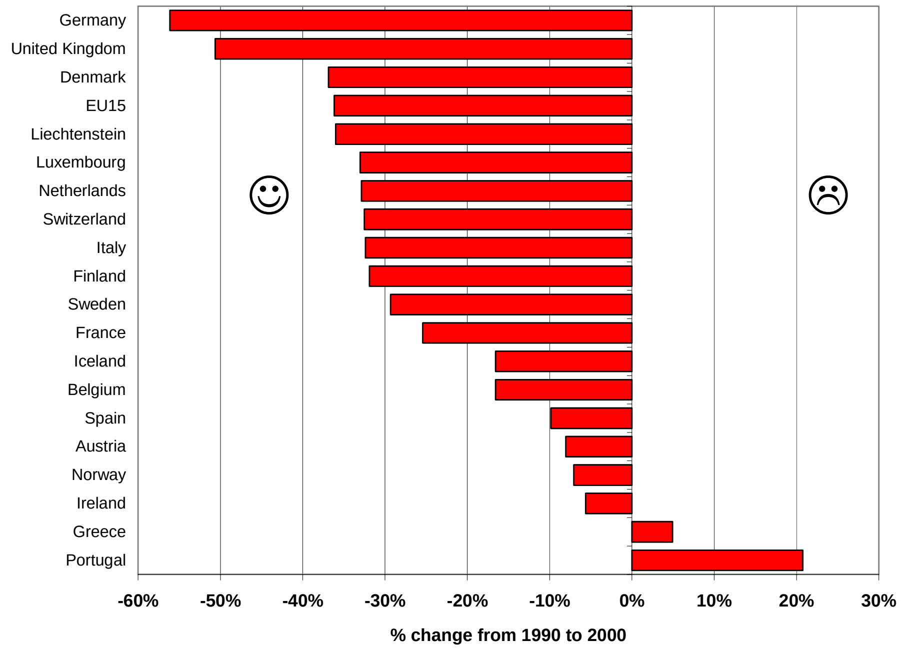
The most important sources of fine particle emissions in 2001 were road transport (27%) and the energy industry (23%) sectors. Emissions of NO_x (53%) and SO_2 (20%) were the most important contributing pollutants to particulate formation in 2001.

The emission reductions between 1990 to 2001 are mainly due to abatement measures in the energy industries (-55%), road transport (-29%) and energy use from industry (-40%). The majority of the reduction in emissions of energy-related particulate pollutants between 1990 and 2001 came from the energy supply sector, although the other sectors also decreased emissions significantly during this period as indicated above. Overall, the reduction in emissions of energy-related particulate pollutants was mainly achieved through a combination of the use of lower sulphur content fuels, fuel switching from coal and oil to natural gas, the deployment of emission abatement technologies in the energy supply (see EN09-EU for further details about emissions of SO_2 and NO_X from public electricity production) and industry sectors, and an increased market penetration of catalytic converters for road vehicles.

Emissions of primary PM_{10}, and secondary PM_{10} precursors are expected to decrease in the future 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 the EU15 territory PM_{10} concentrations will still be well above the limit values, mainly as a result of the continued growth of road transport.

Substantial further reductions are needed to reach the limit values set in the EU First Daughter Directive to the Framework Directive on Ambient Air Quality.

Title: Change in emission of primary and secondary fine particles 1990-2001 (%) per EU15 country and EU as total.



Source: EEA /ETC-ACC (2003)

Assessment

The EU15 emissions have been reduced by 36% since 1990. Two countries, the United Kingdom and Germany have reduced emissions by more than 50% since 1990. Seven other Member States have made emission reductions of more than 25%. As described above, the major reasons for the decrease in emissions within these countries has been the increased penetration of vehicle catalyst technologies, the use of lower sulphur content fuels, fuel switching from coal and oil to natural gas, and the use of pollution abatement technologies in the energy supply sector. Portugal and Greece are the only countries to have increased emissions since 1990, by 21% and 5%, respectively.

References

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de Leeuw, F.A.A.M (2002). (supported by the European topic centre on air and climate change, under contract to the European Environment Agency), A set of emission indicators for long-range transboundary air pollution, Environmental Science & Policy, 5, 135-145. (http://www.sciencedirect.com/science/article/B6VP6-44HYMJ7-1/1/d6e469ff7969874250c6d0f656a8c76b

EEA/ETC-ACC (2003) Manipulated data based on 2003 submission of Parties data reported to UNECE/CLRTAP/EMEP. Base data are available on the EMEP web site (http://webdab.emep.int/).

EMEP (1998). "Transboundary Acidifying Air Pollution in Europe", Part 1: Estimated dispersion of acidifying and eutrophying compounds and comparison with observations. EMEP/MSC-W Report 1/98, July 1998.

EU First Daughter Directive to the Framework Directive on Ambient Air Quality, Council Directive 1999/30/EC of 22 April 1999 relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.

EU National Emission Ceilings Directive (NECD), Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emissions ceilings for certain atmospheric pollutants, 2001/81/EC, OJ L309 27/11/2001

European Commission (2000). The Auto Oil II Programme. A report from the services of the European Commission. Report by the Directorates General for Economic and Financial Affairs, Enterprise, Transport and Energy, Environment, Research and Taxation and Customs Union. http://europa.eu.int/comm/environment/autooil/

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.

Data

EU15 emissions, change in emissions, and respective contribution to the total change in emissions, per sector and per pollutant for primary PM_{10} and PM_{10} precursors 1990-2001 weighted by particulate formation potential (ktonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	Change in emissions 1990-2001	Change in emissions 1990-2001 (%)	% Contribution to total change in emissions 1990 - 2001
Energy Industries	8263	7845	7310	6593	6066	5601	4973	4481	4289	3946	3786	3732	-4531	-55%	-49%
Fugitive Emissions	221	197	194	206	189	185	177	170	170	162	150	127	-94	-42%	-1%
Industry (Energy)	3250	3078	2922	2719	2575	2503	2359	2303	2176	2041	1908	1949	-1301	-40%	-14%
Industry (Processes)	1152	1030	971	909	895	880	855	847	842	818	788	787	-365	-32%	-4%
Other (Energy)	1869	1768	1591	1535	1368	1242	1291	1207	1172	1123	1064	1110	-759	-41%	-8%
Other (Non Energy)	95	93	91	90	90	88	86	84	83	81	79	79	-16	-17%	0%
Road Transport	6394	6388	6396	6189	6029	5800	5618	5296	5126	4925	4718	4558	-1836	-29%	-20%
Other Transport	1742	1694	1644	1618	1615	1620	1685	1657	1677	1671	1595	1580	-162	-9%	-2%
Agriculture	2499	2427	2352	2325	2308	2320	2304	2337	2338	2334	2310	2291	-208	-8%	-2%
Waste	243	247	242	240	237	233	229	232	221	223	214	211	-32	-13%	-0.3%
EU15	**25728**	**24768**	**23713**	**22424**	**21372**	**20473**	**19579**	**18615**	**18095**	**17323**	**16612**	**16424**	**-9304**	**-36%**	**-**
PM10 (Primary)	2873	2876	2801	2726	2646	2583	2560	2482	2449	2388	2316	2342	-531	-18%	-6%
NO_x	11734	11635	11363	10815	10502	10234	10110	9683	9422	9126	8874	8756	-2978	-25%	-32%
SO_2	8839	8050	7409	6756	6110	5524	4799	4309	4079	3660	3302	3218	-5621	-64%	-60%
NH_3	2283	2207	2140	2127	2114	2133	2109	2141	2146	2150	2120	2108	-175	-8%	-2%

Western Europe emissions of primary PM_{10} and secondary PM_{10} precursors (NOx, SO_2 and NH_3) 1990-2001 (ktonnes)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Austria	302	304	287	287	279	277	292	280	286	274	275	278
Belgium	613	647	645	628	603	583	555	537	540	501	498	511
Denmark	451	523	456	436	441	415	467	394	350	324	291	284
Finland	460	417	382	371	365	334	354	346	337	333	318	314
France	3513	3670	3504	3270	3169	3103	3090	2937	2942	2797	2668	2620
Germany	6900	5916	5342	5004	4581	4215	3783	3487	3255	3126	3007	3027
Greece	611	638	643	641	629	648	641	639	667	665	630	642
Ireland	296	295	302	286	291	285	283	293	303	291	279	279
Italy	3122	3090	3019	2901	2777	2784	2678	2542	2454	2299	2111	2111
Luxembourg	39	40	40	40	36	33	33	29	26	26	26	26
Netherlands	837	829	782	762	714	694	656	635	607	603	569	562
Portugal	498	507	562	535	519	556	519	526	567	599	601	602
Spain	2624	2648	2659	2552	2559	2481	2350	2472	2409	2470	2444	2365
Sweden	499	492	468	452	458	432	439	402	384	360	356	353
United Kingdom	4964	4753	4622	4258	3950	3633	3439	3095	2969	2655	2538	2451
EU15	25728	24768	23713	22424	21372	20473	19579	18615	18095	17323	16612	16424
Iceland	46	47	48	49	51	51	45	38	39	39	39	39
Liechtenstein	1	1	1	1	1	1	1	1	1	1	1	0
Norway	310	291	284	298	296	297	308	312	307	306	294	288

Meta data

Technical information

1. *Source:* Officially reported national total and sectoral emissions to UNECE/CLRTAP/EMEP, 2003 data submission. Where primary PM10 data was not available, Auto Oil 2 studies (TNO) provided national totals 1990-2000 (European Commission 2000); with sectoral splits derived from 1995 sector weightings from the CEDMEIP particulate emissions database (CEDMEIP 2001)
2. *Description*: Emissions of secondary PM_{10} made using particulate formation factors, NO_x = 0.88, SO_2 = 0.54 and NH_3 = 0.64, according to de Leeuw (2002).
3. *Spatial Coverage*: EEA 18. There is presently insufficient reporting of primary PM10 emissions by Acceding and Candidate countries to allow compilation of a meaningful indicator. Values from CEDMEIP are available for 1995, but gap-filling to all other years means no useful information is obtainable on trends, changes in sectoral emissions etc. This situation should improve in future years as more countries report PM10 emissions data to fulfil the reporting obligations required under CLRTAP.
4. *Temporal Coverage*: 1990 – 2001.
5. *Methodology*: Annual country data submissions to 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 (2001), 3rd ed, EEA, Copenhagen.
6. *Methodology of manipulation*: Emissions of secondary PM_{10} are estimated using aerosol 'formation factors' obtained from "A set of emission indicators for long range transboundary air pollution" (Frank de Leeuw, 2002). Factors are NO_X = 0.88, SO_2 = 0.54 and NH_3 = 0.64. Results are in PM_{10} equivalents (ktonnes).
   ETC-ACC gap-filling methodology. 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 usually 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
7. Qualitative information
8. *Strengths and weaknesses*:

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

   Weakness: Primary PM_{10} data reported by countries remains uncertain in terms of quality for many countries. In many cases the available reported data does not include all years and had to be interpolated. The incomplete reporting and resultant extrapolation may obscure some trends. The particulate formation factors do not, as yet, have wide international support or recognition.
9. *Reliability, accuracy, robustness, uncertainty*: Sulphur dioxide emission estimates in Europe are thought to have an uncertainty of about ±10% as the sulphur emitted comes from the fuel burnt and therefore can be accurately estimated. However, because of the need for interpolation to account for missing data the complete dataset used here will have higher uncertainty. EMEP has compared modelled and measured concentrations throughout Europe (EMEP 1998). From these studies differences in the annual averages have been estimated in the order of ± 30% consistent with an inventory uncertainty of ±10% (there are also uncertainties in the measurements and especially the modelling).
   NOx emission estimates in Europe are thought to have an uncertainty of about ±30%, as the NOx emitted comes both from the fuel burnt and the combustion air and so cannot be estimated accurately from fuel nitrogen alone. EMEP has compared modelled and

measured concentrations throughout Europe (EMEP 1998). From these studies differences for individual monitoring stations of up to a factor of two have been found. This is consistent with an inventory of national annual emissions having an uncertainty of ±30% (there are also uncertainties in the measurements and especially the modelling).
The trend is likely to be much more accurate than for individual absolute annual values- the annual values are not independent of each other. However it is not clear that all countries backdate changes to methodologies so early years may have been estimated on a different basis to later years. The primary PM_{10} data is likely to be very uncertain. The trend is likely to be much more accurate than to individual absolute annual values

10. *Overall scoring (1-3, 1=no major problems, 3=major reservations)*

    Relevancy: 2

    Accuracy: 2 (3 for primary PM_{10})

    Comparability: over time 2

    Comparability over space: 2

Further work required:

Each country should report Primary PM_{10} on an annual basis. Presently a number of Acceding and Candidate countries do not report emissions of PM_{10} as required under CLRTAP. Bodies such as the UNECE TFEIP/EEA could investigate the reasons for the non-reporting e.g. infrastructure or resource constraints within countries, and provide assistance to help overcome such barriers. Countries should improve the completeness of the time series of their estimates (filling gaps). Further validation and checking is a national responsibility and is needed especially to produce improved detailed sectoral time series of emissions. There is also a need for further validation and checking within the framework of CLRTAP/EMEP and EEA/ETC-ACC activities. The use of aerosol formation factors needs to be given wider recognition and acceptance.