Key message
The emissions intensity of carbon dioxide (CO₂), sulphur dioxide (SO₂) and nitrogen oxides (NOₓ) from public conventional thermal power plants has decreased substantially since 1990, particularly in the case of SO₂ and NOₓ. This is primarily due to a decline in the use of coal, and replacement of old, inefficient coal plant as well as the use of abatement techniques. However, in recent years a rise in the coal-fired electricity production has acted to slow the decline in emissions intensity. Rising overall electricity consumption has also acted to partly offset the environmental benefits from improvements in emissions intensity. While CO₂ intensity has decreased, CO₂ emissions have increased in real terms by around 8% between 1999-2004.

Rationale
Electricity and heat production from public thermal power plants is a significant source of both air pollutants and greenhouse gas emissions. Reducing the emissions per unit of electricity and heat produced (emissions intensity) of these plants can play an important role in helping to reduce their environmental impacts.

Fig. 1: Emissions intensity of public conventional thermal power production, EU-25

Data source: EEA – European Topic Centre on Air and Climate Change, and Eurostat
Notes: The emissions intensity of conventional public thermal power production is the level of CO₂, SO₂ or NOₓ emissions per unit of power (electricity and heat) produced by public thermal power stations. The emission intensities are calculated as the ratio of CO₂, SO₂ and NOₓ emissions from public power production to the output of electricity and heat from public conventional thermal power production. Public thermal power stations generate electricity and/or heat for sale to third parties, as their primary activity. They may be privately or publicly owned. No data are available for Luxembourg and so data for this country is not included in the chart.
1. Indicator assessment

Emissions of carbon dioxide (CO$_2$), sulphur dioxide (SO$_2$) and nitrogen oxides (NO$_x$) per unit of electricity and heat produced by public conventional thermal power plants (i.e. the emissions intensity) decreased substantially during the period 1990-2004, with the majority of the reduction achieved during the 1990s and improvements slowing down from the late 1990s onwards. The reductions in SO$_2$ and NO$_x$ emissions intensity have been particularly significant, influenced by emission abatement techniques such as flue gas desulphurisation and low-NO$_x$ burners, and the greater use of low-sulphur fuels (see EN09 for the quantitative contribution of each factor to reduced emissions). Emission reductions have also been helped by some switch in electricity production from coal and oil to natural gas, prompted by the liberalisation of energy markets and improvements in the efficiency of electricity production. However, action is still required to ensure further reductions, particularly in the new Member States, as on average the emissions intensities of all pollutants, and in particular SO$_2$, in these countries are still higher than the average for the older Member States.

The intensity of carbon dioxide emissions from public conventional thermal power plants in the EU-25 decreased by about 28% from 1990 to 2004 due to improvements in all Member States with the exceptions of Estonia and Slovakia. This reduction has generally occurred as a result of the closure of old and inefficient coal-fired plants and their replacement with either newer, more efficient coal-fired plants or new gas-fired plants. The latter was primarily driven by economic decisions, as over this period the costs of electricity produced from gas-fired plants have typically been less than for coal- and oil-fired plants, leading to a preference for new gas plants. However, increased gas prices towards the end of the period have led to higher utilisation of existing coal plants in some EU countries and, as a result, the CO$_2$ emissions intensity has changed relatively little since 2001. Typically natural gas has approximately 40% less carbon content than coal, and 25% less carbon content than oil. Combined cycle gas turbine (CCGT) technology, the technology most often used with new gas power plants, can achieve at least 55-60% efficiency compared with the 35-40% efficiency of traditional coal-fired power plant, and thus further reduce the emissions intensity. Latvia and Sweden achieved the largest percentage reduction in the intensity of carbon dioxide emissions in the EU-25, with an average annual decrease of 7% and 5.3% respectively. In Latvia this was largely due to greater use of gas at the expense of coal, lignite and oil for electricity production. Sweden had the lowest CO$_2$ emissions intensity in 2004, which was mainly due to a negligible share of coal and lignite in power production and a high share of renewable energies (see EN27). With the exception of France, which produces very little public conventional thermal power, Estonia and Greece have the highest carbon intensity of all Member States. This is due to the continuing dominance of coal and lignite (92.5% in Estonia and 59.6% in Greece) as well as a high share of oil in Greece (14.1%) as a fuel for public conventional thermal power production (see EN-27 for further details on fuel use by countries).

Fig. 2: Emission intensity of carbon dioxide from public conventional thermal power production
During the period 1990-2004, the emissions intensity of nitrogen oxides from public conventional thermal plants decreased by 60%. This was due to the increased use of end-of-pipe abatement techniques such as selective catalytic reduction, low-NO\textsubscript{x} burners and the use of less polluting fuels in public conventional thermal power production in many Member States. Low-NO\textsubscript{x} burners reduce emissions by controlling the mixing and proportions of fuel and air in the combustion process and typically can reduce NO\textsubscript{x} emissions by up to 40\%. Selective catalytic reduction uses a chemical reaction involving ammonia to convert NO\textsubscript{x} to nitrogen and water and removals of up to 90\% can be achieved. NO\textsubscript{x} intensities fell in all Member States (except Estonia), with the largest decreases occurring in Italy and the Czech Republic. While this reduction was mainly due to large increases in the use of gas for electricity production in Italy, in the Czech Republic a combination of constructing new fluidised bed boilers and implementing NO\textsubscript{x} control technologies on existing boilers has significantly reduced NO\textsubscript{x} emissions. The country with the highest NO\textsubscript{x} intensity is France, although it produces relatively small amounts of public conventional thermal power, mostly from coal and oil.

Fig. 3: Emission intensity of nitrogen oxides from public conventional thermal power production

The emissions intensity of sulphur dioxide from public conventional thermal power plants decreased by almost 80\% from 1990 to 2004, a significantly larger reduction than occurred for either CO\textsubscript{2} or NO\textsubscript{x} emissions intensities from public conventional thermal power plants. In particular, Germany, Denmark, Latvia and the Czech Republic showed large reductions in emissions intensity. In Denmark this occurred through a twelve-fold increase in the use of natural gas, while in Latvia there was a substantial decrease in the use of coal, lignite and oil. In Germany the SO\textsubscript{2} reductions have been due mainly to the closure of old, inefficient lignite-based power plants following reunification, but also due to the extensive use of flue gas desulphurisation technologies. Flue gas desulphurisation is an abatement end-of-pipe technology, which is fitted to large combustion plants such as power plants. The application of this technology has been driven by national efforts to reduce SO\textsubscript{2} emissions and also in response to the implementation of EU Directive 88/609/EEC (superseded by Directive 2001/80/EC) on the limitation of emissions from large combustion plants.
emissions of certain atmospheric pollutants into the air from large combustion plants. Cyprus, Greece and Spain had the highest SO₂ emissions intensities in the EU-25 in 2004, influenced by the use of high sulphur content coal and lignite in the two former countries and high sulphur oil in Cyprus.

Fig. 4: Emissions intensity of sulphur dioxide from public conventional thermal power production

Data source: EEA – European Topic Centre on Air and Climate Change, and Eurostat

Note: Emissions intensity is calculated as the amount of pollutant produced (in tonnes) from public electricity and heat production divided by the output of electricity and heat (in toe) from these plants. No emissions data for Luxembourg or Iceland. For Malta, 2003 and 2004 data are available; the 2003 value appears above as the 1990 value.

According to the most recent PRIMES energy projections (European Commission 2006), the CO₂ emissions intensity of public conventional thermal power production in the EU-25 is expected to continue to decline, at an average annual rate of 1.4% over the period 2000-2010. After 2010, the CO₂ intensity is expected to continue declining at a faster rate (1.9%) until 2020. New policy initiatives and the widespread implementation of competition in the energy markets are predicted to encourage further switching to low-carbon fossil fuels (mainly natural gas) and improve the efficiency of public conventional thermal power production.

In the longer term, the prospects for continuing this trend look less certain. PRIMES energy projections suggest a slower rate of decline in CO₂ emissions intensity over the period 2020-2030 (0.4%). Under a low carbon energy pathway (EEA 2005), a greater reduction in emissions intensity, continuing to 2030, would be expected as the energy system responds to rising carbon permit prices. The decline in CO₂ emissions intensity is predicted to be greater in the new Member States (2.1% 2010-2020 and 1.3% 2020-2030).

2. Indicator rationale

2.1 Environmental context

Carbon dioxide is the most abundantly produced greenhouse gas. Increased greenhouse gas emissions lead to higher concentrations in the atmosphere, which contributes to climatic change, including increased temperatures and more variable and erratic weather patterns. The potential consequences of climate change include sea-level rise and increased flooding or drought. Climate change will have adverse impacts on biodiversity with species loss or migration and may also lead to new
patterns of disease e.g. return of malaria to southern and northern Europe. Changes in the availability of water resources could have implications for public supply and other uses within the economy e.g. agricultural supply and tourism development.

Emissions of sulphur dioxide and nitrogen oxides are the main cause of acid deposition leading to changes in soil and water quality and damage to forests, crops and other vegetation, and to adverse effects on aquatic ecosystems in rivers and lakes. Acidification also damages buildings and cultural monuments and potentially has links to human respiratory diseases. Other health impacts can arise if acidification affects groundwater used for public water supply.

2.2 Policy context

Although there are no specific EU targets for reducing the emissions intensity of public thermal power production, such reductions will play an important role in helping the EU to meet its commitments under the Kyoto protocol of the United Nations Framework Convention on Climate Change and the National Emissions Ceiling Directive. The latter requires the introduction of national emission ceilings (upper limits) for emissions of SO₂ and NOₓ (as well as NH₃ and NMVOCs) in each Member State, as well as setting interim environmental objectives for reducing the exposure of ecosystems and human populations to damaging levels of the acid pollutants. Targets for the new Member States are temporary and are without prejudice to the on-going review of the NEC Directive which is to be completed in 2006-2007. In terms of the energy sector, the most relevant NEC Directive targets for the EU-25 as a whole are for SO₂ and NOₓ emissions reductions of 74 % and 53 % respectively by 2010 from 1990 levels.

A number of EU policies have an impact on the emissions intensity of public thermal power plants, including the Large Combustion Plant Directive (2001/80/EC) which aims to control emissions of SO₂, NOₓ and particulate matter from large (>50MW) combustion plants and hence favours the use of higher efficiency CCGT as opposed to coal plants; and plants covered under the IPPC Directive (96/61/EC) which are required to meet a set of emissions abatement and energy efficiency provisions through the use of best available technology not entailing excessive cost (BATNEEC).

The Directive establishing a scheme for greenhouse gas emission allowance trading within the Community (2003/87/EC) is primarily intended to help contribute to the European Union fulfilling its commitments under the Kyoto Protocol and will affect the CO₂ intensity. Under the Directive, each Member State drew up a National Allocation Plan that set caps on CO₂ emissions from all thermal electricity generating plants greater than 20 MW. A shift to less carbon intensive fuels for electricity generation, such as gas, and improvements in efficiency are important options to help generators meet their requirements under the Directive, and these will also have the effect of helping to reduce the emissions intensity of SO₂ and NOₓ.

References


Energy overviews for various countries produced by the Office of Fossil Energy, U.S. Department of Energy
Meta data

Technical information

1. Data source:

2. Description of data:
   Historical emissions of CO₂, NOₓ and SO₂ from the reporting format category 1A1a Public electricity and heat production. Output from public thermal power stations covers gross electricity generation and any heat also produced by public thermal power stations. Public thermal power stations generate electricity and/or heat for sale to third parties as their primary activity. They may be privately or publicly owned. The gross electricity generation is measured at the outlet of the main transformers, i.e. the consumption of electricity in the plant auxiliaries and in transformers is included.
   Emissions intensity is calculated by dividing the emissions of each pollutant from public electricity and heat production (sector 1A1a) by the output from public thermal power stations.

3. Geographical coverage: EU-25 and Romania, Bulgaria, Turkey, Norway and Iceland. No data for Liechtenstein or Switzerland.


5. Methodology and frequency of data collection:

6. Methodology of data manipulation, including making 'early estimates':
   ETC-ACC gap-filling methodology. Where countries have not reported data for one, or several years, data for emissions from public conventional thermal power production has been calculated as a proportion of the emissions from all energy industries (which includes emissions from refineries etc) by applying a scaling factor. This scaling factor has been calculated as the ratio of emissions from public conventional thermal power production to emissions from all energy industries for a year in which both data sets exist (usually 2003). It is recognised that the use of gap-filling can potentially lead to inaccurate trends, but it is considered unavoidable if a comprehensive and comparable set of emissions data for European countries is required for policy analysis purposes. Information on the gap filled data is shown in the section on data weaknesses.
   Emission intensities are calculated as the ratio of CO₂, NOₓ and SO₂ emissions of public conventional thermal power production divided by the electricity and heat output from public conventional thermal power production.
   Average annual rate of growth calculated using: [(last year / base year) ^ (1 / number of years) –1] *100.

Quality information

7. Strengths and weaknesses (at data level):
   Emissions: Officially reported data following agreed procedures. E.g. CO₂ data are based upon annual submissions under the UNFCCC, and SO₂ and NOₓ emissions data are annual submissions to UNECE/CLRTAP/EMEP.
   Energy data have been traditionally compiled by Eurostat through the annual Joint Questionnaires, shared by Eurostat and the International Energy Agency, following a well established and harmonised methodology. Methodological information on the annual Joint Questionnaires and data compilation can be found in Eurostat's web page for metadata on energy statistics http://europa.eu.int/estatref/info/sdds/en/sirene/energy_sm1.htm.

8. Reliability, accuracy, robustness, uncertainty (at data level):
   Indicator uncertainty (historic data):

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EN08 Emissions (CO₂, SO₂ and NOₓ) intensity of public conventional thermal power (electricity and heat) production
The emissions intensity of power production is calculated as the ratio of emissions to total electricity and heat output. For electricity data (unlike that for overall energy consumption) 1990 refers to the West part of Germany only.

The IPCC (IPCC, 2000) suggests that the uncertainty in the total GWP-weighted emission estimates, for most European countries, is likely to be less than ±20%. The IPCC believes that the uncertainty in CO₂ emission estimates from fuel use in Europe is likely to be less than ±5%. Total GHG emission trends are likely to be more accurate than the absolute emission estimates for individual years. The IPCC suggests that the uncertainty in total GHG emission trends is ±4% to 5%. This year for the second time, uncertainty estimates were calculated for the EU-15 in EEA (2006). The results suggest that uncertainties at EU-15 level are between ±4% and ±11% for total EU-15 greenhouse gas emissions. For energy related greenhouse gas emissions the results suggest uncertainties between ±2% (stationary combustion) and ±11% (fugitive emissions). For public electricity and heat production specifically, which is the focus of the indicator, the CO₂ uncertainty is estimated to be ±0.2%. For the new Member States and some other EEA countries, uncertainties are assumed to be higher than for the EU-15 Member States because of data gaps.

The uncertainties of sulphur dioxide emission estimates in Europe are relatively low, 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 (which include emission data as one of the model parameters) and measured concentrations throughout Europe (EMEP 2005). From these studies the uncertainties associated with the modelled annual averages for a specific point in time have been estimated in the order of ±30%. This is consistent with an inventory uncertainty of ±10% (with additional uncertainties arising from the other model parameters, modelling methodologies, and the air quality measurement data etc).

In contrast, NOx emission estimates in Europe are thought to have higher uncertainty, 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 2005). From these studies differences for individual monitoring stations of more than a factor of two have been found. This is consistent with an inventory of national annual emissions having an uncertainty of ±30% or greater (there are also uncertainties in the air quality measurements and especially the modelling).

For all emissions the trend is likely to be much more accurate than individual absolute annual values - the annual values are not independent of each other. However not all countries apply changes to methodologies back to 1990.

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