Energy, climate change and air pollution*
Main trends in the European Union
Énergie, climat et pollution atmosphérique
Principales tendances en Europe

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The challenge for the 21st century is how to develop sustainably and maintain the quality of life for a growing population with higher expectations for well-being. Underlying this challenge is the need for sufficient and sustainable supplies of energy underpinning our economic activity.

According to the recent World Energy Outlook published by the International Energy Agency in November 2008, if governments around the world continue with current policies, the world's energy needs would be 45% higher in 2030 than today, with coal providing more than a third of the rise. Energy production and use, particularly of fossil fuels, have a number **of environmental impacts** including air pollution, greenhouse gas emissions and adverse impacts on ecosystems.

In 2005, energy-related GHG emissions accounted for as much as 80% of total GHG emissions in EU-27 (see Figure 1).

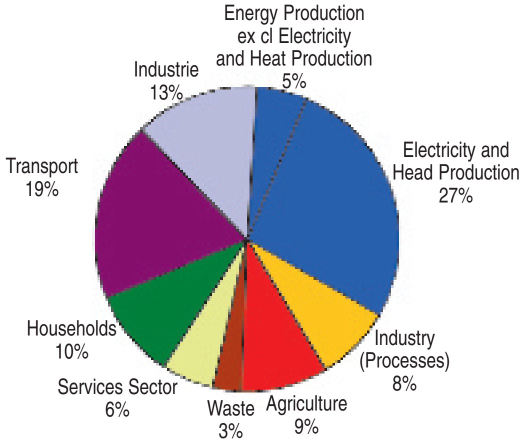

Figure 1.
Structure of total greenhouse gas emissions by sector, EU-27, 2005.
(Source: EEA, 2007a, as reported by countries to UNFCCC and under the EU GHG Monitoring Mechanism Decision).

Energy production and consumption*** also contributes to approximately 55% of the EU-27 emissions of acidifying substances, 76% of emissions of tropospheric ozone precursors and about 67% of (primary) particles emissions (see Figure 2).

Air pollutants and greenhouse gases interact on various temporal scales. Many air pollutants such as nitrogen oxides, carbon oxide and non-methane volatile organic compounds are precursors to tropospheric ozone (an important greenhouse gas as well as air pollutant) and contribute to radiative forcing. Aerosols and particulate matter (PM) can have either a positive or negative forcing effect, depending on the composition.

From the policy perspective, the most important linkages between climate change and air pollution exist at the level of emission sources: both greenhouse gases and air pollution are often emitted by the same sources (e.g. fossil fuels combustion in power plants). Hence, measures taken in the energy sector to reduce greenhouse gases emissions affect also air pollution emissions.

Between 1990 and 2005, the energy-related emissions of acidifying substances, tropospheric ozone precursors and particles decreased by 59%, 45% and 53%, respectively (see Figure 3).

These emission reductions have been the result of the increased application and effectiveness of abatement technologies, improvements in efficiency and fuel switching. For example, the introduction of flue gas desulphurisation technologies and the use of low NO_x-burners in power generation was encouraged by the Large Combustion Plant Directive (EC, 2001c) and the use of best available technologies required by the Integrated Pollution Prevention and Control Directive (EC, 1996).

In addition to the use of abatement technologies, substantial emissions reductions have been made in the power production sector due to a combination of factors: fuel switching (from coal and oil to natural

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**** The contribution of energy production and consumption includes the following sectors: transport, energy supply, industry (energy) and other (energy-related).*

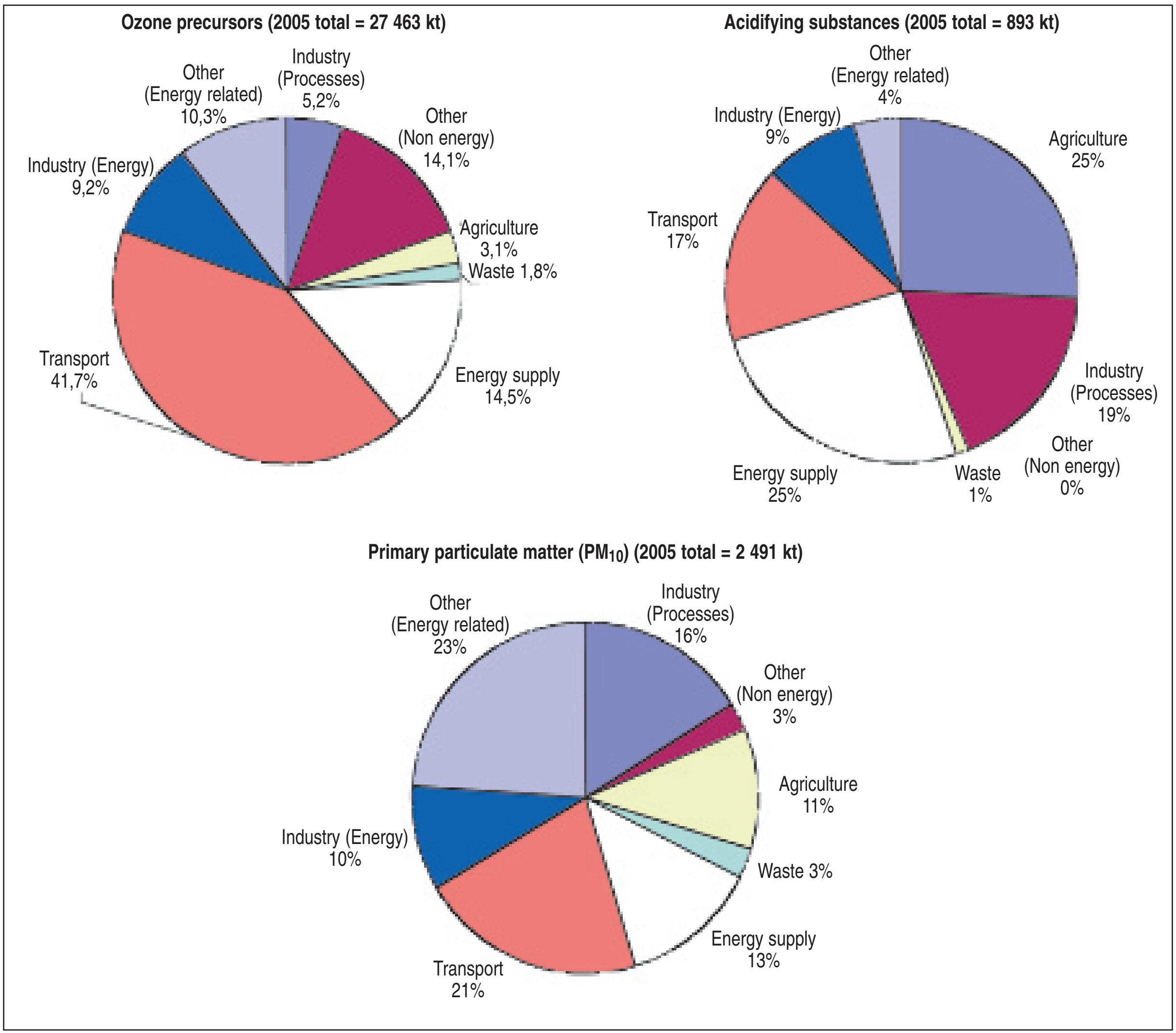

Figure 2.
Emissions of air pollutants by sector in 2005, EU-27.
(Source: EEA).

The graph above shows 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 as follows: NO_x 1.22, NMVOC 1, CO 0.11 and CH_4 0.014 (de Leeuw, 2002). Results are expressed in NMVOC equivalents (kilotonnes – kt). Data not available: for Iceland (emissions of CO, NMVOC, NO_x were not reported) and Malta (CO). The figure also shows the emissions of acidifying pollutants (sulphur dioxide SO_2, nitrogen oxides NO_x and ammonia NH_3), each weighted by an acid equivalency factor prior to aggregation to represent their respective acidification potentials. The acid equivalency factors are given by: w (SO_2) = 2/64 acid eq/g = 31.25 acid eq/kg, w (NO_x) = 1/46 acid eq/g = 21.74 acid eq/kg and w (NH_3) = 1/17 acid eq/g = 58.82 acid eq/kg. The graph shows the emissions of primary PM_{10} particles (particulate matter with a diameter of 10 µm or less, emitted directly into the atmosphere).

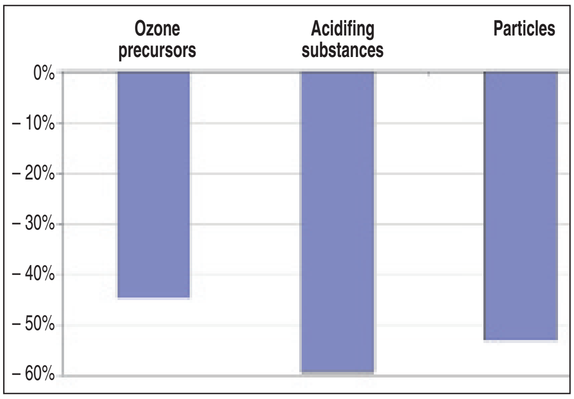

Figure 3.
Overall changes in energy-related emissions
by main group of air pollutants in the EU-27, 1990–2005.
(Source: EEA).

NB: However, the change in particulate matter includes emissions of both primary and secondary particulate-forming pollutants (the fraction of sulphur dioxide, SO_2, nitrogen oxides NO_x and ammonia NH_3 which, as a result of photo-chemical reactions in the atmosphere, transform into particulate matter with a diameter of 10 µm or less). Emissions of the secondary particulate precursor species are weighted by a particle formation factor prior to aggregation: primary PM_{10} = 1, SO_2 = 0.54, NO_x = 0.88, and (NH_3) = 0.64 (de Leeuw, 2002).

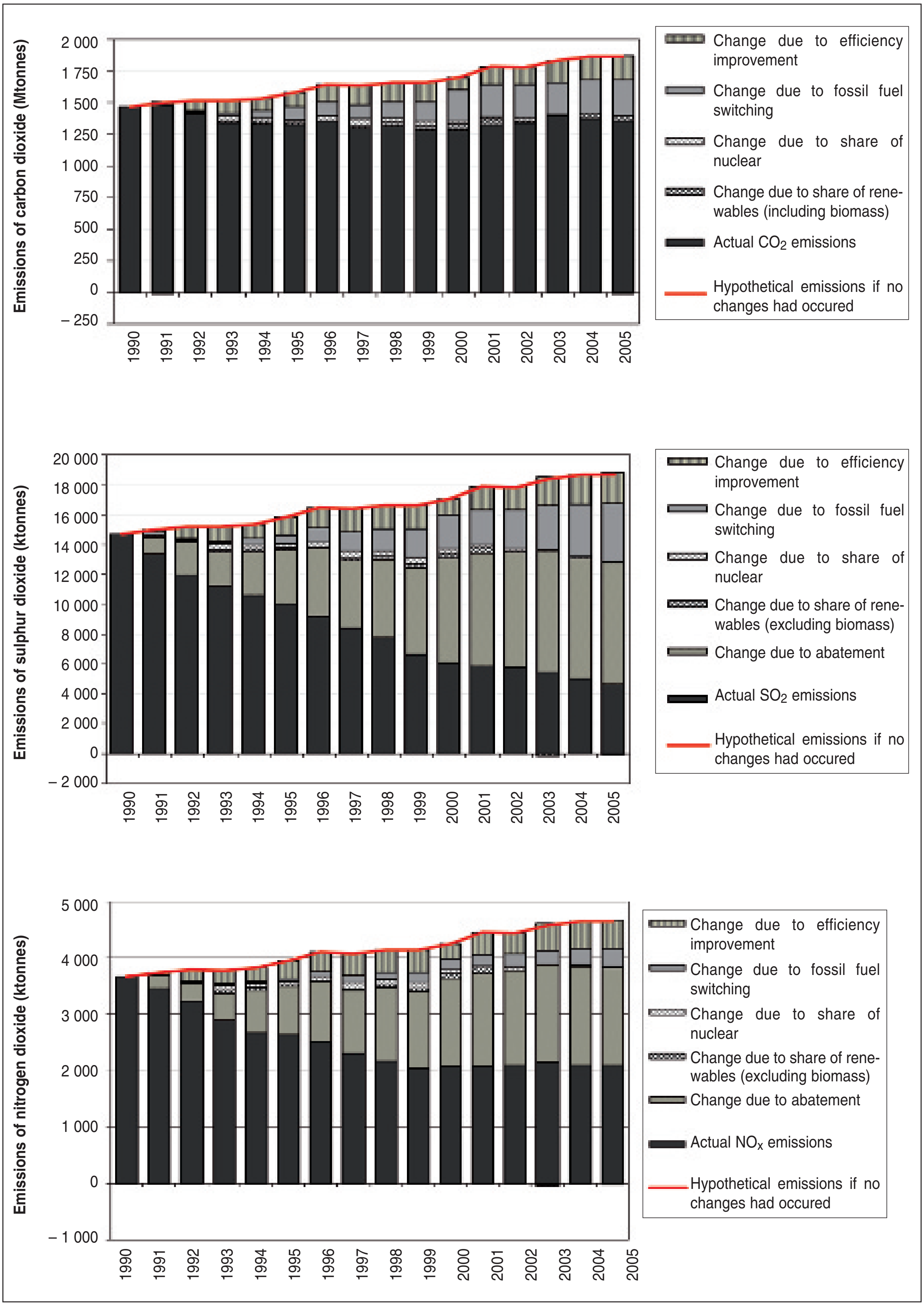

Figure 4.
Estimated impact of different factors on the reduction of CO_2, SO_2 and NO_x emissions from public heat and electricity generation in the EU-27, 1990–2005.
(Source: EEA, Eurostat).

gas), closure of old inefficient coal plants and the overall improvement in generation technology, particularly *via* the use of combined cycle gas turbines (CCGT).

However, rapid reductions in the emissions intensity from power generation seen in the 1990s slowed in recent years for some air pollutants (such as SO_2 and NO_x emissions), due to the continuing rise in the overall electricity consumption and a rise in the use of coal for electricity generation from 1999 onwards.

The direct emissions of CO_2, SO_2 and NO_x from electricity and heat generation depend on both the amount of electricity and heat generated and the emissions per unit produced. The fuel mix in power generation influences the latter, as well as the overall generation efficiency, and in the case of NO_x and SO_2, the extent to which abatement techniques need to be applied.

If the structure of electricity and heat production had remained unchanged since 1990, i.e. if the shares of input fuels and efficiency had remained constant, emissions would have increased in line with the increase in electricity and heat production. This hypothetical development is indicated in the top line of the charts (see Figures 4). The estimated effects of the various factors on emission reductions are shown in each of the bars.

The main factors in reducing CO_2 emissions from electricity and heat generation are the improvement in efficiency and fuel switching (from coal to gas), and to a lesser extent – the change in the contribution of renewables in certain years. However, in 2002 and 2003, and due to limited hydroelectricity production as a result of low levels of rainfall, the share of renewables was relatively low. The share of nuclear in electricity production in 2005 was also below its 1990-levels, which led to increased emissions (as indicated *via* the very small negative portion of the bar for this year).

For SO_2 and NO_x emission reductions, the dominant factor appears to be the use of abatement technology, as it accounts for the most significant difference between the hypothetical line and the actual level of emissions. Efficiency improvements and fuel switching also played an important role in emissions reductions of these pollutants, although the latter was more significant in the case of SO_2 – due to an additional switch towards low-sulphur coal. From around 1999 onwards, the decrease in SO_2 emissions slowed significantly, whilst NO_x emissions have broadly, stabilised.

As explained above, the main factor determining the level of GHG emissions and air pollutants generated by the energy system is the energy mix used to deliver energy services. The current energy system within the EU is heavily dependent on fossil fuels. The share of fossil fuels in total energy consumption declined only slightly between 1990 and 2005: from around 83% to 79%. Over 54% of primary energy consumption in 2005 was imported, and this dependence on imported fossil fuel has been rising steadily (from 51% in 2000). Dependence is increasing rapidly for natural gas and coal. Natural gas imports accounted for some 59% of the total gas-based primary energy consumption in 2005, while for hard-coal-based primary energy, imports accounted for 42%.

Reducing energy import dependency can have positive or negative effects on the environment, both within the EU and outside its borders, depending on the energy sources imported and the ones being replaced. In Europe, a higher penetration of renewable energy sources in the energy mix, coupled with a switch from coal to gas, resulted in reduced energy related GHG emissions and air pollution but also in increased dependency on gas imports. However, these environmental benefits were partially offset by increasing energy consumption and, more recently, by the tendency to increase the use of coal in electricity generation due to concerns about security of supply as well as concerns over high and volatile prices for imported fossil fuels.

Conclusion

Due to the synergies and possible trade-offs between measures to tackle climate change and measures to address air pollution, there is a need for an integrated assessment. Implementing climate change policies can significantly reduce the costs of meeting air pollution targets. In addition, reductions in air pollution may require measures that go beyond end-of-pipe technologies and may require significant structural changes (for instance increasing the share of renewables in the energy mix), changes that would be fully consistent with climate change policy goals.