

ELECTRICITY GENERATION: COAL USE AND CUTTING CO₂ EMISSIONS IN THE FUTURE

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High demand for electricity is an essential feature of developed economies. This is true not only for industrial production in which the growing use of electric energy largely contributes to improving productivity and enables specified production; it also applies to the creation of services in the consumer sector, where the application of power is indispensable and expanding into a growing number of applications. For this reason, electrical energy as a share of final global energy consumption rose from 15.5 percent to 17.3 percent between 2000 and 2009. This figure takes into account that around 83 percent of total gross electricity generation is included in final energy consumption. During this period electricity as a share of final consumption increased by nearly 2 percentage points to 21.6 percent in developed OECD countries. In less developed countries the share of electricity was significantly lower, although some emerging countries are already catching-up fast.

In China, for example, the share of electric energy in final energy consumption increased from 11.7 percent to 18.4 percent between 2000 and 2009, while an increase from 9.9 percent to 13.4 percent was observed in India. Latin America, on the other hand, saw only minor changes to the electric energy component of final energy consumption, which increased from 15.5 percent to 16.9 percent. In Africa the increase in the share of electricity in final energy consumption was even smaller, rising from 8 percent to 8.9 percent, while in Asia (excluding China) an increase from 10.8 percent to 13.4 percent was observed.

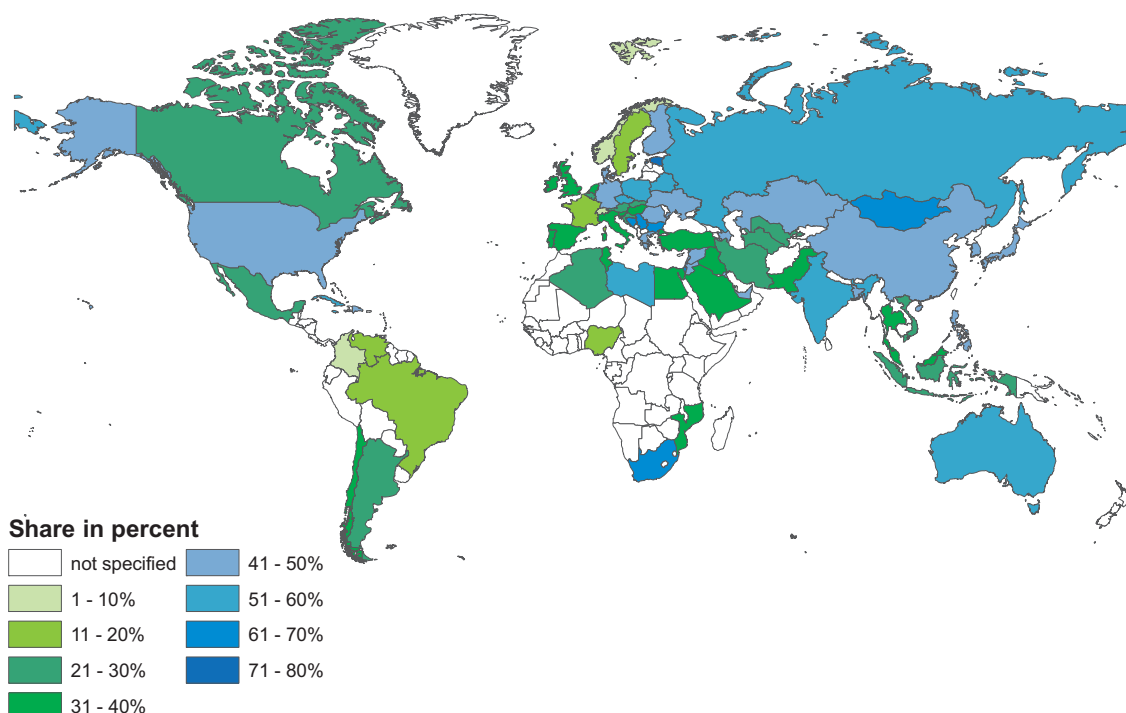
Since the availability of electrical energy is essential to the promotion of economic development and repre-

sents a key way of closing the gap to developed countries, there are extensive plans for the worldwide expansion of electricity supply. Currently, over 1.3 billion people, mostly in Sub-Saharan Africa and large parts of Asia, do not have access to electricity (International Energy Agency 2011). The outstanding importance of electrical energy is also reflected in the size of the investment required to expand the electricity supply compared to total investment in energy supply. According to a recent estimate, the electricity sector will account for nearly 45 percent of total world investments in energy supply in 2011–2035 (see also International Energy Agency 2011). However, the significant advantages offered by electric energy come at a high price. In addition to the high capital costs of building the requisite infrastructure, there is a growing focus on the carbon dioxide emissions associated with electricity generation. The world currently produces around two-thirds of electrical energy from fossil fuels, with coal representing by far the largest share of this figure. Since the production of electricity in thermal power plants suffers from relatively low energy conversion efficiency, the percentage of fuel input usually accounts for a multiple of the electric energy generated. Therefore, the fuels used add up to around a quarter of global primary energy consumption. As a worldwide average, the energy conversion efficiency of fossil power generation amounted to approximately 37.7 percent in 2009 (International Energy Agency 2011), which means that around 62 percent of the fuel energy used was lost in conversion. Power generation is therefore associated with relatively high emissions of greenhouse gases. This applies to the operation of all heat engines, including internal combustion engines, while relatively small losses occur in the conversion of fuels into heat.

Figure 1 depicts the importance of electrical power generation in terms of global CO₂ emissions from fossil fuel combustion. In the 2008 data there is only one statistic for emissions from electricity and heat production, and notably for the provision of heat for district heating networks *via* a third party (International Energy Agency 2011). As electricity generation is likely to account for a share of around 87 percent, it largely determines the emissions from this sector.

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Figure 1

SHARE OF ELECTRICITY AND HEAT PRODUCTION IN TOTAL CO₂ EMISSIONS

Sources: IEA (2011); OECD (2011).

Overall, this sector represented a share of 40.8 percent of worldwide CO₂ emissions from fossil fuels in 2008. While this share totalled 39.5 percent in OECD countries, it reached the even higher level of 44.5 percent in non-OECD countries. The fact that this figure did not rise even higher is due to carbon-free electricity generation from nuclear energy, hydropower and other renewable energies, which accounts for around 30 percent of the electric energy produced worldwide. There are major disparities between the different regions of the world, and even greater differences between individual countries. While in Asia (excluding China), almost 46 percent of carbon emissions stem from the power plant sector, in Latin America this figure is only around 20 percent due to the large share of hydropower in power generation. This share is particularly high in countries where power generation is largely based on coal. In Australia, the Czech Republic and Poland, 50–60 percent of carbon emissions stem from the power plant sector, whereas in South Africa this figure is even higher at around 63 percent.

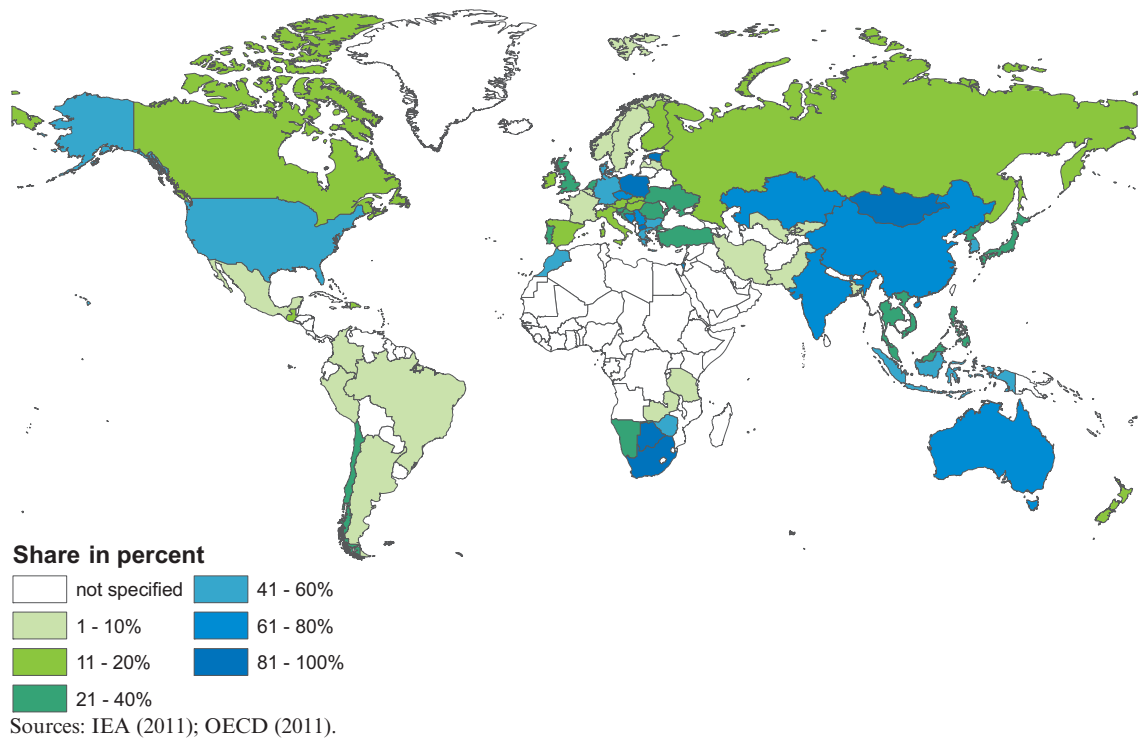
Global electricity production is currently dominated by coal and is likely to remain so in the short-term. In 2009, 40.5 percent of electric energy was provided by coal, followed by gas at 21.4 percent, hydropower at 16.2 percent, nuclear power at 13.5 percent and oil at

5.1 percent. The remaining production of 3.3 percent was accounted for by other renewable energy sources (International Energy Agency 2011). There are, as can be seen in Figure 2, huge disparities in the share of coal in electricity generation by country. At the top of the ranking there are coal-producing countries like South Africa (94 percent), Poland (91 percent), China (79 percent), Australia (78 percent), India (69 percent) and the Czech Republic (62 percent). Even countries like the United States at 49 percent and Germany at 46 percent, however, generate a large part of their electricity from coal. As a result, and also because of its higher specific CO₂ emissions relative to other fuels, coal contributes significantly to global greenhouse gas emissions. In 2009 coal-fired power plants accounted for 72.8 percent of the global CO₂ emissions produced by total electricity generation and for 29.7 percent of the total global CO₂ emissions from fuels. There are good reasons for the importance of coal in electricity production. The following aspects are particularly crucial: in many countries, coal can be produced cheaply, there is global, efficient coal trading and the reserves are, compared to oil and gas, much larger. In addition, combustion is becoming increasingly efficient in larger furnaces.

In view of the growing electricity demand to be expected in the future the goal is to prevent carbon

Figure 2

SHARE OF COAL-GENERATED ELECTRICITY IN TOTAL ELECTRICITY GENERATION



dioxide emissions from increasing further or even to reduce them. To this end, the following measures can, in principle, be taken (in addition to the option of increasing the productivity of electricity use and thus saving electrical energy):

- increase the conversion efficiency of fossil-fired power plants,
- construct additional of facilities for the use of renewable energies, and
- expand nuclear energy.

A significant increase in the efficiency of fossil-fired power plants can only be achieved by replacing the old facilities. The average efficiency of existing global coal-fired power plants is currently 35.5 percent (according to estimates based on figures from the International Energy Agency (2010a), International Energy Agency (2010b), International Energy Agency (2010c)). There is a range which extends from about 25 percent for older power plants up to 46 percent in modern facilities. If all power plants had the highest efficiency today, the use of coal as well as CO₂ emissions could be reduced by around 23 percent. With a further increase in efficiency, which is expected in the coming years, a reduction of around 25 percent would be possible. However, since coal-fired power plants are generally operated for around 40 years, a modern-

ization of all facilities will extend over a long period. The effects of modernization will therefore only be felt in the long run. Another option is to replace coal-fired power plants with gas-fired equivalents. However, on a global scale, this alternative is not really practical given the limited availability and the price of gas. In other words, a large-scale replacement of coal with gas is hardly conceivable. Since modern gas-combined power plants achieve efficiencies of around 60 percent, this would result in a fuel saving of around 40 percent compared to the average of coal plants. Lower specific CO₂ emissions would also make it possible to slash emissions of greenhouse gases by around two-thirds. Overall, increasing power plant efficiency can indeed be an important measure for reducing CO₂ emissions, but the potential of this instrument is limited and it can only be mobilized in the long run.

The facilities for the use of renewable energies and the expansion of nuclear energy represent another option because they allow operation without CO₂ emissions. A key feature of these systems is the high capital expenditure necessary for their construction. However, while nuclear power plants are usually built in large units, and are therefore primarily for industrial and emerging countries with high electricity demand, wind and solar plants in particular can be used for

power generation even in small units to complement and partly replace the existing supply system. The main drawback of electricity generation *via* wind and sun, however, is that it is subject to sharp fluctuations, making sufficient control and reserve power plants a necessity. In many regions of the earth there are relatively good conditions for the generation of solar and wind power, while there is also still considerable potential worldwide for the use of hydropower. However, even the extensive construction of these high-performance facilities requires investment, which can only be realized in the long term. By using these options, it seems possible to significantly decrease the high carbon emissions associated with the employment of fuels to generate electricity in the long-term, and to clearly reduce the weight of the conversion sector as a CO₂ emitter.

References

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