CHAPTER 11

Electricity and Heat

Emissions

Electricity and heat[91] account for about 25 percent of global GHG emissions, making it the largest sector. This is equivalent to 32 percent of global CO_2 emissions and 43 percent of CO_2 emissions from energy-related sources. Within this sector, electricity generation accounts for the largest share, at 68 percent of the sector and 17 percent of global GHG emissions. Heat (including combined heat and power) amounts to about 5 percent of worldwide emissions, and other energy industries[92] account for roughly 3 percent (Figure 11.1).

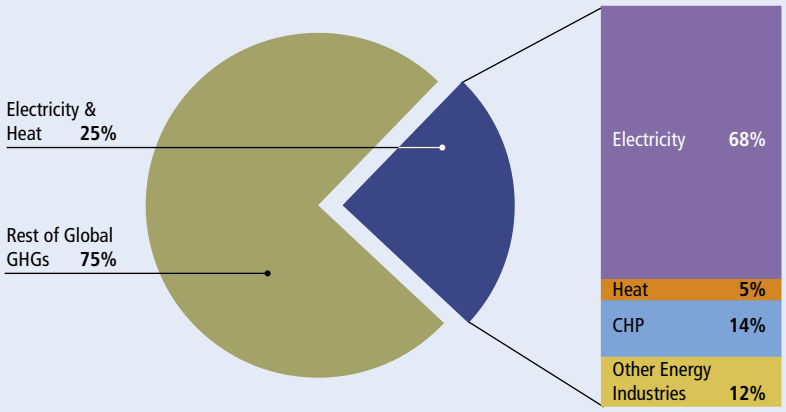
More than 40 percent of all electricity is consumed in buildings, either residential (23 percent) or commercial and public (19 percent, collectively).[93] (The main uses within buildings are discussed in Chapter 14.) Industry accounts for a further 35 percent of all electricity use. About 9 percent of electricity is consumed in energy production and processing (for example, refineries), with an equal amount lost in transmission and distribution (transmission and distribution losses are significantly higher in developing countries). Relatively small amounts are consumed in agriculture (2.3 percent of total) and transport (1.4 percent, mostly from rail). With respect to fuel types, coal powers 38 percent of global electricity supply. Gas, nuclear, and hydropower follow with shares of 20, 17, and 16 percent, respectively (Figure 11.4).

Residential and industry sectors dominate public heat consumption, at 39 and 33 percent of the global total, respectively.[94] Smaller amounts come from energy production and processing (9 percent), other buildings (8 percent), and distribution losses (7 percent). In terms of fuel sources, most heat is generated by gas (53 percent) and coal (36 percent).

Figure 11.5 shows electricity and heat-related CO_2 emissions of the top emitting countries, in both absolute and per capita terms. Together, these countries account for 88 percent of global emissions from this sector, with the 10 largest emitters accounting for 81 percent. The United States, China, and the EU-25 are by far the largest emitters (25, 16, and 14 percent, respectively, of the global total for this sector). The largest per capita emitters, in order, are Australia, the U.S., Saudi Arabia, and Russia.

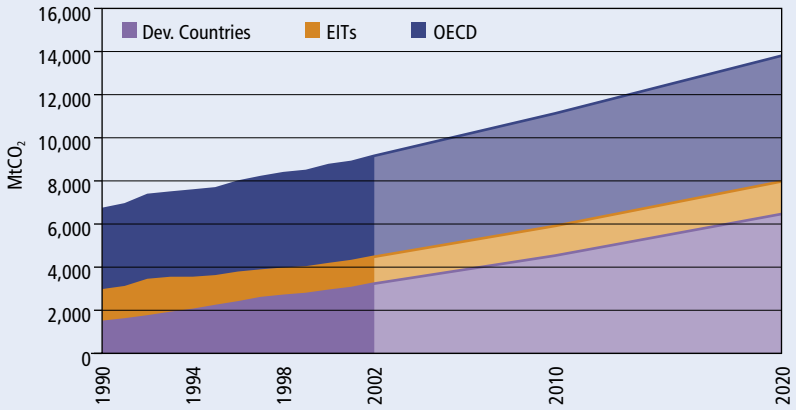
The notable cross-country differences are explained by a variety of factors, discussed in Part I of this report. First, different levels of affluence and access to

Figure 11.1. GHGs from Electricity and Heat



Sources & Notes: IEA, 2004a. See Appendix 2.A for sources and sector definition. Absolute emissions in this sector, estimated here for 2000, are 10,269 $MtCO_2$.

Figure 11.2. GHGs from Electricity and Heat, Trends and Projections



Source: IEA, 2004b,c.

electricity result in large consumption and emissions disparities. Second, power generation efficiencies are higher in some countries than others.[95] Third, fuel mixes for power generation vary significantly across countries, as shown in Figure 11.6.

To some extent, these variances stem from government decisions that favor exploitation of domestic energy resources for electric power generation. Countries with large coal resources—like Australia, the United States, India, China, and South Africa—have tended to exploit those resources, resulting in higher CO_2 emissions. For other countries, like Brazil, hydropower potential has been exploited, resulting in relatively low emissions. Likewise, countries like France that made decisions decades ago to invest in nuclear energy are likely to have lower electricity emissions. For countries with large oil reserves (and production), such as Saudi Arabia, oil is used in domestic power generation despite the fact that oil is the least efficient fossil fuel for electricity generation.

Few countries have large fractions of their power generated from non-hydro renewables (for example, geothermal and wind). Among the major emitters, Indonesia (5.8 percent) and Spain (3.8 percent) have the largest shares of non-hydro renewables.[96] Among countries not ranked in the top 25 emitters, Costa Rica, Denmark, Iceland, and the Philippines are notable in that they all have shares exceeding 15 percent of their national totals.

At the global level, emissions from electricity and heat are growing faster than any other sector, and are projected to keep growing at high rates. From 1990 to 2002, emissions from electricity and heat rose fastest in the developing Asian economies, growing 120 percent or more in South Korea, China, India, and Indonesia (Figure 11.3). In these same countries, growth by 2020 is expected to approach or exceed an additional 100 percent. Emissions since 1990 grew by a modest 8 percent in Europe, and declined in Russia and Ukraine. Increases of about 25 percent are projected in the United States and the European Union (without taking into account the impact of the EU's emissions trading scheme, which began in January 2005).

Sector Context

Electricity and heat provide vital and enabling services, playing a dominant role in the economic life of industrialized and many other countries. The importance of this sector has, to a large degree, shaped its characteristics, including the level of government involvement and international exposure. Government intervention remains heavy in electricity and heat generation, despite liberalization and international investment trends, discussed below. In most countries, electricity and heat production for public consumption is either publicly owned or a regulated enterprise. This is due to the public benefits associated with power and heat, linkages to economic and national security issues, as well as the natural monopoly characteristics of transmission and distribution services.

The electricity and heat sector has a low overall level of international exposure. Trade plays only a minor role, with just over 3 percent of world electricity production traded across borders, and virtually no trade in heat.[97] This is due partly to the requirement of geographic contiguity, which inherently limits trade in this sector. Other factors are also significant, such as governmental preferences to exploit domestic resources (discussed above) and limited cross-border electric transmissions systems. Most electricity trade is within Europe and North America.[98] Although actual trade flows are small, some African countries are heavily reliant on electricity imports.

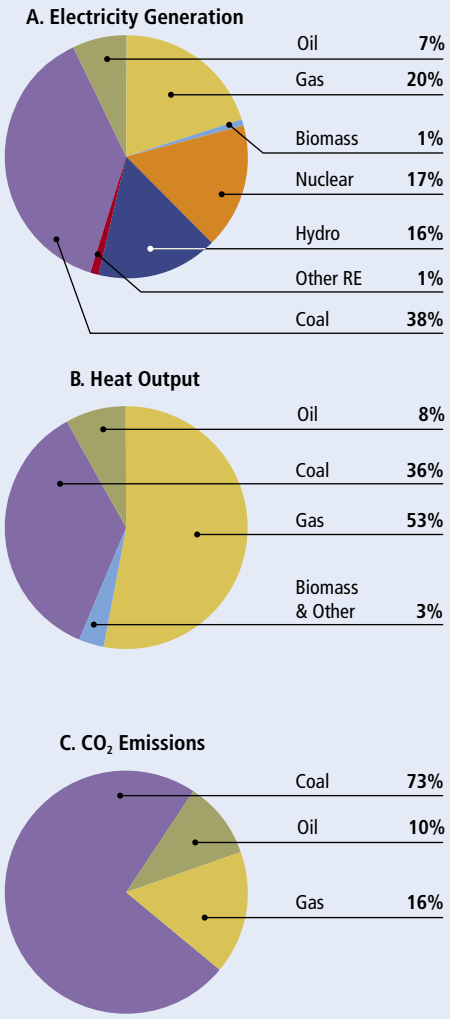
Because electric transmission systems are not deeply integrated internationally, sales of electric power in most countries are not exposed to international competition. Due to trends in liberalization and regulatory restructurings, however, power companies have been expanding their international investment portfolios. More than 20 U.S. power companies have established assets in other countries that are liberalizing their power sectors, such as the United Kingdom, Argentina, Australia, and Chile.[99] Government-owned Electricité de France generates and distributes electricity in 19 countries.[100] Other companies are focusing more exclusively on overseas investment. The U.S.-based AES Corporation, for instance, operates 113 electric power facilities in 17 countries, employing

Figure 11.3. CO_2 from Electricity and Heat

Country	% of World 2002	% Change 1990–2002	% Change Projected 2002–2020*
United States	24.7	26	23
China	15.8	147	104
EU-25	14.0	1	26
Russia	8.6	-17	18
India	5.4	119	83
Japan	4.7	24	–
Australia	2.0	53	19
South Korea	1.8	203	–
Canada	1.8	39	–
Mexico	1.7	75	65
Indonesia	1.1	120	149
Brazil	0.5	80	133
World	**100.0**	**66**	**51**

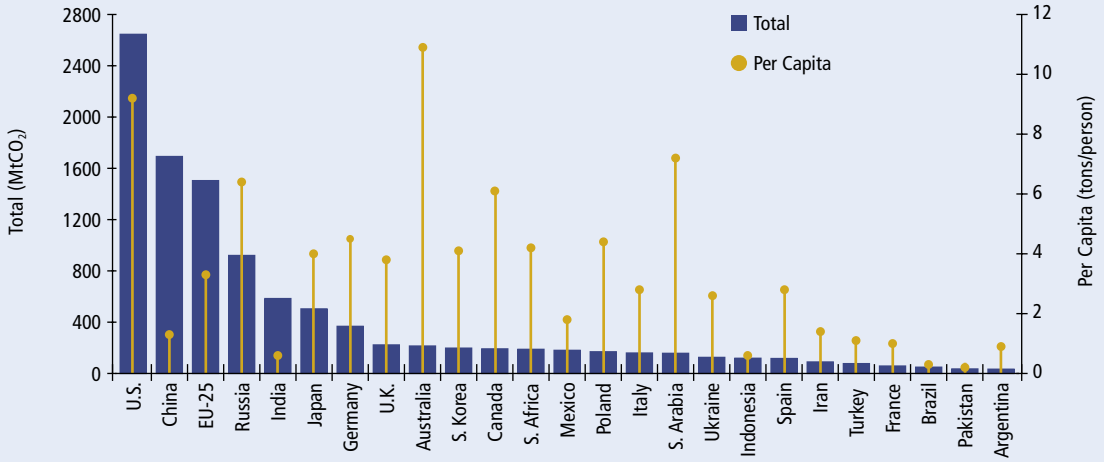
Notes: Growth rates for Russia are from 1992 (not 1990). *Projections are drawn from IEA (2004c). The projected figure for the U.S. includes Canada; Australia includes New Zealand. "–" signifies no data.

Figure 11.4. Electricity and Heat
Shares by fuel



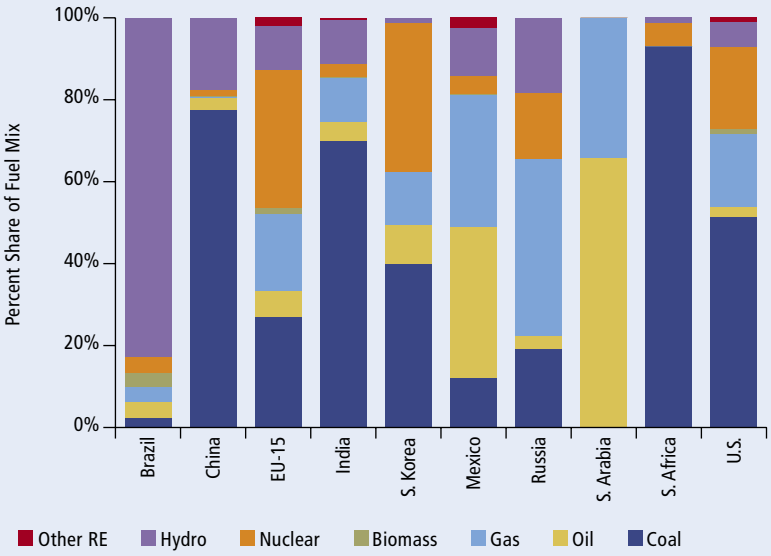
Sources & Notes: WRI, based on IEA, 2004a,b. Electricity generation and heat output are based on gigawatt hours and terajoules, respectively. CO_2 emissions include electricity and heat.

Figure 11.5. **CO_2 from Electricity and Heat, Total and Per Capita, 2002**
Top 25 GHG emitters



Source: WRI, CAIT.

Figure 11.6. **Fuel Mix in the Electricity Sector, 2002**
Relative shares, selected major GHG emitters



Sources & Notes: WRI, based on IEA, 2004b. Shares are based on gigawatt hours of generation.

30,000 people.[101] Still other companies are regionally focused. The South African utility Eskom, for example, has operations in other African countries, and seeks to become the pre-eminent African energy-related service company.[102]

In terms of uniformity, the electricity and heat sector has mixed characteristics. On one hand, electricity itself is almost completely fungible; the end product is the same regardless of the fuels and processes used to generate it. Similarly, the components of generating technologies, such as turbines, are fungible and may offer large advantages for harmonization. The number of basic fuels used to produce electricity is also relatively small. However, technologies used to generate electricity can vary widely. Advances in technology can also take long periods to achieve full potential, as large electricity plants tend to have operating lives of many decades.

Emissions from the electricity and heat sector are dominated by fuel consumption. Practices for estimating emissions from these processes are well understood and estimates are easily calculated when fuel consumption data is available. Consequently, there is little difficulty in measuring emissions from this sector. Large hydroelectric power dams are an exception, particularly in tropical countries where CH_4 emissions may be significant.[103] Attribution likewise does not present large challenges, since most (but not all) emissions occur when fuels are combusted, not when they are extracted or refined. However, regional trade may present some potential attribution controversy, as emissions associated with electricity trade would tend to be allocated only to the producer country.