2. Energy supply and demand: trends and prospects

Energy demand is expected to increase considerably in the coming years as the result of population growth and economic development (EIA, 2007). Many people in the world are currently experiencing dramatic shifts in lifestyle as their economies make the transition from a subsistence to an industrial or service base. The largest increases in energy demand will take place in developing countries where the proportion of global energy consumption is expected to increase from 46 to 58 percent between 2004 and 2030 (EIA, 2007). Per capita consumption figures are, however, likely to remain well below those in Organisation for Economic Co-operation and Development (OECD) countries.

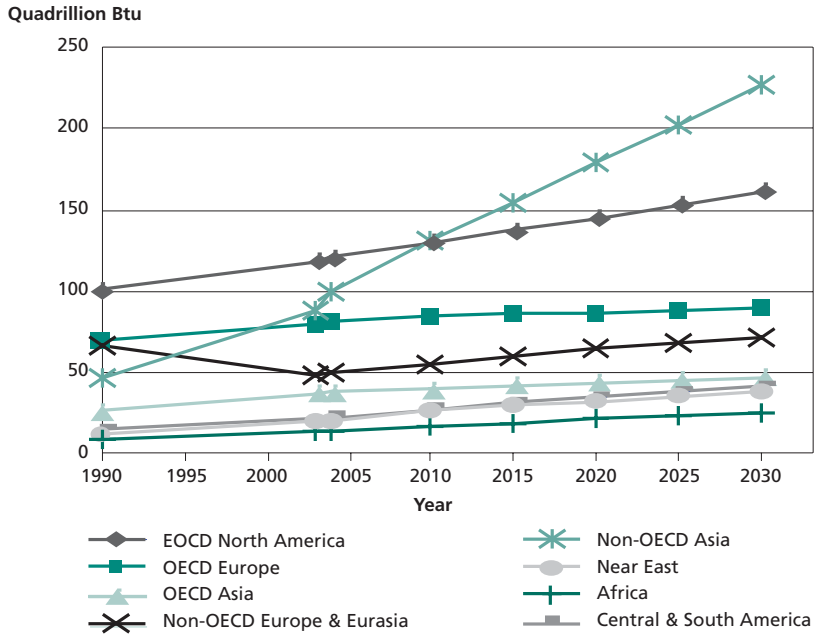
Energy consumption in developing countries is projected to grow at an average annual rate of 3 percent from 2004 to 2020. In industrialized countries, where national economies are mature and population growth is expected to be relatively low, the demand for energy is projected to grow at the lower rate of 0.9 percent per year, albeit from a much higher starting point. Energy consumption in developing regions is projected to surpass that in industrialized regions by 2010. About half of the increase in global energy demand by 2030 will be for power generation and one-fifth for transport needs – mostly in the form of petroleum-based fuels (EIA, 2007).

Much of the increase in energy demand will result from rapid economic growth in Asian economies, especially China and India. Energy demand in the developing countries of Asia is projected to grow at an average rate of 3.7 percent per year, far higher than any other region (Figure 1). Asia will more than double its energy consumption over the next 20 years, and is expected to account for around 65 percent of the total increase in energy demand for all developing countries. Although the energy consumption of developing countries in other regions is expected to grow at a slower pace than in Asia, rates are still expected to exceed the global average (Table 1). While all regions will play a role in future energy supply and demand, the enormous consumption increases projected in Asia make the region of key interest in future energy development.

The vast majority of the world's energy is generated from non-renewable sources, specifically oil, coal and gas (Figure 2). Just over 13 percent of global energy is derived from renewable sources, 10.6 percent of which from combustible renewables and renewable municipal waste. The remainder of renewable energy comes from hydro-, geothermal, solar, wind, and tidal and wave sources.

Projections of total global energy consumption show that between 2004 and 2030, fossil fuels will provide the bulk of the increase, with nuclear and other sources providing relatively minor contributions in absolute terms (Figure 3 and Table 1). In

FIGURE 1
Total marketed energy consumption for OECD and non-OECD countries, 1990–2030*



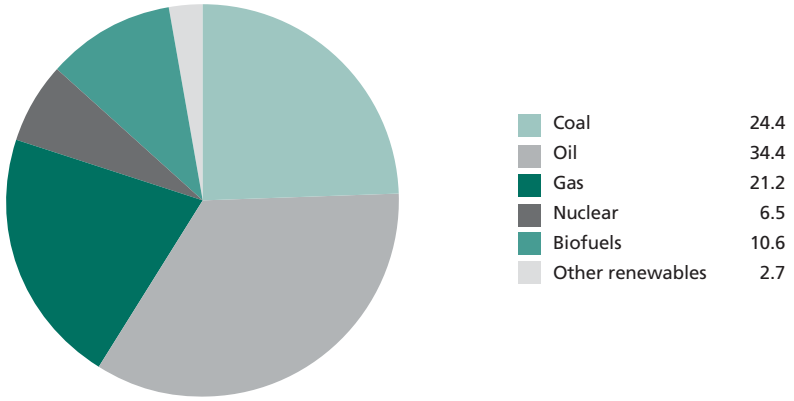
*Projections after 2004
Note: does not include traditional biomass
Source: EIA, 2007

TABLE 1
World total marketed energy consumption by region and fuel, 1990–2030 (quadrillion Btu)

Region/Source	Year					Growth
Region	**1990**	**2004**	**2010**	**2020**	**2030**	**% Annual growth 2004–2030**
OECD North America	100.8	120.9	130.3	145.1	161.6	1.1
OECD Europe	69.9	81.1	84.1	86.1	89.2	0.4
OECD Asia	26.6	37.8	39.9	43.9	47.2	0.9
Non-OECD Europe & Eurasia	67.2	49.7	54.7	64.4	71.5	1.4
Non-OECD Asia	47.5	99.9	131.0	178.8	227.6	3.2
Near East	11.3	21.1	26.3	32.6	38.2	2.3
Africa	9.5	13.7	16.9	21.2	24.9	2.3
Central & South America	14.5	22.5	27.7	34.8	41.4	2.4
Total OECD	**197.4**	**239.8**	**254.4**	**275.1**	**298.0**	**0.8**
Total Non-OECD	**150.0**	**206.9**	**256.6**	**331.9**	**403.5**	**2.6**
Source						
Oil	136.2	168.2	183.9	210.6	238.9	1.4
Natural Gas	75.2	103.4	120.6	147.0	170.4	1.9
Coal	89.4	114.5	136.4	167.2	199.1	2.2
Nuclear	20.4	27.5	29.8	35.7	39.7	1.4
Other	26.2	33.2	40.4	46.5	53.5	1.9
TOTAL WORLD	**347.3**	**446.7**	**511.1**	**607.0**	**701.6**	**1.8**

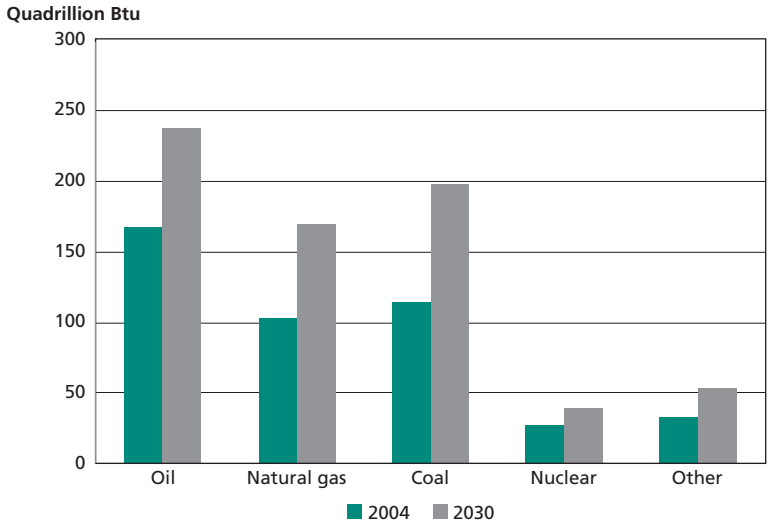
Note: does not include traditional biomass
Source: EIA, 2007

FIGURE 2
Fuel shares of world total primary energy supply in 2004 (%)



Source: IEA, 2007a

FIGURE 3
Total global marketed energy consumption by source in 2004 and projected for 2030



Note: does not include traditional biomass
Source: EIA, 2007

percentage terms, gas and coal are likely to show the greatest change with increases of 65 and 74 percent respectively. Oil consumption is expected to increase by 42 percent while nuclear and renewables, starting from a much lower baseline, are expected to increase by 44 and 61 percent respectively. The ultimate contributions from different sources will be highly dependent on policy directions. Projections should therefore be viewed primarily as a point of departure for further discussion.

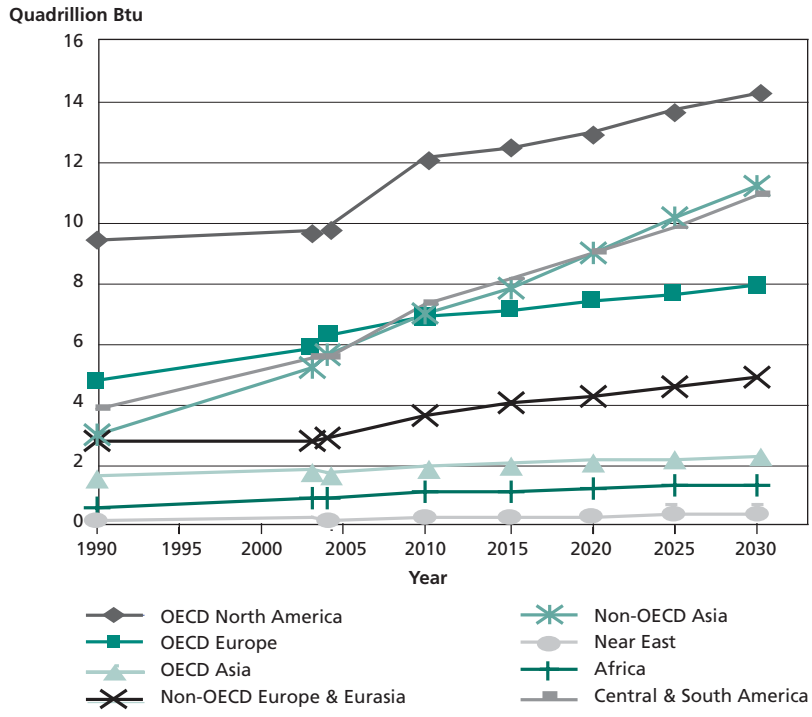
RENEWABLE ENERGY

Renewable energy consists of energy produced and/or derived from sources that can be renewed indefinitely, such as hydro-, solar and wind power, or sustainably produced, such as biomass. Notwithstanding the forecast dominance of fossil fuels, the use of renewable sources of energy is expected to expand. Based on United States Energy Information Administration (EIA) projections, marketed renewables will grow over the next decades at an annual rate of around 1.9 percent. The greatest absolute increases are expected in North America, Asian developing countries and Central and South America (Figure 4). Annual growth rates in consumption of renewables are expected to be highest in the Near East, Asian developing countries and Central and South America (Table 2). In Asian developing countries, the trend is driven more by increased energy consumption than a particular focus on renewables as in Central and South America.

In most of the world's regions, the proportion of energy from marketed renewable sources is expected to increase in the coming years (Figure 5). By far the greatest overall proportion of renewable energy consumption is in Central and South America, where economically competitive non-fossil fuel sources of energy are already well established

FIGURE 4

Marketed renewable energy consumption for OECD and non-OECD countries, 1990–2030*



*Projections after 2004

Note: does not include traditional biomass

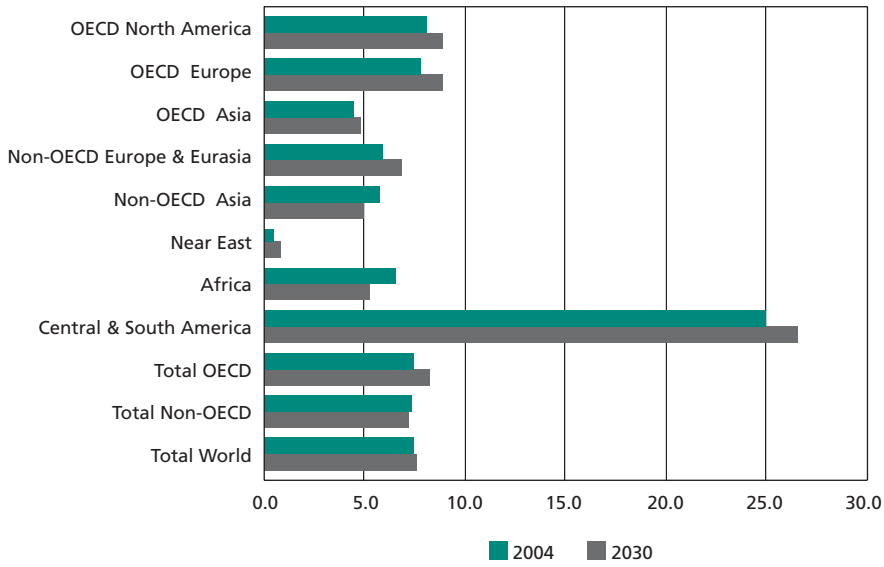
Source: EIA, 2007

TABLE 2
World consumption of hydroelectricity and other marketed renewable energy by region, 1990–2030 (quadrillion Btu)

Region	1990	2004	2010	2020	2030	% Annual growth 2004–2030
OECD North America	9.5	9.9	12.2	13.1	14.4	1.5
OECD Europe	4.8	6.3	6.9	7.5	8.0	0.9
OECD Asia	1.6	1.7	1.9	2.1	2.3	1.2
Non-OECD Europe & Eurasia	2.8	2.9	3.6	4.3	4.9	2.0
Non-OECD Asia	3.0	5.7	7.0	9.1	11.3	2.7
Near East	0.1	0.1	0.2	0.2	0.3	4.3
Africa	0.6	0.9	1.1	1.2	1.3	1.4
Central & South America	3.9	5.6	7.4	9.1	11.0	2.6
Total OECD	**15.9**	**17.9**	**21.1**	**22.7**	**24.7**	**1.2**
Total Non-OECD	**10.3**	**15.3**	**19.3**	**23.9**	**28.8**	**2.5**
TOTAL WORLD	**26.2**	**33.2**	**40.4**	**46.5**	**53.5**	**2.5**

Note: does not include traditional biomass
Source: EIA, 2007

FIGURE 5
Percentage of marketed renewable energy in total energy consumption for OECD and non-OECD countries in 2004 and projected for 2030



Note: does not include traditional biomass
Source: EIA, 2007

(Box 2). These figures do not take into account the recent long-term energy strategy of the European Union (EU), which proposes that by 2020, EU consumption of renewables will increase to 20 percent of total energy use; the proportion of biofuels used in transport will increase to 10 percent; and EU greenhouse gas emissions will be reduced to 20 percent below 1990 levels (European Union, 2007).

BOX 2

Biofuels for transport in Brazil

Worldwide, only about 1 percent of the consumption of transport fuels comes from liquid biofuels. Brazil is a notable exception to this average. During the first global oil crisis in 1975, Brazil launched a national biofuel programme leading to the large-scale production of ethanol from domestic sugar supplies. More than 90 percent of all cars produced and sold in Brazil are "flex", that is equipped with a motor that can run on ethanol, petrol or mixtures. Brazil has recently launched a global campaign to promote biofuels as a viable alternative to fossil fuels for transport.

In Brazil, biofuel from sugar cane sources is more competitive than petrol, when the oil price is above US$35 per barrel. Bioethanol from corn in the United States is, by comparison, competitive at an oil price of US$55 per barrel, and bioethanol in the European Union requires an oil price of US$75 to $100 per barrel to be competitive (Worldwatch Institute, 2007).

The success of biofuels in Brazil is largely a result of the high productivity of sugar cane and the suitability of the feedstock for efficient conversion to ethanol. Approximately 190 000 ha of sugar-cane plantations are established every year, mostly in the southern parts of the country (FAO, 2007c). Brazil is expected to continue to be the major biofuels exporter worldwide (Global Insight, 2007).

Higher fossil fuel prices and government policies and programmes in support of the development of alternative energy will be factors in the competitiveness of renewable energy sources. In spite of national and international efforts, however, forecasts do not show the global share of renewable energy increasing significantly. A minor expansion from 7.4 to 7.6 percent is all that is expected by 2030 (EIA, 2007).

The World Alternative Policy Scenario presented in the World Energy Outlook 2006 (IEA, 2006) shows how the global energy market could evolve if countries around the world were to adopt policies and measures currently under consideration for reducing carbon dioxide emissions and improving energy supply security (Table 3). In the scenario, the share of renewables in global energy consumption remains largely unchanged while the share of traditional biomass falls. Hydropower production will grow but its share will remain stable, while the shares of other renewables (including geothermal, solar and wind) will increase most rapidly, but from such a low base that they will remain the smallest component of renewable energy in 2030.

With the inclusion of traditional biomass, heating and cooking will remain the principal uses of renewable fuels over the next 25 years. The power sector, however, is expected to lead the global increase in renewable energy consumption (IEA, 2004). This sector accounted for a quarter of global renewable energy consumption in 2002, but its share is projected to rise to 38 percent by 2030. Currently, less than 1 percent of fuels used for transport are renewable. According to projections, this share will rise to 3 percent over the next 25 years. The overall

impact of these changes on global energy consumption will be relatively small although the impact on deforestation and food security may be considerable.

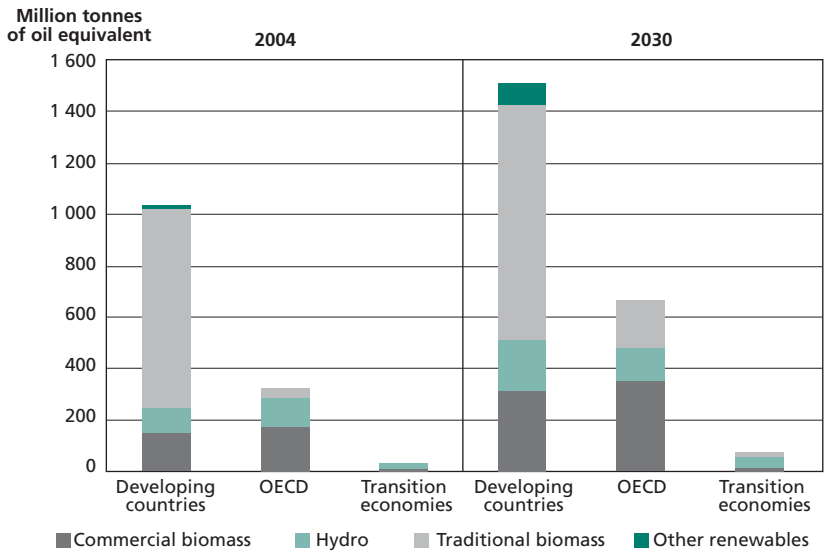
Renewable energy including traditional biomass makes up a greater proportion of total energy supplies in developing than in developed countries. About three-quarters of renewable energy are consumed in developing countries, where most renewable energy production is based on the use of traditional biomass and hydropower. Industrialized countries account for 23 percent of the total renewable energy consumed worldwide, and transition economies for 3 percent (Figure 6).

TABLE 3
Global increase in renewable energy

Energy source	2004	2030	Approximate increase (times)
Electricity generation (TWh)	**3 179**	**7 775**	**>2**
Hydropower	2 810	4 903	<2
Biomass	227	983	>4
Wind	82	1 440	18
Solar	4	238	60
Geothermal	56	185	>3
Tide and wave	<1	25	46
Biofuels (Mtoe)	15	147	10
Industry and buildings (Mtoe)	**272**	**539**	**2**
Commercial biomass	261	450	<2
Solar heat	6.6	64	10
Geothermal heat	4.4	25	6

Note: TWh = Terrawatt hour; Mtoe = Million tonnes of oil equivalent
Source: IEA, 2006; OECD/IEA 2006 cited in IEA, 2007a

FIGURE 6
World renewable energy consumption by region for 2002 and projected for 2030



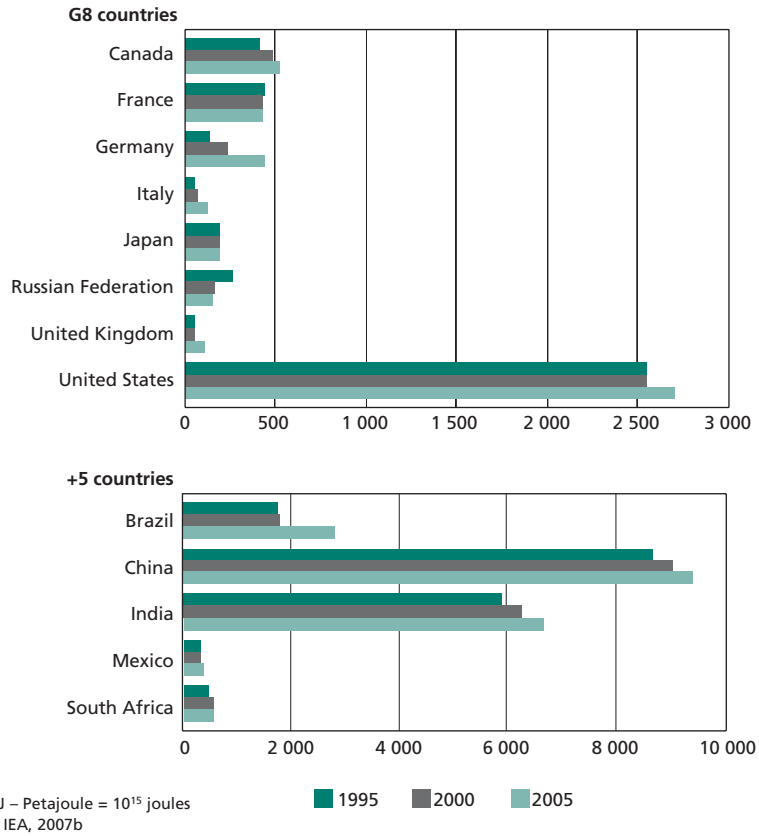
Source: IEA, 2004

The two regions where renewable energy is the most significant are Africa and Latin America. In Africa, this is largely due to consumption of woodfuel for heating and cooking. In Latin America, it is due to the high use of renewables in Brazil, where 45 percent of all energy consumed is based on renewables – hydropower, wood, and sugar-cane ethanol.

Biofuel use is increasing in most of the G8 + 5 countries, which consume the largest amounts of energy in the world, with the notable exception of the Russian Federation where the availability of fossil fuels is increasing. In absolute terms, the United States, China and India consume by far the largest quantities of biofuels (Figure 7).

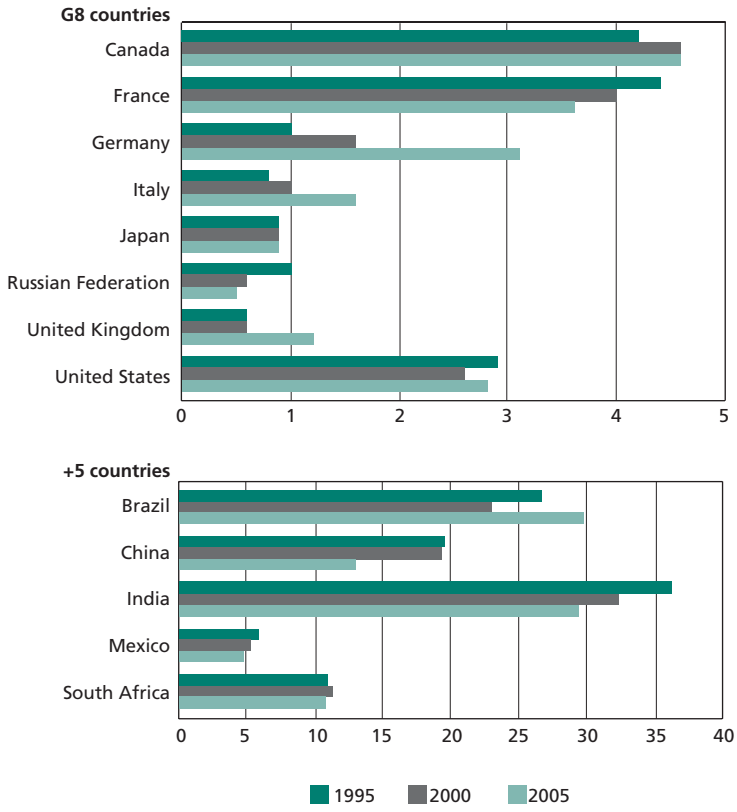
Figure 8 shows clearly the impact of government policies by comparing the relative use of bioenergy as a percentage of total energy consumption in the G8 + 5 countries between 1995 and 2005. Bioenergy increased as a percentage of total energy use between 2000 and 2005 in Germany, Italy, the United Kingdom, the United States and Brazil, all of which provided economic incentives for bioenergy consumption. However, the relative use of biofuels declined in China and India where high rates of economic growth outpaced the impacts of rising fossil fuel prices.

FIGURE 7
Total primary energy supply (TPES) from biofuels for G8+5 countries (PJ)



Note: PJ – Petajoule = 10^{15} joules
Source: IEA, 2007b

FIGURE 8
Percentage primary energy supply from bioenergy



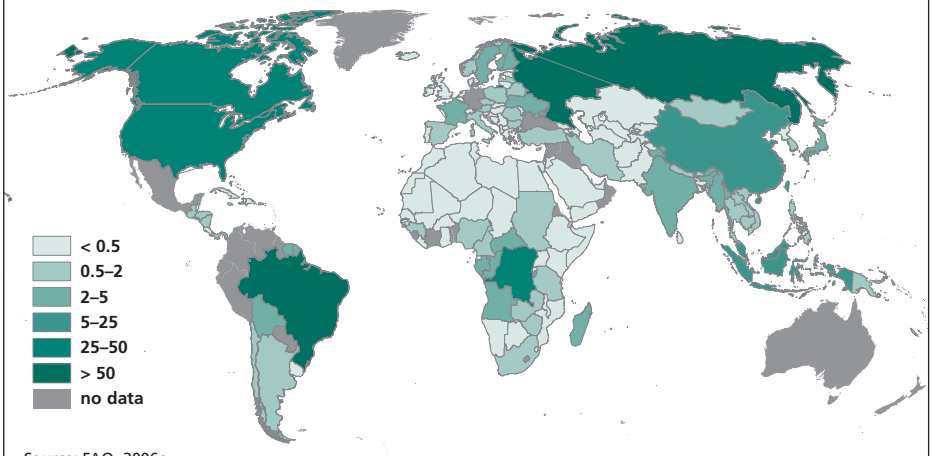
Source: IEA, 2007b

WOOD-BASED ENERGY

The availability of wood, and its potential as a biofuel to substitute for oil in the future, is unevenly distributed throughout the world (Figure 9). Global industrial roundwood production was about 1.7 billion cubic metres in 2005, compared with fuelwood production of approximately 1.8 billion cubic metres (FAO, 2007c). About 65 percent of global industrial roundwood was produced in industrialized countries, compared with only about 13 percent of fuelwood. The largest producers of fuelwood are India (306 million cubic metres), China (191 million cubic metres) and Brazil (138 million cubic metres). Production of fuelwood is significant in only a few industrialized countries including the United States, Mexico, Finland, Sweden and Austria among others. There are, however, problems with data availability, and household surveys of fuelwood-use have shown considerable consumption in several other industrialised countries (Steierer *et al*., 2007).

The vast majority of fuelwood is still produced and consumed locally. Since fuelwood is mainly used in private households and is often traded informally, it

FIGURE 9
Total growing stock (billion m³)



Source: FAO, 2006c

is difficult to collect good country-level data. Many other caveats apply to the accuracy and availability of statistics on woodfuel (Box 3).

Historically, wood has been the most important source of bioenergy. Wood has been used for cooking and heating since the discovery of fire. In developing countries, it is also used in commercial applications such as fish drying, tobacco curing and brick baking. In developed countries, it is predominantly used for energy generation in the forest industry.

In recent years, wood energy has attracted attention as an environmentally friendly alternative to fossil energy, and investments have been made to improve efficiency, especially in relation to industrial applications, for heat and power generation. Changes in energy policy in several parts of the world have favoured the development of wood energy-based systems. New technologies are improving the economic feasibility of energy generation from wood, particularly in countries that are heavily forested and have well established wood processing industries.

In absolute terms, the largest OECD users of wood for industrial bioenergy by volume are the United States, Canada, Sweden and Finland. Most forest biomass used for energy in these countries is recovered from indirect sources, including black liquor from wood pulping and other wood residues (Steierer *et al.*, 2007). Industrial applications accounted for just over 50 percent of total bioenergy-use in each of these countries.

Fuelwood is the predominant form of wood energy in rural areas of most developing countries, while charcoal remains a significant energy source in many African, Asian and Latin American urban households. Developing countries account for almost 90 percent of the world's woodfuel (fuelwood and charcoal) consumption and wood is still the primary source of energy for cooking and heating in developing countries (Broadhead, Bahdon and Whiteman, 2001). Over

BOX 3

Impediments to accurate woodfuel information

Statistical information on woodfuel consumption has always been difficult to obtain. The main reasons are:

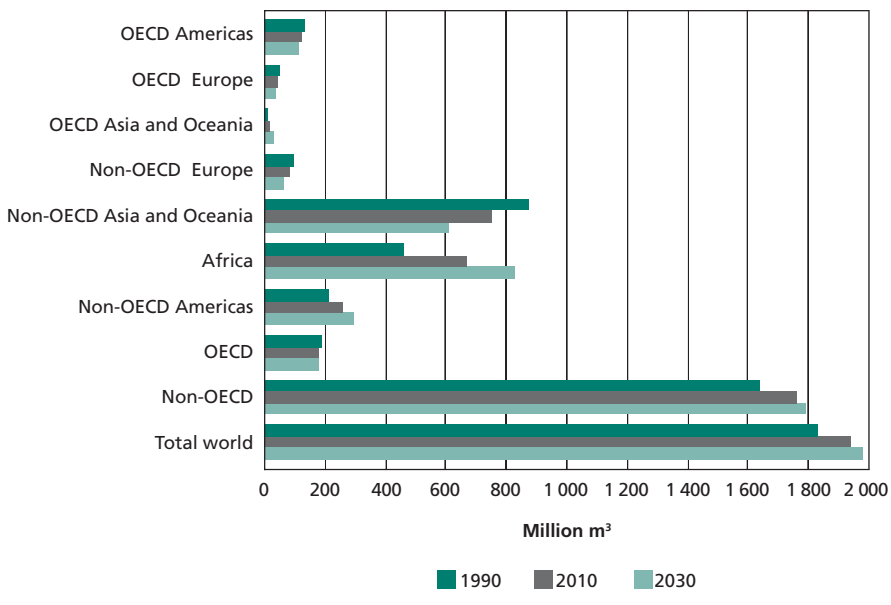
- High intensity surveys are necessary to collect accurate information since woodfuel production and consumption vary greatly across locations and at different times of the year.
- Woodfuel is mostly collected for the collector's own use and not sold in specific locations, such as markets, shops or factories, which would facilitate collection of information.
- Because of the low price of woodfuel in most countries, the sector is of little economic importance and investment in collection of statistics is therefore considered of little value.
- Many countries do not have the financial and human resources required to collect woodfuel information, especially as the countries where woodfuel is most important may also be the poorest.
- There is often poor coordination between institutions with an interest in the sector (e.g. government agencies dealing with agriculture, forestry, energy and rural development), and the benefit of information collection may be insufficient for any one agency.
- Many government forestry agencies focus their efforts on commercial wood production and neglect non-commercial forestry outputs.
- Information about woodfuel suffers from a lack of clear definitions, measurement conventions and conversion factors, which creates difficulties in comparing statistics across regions and over time.
- Because of widespread illegal logging, production may be under-declared and therefore the extent of wood residues available for energy use may be underestimated.

Source: Broadhead, Bahdon and Whiteman, 2001

the last 15 years global consumption of woodfuel has remained relatively stable, at between 1.8 and 1.9 billion cubic metres.

Figure 10 shows woodfuel consumption for OECD and non-OECD country groups between 1990 and 2030. The global trend indicates increasing consumption of woodfuel, largely a reflection of increasing consumption in Africa. Non-OECD countries in Asia and Oceania are, in contrast, showing a downward trend as rapid increases in income occur and urbanization takes place. Future consumption in OECD European countries is expected to be greater than shown in Figure 11 due to recent EU plans to increase the proportion of renewables in total energy use to 20 percent by 2020 (European Union, 2007).

FIGURE 10
Woodfuel consumption for OECD and non-OECD countries 1990, projections for 2010 and 2030



Source: Broadhead, Bahdon and Whiteman, 2001

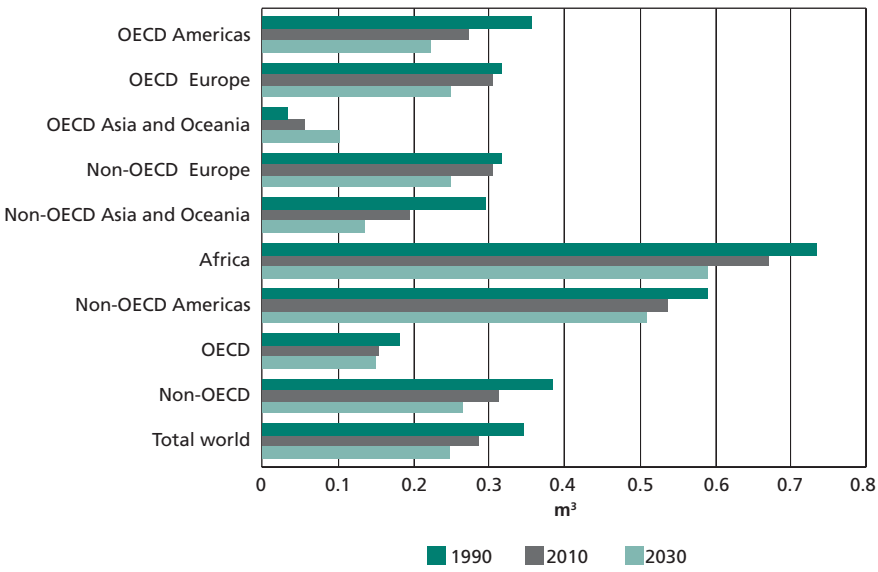
Recent surveys have also found that woodfuel consumption is considerably above previous estimates in several industrialised countries (Steierer *et al*., 2007). Figures shown for OECD countries are therefore probably towards the lower-end of the likely range.

Per capita woodfuel consumption (Figure 11) indicates differing trends in total consumption. In all regions of the world, except Asian OECD countries and Oceania, per capita consumption is decreasing as a result of rising incomes, urbanization, declining availability of wood sources and increasing availability of alternative sources of energy preferred to woodfuel. Despite this trend, total woodfuel consumption is increasing in African and in non-OECD countries in the Americas because of population growth.

Estimates of wood use in Africa show the vast majority of removals are for fuelwood and that the quantities consumed in industrial applications are relatively insignificant everywhere except in Southern Africa (Figure 12). Fuelwood use is increasing in all Africa's regions, although at a diminishing rate.

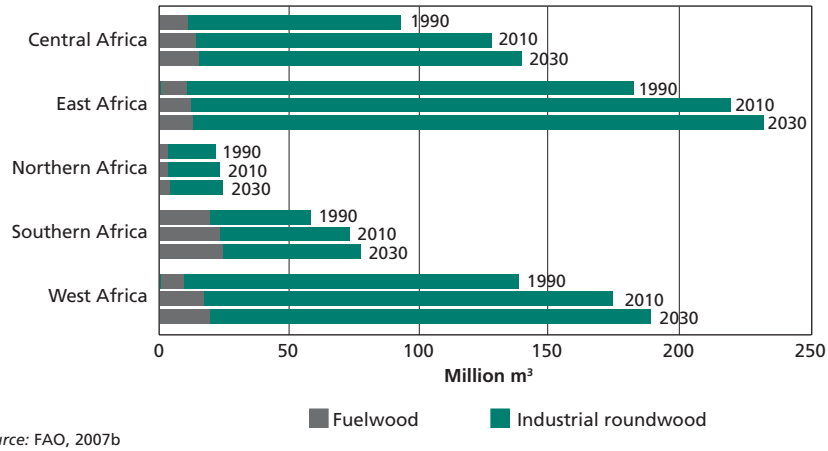
According to data collated by IEA (2006) the number of people using biomass resources as their primary fuel for cooking will increase (Table 4). Considerable increases are expected in Africa and in Asia outside of China. Overall, in the absence of new policies, the number of people relying on biomass will increase from 2.5 to 2.7 billion by 2030.

FIGURE 11
Per capita woodfuel consumption for OECD and non-OECD countries 1990, projections for 2010 and 2030



Source: Broadhead, Bahdon and Whiteman, 2001

FIGURE 12
Wood removals in Africa



Source: FAO, 2007b

Due to difficulties in collecting accurate information on woodfuel consumption, care is required in interpreting data. For example, recent increases in international energy prices have reduced the rate at which woodfuel users have been shifting to cleaner and more efficient fuels for cooking and heating (IEA, 2006).

TABLE 4
People using traditional biomass (millions)

Region/country	2004	2015	2030
Sub-Saharan Africa	575	627	720
North Africa	4	5	5
India	740	777	782
China	480	453	394
Indonesia	156	171	180
Rest of Asia	489	521	561
Brazil	23	26	27
Rest of Latin America	60	60	58
Total	**2 528**	**2 640**	**2 727**

Source: IEA, 2006

FUTURE ENERGY CHOICES – KEY ISSUES

Future energy choices will depend on a number of factors. The significance of different energy sources varies in relation to the key objectives in energy policy. Differences in carbon emissions are of importance to climate change, whereas supply location is of importance to energy dependence. Also of importance are the future price of fossil fuels and the magnitude of efforts to provide alternatives. The weight given to each of these factors and the degree to which different policy objectives compete will, to a large extent, determine future energy consumption.

Oil price

In early May 2008, oil was selling at US$126 per barrel following a steep rise from below US$20 per barrel in 1999 (figure 13). While IEA has projected that oil prices will be considerably lower than this level during most of the next 20 years, uncertainty over whether new production capacity will compensate for declining output at existing fields may mean an increase in oil prices prior to 2015 (IEA, 2007a).

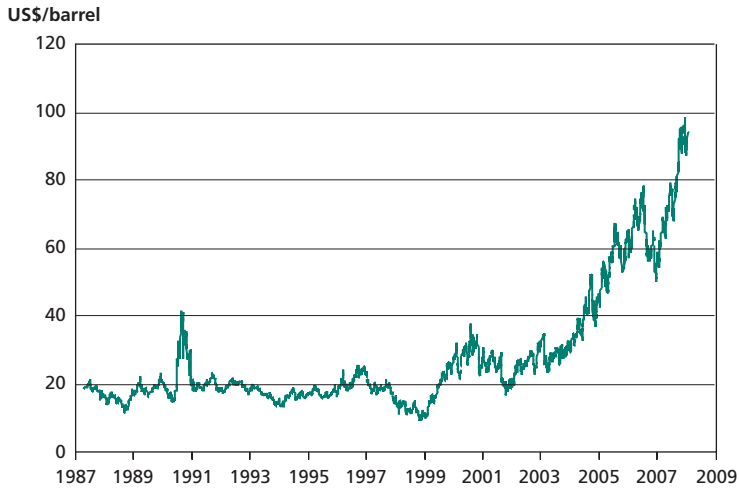
The price of oil and other fossil fuels is likely to considerably affect the adoption of renewables. Falling prices are less likely to encourage policy makers to promote renewables, although in developing countries, in particular, rising oil prices may also forestall investment in renewables by dampening economic growth.

In this respect, developing economies are especially sensitive to fluctuations in global energy supply and demand. The International Energy Agency estimates that a US$10 increase in the price of oil can reduce GDP growth by an average of 0.8 percent in Asia, and up to 1.6 percent in the region's poor highly indebted countries. The loss of GDP growth in sub-Saharan Africa can be even higher, in some countries reaching 3 percent (IEA, 2004). The effects of oil price on the development of renewables and the global distribution of consumption is likely to be convoluted and issues such as trade and technology transfer will be of great importance.

Greenhouse gas emissions

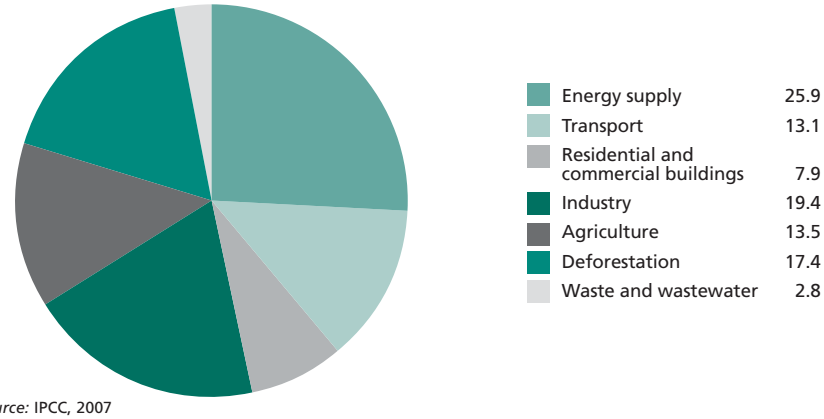
Global greenhouse gas emissions are dominated by energy production (Figure 14). Other sources, including land use change, forestry and agriculture account for around a third of emissions. Fossil fuel use is, however, the single largest human influence on climate, estimated to account for 56.6 of greenhouse gas emissions (IPCC, 2007). Transportation, although accounting for only one-eighth of emissions, has become a central focus in the bioenergy debate due to the carbon intensive nature of transportation, the high public profile of petroleum prices and dependency on producer nations.

FIGURE 13
Europe Brent Spot Price FOB, 1987–2008



Source: EIA, 2008

FIGURE 14
Global greenhouse gas emissions in 2000 by sector (%)



Source: IPCC, 2007

Despite the focus on oil and transportation in recent years, the significance of coal in future energy use and its role in climate change cannot be overlooked, especially if coal gasification processes become widely used in the production of transport fuels (Perley, 2008). Coal, by far the most polluting of the fossil fuels, is also of increasing importance – particularly in Asia where the highest energy demand increases are predicted. Of all fossil fuels, coal is the greatest contributor of climate change gases, surpassing oil in 2003. It provides a similar proportion of total world energy as gas, but emits twice the amount of carbon dioxide (IEA, 2006).

Since the supply of coal is not as restricted as oil, an increase in the share of energy supplied by coal seems inevitable, notwithstanding environmental legislation. Coal reserves are more widely dispersed than oil and gas. Large reserves of coal suitable for power generation are located in Australia, China, Colombia, India, Indonesia, the Russian Federation, South Africa and the United States. Growth projections for coal use point to the most dramatic increases occurring in Asia and the Pacific. China and India together are estimated to account for almost three-quarters of the increase in coal demand in developing countries, and two-thirds of the increase in world coal demand (IEA, 2003).

The considerable proportion of greenhouse gas emissions from deforestation – 17.4 percent annually – must also be taken into account. Efforts to ensure that production of bioenergy does not result in losses of terrestrial carbon through forest removal are critical if climate change objectives are to be achieved. Recent research has suggested that clearing of grassland or forest to produce biofuels may result in losses of carbon that will take centuries to recapture (Searchinger *et al.*, 2008; Fargione *et al.*, 2008).

Energy dependence

Dependence on energy imports is another key factor in determining the extent to which renewables and bioenergy are likely to be promoted. The degree of fuel import dependency in different regions of the world and the proportion of exports in total merchandise trade are given in Table 5. All regions outside the Near East have a high level of importation, and many regions export more than they import, indicating that some substitution could take place. Asia's imports considerably exceed exports. Europe and North America show smaller discrepancies between imports and exports, which are accounted for in part by current moves to promote biofuels.

TABLE 5
Share of fuels in total merchandise by region

Region	% exports	% imports
North America	7.1	11.7
Central and South America	20.2	15.6
Europe	5	8.5
Commonwealth of Independent States	43.9	9.8
Africa	51.9	10.2
Near East	73	4.3
Asia	5.1	14.7
World	**11.1**	**11.1**

Source: WTO, 2004