

GLOBAL ENERGY TRENDS

HIGHLIGHTS

- Global primary energy demand in the Reference Scenario is projected to increase by 53% between 2004 and 2030 – an average annual rate of 1.6%. Over 70% of this increase comes from developing countries. The power-generation sector contributes close to one-half of the global increase. Demand grows by one-quarter in the period to 2015 alone.
- Globally, fossil fuels remain the dominant source of energy, accounting for 83% of the overall increase in energy demand between 2004 and 2030. As a result, their share of world demand edges up, from 80% to 81%. In contrast to *WEO-2005*, coal sees the biggest increase in demand in absolute terms, its percentage share in global demand – like that of gas – increasing slightly. The share of oil drops. Non-hydro renewables grow quickest, but from a small base.
- The world's remaining economically exploitable energy resources are adequate to meet the projected increases in demand through to 2030. With sufficient investment in production and transportation capacity, international energy trade would grow steadily over the *Outlook* period to accommodate the increasing mismatch between the location of demand and that of production. Energy exports from non-OECD to OECD regions rise by 47%. Oil remains the most heavily traded fuel in 2030, but gas trade grows most rapidly.
- Cumulative investment in energy-supply infrastructure amounts to just over \$20 trillion (in year-2005 dollars) over 2005-2030 – significantly more than in *WEO-2005* because of higher unit costs. The power sector requires more than \$11 trillion, equal to 56% of total energy investment needs (two-thirds if investment in the supply chain to meet the fuel needs of power stations is included). Capital expenditure amounts to \$4.3 trillion in the oil sector and \$3.9 trillion in the gas sector. Roughly half of all the energy investment needed worldwide is in developing countries, where demand and production are projected to increase fastest.
- Global energy-related carbon-dioxide emissions increase slightly faster than primary energy use, because the fuel mix becomes more carbon-intensive. The power sector contributes around half the increase in emissions from 2004 to 2030. Coal remains the leading contributor to global emissions over the *Outlook* period. China accounts for 39% of the increase between 2004 and 2030, overtaking the United States as the world's biggest emitter before 2010.

Demand

Primary Energy Mix

Global primary energy demand¹ in the Reference Scenario is projected to increase by 1.6% per year between 2004 and 2030, reaching 17.1 billion tonnes of oil equivalent (Table 2.1). The increase in demand amounts to almost 6 billion toe, or 53% of current demand. The average projected rate of growth is, nevertheless, slower than that over the period 1980-2004, when demand grew by 1.8% per year. The pace of demand growth slackens progressively over the projection period: in the period 2004-2015, it grows by 2.1%. By 2015, total global energy demand is one-quarter higher than in 2004. The rate of growth drops to 1.3% in 2015-2030.

Table 2.1: World Primary Energy Demand in the Reference Scenario
(Mtoe)

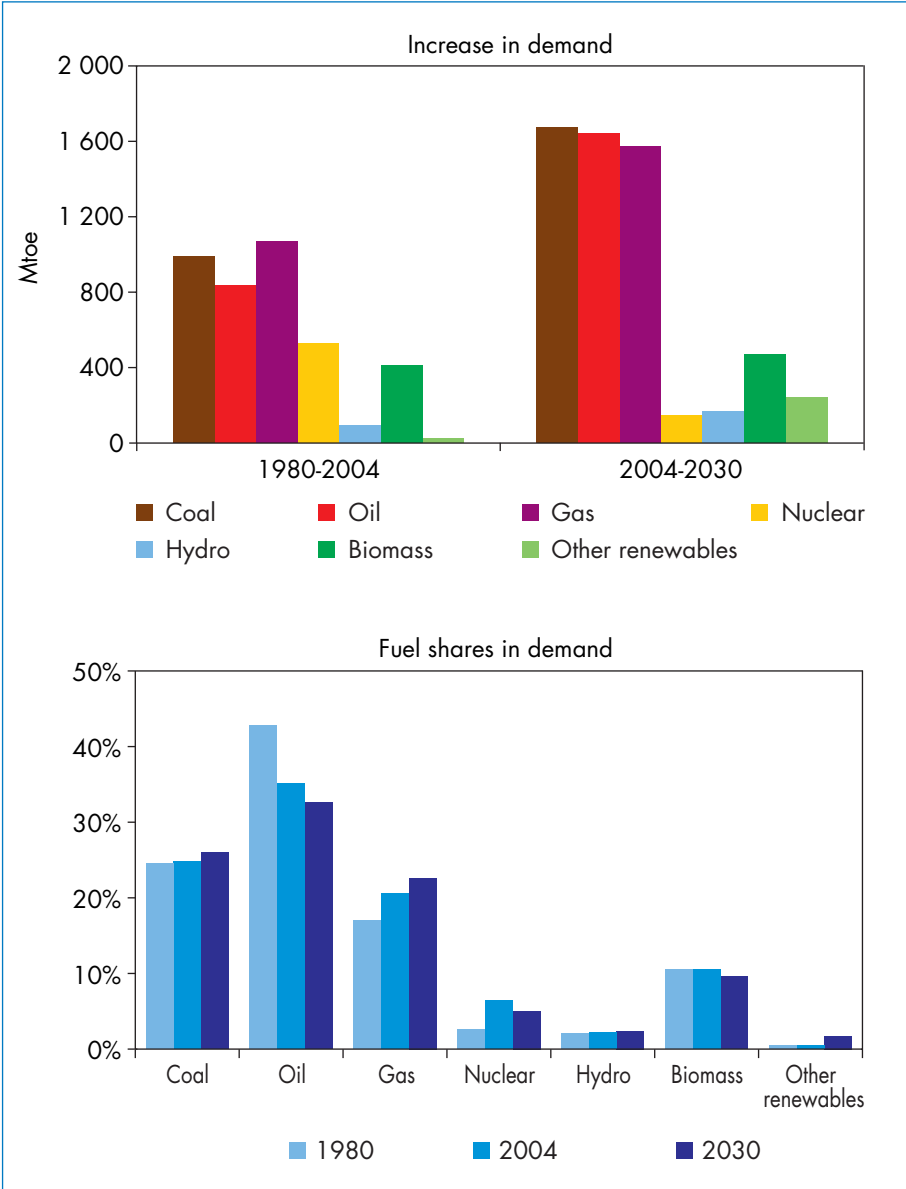
	1980	2004	2010	2015	2030	2004 - 2030*
Coal	1 785	2 773	3 354	3 666	4 441	1.8%
Oil	3 107	3 940	4 366	4 750	5 575	1.3%
Gas	1 237	2 302	2 686	3 017	3 869	2.0%
Nuclear	186	714	775	810	861	0.7%
Hydro	148	242	280	317	408	2.0%
Biomass and waste	765	1 176	1 283	1 375	1 645	1.3%
Other renewables	33	57	99	136	296	6.6%
Total	7 261	11 204	12 842	14 071	17 095	1.6%

* Average annual growth rate.

Fossil fuels are projected to remain the dominant sources of primary energy globally. They account for close to 83% of the overall increase in energy demand between 2004 and 2030. Their share of world demand edges up from 80% in 2004 to 81% in 2030. Coal sees the biggest increase in demand in volume terms in 2004-2030, closely followed by oil (Figure 2.1). In *WEO-2005*, oil and gas

1. World total primary energy demand, which is equivalent to total primary energy supply, includes international marine bunkers, which are excluded from the regional totals. Primary energy refers to energy in its initial form, after production or importation. Some energy is transformed, mainly in refineries, power stations and heat plants. Final consumption refers to consumption in end-use sectors, net of losses in transformation and distribution. In all regions, total primary and final demand includes traditional biomass and waste such as fuel wood, charcoal, dung and crop residues, some of which are not traded commercially.

Figure 2.1: World Primary Energy Demand by Fuel in the Reference Scenario



were projected to grow the most. Oil nonetheless remains the single largest fuel in the primary fuel mix in 2030, though its share drops, from 35% now to 33%. Coal remains the second-largest fuel, with its share increasing one percentage point to 26%. Gas demand grows faster than coal, but – in contrast to *WEO-2005* – does not overtake it before 2030. The growth in demand for gas has

been revised down and that for coal up, mainly owing to relatively higher gas prices. In the Reference Scenario, the share of nuclear power is expected to fall (albeit less rapidly than in *WEO-2005*), on the assumption that few new reactors are built and that several existing ones are retired between now and 2030. Hydropower's share of primary energy use rises slightly. The share of traditional biomass falls, as developing countries increasingly switch to using modern commercial energy. Other renewable energy technologies, including wind, solar, geothermal, wave and tidal energy, see the fastest increase in demand, but their share of total energy use still reaches only 1.7% in 2030 – up from 0.5% today.

Global primary energy intensity, measured as energy use per unit of gross domestic product, falls on average by 1.7% per year over 2004-2030. The decline is most rapid in the non-OECD regions, mainly because they profit from the greater scope for improving energy efficiency and because their economies become less reliant on energy-intensive heavy manufacturing industries as the services sector grows faster. The transition economies see the sharpest fall in intensity, which almost halves between 2004 and 2030, as new technologies are introduced, wasteful practices are dealt with and consumption subsidies are reduced (see Chapter 11). Yet they remain far more energy-intensive than either developing or OECD countries in 2030. The shift to services is much more advanced in the OECD, so there is less scope for reducing energy intensity.

Regional Trends

Over 70% of the increase in world primary energy demand between 2004 and 2030 comes from the developing countries (Figure 2.2). OECD countries account for almost one-quarter and the transition economies for the remaining 6%. As a result, the OECD's share of world demand drops, from just under half in 2004 to 40% in 2030, while that of the developing countries jumps, from 40% to 50%. The share of China alone rises from 15% to 20%, though this projection is particularly uncertain (Box 2.1). The transition economies' share falls from 10% to 8%. The increase in the share of the developing regions in world energy demand results from their more rapid economic and population growth. Industrialisation and urbanisation boost demand for modern commercial fuels.

The developing regions account for 23 mb/d, or 71%, of the 33 mb/d increase in oil demand between 2005 and 2030, with demand growing most rapidly in volume terms in the developing Asian countries. Oil demand increases less quickly in the OECD regions and the transition economies. In volume terms, gas demand expands most in the Middle East. Coal demand grows most in developing Asia, where there are large, low-cost resources. Coal

Box 2.1: Uncertainty Surrounding China's Energy Trends

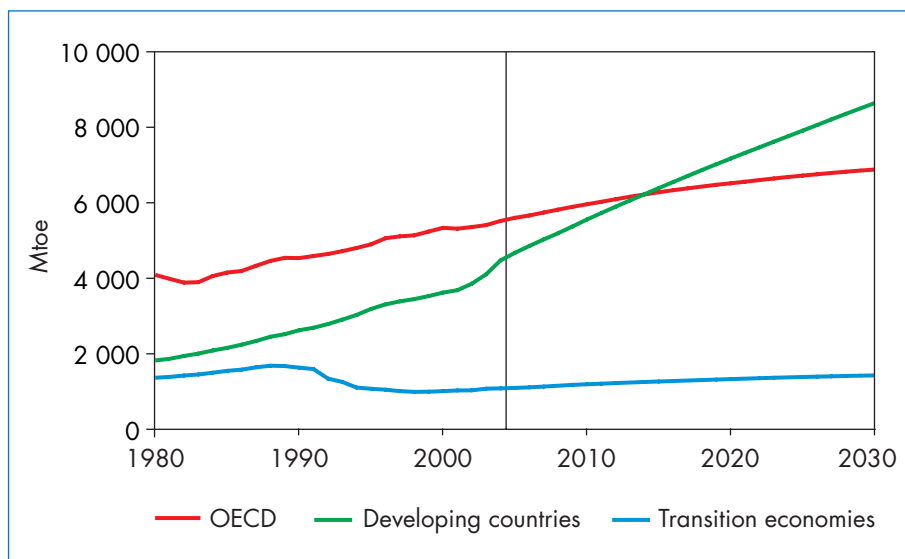
2

China is a major source of uncertainty for our global energy projections. The country is already a key player in the global energy market, and its role is expected to grow significantly over the projection period. In the Reference Scenario, the country accounts for 20% of the world primary energy demand in 2030 – up from 15% today. Its share of global coal demand rises from 36% today to 46% in 2030 (on an energy-content basis). Small changes in the outlook for China would, therefore, have a significant impact on the global energy picture. For example, a one-percentage point higher average annual rate of growth in China's demand would raise world primary energy demand by nearly 1 000 Mtoe, or 6%, and oil demand by 4.4 million barrels per day, or 4%, in 2030. Several factors could change energy prospects in China:

- **Long-term macroeconomic prospects:** China's economy has grown by about 10% per year on average for the past two decades, the fastest rate of any major country. The government's 11th five-year plan aims to moderate growth to 7.5% per year between 2005 and 2010 to prevent the economy from over-heating. But the preliminary estimate for its growth rate in the first half of 2006 is nearly 11%. In the longer term, growth is nonetheless expected to slow as the economy matures and population growth declines, but how quickly this occurs is very uncertain.
- **The link between energy demand and GDP growth:** Energy demand has not grown in a stable ratio to GDP in the past. For example, primary coal demand grew steadily between 1971 and 1996, but fell between 1997 and 2001 – despite continuing rapid economic growth. Demand started to grow again in 2002, surging in 2003 and 2004 by around 20% per year. Demand for other fuels has also soared relative to GDP in the past few years (see Chapter 11). Several factors, such as a surge in vehicle ownership, periodic government measures to limit energy use, the Asian financial crisis and statistical problems help to explain these erratic trends in demand.
- **The impact of structural reforms in the energy sector:** End-use energy prices, which have been under the government's control, are expected to be more liberalised in future. How quickly this occurs will have a significant impact on energy markets. In the coal industry, the government has encouraged the closure and consolidation of inefficient small mines. By the end of 2005, more than 2000 small mines had been closed. Restructuring of the coal industry and the pace of demand growth will determine whether China remains a net coal exporter.

World Energy Outlook 2007 will be devoted to an extensive analysis of energy developments in China, as well as India, and their implications for global energy markets.

Figure 2.2: World Primary Energy Demand by Region in the Reference Scenario



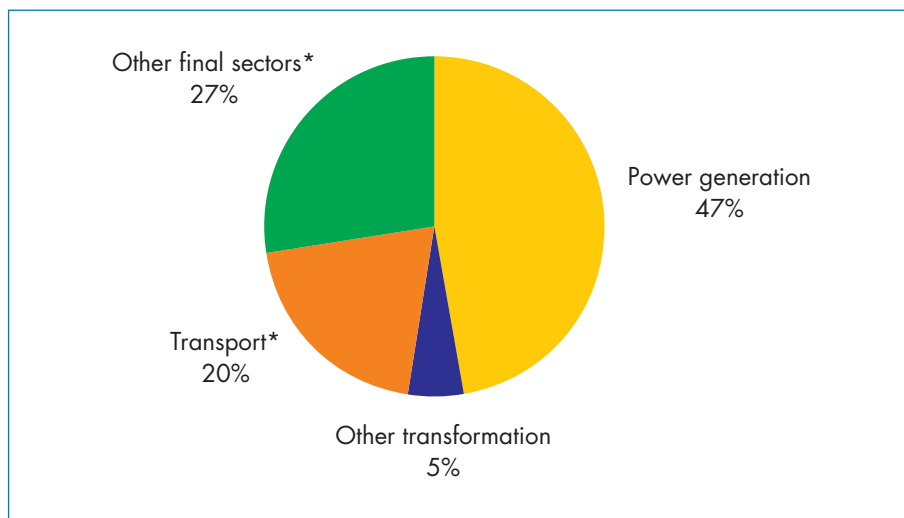
continues to dominate the fuel mix in India and China. By 2030, they account together for 57% of world coal demand, up from 43% in 2004. On the policy assumptions of the Reference Scenario, nuclear power declines in Europe, but increases in all other regions. The biggest increases in nuclear power production occur in Russia, Japan, Korea and developing Asian countries. Overall, nuclear power's share of world primary energy drops from 6% in 2004 to 5% in 2030.

Sectoral Trends

The power-generation sector accounts for 47% of the increase in global energy demand over the projection period (Figure 2.3). Its share of primary demand increases from 37% in 2004 to 41% in 2030. Demand for electricity-related services, the main determinant of how much fuel is needed to generate power, is closely linked to incomes. Nonetheless, continued improvements in the thermal efficiency of power stations mean that the rate of growth in power-sector energy demand is somewhat lower than that of final electricity demand. The transport sector (excluding electricity used in rail transportation) accounts for about another fifth of the increase in global demand.

World energy consumption in end-use sectors as a whole – industry, transport, residential, services (including agriculture) and non-energy uses – increases by 1.6% per year over 2004-2030, the same rate as primary demand. Among all major end-use energy sources, electricity is projected to grow most rapidly, by

Figure 2.3: Incremental World Primary Energy Demand by Sector in the Reference Scenario, 2004-2030



* Excluding electricity and heat.

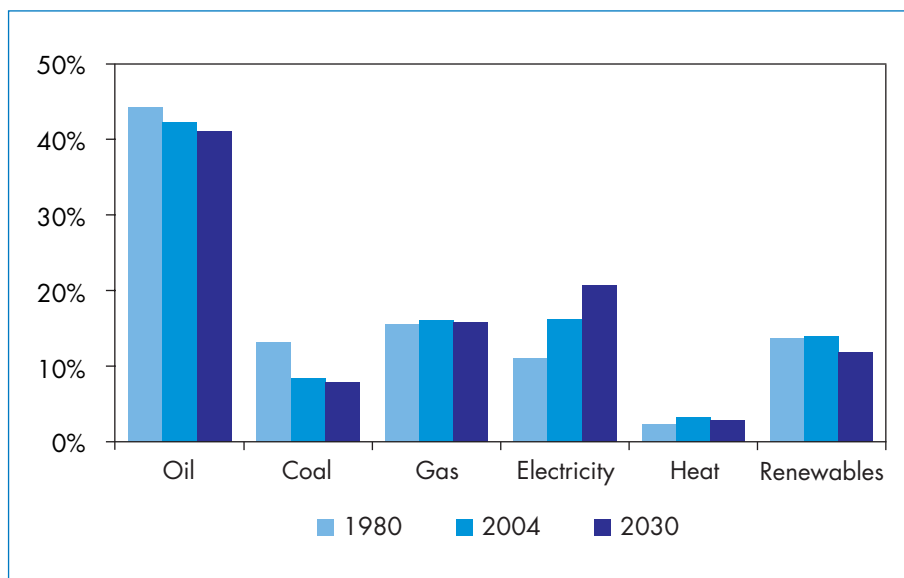
2.6% per year, nearly doubling between 2004 and 2030. As a result, electricity's share of total final consumption grows from 16% to 21% (Figure 2.4). In 1980, it was only 11%. Electricity use grows most rapidly in developing countries, as the number of people with access to electricity and incomes rises steadily. By 2030, the share of electricity in final energy use in developing countries almost reaches that of OECD countries. Yet per-capita consumption remains much lower, mainly because incomes are far smaller – even though the gap between OECD and developing country incomes narrows significantly over the projection period. In 2030, per-capita consumption reaches 26.9 kWh per day in OECD countries but only 6.2 kWh in non-OECD countries. The share of traditional biomass in final consumption declines, as developing-country households switch to modern fuels for cooking and heating (see Chapter 15). The share of other renewables increases, but is still less than 1% in 2030. The shares of all other fuels hardly change over 2004-2030.

Energy Production and Trade

Resources and Production Prospects

Sufficient resources exist worldwide to permit the world's energy industry to expand capacity in order to meet the projected increases in demand through to 2030 for each form of energy described above. The world's remaining economically exploitable fossil-fuel, hydroelectric and uranium resources are

Figure 2.4: Fuel Shares in World Final Energy Demand in the Reference Scenario



adequate. At issue is whether these resources will actually be developed quickly enough and at what cost. The Reference Scenario is predicated on the assumption that the stated prices will be high enough to stimulate sufficient investment in new supply infrastructure to enable all the projected demand to be met. Notwithstanding this assumption, it is far from certain whether energy companies will be willing or able to invest in developing those resources and in bringing them to market, and how much it will cost. A number of factors may impede required investments from being made in a particular sector or region. These include a worsening of the investment climate, changes in government attitudes to foreign investment and capacity expansions, the adoption of more stringent environmental regulations and less favourable licensing and fiscal conditions.²

Proven reserves of natural gas and coal are much larger than the cumulative amounts of both fuels that will be consumed over the projection period. Today, proven reserves are equal to 64 years of current consumption of gas and 164 years of coal. And substantial new reserves will undoubtedly be added between

2. The impact of a deferral of investment in the upstream oil industry is assessed in Chapter 3. A detailed assessment of current trends in oil and gas investment is provided in Chapter 12. The impact of new government policies to bolster energy security and curb energy-related greenhouse-gas emissions is assessed in the Alternative Policy Scenario, described in detail in Part B (Chapters 7-10).

now and 2030. Proven reserves of crude oil and natural gas liquids are much smaller in relation to current consumption, covering barely 42 years. Although that is enough to meet all the oil consumed in the Reference Scenario through to 2030, more oil would need to be found were conventional production not to peak before then. Even if it were to do so, non-conventional sources of oil – including oil sands and gas- and coal-to-liquids plants – could meet any shortfall in conventional oil supply if the necessary investment is forthcoming. There is no lack of uranium for projected nuclear power production in the Reference Scenario for the next several decades at least. There is also significant remaining potential for expanding hydropower and energy from biomass and other renewable sources.

The Middle East and North Africa, which have massive hydrocarbon resources (IEA, 2005a), are expected to meet much of the growth in world oil and gas demand over 2004-2030. Latin America (especially Venezuela and Brazil), Africa and the transition economies also increase production of both oil and gas. Conventional oil production declines in most other regions, including OECD North America and Europe. Production of natural gas, resources of which are more widely dispersed than oil, increases in every region other than Europe. Although there are abundant coal reserves in most regions, increases in coal production are likely to be concentrated in China, India, the United States, Australia, South Africa, Indonesia, and Colombia, where extraction, processing and transportation costs are lowest. The production prospects for each fuel are discussed in more detail in later chapters.

Inter-Regional Trade

International energy trade is expected to grow steadily over the *Outlook* period to accommodate the increasing mismatch between the location of demand and that of production. In the Reference Scenario, the OECD accounts for 23% of the total increase in world primary energy demand, but only 5% of the growth in output. As a result, exports from non-OECD regions to OECD regions expand by 47%. Total OECD imports, including trade between OECD regions, will also increase by 47% between 2004 and 2030 (Table 2.2). By 2030, 43% of all the primary energy consumed in the OECD is imported. The transition economies and the developing countries in aggregate become bigger net exporters. Trade between major non-OECD regions also increases sharply. The Middle East sees the biggest increase in energy exports, while imports grow most in developing Asia.

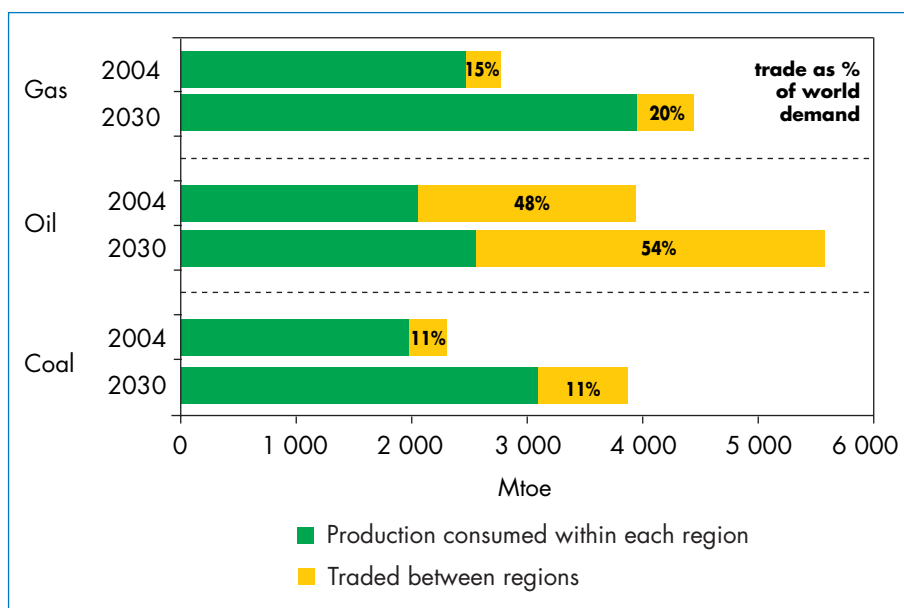
Almost all of the projected increase in inter-regional energy trade is in the form of conventional oil, gas and coal, but biofuels make a growing contribution. Trade in electricity remains minimal. Oil remains the most traded fuel in both percentage and volume terms (Figure 2.5). By 2030, 54% of all the oil

Table 2.2: Net Energy Imports by Major Region (Mtoe)

	2004	2015	2030
OECD	1 657	2 123	2 444
Coal	113	117	98
Oil	1 272	1 569	1 712
Gas	272	436	634
Transition economies	-492	-641	-745
Coal	-27	-39	-46
Oil	-345	-476	-541
Gas	-120	-126	-158
Developing countries	-1 228	-1 549	-1 776
Coal	-70	-71	-45
Oil	-1 007	-1 168	-1 256
Gas	-152	-310	-476

Note: Trade in other forms of energy is negligible. Negative figures are net exports. Total imports do not always equal total exports because of processing gains, international marine bunkers and statistical discrepancies.

Figure 2.5: Share of Inter-Regional Trade in World Primary Demand by Fossil Fuel in the Reference Scenario



Note: Takes account of all trade between WEO regions.

consumed in the world is traded between the *WEO* regions, up from 48% in 2004. The volume of oil traded grows by 60%. The Middle East accounts for the bulk of the increase in oil exports, with most of this oil going to developing countries, especially in Asia. The transition economies, Africa and Latin America also export more oil. OECD oil-import dependence, taking account of trade between OECD regions, rises from 56% now to 65% in 2030, as a result of dwindling indigenous production and rising consumption. Intra-regional trade, which is not captured by our projections, is also likely to expand.

Inter-regional natural gas trade expands quickly too, though the bulk of the gas consumed around the world is still produced within each consuming region in 2030. Most of the *additional* gas traded between now and 2030 is in the form of liquefied natural gas. An unprecedented boom in LNG developments is under way. LNG trade increased by almost one-third between 2000 and 2005, and it is expected to double by 2010, as projects that are currently under construction or that are at an advanced stage of planning come on stream. More liquefaction capacity is expected to be added through to 2030. Although a number of major long-distance pipelines are also likely to be completed, the share of piped gas in total inter-regional trade is expected to drop from 77% today to about 50% in 2030. The largest volume increases in gas imports occur in Europe and North America. Several developing countries – including China and India – emerge as major gas importers over the projection period. The Middle East, Africa and the transition economies meet most of the increase in demand for gas imports.

Inter-regional hard-coal trade increases in volume terms over 2004-2030, but the share of coal trade in total world coal supply is flat. Most of the increase in traded coal goes to OECD Europe, already the largest importing region, where demand is projected to rise and coal mining to continue to decline through to 2030. Steam coal accounts for a growing share of world hard-coal trade, driven mainly by power-sector needs.

Investment in Energy Infrastructure

The Reference Scenario projections in this *Outlook* call for cumulative investment in energy-supply infrastructure of just over \$20 trillion (in year-2005 dollars) over 2005-2030. This projection is around \$3 trillion higher than in *WEO-2005*. The increase is explained by recent sharp increases in unit capital costs, especially in the oil and gas industry. Projected capital spending includes that needed to expand supply capacity to meet rising demand and to replace existing and future supply facilities that will be retired during the projection period. Just over half of the investment will go simply to maintain the current level of supply capacity: much of the world's current production

capacity for oil, gas, coal and electricity will need to be replaced by 2030. In addition, some of the new production capacity brought on stream in the early years of the projection period will itself need to be replaced before 2030. Many power plants, electricity and gas transmission and distribution facilities, and oil refineries will also need to be replaced or refurbished. Box 2.2 describes the methodology used to project energy investment.

Box 2.2: Methodology for Projecting Energy Investment

The projections of investment in both the Reference and Alternative Policy Scenarios for the period 2005-2030 are derived from the projections of energy supply. The calculation of the amount of investment corresponding to projected supply for each fuel and each region involved the following steps:

- New-build capacity needs for production, transportation and (where appropriate) transformation were calculated on the basis of projected supply trends, estimated rates of retirement of the existing supply infrastructure and natural decline rates for oil and gas production.
- Unit capital cost estimates were compiled for each component in the supply chain. These costs were then adjusted for each year of the projection period using projected rates of change based on a detailed analysis of the potential for technology-driven cost reductions and on country-specific factors.
- Incremental capacity needs were multiplied by unit costs to yield the amount of investment needed.

All the results are presented in year-2005 dollars. The projections take account of projects that have already been decided and expenditures that have already been incurred. Capital spending is attributed to the year in which the plant in question becomes operational. In other words, no attempt has been made to estimate the lead times for each category of project. This is because of the difficulties in estimating lead times and how they might evolve in the future. Investment is defined as capital expenditure only. It does not include spending that is usually classified as operation and maintenance.

The power sector requires more than \$11 trillion of investment, 56% of that for the energy sector as a whole (Table 2.3). That share rises to two-thirds if investment in the supply chain to meet the fuel needs of power stations is included. More than half of the investment in the electricity industry is in transmission and distribution networks, with the rest going to power generation. Capital expenditure in the oil industry amounts to \$4.3 trillion, or just over one-fifth of total energy investment. More than three-quarters of total

oil investment is in upstream projects. Gas investment is \$3.9 trillion, or 19%. The upstream absorbs 56% of total gas investment (Figure 2.6).³ Coal investment is about \$560 billion, or 3% of total energy investment. Producing, transporting and delivering coal to power stations and end users is much less capital-intensive than oil or gas, but operating and maintenance costs are higher per unit of output on an energy-content basis.

More than half of all the energy investment needed worldwide is in developing countries, where demand and production increase most quickly. China alone needs to invest about \$3.7 trillion – 18% of the world total. Russia and other transition economies account for 9% of total world investment and the OECD for the remaining 37%.

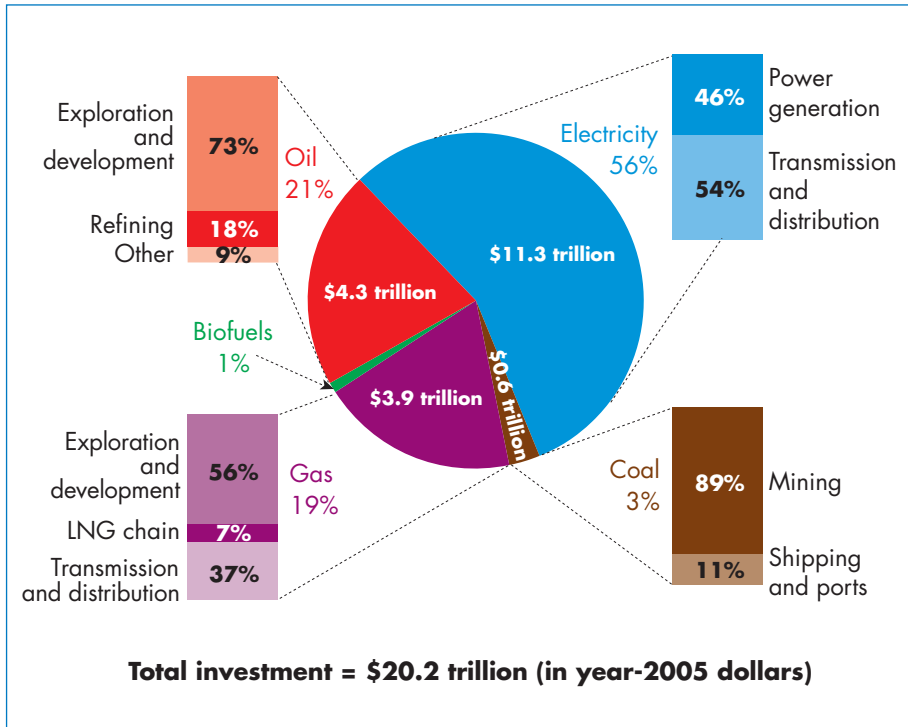
Table 2.3: Cumulative Investment in Energy-Supply Infrastructure in the Reference Scenario, 2005-2030
(\$ billion in year-2005 dollars)

	Coal	Oil	Gas	Power	Total
OECD	156	1 149	1 744	4 240	7 289
North America	80	856	1 189	1 979	4 104
Europe	34	246	417	1 680	2 376
Pacific	42	47	139	582	809
Transition economies	33	639	589	590	1 850
Russia	15	478	440	263	1 195
Developing countries	330	2 223	1 516	6 446	10 515
Developing Asia	298	662	457	4 847	6 264
<i>China</i>	238	351	124	3 007	3 720
<i>India</i>	38	48	55	967	1 108
<i>Indonesia</i>	13	49	86	187	335
Middle East	1	698	381	396	1 476
Africa	20	485	413	484	1 402
Latin America	12	378	265	719	1 374
<i>Brazil</i>	1	138	48	252	439
Inter-regional transport	45	256	76	–	376
World	563	4 266	3 925	11 276	20 192

Note: World total includes \$161 billion of investment in biofuels.

3. See Chapter 12 for a detailed discussion of the near-term prospects for oil and gas investment.

Figure 2.6: Cumulative Investment in Energy Infrastructure in the Reference Scenario by Fuel and Activity, 2005-2030
(in year-2005 dollars)



Energy-Related CO₂ Emissions

Global energy-related carbon-dioxide (CO₂) emissions increase by 1.7 % per year over 2004-2030 in the Reference Scenario. They reach 40.4 billion tonnes in 2030, an increase of 14.3 billion tonnes, or 55%, over the 2004 level (Table 2.4). By 2010, emissions are 48% higher than in 1990. However, the aggregate increase is much smaller for Annex I countries with commitments to limit emissions under the Kyoto Protocol (Box 2.3). Power generation is projected to contribute a little less than half the increase in global emissions from 2004 to 2030. Transport contributes one-fifth, with other uses accounting for the rest. By 2030, the power sector accounts for 44% of total emissions, up from 41% today. Continuing improvements in the thermal efficiency of power stations are largely outweighed by the strong growth in demand for electricity. Transport remains the second-largest sector for emissions worldwide, with its share of total emissions stable at around 20% throughout the projection period.

Box 2.3: Will Signatories to the Kyoto Protocol Respect their Greenhouse-Gas Emission-Limitation Commitments?

2

The energy-related CO₂ emissions projected in the Reference Scenario give an indication of how likely it is that those countries that have agreed to limit their emissions, known as Annex I countries, under the Kyoto Protocol will meet their commitments. The Kyoto Protocol, which came into effect on 16 February 2005, sets binding targets for developed countries to reduce greenhouse-gas emissions by an average of 5.2% below 1990 levels by 2008-2012. The Protocol covers six types of emissions and the contribution of sinks (vegetation that absorbs carbon dioxide). Although our projections reflect only energy-related CO₂ emissions, these account for the bulk of greenhouse-gas emissions.

Our analysis suggests that, if total greenhouse-gas emissions rise at the same rate as energy-related emissions, Annex I countries in aggregate would not be able to meet the overall emissions-reduction target on current trends. In 2010, the total emissions of Annex I OECD countries are projected to be 29% above the target. Excluding the United States and Australia, which have not ratified the Protocol, the gap would be 19%. The emissions of Annex I transition economies are projected to be 22% *below* target. This would not be enough to make up all of the gap in all Annex I OECD countries, even if the United States and Australia are not included. Even if Annex I countries were to adopt a new set of policies and measures, they would be unlikely to significantly affect emission trends before 2010 – a key message that emerges from the Alternative Policy Scenario (see Part B). The recent surge in emissions makes it even less likely that the targets will be met: global emissions rose at a much faster rate in the four years to 2004 than they did in the 1990s (Figure 2.7).

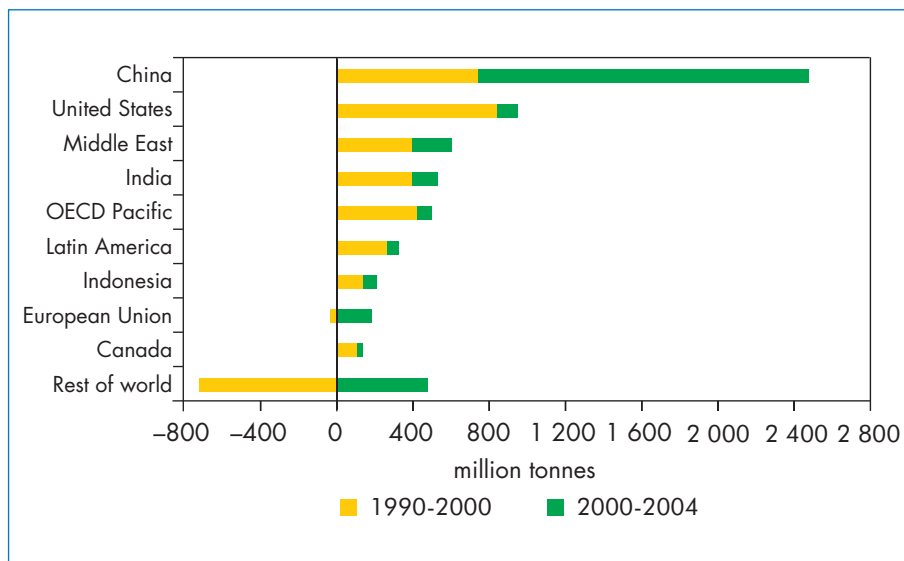
The Kyoto Protocol was always intended to be a first step. There is little that governments can do today that will have any significant effect on emissions before 2010. The challenge now is to forge an international framework that engages all major emitting countries in an effective long-term effort to mitigate greenhouse-gas emissions (IEA, 2005b). In May 2005, parties to the UN Framework Convention on Climate Change convened a seminar of government experts to discuss possible future efforts, but explicitly did not open negotiations on new commitments. In July 2005, at the Gleneagles Summit, G8 leaders pledged to introduce innovative measures to achieve substantial reductions in greenhouse-gas emissions as part of an agreed long-term plan. This pledge was reaffirmed at the 2006 St Petersburg Summit.

Table 2.4: World Energy-Related CO₂ Emissions by Sector in the Reference Scenario (million tonnes)

	1990	2004	2010	2015	2030	2004-2030*
Power generation	6 955	10 587	12 818	14 209	17 680	2.0%
Industry	4 474	4 742	5 679	6 213	7 255	1.6%
Transport	3 885	5 289	5 900	6 543	8 246	1.7%
Residential and services**	3 353	3 297	3 573	3 815	4 298	1.0%
Other***	1 796	2 165	2 396	2 552	2 942	1.2%
Total	20 463	26 079	30 367	33 333	40 420	1.7%

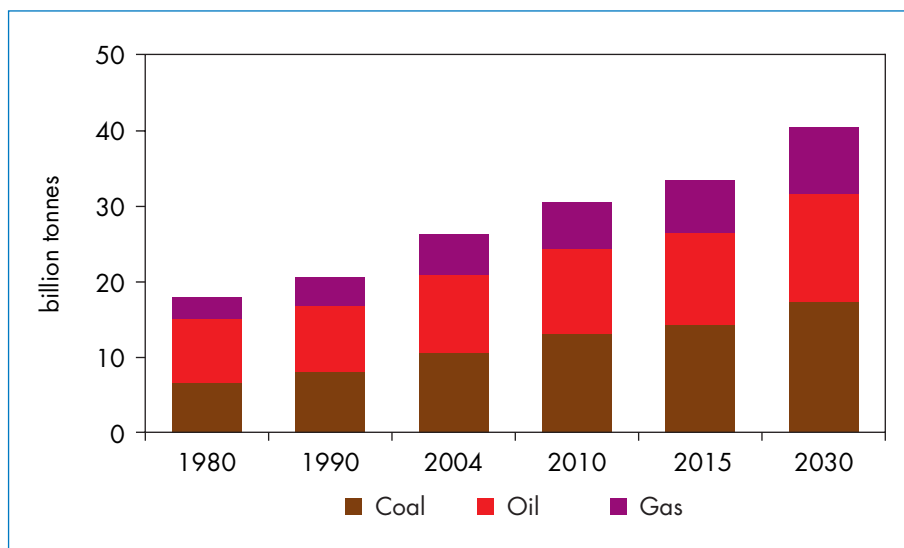
*Average annual growth rate. **Includes agriculture and public sector. ***Includes international marine bunkers, other transformation and non-energy use.

Figure 2.7: Increase in Energy-Related CO₂ Emissions by Region



Coal recently overtook oil as the leading contributor to global energy-related CO₂ emissions and, in the Reference Scenario, consolidates this position through to 2030 (Figure 2.8). Coal's share of emissions increases slightly, from 41% today to 43%. The share of natural gas also increases, from 20% to 22%, while that of oil falls, from 39% to 35%. Gas-related emissions increase most rapidly, by two-thirds between 2004 and 2030.

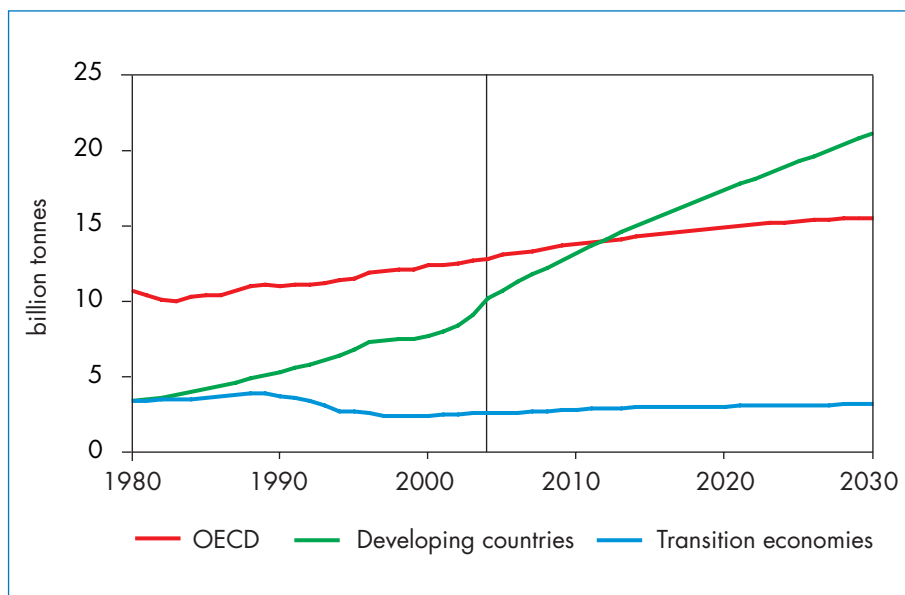
Figure 2.8: World Energy-Related CO₂ Emissions by Fuel in the Reference Scenario



Developing countries account for over three-quarters of the increase in global CO₂ emissions between 2004 and 2030. They overtake the OECD as the biggest emitter by around 2012 (Figure 2.9). The share of developing countries in world emissions rises from 39% at present to 52% by 2030. This increase is faster than that of their share in energy demand, because their incremental energy use is more carbon-intensive than that of the OECD and transition economies. In general, they use more coal and less gas. China alone is responsible for 39% of the rise in global emissions. China's emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in industry and power generation. China overtakes the United States as the world's biggest emitter before 2010. Other Asian countries, notably India, also contribute heavily to the increase in global emissions.

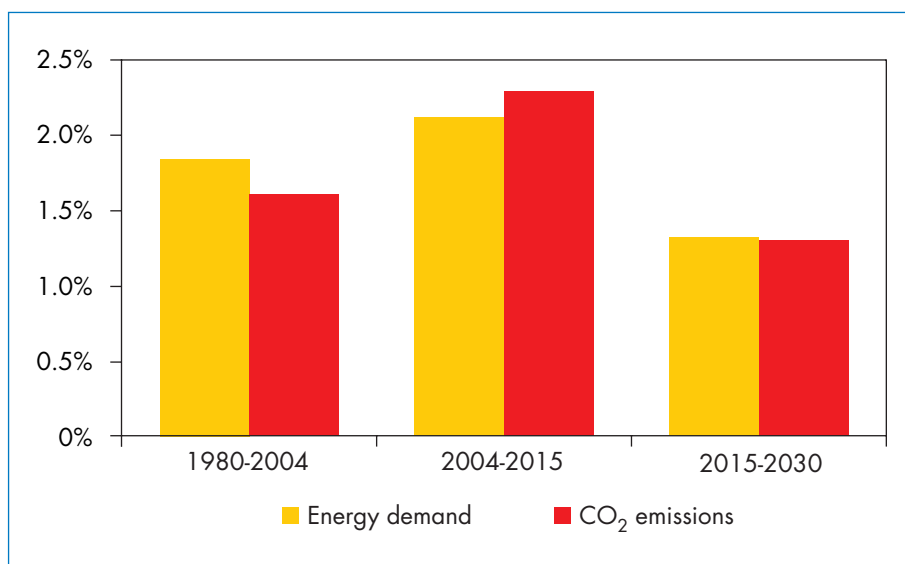
Over the past two-and-a-half decades, energy-related CO₂ emissions worldwide grew less rapidly than primary energy demand, largely because of the rising shares of gas, which is less carbon-intensive than coal and oil, and of nuclear power in the energy mix. Carbon emissions grew by 1.6% per year, while energy demand grew by 1.8%. In the Reference Scenario, the trend is reversed over the projection period, as the rate of growth in emissions, at 1.7% per year, is faster than the 1.6% rate of demand growth (Figure 2.10). This is because the average carbon content of primary energy consumption increases from 2.33 tonnes of CO₂ per toe of energy to 2.36 tonnes

Figure 2.9: Energy-Related CO₂ Emissions by Region in the Reference Scenario



Note: Excludes emissions from international marine bunkers.

Figure 2.10: Average Annual Growth in World Energy-Related CO₂ Emissions and Primary Energy Demand in the Reference Scenario



(Table 2.5). Per-capita emissions also rise, mainly because rising incomes push up per capita energy consumption. They grow most rapidly in the developing countries. Yet the OECD still has by far the highest per-capita emissions and developing countries the lowest in 2030. Developing countries have lower per-capita incomes and energy consumption, and rely more heavily on biomass and waste, which are assumed to produce no emissions on a net basis.⁴ By contrast, the carbon intensity of the global economy, measured by emissions per unit of GDP, is projected to decline steadily in all regions in line with the fall in primary energy intensity.

Table 2.5: World Energy-Related CO₂ Emission Indicators by Region in the Reference Scenario (tonnes of CO₂)

	OECD			Non-OECD			World		
	2004	2015	2030	2004	2015	2030	2004	2015	2030
Per capita	11.02	11.69	11.98	2.45	3.09	3.55	4.11	4.65	4.97
Per unit of GDP*	0.39	0.33	0.27	0.49	0.39	0.30	0.44	0.37	0.29
Per toe of primary energy	2.33	2.30	2.26	2.30	2.41	2.42	2.33	2.37	2.36

* Thousand dollars in year-2005 dollars and PPP terms.

4. For the purposes of this analysis, all biomass is assumed to be replaced eventually. As a result, the carbon emitted when biomass fuels are burned is cancelled out by the carbon absorbed by the replacement biomass as it grows.

TABLE OF CONTENTS

PART A
**THE
REFERENCE
SCENARIO**

PART B
**THE
ALTERNATIVE
POLICY
SCENARIO**

PART C
**FOCUS
ON KEY TOPICS**

ANNEXES

KEY ASSUMPTIONS	1
GLOBAL ENERGY TRENDS	2
OIL MARKET OUTLOOK	3
GAS MARKET OUTLOOK	4
COAL MARKET OUTLOOK	5
POWER SECTOR OUTLOOK	6
MAPPING A NEW ENERGY FUTURE	7
ASSESSING THE COST-EFFECTIVENESS OF ALTERNATIVE POLICIES	8
DEEPENING THE ANALYSIS: RESULTS BY SECTOR	9
GETTING TO AND GOING BEYOND THE ALTERNATIVE POLICY SCENARIO	10
THE IMPACT OF HIGHER ENERGY PRICES	11
CURRENT TRENDS IN OIL AND GAS INVESTMENT	12
PROSPECTS FOR NUCLEAR POWER	13
THE OUTLOOK FOR BIOFUELS	14
ENERGY FOR COOKING IN DEVELOPING COUNTRIES	15
FOCUS ON BRAZIL	16
ANNEXES	

Foreword	3
Acknowledgements	5
List of Figures	22
List of Tables	29
List of Boxes	33
Summary and Conclusions	37
Introduction	49

Part A: The Reference Scenario **51**

1	Key Assumptions	53
	Highlights	53
	Government Policies and Measures	54
	Population	55
	Macroeconomic Factors	57
	Energy Prices	59
	Technological Developments	63
2	Global Energy Trends	65
	Highlights	65
	Demand	66
	<i>Primary Energy Mix</i>	66
	<i>Regional Trends</i>	68
	<i>Sectoral Trends</i>	70
	Energy Production and Trade	71
	<i>Resources and Production Prospects</i>	71
	<i>Inter-Regional Trade</i>	73
	<i>Investment in Energy Infrastructure</i>	75
	Energy-Related CO ₂ Emissions	78
3	Oil Market Outlook	85
	Highlights	85
	Demand	86
	Supply	88
	<i>Resources and Reserves</i>	88
	<i>Production</i>	91
	<i>Trade</i>	100
	<i>Investment</i>	102
	<i>Implications of Deferred Upstream Investment</i>	107

4	Gas Market Outlook	111
	Highlights	111
	Demand	112
	Supply	114
	<i>Resources and Reserves</i>	114
	<i>Production</i>	115
	<i>Inter-Regional Trade</i>	117
	<i>Investment</i>	121
5	Coal Market Outlook	125
	Highlights	125
	Demand	126
	Reserves and Production	127
	Inter-Regional Trade	131
	Coal Supply Costs and Investment	133
6	Power Sector Outlook	137
	Highlights	137
	Electricity Demand Outlook	138
	Power Generation Outlook	139
	<i>Energy-Related CO₂ Emissions from Power Generation</i>	144
	<i>The Economics of New Power Plants</i>	145
	<i>Capacity Requirements and Investment Outlook</i>	147
	<i>Power Generation Investment Trends in the OECD</i>	150
	<i>Investment Trends in Developing Countries</i>	153
	Part B: The Alternative Policy Scenario	159
7	Mapping a New Energy Future	161
	Highlights	161
	Background	162
	<i>Why an Alternative Policy Scenario?</i>	162
	<i>Methodology</i>	164
	<i>Policy Assumptions</i>	165
	<i>Energy Prices and Macroeconomic Assumptions</i>	170
	<i>Technological Developments</i>	170
	Global Energy Trends	173
	<i>Primary and Final Energy Mix</i>	173
	<i>Energy Intensity</i>	177
	<i>Investment and Fuel Expenditures</i>	178
	Oil Markets	178
	<i>Demand</i>	178

<i>Supply</i>	179
<i>Inter-Regional Trade</i>	181
Gas Markets	182
<i>Demand</i>	182
<i>Production and Trade</i>	183
Coal Markets	184
<i>Demand</i>	184
<i>Production and Trade</i>	186
Energy Security in Importing Countries	186
Energy-Related CO ₂ Emissions	188

8

Assessing the Cost-Effectiveness of Alternative Policies	193
Highlights	193
Investment in Energy-Supply Infrastructure and End-Use Equipment	194
<i>Overview</i>	194
<i>Investment along the Electricity Chain</i>	196
<i>Demand-Side Investment</i>	198
<i>Supply-Side Investment</i>	202
Implications for Energy Import Bills and Export Revenues	203
Implications for Consumers	205
<i>Barriers to Investment in End-Use Energy Efficiency</i>	210

9

Deepening the Analysis: Results by Sector	213
Highlights	213
Power Generation	214
<i>Summary of Results</i>	214
<i>Electricity Mix</i>	216
<i>Policy Assumptions and Effects</i>	221
Transport	222
<i>Summary of Results</i>	222
<i>Road Transport</i>	224
<i>Policy Assumptions and Effects</i>	224
<i>Aviation</i>	231
Industry	234
<i>Summary of Results</i>	234
<i>Policy Assumptions and Effects</i>	237
Residential and Services Sectors	241
<i>Summary of Results</i>	241
<i>Policy Overview</i>	246

10	Getting to and Going Beyond the Alternative Policy Scenario	249
	Highlights	249
	Making the Alternative Policy Scenario a Reality	250
	<i>Identifying Policy Priorities</i>	250
	<i>Hurdles to Policy Adoption and Implementation</i>	253
	Going Beyond the Alternative Policy Scenario	256
	<i>Achieving the BAPS Goal</i>	256
	<i>Implications for Energy Security</i>	262
	Beyond 2030: the Need for a Technology Shift	262
	 Part C: Focus on Key Topics	 267
11	The Impact of Higher Energy Prices	269
	Highlights	269
	Introduction	270
	Energy Price Trends and Relationships	270
	<i>International Prices</i>	270
	<i>Final Prices to End Users</i>	275
	<i>Quantifying Energy Subsidies</i>	277
	Impact of Higher Energy Prices on Demand	282
	<i>Energy Demand Trends since Prices Started Rising</i>	282
	<i>Responsiveness of Energy Demand to Price Changes</i>	283
	<i>Explaining Recent Trends in Energy Demand</i>	289
	<i>Price Sensitivity Analysis</i>	295
	Macroeconomic Impact of Higher Energy Prices	297
	<i>How Higher Energy Prices Affect the Macroeconomy</i>	297
	<i>Quantifying the Recent Shift in the Terms of Trade</i>	299
	<i>Simulating the Macroeconomic Effects of Higher Energy Prices</i>	301
	<i>Explaining Macroeconomic Resilience to Higher Energy Prices</i>	306
	Energy Policy Implications	313
12	Current Trends in Oil and Gas Investment	315
	Highlights	315
	Overview	316
	Exploration and Development	321
	<i>Investment Trends</i>	321
	<i>Impact of Cost Inflation on Upstream Investment</i>	327
	<i>Implications for Oil and Gas Production Capacity</i>	331
	Oil Refining	335
	Liquefied Natural Gas Facilities	336
	Gas-to-Liquids Plants	340
	Oil Sands and Extra-Heavy Oil	341
	Investment beyond the Current Decade	341

Prospects for Nuclear Power	343
Highlights	343
Current Status of Nuclear Power	344
<i>Renewed Interest in Nuclear Power</i>	344
<i>Nuclear Power Today</i>	346
<i>Historical Development</i>	348
Policy Overview	351
<i>Nuclear Power Generation</i>	351
<i>Nuclear Fuel and Waste Management</i>	356
<i>Proliferation and International Conventions</i>	357
Outlook for Nuclear Power	360
<i>Reference Scenario</i>	361
<i>Alternative Policy Scenario</i>	361
Nuclear Power Economics in Competitive Markets	364
<i>Generating Costs under Different Discount Rate Assumptions</i>	364
<i>Sensitivity Analysis of Nuclear Power Generating Costs</i>	368
<i>Other Factors Influencing the Generating Cost of Nuclear Power</i>	371
<i>Financing Nuclear Power Plants</i>	374
Nuclear Fuel Outlook	376
<i>Demand for Uranium</i>	376
<i>Uranium Resources</i>	377
<i>Uranium Production</i>	380
<i>Uranium Prices and Investment in Exploration and Production</i>	381
Policy Issues	382

The Outlook for Biofuels	385
Highlights	385
Current Status of Biofuels Production and Use	386
<i>Market Overview</i>	386
<i>Ethanol</i>	388
<i>Biodiesel</i>	389
<i>The Environmental Impact of Biofuels</i>	391
Prospects for Biofuels Production and Use	394
<i>Summary of Projections to 2030</i>	394
<i>Regional Trends</i>	400
Key Drivers and Uncertainties	405
<i>Technology and Production Costs</i>	405
<i>Biomass and Land Needs for Biofuels Production</i>	412
<i>International Trade in Biofuels</i>	416

Energy for Cooking in Developing Countries	419
Highlights	419
Household Energy Use in Developing Countries	420
Harmful Effects of Current Cooking Fuels and Technologies	424
<i>Health</i>	424
<i>Environment</i>	427
<i>The Burden of Fuel Collection</i>	428
Outlook for Household Biomass Use in Developing Countries	431
<i>Improving the Way Biomass is Used</i>	433
<i>Modern Cooking Fuels and Stoves</i>	433
<i>Quantifying the Potential Impact of Modern Cooking Fuels and Stoves</i>	435
Policy Implications	440

Focus on Brazil	447
Highlights	447
Overview	448
The Political and Economic Outlook	449
<i>The Political Scene</i>	449
<i>The National Economy</i>	450
Recent Trends and Developments in the Energy Sector	452
Outlook for Energy Demand	454
<i>Reference Scenario</i>	455
<i>Alternative Policy Scenario</i>	462
Outlook for Supply	464
<i>Oil</i>	464
<i>Natural Gas</i>	471
<i>Coal</i>	474
<i>Biomass</i>	474
<i>Power and Heat</i>	479
Environmental Issues	484
Investment	486

ANNEXES **489**

Annex A Tables for Reference and Alternative Policy Scenario Projections	491
Annex B Electricity Access	565
Annex C Abbreviations and Definitions	573
Annex D Acronyms	581
Annex E References	585

List of Figures

Chapter 1. Key Assumptions

1.1	World Population by Region	57
1.2	Growth in Real GDP Per Capita by Region	60
1.3	Average IEA Crude Oil Import Price in the Reference Scenario	62
1.4	Crude Oil Price and Differentials to Oil Product Prices	62

Chapter 2. Global Energy Trends

2.1	World Primary Energy Demand by Fuel in the Reference Scenario	67
2.2	World Primary Energy Demand by Region in the Reference Scenario	70
2.3	Incremental World Primary Energy Demand by Sector in the Reference Scenario, 2004-2030	71
2.4	Fuel Shares in World Final Energy Demand in the Reference Scenario	72
2.5	Share of Inter-Regional Trade in World Primary Demand by Fossil Fuel in the Reference Scenario	74
2.6	Cumulative Investment in Energy Infrastructure in the Reference Scenario by Fuel and Activity, 2005-2030	78
2.7	Increase in Energy-Related CO ₂ Emissions by Region	80
2.8	World Energy-Related CO ₂ Emissions by Fuel in the Reference Scenario	81
2.9	Energy-Related CO ₂ Emissions by Region in the Reference Scenario	82
2.10	Average Annual Growth in World Energy-Related CO ₂ Emissions and Primary Energy Demand in the Reference Scenario	82

Chapter 3. Oil Market Outlook

3.1	Incremental World Oil Demand by Region and Sector in the Reference Scenario, 2004-2030	87
3.2	Top Twenty Countries' Proven Oil Reserves, end-2005	89
3.3	Undiscovered Oil Resources and New Wildcat Wells Drilled, 1996-2005	90
3.4	Cumulative Oil and Gas Discoveries and New Wildcat Wells	91
3.5	World Oil Supply by Source	95
3.6	Non-OPEC Conventional Crude Oil and NGLs Production	95
3.7	Gravity and Sulphur Content of Selected Crude Oils, 2005	96
3.8	Non-Conventional Oil Production and Related Natural Gas Needs in Canada	100
3.9	Net Oil Exports in the Reference Scenario	101
3.10	Cumulative Oil Investment by Activity in the Reference Scenario, 2005-2030	103
3.11	Cumulative Investment in Oil Refining by Region, 2005-2030	103

3.12	Access to World Proven Oil Reserves, end-2005	105
3.13	Reduction in World Oil Demand and OPEC Market Share	108
3.14	World Oil Production in the Deferred Investment Case Compared with the Reference Scenario	109

Chapter 4. Gas Market Outlook

4.1	World Primary Natural Gas Demand by Sector in the Reference Scenario	113
4.2	Proven Gas Reserves and Production by Region, 2005	115
4.3	Natural Gas Production by Region in the Reference Scenario	116
4.4	Main Net Inter-Regional Natural Gas Trade Flows in the Reference Scenario, 2004 and 2030	119
4.5	World Inter-Regional Natural Gas Trade by Type in the Reference Scenario	121
4.6	Cumulative Investment in Gas-Supply Infrastructure by Region and Activity in the Reference Scenario, 2005-2030	122

Chapter 5. Coal Market Outlook

5.1	Share of Power Generation in Total Coal Consumption by Region in the Reference Scenario	128
5.2	Proven Coal Reserves by Country	129
5.3	Global Coal Production by Type in the Reference Scenario	131
5.4	Net Inter-Regional Trade in Hard Coal in the Reference Scenario	133
5.5	Indicative Supply Costs for Internationally Traded Steam Coal	134
5.6	Structure of Steam Coal Supply Costs for Major Exporting Countries	135

Chapter 6. Power Sector Outlook

6.1	World Electricity Demand by Region in the Reference Scenario	138
6.2	Average Annual Growth in Electricity Demand by Region in the Reference Scenario	139
6.3	World Incremental Electricity Generation by Fuel in the Reference Scenario	140
6.4	Incremental Coal-Fired Electricity Generation by Region in the Reference Scenario, 2004-2030	141
6.5	World Hydropower Potential	143
6.6	Increase in Power-Sector CO ₂ Emissions by Fuel in the Reference Scenario, 2004-2030	144
6.7	Electricity Generating Cost Ranges of Baseload Technologies	145
6.8	Impact of Capacity Factor on Generating Costs	146

6.9	Impact of Carbon Value on Generating Costs	147
6.10	Cumulative Power-Sector Investment by Region in the Reference Scenario, 2005-2030	149
6.11	Cumulative Power-Sector Investment by Type in the Reference Scenario, 2005-2030	150
6.12	European Generation Margins	151
6.13	US Capacity Reserve Margins	152
6.14	Japan Power-Sector Investment, 1998 to 2003	153
6.15	Private Investment in Electricity Infrastructure in Developing Countries, 1990-2004	154
6.16	Cumulative Private Investment in Electricity Infrastructure in Developing Countries, 1990-2004	155
6.17	Population without Electricity, 2005	156

Chapter 7. Mapping a New Energy Future

7.1	Years Saved in the Alternative Policy Scenario in Meeting the Levels of Deployment of the Reference Scenario in 2030	172
7.2	World Primary Energy Demand in the Reference and Alternative Policy Scenarios	174
7.3	Incremental Demand and Savings in Fossil Fuels in the Alternative Policy Scenario, 2004-2030	174
7.4	Incremental Non-Fossil Fuel Demand in the Reference and Alternative Policy Scenarios, 2004-2030	176
7.5	Change in Primary Energy Intensity by Region in the Reference and Alternative Policy Scenarios, 2004-2030	177
7.6	Oil Supply in the Alternative Policy Scenario	180
7.7	Increase in Net Oil Imports in Selected Importing Regions in the Alternative Policy Scenario	182
7.8	Natural Gas Imports in Selected Importing Regions in the Reference and Alternative Policy Scenarios	184
7.9	Coal Demand in the Reference and Alternative Policy Scenarios	185
7.10	Change in Oil and Gas Imports in the Reference and Alternative Policy Scenarios, 2004-2030	187
7.11	Energy-Related CO ₂ Emissions by Region in the Alternative Policy Scenario	189
7.12	Change in Energy-Related CO ₂ Emissions by Region in the Reference and Alternative Policy Scenarios, 2004-2030	189
7.13	Energy-Related CO ₂ Emissions Savings by Region in the Alternative Policy Scenario, 2030	191
7.14	Global Savings in CO ₂ Emissions in the Alternative Policy Scenario Compared with the Reference Scenario	192

Chapter 8. Assessing the Cost-Effectiveness of Alternative Policies

8.1	Change in Cumulative Demand- and Supply-Side Investment in the Alternative Policy Scenario, 2005-2030	195
8.2	Demand-Side Investment and Final Energy Savings by Region in the Alternative Policy Scenario	200
8.3	Cumulative Global Investment in Electricity-Supply Infrastructure by Scenario, 2005-2030	202
8.4	Investment in Fossil-Fuel Supply in the Reference and Alternative Policy Scenarios, 2005-2030	203
8.5	Oil and Gas Export Revenues in the Middle East and North Africa in the Reference and Alternative Policy Scenarios	205
8.6	Indicative Average Payback Period of Selected Policies in the Alternative Policy Scenario by Region	206
8.7	Change in End-Use Electricity Investment and in Consumers' Electricity Bills in the Alternative Policy Scenario, 2005-2030	207
8.8	Change in End-Use Investment in Transport and Consumers' Fuel Bills in the Alternative Policy Scenario, 2005-2030	209
8.9	World Bank Investment in Energy by Sector, 1990-2005	211

Chapter 9. Deepening the Analysis: Results by Sector

9.1	Reduction in Electricity Generation in the Alternative Policy Scenario by Region, 2030	214
9.2	Global Fuel Shares in Electricity Generation	215
9.3	Reduction in Coal-Fired Generation by Region in the Alternative Policy Scenario	217
9.4	Share of Nuclear Power in Electricity Generation by Region in the Alternative Policy Scenario	218
9.5	Shares of non-Hydro Renewable Energy in Electricity Generation by Region in the Alternative Policy Scenario	219
9.6	Investment Costs of Renewables-Based Power-Generation Technologies in the Alternative Policy Scenario, 2004 and 2030	220
9.7	CO ₂ Emissions per kWh of Electricity Generated in the Reference and Alternative Policy Scenarios	220
9.8	World Transport Oil Demand in the Alternative Policy Scenario and Savings Compared with the Reference Scenario by Source	223
9.9	Road Transport Demand in the Reference and Alternative Policy Scenarios	225
9.10	World On-Road Passenger Light-Duty Vehicle Stock	229
9.11	New Vehicle Sales by Region, 2005-2030	230
9.12	Technology Shares in New Light-Duty Vehicles Sales in the Reference and Alternative Policy Scenarios	231

9.13	Growth in Road and Aviation Oil Consumption in the Reference Scenario	232
9.14	World Aviation CO ₂ Emissions	234
9.15	Change in Industrial Energy Demand by Region and Sector in the Alternative Policy Scenario, 2030	236
9.16	Change in Final Energy Consumption in the Residential and Services Sectors in the Alternative Policy Scenario by Fuel, 2030	242
9.17	Change in Electricity Demand in the Residential and Services Sectors in the Alternative Policy Scenario by Use, 2030	243

Chapter 10. Getting to and Going Beyond the Alternative Policy Scenario

10.1	Cumulative Energy-Related CO ₂ Emissions in the Reference and Alternative Policy Scenarios, 2005-2030	251
10.2	Reduction in Energy-Related CO ₂ Emissions in the BAPS Case Compared with the Alternative Policy Scenario by Option	258
10.3	Fuel Mix in Power Generation in Different Scenarios	260
10.4	CO ₂ Intensity of Electricity Generation	261

Chapter 11. The Impact of Higher Energy Prices

11.1	Average IEA Crude Oil Import Price	271
11.2	Average Crude Oil Import Prices by Region in Real Terms and Local Currencies	272
11.3	Average IEA Crude Oil and Natural Gas Import Prices	274
11.4	Average IEA Crude Oil and Coal Import Prices	275
11.5	Change in Real Energy End-Use Prices by Region and Fuel, 1999-2005	276
11.6	Change in Average Annual IEA Crude Oil Import Price and Road Fuel Prices in Ten Largest Oil-Consuming Countries, 1999-2005	277
11.7	Economic Value of Energy Subsidies in non-OECD Countries, 2005	280
11.8	Increase in World Primary Oil Demand by Region	284
11.9	Increase in Natural Gas Demand by Region	284
11.10	The Link between Fuel Price and Demand	285
11.11	Crude Oil Price Elasticities of Road Transport Oil Demand versus the Share of Tax in the Pump Price	288
11.12	World Oil Demand and Real GDP	290
11.13	World Oil Demand and Real GDP Per Capita	291
11.14	Share of Transport Sector in Primary Oil Consumption in the Reference and Alternative Policy Scenarios	292
11.15	World Stationary Final Fossil Fuel Demand and Real GDP Per Capita	294

11.16	World Electricity Demand and Real GDP Per Capita	295
11.17	Change in Primary Oil Demand in the High Energy Prices Case by Region and Sector Compared with the Reference Scenario, 2030	297
11.18	Oil-Import Intensity by Region	300
11.19	Increase in the Net Oil and Gas Import Bill in 2005 over 2002	301
11.20	Real GDP Growth by Region	307
11.21	Commodity Price Indices	308
11.22	Current Account Balance in Selected Countries/Regions	309
11.23	Current Account Balances of the United States, China and Oil Exporters	310

Chapter 12. Current Trends in Oil and Gas Investment

12.1	Total Oil and Gas Industry Investment, 2000-2010	317
12.2	Total Oil and Gas Industry Investment by Sector	320
12.3	Oil and Gas Industry Investment by Type of Company	321
12.4	Investment in Oil and Gas Exploration and Development	322
12.5	Upstream Investment by Activity, 2000-2010	323
12.6	Sanctioned and Planned Project Investment on New Oil and Gas Fields by Region, 2006-2010	323
12.7	Oil and Gas Exploration Investment	326
12.8	New Oil and Gas Project Investment by Source and Destination, 2006-2010	327
12.9	Active Drilling Rigs and Offshore Drilling Rigs under Construction, 1997-2006	328
12.10	Upstream Oil and Gas Industry Investment in Nominal Terms and Adjusted for Cost Inflation	329
12.11	Availability of Petroleum-Industry Graduates by Region	330
12.12	Estimated Capital Intensity of Upstream Development Projects by Region, 2006-2010	331
12.13	Gross Oil Capacity Additions from New Sanctioned and Planned Projects by Region	332
12.14	Cumulative Additions to Global Oil Demand and Net Oil Production Capacity Based on Observed Rates of Decline of Existing Production	334
12.15	World Oil Refinery Investment by Type, 2006-2010	336
12.16	World Oil Refinery Capacity Additions by Region, 2006-2010	337

Chapter 13. Prospects for Nuclear Power

13.1	Power Sector CO ₂ Emissions per kWh and Shares of Nuclear Power and Renewables in Selected Countries, 2004	345
13.2	Historical World Nuclear Capacity Additions	349

13.3	Shares of Nuclear Power in Electricity Generation by Region	350
13.4	Increases in Average Nuclear Capacity Factors, 1991-2005	350
13.5	World Nuclear Capacity in the Reference and Alternative Policy Scenarios	360
13.6	Share of Nuclear Power in Total Electricity Generation in the Alternative Policy Scenario	363
13.7	Electricity Generating Costs in the Low Discount Rate Case	367
13.8	Electricity Generating Costs in the High Discount Rate Case	368
13.9	Comparison of Nuclear, Coal and CCGT Generating Costs under Different Coal and Gas Prices	369
13.10	Impact of a 50% Increase in Fuel Price on Generating Costs	370
13.11	Impact of CO ₂ Price on Generating Costs	370
13.12:	Construction Time of Existing Nuclear Power Plants	373
13.13	Identified Uranium Resources in Top Twenty Countries	378
13.14	Uranium Resources versus Cumulative Uranium Demand	379
13.15	World Uranium Production Capability and Reactor Requirements in the Reference and Alternative Policy Scenarios	381
13.16	Uranium Oxide Spot Prices and Exploration Expenditures	382

Chapter 14. The Outlook for Biofuels

14.1	Share of Biofuels in Total Road-Fuel Consumption in Energy Terms by Country, 2004	388
14.2	World Ethanol Production	390
14.3	World Biodiesel Production	391
14.4	Share of Biofuels in Road-Transport Fuel Consumption in Energy Terms	396
14.5	Share of Ethanol in Total Biofuels Consumption in Energy Terms in Brazil, the European Union and the United States in the Reference Scenario	396
14.6	Biofuels Consumption in Selected EU Countries	403
14.7	Biofuel Production Costs versus Gasoline and Diesel Prices	406
14.8	Production Costs of Ethanol in Brazil, the European Union and the United States	407
14.9	Production Costs of Biodiesel in the European Union and the United States	408

Chapter 15. Energy for Cooking in Developing Countries

15.1	Share of Traditional Biomass in Residential Consumption by Country	423
15.2	Primary Energy Source for Cooking in Households in India and Botswana	424

15.3	Annual Deaths Worldwide by Cause	425
15.4	Deaths per Year Caused by Indoor Air Pollution, by WHO region	426
15.5	Woodfuel Supply and Demand Balance in East Africa	429
15.6	Distance Travelled to Collect Fuelwood in Rural Tanzania	430
15.7	Additional LPG Demand Associated with Switching Compared with World Oil Demand	437
15.8	Comparison of Average Annual Cost of LPG Fuel and Technology, 2007-2015, with Other Annual Allocations of Resources	439
15.9	Saudi Aramco Contract LPG Price	441
15.10	Residential Biomass Consumption and LPG Retail Price in Brazil	442

Chapter 16. Focus on Brazil

16.1	Primary Fuel Mix, 1980 and 2004	454
16.2	Oil Import Intensity in Brazil	456
16.3	Passenger Car Stock in Brazil in the Reference and Alternative Policy Scenarios	457
16.4	Industrial Energy Intensity in Selected Regions, 1970-2030	458
16.5	Primary Energy Demand in the Reference and Alternative Policy Scenarios in Brazil	459
16.6	Residential and Services Energy Demand in the Reference and Alternative Policy Scenarios	463
16.7	Brazil's Proven Reserves by Date of Discovery	465
16.8	Oil and Gas Fields and Related Infrastructure in Brazil	466
16.9	Brazil's Oil Balance in the Reference Scenario	468
16.10	Brazil's Crude Oil Production by Source in the Reference Scenario	470
16.11	Natural Gas Balance in Brazil in the Reference Scenario	472
16.12	Biofuels Penetration in the Road-Transport Sector in Brazil in the Reference and Alternative Policy Scenarios, 2004-2030	475
16.13	Planned Infrastructural Developments for Ethanol in Brazil	478
16.14	Power Generating Capacity in Brazil in the Reference Scenario	483
16.15	Brazil's Energy-Related CO ₂ Emissions in the Reference and Alternative Policy Scenarios	485
16.16	Brazil's Cumulative Investment in Energy-Supply Infrastructure in the Reference Scenario, 2005-2030	486

List of Tables

Chapter 1. Key Assumptions

1.1	World Population Growth	56
1.2	World Real GDP Growth	59
1.3	Fossil-Fuel Price Assumptions in the Reference Scenario	61

Chapter 2. Global Energy Trends

2.1	World Primary Energy Demand in the Reference Scenario	66
2.2	Net Energy Imports by Major Region	74
2.3	Cumulative Investment in Energy-Supply Infrastructure in the Reference Scenario, 2005-2030	77
2.4	World Energy-Related CO ₂ Emissions by Sector in the Reference Scenario	80
2.5	World Energy-Related CO ₂ Emission Indicators by Region in the Reference Scenario	83

Chapter 3. Oil Market Outlook

3.1	World Primary Oil Demand	86
3.2	World Oil Supply	92
3.3	Major New Oil-Sands Projects and Expansions in Canada	98
3.4	Oil-Import Dependence by Major Importing Region in the Reference Scenario	101

Chapter 4. Gas Market Outlook

4.1	World Primary Natural Gas Demand in the Reference Scenario	112
4.2	Inter-Regional Natural Gas Trade by Region in the Reference Scenario	118

Chapter 5. Coal Market Outlook

5.1	World Coal Demand	127
5.2	World Coal Production in the Reference Scenario	130
5.3	Hard Coal Net Inter-Regional Trade in the Reference Scenario	132

Chapter 6. Power Sector Outlook

6.1	New Electricity Generating Capacity and Investment by Region in the Reference Scenario, 2005-2030	148
-----	---	-----

Chapter 7. Mapping a New Energy Future

7.1	Selected Policies Included in the Alternative Policy Scenario	168
7.2	World Energy Demand in the Alternative Policy Scenario	173
7.3	Final Energy Consumption in the Alternative Policy Scenario	177
7.4	World Oil Demand in the Alternative Policy Scenario	179
7.5	Net Imports in Main Importing Regions	181
7.6	World Primary Natural Gas Demand in the Alternative Policy Scenario	183

Chapter 8. Assessing the Cost-Effectiveness of Alternative Policies

8.1	Change in Cumulative Electricity Investment in the Alternative Policy Scenario, 2005-2030	197
8.2	Additional Demand-Side Investment in the Alternative Policy Scenario, 2005-2030	198
8.3	Cumulative Oil and Gas Import Bills in Main Net Importing Regions by Scenario, 2005-2030	204

Chapter 9. Deepening the Analysis: Results by Sector

9.1	Electricity Generation and Electricity Intensity Growth Rates	215
9.2	Changes in Electricity-Generating Capacity Additions in the Alternative Policy Scenario, 2005-2030	217
9.3	Transport Energy Consumption and Related CO ₂ Emissions in the Alternative Policy Scenario	223
9.4	Key Selected Policies on Light-Duty Vehicle Fuel Economy in the Alternative Policy Scenario	227
9.5	Average On-Road Vehicle Fuel Efficiency for New Light-Duty Vehicles in the Reference and Alternative Policy Scenarios	228
9.6	Aviation Fuel Consumption and CO ₂ Emissions in the Alternative Policy Scenario	233
9.7	Change in Industrial Energy Consumption in the Alternative Policy Scenario, 2030	235
9.8	Energy Intensities in the Steel, Cement and Ammonia Industries in Selected Countries, 2004	238
9.9	Average Electricity Intensity of Primary Aluminium Production, 2004	239

Chapter 10. Getting to and Going Beyond the Alternative Policy Scenario

10.1	Most Effective Policies for Reducing Cumulative CO ₂ Emissions in 2030 in the Alternative Policy Scenario Compared with the Reference Scenario	252
10.2	Options for Emissions Reductions beyond 2030	263

Chapter 11. The Impact of Higher Energy Prices

11.1	Consumption Subsidy as Percentage of Final Energy Prices in non-OECD Countries, 2005	281
11.2	Change in Energy Demand by Fuel and Region	283
11.3	Crude Oil Price and Income Elasticities of Oil Demand Per Capita by Region	287

11.4	Change in Primary Energy Demand by Fuel and Region in the High Energy Prices Case Compared with the Reference Scenario	296
11.5	IMF Analysis of the Macroeconomic Impact of an Increase in the International Crude Oil Price to \$80 per Barrel	304
11.6	Macroeconomic Effects in EIA/IEA High Oil Price Case, 2007-2010	305
11.7	Estimated Impact of Higher Oil Prices since 2002 on Real GDP	306

Chapter 12. Current Trends in Oil and Gas Investment

12.1	Oil and Gas Production of Surveyed Companies by Type, 2005	319
12.2	Sanctioned and Planned Upstream Oil and Gas Developments for Completion in 2006-2010	324
12.3	Natural Gas Liquefaction Plants to be Commissioned by 2010	338

Chapter 13. Prospects for Nuclear Power

13.1	Key Nuclear Statistics, 2005	347
13.2	The Ten Largest Nuclear Operators in the World, 2005	348
13.3	Timeline Leading to the Construction of New Nuclear Reactors in the United States	351
13.4	Timeline Leading to the Construction of a New Nuclear Reactor in Finland	352
13.5	Timeline Leading to the Construction of a New Nuclear Reactor in France	353
13.6	Main Policies Related to Nuclear Power Plants in OECD Countries	354
13.7	Examples of High-Level Waste Disposal Strategies	358
13.8	Nuclear Capacity and Share of Nuclear Power in the Reference and Alternative Policy Scenarios	362
13.9	Main Cost and Technology Parameters of Plants Starting Commercial Operation in 2015	365
13.10	Summary of Financial Parameters	367
13.11	Average Estimated and Realised Investment Costs of Nuclear Power Plants by Year of Construction Start, 1966-1977	372
13.12	Total World Uranium Resources	377
13.13	World Uranium Production in Selected Countries, 2004	380
13.14	Summary of Nuclear Power Economics	383

Chapter 14. The Outlook for Biofuels

14.1	Biofuels Production by Country, 2005	387
14.2	World Biofuels Consumption by Scenario	394

14.3	Summary of Current Government Support Measures for Biofuels in Selected Countries/Regions	398
14.4	US Biofuels Production Capacity	402
14.5	Performance Characteristics of Biofuel Crops in Europe	410
14.6	Global Potential Biomass Energy Supply to 2050	415
14.7	Land Requirements for Biofuels Production	416

Chapter 15. Energy for Cooking in Developing Countries

15.1	People Relying on Biomass Resources as their Primary Fuel for Cooking, 2004	422
15.2	People Relying on Traditional Biomass	431
15.3	Costs and Characteristics of Selected Fuels	434
15.4	Additional Number of People Needing to Gain Access to Modern Fuels	436
15.5	Purchase Cost of LPG Stoves and Cylinders by Region	439
15.6	Benefits of Cleaner Cooking	440

Chapter 16. Focus on Brazil

16.1	Key Energy Indicators for Brazil	448
16.2	GDP and Population Growth Rates in Brazil in the Reference Scenario	451
16.3	Primary Energy Demand in the Reference Scenario in Brazil	455
16.4	Primary Energy Demand in the Alternative Policy Scenario in Brazil	459
16.5	Main Policies and Programmes Considered in the Alternative Policy Scenario	460
16.6	Change in Total Final Consumption in the Alternative Policy Scenario in 2030	463
16.7	Major Oilfields Currently in Production in Brazil	467
16.8	Brazil's Oil Production in the Reference Scenario	468
16.9	Electricity Generation Mix in Brazil in the Reference Scenario	481

List of Boxes

Chapter 1. Key Assumptions

1.1	Improvements to the Modelling Framework in <i>WEO-2006</i>	55
-----	--	----

Chapter 2. Global Energy Trends

2.1	Uncertainty Surrounding China's Energy Trends	69
2.2	Methodology for Projecting Energy Investment	76
2.3	Will Signatories to the Kyoto Protocol Respect their Greenhouse-Gas Emission-Limitation Commitments?	79

Chapter 3. Oil Market Outlook		
3.1	Canadian Oil-Sands Production Costs	99
Chapter 4. Gas Market Outlook		
4.1	LNG Set to Fill the Growing US Gas-Supply Gap	120
Chapter 5. Coal Market Outlook		
5.1	The Economics of Coal-to-Liquids Production	128
Chapter 6. Power Sector Outlook		
6.1	Prospects for Hydropower in Developing Countries	142
6.2:	Siting New Power Infrastructure	149
Chapter 7. Mapping a New Energy Future		
7.1	New Vehicle Fuel Economy in the United States	167
7.2	Current Status and Development of CO ₂ Capture and Storage Technology	171
Chapter 8. Assessing the Cost-Effectiveness of Alternative Policies		
8.1	Comparing Costs and Savings	194
8.2	Energy Efficiency Codes and Standards in China's Residential and Services Sectors	199
8.3	Energy Efficiency Project in Industry in China	201
8.4:	Energy Savings Programme in the UK Residential Sector	208
8.5:	Increasing Light-Duty Vehicle Efficiency	209
Chapter 9. Deepening the Analysis: Results by Sector		
9.1	The Efficiency of Energy Use in the Aluminium Industry	239
9.2	Improving the Energy Efficiency of Motor Systems	240
9.3:	Opportunities to Save Energy Through More Efficient Lighting	244
Chapter 11. The Impact of Higher Energy Prices		
11.1	Contractual Links between Oil and Gas Prices	273
11.2	Quantifying Global Energy Subsidies	278
Chapter 12. Current Trends in Oil and Gas Investment		
12.1	Analysis of Current Oil and Gas Investment Plans	317
Chapter 13. Prospects for Nuclear Power		
13.1	Recent Trends and Outlook for Nuclear Reactor Technology	363
13.2	Financing Finland's New Nuclear Reactor	375
13.3	Impact of Incentives in the US 2005 Energy Policy Act on Nuclear Power Generating Costs	376

Chapter 15. Energy for Cooking in Developing Countries		
15.1	The Brazilian Experience with LPG	432
15.2	Household Coal and Alternatives in China	435
15.3	The Role of Microfinance in Expanding the Use of Modern Fuels	443
Chapter 16. Focus on Brazil		
16.1	Regional Integration in South American Energy Markets	453
16.2	Petrobras' Development of Deep-water Crude Oil Production	469
16.3	Refinery Conversion with H-BIO Technology	470
16.4	Technological Developments in Sugar-Cane and Ethanol Production	477
16.5	Prospects for Renewable Energy-based Generation	482

World Energy Outlook Series

World Energy Outlook 1993

World Energy Outlook 1994

World Energy Outlook 1995

World Energy Outlook 1996

World Energy Outlook 1998

World Energy Outlook: 1999 Insights

Looking at Energy Subsidies: Getting the Prices Right

World Energy Outlook 2000

World Energy Outlook: 2001 Insights

Assessing Today's Supplies to Fuel Tomorrow's Growth

World Energy Outlook 2002

World Energy Investment Outlook: 2003 Insights

World Energy Outlook 2004

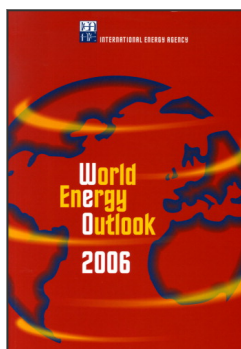
World Energy Outlook 2005

Middle East and North Africa Insights

World Energy Outlook 2006

World Energy Outlook 2007 (forthcoming)

China and India Insights: Implications for Global Energy Markets



From:
World Energy Outlook 2006

Access the complete publication at:

<https://doi.org/10.1787/weo-2006-en>

Please cite this chapter as:

International Energy Agency (2006), "Global Energy Trends", in *World Energy Outlook 2006*, OECD Publishing, Paris.

DOI: <https://doi.org/10.1787/weo-2006-3-en>

This work is published under the responsibility of the Secretary-General of the OECD. The opinions expressed and arguments employed herein do not necessarily reflect the official views of OECD member countries.

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

You can copy, download or print OECD content for your own use, and you can include excerpts from OECD publications, databases and multimedia products in your own documents, presentations, blogs, websites and teaching materials, provided that suitable acknowledgment of OECD as source and copyright owner is given. All requests for public or commercial use and translation rights should be submitted to rights@oecd.org. Requests for permission to photocopy portions of this material for public or commercial use shall be addressed directly to the Copyright Clearance Center (CCC) at info@copyright.com or the Centre français d'exploitation du droit de copie (CFC) at contact@cfcopies.com.