

INTERNATIONAL ENERGY AGENCY



WORLD ENERGY OUTLOOK 2004

**EXECUTIVE
SUMMARY**

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six* of the OECD's thirty member countries. The basic aims of the IEA are:

- to maintain and improve systems for coping with oil supply disruptions;
- to promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- to operate a permanent information system on the international oil market;
- to improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- to assist in the integration of environmental and energy policies.

** IEA member countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Republic of Korea, Luxembourg, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States. The European Commission also takes part in the work of the IEA.*

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article 1 of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations.

The original member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), the Republic of Korea (12th December 1996) and Slovakia (28th September 2000). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

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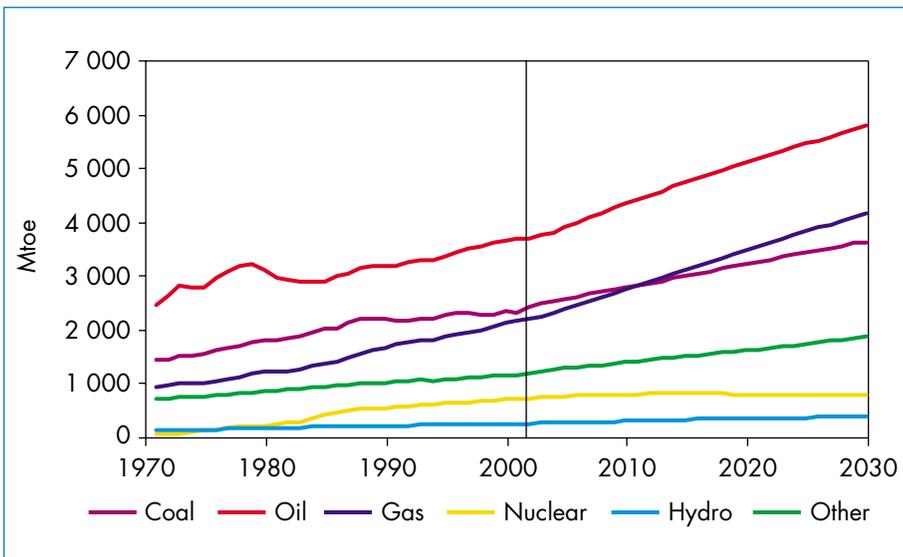
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Energy Security in a Dangerous World

World Energy Outlook 2004 paints a sobering picture of how the global energy system is likely to evolve from now to 2030. If governments stick with the policies in force as of mid-2004, the world's energy needs will be almost 60% higher in 2030 than they are now. Fossil fuels will continue to dominate the global energy mix, meeting most of the increase in overall energy use. The shares of nuclear power and renewable energy sources will remain limited.

The Earth's energy resources are more than adequate to meet demand until 2030 and well beyond. Less certain is how much it will cost to extract them and deliver them to consumers. Fossil-fuel resources are, of course, finite, but we are far from exhausting them. The world is not running out of oil just yet. Most estimates of proven oil reserves are high enough to meet the cumulative world demand we project over the next three decades. Our analysis suggests that global production of conventional oil will not peak before 2030 if the necessary investments are made. Proven reserves of gas and coal are even more plentiful than those of oil. There is considerable potential for discovering more of all these fuels in the future.

World Primary Energy Demand by Fuel



But serious concerns about energy security emerge from the market trends projected here. The world's vulnerability to supply disruptions will increase as international trade expands. Climate-destabilising carbon-dioxide emissions will continue to rise, calling into question the sustainability of the current energy system. Huge amounts of new energy infrastructure will need to be financed. And many of the world's poorest people will still be deprived of modern energy services. These challenges call for urgent and decisive action by governments around the world.

A central message of this *Outlook* is that short-term risks to energy security will grow. Recent geopolitical developments and surging energy prices have brought that message dramatically home. Major oil- and gas-importers – including most OECD countries, China and India – will become ever more dependent on imports from distant, often politically-unstable parts of the world. Flexibility of oil demand and supply will diminish. Oil use will become ever more concentrated in transport uses in the absence of readily-available substitutes. Rising oil demand will have to be met by a small group of countries with large reserves, primarily Middle East members of OPEC and Russia. Booming trade will strengthen the mutual dependence among exporting and importing countries. But it will also exacerbate the risks that wells or pipelines could be closed or tankers blocked by piracy, terrorist attacks or accidents. Rapid worldwide growth in natural gas consumption and trade will foster similar concerns.

If current government policies do not change, energy-related emissions of carbon dioxide will grow marginally faster than energy use. CO₂ emissions will be more than 60% higher in 2030 than now. The average carbon content of energy, which fell markedly during the past three decades, will hardly change. Well over two-thirds of the projected increase in emissions will come from developing countries, which will remain big users of coal – the most carbon-intensive of fuels. Power stations, cars and trucks will give off most of the increased energy-related emissions.

Converting the world's resources into available supplies will require massive investments. In some cases, financing for new infrastructure will be hard to come by. Meeting projected demand will entail cumulative investment of some \$16 trillion from 2003 to 2030, or \$568 billion per year. The electricity sector will absorb the majority of this investment. Developing countries, where production and demand are set to increase most, will require about half of global energy investment. Those countries will face the biggest challenge in raising finance, because their needs are larger relative to the size of their economies and because the investment risks are bigger. The global financial system has the capacity to fund the required investments, but it will not do so unless conditions are right.

Reducing energy poverty is an urgent necessity. There will be some encouraging advances in energy development in non-OECD countries over the projection period. But even for the most developed among them in energy terms, the use of modern energy and the per capita consumption of every kind of energy will remain far below that of OECD countries. Little progress will be made in reducing the total number of people who lack access to electricity. And the ranks of those using traditional fuels in unsustainable and inefficient ways for cooking and heating will actually *increase* over the projection period. Developing countries are unlikely to see their incomes and living standards increase without improved access to modern energy services.

These trends, from our Reference Scenario, are, however, not unalterable. More vigorous government action *could* steer the world onto a markedly different energy path. This *Outlook* presents an Alternative Scenario, which analyses, for the first time, the global impact of environmental and energy-security policies that countries around the world are already considering, as well as the effects of faster deployment of energy-efficient technologies. In this scenario, global energy demand and carbon-dioxide emissions are significantly lower than in our Reference Scenario. Dependence on imported energy in major consuming countries and the world's reliance on Middle East oil and gas are also lower. However, even in this Alternative Scenario energy imports and emissions would still be higher in 2030 than today.

It is clear from our analysis that achieving a truly sustainable energy system will call for technological breakthroughs that radically alter how we produce and use energy. The government actions envisioned in our Alternative Scenario could slow markedly carbon-dioxide emissions, but they could not reduce them significantly using existing technology. Carbon capture and storage technologies, which are not taken into account in either the Reference or the Alternative Scenario, hold out the tantalising prospect of using fossil fuels in a carbon-free way. Advanced nuclear-reactor designs or breakthrough renewable technologies could one day help free us from our dependence on fossil fuels. This is unlikely to happen within the timeframe of our analysis. The pace of technology development and deployment in these and other areas is the key to making the global energy system more economically, socially and environmentally sustainable in the long term. But consumers will have to be willing to pay the full cost of energy – including environmental costs – before these technologies can become competitive. Governments must decide today to accelerate this process.

Main Findings and Projections

Fossil Fuels will Still Meet most of the World's Energy Needs

World primary energy demand in the Reference Scenario is projected to expand by almost 60% between 2002 and 2030. But the projected annual rate of demand growth, at 1.7%, is slower than the average of the past three decades, which was 2%. Energy intensity – the amount of energy needed to produce a dollar's worth of GDP – will continue to decline as energy efficiency improves and the global economy relies less on heavy industry.

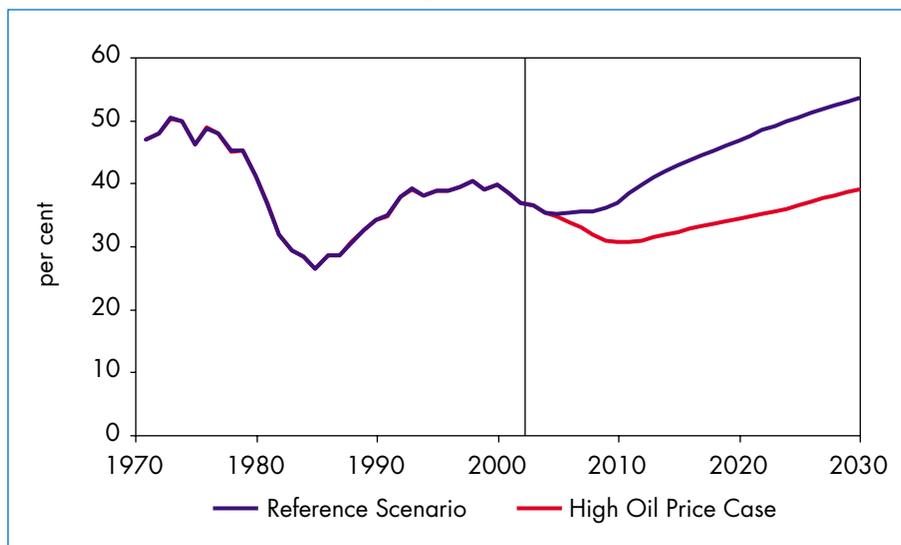
Fossil fuels will continue to dominate global energy use, accounting for some 85% of the increase in world primary demand. Oil will remain the single largest fuel in the primary energy mix, even though its percentage share will fall marginally. Among the fossil fuels, demand for natural gas will grow most rapidly, mainly due to strong demand from power generators. The share of coal will fall slightly, but coal will remain the leading fuel for generating electricity. Nuclear power's share will decline during the *Outlook* period.

Two-thirds of the increase in global energy demand will come from developing countries. By 2030, they will account for almost half of total demand, in line with their more rapid economic and population growth. More households will live in towns and cities and so will be better placed to gain access to energy services. The developing countries' share of global demand will increase for all of the primary energy sources except non-hydro renewables. Their share of nuclear-power production will increase fastest, because of strong growth in China and other parts of Asia. Their share of coal consumption will also increase sharply, mainly because of booming demand in China and India.

Oil-Supply Patterns will Shift as Demand and Trade Grow

Global primary oil demand is projected to grow by 1.6% per year, reaching 121 mb/d in 2030. Demand will continue to grow most quickly in developing countries. Most of the increase in world oil demand will come from the transport sector. Oil will face little competition from other fuels in road, sea and air transportation during the projection period. OPEC countries, mainly in the Middle East, will meet most of the increase in global demand. By 2030, OPEC will supply over half of the world's oil needs – an even larger share than in the 1970s. Net inter-regional oil trade will more than double, to over 65 mb/d in 2030 – a little more than half of total oil production. Huge investments will be needed in oilfields, tankers, pipelines and refineries, \$3 trillion from 2003 to 2030. Most upstream investment will, in fact, offset production declines from already-producing fields. Financing will be a major challenge.

Share of OPEC in World Oil Production in the Reference Scenario and the High Oil Price Case



The International Energy Agency calls on all parties to work together to devise and implement a universally-recognised, transparent, consistent and comprehensive data-reporting system for oil and gas reserves. The reliability of reserves data reported by oil companies has been called into severe question. Doubts about the accuracy of reserve estimates – an issue highlighted in this *Outlook* – could undermine investor confidence and slow investment. Governments should be concerned about reserves-data problems, since the long-term security of energy supplies depends on the timely development of oil and gas reserves. The future availability and affordability of hydrocarbons affect decisions about what new policies and measures governments ought to adopt now to develop alternative sources of energy and to save energy.

As international trade expands, risks will grow of a supply disruption at the critical chokepoints through which oil must flow. A total of 26 million barrels currently pass through the Straits of Hormuz in the Persian Gulf and the Straits of Malacca in Asia every day. Traffic through these and other vital channels will more than double over the projection period. A disruption in supply at any of these points could have a severe impact on oil markets. Maintaining the security of international sea-lanes and pipelines will take on added urgency.

Future trends in oil prices are a major source of uncertainty. Prices of crude oil and refined products have risen sharply since 1999, hitting all-time highs in nominal terms in mid-2004. In a special analysis of sustained high oil

prices, we have assumed that the price of crude oil imported into IEA countries would average \$35 per barrel (in year-2000 dollars) from now to 2030 – about \$10 more than in our Reference Scenario. In this high price case, global oil demand falls by 15%, or 19 mb/d in 2030, an amount almost equal to total US oil consumption today. Conventional and non-conventional oil production outside OPEC countries increases markedly at the \$35 price, causing OPEC's market share to fall considerably. Cumulative OPEC revenues in 2003-2030 are about \$750 billion, or 7% lower, than in the Reference Scenario. Plainly, OPEC would not benefit from higher prices in the long term.

Demand for Natural Gas will Overtake that for Coal

Worldwide consumption of natural gas will almost double by 2030, overtaking that of coal within the next decade. Gas demand is projected to grow most rapidly in Africa, Latin America and developing Asia. Yet the total volume increase in demand will be bigger in the mature markets of OECD North America, OECD Europe and the transition economies, where per capita gas use is much higher. Most of the increase in gas demand will come from power stations. Gas is often preferred to coal in new thermal plants for its environmental advantages, its lower capital costs and operational flexibility. Gas-to-liquids plants will emerge as a new market for natural gas, making use of reserves located far from traditional markets and meeting rising demand for cleaner oil products.

Gas reserves are easily large enough to meet the projected increase in global demand. Additions to proven reserves have outpaced production by a wide margin since the 1970s. Production will increase most in Russia and in the Middle East, which between them hold most of the world's proven gas reserves. Most of the incremental output in these regions will be exported to North America, Europe and Asia, swelling the surge in international energy trade. All regions that are currently net importers of gas will see their imports rise, and a growing number of countries and regions will become net importers for the first time. Liquefied natural gas, the bulk of which will be used for power generation, will account for most of the increase in traded gas. By 2030, just over half of all inter-regional gas trade will be in the form of LNG, up from 30% at present. OPEC countries will continue to dominate the supply of LNG. Cumulative investment needs for gas-supply infrastructure to 2030 will amount to \$2.7 trillion, or about \$100 billion per year from now to 2030. More than half will be for exploration and development of gas fields.

Even though coal's share of the global energy market will drop slightly over the *Outlook* period, coal will continue to play a key role in the world energy mix. In 2030, coal will meet 22% of all energy needs, essentially the same proportion as today. Virtually all the increase in coal

consumption will be for power generation, and coal will remain that sector's main fuel – despite a loss of market share to natural gas. Coal demand will increase most in developing Asian countries. China and India alone will be responsible for 68% of the increase in demand over the period 2002 to 2030. Demand growth in the OECD will be minimal.

Carbon-free Energy Sources will Meet only a Small Part of Surging Electricity Needs

World electricity demand is expected to double between now and 2030, with most of the growth occurring in developing countries. By 2030, power generation will account for nearly half of world consumption of natural gas. It will also have absorbed over 60% of total investment in energy-supply infrastructure between now and then. The global power sector will need about 4 800 GW of new capacity to meet the projected increase in electricity demand and to replace ageing infrastructure. In total, electricity investment will amount to about \$10 trillion, more than \$5 trillion of that amount for developing countries alone. For many of them, investment will need to increase substantially. The electricity-supply industry is set for further restructuring and more far-reaching regulatory reforms. Reforms in the OECD have yielded positive results, but many challenges remain to be met. Blackouts in 2003 and 2004 highlighted the importance of adequate reserve margins, the need to improve the resilience of networks and the importance of providing adequate regulatory incentives for investment.

Worldwide nuclear capacity is projected to increase slightly, but the share of nuclear power in total electricity generation will decline. A substantial amount of capacity will be added, but this will be mostly offset by reactor retirements. Three-quarters of existing nuclear capacity in OECD Europe is expected to be retired by 2030, because reactors will have reached the end of their life or because governments plan to phase out nuclear power. Nuclear power generation will increase in a number of Asian countries, notably in China, South Korea, Japan and India.

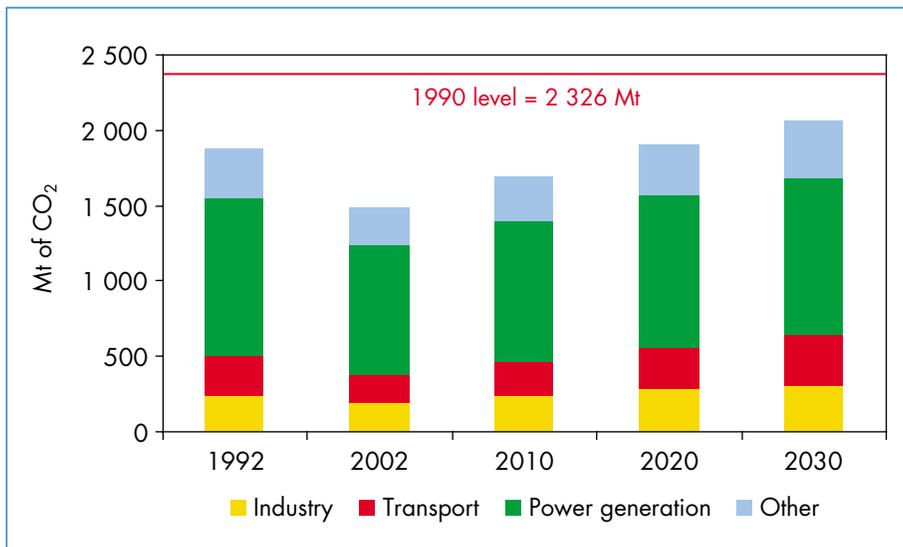
Renewable energy sources as a whole will increase their share of electricity generation. The share of hydroelectricity will fall, but the shares of other renewables in electricity generation will triple, from 2% in 2002 to 6% in 2030. Most of the increase will be in wind and biomass. Wind power will be the second-largest renewable source of electricity in 2030, after hydroelectricity. Finding good sites for land-based wind turbines is becoming more difficult in some areas. The largest increases in renewables will occur in OECD Europe, where they enjoy strong government backing.

Russian Oil and Gas Exports are Poised for Further Growth in the Near Term

Russia will play a central role in global energy supply and trade over the *Outlook* period, with major implications for the world's energy security. The Russian energy sector has undergone a dramatic transformation in recent years. It has been the principal force behind the country's economic recovery since the late 1990s. The Russian economy's dependence on the oil and gas sectors has grown in recent years. Russia's long-term economic prospects hinge on improving the competitiveness and diversity of its other manufacturing sectors and internationally traded services.

The prospects for Russian oil production are very uncertain. Oil production has surged in recent years, mainly thanks to the rehabilitation of existing wells to enhance the recovery of reserves. Production is projected to continue its increase, though more slowly than in recent years. In the short to medium term, most of the extra production will be exported. But the share of Russian exports in world trade will fall after 2010, as Russian production stabilises, domestic demand expands and output picks up in the Middle East.

Energy-Related CO₂ Emissions in Russia



Russia's huge gas resources will underpin a continued increase in production. Higher output will not only meet rising domestic demand, but also provide increased exports to Europe and to new markets in Asia. Russia will still be the world's biggest gas exporter in 2030. But output from the country's old super-giant fields is declining, and huge investments

in greenfield projects will be needed to replace them. The prospects of independent producers contributing more gas – and thereby allowing Russia to increase exports – will depend on whether Gazprom’s network is effectively opened to them.

Developing Russia’s huge energy resources, modernising existing infrastructure and improving efficiency will call for enormous investments. A stable and predictable business regime and market reforms are urgently required if these investments are to be financed. If gas-sector reform is delayed, worries about the security of future supply will increase. Large amounts of foreign capital are unlikely to be made available for energy projects that are not aimed at export markets.

Expanding Modern Energy Services in Poor Countries Will Remain Vital to Their Prospects for Development

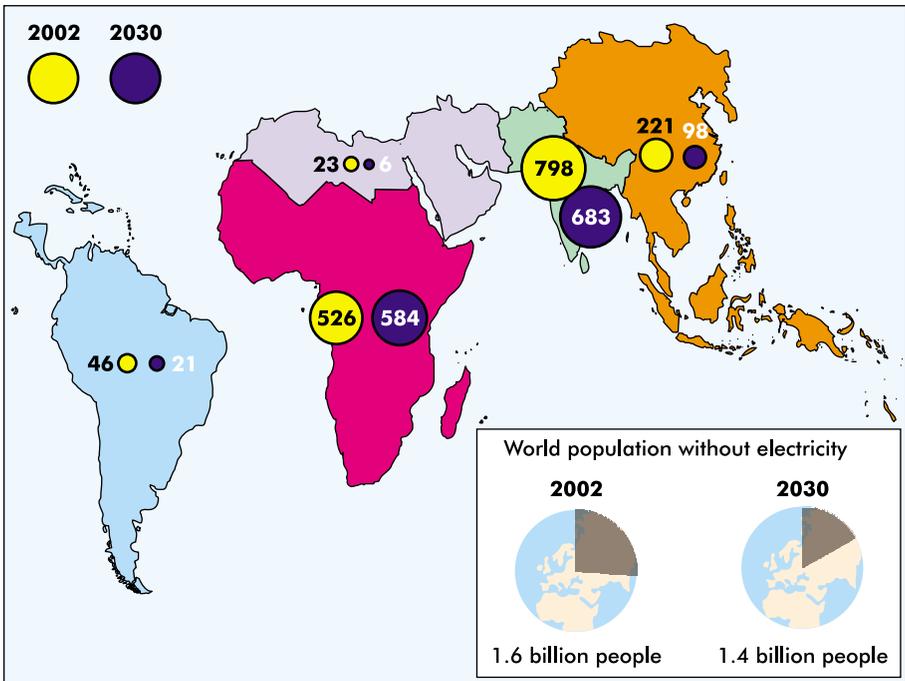
Energy is a prerequisite to economic development. The prosperity that economic development brings, in turn, stimulates demand for more and better energy services. Energy services also help to meet such basic human needs as food and shelter. They contribute to social development by improving education and public health. Electricity plays a particularly important role in human development. Most developed countries have established a virtuous circle of improvements in energy infrastructure and economic growth. But in the world’s poorest countries, the process has barely got off the ground.

Electrification rates will rise over the projection period, but the total number of people still without electricity will fall only slightly, from 1.6 billion in 2002 to just under 1.4 billion in 2030. Most of the net decrease in the number of people without electricity will occur only after 2015. The ranks of the electricity-deprived will fall in Asia, but will continue to swell in Africa. Access to electricity will remain easier in urban areas, but the absolute number of people without electricity will increase slightly in towns and cities, while it will fall in the countryside. The number of people using only traditional biomass for cooking and heating in unsustainable ways will continue to grow, from just under 2.4 billion in 2002 to over 2.6 billion in 2030.

Developing countries can look forward to further advances in energy and human development. According to the Energy Development Index, which the IEA presents for the first time in this *Outlook*, all developing regions can expect to experience increases in per capita energy use and improved access to modern energy services – including electricity. Yet only a few Middle East and Latin American countries will have reached the stage of energy development in 2030 that OECD countries had attained in 1971. Africa and South Asia will remain far behind.

Our analysis suggests that halving the proportion of very poor people will require much faster energy development than is projected in our Reference Scenario. The UN's Millennium Development Goals aim to reduce by 50% the proportion of people living on less than a dollar a day between 2000 and 2015. We estimate that this target will not be met unless access to electricity can be provided to more than half-a-billion people who, according to our Reference Scenario, will still lack it in 2015. To do that would require about \$200 billion of additional investment in electricity supply. Meeting the target also implies a need to expand the use of modern cooking and heating fuels to 700 million more people by 2015 than projected in our Reference Scenario.

Electricity Deprivation (million)



Governments must act decisively to accelerate the transition to modern fuels and to break the vicious circle of energy poverty and human under-development in the world's poorest countries. This will require increasing the availability and affordability of commercial energy, particularly in rural areas. Good governance in the energy sector and more generally will be critical to improving both the quantity and quality of

energy services. The rich industrialised countries have clear economic and security interests in helping developing countries along the energy-development path.

New Policies Could Achieve a More Sustainable Energy System

This study presents a World Alternative Policy Scenario, which depicts a more efficient and more environment-friendly energy future than does the Reference Scenario. It analyses how global energy trends could evolve were countries around the world to implement a set of policies and measures that they are currently considering or might reasonably be expected to adopt. These policies would foster the faster deployment of more efficient and cleaner technologies. In this scenario, global primary energy demand would be about 10% lower in 2030 than in the Reference Scenario. The reduction in demand for fossil fuels would be even bigger, thanks largely to policies that promote renewable energy sources.

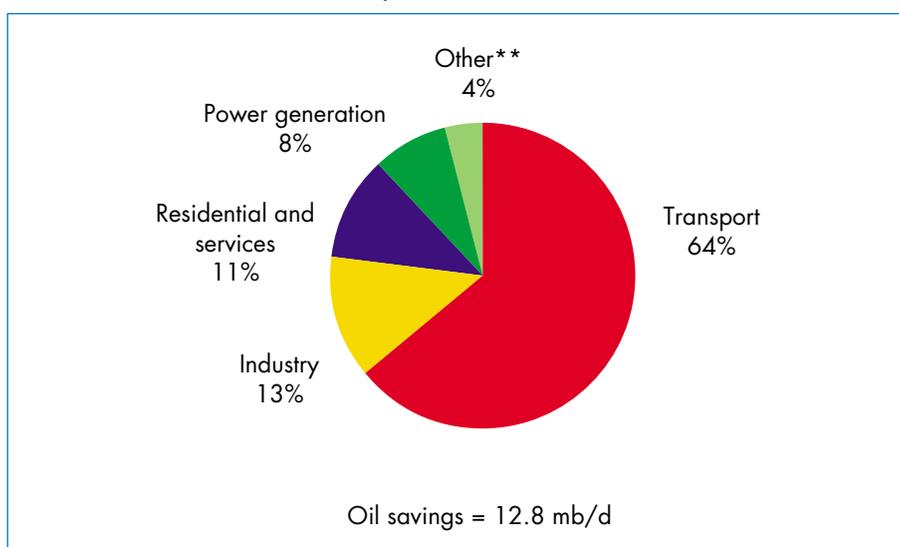
Demand for oil would be markedly lower than in the Reference Scenario. Global oil demand would be 12.8 mb/d, or 11%, lower in 2030 – an amount equal to the current combined production of Saudi Arabia, the United Arab Emirates and Nigeria. Stronger measures to improve fuel economy in OECD countries and the faster deployment of more efficient vehicles in non-OECD countries would contribute almost two-thirds of these savings in 2030. Oil-import dependence in the OECD countries and China would drop as a result. Coal demand would fall even more in percentage terms – by 24% in 2030. The amount saved would be around the current coal consumption of China and India combined. World natural gas demand would be 10% lower than in the Reference Scenario. Gas-import needs would be 40% lower in OECD North America and 13% lower in Europe. China's gas imports would be higher, after a shift from coal to gas.

By 2030, energy-related emissions of carbon dioxide would be 16% lower than in the Reference Scenario. This is roughly equal to the combined current emissions of the United States and Canada. Almost 60% of the cumulative reduction of CO₂ emissions would occur in non-OECD countries. In fact, OECD emissions would level off by the 2020s, and then begin to *decline*. More efficient use of energy in vehicles, electric appliances, lighting and industry account for more than half of the reduction in emissions. A shift in the power generation fuel mix in favour of renewables and nuclear power accounts for most of the rest.

The pattern of investment in energy supply and end-use equipment in the Alternative Scenario is substantially different from that in the Reference Scenario. The total amount of capital required over the projection

period for the entire energy chain – from energy production to end use – does not differ much between the two scenarios. Larger capital needs on the demand side would be entirely offset by lower investment needs on the supply side – despite a 14% increase in the capital intensity of electricity supply in the Alternative Scenario. Electricity prices would rise – for example, by 12% in the European Union. It is uncertain, however, whether all the investment invoked in the Alternative Scenario could actually be financed, especially in developing countries. This is mainly because end-users, who would have to invest more, are likely to find it harder to secure financing than would suppliers, who would need to invest less.

Reduction in Oil Demand by Sector in the Alternative Scenario*, 2030



* Compared with the Reference Scenario.

** Includes non-energy use and other transformation.

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