

EXECUTIVE SUMMARY

This edition of the *World Energy Outlook*, which sets out the IEA's latest energy projections to 2030, depicts a future in which energy use continues to grow inexorably, fossil fuels continue to dominate the energy mix and developing countries fast approach OECD countries as the largest consumers of commercial energy. The Earth's energy resources are undoubtedly adequate to meet rising demand for at least the next three decades. But the projections in this *Outlook* raise serious concerns about the security of energy supplies, investment in energy infrastructure, the threat of environmental damage caused by energy production and use and the unequal access of the world's population to modern energy.

Governments will have to take strenuous action in many areas of energy use and supply if these concerns are to be met. The core projections presented here are derived from a Reference Scenario that takes into account only those government policies and measures that had been adopted by mid-2002. A separate Alternative Policy Scenario assesses the impact of a range of new energy and environmental policies that OECD countries are considering adopting as well as of faster deployment of new energy technologies. Both scenarios confirm the extent of the policy challenges facing governments around the world.

A key result of the *Outlook* is that energy trade will expand rapidly. In particular, the major oil- and gas-consuming regions will see their imports grow substantially. This trade will increase mutual dependence among nations. But it will also intensify concerns about the world's vulnerability to energy supply disruptions, as production is increasingly concentrated in a small number of producing countries. Supply security has moved to the top of the energy policy agenda. The governments of oil- and gas-importing countries will need to take a more proactive role in dealing with the energy security risks inherent in fossil-fuel trade. They will need to pay more attention to maintaining the security of international searoutes and pipelines. And they will look anew at ways of diversifying their fuels, as well as the geographic sources of those fuels. The OECD Alternative Policy Scenario demonstrates the strong impact that new policies to curb energy demand growth and encourage switching away

from fossil fuels could have on import dependence. Governments and consumers are, nonetheless, likely to continue accepting a degree of risk in return for competitively priced energy supplies.

Necessary expansion of production and supply capacity will call for massive investment at every link in the energy supply chain. Investment of almost \$4.2 trillion will be needed for new power generation capacity alone between now and 2030. Mobilising this investment in a timely fashion will require the lowering of regulatory and market barriers and the creation of an attractive investment climate – a daunting task in many countries in the developing world and the former Soviet Union. Most investment will be needed in developing countries, and it is unlikely to materialise without a huge increase in capital inflows from industrialised countries.

Energy-related emissions of carbon dioxide are set to grow slightly faster than energy consumption in the Reference Scenario, despite the policies and measures taken so far. In the Alternative Policy Scenario, however, new policies that many OECD countries are currently considering, together with faster deployment of more efficient and cleaner technologies, would achieve energy savings and promote switching to less carbon-intensive fuels. These developments would eventually stabilise CO₂ emissions in OECD countries, but only towards the end of the *Outlook* period.

More than a quarter of the world's population has no access to electricity, and two-fifths still rely mainly on traditional biomass for their basic energy needs. Although the number of people without power supplies will fall in the coming decades, a projected 1.4 billion people will still be without electricity in 2030. And the number of people using wood, crop residues and animal waste as their main cooking and heating fuels will actually *grow*. To extend electricity supplies to the energy poor and give them better access to other forms of modern energy, stronger government policies and co-ordinated international action will be essential.

Fossil Fuels Will Continue to Dominate Global Energy Use

World energy use will increase steadily through 2030 in the Reference Scenario. Global primary energy demand is projected to increase by 1.7% per year from 2000 to 2030, reaching an annual level of 15.3 billion tonnes of oil equivalent. The increase will be equal to two-thirds of current demand. The projected growth is, nevertheless, slower than growth over the past three decades, which ran at 2.1% per year.

Fossil fuels will remain the primary sources of energy, meeting more than 90% of the increase in demand. Global *oil* demand will rise by about 1.6% per year, from 75 mb/d in 2000 to 120 mb/d in 2030. Almost three-quarters of the increase in demand will come from the transport sector. Oil will remain the fuel of choice in road, sea and air transportation. As a result, there will be a shift in all regions towards light and middle distillate products, such as gasoline and diesel, and away from heavier oil products, used mainly in industry. This shift will be more pronounced in developing countries, which currently have a lower proportion of transportation fuels in their product mix.

Demand for *natural gas* will rise more strongly than for any other fossil fuel. Primary gas consumption will double between now and 2030, and the share of gas in world energy demand will increase from 23% to 28%. New power stations will take over 60% of the increase in gas supplies over the next three decades. Most of these stations will use combined-cycle gas turbine technology, a form of generation favoured for its high energy-conversion efficiency and low capital costs. Gas is also often preferred to coal and oil for its relatively benign environmental effects, especially its lower carbon content.

Consumption of *coal* will also grow, but more slowly than that of oil and gas. China and India together will account for two-thirds of the increase in world coal demand over the projection period. In all regions, coal use will become increasingly concentrated in power generation, where it will remain the dominant fuel. Power-sector coal demand will grow with the expected increase in gas prices. The deployment of advanced technologies will also increase coal's attractiveness as a generating fuel in the long term.

The role of *nuclear power* will decline markedly, because few new reactors will be built and some will be retired. Nuclear production will peak at the end of this decade, then decline gradually. Its share of world primary demand will hold steady at about 7% through 2010, then fall to 5% by 2030. Its share of total electricity generation will fall even faster, from 17% in 2000 to 9% in 2030. Nuclear output will increase in only a few countries, mostly in Asia. The biggest declines in nuclear production are expected to occur in North America and Europe. The prospects for nuclear power are particularly uncertain. Some governments have expressed renewed interest in the nuclear option as a means to reduce emissions and to improve security of supply.

Renewable energy will play a growing role in the world's primary energy mix. Hydropower has long been a major source of electricity production. Its share in global primary energy will hold steady, but its share of electricity generation will fall. Non-hydro renewables, taken as a group, will grow faster than any other primary energy source, at an average rate of 3.3% per year over the projection period. Wind power and biomass will grow most rapidly, especially in OECD countries. But non-hydro renewables will still make only a small dent in global energy demand in 2030, because they start from a very low base. OECD countries, many of which have adopted strong measures to promote renewables-based power projects, will account for most of the growth in renewables.

Demand Will Rise Fastest in Developing Countries...

More than 60% of the increase in world primary energy demand between 2000 and 2030 will come from developing countries, especially in Asia. These countries' share of world demand will increase from 30% to 43%. The OECD's share will fall from 58% to 47%. The share of the former Soviet Union and Eastern and Central Europe (the transition economies) will fall slightly, to 10%. The surge in demand in the developing regions results from their rapid economic and population growth. Industrialisation and urbanisation will also boost demand. The replacement of traditional biomass by commercially traded energy will increase recorded demand. Higher consumer prices as energy subsidies are phased out and international prices rise, are not expected to curb energy demand growth.

China, already the world's second-largest energy consumer, will continue to grow in importance on world energy markets as strong economic growth drives up demand and imports. The Chinese economy will remain exceptionally dependent on coal, but the shares of oil, natural gas and nuclear will grow in China's energy mix. Increasing oil- and gas-import needs will make China a strategic buyer on world markets.

...and Transport Uses Will Outstrip All Others

Transport demand, almost entirely for oil, will grow the most rapidly of all end-use sectors, at 2.1% per annum. It will overtake industry in the 2020s as the largest final-use sector. Transport demand will increase everywhere, but most rapidly in the developing countries. OECD transport demand will grow at a slower pace, as markets become more saturated. Consumption in the residential and services sectors will

grow at an average annual rate of 1.7%, slightly faster than in industry, where it will rise by 1.5% per year.

Electricity will grow faster than any other end-use source of energy, by 2.4% per year over the *Outlook* period. World electricity demand will double through 2030, while its share of total final energy consumption will rise from 18% in 2000 to 22% in 2030. The biggest increase in demand will come from developing countries. Electricity use increases most rapidly in the residential sector, especially in developing countries. But the huge difference in per capita electricity consumption between the OECD and developing countries will hardly change over the projection period. The shares of oil and gas in world final consumption will also remain broadly unchanged. Oil products will account for roughly half of final energy use in 2030. The share of coal will drop from 9% to 7%. Coal use will expand in industry, but only in non-OECD countries. It will stagnate in the residential and services sectors.

Fossil Energy Resources Are Ample, but Technologies and Supply Patterns Will Change

The world's energy resources are adequate to meet the projected growth in energy demand. Oil resources are ample, but more reserves will need to be identified in order to meet rising oil demand to 2030. Reserves of natural gas and coal are particularly abundant, while there is no lack of uranium for nuclear power production. The physical potential for renewable energy production is also very large. But the geographical sources of incremental energy supplies will shift over the next three decades, in response to cost, geological and technical factors. In aggregate, almost all the increase in energy production will occur in non-OECD countries, compared to just 60% from 1971 to 2000.

Increased production in the Middle East and the former Soviet Union, which have massive hydrocarbon resources, will meet much of the growth in world oil and gas demand. Most of the projected 60% increase in global oil demand in the next three decades will be met by OPEC producers, particularly those in the Middle East. Output from mature regions such as North America and the North Sea will gradually decline. More oil will become available from Russia and the Caspian region, and this will have major implications for the diversity of supply sources for oil-importing countries.

Global crude oil refining capacity is projected to increase by an average 1.3% a year, reaching 121 mb/d in 2030. The growth of capacity

will be slightly less than that of demand for refined products, because of increased utilisation rates and the elimination of some refinery bottlenecks. Over 80% of new refining capacity will be built outside the OECD, much of it in Asia. Refineries will have to boost their yields of transportation fuels relative to heavier oil products, as well as improve product quality.

Production of natural gas, resources of which are more widely dispersed than oil, will increase in every region other than Europe. The cost of gas production and transportation is likely to rise in many places as low-cost resources close to markets are depleted and supply chains lengthen.

There are abundant coal reserves in most regions. Increases in coal production, however, are likely to be concentrated where extraction, processing and transportation costs are lowest — in South Africa, Australia, China, India, Indonesia, North America and Latin America.

New sources of energy and advanced technologies will emerge during the *Outlook* period. Non-conventional sources of oil, such as oil sands and gas-to-liquids, are set to expand, as their production costs decline. Fuel cells are also projected to make a modest contribution to global energy supply after 2020, mostly in small decentralised power plants. The fuel cells that are expected to achieve commercial viability first will involve the steam reforming of natural gas. Fuel cells in vehicles are expected to become economically attractive only towards the end of the projection period. As a result, they will power only a small fraction of the vehicle fleet in 2030.

International energy trade, almost entirely in fossil fuels, will expand dramatically. Energy trade will more than double between now and 2030. All oil-importing regions – including the three OECD regions – will import more oil, mostly from the Middle East. The increase will be most striking in Asia. The biggest growth markets for natural gas are going to become much more dependent on imports. In absolute terms, Europe will see the biggest increase in gas imports. Cross-border gas pipeline projects will multiply, and trade in liquefied natural gas will surge.

Rising Demand Will Drive Up Carbon Dioxide Emissions

Global energy-related emissions of carbon dioxide will grow slightly more quickly than primary energy demand. They are projected to increase by 1.8% per year from 2000 to 2030 in the Reference Scenario, reaching 38 billion tonnes in 2030. This is 16 billion tonnes, or 70% more than today. Two-thirds of the increase will come in developing countries. Power

generation and transport will account for about three-quarters of new emissions.

The geographical sources of new emissions will shift drastically, from the industrialised countries to the developing world. The developing countries' share of global emissions will jump from 34% now to 47% in 2030, while the OECD's share will drop from 55% to 43%. China alone will contribute a quarter of the increase in CO₂ emissions, or 3.6 billion tonnes, bringing its total emissions to 6.7 billion tonnes per year in 2030. Even then, however, Chinese emissions remain well below those of the United States.

The steep rise in projected emissions in the Reference Scenario illustrates the challenge that most OECD countries face in meeting their commitments under the Kyoto Protocol. Emissions in those OECD countries that signed the Protocol will reach 12.5 billion tonnes in 2010, the middle of the Protocol's target period of 2008-2012. That is 2.8 billion tonnes, or 29%, above the target. Russia, like Central and Eastern Europe, is in a very different situation, with projected emissions considerably *lower* than their commitments. Under the Protocol, lower emissions in Russia, Ukraine and Eastern Europe, known as "hot air", can be sold to countries with emissions over their target. But even "hot air" will not suffice to compensate for over-target emissions in other countries. The overall gap will be about 15% of projected emissions in 2010. If the United States, which does not intend to ratify the Kyoto Protocol, is excluded, the gap falls to 2%.

Carbon sequestration and storage technologies hold out the long-term prospect of enabling fossil fuels to be burned without emitting carbon into the atmosphere. These technologies, however, are unlikely to be deployed on a large scale before 2030. They are at an early stage of development and are very costly. If their costs could be lowered more quickly than assumed here, this would have a major impact on the long-term prospects for energy supply.

Policies under Consideration in the OECD Would Curb Energy Demand and Emissions

In the Alternative Policy Scenario, implementation of policies that are already under consideration in OECD countries would reduce CO₂ emissions by some 2,150 Mt in 2030, or 16% below the Reference Scenario projections described above. This is roughly equal to the total emissions of Germany, the United Kingdom, France and Italy today.

Energy savings achieved by the new policies and measures and by faster deployment of more efficient technologies would be 9% of projected demand in the Reference Scenario in 2030. CO₂ savings would be even bigger, because of the additional impact of fuel switching to less carbon-intensive fuels. Because of the slow pace at which energy capital stock is replaced, CO₂ savings in the early years would be relatively small – only 3% by 2010 and 9% by 2020.

The biggest reduction in CO₂ emissions in the Alternative Policy Scenario would come from power-generation, because of the rapid growth of renewables and savings in electricity demand. OECD governments are currently emphasising renewables and electricity in their long-term plans to curb CO₂ emissions and enhance energy security. Although the three OECD regions would still not individually reach the targets under the Kyoto Protocol, “hot air” could allow the targets to be met.

The Alternative Scenario projections show a marked reduction in import dependence in the major energy-importing regions. In 2030, OECD gas demand would be 260 bcm, or 13%, below the Reference Scenario. The percentage fall in imports would be even greater. The reduction in EU gas imports by 2030 would be greater than total current imports from Russia and Norway. The savings in oil demand would reach 10%, or 4.6 mb/d.

Providing Modern Energy to the World's Poor Will be an Unfinished Task

Some 1.6 billion people have no access to electricity, according to data compiled specially for this study. More than 80% of the people who currently lack electricity access live in South Asia and sub-Saharan Africa. The majority of them live on less than \$2 per day, but income is not the only determinant of electricity access. China, with 56% of its people still “poor” by international definition, has managed to supply electricity to the vast majority of its population.

In the absence of major new government initiatives, 1.4 billion people, or 18% of the world's population, will still lack electricity in 2030, despite more widespread prosperity and more advanced technology. The number without electricity in 2030 will be 200 million less than today, even though world population is assumed to rise from 6.1 billion in 2000 to 8.3 billion. Four out of five people without electricity live in rural areas. But the pattern of electricity-deprivation is set

to change, because 95% of the increase in population in the next three decades will occur in urban areas.

Poor people in developing countries rely heavily on traditional biomass –wood, agricultural residues and dung –for their basic energy needs. According to information specifically collected for this study, 2.4 billion people in developing countries use only such fuels for cooking and heating. Many of them suffer from ill-health effects associated with the inefficient use of traditional biomass fuels. Over half of all people relying heavily on biomass live in India and China, but the *proportion* of the population depending on biomass is heaviest in sub-Saharan Africa.

The share of the world’s population relying on biomass for cooking and heating is projected to decline in most developing regions, but the total number of people will rise. Most of the increase will occur in South Asia and sub-Saharan Africa. Over 2.6 billion people in developing countries will continue to rely on biomass for cooking and heating in 2030. That is an increase of more than 240 million, or 9%. In developing countries, biomass use will still represent over half of residential energy consumption at the end of the *Outlook* period.

Lack of electricity exacerbates poverty and contributes to its perpetuation, as it precludes most industrial activities and the jobs they create. Experience in China and elsewhere demonstrates how governments can help expand access to modern sources of energy. But electrification and access to modern energy services do not *per se* guarantee poverty alleviation. A variety of energy sources for thermal and mechanical applications are needed to bring productive, income-generating activities to developing countries. Nonetheless, because biomass will continue to dominate energy demand in these countries in the foreseeable future, the development of more efficient biomass technologies is vital for alleviating poverty in rural areas. Renewable energy technologies such as solar, wind and biomass may be cost-effective options for specific off-grid applications, but conventional fuels and established technologies are more likely to be preferred for on-grid capacity expansion.