China and India are the emerging giants of the world economy and international energy markets. Energy developments in China and India are transforming the global energy system by dint of their sheer size and their growing weight in international fossil-fuel trade. Similarly, both countries are increasingly exposed to changes in world energy markets. The staggering pace of Chinese and Indian economic growth in the past few years, outstripping that of all other major countries, has pushed up sharply their energy needs, a growing share of which has to be imported. The momentum of economic development looks set to keep their energy demand growing strongly. As they become richer, the citizens of China and India are using more energy to run their offices and factories, and buying more electrical appliances and cars. These developments are contributing to a big improvement in their quality of life, a legitimate aspiration that needs to be accommodated and supported by the rest of the world.

The consequences for China, India, the OECD and the rest of the world of unfettered growth in global energy demand are, however, alarming. If governments around the world stick with current policies – the underlying premise of our Reference Scenario – the world's energy needs would be well over 50% higher in 2030 than today. China and India together account for 45% of the increase in demand in this scenario. Globally, fossil fuels continue to dominate the fuel mix. These trends lead to continued growth in energy-related emissions of carbon-dioxide (CO_2) and to increased reliance of consuming countries on imports of oil and gas – much of them from the Middle East and Russia. Both developments would heighten concerns about climate change and energy security.

The challenge for all countries is to put in motion a transition to a more secure, lower-carbon energy system, without undermining economic and social development. Nowhere will this challenge be tougher, or of greater importance to the rest of the world, than in China and India. Vigorous, immediate and collective policy action by *all* governments is essential to move the world onto a more sustainable energy path. There has so far been more talk than action in most countries. Were all the policies that governments around the world are considering today to be implemented, as we assume in an Alternative Policy Scenario, the world's energy demand and related emissions would be reduced substantially. Measures to improve energy efficiency stand out as the cheapest and fastest way to curb demand and emissions growth in the near term. But even in this scenario, CO_2 emissions are still one-quarter

above current levels in 2030. To achieve a much bigger reduction in emissions would require immediate policy action and technological transformation on an unprecedented scale.

Both the Reference and Alternative Policy Scenario projections are based on what some might consider conservative assumptions about economic growth in the two giants. They envisage a progressive and marked slow-down in the rate of growth of output over the projection period. In a High Growth Scenario, which assumes that China's and India's economies grow on average 1.5 percentage points per year faster than in the Reference Scenario (though more slowly than of late), energy demand is 21% higher in 2030 in China and India combined. The global increase in energy demand amounts to 6%, making it all the more urgent for governments around the world to implement policies, such as those taken into account in the Alternative Policy Scenario, to curb the growth in fossil-energy demand and related emissions.

The World Faces a Fossil Energy Future to 2030

The world's primary energy needs in the Reference Scenario are projected to grow by 55% between 2005 and 2030, at an average annual rate of 1.8% per year. Demand reaches 17.7 billion tonnes of oil equivalent, compared with 11.4 billion toe in 2005. Fossil fuels remain the dominant source of primary energy, accounting for 84% of the overall increase in demand between 2005 and 2030. Oil remains the single largest fuel, though its share in global demand falls from 35% to 32%. Oil demand reaches 116 million barrels per day in 2030 – 32 mb/d, or 37%, up on 2006. In line with the spectacular growth of the past few years, coal sees the biggest increase in demand in absolute terms, jumping by 73% between 2005 and 2030 and pushing its share of total energy demand up from 25% to 28%. Most of the increase in coal use arises in China and India. The share of natural gas increases more modestly, from 21% to 22%. Electricity use doubles, its share of final energy consumption rising from 17% to 22%. Some $22 trillion of investment in supply infrastructure is needed to meet projected global demand. Mobilising all this investment will be challenging.

Developing countries, whose economies and populations are growing fastest, contribute 74% of the increase in global primary energy use in this scenario. China and India alone account for 45% of this increase. OECD countries account for one-fifth and the transition economies the remaining 6%. In aggregate, developing countries make up 47% of the global energy market in 2015 and more than half in 2030, compared with only 41% today. The developing countries' share of global demand expands for all primary

energy sources, except non-hydro renewables. About half of the increase in global demand goes to power generation and one-fifth to meeting transport needs – mostly in the form of petroleum-based fuels.

World oil resources are judged to be sufficient to meet the projected growth in demand to 2030, with output becoming more concentrated in OPEC countries – on the assumption that the necessary investment is forthcoming. Their collective output of conventional crude oil, natural gas liquids and non-conventional oil (mainly gas-to-liquids) is projected to climb from 36 mb/d in 2006 to 46 mb/d in 2015 and 61 mb/d in 2030 in the Reference Scenario. As a result, OPEC's share of world oil supply jumps from 42% now to 52% by the end of the projection period. Non-OPEC production rises only slowly to 2030, with most of the increase coming from non-conventional sources – mainly Canadian oil sands – as conventional output levels off at around 47 mb/d by the middle of the 2010s. These projections are based on the assumption that the average IEA crude oil import price falls back from recent highs of over $75 per barrel to around $60 (in year-2006 dollars) by 2015 and then recovers slowly, reaching $62 (or $108 in nominal terms) by 2030. Although new oil-production capacity additions from greenfield projects are expected to increase over the next five years, it is very uncertain whether they will be sufficient to compensate for the decline in output at existing fields and keep pace with the projected increase in demand. A supply-side crunch in the period to 2015, involving an abrupt escalation in oil prices, cannot be ruled out.

The resurgence of coal, driven primarily by booming power-sector demand in China and India, is a marked departure from past *WEOs*. Higher oil and gas prices are making coal more competitive as a fuel for baseload generation. China and India, which already account for 45% of world coal use, drive over four-fifths of the increase to 2030 in the Reference Scenario. In the OECD, coal use grows only very slowly, with most of the increase coming from the United States. In all regions, the outlook for coal use depends largely on relative fuel prices, government policies on fuel diversification, climate change and air pollution, and developments in clean coal technology in power generation. The widespread deployment of more efficient power-generation technology is expected to cut the amount of coal needed to generate a kWh of electricity, but boost the attraction of coal over other fuels, thereby leading to higher demand.

In the Alternative Policy Scenario, global primary energy demand grows by 1.3% per year over 2005-2030 – 0.5 percentage points less than in the Reference Scenario. Global oil demand is 14 mb/d lower in 2030 – equal to the entire current output of the United States, Canada and Mexico combined. Coal use falls most in absolute and percentage terms. Energy-related CO_2 emissions stabilise in the 2020s and, in 2030, are 19% lower than in the

Reference Scenario. In the High Growth Scenario, faster economic growth in China and India, absent any policy changes, boosts their energy demand. The stimulus to demand provided by stronger economic growth more than offsets the dampening effect of the higher international energy prices that accompany stronger demand. Worldwide, the increase in primary energy demand amounts to 6% in 2030, compared with the Reference Scenario. Demand is higher in some regions and lower in others.

China's Share of World Energy Demand will Continue to Expand

That China's energy needs will continue to grow to fuel its economic development is scarcely in doubt. However, the rate of increase and how those needs are met are far from certain, as they depend on just how quickly the economy expands and on the economic and energy-policy landscape worldwide. In the Reference Scenario, China's primary energy demand is projected to more than double from 1 742 million toe in 2005 to 3 819 Mtoe in 2030 – an average annual rate of growth of 3.2%. China, with four times as many people, overtakes the United States to become the world's largest energy consumer soon after 2010. In 2005, US demand was more than one-third larger. In the period to 2015, China's demand grows by 5.1% per year, driven mainly by a continuing boom in heavy industry. In the longer term, demand slows, as the economy matures, the structure of output shifts towards less energy-intensive activities and more energy-efficient technologies are introduced. Oil demand for transport almost quadruples between 2005 and 2030, contributing more than two-thirds of the overall increase in Chinese oil demand. The vehicle fleet expands seven-fold, reaching almost 270 million. New vehicle sales in China exceed those of the United States by around 2015. Fuel economy regulations, adopted in 2006, nonetheless temper oil-demand growth. Rising incomes underpin strong growth in housing, the use of electric appliances and space heating and cooling. Increased fossil-fuel use pushes up emissions of CO_2 and local air pollutants, especially in the early years of the projection period: SO_2 emissions, for example, rise from 26 million tonnes in 2005 to 30 Mt by 2030.

China's energy resources – especially coal – are extensive, but will not meet all the growth in its energy needs. More than 90% of Chinese coal resources are located in inland provinces, but the biggest increase in demand is expected to occur in the coastal region. This adds to the pressure on internal coal transport and makes imports into coastal provinces more competitive. China became a net coal importer in the first half of 2007. In the Reference Scenario, net imports reach 3% of its demand and 7% of global coal trade in 2030. Conventional oil production in China is set to peak at 3.9 mb/d early in the

next decade and then start to decline. Consequently, China's oil imports jump from 3.5 mb/d in 2006 to 13.1 mb/d in 2030, while the share of imports in demand rises from 50% to 80%. Natural gas imports also increase quickly, as production growth lags demand over the projection period. China needs to add more than 1 300 GW to its electricity-generating capacity, more than the total current installed capacity in the United States. Coal remains the dominant fuel in power generation. Projected cumulative investment in China's energy-supply infrastructure amounts to $3.7 trillion (in year-2006 dollars) over the period 2006-2030, three-quarters of which goes to the power sector.

China is already making major efforts to address the causes and consequences of burgeoning energy use, but even stronger measures will be needed. China is seeking ways to enhance its energy-policy, regulatory and institutional framework to meet current and future challenges. In the Alternative Policy Scenario, a set of policies the government is currently considering would cut China's primary energy use in 2030 by about 15% relative to the Reference Scenario. Energy-related emissions of CO_2 and local pollutants fall even more. Energy demand, nonetheless, increases by almost 90% between 2005 and 2030 in the Alternative Policy Scenario. Energy-efficiency improvements along the entire energy chain and fuel switching account for 60% of the energy saved. For example, policies that lead to more fuel-efficient vehicles produce big savings in consumption of oil-based fuels. Structural change in the economy accounts for all the other energy savings. Demand for coal and oil is reduced substantially. In contrast, demand for other fuels – natural gas, nuclear and renewables – increases. In this scenario, the government's goal of lowering energy intensity – the amount of energy consumed per unit of GDP – by 20% between 2005 and 2010 is achieved soon after. The majority of the measures analysed have very short payback periods. In addition, each dollar invested in more efficient electrical appliances saves $3.50 of investment on the supply side. And China's efforts to improve the efficiency of vehicles and electrical appliances contribute to improved efficiency in the rest of the world, as the country is a net exporter of these products. Such policies would be all the more critical were China's economy to grow more quickly than assumed in the Reference and Alternative Policy Scenarios. China's primary energy demand is 23% higher in 2030, and coal use alone 21% higher, in the High Growth Scenario than in the Reference Scenario.

India's Energy Use is Similarly Poised for Rapid Growth

Rapid economic expansion will also continue to drive up India's energy demand, boosting the country's share of global energy consumption. In the

Reference Scenario, primary energy demand in India more than doubles by 2030, growing on average by 3.6% per year. Coal remains India's most important fuel, its use nearly tripling between 2005 and 2030. Power generation accounts for much of the increase in primary energy demand, given surging electricity demand in industry and in residential and commercial buildings, with most new generating capacity fuelled by coal. Among end-use sectors, transport energy demand sees the fastest rate of growth as the vehicle stock expands rapidly with rising economic activity and household incomes. Residential demand grows much more slowly, largely as a result of switching from traditional biomass, which is used very inefficiently, to modern fuels. The number of Indians relying on biomass for cooking and heating drops from 668 million in 2005 to around 470 million in 2030, while the share of the population with access to electricity rises from 62% to 96%.

Much of India's incremental energy needs to 2030 will have to be imported. It is certain that India will continue to rely on imported coal for reasons of quality in the steel sector and for economic reasons at power plants located a long way from mines but close to ports. In the Reference Scenario, hard coal imports are projected to rise almost seven-fold, their share of total Indian coal demand rising from 12% in 2005 to 28% in 2030. Net oil imports also grow steadily, to 6 mb/d in 2030, as proven reserves of indigenous oil are small. Before 2025, India overtakes Japan to become the world's third-largest net importer of oil, after the United States and China. Yet India's importance as a major exporter of refined oil products will also grow, assuming the necessary investments are forthcoming. Although recent discoveries are expected to boost gas production, it is projected to peak between 2020 and 2030, and then fall back. A growing share of India's gas needs is, therefore, met by imports, entirely in the form of liquefied natural gas. Power-generation capacity, most of it coal-fired, more than triples between 2005 and 2030. Gross capacity additions exceed 400 GW – equal to today's combined capacity of Japan, Korea and Australia. To meet demand in the Reference Scenario, India needs to invest about $1.25 trillion in energy infrastructure – three-quarters in the power sector – in 2006-2030. Attracting electricity investment in a timely manner – a huge challenge for India – will be crucial for sustaining economic growth.

Stronger policies that the Indian government is now considering could yield large energy savings. In the Alternative Policy Scenario, India's primary energy demand is 17% lower than in the Reference Scenario in 2030. Coal savings – mainly in power generation – are the greatest in both absolute and percentage terms, thanks to lower electricity-demand growth, higher power-generation efficiency and fuel-switching in the power sector and in industry. As a result, coal imports in 2030 are little more than half their Reference Scenario level. Oil imports are 1.1 mb/d lower in 2030 than in the Reference Scenario, but oil-import dependence remains high at 90%. Lower fossil-fuel use results

in a 27% reduction in CO_2 emissions in 2030, most of which stems from energy-efficiency improvements on the demand and supply sides. Lower energy demand in the power and transport sectors also reduces emissions of local pollutants: SO_2 emissions fall by 27% and NO_x emissions by 23% in 2030, compared with the Reference Scenario. The picture is markedly different in the High Growth Scenario. Primary demand is 16% *higher* than in the Reference Scenario, with coal and oil accounting for most of the difference. Faster economic growth accelerates the alleviation of energy poverty, but results in much higher energy imports, local pollution and CO_2 emissions.

The World Benefits Economically from Growth in China and India

Rapid economic development in China and India will inevitably push up global energy demand, but it will also bring major economic benefits to the rest of the world. Economic expansion in China and India is generating opportunities for other countries to export to them, while increasing other countries' access to a wider range of competitively priced imported products and services. But growing exports from China and India also increase competitive pressures on other countries, leading to structural adjustments, particularly in countries with competing export industries. Rising commodity needs risk driving up international prices for commodities, including energy – especially if supply-side investment is constrained.

Commodity exporters would gain most from even faster economic expansion in China and India than assumed in the Reference Scenario. In the High Growth Scenario, the Middle East, Russia and other energy-exporting countries see a significant net increase in their gross domestic product in 2030, compared with the Reference Scenario. GDP growth in other developing Asian countries, the United States, the European Union and OECD Pacific slows marginally, mainly because of higher commodity import costs. Assuming there are no policy changes in major countries, the average IEA crude oil import price rises to $87 per barrel (in year-2006 dollars) in 2030 – 40% higher than in the Reference Scenario. Overall, world GDP grows by 4.3% per year on average, compared with 3.6% in the Reference Scenario.

Structural changes in China's and India's economies will affect their trade with the rest of the world, including their need to import energy. Light industry and services are expected to play a more important role in driving economic development in both countries in the longer term. The economic policies of all countries will be crucial to sustaining the pace of global economic growth and redressing current imbalances. Rising protectionism could radically change the positive global impact of economic growth in China and India.

By contrast, faster implementation of energy and environmental policies to save energy and reduce emissions worldwide, such as those included in the Alternative Policy Scenario, would boost significantly the net global benefits, by reducing pressures on international commodity markets and lowering fuel-import bills for all. More rapid economic development worldwide may also pave the way for faster development and deployment of emerging, clean energy technologies, such as second-generation biofuels and CO_2 capture and storage, given the right policy environment.

But Threats to the World's Energy Security Must be Tackled

Rising global energy demand poses a real and growing threat to the world's energy security. Oil and gas demand and the reliance of all consuming countries on oil and gas imports increase in all three scenarios presented in this *Outlook*. In the Reference Scenario, China's and India's combined oil imports surge, from 5.4 mb/d in 2006 to 19.1 mb/d in 2030 – more than the combined imports of Japan and the United States today. Ensuring reliable and affordable supply will be a formidable challenge. Inter-regional oil and gas trade grows rapidly over the projection period, with a widening of the gap between indigenous output and demand in every consuming region. The volume of oil trade expands from 41 mb/d in 2006 to 51 mb/d in 2015 and 65 mb/d in 2030. The Middle East, the transition economies, Africa and Latin America export more oil. All other regions – including China and India – have to import more oil. As refining capacity for export increases, a growing share of trade in oil is expected to be in the form of refined products, notably from refineries in the Middle East and India.

The consuming countries' growing reliance on oil and gas imports from a small number of producing countries threatens to exacerbate short-term energy-security risks. Increasing import dependence in any country does not necessarily mean less secure energy supplies, any more than self-sufficiency guarantees uninterrupted supply. Indeed, increased trade could bring mutual economic benefits to all concerned. Yet it could carry a *risk* of heightened short-term energy insecurity for all consuming countries, as geographic supply diversity is reduced and reliance grows on vulnerable supply routes. Much of the additional oil imports are likely to come from the Middle East, the scene of most past supply disruptions, and will transit vulnerable maritime routes to both eastern and western markets. The potential impact on international oil prices of a supply interruption is also likely to increase: oil demand is becoming less sensitive to changes in price as the share of transport demand – which is price-inelastic, relative to other energy services – in overall oil consumption rises worldwide.

Longer-term risks to energy security are also set to grow. With stronger global energy demand, all regions would be faced with higher energy prices in the medium to long term in the absence of concomitant increases in supply-side investment or stronger policy action to curb demand growth in all countries. The increasing concentration of the world's remaining oil reserves in a small group of countries – notably Middle Eastern members of OPEC and Russia – will increase their market dominance and may put at risk the required rate of investment in production capacity. OPEC's global market share increases in all scenarios – most of all in the Reference and High Growth Scenarios. The greater the increase in the call on oil and gas from these regions, the more likely it will be that they will seek to extract a higher rent from their exports and to impose higher prices in the longer term by deferring investment and constraining production. Higher prices would be especially burdensome for developing countries still seeking to protect their consumers through subsidies.

China's and India's growing participation in international trade heightens the importance of their contribution to collective efforts to enhance global energy security. How China and India respond to the rising threats to their energy security will also affect the rest of the world. Both countries are already taking action. The more effective their policies are to avert or handle a supply emergency, the more other consuming countries – including most IEA members – stand to benefit, and vice-versa. In addition, many policies to enhance energy security also directly support policies to address the environmental damage from energy production and use. Diversification of the energy mix, of the sources of imported oil and gas, and of supply routes, together with better emergency preparedness, especially through the establishment of emergency stockpiles and co-ordinated response mechanisms, will be necessary to safeguard their energy security. China and India are increasingly aware that overseas acquisitions of oil assets will do little to help protect them from the effects of supply emergencies. China's and India's oil security – like that of all consuming countries – is increasingly dependent on a well-functioning international oil market.

Unchecked Growth in Fossil Fuel Use will Hasten Climate Change

Rising CO_2 and other greenhouse-gas concentrations in the atmosphere, resulting largely from fossil-energy combustion, are contributing to higher global temperatures and to changes in climate. Growing fossil-fuel use will continue to drive up global energy-related CO_2 emissions over the projection period. In the Reference Scenario, emissions jump by 57% between 2005 and 2030. The United States, China, Russia and India contribute two-thirds

of this increase. China is by far the biggest contributor to incremental emissions, overtaking the United States as the world's biggest emitter in 2007. India becomes the third-largest emitter by around 2015. However, China's per-capita emissions in 2030 are only 40% of those of the United States and about two-thirds those of the OECD as a whole in the Reference Scenario. In India, they remain far lower than those of the OECD, even though they grow faster than in almost any other region.

Urgent action is needed if greenhouse-gas concentrations are to be stabilised at a level that would prevent dangerous interference with the climate system. The Alternative Policy Scenario shows that measures currently being considered by governments around the world could lead to a stabilisation of global emissions in the mid-2020s and cut their level in 2030 by 19% relative to the Reference Scenario. OECD emissions peak and begin to decline after 2015. Yet global emissions would still be 27% higher than in 2005. Assuming continued emissions reductions after 2030, the Alternative Policy Scenario projections are consistent with stabilisation of long-term CO_2-equivalent concentration in the atmosphere at about 550 parts per million. According to the best estimates of the Intergovernmental Panel on Climate Change, this concentration would correspond to an increase in average temperature of around 3°C above pre-industrial levels. In order to limit the average increase in global temperatures to a maximum of 2.4°C, the smallest increase in any of the IPCC scenarios, the concentration of greenhouse gases in the atmosphere would need to be stabilised at around 450 ppm. To achieve this, CO_2 emissions would need to peak by 2015 at the latest and to fall between 50% and 85% below 2000 levels by 2050. We estimate that this would require energy-related CO_2 emissions to be cut to around 23 Gt in 2030 – 19 Gt less than in the Reference Scenario and 11 Gt less than in the Alternative Policy Scenario. In a "450 Stabilisation Case", which describes a notional pathway to achieving this outcome, global emissions peak in 2012 at around 30 Gt. Emissions savings come from improved efficiency in fossil-fuel use in industry, buildings and transport, switching to nuclear power and renewables, and the widespread deployment of CO_2 capture and storage (CCS) in power generation and industry. Exceptionally quick and vigorous policy action by all countries, and unprecedented technological advances, entailing substantial costs, would be needed to make this case a reality.

Government action must focus on curbing the rapid growth in CO_2 emissions from coal-fired power stations – the primary cause of the surge in global emissions in the last few years. Energy efficiency and conservation will need to play a central role in curbing soaring electricity demand and reducing inputs to generation. Nuclear power and renewables can also make a

major contribution to lowering emissions. Clean coal technology, notably CCS, is one of the most promising routes for mitigating emissions in the longer term – especially in China, India and the United States, where coal use is growing fastest. CCS could reconcile continued coal burning with the need to cut emissions in the longer term – if the technology can be demonstrated on a large scale and if adequate incentives to invest are put in place.

Collective Action is Needed to Address Global Energy Challenges

The emergence of China and India as major players in global energy markets makes it all the more important that *all* countries take decisive and urgent action to curb runaway energy demand. The primary scarcity facing the planet is not of natural resources nor money, but time. Investment now being made in energy-supply infrastructure will lock in technology for decades, especially in power generation. The next ten years will be crucial, as the pace of expansion in energy-supply infrastructure is expected to be particularly rapid. China's and India's energy challenges are the world's energy challenges, which call for collective responses. No major energy consumer can be confident of secure supply if supplies to others are at risk. And there can be no effective long-term solution to the threat of climate change unless all major energy consumers contribute. The adoption and full implementation of policies by IEA countries to address their energy-security and climate-change concerns are essential, but far from sufficient.

Many of the policies available to alleviate energy insecurity can also help to mitigate local pollution and climate change, and vice-versa. As the Alternative Policy Scenario demonstrates, in many cases, those policies bring economic benefits too, by lowering energy costs – a "triple-win" outcome. An integrated approach to policy formulation is, therefore, essential. The right mix of policies to address both energy-security and climate concerns depends on the balance of costs and benefits, which vary among countries. We do not have the luxury of ruling out any of the options for moving the global energy system onto a more sustainable path. The most cost-effective approach will involve market-based instruments, including those that place an explicit financial value on CO_2 emissions. Regulatory measures, such as standards and mandates, will also be needed, together with government support for long-term research, development and demonstration of new technologies. In China and India, the urgent need to tackle local air pollution will undoubtedly continue to provide the primary rationale for further efforts to stem the growth in greenhouse-gas emissions.

There are large potential gains to IEA countries, on the one hand, and to China and India, on the other, from enhanced policy co-operation. IEA countries have long recognised the advantages of co-operation with China and India, reflected in a steady broadening of the range of co-operative activities through the IEA and other multilateral and bilateral agreements. These activities need to be stepped up, with China and India establishing a deeper relationship with the Agency. IEA co-operation with China and India on enhancing oil-emergency preparedness and on developing cleaner and more efficient technologies, especially for coal, remains a priority. Collaboration between IEA countries and developing countries, including China and India, is already accelerating deployment of new technologies – a development that will yield big dividends in the longer term. Mechanisms need to be enhanced to facilitate and encourage the financing of such technologies in China, India and other developing countries. Given the scale of the energy challenge facing the world, a substantial increase is called for in public and private funding for energy technology research, development and demonstration, which remains well below levels reached in the early 1980s. The financial burden of supporting research efforts will continue to fall largely on IEA countries.