Energy Security: Investment or Insecurity

Coping with Crisis

Working Paper Series

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About the Author

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Foreword

Terje Rød-Larsen
President, International Peace Academy

The International Peace Academy (IPA) is pleased to introduce a new series of Working Papers within the program *Coping with Crisis, Conflict, and Change: The United Nations and Evolving Capacities for Managing Global Crises*, a four-year research and policy-facilitation program designed to generate fresh thinking about global crises and capacities for effective prevention and response.

In this series of Working Papers, IPA has asked leading experts to undertake a mapping exercise, presenting an assessment of critical challenges to human and international security. A first group of papers provides a horizontal perspective, examining the intersection of multiple challenges in specific regions of the world. A second group takes a vertical approach, providing in-depth analysis of global challenges relating to organized violence, poverty, population trends, public health, and climate change, among other topics. The Working Papers have three main objectives: to advance the understanding of these critical challenges and their interlinkages; to assess capacities to cope with these challenges and to draw scenarios for plausible future developments; and to offer a baseline for longer-term research and policy development.

Out of these initial Working Papers, a grave picture already emerges. The Papers make clear that common challenges take different forms in different regions of the world. At the same time, they show that complexity and interconnectedness will be a crucial attribute of crises in the foreseeable future.

First, new challenges are emerging, such as climate change and demographic trends. At least two billion additional inhabitants, and perhaps closer to three billion, will be added to the world over the next five decades, virtually all in the less developed regions, especially among the poorest countries in Africa and Asia. As a result of climate change, the magnitude and frequency of floods may increase in many regions; floods in coastal Bangladesh and India, for example, are expected to affect several million people. The demand for natural resources—notably water—will increase as a result of population growth and economic development; but some areas may have diminished access to clean water.

Second, some challenges are evolving in more dangerous global configurations such as transnational organized crime and terrorism. Illicit and violent organizations are gaining increasing control over territory, markets, and populations around the world. Non-state armed groups complicate peacemaking efforts due to their continued access to global commodity and arms markets. Many countries, even if they are not directly affected, can suffer from the economic impact of a major terrorist attack. States with ineffective and corrupted institutions may prove to be weak links in global arrangements to deal with threats ranging from the avian flu to transnational terrorism.

Finally, as these complex challenges emerge and evolve, "old" problems still persist. While the number of violent conflicts waged around the world has recently declined, inequality—particularly between groups within the same country—is on the rise. When this intergroup inequality aligns with religious, ethnic, racial and language divides, the prospect of tension rises. Meanwhile, at the state level, the number of actual and aspirant nuclear-armed countries is growing, as is their ability to acquire weapons through illicit global trade.

As the international institutions created in the aftermath of World War II enter their seventh decade, their capacity to cope with this complex, rapidly evolving and interconnected security landscape is being sharply tested. The United Nations has made important progress in some of its core functions—"keeping the peace," providing humanitarian relief, and helping advance human development and security. However, there are

reasons to question whether the broad UN crisis management system for prevention and response is up to the test.

Not only the UN, but also regional and state mechanisms are challenged by this complex landscape and the nature and scale of crises. In the Middle East, for example, interlinked conflicts are complicated by demographic and socioeconomic trends and regional institutions capable of coping with crisis are lacking. In both Latin America and Africa, "old" problems of domestic insecurity arising from weak institutions and incomplete democratization intersect with "new" transnational challenges such as organized crime. Overall, there is reason for concern about net global capacities to cope with these challenges, generating a growing sense of global crisis.

Reading these Working Papers, the first step in a four-year research program, one is left with a sense of urgency about the need for action and change: action where policies and mechanisms have already been identified; change where institutions are deemed inadequate and require innovation. The diversity of challenges suggests that solutions cannot rest in one actor or mechanism alone. For example, greater multilateral engagement can produce a regulatory framework to combat small arms proliferation and misuse, while private actors, including both industry and local communities, will need to play indispensable roles in forging global solutions to public health provision and food security. At the same time, the complexity and intertwined nature of the challenges require solutions at multiple levels. For example, governments will need to confront the realities that demographic change will impose on them in coming years, while international organizations such as the UN have a key role to play in technical assistance and norm-setting in areas as diverse as education, urban planning and environmental control.

That the world is changing is hardly news. What is new is a faster rate of change than ever before and an unprecedented interconnectedness between different domains of human activity—and the crises they can precipitate. This series of Working Papers aims to contribute to understanding these complexities and the responses that are needed from institutions and decision-makers to cope with these crises, challenges and change.

Terje Rød-Larsen

Introduction

The world is facing twin energy-related threats: that of not having adequate and secure supplies of energy at affordable prices and that of environmental harm caused by consuming too much of it. Soaring energy prices and recent geopolitical events have reminded us of the essential role energy plays in economic growth and development and of the vulnerability of the energy system to supply disruptions. Safeguarding energy supplies is once again at the top of the international policy agenda. Yet the current pattern of energy supply carries the threat of severe and irreversible environmental damage, including changes in global climate. Reconciling the goals of energy security and environmental protection requires strong and coordinated government action and public support.

In recent years, demand for energy has surged. This unrelenting increase has helped fuel global economic growth but placed considerable pressure on suppliers buffeted by geopolitics, violent weather conditions and other potentially disruptive factors. On the demand side, increased energy security and environmental concerns may lead to changes in consuming countries' energy policies. These uncertainties have been reflected in the market through volatility and high prices. Is the world running out of energy? Where will future supplies come from? Will sufficient investment be made to make available adequate energy supplies to meet future demand? What role will governments play?

At the same time, the need to curb the growth in energy demand, to increase geographic and fuel diversity and to mitigate climate change is more urgent than ever.[1] *The World Energy Outlook 2006* confirms that fossil fuels and greenhouse-gas emissions would follow their current unsustainable paths through to 2030 in the absence of new government action (the underlying premise of its Reference Scenario). It also demonstrates, in an Alternative Policy Scenario, that a package of policies and measures that countries around the world are considering would, if implemented, significantly reduce the rate of increase in demand and emissions. Importantly, the economic cost of these policies would be more than outweighed by the economic benefits that would come from using and producing energy more efficiently.

Global Energy Trends: Fossil Energy Will Remain Dominant to 2030

Energy trends are analyzed by creating a range of scenarios based on differing assumptions. The Reference Scenario of the World Economic Outlook series, for example, assumes that no new government policies are introduced during the projection period (to 2030). This scenario provides a baseline vision of how global energy markets are likely to evolve if governments make no extra effort to affect underlying trends in energy demand and supply. The appeal of such an approach is that it provides a platform against which alternative assumptions about future government policies can be tested. An Alternative Policy Scenario analyses the impact and costs of a package of additional measures to address energy-security and climate-change concerns.

Global energy needs are likely to continue growing steadily for at least the next two-and-a-half decades. Global primary energy demand in the Reference Scenario is projected to increase by just over one-half between now and 2030, an average annual growth rate of 1.6 percent. Demand grows by more than one-quarter in the period to 2015 alone. Over 70 percent of the increase in demand over the projection period comes from developing countries, with China alone accounting for 30 percent (Figure 1). Their economies and population grow much faster than in the Organization for Economic Cooperation and Development (OECD), shifting the center of gravity of global energy demand. Almost half of the increase in global primary energy use goes to generating electricity and one-fifth to meeting expanding transport needs—almost entirely in the form of oil-based fuels.

Globally, fossil fuels will remain the dominant source of energy to 2030 in both scenarios. In the Reference Scenario, they account for 83 percent of the projected increase in primary energy demand (Figure 2). As a result, their share of world demand edges up, from 80 percent to 81 percent. The share of oil drops, though oil remains the largest single fuel in the global energy mix in 2030. Most of the increase in oil use comes from the transport sector. Coal sees the biggest increase in demand in absolute terms, driven mainly by power generation. China and India account for almost four-fifths of the incremental demand for

[1] G8 leaders, meeting with the leaders of several major developing countries and heads of international organizations – including the International Energy Agency – at Gleneagles in July 2005 and in St Petersburg in July 2006 called on the International Energy Agency (IEA) to "advise on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future." *The World Energy Outlook 2006*, published by the IEA, responds to that request.

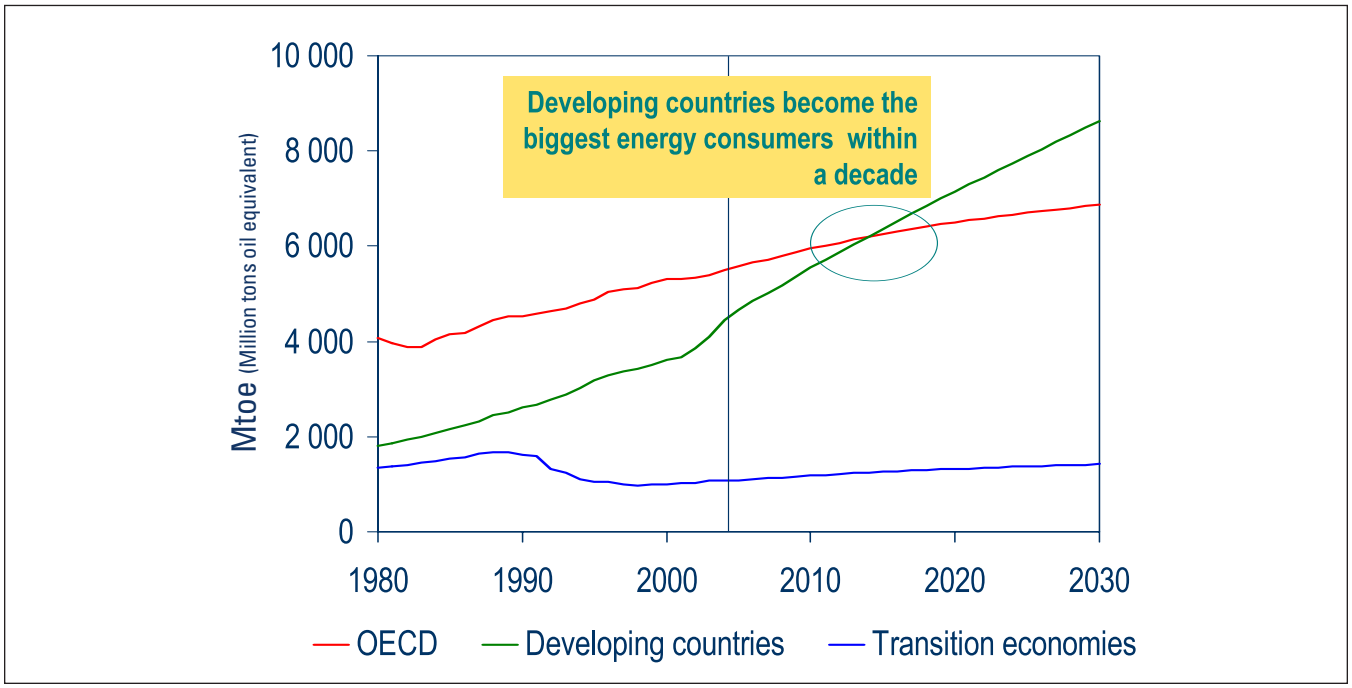

Figure 1. Primary Energy Demand by Region

coal. It remains the second-largest primary fuel, its share in global demand increasing slightly. The share of natural gas also rises, due to higher prices. Hydropower's share of primary energy use rises slightly, while that of nuclear power falls. The share of biomass falls marginally, as developing countries increasingly switch to using modern commercial energy, offsetting the growing use of biomass as feedstock for biofuels production. Non-hydro renewables—including wind, solar, and geothermal—grow quickest, but from a small base.

The world's energy resources are adequate to meet the projected growth in energy demand in the Reference Scenario. 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. Oil remains the most heavily traded fuel in 2030, but gas trade grows most rapidly.

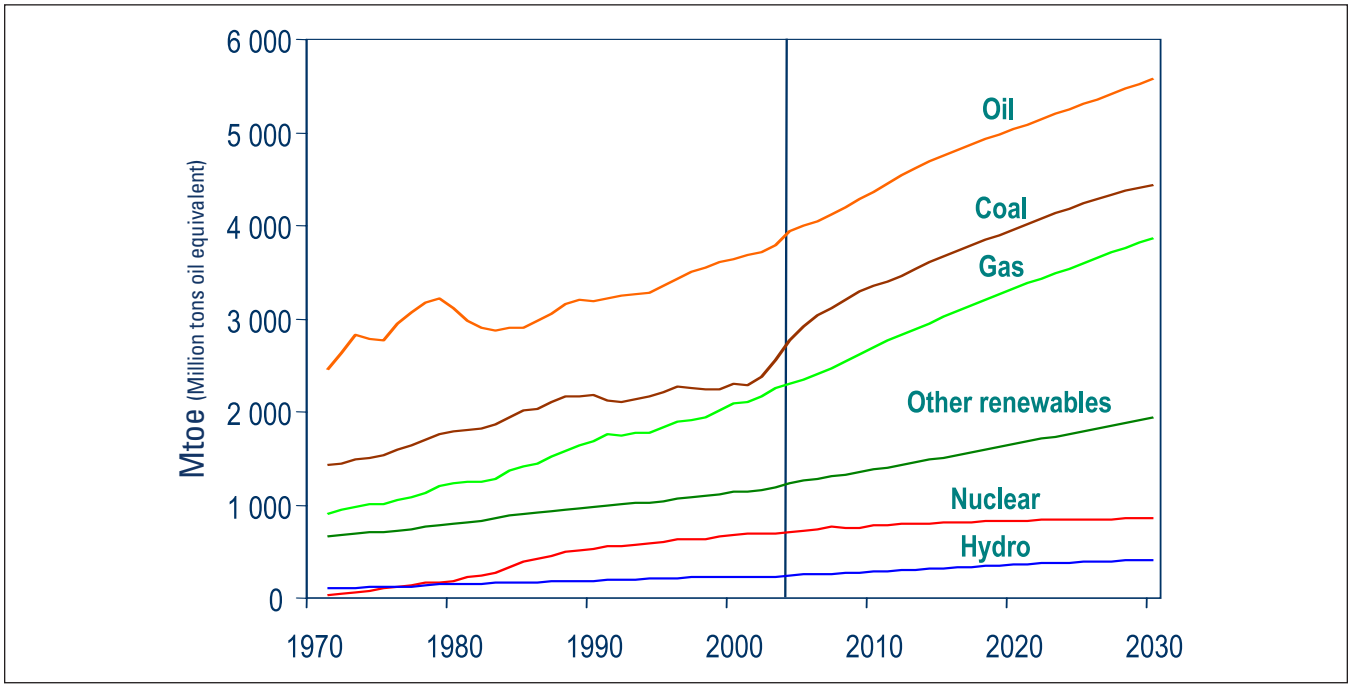

Figure 2. World Primary Energy Demand

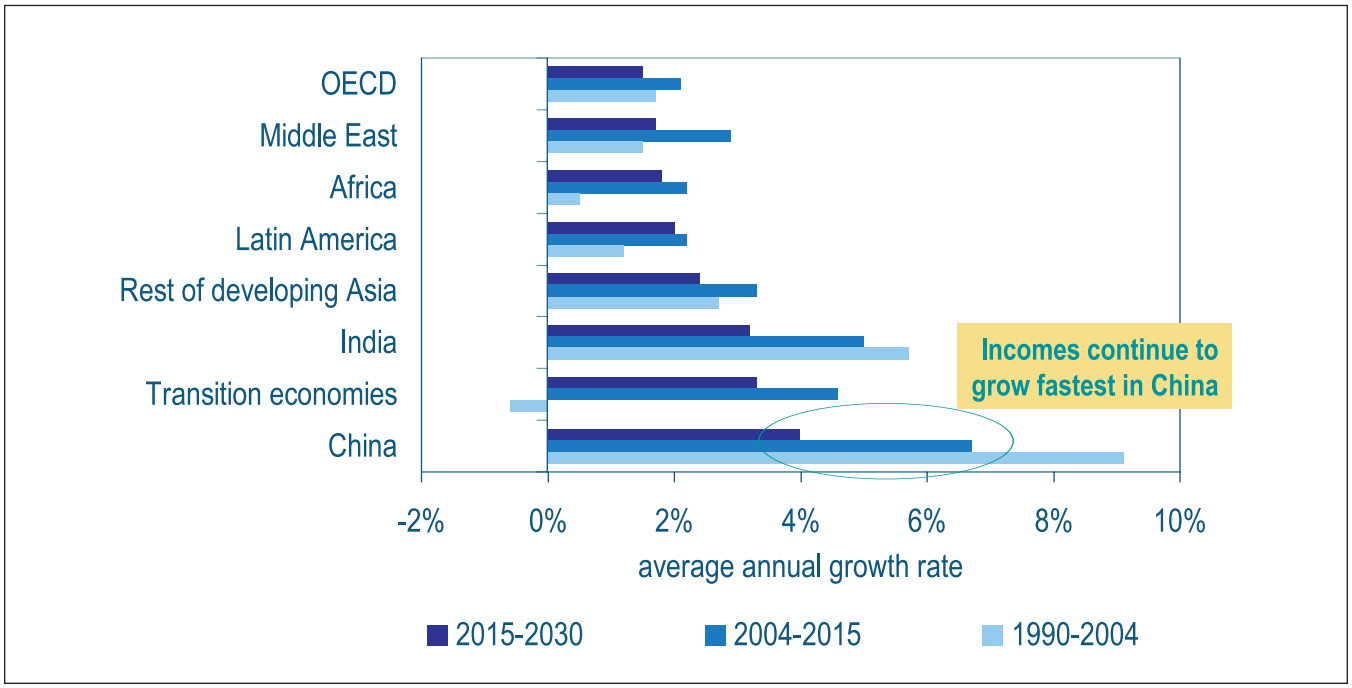

Figure 3. Per Capita GDP

The primary driver of this surge in energy demand is GDP growth. The rate of growth in world GDP is assumed to average 3.4 percent per year over the period 2004-2030, compared with 3.2 percent from 1980 to 2004. It falls progressively over the projection period, from 4 percent in 2004-2015 to 2.9 percent in 2015-2030. China, India, and other developing Asian countries are expected to continue growing faster than any other region (Figure 3). All regions continue to experience a decline in the share of energy-intensive heavy manufacturing in economic output and a rise in the share of lighter industries and services, particularly in the developing world.

Population growth also drives energy demand, though not as much as GDP. Global population is assumed to grow by 1 percent per year on average, from an estimated 6.4 billion in mid-2004 to 8.1 billion in 2030. Population growth slows progressively over the projection period, as it did in the last three decades. Population expanded by 1.5 percent per year from 1980 to 2004. As Joseph Chamie's paper on demographics emphasizes, population growth will continue to be concentrated in developing regions, boosting their share of the world's population and of world energy demand.[2] That paper rightly highlights the challenge and opportunity of urbanization, which is a key demographic trend for the coming decades. In energy terms, for example, urbanization may help many households avoid inefficient, unsustainable cooking and heating practices while at the same time placing electricity infrastructure and supplies of modern commercial fuels (including commercial biomass resources such as charcoal) under great strain.

The exact cost of finding and exploiting energy resources over the coming decades is uncertain, but it will certainly be substantial. Cumulative investment in energy-supply infrastructure amounts to around $20 trillion (in year-2005 dollars) over 2005-2030. The power sector requires more than $11 trillion. 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. Financing the required investments in non-OECD countries is one of the biggest challenges facing the energy industry.

Oil analysts worldwide have revised upwards their assumptions for oil prices this year, in the expectation that crude oil and refined-product markets remain tight. Market fundamentals point to a modest easing of prices as new capacity comes on stream and demand growth slows. But new geopolitical tensions or, worse, a major supply disruption could drive prices even higher. We assume the average IEA crude oil import price falls back to $47 per barrel in real terms in the early part of the next decade and then rises steadily

[2] Joseph Chamie, "Population Trends: Humanity in Transition," *Coping with Crisis* Working Paper Series, International Peace Academy, New York, May 2007.

through to 2030. Natural gas prices are assumed broadly to follow the trend in oil prices, because of the continuing widespread use of oil-price indexation in long-term gas supply contracts and because of inter-fuel competition. Coal prices are assumed to change proportionately less over time, but following the direction of oil and gas prices.

Growing Energy Security and Environmental Concerns

The Threat to the World's Energy Security is Real and Growing

Rising oil and gas demand, if unchecked, would accentuate the consuming countries' vulnerability to a severe supply disruption and resulting price shock. Over time, consuming countries will grow increasingly reliant on oil and gas imports from an ever-smaller group of suppliers—notably Russia and the big producers in the Middle East. OECD and developing Asian countries become increasingly dependent on imports as their indigenous production fails to keep pace with demand. Non-OPEC production of conventional crude oil and natural gas liquids is set to peak within a decade. By 2030, the OECD as a whole imports two-thirds of its oil needs in the Reference Scenario, compared with 56 percent today. Much of the additional imports come from the Middle East, along vulnerable maritime routes. The concentration of oil production in a small group of countries with large reserves—notably Middle East OPEC members and Russia—will increase their market dominance and their ability to impose higher prices. An increasing share of gas demand is also expected to be met by imports, via pipeline or in the form of liquefied natural gas from increasingly distant suppliers.

Expanding trade is to be welcomed as it binds suppliers and customers in mutually beneficial relationships. But at the same time, the risk of a major supply disruption—whether from terrorism, piracy, accidents, severe weather, political tensions or war—will undoubtedly increase. For example, Russia's decision to cut off gas supplies to Ukraine in early 2006 called into question its reputation as a reliable supplier and raised doubts about how Europe would deal with a more prolonged disruption. Further cause for concern is the growing reliance on strategic transportation channels through which almost all the oil and gas exported by Middle Eastern countries must flow. Consuming countries' vulnerability to a disruption in supplies from that region will, therefore grow—as will the risk that some producing countries may use their dominant market position to raise prices or to withhold supplies for political reasons. The diversity of sources, of suppliers and of routes is crucial to managing potential conflict.

The growing insensitivity of oil demand to price accentuates the potential impact on international oil prices of a supply disruption. The share of transport demand—which is price-inelastic relative to other energy services—in global oil consumption is projected to rise in the Reference Scenario. As a result, oil demand becomes less and less responsive to movements in international crude oil prices. The corollary of this is that prices would fluctuate more than in the past in response to future short-term shifts in demand and supply. The cushioning effect of subsidies to oil consumers on demand contributes to the insensitivity of global oil demand to changes in international prices. Current consumer price subsidies on oil products in non-OECD countries are estimated at well over $90 billion annually. Price subsidies on all forms of final energy outside the OECD amount to over $260 billion per year—equal to all the investment needed in the power sector each year, on average, in those countries.

Energy consumption subsidies—government measures that result in an end-user price that is below the price that would prevail in a truly competitive market including all the costs of supply—are large in some countries. Energy is most commonly subsidized through price controls, often through state-owned companies. Consumption subsidies have been largely eliminated in the OECD, but remain large in some non-OECD countries, both in gross terms and net of any taxes. Electricity and household heating and cooking fuels are usually most heavily subsidized, though several countries still subsidize road transport fuels. Remaining energy subsidies in OECD countries are mainly directed to production and do not necessarily reduce end-user prices below market levels.

Many developing countries, especially in Asia and Africa, continue to subsidize implicitly or explicitly the consumption of energy services. In many cases, price controls prevent the full cost of higher imported energy from being passed through to end users. As a result, consumption does not respond to increases in the prices of imported fuels, so import costs remain unnecessarily high. They can also place a heavy direct burden on government finances and weaken the potential for economic growth. In addition, by encouraging higher consumption and waste, subsidies

exacerbate the harmful effects of energy use on the environment. They also impede the development of more environmentally benign energy technologies. Although usually meant to help the poor, subsidies often benefit better-off households. Targeted and transparent social welfare programs are a more efficient and effective way of compensating the poor for higher fuel prices. They could be funded by the budget savings from lower energy subsidies.

Oil prices still matter to the economic health of the global economy. Although most oil-importing economies around the world have continued to grow strongly since 2002, they would have grown even more rapidly had the price of oil and other forms of energy not increased. In many importing countries, increases in the value of exports of non-energy commodities, the prices of which have also risen, have offset at least part of the impact of higher energy prices. The eventual impact of higher energy prices on macroeconomic prospects remains uncertain, partly because the effects of recent price increases have not fully worked their way through the economic system. There are growing signs of inflationary pressures, leading to higher interest rates. Most OECD countries have experienced a worsening of their current account balances, most obviously the United States. The recycling of petrodollars may have helped to mitigate the increase in long-term interest rates, delaying the adverse impact on real incomes and output of higher energy prices. The longer prices remain at current levels or the more they rise, the greater the threat to economic growth in importing countries. An oil-price shock caused by a sudden and severe supply disruption would be particularly damaging—for heavily indebted poor countries most of all.

An increase in the price of oil and other traded forms of energy leads to a transfer of income from importing to exporting countries through a shift in the terms of trade. For oil-importing countries, the immediate magnitude of the direct effect of a given oil-price increase on national income depends on the ratio of oil imports to GDP. This, in turn, is a function of the amount of oil consumed for a given level of national income (oil intensity) and the degree of dependence on imported oil (import dependence). It also depends on the extent to which gas and other energy prices rise in response to an oil-price increase and the gas-import intensity of the economy. Naturally, the bigger the initial oil-price increase and the longer higher prices are sustained, the bigger the macroeconomic impact. In the longer term, however, the impact will be reduced according to how much end-users reduce their energy consumption and switch away from oil and how much domestic production of oil and other fuels increases in response to sustained higher prices. For net oil-exporting countries, a price increase directly increases real national income through higher export earnings. However, part of this gain would be later offset by losses from lower demand for their exports, generally due to the decline in GDP suffered by trading partners and possibly to a fall in non-oil exports caused by a rise in the exchange rate—a phenomenon known as "Dutch disease."

An oil-price increase leads to a reduction in the purchasing power of the export earnings of importing countries. If an importer continues to import the same value of non-oil goods and services while the cost of oil imports increases, the balance of payments will deteriorate, putting downward pressure on exchange rates. As a result, imports become more expensive, leading to a drop in real national income and lower domestic consumption. The dollar will also tend to rise, if oil-producing countries' demand for dollar-denominated international reserve assets grows, aggravating the downward adjustment in real income for economies other than the United States and others with a currency linked to the US dollar.

Domestic output is not directly affected by higher oil prices. But adjustment, or second-round effects, which result from nominal wage, price, and structural rigidities in the economy, typically lead to a fall in GDP in practice in net oil-importing countries. Higher oil prices push up inflation, increasing input costs for businesses, reducing non-oil demand and lowering investment. Unless firms are able to pass through all of the increase in energy costs to higher prices for their final goods and services, profits fall, dragging down investment further. Tax revenues fall and the budget deficit increases, due to rigidities in government expenditure. If oil-product prices are directly subsidized by the government such that not all of the increase in bulk prices feeds through into final prices, as in many Asian countries, spending on subsidies rises. This leads either to a reduction in other forms of government spending, cutting overall demand, or a deterioration in the fiscal balance. Because of resistance to any real decline in wages, an oil-price increase may lead to upward pressure on nominal wage levels, which, together with reduced demand, tends to lead to higher unemployment. These effects are greater if the price increase is sudden (for example, if it results from a serious supply disruption)

and sustained, and are magnified by the negative impact of higher prices on consumer and business confidence.

The fiscal and monetary policy measures chosen in response to higher energy prices also affect the overall impact on the economy over the longer term. Government policy cannot eliminate the adverse effects described above, but it can minimize them; inappropriate policies can worsen them. The reaction of the monetary authorities to the threat of inflation and, perhaps more importantly, their ex-ante credibility in fighting inflationary pressures are critical. The quicker the authorities respond to inflation by raising interest rates, the bigger the short-term dip in GDP growth will be but the more likely it is that inflationary pressures will be squeezed out of the economy before expectations of higher rates of price and wage increases become entrenched. In practice, the monetary authorities need to strike a balance between dampening inflationary expectations and limiting the fall in GDP growth. Monetary and fiscal policies which are too tight could exacerbate the recessionary effects on income and employment. But unduly expansionary policies may simply delay the fall in real income necessitated by the increase in oil prices, stoke up inflationary pressures and worsen the impact of higher prices in the long run.

A fall in oil prices affects the economies of oil-importing countries in a reverse manner, but as in the case of a price rise, the magnitude of the impact does not match the full extent of the price change because of the offsetting costs of structural change. Similarly, the boost to economic growth in oil-exporting countries provided by higher oil prices has, in the past, always been less than the loss of economic growth in importing countries, such that the net global effect has always been negative. This is explained both by the cost of structural change and by the fact that the fall in spending in net importing countries is typically bigger than the stimulus to spending in the exporting countries in the first few years following a price increase. Demand in the latter countries tends to rise only gradually, so that net global demand tends to fall in the short term.

The adverse economic impact of higher oil prices on oil-importing developing countries is generally more severe than for OECD countries, because their economies are more dependent on imported oil and are more energy-intensive. Heavily indebted poor countries on average would lose 1.6 percent of GDP and Sub-Saharan African countries as a whole more than 3 percent in the year following a $10 oil-price increase. GDP in oil-importing developing Asian countries would be 0.8 percent lower. Overall, world GDP would be at least 0.5 percent lower—equivalent to $255 billion—in the year following a $10 oil price increase. This is because the economic stimulus provided by higher oil-export earnings in exporting countries would be more than outweighed by the depressive effect of higher prices on economic activity in the importing countries.

As many developing countries are major net exporters of non-oil commodities, the impact of higher energy prices has, in many cases, been partially compensated or even more than offset by the increase in the value of exports. In effect, higher export prices provided additional foreign currency to pay for the higher cost of oil imports. In some cases, the appreciation of local currencies against the dollar has also boosted the dollar value of exports (while limiting the impact of higher prices on the oil-import bill). These factors explain why the current account balance in some net oil-importing countries, particularly in the developing world, has actually improved in the last three years, though the improvement would have been still greater in the absence of the oil-price increase. Some countries, particularly those that rely most heavily on imported oil, such as India, have seen a significant deterioration in their current account balance.

Will the Investment Come? What if Oil Investment is Deferred?

Meeting the world's growing hunger for energy requires investment in energy-supply infrastructure, but there is no guarantee that it will be forthcoming. Capital spending by the world's leading oil and gas companies increased sharply in nominal terms over the course of the first half of the current decade and, according to company plans, will rise further until 2010. But the impact on new capacity of higher spending is being blunted by rising costs. Expressed in cost-inflation adjusted terms, investment in 2005 was actually lower than in 2000. Planned upstream investment out to 2010 is expected to boost global spare crude oil production capacity slightly. But capacity additions could be smaller on account of shortages of skilled personnel and equipment, regulatory delays, cost inflation, higher decline rates at existing fields and geopolitics. Beyond the current decade, higher investment in real terms will be needed to maintain growth in upstream and downstream capacity.

Securing reliable and affordable energy will hinge on adequate investment. The rate of investment in

developing crude oil production capacity in the Middle East is particularly important for world energy markets. Current rates of investment in that region are not high enough to meet the gap that is expected to open up between global oil demand and oil-production capacity in other parts the world. Without urgent and sizable increases in Middle East investment, a shortfall in production capacity will emerge and prices will rise and become more volatile—to the long-term economic detriment of both producers and consumers. Under-investment also carries short-term security risks. The relatively low level of spare oil-production capacity currently available to counteract any unexpected loss of supply has resulted from many years of under-investment. This increases the likelihood that the sudden loss of even a modest volume of oil will lead to a very sharp increase in prices.

A major shortfall in investment in upstream oil, especially in the Middle East and North Africa (MENA) region, would radically alter the global energy balance. Governments could choose deliberately to develop production capacity more slowly; or external factors such as capital shortages could prevent producers from investing as much in expanding capacity as they would like. The Deferred Investment Scenario of *World Energy Outlook 2005* found that upstream investment in each MENA country remaining constant as a share of GDP at the average level of the past decade would cause MENA oil production to drop by almost a third by 2030 compared with the Reference Scenario. As a result of higher prices and lower world GDP, global energy demand and GDP growth are reduced significantly in 2030 compared with the Reference Scenario. Among the primary fuels, global demand for oil falls most. Demand for both gas and coal also falls, mainly as a result of lower demand for fuel inputs to power generation. The analysis suggests that MENA producers would lose out financially were investment to be reduced in that way. Over 2004-2030, the cumulative value of aggregate MENA oil- and gas-export revenues would be more than a trillion dollars lower (in year-2004 prices) than in the Reference Scenario. Unemployment and underemployment—especially among young people—would be exacerbated. The loss of revenues is almost four times more than the reduction in investment. Revenues also fall in terms of net present value.

Uncertainty about future supply-side infrastructure investments is by no means limited to the Middle East or to crude oil production. The prospects for urgently needed investment in new refining capacity are clouded by environmental restrictions and local opposition, especially in OECD countries. Current capital flows to the electricity sector in many countries—notably in the poorest developing regions—cannot even maintain system reliability, let alone meet the increasing demands of economic and population growth. The future rate of investment in Russia's gas industry is a particularly critical uncertainty. The bulk of Russia's gas production comes from three super-giant fields, which are declining at a combined rate of 20 billion cubic meters per year. Production at a fourth super-giant has already peaked. Enormous investments are needed to develop new fields in deeper strata and/or in the Arctic region and other regions where reserves are expensive to develop, simply to compensate for the depletion at the old super-giants. Gazprom, which produces 90 percent of Russia's gas, recently announced an increase in its capital spending to almost $13 billion per year, but this is still below what the Russian gas industry will need to spend on average over the projection period. Moreover, much of Gazprom's spending is being directed at foreign acquisitions and export infrastructure, rather than the domestic network and upstream sector. One relatively low-cost option for augmenting supplies would be to allow oil companies and independent gas companies, which could sharply increase their marketed gas output, to gain access to Gazprom's network.

Based on Current Energy Trends, Carbon Emissions Will Accelerate

Consumer country concerns are not limited to energy security. Because energy consumption accounts for approximately 80 percent of global greenhouse gas (GHG) emissions, consumer governments are under increasing pressure to take steps to reduce or mitigate the effects of domestic energy consumption. The G8 leaders, meeting with leaders from several key developing countries at Gleneagles in July 2005, acknowledged as much when they called for stronger action to combat rising consumption of fossil fuels and related greenhouse-gas emissions.

Global energy-related carbon-dioxide (CO_2) emissions increase by about 55 percent between 2004 and 2030 in the Reference Scenario. Power generation contributes half of the increase in global

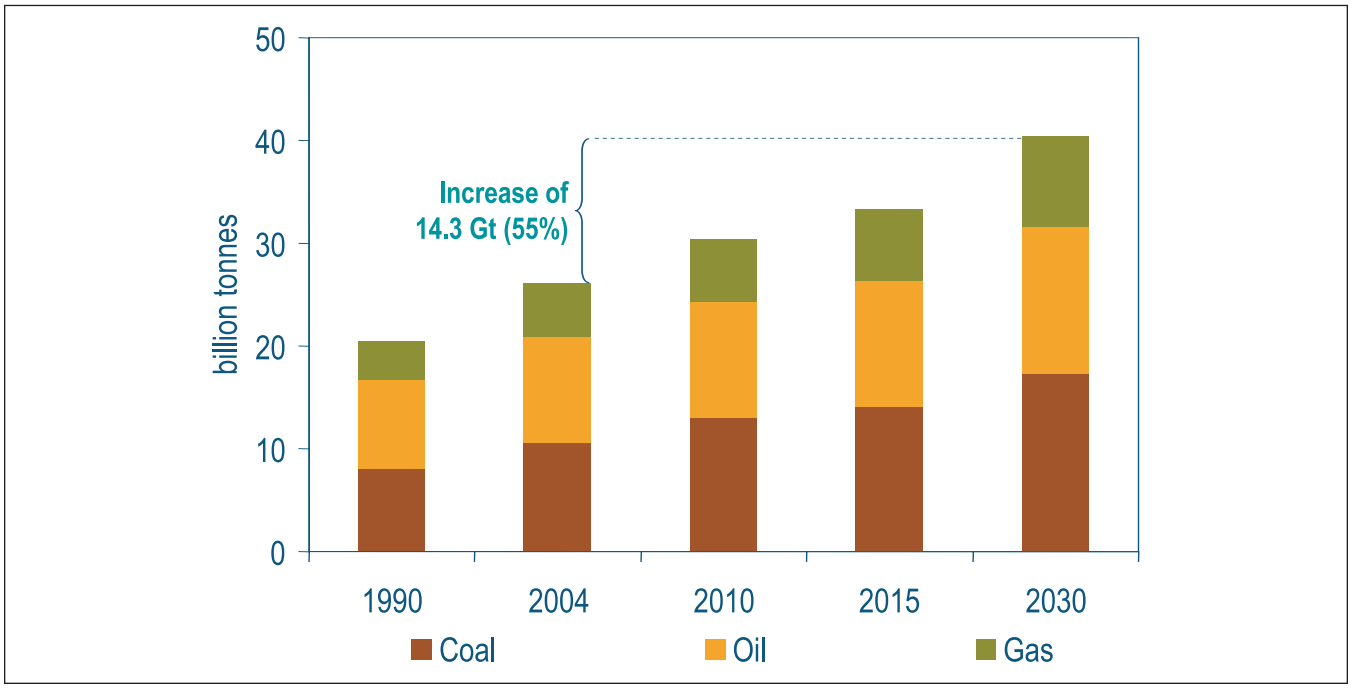

Figure 4. Implications for CO_2 emissions

emissions over the projection period. Coal overtook oil in 2003 as the leading contributor to global energy-related CO_2 emissions and consolidates this position through to 2030. Emissions are projected to grow slightly faster than primary energy demand—reversing the trend of the last two-and-a-half decades—because the average carbon content of primary energy consumption increases.

Developing countries account for over three-quarters of the increase in global CO_2 emissions between 2004 and 2030 in this scenario. They overtake the OECD as the biggest emitter around the year 2010. The share of developing countries in world emissions rises from 39 percent at present to just over one-half 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, developing countries use proportionately more coal and less gas. China alone is responsible for about 39 percent of the rise in global emissions. China's emissions more than double between 2004 and 2030, driven by strong economic growth and a heavy reliance on coal. 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. The per capita emissions of non-OECD countries nonetheless remain well below those of the OECD.

Prompt Government Action Can Alter Energy and Emission Trends

The Reference Scenario trends described above are not set in stone. Indeed, governments may well decide to take stronger action to steer the energy system onto a more sustainable path. In the Alternative Policy Scenario, the policies and measures that governments are currently considering aimed at curbing energy use and reducing emissions—ranging from increased production of biofuels, to renewed investment in nuclear power, to incentives for improved energy efficiency—are assumed to be implemented.[3] This would result in significantly slower growth in fossil-fuel demand, in oil and gas imports and in emissions. These interventions include efforts to improve efficiency in energy production and use, to increase indigenous output of fossil fuels in importing countries, nuclear power and renewable energy sources, and to encourage the development and deployment of other clean and more efficient energy-related technologies.

World primary energy demand in 2030 is about 10 percent lower in the Alternative Policy Scenario than in the Reference Scenario—roughly equivalent to China's entire energy consumption today. Global demand still grows, by 37 percent between 2004 and 2030, but more slowly: 1.2 percent annually as against 1.6 percent in the Reference Scenario. The biggest energy savings in both absolute and percentage terms

[3] More than 1,400 policies were considered. See www.worldenergyoutlook.org.

come from coal. For example, the EU Emissions Trading Scheme introduced in 2005—which involves national caps on greenhouse-gas emissions and EU-wide trading of allowances—could contribute to declining coal demand in the EU. The impact on energy demand of new policies is less marked in the first decade of the *Outlook* period, but far from negligible. The difference in global energy demand between the two scenarios in 2015 is about 4 percent.

In stark contrast with the Reference Scenario, OECD oil imports level off by around 2015 and then begin to fall. Even so, all three OECD regions and developing Asia are more dependent on oil imports by the end of the projection period, though markedly less so than in the Reference Scenario. About 60 percent of the oil savings would come from the transport sector. Efficient new vehicles and increased bio-fuels use and production, especially in Brazil, Europe, and the United States, help reduce oil needs. Globally, gas demand and reliance on gas imports are also sharply reduced vis-à-vis the Reference Scenario.

Energy-related carbon-dioxide emissions are cut by 6.3 gigatons (Gt), or 16 percent, in 2030 relative to the Reference Scenario. The actions taken in the Alternative Policy Scenario cause emissions in the OECD and in the transition economies to stabilize and then decline before 2030. Their emissions in 2030 are still slightly higher than in 2004, but well below the Reference Scenario level. Emissions in the EU and Japan fall to below current levels. Emissions in developing regions carry on growing, but the rate of increase slows appreciably over the *Outlook* period compared with the Reference Scenario.

Policies that encourage the more efficient production and use of energy contribute almost 80 percent of the avoided CO_2 emissions. The remainder comes from switching to low or zero-carbon fuels. More efficient use of fuels, mainly through more efficient cars and trucks, accounts for almost 36 percent of the emissions saved. More efficient use of electricity in a wide range of applications, including lighting, air conditioning, appliances and industrial motors accounts for another 30 percent. More efficient energy production contributes 13 percent. Renewables and bio-fuels together yield another 12 percent and nuclear the remaining 10 percent. The implementation of only a dozen policies would result in nearly 40 percent of avoided CO_2 emissions by 2030. The policies that are most effective in reducing emissions also yield the biggest reductions in oil and gas imports.

Capacities and Crises

New Policies and Measures Would Pay for Themselves

In aggregate, the new policies and measures analyzed yield financial savings that far exceed the initial extra investment cost for consumers—a key result of the Alternative Policy Scenario. Cumulative investment in 2005-2030 along the energy chain—from the producer to the consumer—is $560 billion lower than

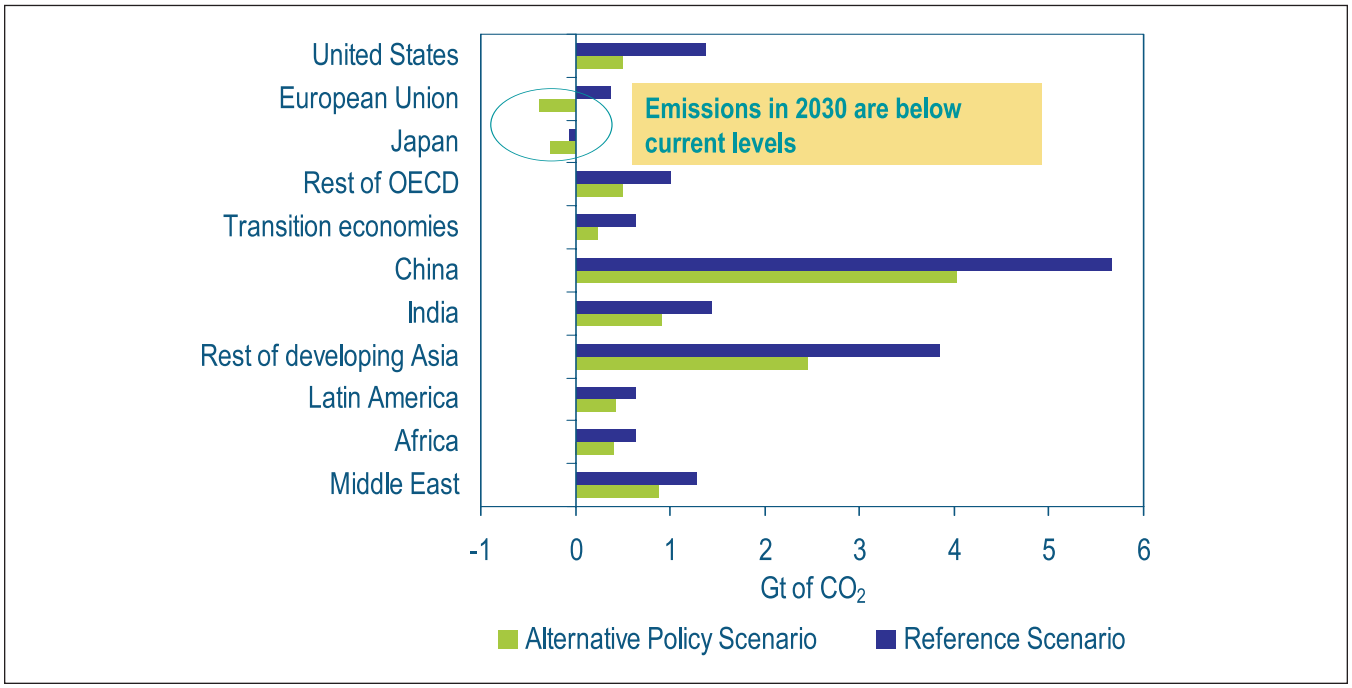

Figure 5. Change in Energy-Related CO_2 Emissions, 2004-2030

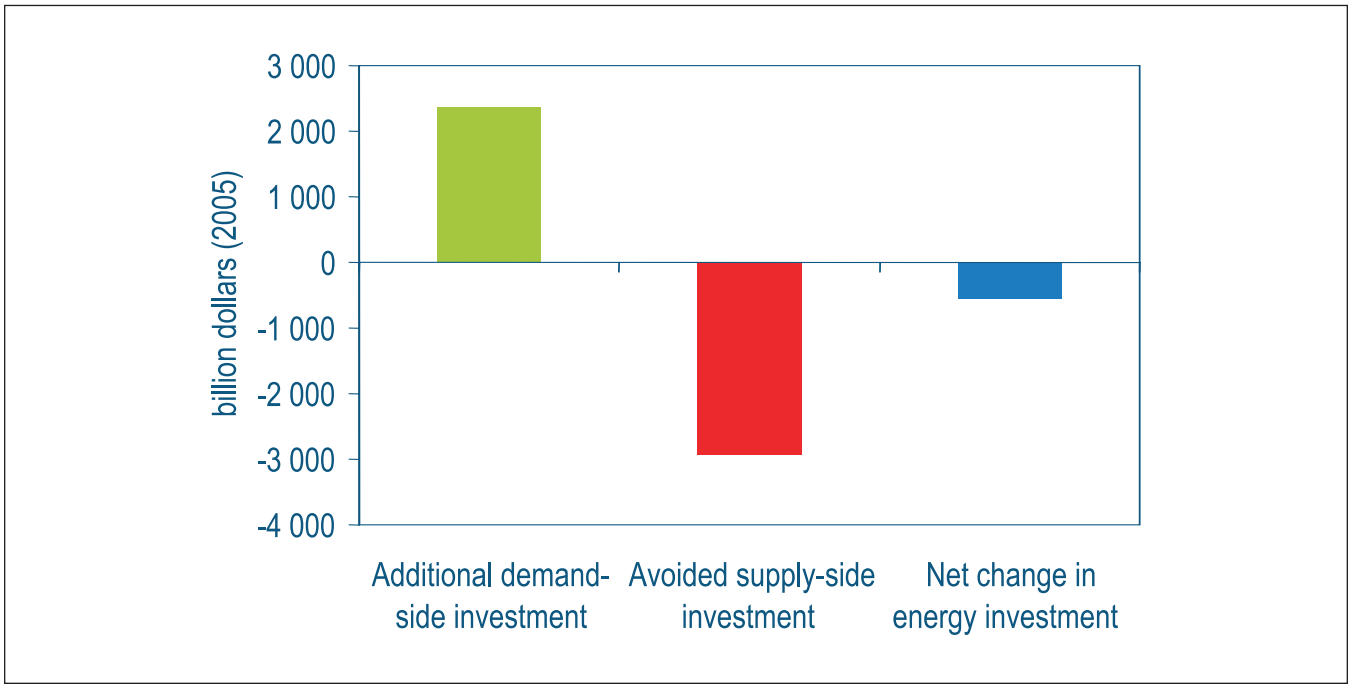

Figure 6. Change in Cumulative Energy-Related Investment versus Reference Scenario, 2005-2030

in the Reference Scenario. Investment in end-use equipment and buildings is $2.4 trillion higher, but this is more than outweighed by the $3 trillion of investment that is avoided on the supply side. Over the same period, the cost of the fuel saved for consumers amounts to $8.1 trillion, more than offsetting the extra demand-side investments required to generate these savings.

The changes in electricity-related investment brought about by the policies included in the Alternative Policy Scenario yield particularly large savings. On average, an additional dollar invested in more-efficient electrical equipment, appliances and buildings avoids more than two dollars in investment in electricity supply. This ratio is highest in non-OECD countries. Two-thirds of the additional demand-side capital spending is borne by consumers in OECD countries. The payback periods of the additional demand-side investments are very short, ranging from one to ten years. They are shortest in developing countries and for those policies introduced before 2015.

Nuclear Power has Renewed Promise—If Public Concerns Are Met

Nuclear power—a proven technology for baseload electricity generation—could make a major contribution to reducing dependence on imported gas and curbing CO_2 emissions. In the Reference Scenario, world nuclear power generating capacity increases from 368 gigawatts (GW) in 2005 to 416 GW in 2030. But its share in the primary energy mix still falls, on the assumption that few new reactors are built and that several existing ones are retired. In the Alternative Policy Scenario, more favorable nuclear policies raise nuclear power generating capacity to 519 GW by 2030, so that its share in the energy mix rises. Interest in building nuclear reactors has increased as a result of higher fossil-energy prices, which have made nuclear power relatively more competitive. New nuclear power plants could produce electricity at a cost of less than five cents per kilowatt-hour (kWh), if construction and operating risks are appropriately managed by plant vendors and power companies. At this cost, nuclear power would be cheaper than gas-based electricity if gas prices are above $4.70 per Million British Thermal Units (MBTU). Nuclear power would still be more expensive than conventional coal-fired plants at coal prices of less than $70 per ton. The breakeven costs of nuclear power would be lower if a financial penalty on CO_2 emissions were introduced.

Nuclear power will only become more important if the governments of countries where nuclear power is acceptable play a stronger role in facilitating private investment, especially in liberalized markets. Nuclear power plants are capital-intensive, requiring initial investment of $2 billion to $3.5 billion per reactor. On the other hand, nuclear power generating costs are less vulnerable to fuel-price changes than coal- or gas-fired generation. Moreover, uranium resources are abundant and widely distributed around the globe. These two advantages make nuclear power a

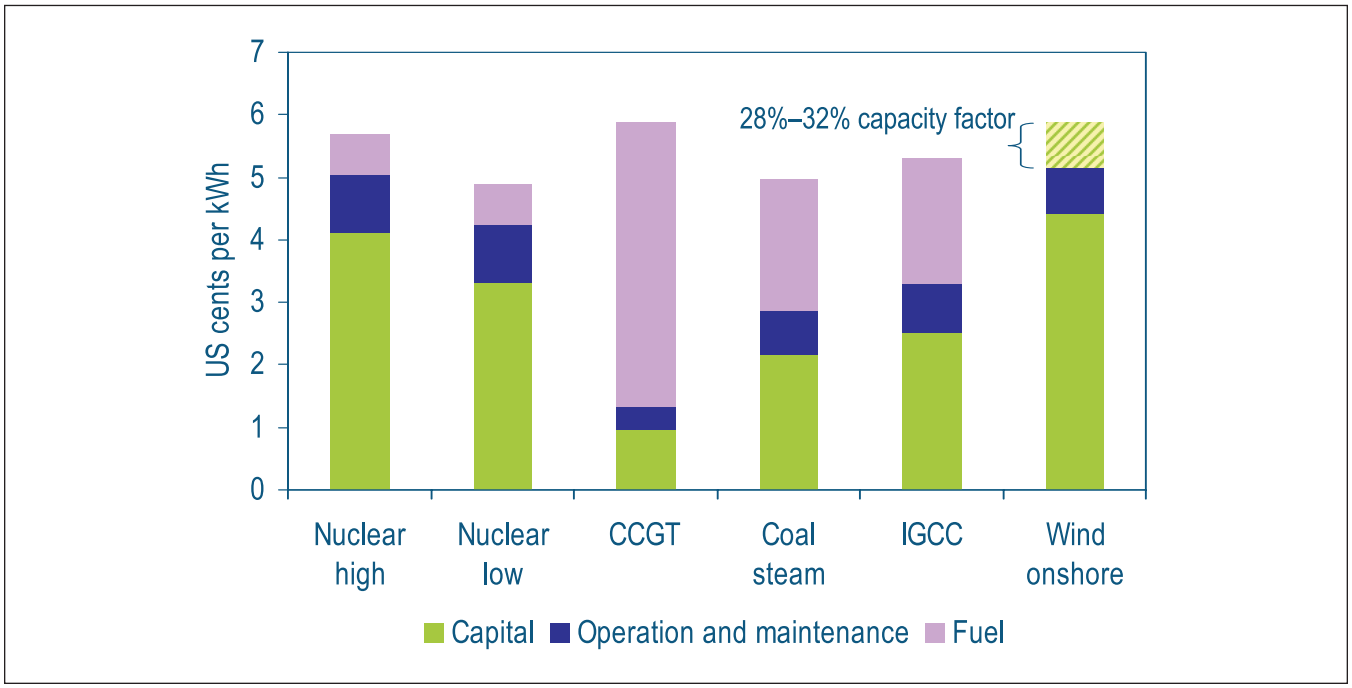

Figure 7. Comparative Generating Costs Based on Low Discount Rate

potentially attractive option for enhancing the security of electricity supply—if concerns about plant safety, nuclear waste disposal, and the risk of proliferation can be solved to the satisfaction of the public and investors.

The Contribution of Bio-fuels Hinges on New Technology

Bio-fuels are expected to make a significant contribution to meeting global road-transport energy needs, especially in the Alternative Policy Scenario. They account for 7 percent of the road-fuel consumption in 2030 in that scenario, up from 1 percent today. In the Reference Scenario, the share reaches 4 percent. In both scenarios, the US, the EU, and Brazil account for the bulk of the increase and remain the leading producers and consumers of bio-fuels. Ethanol is expected to account for most of the increase in bio-fuels use worldwide, as production costs are expected to fall faster than those of bio-diesel—their main competitor. The share of bio-fuels in transport-fuel use remains far and away the highest in Brazil—the world's lowest cost producer of ethanol.

Rising food demand, which competes with bio-fuels for existing arable and pasture land, will constrain the potential for their production using current technology. As Marc Cohen describes in his paper, security of food supply is still a major concern in many countries.[4] Those countries would need to weigh gains in energy security against the potential for increased food insecurity. About 14 million hectares of land are now used for the production of bio-fuels, equal to about 1 percent of the world's currently available arable land. This share rises to 2 percent in the Reference Scenario and 3.5 percent in the Alternative Policy Scenario. The amount of arable land needed in 2030 is equal to that of the entire surface area of France in the Reference Scenario and that of all the OECD Pacific countries—including Australia—in the Alternative Policy Scenario.

New bio-fuels technologies being developed today, notably lignocellulosic ethanol, could allow bio-fuels to play a much bigger role than that foreseen in either scenario. But significant technological challenges still need to be overcome for these second-generation technologies to become commercially viable. Trade and subsidy policies will be critical factors in determining where and with what resources and technologies bio-fuels will be produced in the coming decades, the overall burden of subsidy on tax-payers and the cost-effectiveness of bio-fuels as a way of promoting energy diversity and reducing carbon-dioxide emissions.

Making the Alternative Policy Scenario a Reality

There are formidable hurdles to the adoption and

[4] Marc Cohen, "Food Security: Vulnerability Despite Abundance," *Coping with Crisis* Working Paper Series, International Peace Academy, New York, May 2007.

implementation of the policies and measures in the Alternative Policy scenario. In practice, it will take considerable political will to push these policies through, many of which are bound to encounter resistance from some industry and consumer interests. Governments and national administrations need to spell out clearly the benefits to the economy and to society as a whole of the proposed measures. In most countries, the public is becoming familiar with the energy-security and environmental advantages of action to encourage more efficient energy use and to boost the role of renewables.

Private-sector support and international cooperation will be needed for more stringent government policy initiatives. While most energy-related investment will have to come from the private sector, governments have a key role to play in creating the appropriate investment environment. The industrialized countries will need to help developing countries leapfrog to the most advanced technologies and adopt efficient equipment and practices. This will require programs to promote technology transfer, capacity building, and collaborative research and development. To make the Alternative Policy Scenario a reality, private-sector support for more stringent government policy initiatives would be essential, together with a strong degree of cooperation between industry and government and between countries (for example in relation to emissions charges for aviation fuel use). Multilateral lending institutions and other international organizations can support non-OECD countries in devising and implementing new policies. Governments can also facilitate access to advice and expertise on energy policymaking and implementation and can improve conditions for technology transfer. Access to capital is a particular problem for smaller developing countries, which, unlike China and India, are not besieged by investors seeking opportunities. Programs are required to promote technology transfer, to help build the capacity to implement change and to offer opportunities for collaborative research and development. Developing countries need to make complementary changes to facilitate exchanges. Australia, India, Japan, China, the Republic of Korea, and the United States agreed in January 2006 to cooperate on the development and transfer of technology to enable greenhouse-gas emissions to be reduced. Under this agreement, known as the Asia-Pacific Partnership on Clean Development and Climate (AP6), member countries are working with private-sector partners in several industry and energy sectors to voluntarily reduce emissions.

The analysis of the Alternative Policy Scenario demonstrates the urgency with which policy action is required. Each year of delay in implementing the policies analyzed would have a disproportionately larger effect on emissions. For example, if the policies were to be delayed by ten years, with implementation starting only in 2015, the cumulative avoided emissions by 2030 vis-à-vis the Reference Scenario would be only 2 percent, compared with 8 percent in the Alternative Policy Scenario. In addition, delays in stepping up energy-related research and development efforts, particularly in the field of carbon capture and storage, would hinder prospects for bringing down emissions after 2030.

Larger Energy Savings Would Require an Even Bigger Policy Rush

Even if governments actually implement, as we assume, all the policies they are considering to curb energy imports and emissions, both would still rise through to 2030. Keeping global CO_2 emissions at current levels would require much stronger policies. In practice, technological breakthroughs that change profoundly the way we produce and consume energy will almost certainly be needed as well. The difficulties in making this happen in the timeframe of our analysis do not justify inaction or delay, which would raise the long-term economic, security, and environmental cost. The sooner a start is made, the quicker a new generation of more-efficient and low- or zero-carbon energy systems can be put into place.

A much more sustainable energy future is within our reach, using technologies that are already available or close to commercialization. In the World Energy Outlook 2006, a Beyond the Alternative Policy Scenario (BAPS) Case illustrates how the extremely challenging goal of capping CO_2 emissions in 2030 at today's levels could be achieved. This would require emissions to be cut by 8 Gt more than in the Alternative Policy Scenario. Four-fifths of the energy and emissions savings in the BAPS Case come from even stronger policy efforts to improve energy efficiency, to boost nuclear power and renewables-based electricity generation and to support the introduction of carbon capture and storage technology—one of the most promising options for mitigating emissions in the longer term. Yet the technology shifts outlined in the BAPS Case, while technically feasible, would be unprecedented in scale and speed of deployment.

Bringing Modern Energy to the World's Poor is an Urgent Necessity

Although steady progress is made in both scenarios in expanding the use of modern household energy services in developing countries, many people still depend on traditional biomass in 2030. Today, 2.5 billion people use fuelwood, charcoal, agricultural waste, and animal dung to meet most of their daily energy needs for cooking and heating. In many countries, these resources account for over 90 percent of total household energy consumption. The inefficient and unsustainable use of biomass has severe consequences for health, the environment, and economic development. Shockingly, about 1.3 million people—mostly women and children—die prematurely every year because of exposure to indoor air pollution from biomass. There is evidence that, in Brazil and other countries where local prices have adjusted to recent high international energy prices, the shift to cleaner, more efficient cooking has actually slowed and even reversed. In the Reference Scenario, the number of people using biomass increases to 2.6 billion by 2015 and to 2.7 billion by 2030 as population rises. That is, one-third of the world's population will still be relying on these fuels, a share barely smaller than today.

Action to encourage more efficient and sustainable use of traditional biomass and help people switch to modern cooking fuels and technologies is needed urgently. The appropriate policy approach depends on local circumstances such as per capita incomes and the availability of a sustainable biomass supply. Alternative fuels and technologies are already available at reasonable cost. Halving the number of households using biomass for cooking by 2015—a recommendation of the UN Millennium Project—would involve 1.3 billion people switching to liquefied petroleum gas and other commercial fuels. This would not have a significant impact on world oil demand and would not be prohibitively costly. But vigorous and concerted government action—with support from the industrialized countries—is needed to achieve this target, together with increased funding from both public and private sources. Policies would need to address barriers to access, affordability and supply, and to form a central component of broader development strategies. There are many ways in which policy-makers and other stakeholders can help make clean fuels affordable. The LP Gas Rural Energy Challenge (led by the UNDP and the World LP Gas Association), among other initiatives, is working toward this end. One approach is to encourage the development of microfinancing. There may also be a case for subsidizing the up-front costs of buying gas stoves and cylinders, in view of the potentially large impact and relatively small overall cost of such a program. Governments could also facilitate commercialization of modern fuels by designing financial incentives and training private entrepreneurs, setting technical standards, extending credit facilities to stove-makers and providing marketing support. Another approach is to promote the use of smaller cylinders for fuels such as liquefied petroleum gas (LPG). These would lower the initial deposit fee and refilling costs, encouraging more regular LPG consumption, especially in rural areas, and more widespread use of the fuel. This approach has had some success in Morocco for example. Reliance on more frequent refills, of course, creates a need for a reliable supply system.

Providing improved stoves and canisters is a necessary, but not a sufficient condition for expanding the use of modern fuels. Annual fuel costs are typically several times the annualized cost of stoves and canisters. Many rural households would not be able to afford LPG, for example, even with microfinance or subsidized capital investment. The challenge is especially daunting for those dependent on agriculture, where incomes are not only low but volatile. In such cases, efforts to tackle energy poverty would clearly need to go hand in hand with broader policies aimed at alleviating poverty more generally and promoting economic development. Clean-cooking initiatives would ideally be carried out in parallel with programs for education, rural electrification, and industrialization, which would also enable time freed up to be productively reallocated. In general, income-support or social welfare programs are a far more effective way of addressing poverty than subsidies to the fuels themselves.

One of the recommendations of the UN Millennium Project was that objectives regarding energy services should be placed on a par with the original Millennium Development Goals. At the global level, the resources and attention devoted to improving energy use for cooking are not commensurate with the magnitude of the problem. Compared with the international response to hunger, HIV/AIDS, dirty water, poor sanitation, and malaria, energy use for cooking has received extremely limited funding and high-level political backing. Large electricity generation, transmission and distribution projects primarily benefit industry and urban populations, while most rural and poor people depend on biomass. Effective, comprehensive policies need to

include the forms of energy used by the poor—for cooking, lighting, productive appliances, and transport—rather than concentrate on the provision of electricity alone as an end in itself. Even in countries where the vast majority of the population relies on traditional biomass for cooking, access to electricity has received much more attention and investment. Climate-driven programs have also tended to bypass household energy use for cooking, since biomass-based energy sources were regarded as emissions-neutral. There are opportunities for the private sector to make up the shortfall in funding. Support to microfinance institutions could also be an effective approach, as would new financing mechanisms, such as the MDG Carbon Facility of the UNDP.

Governments could increase provision of training programs to develop skills and expertise in the area of improved stoves and housing design, and to educate people about the health risks of indoor air pollution. Simple measures can be very effective, such as improving public awareness of changes that can reduce smoke levels, like drying wood thoroughly before use and shortening cooking time (by using a pot lid). Similar gains can be made from improvements in household design, such as increasing the number of window openings in the kitchen, providing gaps between roof and wall and moving the stove out of the living area. Regulatory reforms can improve the affordability, availability, and safety of a range of cooking fuels and technologies. Governments can also support cleaner cooking by developing national databases which include information on the population to be served, potential fuels, stoves, the infrastructure and potential providers, together with cost analyses and estimates of the ability and willingness to pay, as a function of income. Long-term commitments are needed from development partners to scale up energy investments, transfer knowledge, and deploy financing instruments which will leverage private capital, particularly in countries with the largest concentration of the energy-poor, such as those in Sub-Saharan Africa and South Asia.

Deepening the Consumer-Producer Dialogue

The policies of producing and consuming countries will change over time in response to each other, to market developments, and to shifts in market power. If upstream investment in producer countries (notably those members of the Organization of Petroleum Exporting Countries [OPEC]) falters and prices rise, the more likely it becomes that consuming countries will adopt additional policies to curb demand growth and import dependence. This would have the effect of tempering the long-term impact on prices of lower producer investment. It would also amplify the depressive effect of higher prices on oil and gas demand. The more successful the importing countries' policies are, the more likely it is that the producing countries will adopt policies to sustain their production and their global market share, resulting in lower prices. These interactions illustrate the case for improving market transparency, for more effective mechanisms for exchanging information between oil producers and consumers, and for a more profound dialogue between them.

The uncertainty surrounding the outlook for global energy markets has rarely been greater. For as long as the world economy continues to expand, we can be sure that demand for oil and other forms of energy will increase commensurately. But the rate of growth in primary energy needs and the mix of fuels will depend on what action governments decide to take to curb demand and emissions and on developments in energy technology. Other factors, including extreme weather, natural disasters, and geopolitics, will complicate our ability to anticipate near- medium- and long-term energy-market developments with confidence. More than ever, energy security is a matter of managing risk and coping with uncertainty.

Consuming countries must identify policies and measures aimed at reducing the risk of disruptions and higher prices, as well as mitigating their consequences. They need to strengthen their ability to handle a supply emergency, including maintaining adequate volumes of strategic stocks. Consuming-country governments also need to consider long-term policies that promote further diversification of their energy supplies as a means of both lowering their vulnerability to supply disruptions and of addressing environmental challenges, including rising greenhouse-gas emissions. Reducing dependence on oil and gas through diversification of fuels and their geographic sources, and more efficient use of energy must be central to long-term policies aimed at enhancing energy security.

Deepening the dialogue between oil and gas producers and consumers (for example, as represented by OPEC and the IEA respectively) would help all energy players handle uncertainty and help industry mobilize much-needed investment. The aim should be to improve market transparency, by developing more effective ways of exchanging information, and cooperating on policies to enhance the efficiency of

the oil and gas sector. The International Energy Forum, set up in December 2003 and based in Riyadh, is an important initiative in this regard. Producing countries are as much concerned about security of demand as consuming countries are about security of supply. Working together, consumer and producer governments can improve the mechanisms by which we meet our common challenges and achieve mutually beneficial outcomes. But they need to identify this objective as a priority and take the first steps. And they should start now.

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