OECD MULTILINGUAL SUMMARIES

World Energy Outlook 2005

Summary in English

Two visions of the energy future:

- under-invested, vulnerable and dirty, or
- clean, clever and competitive.

Both are explored in this new edition of the authoritative *World Energy Outlook*.

In it, the International Energy Agency responds to the remit of the G8 world leaders by **mapping a new energy future**, contrasting it with where we are now headed. *WEO 2006* shows how to change course. It counts the costs and benefits - and the benefits win. World Energy Outlook 2006 also answers these questions:

- is the economic reaction to high energy prices merely delayed?
- is oil and gas investment on track?
- are the conditions shaping up for a nuclear energy revival?
- can biofuels erode the oil monopoly in road transport?
- can 2.5 billion people in developing countries switch to modern energy for cooking?
- is Brazil learning new lessons or teaching the world?

With extensive statistics, detailed projections, analysis and advice, *WEO 2006* equips policy-makers and the public to re-make the energy future.

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Summary and Conclusions

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 affordable energy plays in economic growth and human development and of the vulnerability of the global energy system to supply disruptions. Safeguarding energy supplies is once again back at the top of the international policy agenda. Yet the current pattern of energy supply carries the threat of massive and irreversible environmental damage – including changes in global climate caused by burning fossil energy. Reconciling the goals of energy security and environmental protection requires strong and coordinated government action.

The need to curb the growth in fossil-energy demand, to increase geographic and fuel-supply diversity and to mitigate climate-destabilising emissions is more urgent than ever. G8 leaders, meeting with the leaders of several major developing countries and heads of international organisations – including the International Energy Agency – at Gleneagles in July 2005 and in St Petersburg in July 2006 called on the IEA to "advise on alternative energy scenarios and strategies aimed at a clean, clever and competitive energy future". This year's *Outlook* responds to that request. It confirms that fossil-fuel demand and trade flows, and greenhouse-gas emissions would follow their current unsustainable paths through to 2030 in the absence of new government action – the underlying premise of our 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 reduce significantly 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.

Fossil energy will remain dominant to 2030

Global primary energy demand in the Reference Scenario is projected to increase by just over one-half between now and 2030 – an average annual rate of 1.6%. Demand grows by more than one-quarter in the period to 2015 alone. Over 70% of the increase in demand over the projection period comes from developing countries, with China alone accounting for 30%. Their economies and population grow much faster than in the OECD, shifting the centre 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 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% of the overall increase in energy demand between 2004 and 2030. As a result, their share of world demand edges up, from 80% to 81%. The share of oil drops, though oil remains the largest single fuel in the global energy mix in 2030. Global oil demand reaches 99 million barrels per day in 2015 and 116 mb/d in 2030 – up from 84 mb/d in 2005. In contrast to *WEO-2005*, 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

coal. It remains the second-largest primary fuel, its share in global demand increasing slightly. The share of natural gas also rises, even though gas use grows less quickly than projected in the last *Outlook* 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.

We have revised upwards our assumptions for oil prices in this *Outlook*, on the expectation that crude oil and refined-product markets remain tight. Market fundamentals point to a modest easing of prices beyond 2007 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 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 follow the direction of oil and gas prices.

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. 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 55% 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. In 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.

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 for 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 need to 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 international prices. Current subsidies on oil products in non-OECD countries are estimated at over $90 billion annually. Subsidies on all forms of final energy outside the OECD amount to over $250 billion per year – equal to all the investment needed in the power sector each year on average in those countries.

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 non-energy commodities exports, the prices of which have also risen, have offset at least part of the impact of higher energy. 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 petro-dollars 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.

Will the investment come?

Meeting the world's growing hunger for energy requires massive investment in energy-supply infrastructure. The Reference Scenario projections in this *Outlook* call for cumulative investment of just over $20 trillion (in year-2005 dollars) over 2005-2030. This is around $3 trillion higher than in *WEO-2005*, mainly because of recent sharp increases in unit capital costs, especially in the oil and gas industry. The power sector accounts for 56% of total investment – 68% if investment in the supply chain to meet the fuel needs of power stations is included. Oil investment – three-quarters of which goes to the upstream – amounts to over $4 trillion in total over 2005-2030. Upstream investment needs are more sensitive to changes in decline rates at producing fields than to the rate of growth of demand for oil. Roughly half of all the energy investment needed worldwide is in developing countries, where demand and production increase most quickly. China alone needs to invest about $3.7 trillion – 19% of the world total.

There is no guarantee that all of the investment needed will be forthcoming. Government policies, geopolitical factors, unexpected changes in unit costs and prices, and new technology could all affect the opportunities and incentives for private and publicly-owned companies to invest in different parts of the various energy-supply chains. The investment decisions of the major oil and gas producing countries are of crucial importance, as they will increasingly affect the volume and cost of imports in the consuming countries. There are doubts, for example, about whether investment in Russia's gas industry will be sufficient even to maintain current export levels to Europe and to start exporting to Asia.

The ability and willingness of major oil and gas producers to step up investment in order to meet rising global demand are particularly uncertain. 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 to 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 to 2010 is expected to boost slightly

global spare crude oil production capacity. 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. Increased capital spending on refining is expected to raise throughput capacity by almost 8 mb/d by 2010. Beyond the current decade, higher investment in real terms will be needed to maintain growth in upstream and downstream capacity. In a Deferred Investment Case, lower OPEC crude oil production, partially offset by increased non-OPEC production, pushes oil prices up by one-third, trimming global oil demand by 7 mb/d, or 6%, in 2030 relative to the Reference Scenario.

On current energy trends, carbon emissions will accelerate

Global energy-related carbon-dioxide (CO_2) emissions increase by 55% between 2004 and 2030, or 1.7% per year, in the Reference Scenario. They reach 40 gigatonnes in 2030, an increase of 14 Gt over the 2004 level. Power generation contributes half of the increase in global 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 by soon after 2010. The share of developing countries in world emissions rises from 39% 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, the developing countries use proportionately more coal and less gas. China alone is responsible for about 39% of the rise in global emissions. China's emissions more than double between 2004 and 2030, driven by strong economic growth and heavy reliance on coal in power generation and industry. 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 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 enhancing energy security and mitigating CO_2 emissions, which are assumed to implemented, 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% 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% between 2004 and 2030, but more slowly: 1.2% annually against 1.6% in the Reference Scenario. The biggest energy savings in both absolute and percentage terms come from coal. 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%.

In stark contrast with the Reference Scenario, OECD oil imports level off by around 2015 and then begin to fall steadily. 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. Global oil demand reaches 103 mb/d in 2030 in the Alternative Policy Scenario – an increase of 20 mb/d on the 2005 level but 13 mb/d less than in the Reference Scenario. Measures in the transport sector produce close to 60% of all the oil savings in the Alternative Policy Scenario. More than two-thirds come from more efficient new vehicles. Increased biofuels use and production, especially in Brazil, Europe and the United States, also helps 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 1.7 Gt, or 5%, in 2015 and by 6.3 Gt, or 16%, 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 stabilise 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 European Union 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% 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% 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%. More efficient energy production contributes 13%. Renewables and biofuels together yield another 12% and nuclear the remaining 10%. The implementation of only a dozen policies would result in nearly 40% of avoided CO2 emissions by 2030. The policies that are most effective in reducing emissions also yield the biggest reductions in oil and gas imports.

New policies and measures would pay for themselves

In aggregate, the new policies and measures analysed 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 $580 billion lower than 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 to 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 big 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 polices introduced before 2015.

Nuclear power could play a key role – if accepted by the public

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 GW in 2005 to 417 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 favourable 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 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 MBtu. Nuclear power would still be more expensive than conventional coal-fired plants at coal prices of less than $70 per tonne. 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 liberalised 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 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 biofuels hinges on new technology

Biofuels are expected to make a significant contribution to meeting global road-transport energy needs, especially in the Alternative Policy Scenario. They account for 7% of the road-fuel consumption in 2030 in that scenario, up from 1% today. In the Reference Scenario, the share reached 4%. In both scenarios, the United States, the European Union and Brazil account for the bulk of the increase and remain the leading producers and consumers of biofuels. Ethanol is expected to account for most of the increase in biofuels use worldwide, as production costs are expected to fall faster than

those of biodiesel – the other main biofuel. The share of biofuels 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 biofuels for existing arable and pasture land, will constrain the potential for biofuels production using current technology. About 14 million hectares of land are now used for the production of biofuels, equal to about 1% of the world's currently available arable land. This share rises to 2% in the Reference Scenario and 3.5% 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 biofuels technologies being developed today, notably ligno-cellulosic ethanol, could allow biofuels 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 biofuels will be produced in the coming decades, the overall burden of subsidy on tax-payers and the cost-effectiveness of biofuels 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 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 industry and consumer interests. Politicians need to spell out clearly the overall benefits to the economy and to society as a whole of proposed measures to counter political inertia. 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, making it easier politically to introduce new policies.

Private-sector support for more stringent government policy initiatives and international cooperation would be essential. While most energy-related investment will have to come from the private sector, governments have a key role in creating appropriate investment. The industrialised countries have an important role to play in helping developing countries leapfrog to the most advanced technologies and adopt efficient equipment and practices. This would require programmes to promote technology transfer, capacity building and collaborative research and development. A strong degree of co-operation between countries, and between industry and government will be needed. Non-OECD countries could seek support from multilateral lending institutions and other international organisations in devising and implementing new policies. This may be particularly critical for small developing countries, unlike China and India, which may struggle to attract investment.

The analysis of the Alternative Policy Scenario demonstrates the urgency with which policy action is required. Each year of delay in implementing the policies analysed 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%, compared with 8% 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 push

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 provide an excuse for 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 commercialisation. A recently-published IEA report, *Energy Technology Perspectives*, demonstrates that, for this to happen, a portfolio approach to technology development and deployment is needed. In this *Outlook*, 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 stronger policy efforts to further improve energy efficiency, to boost nuclear power and renewables-based electricity generation and to support the introduction of carbon capture and storage technology – one 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% 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 cost, at most, $1.5 billion per year. But vigorous and concerted government action – with support from the industrialised 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.

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