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What does the global energy outlook to 2035 look like?

- **The pace of the global economic recovery holds the key to energy prospects for the next several years, but it will be governments' responses to the twin challenges of climate change and energy security that will shape the future of energy in the longer term.** The level and pattern of energy use worldwide varies markedly across the three scenarios in this year's *Outlook*, which differ according to assumptions about energy and environmental policies.

- **In the New Policies Scenario – the central scenario this year – world primary energy demand increases by 36% between 2008 and 2035, or 1.2% per year on average.** This compares with 2% per year over the previous 27-year period. The scenario assumes cautious implementation of the policy commitments and plans announced by countries around the world, including the national pledges to reduce greenhouse-gas emissions and plans to phase out fossil-fuel subsidies. Projected demand growth is slower than in the Current Policies Scenario, in which no change in policies beyond those already adopted is assumed; demand grows by 1.4% per year over 2008-2035. In the 450 Scenario, which sets out an energy pathway to limit the concentration of greenhouse gases in the atmosphere to around 450 parts per million of CO_2 equivalent consistent with an increase in global temperature of 2°C, demand still increases, but by only 0.7% per year.

- **In the New Policies Scenario, non-OECD countries account for 93% of the projected increase in global energy demand, reflecting mainly faster rates of growth of economic activity.** China, where demand has surged over the past decade, contributes 36% to the projected growth in global energy use, its demand rising by 75% between 2008 and 2035 (our preliminary data suggest that, although Americans consume more on a per-capita basis, China overtook the United States in 2009 to become the world's largest energy user). Aggregate energy demand in OECD countries rises very slowly. Nonetheless, by 2035, the United States remains the world's second largest energy consumer behind China.

- **Global demand for each fuel source increases, with fossil fuels – coal, oil and gas – accounting for over 50% of the increase in total primary energy demand.** Rising fossil-fuel prices for end uses, resulting from upward price pressures in international markets and increasingly onerous carbon penalties in many countries, together with policies to encourage energy savings and switching to low carbon energy sources, help to restrain demand growth for all three fuels.

- **Oil remains the dominant fuel in the primary energy mix to 2035**. Nonetheless, its share of the primary fuel mix diminishes as higher oil prices and government measures to promote fuel efficiency lead to further switching away from oil in all sectors. Demand for coal rises through to around 2020 and starts to decline towards the end of the *Outlook* period. The share of nuclear power increases from 6% in 2008 to 8% in 2035. The use of modern renewable energy — including hydro, wind, solar, geothermal, modern biomass and marine energy — triples between 2008 and 2035, its share in total energy demand increasing from 7% to 14%.

- **Natural gas is set to play a central role in meeting the world's energy needs for at least the next two-and-a-half decades.** Global natural gas demand, which fell in 2009 with the economic downturn, is set to resume its long-term upward trajectory from 2010. Demand increases by 44% between 2008 and 2035 – an average rate of increase of 1.4% per year. Growth in demand for gas far surpasses that for the other fossil fuels due to its more favourable environmental and practical attributes, and constraints on how quickly low-carbon energy technologies can be deployed. China's gas demand grows fastest, accounting for more than one-fifth of the increase in global demand to 2035. The Middle East leads the expansion of gas production, its output doubling by 2035. Over a third of the global increase in gas output comes from unconventional sources — shale gas, coalbed methane and tight gas — in the United States and, increasingly, from other regions. A glut in global gas-supply capacity, which could peak in 2011, will keep the pressure on gas exporters to move away from oil-price indexation, notably in Europe.

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What will shape the future of oil?

- **The global outlook for oil remains highly sensitive to policy action to curb rising demand and emissions.** In the Current Policies and New Policies Scenarios, global primary oil use increases in absolute terms between 2009 and 2035, driven by population and economic growth, but demand falls in the 450 Scenario in response to radical policy action to curb fossil-fuel use.

- **The oil price needed to balance oil markets is set to rise, reflecting the growing insensitivity of both demand and supply to price.** The growing concentration of oil use in transport and a shift of demand towards markets where subsidies are most prevalent are limiting the scope for higher prices to choke off demand and discouraging fuel switching. At the same time constraints on investment mean that higher prices lead to only modest increases in production. In the New Policies Scenario, the average IEA crude oil price reaches $113 per barrel (in year-2009 dollars) in 2035 – up from just over $60 in 2009.

- **Oil demand (excluding biofuels) continues to grow steadily in the New Policies Scenario, reaching about 99 million barrels per day by 2035 – 15 mb/d up on 2009.** All of the net growth comes from non-OECD countries, almost half from China alone; demand in the OECD falls by over 6 mb/d. Global oil production reaches 96 mb/d, the balance of 3 mb/d coming from processing gains. Crude oil output reaches an undulating plateau of around 68-69 mb/d by 2020, but never regains its all time peak of 70 mb/d reached in 2006, while production of natural gas liquids (NGLs) and unconventional oil grows strongly. Total OPEC production rises continually through to 2035 in this Scenario, its share of global output increasing from 41% to 52%. Iraq accounts for a large share of the increase in OPEC output. By contrast, total non-OPEC oil production is broadly constant to around 2025, as rising production of NGLs and unconventional production offsets a fall in that of crude oil; thereafter, production starts to drop.

- **The eventual peak in oil will be determined by factors affecting both demand and supply.** In the New Policies Scenario, production in total does not peak before 2035, though it comes close to doing so. By contrast, in the 450 Scenario, production does peak, at 86 mb/d, just before 2020, as a result of weaker demand, falling briskly thereafter. Oil prices are much lower as a result. The message is clear: if governments act more vigorously than currently planned to encourage more efficient use of oil and the development of alternatives, then demand for oil might begin to ease soon. As a result, we might see a fairly early peak in oil production, which would help prolong the world's oil reserves.

- **Unconventional oil is set to play an increasingly important role in world oil supply through to 2035, regardless of what governments do to curb demand.** It meets about 10% of world oil demand in all three scenarios by 2035 compared with less than 3% today. In the New Policies Scenario, output of unconventional oil in aggregate rises from 2.3 mb/d in 2009 to 9.5 mb/d in 2035. Canadian oil sands and Venezuelan extra-heavy oil dominate the mix, but coal-to-liquids, gas-to-liquids and, to a lesser extent, oil shales also make a growing contribution in the second half of the *Outlook* period. In the New Policies Scenario, oil-sands production alone climbs from about 1.3 mb/d in 2009 to 4.2 mb/d in 2035, making an important contribution to the world's energy security.

- **The rate at which unconventional resources are exploited will be determined by economic considerations and the cost of mitigating their environmental impact.** Unconventional sources of oil are thought to be huge – several times larger than conventional oil resources – but are among the most expensive available. Consequently, they will play a key role in setting future oil prices. The production of unconventional oil generally emits more greenhouse gas per barrel than that of most types of conventional oil, but, on a well-to-wheels basis, the difference is much less, as most emissions occur at the point of use. In the case of Canadian oil sands, well-to-wheels CO_2 emissions are typically between 5% and 15% higher than for conventional crude oils. Mitigation measures will be needed to reduce emissions from unconventional oil production.

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What will it take to unlock the Caspian region's energy riches?

- **The Caspian region has the potential to make a significant contribution to ensuring energy security in the rest of the world by reducing the need to develop more expensive sources of hydrocarbons and increasing the diversity of global oil and gas supplies.** The Caspian region contains substantial resources of both oil and natural gas, which could underpin a sizeable increase in production and exports over the next two decades. But potential barriers to the development of these resources, notably the complexities of financing and constructing pipelines through several countries, are expected to constrain this expansion to some degree.

- **In the New Policies Scenario, Caspian oil production grows strongly — especially over the first 15 years of the projection period.** It jumps from 2.9 mb/d in 2009 to a peak of around 5.4 mb/d between 2025 and 2030, before falling back to 5.2 mb/d by 2035. Kazakhstan contributes all of this increase. After Saudi Arabia, Iraq and Brazil, it ranks fourth in the world for output growth in volume terms to 2035. Most of the incremental oil output goes to exports, which double to a peak of 4.6 mb/d soon after 2025. Investment decisions on new export infrastructure, in particular from Kazakhstan, will be needed soon to pave the way for this expansion.

- **Caspian gas production is also projected to expand substantially in that scenario, from an estimated 159 billion cubic metres (bcm) in 2009 to nearly 260 bcm by 2020 and over 310 bcm in 2035.** Turkmenistan and, to a lesser extent, Azerbaijan and Kazakhstan drive this expansion. As with oil, gas exports are projected to grow rapidly, rising from less than 30 bcm in 2009 to nearly 100 bcm in 2020 and 130 bcm in 2035.

- **While Russia will remain a purchaser of Caspian gas, there will be greater diversity in Caspian gas trade as the region expands its access to new markets in Europe and China, which emerges as a major new customer.** Further development of a southern corridor from Azerbaijan to Turkey and other European markets enables larger volumes of Azerbaijan gas to move westwards. The commissioning of the Turkmenistan-China pipeline has shifted the centre of gravity of Central Asia's gas sector eastwards. Chinese imports from the Caspian region reach about 60 bcm by 2035 in the New Policies Scenario, although concerns about over-reliance on this supply route may limit the rate of import growth. Northward export to Russia will be constrained by development of Russia's own resources, its more efficient gas use and the evolution of demand for Russia's exports in Europe and the Far East.

- **In all three scenarios, the share of the Caspian in world inter-regional trade of both oil and gas increases between now and 2035: from 6% to 9% for oil and from 4% to 11% for gas in the New Policies Scenario.** Creating a diverse and flexible system of export routes will enable the Caspian region to gain access to international market prices for its resources and contribute fully to global oil and gas security.

- **Domestic energy policies and market trends, beyond being critical to the Caspian's social and economic development, will affect the volumes of oil and gas available for export.** Despite some improvement in recent years, the region remains highly energy intensive, reflecting continuing gross inefficiencies in the way energy is used (a legacy of the Soviet era), as well as climatic and structural economic factors. If the region were to use energy as efficiently as OECD countries, consumption of primary energy in the Caspian as a whole would be cut by half.

- **How quickly this energy efficiency potential might be exploited hinges largely on government policies, especially on energy pricing (all the main Caspian countries subsidise at least one form of fossil energy), market reform and financing.** In the New Policies Scenario, total Caspian primary energy demand expands progressively through the Outlook period, at an average rate of 1.4% per year, with gas remaining the predominant fuel. By 2035, demand is about 50% higher than in 2008. Kazakhstan and Turkmenistan see the fastest rates of growth in energy use, mainly reflecting more rapid economic growth.

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How big are the potential gains from getting rid of fossil-fuel subsidies?

- **Fossil-fuel subsidies, which remain commonplace in many countries, result in an economically inefficient allocation of resources and market distortions, while often failing to meet their stated objectives.** Subsidies that artificially lower energy prices encourage wasteful consumption, exacerbate energy-price volatility by blurring market signals, incentivise fuel adulteration and smuggling, and undermine the competitiveness of renewables and other low-emission energy technologies. For importing countries, subsidies often impose a significant fiscal burden on state budgets, while for producers they quicken the depletion of resources and can thereby reduce export earnings over the long term.

- **Fossil-fuel consumption subsidies, comprising subsidies to fossil fuels used in final consumption and to fossil-fuel inputs to power generation, worldwide amounted to $312 billion in 2009.** The annual level fluctuates widely with changes in international energy prices, domestic pricing policy, exchange rates and demand. In 2008, when international energy prices spiked, subsidies amounted to $558 billion. In 2009, oil products and natural gas were the most heavily subsidised fuels, attracting subsidies totalling $126 billion and $85 billion, respectively. Subsidies to electricity consumption were also significant, reaching $95 billion in 2009. At only $6 billion, coal subsidies were comparatively small. The vast majority of these subsidies are in non-OECD countries, which are projected to contribute 93% of incremental global energy demand to 2035 in the New Policies Scenario.

- **Considerable momentum is building globally to cut fossil-fuel subsidies.** In September 2009, G20 leaders committed to phase out and rationalise inefficient fossil-fuel subsidies, a move that was closely mirrored in November 2009 by APEC leaders. Many countries are now pursuing reforms, but steep economic, political and social hurdles will need to be overcome to realise lasting gains.

- **Eradicating subsidies to fossil fuels would have a dramatic effect on global energy balances, enhancing energy security, reducing emissions of greenhouse gases and air pollution, and bringing economic benefits.** *WEO-2010* estimates that a universal phase-out of all fossil-fuel consumption subsidies by 2020 — ambitious though it may be as an objective — would cut global primary energy demand by 5%, compared with a baseline in which subsidies remain unchanged. This amounts to the current consumption of Japan, Korea and New Zealand combined. Oil demand would be cut by 4.7 mb/d by 2020, or around one-quarter of current US demand.

- **Phasing out fossil-fuel consumption subsidies could represent an integral building block for tackling climate change.** A complete phase-out would reduce carbon-dioxide emissions by 5.8%, or 2 Gigatonne (Gt), by 2020, equivalent to the current combined emissions of Germany, France, the United Kingdom and Italy. This amounts to over 40% of the abatement needed to be on track by 2020 to limit global warming to a 2°C rise.

- **Although the stated intent of many energy-consumption subsidies is to make energy services more affordable and accessible for the poor, the reality is that only a small proportion of fossil-fuel subsidies go to poor households.** In countries with low levels of modern-energy access, subsidies in the residential sector for kerosene, electricity and LPG — fuels that often support the basic needs of the poor — represented just 15% of fossil-fuel consumption subsidies in 2009. Nonetheless, subsidy-reform programmes need to be carefully designed as low-income households are likely to be disproportionately affected by their removal.

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How green will the energy future be?

- **Renewable energy sources will have to play a central role in moving the world onto a more secure, reliable and sustainable energy path.** The potential is unquestionably large, but how quickly their contribution to meeting the world's energy needs grows hinges critically on the strength of government support to stimulate technological advances and make renewables cost competitive with other energy sources. Government support for renewables can, in principle, be justified by the long-term economic, energy security and environmental benefits they can bring, though it is essential that support mechanisms are cost-effective.

- **The greatest scope for increasing the use of renewables in absolute terms lies in the power sector.** In the New Policies Scenario, renewables-based generation triples between 2008 and 2035 and the share of renewables in global electricity generation increases from 19% in 2008 to almost one-third (catching up with coal). The increase comes primarily from wind and hydropower, though hydropower remains dominant over the *Outlook* period. Electricity produced from solar photovoltaics increases very rapidly, though its share of global generation reaches only around 2% in 2035. The share of modern renewables in heat production in industry and buildings increases from 10% to 16%. The use of biofuels grows more than four-fold over the *Outlook* period, meeting 8% of road transport fuel demand by the end (up from 3% now).

- **Renewables are generally more capital intensive than fossil fuels, so the investment needed to provide the extra renewables capacity is very large.** Investment in renewables to produce electricity is estimated at $5.7 trillion (in year-2009 dollars) over the period 2010-2035. Investment needs are greatest in China, which has now emerged as a leader in wind power and photovoltaic production, as well as a major supplier of the equipment. The Middle East and North Africa region holds enormous potential for large-scale development of solar power, but there are many market, technical and political challenges that need to be overcome.

- **Although renewables are expected to become increasingly competitive as fossil fuel prices rise and renewable technologies mature, the total value of government support is set to rise as their contribution to the global energy mix increases.** We estimate that government support worldwide in 2009 amounted to $37 billion for electricity from renewables and $20 billion for biofuels. In the New Policies Scenario, total support grows to $205 billion (in year-2009 dollars), or 0.17% of global GDP, by 2035. Over the *Outlook* period, 63% of the support goes to renewables-based electricity. Support per unit of generation on average worldwide drops over time, from $55 per megawatt-hour (MWh) in 2009 to $23/MWh by 2035, as wholesale electricity prices increase and their production costs fall due to technological learning. This does not take account of the additional costs of integrating them into the network, which can be significant in some cases, for example, because of the variability of some types of renewables, such as wind and solar energy.

- **The use of biofuels – transport fuels derived from biomass feedstock – is expected to continue to increase rapidly over the projection period, thanks to rising oil prices and government support.** In the New Policies Scenario, global biofuels use increases from about 1 mb/d today to 4.4 mb/d in 2035. The United States, Brazil and the European Union are expected to remain the world's largest producers and consumers of biofuels. Advanced biofuels, including those from ligno-cellulosic feedstocks, are assumed to enter the market by around 2020. The cost of producing biofuels today is often higher than the current cost of imported oil, so strong government incentives are usually needed to make them competitive with oil-based fuels. Globally, government support to biofuels is projected to rise to about $45 billion per year between 2010 and 2020, and $65 billion per year between 2021 and 2035. Government support typically raises costs to the economy as a whole. But the benefits can be significant too, including reduced imports of oil and reduced CO_2 emissions – if sustainable biomass is used and the fossil energy used in processing the biomass is not excessive.

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What will tackling climate change mean for the energy sector?

- **The outcome of the landmark UN conference on climate change held in December 2009 in Copenhagen was a step forward, but still fell a very long way short of what is required to set the world on the path to a sustainable energy system.** The Copenhagen Accord established a non-binding objective of limiting the increase in average global temperature to two degrees Celsius (2°C) above pre-industrial levels. It also set a goal of mobilising funds for climate mitigation and adaptation in developing countries and requires the industrialised countries to set emissions targets for 2020.

- **Were those commitments to be implemented in a *cautious* manner, as assumed in the New Policies Scenario, rising demand for fossil fuels would continue to drive up energy-related CO_2 emissions, making it all but impossible to achieve the 2°C goal.** This is because the reductions in emissions needed after 2020 would become prohibitively expensive or even impossible with today's technologies. In that scenario, global emissions continue to rise through the projection period, though the rate of growth falls progressively. Emissions jump to over 35 Gigatonne (Gt) in 2035 — 21% up on the 2008 level of 29 Gt. Non-OECD countries account for all of the increase; OECD emissions peak before 2015 and then begin to fall. These trends are in line with stabilising the concentration of greenhouse gases (GHG) at over 650 parts per million (ppm) of CO_2-equivalent, resulting in a likely temperature rise of more than 3.5°C in the long term.

- **The 2°C goal can only be achieved with vigorous implementation of current commitments in the period to 2020 and much stronger action thereafter.** According to climate experts, in order to have a reasonable chance of achieving the goal, the concentration of GHGs would need to be stabilised at a level no higher than 450 ppm CO_2-equivalent. Accordingly, the 450 Scenario describes how the energy sector could evolve in order to achieve this objective. It assumes implementation of the measures to realise the more ambitious end of target ranges announced under the Accord as well as more rapid implementation of the removal of fossil-fuel subsidies agreed by the G-20 than assumed in the New Policies Scenario. Emissions reach a peak of 32 Gt just before 2020 and then slide to 22 Gt by 2035 in the 450 Scenario.

- **Cutting emissions sufficiently to meet the 2°C goal would require a far-reaching transformation of the global energy system.** In the 450 Scenario, oil demand peaks just before 2020 at 88 mb/d, only 4 mb/d above current levels, and declines to 81 mb/d in 2035. Coal demand peaks before 2020, returning to 2003 levels by 2035. Among the fossil fuels, demand for natural gas is least affected, though it too reaches a peak before the end of the 2020s. Renewables and nuclear double their current combined share to 38% in 2035. Global energy security is enhanced by the greater diversity of the energy mix.

- **The cost of getting on track to meet the climate goal for 2030 has risen by about $1 trillion compared with the estimated cost in last year's *Outlook*.** This is because much stronger efforts, costing considerably more, will be needed after 2020. In the 450 Scenario in this year's *Outlook,* the additional spending on low-carbon energy technologies (business investment and consumer spending) amounts to nearly $18 trillion (in year- 2009 dollars) more than in the Current Policies Scenario, in which no new policies are assumed, in the period 2010-2035. It is around $13.5 trillion more than in the New Policies Scenario.

- **The timidity of current commitments has undoubtedly made it less likely that the 2°C goal will be achieved.** Reaching that goal would require a phenomenal policy push by governments worldwide: carbon intensity — the amount of CO_2 emitted per dollar of GDP — would have to fall at twice the rate of 1990-2008 in 2008-2020 and four times faster in 2020-2035. The technology exists today to enable such a change, but such a rate of technological transformation would be unprecedented. These commitments must be interpreted in the strongest way possible with much stronger commitments adopted and acted upon after 2020, if not before.