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How will global energy markets evolve to 2035?

- **Major events of the last year have had an impact on short- and medium-term energy trends, but have done little to quench the world's increasing thirst for energy in the long term.** The level and pattern of energy use worldwide varies markedly across the three scenarios in this year's *World Energy Outlook (WEO-2011)*, which differ according to assumptions about government policies on energy and climate change. The New Policies Scenario is the central scenario of *WEO-2011.* It assumes that recent government policy commitments are implemented in a cautious manner.

- **In the New Policies Scenario, world primary demand for energy increases by one-third between 2010 and 2035 and energy-related CO_2 emissions increase by 20%, following a trajectory consistent with a long-term rise in the average global temperature in excess of 3.5°C.** A lower rate of global economic growth in the short term would make only a marginal difference to longer-term energy and climate trends.

- **The dynamics of energy markets are determined more and more by the emerging economies.** Over the next 25 years, 90% of the projected growth in global energy demand comes from non-OECD economies; China alone accounts for more than 30%, consolidating its position as the world's largest energy consumer. In 2035, China consumes nearly 70% more energy than the United States, the second-largest consumer, even though, by then, per-capita energy consumption in China is still less than half the level in the United States. The rates of growth in energy consumption in India, Indonesia, Brazil and the Middle East are even faster than in China. Emerging economies also dominate the expansion of supply: the world will rely increasingly on OPEC oil production as it grows to reach more than half of the global total in 2035. Non-OECD countries account for more than 70% of global gas production in 2035, focused in the largest existing gas producers, including Russia, the Caspian and Qatar.

- **World demand grows for all energy sources.** The share of fossil fuels in global primary energy consumption falls slightly from 81% in 2010 to 75% in 2035. Natural gas is the only fossil fuel to increase its share in the global mix over the period to 2035. Absolute growth in natural gas demand is similar to that of oil and coal combined. Oil demand increases by 15% and is driven by transport demand. Coal demand, dictated largely by emerging economies, increases for around the next ten years but then stabilises, ending around 17% higher than 2010.

- **In the power sector, nuclear generation grows by about 70%, led by China, Korea and India.** Renewable energy technologies, led by hydropower and wind, account for half of the new capacity installed to meet growing demand. Overall, modern renewables grow faster than any other energy form in relative terms, but in absolute terms total supply is still not close to the level of any single fossil fuel in 2035.

- **Large-scale investment in future energy supply is needed.** In the New Policies Scenario, $38 trillion in global investment in energy-supply infrastructure is required from 2011 to 2035, an average of $1.5 trillion per year. Two-thirds of this is required in non-OECD countries. The power sector claims nearly $17 trillion of the total investment. Oil and gas combined require nearly $20 trillion, increasing to reflect higher costs and a need for more upstream investment in the medium and long term. Coal and biofuels account for the remaining investment.

- **The energy world becomes more inter-connected and more focused on Asia.** More than half of world oil consumption is traded across regions in 2035, increasing by around 30% in absolute terms compared with today. Trade in natural gas nearly doubles, with gas from Russia and the Caspian region going increasingly to Asia. India becomes the largest coal importer by around 2020, but China remains the determining factor in global coal markets.

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What will avoiding irreversible climate change mean for the energy sector?

- **On planned policies, rising fossil energy use will lead to irreversible and potentially catastrophic climate change.** Global energy-related emissions of carbon dioxide (CO_2) – the principal greenhouse gas – jumped by 5.3% in 2010 to a record 30.4 gigatonnes (Gt). In the New Policies Scenario, our central scenario, emissions continue to rise, reaching 36.4 Gt in 2035 – an increase of 20%. This trajectory is consistent with a long-term global temperature increase of more than 3.5°C.

- **In the 450 Scenario, global energy-related CO_2 emissions peak before 2020 and then decline to 21.6 Gt by 2035.** This scenario assumes strong policy action to have a 50% probability of limiting temperature increase to 2° Celsius – the globally agreed goal under the United Nations Framework Convention on Climate Change – which would require the long-term atmospheric concentration of greenhouse gases in the atmosphere to be limited to 450 parts per million of CO_2 equivalent.

- **In the 450 Scenario, the primary energy mix is markedly different from that in the New Policies Scenario.** The share of fossil fuels in the global energy mix falls from 81% in 2009 to 62% in 2035. Global demand for both coal and oil peak before 2020, and then decline by 30% and 8% respectively by 2035, relative to their 2009 levels. By contrast, natural gas demand grows by 26%, though it plateaus by around 2030. The 450 Scenario involves additional cumulative investment in and consumer spending on energy-related equipment on the demand and supply sides, totalling $15.2 trillion relative to the New Policies Scenario, but delivers lower fossil-fuel import bills, reduced pollution and improved health benefits.

- **The long economic lifetimes of much of the world's energy-related capital stock mean that there is little scope for delaying action to move onto the 450 emissions trajectory without having to retire some stock early.** We calculate that 80% of the cumulative CO_2 emitted worldwide between 2009 and 2035 in the 450 Scenario is already "locked-in" by capital stock – including power stations, buildings and factories – that either exists now or is under construction and will still be operational by 2035, leaving little additional room for manoeuvre. If internationally co-ordinated action is not taken by 2017, we project that all permissible emissions in the 450 Scenario would come from the infrastructure then existing, so that all new infrastructure from then until 2035 would need to be zero-carbon, unless emitting infrastructure is retired before the end of its economic lifetime to make headroom for new investment. This would theoretically be possible at very high cost, but is probably not practicable politically.

- **The long lifetime of capital stock in the power sector means that the sector accounts for half of the emissions locked-in to 2035.** If action were to be delayed until 2015, around 45% of the global fossil-fuel capacity installed by then would have to be retired early or refurbished by 2035. Delaying action is a false economy. For every $1 of investment in the power sector avoided before 2020, an additional $4.3 would need to be spent after 2020 to compensate for the higher emissions.

- **Carbon capture and storage (CCS) is a key abatement option, accounting for 18% of emissions savings in the 450 Scenario relative to the New Policies Scenario.** But CCS faces regulatory, policy and technical barriers that make its deployment uncertain. In a Delayed CCS 450 Case, adoption is delayed by ten years, compared with the 450 Scenario, meaning CCS is widely deployed only after 2030. This increases the cost of the 450 Scenario by $1.1 trillion, or 8%, and puts unprecedented pressure on other low-carbon technologies. This lends support to the economic case to invest now in CCS.

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What future for oil and gas?

- **Policy action to curb demand for energy-security and climate reasons, and the ability to develop new supplies, will be critical to the long-term outlook for international oil and gas markets.** Global oil demand in the New Policies Scenario increases slowly to 2035, reaching 99 mb/d – up from 87 mb/d in 2010. Oil's share of global primary energy use nonetheless drops from 33% today to 27% in 2035. Growth in demand comes mostly from non-OECD Asia, whilst OECD demand falls. The crude oil price rises to $120/barrel (in year-2010 dollars) in 2035.

- **The transport sector in emerging economies drives all the net oil demand growth.** Non-OECD car markets expand substantially; car sales there exceed those in the OECD by 2020, and the global passenger car fleet is set to double, reaching almost 1.7 billion by 2035, driving up oil consumption despite impressive gains in vehicle fuel economy and increased supplies of biofuels. Alternative vehicle technologies are emerging that use oil much more efficiently or not at all, such as electric vehicles, but it will take time and concerted policy and industry action for them to become commercially viable and penetrate markets.

- **Global oil production (net of processing gains) reaches 96 mb/d in 2035, a rise of 13 mb/d on 2010 levels. A growing share of output** comes from natural gas liquids and unconventional sources. Crude oil supply increases marginally to a plateau of around 69 mb/d (just below the historic high of 70 mb/d in 2008) and then declines slightly to around 68 mb/d by 2035. Nonetheless, gross capacity additions of 47 mb/d – twice current OPEC Middle East production – are needed just to compensate for declining production at existing fields. Non-OPEC production falls marginally, while OPEC's market share expands from 42% in 2010 to 51% in 2035. Increasing reliance on imports in the importing non-OECD regions, notably Asia, will inevitably heighten concerns about the cost of imports and supply security.

- **In a Deferred Investment Case, we examine the implications of upstream investment in the Middle East and North Africa running one-third below the level in the New Policies Scenario in 2011 to 2015.** MENA production is, as a result, more than 6 mb/d lower by 2020; prices jump to $150/barrel, before falling back as production rises. MENA exporters earn more in the near term, thanks to higher prices, but less in the longer term, as they lose market share.

- **Natural gas is projected to play an increasingly important role in the global energy economy.** In the New Policies Scenario, world demand increases to 4.75 tcm in 2035 at an average rate of 1.7% per year. Global gas consumption almost catches up with coal consumption by 2035. Non-OECD countries account for 81% of global gas demand growth. A major expansion of gas use in China pushes domestic demand above 500 bcm by 2035, from 110 bcm in 2010. By sector, power generation is the leading contributor to the global increase in gas demand.

- **Unconventional gas – tight gas, shale gas and coalbed methane – is set to play an increasingly important role**. It accounts for roughly half the estimated global resource base of over 800 tcm; its share in output rises from 13% in 2009 to above 20% in 2035 on the assumption that the industry is successful in dealing with environmental challenges. Gas demand rebounded strongly in 2010, helping Russia regain its position as the worlds largest producer, which it maintains throughout the *Outlook*, with output reaching nearly 860 bcm in 2035; it makes the largest single contribution to total gas supply growth over the projection period.

- **The prospects for oil and gas demand hinge to a large degree on future policy decisions.** In the 450 Scenario, oil demand falls in absolute terms, while gas demand grows more slowly than in New Policies Scenario (by only 0.9% per year on average). Although gas is the cleanest of the fossil fuels, switching from coal and oil to gas (without CCS) only, would not be enough to put us on a CO_2 emissions path consistent with limiting the rise in average global temperatures to 2°C.

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What role for Russia in world energy supply?

- **The energy-policy choices of Russia – a key player in global energy – in the coming years will shape the prospects for Russia's own economic development, but will also have important implications for global energy security and environmental sustainability.** Russia's policies will affect both the outlook for domestic energy demand, which will determine the availability of oil and gas for export, and related CO_2 emissions, as well as investment in energy supply.
- **The energy intensity of Russian GDP has improved in recent years but, even allowing for Russia's industrial structure and harsh climate, energy use in Russia is still highly inefficient.** Raising efficiency in each sector of the economy to the levels of comparable OECD countries would save more than 200 million tonnes of oil equivalent (Mtoe) of primary energy per year – equal to 30% of total demand and an amount similar to the energy used in a year by the United Kingdom.
- **New energy-efficiency policies and price reforms in the New Policies Scenario start to tap into this energy-savings potential, dampening overall increases in demand**. Total demand nonetheless expands by 28% between 2009 and 2035, an annual average growth rate of 1%. The energy efficiency gap between Russia and OECD economies narrows, but it remains significant even in 2035: Russia's energy savings potential, based on projected OECD efficiencies, would still be 18% of total primary consumption. Faster implementation of energy efficiency measures could help to accelerate the modernisation of the Russian economy and thereby reduce more quickly the risks from excessive reliance on the oil and gas sectors.
- **Fossil fuels remain the main sources of energy for Russia and natural gas retains its predominant position in the primary energy supply in the New Policies Scenario.** The share of nuclear and renewable energy rises over the projection period from 10% in 2009 to 15% in 2035, mainly due to an expansion of nuclear power. The contribution of non-hydro renewables increases quickly, but remains small relative both to other fuels and to the large potential.
- **Russia has world-class energy resources sufficient to underpin its continuing role as a major producer and exporter through the projection period and beyond.** But future production levels will be constrained by the long time scales and technical challenges involved in developing new fields in remote areas to compensate for declining production from existing fields.
- **Oil production plateaus at around 10.5 mb/d over the coming five years before starting a slight decline to 9.7 mb/d in 2035 in the New Policies Scenario.** Oil exports decline from 7.5 mb/d in 2010 to 6.4 mb/d in 2035. There is a shift to new, higher-cost production areas in Eastern Siberia, the Caspian and the Arctic, but the key to Russia's oil outlook remains the incentives for investment in the core region of Western Siberia.
- **Gas production is projected to increase from 637 bcm in 2010 to 860 bcm in 2035. Total gas exports rise substantially, from 190 bcm to close to 330 bcm.** Production from the Yamal peninsula becomes the new anchor for Russian gas supply, helping to offset declines in other parts of Western Siberia and to meet demand growth, alongside the Barents Sea and Eastern Siberia. By 2035, Russia provides more than 30% of the gas imported both by the European Union (over 170 bcm) and by China (75 bcm), underlining Russia's central position in Eurasian and global gas security. Although not at the levels of westward Russian gas export to Europe, the Russia-China relationship is set to become one of the main arteries of global gas trade.
- **Total revenues from the export of fossil fuels rise from $255 billion in 2010 to $420 billion (in year-2010 dollars) in 2035.** The shift towards Asian markets for export of Russian oil, gas and coal is reflected in the sources of this revenue: the share of China increases from 2% to 20% over the period from 2010-2035 while that of the European Union falls from 61% to 48%.

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What role for coal in an emissions-constrained world?

- **The long-term outlook for coal markets, more than for the other fossil fuels, depends markedly on government policies towards energy and the environment, especially in China, India and other emerging economies, and how they affect the pace of investment into existing clean coal technologies and the uptake of carbon capture and storage (CCS).** Coal accounted for nearly half of the increase in global energy use over the past decade, driven mainly by surging demand in China's power and industrial sectors.

- **In the New Policies Scenario, global coal use rises through the early 2020s and then remains broadly flat, above 5 850 million tonnes of coal equivalent (Mtce), through to 2035 – one-quarter higher than in 2009.** Coal remains the second-largest primary fuel and the backbone of electricity generation. In the Current Policies Scenario, demand carries on rising after 2020, increasing overall by nearly two-thirds to 2035. But in the 450 Scenario, coal demand peaks before 2020 and then falls heavily, declining one-third between 2009 and 2035.

- **China, responsible for nearly half of global coal use in 2009, holds the key to the future of the coal market with an ambitious 12th Five-Year Plan for 2011-2015 to reduce energy and carbon intensity through enhanced energy efficiency and diversifying the energy mix.** In the New Policies Scenario, China accounts for more than half of global coal-demand growth, its consumption growing by around one-third by 2020 and then declining slightly before remaining broadly stable, above 2 800 Mtce, through to 2035. India also plays an increasingly important role. By more than doubling its coal use to 880 Mtce by 2035 in the New Policies Scenario, India displaces the United States as the world's second-largest coal consumer by 2025.

- **Power generation remains the main driver of global coal demand over the projection period, accounting for at least three-quarters of the increase in both the New and Current Policies Scenarios.** Stronger uptake of existing clean coal technologies and carbon capture and storage could boost the long-term prospects for coal use. If the average efficiency of all coal-fired power plants were to be five percentage points higher than in the New Policies Scenario in 2035, such an accelerated move away from the least efficient combustion technologies would lower CO_2 emissions from the power sector by 8% and reduce local air pollution.

- **Coal is the most abundant fossil fuel globally, with reserves totalling 1 trillion tonnes, or some 150 years of current production.** In the New Policies Scenario, the lion's share of the 20% increase in global coal production between 2009 and 2035 occurs in non-OECD countries. China contributes more than half of the increase in global supply to 2035; the bulk of the rest comes from India and Indonesia. Australia is the only major OECD producer to increase production to 2035; output in the United States falls around 2020, while European output continues its historical decline. Continued depletion of economically attractive seams and the need to shift new investment to deposits that are less easy-to-mine and/or more distant from existing infrastructure are expected to drive supply costs further upwards.

- **In the New Policies Scenario, inter-regional trade in hard coal grows rapidly to 2020, stabilising thereafter above 1 000 Mtce.** The pattern of trade continues to shift towards Pacific Basin markets. Australia and Indonesia command nearly 60% of inter-regional hard coal trade in 2035. India is poised to become the world's biggest importer of hard coal soon after 2020, as rapid demand growth outstrips the rise in indigenous production and India's inland transport capacity. Projected imports reach nearly 300 Mtce in 2035 – about 35% of India's hard coal use and 30% of inter-regional trade in the New Policies Scenario. The international coal market will become increasingly sensitive to developments in China, where marginal variations between very large volumes of coal production and demand will determine China's net trade position.

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How big are energy subsidies and which fuels benefit?

- **Energy subsidies – government measures that artificially lower the price of energy paid by consumers, raise the price received by producers or lower the cost of production – are large and pervasive.** When they are well-designed, subsidies to renewables and low-carbon energy technologies can bring long-term economic and environmental benefits. However, when they are directed at fossil fuels, the costs generally outweigh the benefits.

- **Fossil-fuel consumption subsidies worldwide amounted to $409 billion in 2010, with subsidies to oil products representing almost half of the total.** Persistently high oil prices have made the cost of subsidies unsustainable in many countries and prompted some governments to try to reduce them. In a global survey covering 37 countries where subsidies exist, at least 15 have taken steps to phase them out since the start of 2010. Without further reform, the cost of fossil-fuel consumption subsidies is set to reach $660 billion in 2020, or 0.7% of global GDP (at market exchange rates).

- **Fossil-fuel subsidies carry large costs.** They 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, they often impose a significant fiscal burden on state budgets, while for producers they quicken the depletion of resources and can reduce export earnings over the long term. Furthermore, they are an inefficient means of assisting the poor: only 8% of fossil-fuel subsidies in 2010 were distributed to the poorest 20% of the population.

- **Eliminating fossil-fuel subsidies could bring important economic and environmental benefits.** Relative to a baseline in which rates of subsidy remain unchanged, phasing out those subsidies completely by 2020 would result in savings in oil demand in 2035 of 4.4 mb/d. Global primary energy demand would be cut by nearly 5% and CO_2 emissions by 5.8%.

- **The share of energy subsidies going to renewable energy is poised to continue to grow.** Global renewable-energy subsidies increased from $39 billion in 2007 to $66 billion in 2010, in line with rising production of biofuels and electricity from renewable sources. Despite a projected decline in unit production costs due to cost reductions and rising wholesale prices for electricity and transport fuels, subsidies would need to expand even further to meet existing targets for renewable energy production. In all three scenarios most renewable energy sources need to be subsidised in order to compete in the market.

- **In 2035, subsidies to renewables reach almost $250 billion in the New Policies Scenario.** Onshore wind becomes competitive around 2020 in the European Union and 2030 in China, but not in the United States by the end of the projection period. All other technologies require continuing subsidies.

- **By encouraging deployment, renewable-energy subsidies can help cut greenhouse-gas emissions.** By 2035, the increased use of renewables reduces energy-related CO_2 emissions by 3.4 Gt in the New Policies Scenario (compared with the fuel mix in 2009). The benefits in the 450 Scenario relative to the New Policies Scenario are even greater: additional CO_2 emissions savings of 3.5 Gt and fossil-fuel import-bill savings of $350 billion. However, such subsidies can impose a large financial burden on public finances and on consumers, and may not be the most economically efficient way of reducing emissions.

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