# orld Energy Outlook & Implications of Fukushima



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Without strong and decisive policy action, energy-related emissions will soon be "locked-in," putting the world on a path towards an unsustainable energy future and dangerous climate change. This is one important message from the International Energy Agency's (IEA) flagship publication, the *World Energy Outlook 2011* (WEO 2011), released in November, 2011. In this article, I would like to highlight the key issues necessary to understand the energy landscape through 2035, including implications of less nuclear power in Japan as a consequence of the events in Fukushima.

There are few signs that the urgently needed change in direction in global energy trends is underway. Although the recovery in the world economy since 2009 has been uneven, and future economic prospects remain uncertain, global primary energy demand rebounded by a remarkable 5% in 2010, pushing CO<sub>2</sub> emissions to a new high. Subsidies that encourage wasteful consumption of fossil fuels jumped to over \$400 billion. Despite the priority in many countries to increase energy efficiency, global energy intensity worsened for the second straight year. Against this unpromising background, events such as those at the Fukushima Daiichi nuclear power plant and the turmoil in parts of the Middle East and North Africa (MENA) have cast doubts on the reliability of energy supply, while concerns about sovereign financial integrity have shifted the focus of government attention away from energy policy and limited their means of policy intervention, boding ill for agreed global climate change objectives.

#### General Outlook: Short-term Uncertainty Does Little to Alter Longer-term Picture

Despite uncertainty over the prospects for short-term economic growth, demand for energy grows strongly in the future, increasing by one-third from 2010 to 2035 in the New Policies Scenario. This is the central scenario for the WEO 2011 in which recent government policy commitments are assumed to be implemented in a cautious manner *(Chart 1)*. The assumptions of a global population that increases by 1.7 billion people and 3.5% annual average growth in the global economy generate ever-higher demand for energy services and mobility. A lower assumption of the rate of global GDP growth in the short term would make only a marginal difference to longer-term

### CHART 1

### Growth in primary energy demand



trends.

The dynamics of energy markets are increasingly determined by countries outside the OECD. With continued growth, China consolidates its position as the world's largest energy consumer. The rates of growth in energy consumption in India, Indonesia, Brazil and the Middle East are even faster than in China.

Global investment in energy supply infrastructure of \$38 trillion (in year-2010 dollars) is required over the period 2011 to 2035. Almost two-thirds of the total investment is in countries outside of the OECD. Oil and gas collectively account for almost \$20 trillion, as both the need for upstream investment and the associated cost rise in the medium and long terms. The power sector claims most of the remainder, with over 40% of this being for transmission and distribution networks.

The age of fossil fuels is far from over, but their dominance declines. Oil, coal, and natural gas remain the largest energy sources in the future. However, natural gas is the only fossil fuel to increase its share in the global mix over the period to 2035. Renewable energy sources experience the largest growth, coming mainly from wind and hydropower in the power sector.

### Climate Change: Steps in Right Direction, but Door to 2°C Closing

We cannot afford to delay further action to tackle climate change if the long-term target of limiting the global average temperature increase to 2°C above pre-industrial levels, as analysed in the 450 Scenario, is to be achieved at a reasonable cost. In the New Policies Scenario, the world is on a trajectory that results in a level of emissions consistent with a long-term average temperature increase

Source: OECD/IEA 2011

## CHART 2 CO2 emissions



Source: OECD/IEA 2011

of more than 3.5°C. Without these new policies, we are on an even more dangerous track, for a temperature increase of 6°C or more.

Four-fifths of the total energy-related CO<sub>2</sub> emissions permissible by 2035 in the 450 Scenario are already "locked-in" by our existing capital stock (power plants, buildings, factories, etc.) *(Chart 2)*. If stringent new action is not forthcoming by 2017, the energy-related infrastructure then in place will generate all the CO<sub>2</sub> emissions allowed in the 450 Scenario up to 2035. This would leave no room for additional power plants, factories and other infrastructure unless they are zero-carbon, which would be extremely costly. Delaying action is a false economy: for every \$1 of investment avoided in the power sector before 2020 an additional \$4.3 would need to be spent after 2020 to compensate for the increased emissions.

New energy efficiency measures make a difference, but much more is required. Energy efficiency improves in the New Policies Scenario at a rate twice as high as that seen over the last 25 years, stimulated by tighter standards across all sectors and a partial phase-out of subsidies to fossil fuels. In the 450 Scenario, we need to achieve an even higher pace of change, with efficiency improvements accounting for half of the additional reduction in emissions. The most important contribution to reaching energy security and climate goals comes from the energy that we do not consume.

# Oil: Rising Transport Demand & Upstream Costs Reconfirm End of Cheap Oil

Short-term pressures on oil markets may be eased by slower economic growth and by the expected return of Libyan oil to the market, but trends on both the oil demand and supply sides maintain pressure on prices.

All of the net increase in oil demand comes from the transport sector in emerging economies, as economic growth pushes up demand for personal mobility and freight. Oil demand (excluding biofuels) rises from 87 million barrels per day (mb/d) in 2010 to 99 mb/d in 2035. The total number of passenger cars doubles to almost 1.7 billion in 2035. Sales in non-OECD markets exceed those in the OECD by 2020, with the center of gravity of car manufacturing

shifting to non-OECD countries before 2015. The rise in oil use comes despite some impressive gains in fuel economy in many regions, notably for passenger vehicles in Europe and for heavy freight in the US. Alternative vehicle technologies emerge that use oil much more efficiently or not at all, such as electric vehicles, but it takes time for them to become commercially viable and penetrate markets. With limited potential for substitution for oil as a transportation fuel, the concentration of oil demand in the transport sector makes demand less responsive to changes in the oil price (especially where oil products are subsidised).

The cost of bringing oil to market rises as oil companies are forced to turn to more difficult and costly sources to replace lost capacity and meet rising demand. Oil imports to the US, currently the world's biggest importer, drop as efficiency gains reduce demand and new supplies such as light tight oil are developed. However, increasing reliance on oil imports elsewhere heightens concerns about the cost of imports and supply security. Four-fifths of oil consumed in non-OECD Asia comes from imports in 2035, compared with just over half in 2010. Globally, reliance grows on a relatively small number of producers, mainly in the MENA region, with oil shipped along vulnerable supply routes. In aggregate, the increase in production from this region is over 90% of the required growth in world oil output, pushing the share of OPEC in global production above 50% in 2035.

#### **Natural Gas: Golden Prospects**

There is much less uncertainty over the outlook for natural gas: factors on both the supply and demand sides point to a bright future, even a golden age, for natural gas. The WEO 2011 reinforces the main conclusions of a WEO special report on gas released in June 2011: gas consumption rises in all three scenarios, underlining how gas does well under a wide range of future policy directions. In the New Policies Scenario, demand for gas all but reaches that for coal, with 80% of the additional demand coming from non-OECD countries. Policies promoting fuel diversification support a major expansion of gas use in China; this is met through higher domestic production and through an increasing share of LNG trade and Eurasian pipeline imports. Global trade doubles and more than onethird of the increase goes to China. Russia remains the largest gas producer in 2035 and makes the largest contribution to global supply growth, followed by China, Qatar, the US and Australia.

Unconventional gas now accounts for half of the estimated natural gas resource base and it is more widely dispersed than conventional resources, a fact that has positive implications for gas security. The share of unconventional gas rises to one-fifth of total gas production by 2035, although the pace of this development varies considerably by region. The growth in output will also depend on the gas industry dealing successfully with the environmental challenges: a golden age of gas will require golden standards for production. Natural gas is the cleanest of the fossil fuels, but increased use of gas in itself (without carbon capture and storage) will not be enough to put us on a carbon-emissions path consistent with limiting the rise in average global temperatures to 2°C.

#### **Coal: Treading Water or Full Steam Ahead?**

Coal has met almost half of the increase in global energy demand over the last decade. Whether this trend alters and how quickly is among the most important questions for the future of the global energy economy. Maintaining current policies would see coal use rise by a further 65% by 2035, overtaking oil as the largest fuel in the global energy mix. In the New Policies Scenario, global coal use rises for the next ten years, but then levels off to finish 25% above the levels of 2009. Realisation of the 450 Scenario requires coal consumption to peak well before 2020 and then decline. The range of projections for coal demand in 2035 across the three scenarios is nearly as large as total world coal demand in 2009. The implications of policy and technology choices for the global climate are huge.

China's consumption of coal is almost half of the global demand and its five-year plan for 2011 to 2015, which aims to reduce the energy and carbon intensity of the economy, will be a determining factor for world coal markets. In the New Policies Scenario, the main market for traded coal continues to shift from the Atlantic to the Pacific, but the scale and direction of international trade flows are highly uncertain, particularly after 2020. It would take only a relatively small shift in domestic demand or supply for China to become a net-exporter again, competing for markets against the countries that are now investing to supply its needs.

Widespread deployment of more efficient coal-fired power plants and carbon capture and storage (CCS) technology could boost the long-term prospects for coal, but there are still considerable hurdles.

#### Renewables: Pushed Towards Center Stage

The share of non-hydro renewables in power generation increases from 3% in 2009 to 15% in 2035, underpinned by annual subsidies to renewables that rise almost five-times to \$180 billion (*Chart 3*).

#### CHART 3

### Share of non-hydro renewables in power generation



Source: OECD/IEA 2011

China and the EU drive this expansion, providing nearly half of the growth. Even though the subsidy cost per unit of output is expected to decline, most renewable-energy sources need continued support throughout the projection period in order to compete in electricity markets. The increase of renewables brings lasting benefits in terms of energy security and environmental protection. To accommodate more electricity from renewable sources, sometimes in remote locations, will require additional investment in transmission networks, amounting to 10% of global transmission investment. In the EU, 25% of the investment in transmission networks is needed for this purpose. The contribution of hydropower to global power generation remains at around 15%, with China, India and Brazil accounting for almost half of the 680 gigawatts of new capacity.

#### Nuclear: Second Thoughts Would Have Far-reaching Consequences

Events at Fukushima Daiichi have raised questions about the future role of nuclear power, although they have not changed policies in countries such as China, India, Russia and South Korea that are driving its expansion. In the New Policies Scenario, nuclear output rises by more than 70% over the period to 2035, only slightly less than projected last year. However, we also examine the possible implications of a more substantial shift away from nuclear power in a Low Nuclear Case, which assumes that no new OECD reactors are built, that non-OECD countries build only half of the additions projected in our New Policies Scenario. While creating opportunities for renewables, such a low-nuclear future would also boost demand for fossil fuels: the increase in global coal demand is equal to twice the level of Australia's current steam coal exports and the rise in gas demand is equivalent to two-thirds of Russia's current natural gas exports. The net result would be to put additional upward pressure on energy prices, raise additional concerns about energy security. and make it harder and more expensive to combat climate change. The consequences would be particularly severe for those countries with limited indigenous energy resources that have been planning to rely relatively heavily on nuclear power. It would also make it considerably more challenging for emerging economies to satisfy their rapidly growing demand for electricity.

#### Japan's Energy Outlook

In Japan, energy demand is projected to peak around 2015, and then begin a slow decline. This is driven by a contracting population and falling energy intensity, even though Japan is already one of the most energy-efficient economies in the world, having made strong improvements in recent decades.

Fossil fuels continue to meet the majority of energy demand in Japan. Oil remains the largest energy source, though the amount consumed declines as hybrid, plug-in hybrid and electric vehicles gain market shares. Coal use also falls over time, with its use in the power sector falling by over one-third. Gas use increases, driven by

#### CHART 4

# Japanese primary energy demand in the New Policies Scenario



Source: OECD/IEA 2011

rising demand in the power sector, industry and buildings. Renewables also see rapid growth in Japan, more than doubling in share to meet about 8% of primary energy demand in 2035. In the New Policies Scenario, nuclear is set to provide a larger portion of energy demand. (*Chart 4*)

In preparation for the new Strategic Energy Plan of Japan, there is intense discussion about the future Japanese energy mix. It is important for consideration to be given to the energy security, cost and environmental aspects of each technology, reflecting the unique demand and supply structure of Japan. This is particularly challenging following the events in Fukushima.

#### Low Nuclear Case in Japan: Implications for Japan's Energy Security; Cost & Concern over Climate Change

The IEA has conducted an extended study of the Low Nuclear Case with particular focus on Japan, which illustrates the impacts of a smaller role for nuclear power in Japan, assuming that no new reactors are built beyond those already under construction. In the New Policies Scenario, the rise in the electricity demand in Japan will be supported by a rapid increase in renewables and greater reliance on nuclear and gas. By contrast, the nuclear capacity drops dramatically under the Low Nuclear Case due to the gradual retirement of existing nuclear plants in operation today. The drop in nuclear power generation would be mostly made up by gas power and somewhat more renewables. In the Strategic Energy Plan of Japan of 2010, there is a target for nuclear power to provide 53% of total power supply by 2030. However, in our Low Nuclear Case, the share of nuclear power is around one-third of that level.

The Low Nuclear Case has important implications for Japan's energy security. With scarce fossil fuel production, Japan currently has one of the lowest energy self-sufficiency rates amongst IEA members: 19% including nuclear and 4% without nuclear. In the Low Nuclear Case, the rate of energy self-sufficiency does not change dramatically, with gains made by increasing renewables offset by more gas from overseas. By contrast, self-sufficiency increases to 27% in the New Policies Scenario in 2035. For comparison, other regions such as the US and the EU achieve much higher rates of self-sufficiency.

Another implication of the Low Nuclear Case is the significant additional economic cost. Japan will particularly see a rise in spending on imports of natural gas. In the New Policies Scenario, a shift towards higher use of natural gas will push up the spending on natural gas imports to \$66 billion in 2035, or twice that of today in 2035. Under the Low Nuclear Case, the gas import bill would reach considerably higher levels.

Lastly, less reliance on nuclear in the future would make it more difficult for Japan to meet climate goals. Under the Low Nuclear Case, carbon emissions are higher than in the New Policies Scenario, as the abatement from increased renewables will be more than offset by the greater use of gas. For the Copenhagen Accord, Japan made an ambitious pledge to reduce emissions by 25% in 2020 compared to 1990 levels. This looks very challenging, as under both the New Policies Scenario and the Low Nuclear Case the CO<sub>2</sub> emissions would increase slightly compared to 1990.

#### Implications for Japan from WEO 2011

I'd like to conclude by outlining the implications of recent events and analysis of WEO 2011 on Japan's energy future.

Firstly, Japan's response to Fukushima has the potential to provide several valuable lessons to the global energy community. The efforts to manage the accident and bring the plant to cold shutdown, as well as the plants that were able to endure the earthquake and tsunami provide valuable information for enhanced nuclear safety. The successful energy efficiency measures that overcame the severe summer power shortage after the accident make it clear that there is much more energy-saving potential globally, even in the most energy-efficient countries. The recovery plan includes building smart-cities in the earthquake-affected areas, providing an opportunity to see the application of cutting-edge technologies.

Secondly, energy policymaking needs to consider security, affordability and sustainability. Energy efficiency, renewables and the safe use of nuclear are all essential.

Thirdly, our analysis of the Low Nuclear Case found that it would carry large economic costs for Japan, raise energy security concerns, and increase emissions, compared to the New Policies Scenario.

Fourthly, in all scenarios, the role of renewables expands, but this requires improved flexibility of generating capacity, strengthened grids, and better regulatory/market frameworks.

Finally, the end of the 'cheap energy era' gives Japan further impetus to push towards a low-carbon economy, which incorporates energy efficiency, renewables, nuclear, smart-grids, electric vehicles, and other advanced technologies.

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