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World Energy Outlook 2015

EXECUTIVE
SUMMARY

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
 - Improve transparency of international markets through collection and analysis of energy data.
 - Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
 - Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

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The European Commission also participates in the work of the IEA.

Signs of change in global energy have multiplied in the 12 months since the last *World Energy Outlook (WEO)*. Oil prices fell sharply, with the prices of other fuels moving in tandem in many parts of the world. Countries including India and Indonesia took advantage of the oil price decline to move ahead with their phase-out of fossil-fuel subsidies. Amid turmoil in parts of the Middle East, a clear pathway opened up that could lead to the return of Iran, one of the world's largest hydrocarbon resource-holders, to oil markets. China's role in driving global trends is changing as it enters a much less energy-intensive phase in its development. Renewables contributed almost half of the world's new power generation capacity in 2014. The coverage of mandatory energy efficiency regulation worldwide expanded to more than a quarter of global consumption. There was also a tantalising hint in the 2014 data of a de-coupling in the relationship between CO₂ emissions and economic activity, until now a very predictable link. As countries prepare for the critically important UN climate summit in Paris (also known as COP21) and its legacy, it is more important than ever for policy-makers, industry and other stakeholders to have a clear understanding of the state of the energy sector today, to see which changes are transient or cyclical, which are here to stay, what risks and opportunities might lie ahead – and what can be done to put the energy system on a more secure and sustainable footing. The *WEO-2015*, with scenario-based analysis looking out to 2040 and multiple case studies along the way, provides insights on all of these questions.

Pledges made in advance of COP21 promise to give new impetus to the move towards a lower-carbon and more efficient energy system, but do not alter the picture of rising global needs for energy. Energy use worldwide is set to grow by one-third to 2040 in our central scenario, driven primarily by India, China, Africa, the Middle East and Southeast Asia. Non-OECD countries account together for all the increase in global energy use, as demographic and structural economic trends, allied with greater efficiency, reduce collective consumption in OECD countries from the peak reached in 2007. Declines are led by the European Union (-15% over the period to 2040), Japan (-12%) and the United States (-3%). The preparations for COP21 have been a rich source of guidance on future energy policy intentions and the energy-related components of COP21 pledges are reflected, based on a country-by-country assessment, in our central scenario. They provide a boost to lower-carbon fuels and technologies in many countries, bringing the share of non-fossil fuels up from 19% of the global mix today to 25% in 2040. Among the fossil fuels, natural gas – the least-carbon intensive – is the only one that sees its share rise.

China re-tunes the engine of global energy demand

China's transition to a less energy-intensive model for growth has major implications for global trends. China carries huge weight in the world of energy: it remains by a distance the world's largest producer and consumer of coal throughout our *Outlook* period; it deploys more renewable power generation capacity than any other country; and by the 2030s it

overtakes the United States as the biggest consumer of oil and has a larger gas market than the European Union. China's total energy demand in 2040 is almost double that of the United States. But structural shifts in the economy, favouring expansion of the services sector rather than heavy industry (both steel and cement production are likely to have peaked in 2014), mean that 85% less energy is required to generate each unit of future economic growth than was the case in the past 25 years. Policy choices also change the face of China's energy system and the pace at which it expands. China is set to introduce an emissions trading scheme in 2017 covering the power sector and heavy industry, helping to curb the appetite for coal. From a mere 3% in 2005, half of China's energy use today is already subject to mandatory efficiency standards, and continued improvements in efficiency, alongside large-scale deployment of wind, solar, hydro and nuclear power, lead to a flattening and then a peak in China's CO₂ emissions around 2030.

India seizes the centre of the world energy stage

India – the subject of an in-depth country focus in *WEO-2015* – contributes the single largest share of growth, around one-quarter, in global energy demand. India today is home to one-sixth of the world's population and its third-largest economy, but accounts for only 6% of global energy use and one in five of the population – 240 million people – still lacks access to electricity. With policies in place to accelerate the country's modernisation and develop its manufacturing base (via the "Make in India" programme), population and incomes on the rise and an additional 315 million people anticipated to live in India's cities by 2040, India is entering a sustained period of rapid growth in energy consumption. Demand for coal in power generation and industry surges, increasing the share of coal to almost half of the energy mix and making India by a distance the largest source of growth in global coal use. Oil demand increases by more than in any other country, approaching 10 mb/d by the end of the period. India also steps up its deployment of low-carbon technologies, although uncertainty over the pace at which new large dams or nuclear plants can be built means strong reliance on solar and wind power (areas where India has high potential and equally high ambition) to deliver on its pledge to have a 40% share of non-fossil fuel capacity in the power sector by 2030.

Meeting India's energy needs requires a huge commitment of capital and constant vigilance as to the implications for energy security and the environment. Pressing ahead with the overhaul of India's energy regulatory framework is critical to secure the estimated \$2.8 trillion of investment that is needed in energy supply to 2040. Three-quarters of this investment goes to the power sector, which needs to almost quadruple in size to keep up with projected electricity demand but which remains beset for now by high network losses and high financial losses among the local distribution utilities. The expansion of coal supply makes India the second-largest coal producer in the world, but also, already by 2020, the world's largest coal importer, overtaking Japan, the EU and China. Oil production falls well behind the growth in demand, pushing oil import dependence above 90% by 2040. A rapidly expanding energy sector could exacerbate already serious challenges with water

stress and local air pollution: integrated policies on land use and urbanisation (the “smart cities” initiative), pollution controls, technology development, and a relentless focus on energy efficiency can mitigate these risks and avoid locking in an inefficient capital stock.

A faster pace is essential to reach the 2030 goal of universal energy access

India makes rapid gains in bringing energy access to its people, but the world as a whole is falling short of its ambition to provide affordable, reliable, sustainable and modern energy for all. Despite the serious efforts already made, today an estimated 1.2 billion people – 17% of the global population – remain without electricity, and 2.7 billion people – 38% of the global population – put their health at risk through reliance on the traditional use of solid biomass for cooking. The newly agreed UN Sustainable Development Goals embrace a goal on energy, a move long advocated by the IEA, including the target to achieve universal access to energy by 2030. In our *Outlook*, the number of people without electricity falls to 800 million by 2030 and the number without access to clean cooking fuels declines only gradually to 2.3 billion in 2030.

Oil prices head higher as markets work off the excess supply, but risks remain

The process of adjustment in the oil market is rarely a smooth one, but, in our central scenario, the market rebalances at \$80/bbl in 2020, with further increases in price thereafter. Demand picks up to 2020, adding an average of 900 kb/d per year, but the subsequent rise to 103.5 mb/d in 2040 is moderated by higher prices, efforts to phase out subsidies (provided that momentum behind reform is maintained, even as oil prices pick up), efficiency policies and switching to alternative fuels. Collectively, the United States, EU and Japan see their oil demand drop by around 10 mb/d by 2040. On the supply side, the decline in current upstream spending, estimated at more than 20% in 2015, results in the combined production of non-OPEC producers peaking before 2020 at just above 55 mb/d. Output growth among OPEC countries is led by Iraq and Iran, but both countries face major challenges: the risk of instability in Iraq, alongside weaknesses in infrastructure and institutions; and the need in Iran (assuming the path to sanctions relief is followed successfully) to secure the technology and large-scale investment required. An annual \$630 billion in worldwide upstream oil and gas investment – the total amount the industry spent on average each year for the past five years – is required just to compensate for declining production at existing fields and to keep future output flat at today’s levels. The current overhang in supply should give no cause for complacency about oil market security.

The short investment cycle of tight oil and its ability to respond quickly to price signals is changing the way that the oil market operates, but the intensity with which the tight oil resource is developed in the United States eventually pushes up costs. US tight oil production stumbles in the short term but resumes its upward march as prices recover, helped by continued improvements in technology and efficiency improvements. But tight oil’s rise is ultimately constrained by the rising costs of production, as operators deplete the “sweet spots” and move to less productive acreage. US tight oil output reaches a plateau in the early-2020s, just above 5 mb/d, before starting a gradual decline.

What if prices stay lower for longer?

A more prolonged period of lower oil prices cannot be ruled out. We examine in a Low Oil Price Scenario what it would take for this to happen – and what it would mean for the entire energy sector if it did. The oil price in this scenario remains close to \$50/bbl until the end of this decade, before rising gradually back to \$85/bbl in 2040. This trajectory is based on assumptions of lower near-term growth in the global economy; a more stable Middle East and a lasting switch in OPEC production strategy in favour of securing a higher share of the oil market (as well as a price that defends the position of oil in the global energy mix); and more resilient non-OPEC supply, notably from US tight oil. With higher demand, led by the transport sector, pushing oil use up to 107 mb/d in 2040, the durability of this scenario depends on the ability and willingness of the large low-cost resource-holders to produce at much higher levels than in our central scenario. In the Low Oil Price Scenario, the Middle East's share in the oil market ends up higher than at any time in the last forty years.

The likelihood of the oil market evolving in this way over the long term is undercut by the effect on producer revenues: OPEC oil export revenue falls by a quarter relative to our central scenario, despite the higher output. Lower prices are not all good news for consumers. The economic benefits are counterbalanced by increasing reliance on the Middle East for imported crude oil and the risk of a sharp rebound in price if investment dries up. Concerns about gas supply security would also be heightened if prices stay too low to generate the necessary investment in supply. Lower oil prices alone do not have a large impact on the deployment of renewable energy technologies in the power sector, but only if policymakers remain steadfast in providing the necessary market rules, policies and subsidies. The outlook for biofuels is hit by cheaper conventional transport fuels, as is the uptake of vehicles powered by electricity and natural gas and the incentive to invest in more efficient technologies. In a Low Oil Price Scenario, longer payback periods mean that the world misses out on almost 15% of the energy savings seen in our central scenario, foregoing around \$800 billion-worth of efficiency improvements in cars, trucks, aircraft and other end-use equipment, holding back the much-needed energy transition.

No plain sailing for natural gas

Where it replaces more carbon-intensive fuels or backs up the integration of renewables, natural gas is a good fit for a gradually decarbonising energy system: a consumption increase of almost 50% makes it the fastest-growing of the fossil fuels. China and the Middle East are the main centres of gas demand growth, both becoming larger consumers than the European Union, where gas use does not return to the peak reached in 2010. With gas prices already low in North America, and dragged lower elsewhere by ample supply and contractual linkages to oil prices, there is plenty of competitively priced gas seeking buyers in the early part of the *Outlook*. But the extent of the longer term expansion is constrained by efficiency policies, notably in the buildings sector, and competition from renewables and (in some countries) from coal in power generation; and could be limited further if deferred investment in the current low-price environment brings tighter markets in the 2020s. One-fifth of the projected rise in global demand consists of gas transported over long distances via very capital-

intensive pipeline or LNG projects. Keeping these project costs under control (contrary to numerous recent examples of overruns) will be vital to the future competitive positioning of gas. Emissions of methane, a powerful greenhouse gas, along the supply chain will dent the environmental credentials of gas if there is no concerted policy action to tackle these leaks. Unconventional gas accounts for some 60% of the growth in global gas supply, but the spread of its development beyond North America, the home of the shale gas revolution, is more gradual and uneven. The pace of China's unconventional gas growth is a major uncertainty: policies encouraging this development are in place – with production projected to exceed 250 bcm by 2040 – but aspects of the geology, limited water availability and population density in some key resource-rich areas, alongside regulatory issues related to pricing, access to resources and to domestic pipelines, militate against a very rapid rise in output.

And turbulent times ahead for coal

Coal has increased its share of the global energy mix from 23% in 2000 to 29% today, but the momentum behind coal's surge is ebbing away – and the fuel faces a reversal of fortune. Expectations within the industry of continued strong demand growth, especially in China, triggered major investments in supply in recent years but actual coal use has fallen well short, resulting in over-capacity and plummeting prices. In our projections, the fuel that met 45% of the increase in global energy demand over the last decade meets only around 10% of further growth to 2040, largely due to a tripling in coal demand in India and in Southeast Asia.¹ Consumption in the OECD, where coal use faces strong policy headwinds, is projected to drop by 40% over the same period: coal consumption in the European Union in 2040 falls to around one-third of current levels. From a position as a perceived safe bet, China is becoming the wild card of coal markets, with the risks to our projection of a plateau and then a slow decline in coal demand arguably weighted to the downside. By 2040, Asia is projected to account for four out of every five tonnes of coal consumed globally, and coal remains the backbone of the power system in many countries in our central scenario. However, its continued use around the world is compatible with stringent environmental policies only if it is used in the most efficient way, with advanced control technologies to reduce air pollution, and if progress is made in demonstrating that CO₂ can be safely and cost-effectively captured and stored.

The power sector is leading the charge to decarbonise

Electricity gains ground in many end-use sectors, making up almost a quarter of final energy consumption by 2040; the power sector leads the way towards a decarbonised energy system. Non-OECD countries account for seven out of every eight additional units of electricity demand. With 60 cents of every dollar invested in new power plants to 2040 spent on renewable energy technologies, global renewables-based electricity generation increases by some 8 300 TWh (more than half of the increase in total generation),

1. The energy outlook for Southeast Asia was the subject of a *WEO-2015* special report, released in October 2015. Download at: www.worldenergyoutlook.org/southeastasiaenergyoutlook/.

equivalent to the output of all of today's fossil-fuel generation plants in China, the United States and the European Union combined. The net result is that the share of coal in the global electricity mix drops from 41% to 30%, with non-hydro renewables gaining a similar amount, while gas, nuclear and hydro broadly maintain their existing shares. By 2040, renewables-based generation reaches a share of 50% in the European Union, around 30% in China and Japan, and above 25% in the United States and India: by contrast, coal accounts for less than 15% of electricity supply outside of Asia. Despite both more costly technologies and rising fossil-fuel prices, electricity is set to become more affordable, relative to GDP, in most regions. With more generation from renewables energy and nuclear power, and more efficient thermal plants, CO₂ emissions from power generation are set to grow at only one-fifth of the rate at which power output rises to 2040; this was a one-to-one relationship over the last 25 years. To realise these projections, the world needs to add more capacity by 2040 than is globally installed today, while average utilisation rates for capacity go down because of the need to integrate variable renewable technologies. This raises questions in many countries about the appropriate market mechanisms that can generate the necessary investment in generation and grids.

And efficiency measures are gathering strength

Energy efficiency plays a critical role in limiting world energy demand growth to one-third by 2040, while the global economy grows by 150%. Mandatory targets in China and India (following on from first-mover Japan) have increased the global coverage of efficiency regulation in industry from 3% in 2005 to more than a third today, and such energy policies continue to expand their reach and effectiveness through to 2040. In OECD countries, efficiency measures reduce demand growth to 60% of what would otherwise be expected. But our central scenario far from exhausts the potential for efficiency improvements. We estimate that the energy efficiency of new equipment bought worldwide in 2030 can be increased by a further 11%, with the average cost of the energy saved being \$300 per tonne of oil equivalent (toe), far below the weighted average energy price of \$1 300/toe. Energy consumption in trucks and heavy-duty vehicles is currently regulated only in the United States, Canada, Japan and China, with regulation planned also in the European Union: wider geographical coverage and more stringent standards could cut oil demand from new trucks in 2030 by 15%. Changing product design, re-use and recycling ("material efficiency") also offers huge potential for energy saving; for energy-intensive products such as steel, cement, plastics or aluminium, efficient use and re-use of materials can save more than twice as much energy as can be saved by efficiency measures in the production process to 2040.

The balance is shifting towards low-carbon technologies

Policy preferences for lower carbon energy options are reinforced by trends in costs, as oil and gas gradually become more expensive to extract while the costs of renewables and of more efficient end-use technologies continue to fall. Oil and gas production costs increase for most resource types as operators are forced to move to

smaller, more remote or more challenging reservoirs, although the effect is dampened by technology and efficiency improvements. By contrast, cost reductions are the norm for more efficient equipment and appliances, as well as for wind power and solar PV, where technology gains are proceeding apace and there are plentiful suitable sites for their deployment. Fossil-fuel consumption continues to benefit from large subsidies: we estimate this global subsidy bill at around \$490 billion in 2014, although it would have been around \$610 billion without reforms enacted since 2009. Subsidies to aid the deployment of renewable energy technologies in the power sector were \$112 billion in 2014 (plus \$23 billion for biofuels). Supportive government policies and related subsidies continue to be critical to most of the capacity deployed, as only a few countries put a significant price on carbon in our central scenario. The need for subsidies however, is restrained by a shift in deployment to countries with higher quality renewable resources, by continued cost reductions and higher wholesale prices. A 50% rise in subsidies, to an estimated \$170 billion in 2040, secures a five-fold increase in generation from non-hydro renewables (without the cost reductions and higher wholesale prices, the subsidy bill in 2040 would exceed \$400 billion). The share of non-hydro-renewables that is competitive without any subsidy support doubles to one-third.

The direction of travel is changing, but the destination is still not 2 degrees

Despite the shift in policy intentions catalysed by COP21, more is needed to avoid the worst effects of climate change. There are unmistakable signs that the much-needed global energy transition is underway, but not yet at a pace that leads to a lasting reversal of the trend of rising CO₂ emissions. Annual investment in low-carbon technologies in our central scenario increases, but the cumulative \$7.4 trillion invested in renewable energy to 2040 represents only around 15% of total investment in global energy supply. The steady decarbonisation of electricity supply is not matched by a similarly rapid shift in end-use sectors, where it is much more difficult and expensive to displace coal and gas as fuels for industry, or oil as a transport fuel. The net result is that energy policies, as formulated today, lead to a slower increase in energy-related CO₂ emissions, but not the full de-coupling from economic growth and the absolute decline in emissions necessary to meet the 2 °C target. A *WEO* special report released in June 2015, *Energy and Climate Change*, showed what more can be done, at no net economic cost, to bring about a peak in energy-related emissions by 2020 – an essential step if the door to a 2 °C outcome is to remain open:

- Increasing energy efficiency in the industry, buildings and transport sectors.
- Progressively reducing the use of the least-efficient coal-fired power plants and banning their construction.
- Increasing investment in renewable energy technologies in the power sector from \$270 billion in 2014 to \$400 billion in 2030.
- Phasing out of remaining fossil-fuel subsidies to end-users by 2030.
- Reducing methane emissions in oil and gas production.

The conclusion, reinforced by projections from our *WEO-2015* central scenario, is that the framework for climate action agreed at COP21 needs to provide a procedure which will secure progressively stronger climate commitments over time if the world is to keep to an emissions trajectory consistent with the 2 °C goal. A clear and credible vision of long-term decarbonisation is vital to provide the right signals for investment and to allow a low-carbon, high-efficiency energy sector to be at the core of international efforts to combat climate change.

This publication and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

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World Outlook Energy 2015

Big questions abound in global energy in 2015:

- Could **oil prices** stay lower for longer? What would it take for this to happen and what would it mean for energy security and for the energy transition?
- **India** is set for a period of rapid, sustained growth in energy demand: how could this re-shape the energy scene?
- What do new **climate pledges** mean for the way that the world meets its rising needs for energy?
- What are the implications of the rising coverage of **energy efficiency** policies and the growing competitiveness of **renewables**?
- Is the **unconventional gas revolution** going to go global or to remain a North American phenomenon?

These issues – and many more – are discussed here, with a special focus on India accompanying the customary, in-depth *WEO* analysis of the prospects for all fossil fuels, renewables, the power sector and energy efficiency around the world to 2040.

For more information, please visit: www.worldenergyoutlook.org