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Key Points

Oil market

- Rising non-OPEC **oil production** is changing global trade patterns, but is unlikely to bring prices down;
- long-haul trade may decline in the medium term as more oil is refined closer to the well-head; meanwhile, US refining has become more profitable, and is affecting investments elsewhere: once the world's biggest product importer, the US is now its biggest exporter;
- this transformation both up-stream and down-stream raises significant energy security challenges and may also have important consequences for price formation and market volatility.

Gas

- By contrast, the proportion of **gas** delivered by long distance transportation has risen rapidly and non-conventional development is not expected to change this trend;
- gas supply security has to be multi-dimensional: flexibility in fuel-switching, diversified markets, better storage.

Power sector

- **Electricity** is the fastest-growing energy sector: it represents half the energy investment needs in the coming decades;
- electricity security needs adequate generation capacity and flexible distribution systems: regulators must ensure the market delivers enough investment.

Long-term outlook

- **Global trends to 2035** reflect major shifts in economic growth, demographics, electrification and efforts at de-carbonisation – and also rapid innovation in the energy sector;
- but there is a growing disconnect between the greenhouse-gas emissions trajectory that the world is on and one that is consistent with the **2 °C climate goal**.
- The New Policies Scenario sees **oil** demand reach 101.4 mb/d by 2035 (up by 1.1% pa to 2020, then more slowly thereafter) with increases mainly in Asia and the Middle East and declines in OECD;
- conventional crude share falls from 80% to 67% (because of non-conventionals and NGLs), but call on OPEC, mainly Middle East and especially Iraq, rises again after 2020;
- major changes in trade patterns for both crude and products continue to pose challenges: consumption shifts to Asia and the Middle East putting 10 mb/d of refining capacity at risk.

- **Coal** remains cheap, but demand will be affected by policy choices, especially in China.
- Growth in **natural gas** out-paces other fuels, growing by more than oil and coal combined by 2035.
- **Nuclear** power increases by two thirds to reach 4,300 twh – dominated by China, Korea, India and Russia: the non-OECD share rises from 20% TO 45%.

Renewables

- Modern **renewables** rise nearly 2 ½ times by 2035, driven by government incentives, high fossil fuel prices and technology-driven cost reductions;
- in recent years, renewables have consistently beaten expectations, rising by 5.8% pa between 2006 and 2013. They should rise another 40% by 2018 given strong policies in emerging markets and increasing competitiveness against fossil fuels.
- Large-scale integration of renewables is possible but needs increased flexibility in the grid system.

Energy Efficiency

- Energy productivity is now improving more rapidly. With major investments, energy efficiency can yield even greater dividends over the long term. In some countries it is estimated energy saved could represent the biggest single fuel source.

Sustainable energy for all

- **Access to energy** by 2035 is globally better, but still poor in certain areas such as sub-Saharan Africa

The current oil market

A non-conventional supply revolution in North America is reshaping the global oil market and industry, sending shock waves across the globe and through the entire supply chain. This process of transformation, profound as it may be, should not however be construed as ushering in a new era of energy “abundance,” or signalling a looming supply glut leading to lower prices. Nor does it suggest that oil from conventional sources may no longer be as badly needed by the market as it once was, or that conventional producers from OPEC countries or elsewhere will face the need to “cut back” and ”make room” for non-conventional supply.

While non-OPEC supply growth has risen to levels unseen in decades, oil prices have remained relentlessly high. High prices and unconventional supply growth in fact go hand in hand. Record prices played a key role in making the non-conventional supply revolution possible in the first place, unlocking challenging resources that were previously deemed too costly to produce. Although light tight oil production has since become more efficient, most US plays still require high prices to produce. Should prices fall, it is widely expected that US light tight oil production growth would quickly slow down, in turn shoring up prices. Non-OPEC supply growth is projected to remain extremely high in the short and medium term. While oil prices may ease somewhat over that period, there is nothing inevitable about this outcome.

Rather than creating an oil glut, surging non-conventional supply growth has so far merely offset disruptions elsewhere, such as the partial unavailability of Iranian crude due to international sanctions, or protracted disruptions in Libyan crude and exports after the Libyan civil war of 2011 and the subsequent resumption of political unrest in 2013. What has been called the “Arab Spring” has also caused supply disruptions in Yemen and Syria, while insecurity has re-emerged as a growing impediment to supply growth elsewhere in the MENA region, including, but not limited to, Iraq and Algeria. Since 2011, about the time when surging non-conventional production emerged as a major factor in the market, unplanned supply disruptions have risen from an annual average of less than 500 kb/d to somewhere around 2 mb/d-3 mb/d (depending on how it is counted). Elsewhere, production growth has been adversely affected by below-ground issues, such as unplanned or longer-than-planned maintenance at aging fields and accelerating decline rates. If non-conventional oil production is excluded, non-OPEC supply growth has in recently years been exceptionally poor, and is largely expected to remain so on balance in the foreseeable future.

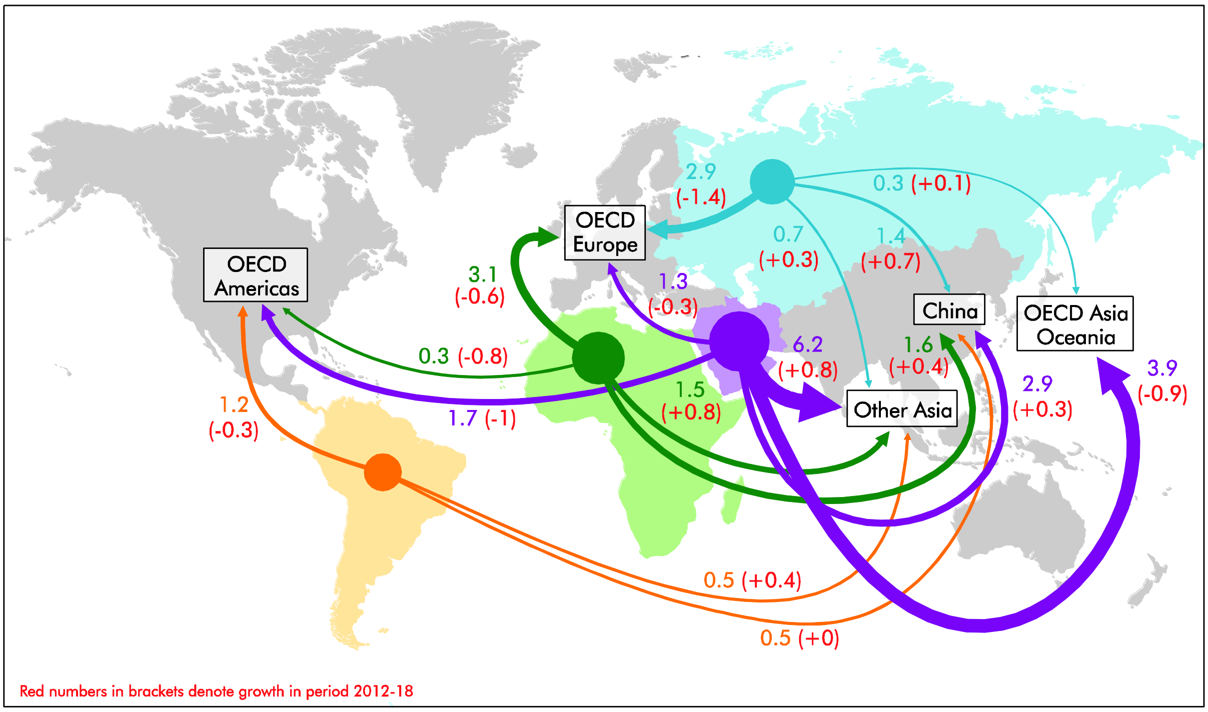
Not surprisingly, recent energy market statistics have yet to provide evidence of a supply overhang. Far from building, commercial oil inventories in OECD countries plummeted in late 2013, falling by around 1.5 mb/d in the fourth quarter of 2013 for a total drop of 137 million barrels. That was the steepest quarterly OECD stock draw since 1999, when OPEC producers implemented large-scale, coordinated production cuts to shore up falling oil prices. The deficit of oil inventories to their five-year average widened to levels unseen since the 2003-2008 price rally.

Demand effects of surging non-conventional supply have played a part in tightening fundamentals. While new supply has been largely counter-balanced by supply disruptions elsewhere, surging non-conventional oil production in North America has stimulated demand, spurring an unexpected ‘Renaissance’ in the North American petrochemical industry. Reversing two years of contraction, OECD demand rebounded in 2013 by an estimated 0.1 mb/d on average over the year, led by a 0.4 mb/d rebound in US demand. In contrast, non-OECD demand growth was weaker than expected in 2013, on slowing economic growth, in particular in China, and currency issues in several other non-OECD Asian countries.

Two other key, lasting impacts on the non-conventional supply revolution can be singled out. First, the geographical redistribution of non-OPEC supply growth from the FSU to the western hemisphere, compounding the impact of shifting demand growth to the East of Suez markets of Asia and the Middle East, is profoundly redrawing long-haul crude trade flows. The volumes of internationally traded crude are expected to decrease in the medium term, as more and more crude is being processed closer to the wellhead: on the one hand, North American refiners source more crude at home, while on the other hand Middle Eastern refiners have been expanding their refining capacity and processing more crude at home instead of exporting it. The main trade routes are also migrating eastward: the western hemisphere becomes increasingly self-sufficient, whereas the oil partnership between import-dependent Asian consumer economies and export-oriented MENA producer economies is getting deeper.

Figure 1. Crude Exports in 2018 and Growth over 2012-18 for Key Trade Routes

(million barrels per day)



This map is 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.

Note: Excludes intra-regional trade. Source: IEA Medium Term Oil Market Report, 2013

Second, the non-conventional supply revolution is having a deep impact on the downstream sector. Thanks to surging domestic production of shale gas and light tight oil, the US, just a few years ago the world's largest importer of refined products, has become its largest product exporter. The global refining story is being rewritten.

For the last decade, the refining industry largely tracked underlying developments in the broader economy and global oil demand. As both economic growth and oil demand shifted towards emerging markets, so did investments in the downstream sector and in turn refinery capacity and crude oil throughputs. The mature OECD market saw both its oil demand contract and its refining industry consolidate, while the non-OECD, and in particular Asia, experienced unprecedented growth. Due to the long lead time of refining expansion projects, emerging-market economies tried to anticipate future demand growth by aggressively investing in the downstream sector. Thus global refining capacity has been migrating even faster than end-user demand from one part of the global economy to the other: while non-OECD economies are only expected to overtake the OECD in oil demand some time this year, in the downstream sector the shift already occurred in 2011.

The non-conventional supply revolution has derailed this trend. The shale and light tight oil revolution has given US refiners a huge competitive advantage, building on the advantages that economies of scale, good logistical connections and state-of-the-art technology were already giving them. US capacity is expanding, as is US refinery utilisation. With domestic consumption down on 2007 levels, exports have surged. This is now causing non-OECD refiners to revisit their expansion plans: Chinese companies, concerned about looming domestic and global capacity surplus, have been scaling back or putting on hold major expansion or grassroots projects.

The non-conventional supply revolution is first and foremost an upstream revolution. But this supply shock is causing ripple effects downstream, including in transportation, storage, refining and petrochemicals. This transformation is raising significant energy security challenges and will likely also come with important consequences for price formation and market volatility.

Maintaining gas and electricity supply security

Gas supply security and market functioning

Natural gas is increasing its share in global energy consumption. In the past decade the proportion of gas delivered by long distance transportation has risen rapidly and non-conventional development is not expected to change this trend: geological endowments and industry capabilities differ measurably, so non-conventional gas production will have a different but also uneven geographical distribution. Gas fired power generation plays a critical role in electricity security in a number of countries, whereas building heating in winter is an application where short term substitution is limited and the social consequences of an interruption are very serious. Consequently gas supply security is a legitimate policy concern and was made formally part of the IEA's agenda in the 2009 Ministerial.

Nevertheless, there are major fundamental differences between oil and gas in both market functioning as well as demand side technologies that make the mechanistic expansion of the existing oil supply security framework neither feasible not desirable. Oil is predominantly used in the transportation sector, where short term substitution is all but impossible, and even long term substitution options are limited. Infrastructure and transportation costs are minor compared to the value of the commodity, leading to efficient global markets; and storage costs are also low enough to make a substantial strategic stockpile system a realistic policy option. If sufficient supplies are available globally, under normal circumstances the market can be trusted to deliver them. Gas has a more diversified utilisation, with the main sectors being:

- Building heating, which has very little flexibility in the short term, but a large potential to improve efficiency in the long term.
- Industrial heat and chemical processes, which theoretically have flexible ability to respond to a crisis (shutting down facilities) but only at a very high economic cost in lost GDP.
- Power generation, which depending on the structure of the electricity system can have meaningful demand side flexibility.

For the same upstream investment an order of magnitude higher infrastructure investment is needed to bring gas to markets. This leads to segmentation: a global natural gas market does not exist; infrastructure barriers, rigid long term contracts and destination clauses hinder the ability of markets to direct supply where it is most needed. Gas storage is much more expensive than oil storage, and the cheapest option, depleted gas field storage, is of limited use in emergency response as such facilities are usually designed for a winter – summer cycle.

As a result of these fundamental differences gas supply security policy has to be multi-dimensional and adequately reflect regional characteristics. Three main sets can be identified:

Maintain fuel switching flexibility in the electricity sector

In practice the substitution is between coal and gas in the power sector as both renewables and nuclear plants have limited operational flexibility. A major component of gas supply security is to ensure that coal remains a viable energy source while not jeopardising environmental objectives. Increasing coal fired power generation in the UK was a significant contributor to ensuring additional gas supplies to Japan by reducing UK LNG imports and enabling their redirection to Japan. In fact coal imported to Europe from the United States and South Africa was the single biggest source of additional energy supply that enabled the adjustment of gas markets to post Fukushima demand increase. EU LNG imports declined by more than the entire exports of Nigeria. However, as every single coal plant in the UK is slated for decommissioning and several on the continent as well, this strategic flexibility will largely be lost. In addition to adequate power generation capacity, IEA analysis suggests that fuel switching flexibility and consequently gas supply security is enhanced by efficient wholesale competition in electricity and by an adequate transmission system that enables physical substitution between power plants in different locations. Current network bottlenecks in Japan, for example, hinder the adaptability of the Japanese power system; and relieving them is rightly a policy priority.

Develop and maintain diversified well-functioning markets with efficient price signals and adequate infrastructure

The general principles of diversification and infrastructure apply to natural gas as well. Europe is a good example. Norwegian supplies as well as LNG were able to respond to disruptions in the transit flows of Russian gas in both January 2009 as well as January 2012. In both cases the countries with the highest energy security risk were the ones with isolated gas infrastructure such as Serbia and Bulgaria, whereas in North Western Europe the infrastructure increasingly has the ability to respond to changing gas flows. In 2011, almost the entire LNG exports of Nigeria were redirected from Europe to Japan in a matter of months. In 2013, as a reaction to record high LNG demand in Asia, Europe drew an unprecedented quantity of Russian gas. Consequently the excess capacity in the Russian upstream and multiple transit routes to Europe have played a major role in Asia's supply security as - together with coal – they enabled the LNG industry to redirect substantial quantities of LNG to Asia.

However, there are still plenty of examples of market rigidities that hinder flexible adjustment. This is primarily due to rigid contractual practices limiting secondary trade, which together with infrastructure constraints hinder the emergence of efficient LNG spot markets. Long term contracts undoubtedly play an important role in maintaining investor confidence and thus supply security. Nevertheless, they can and should be structured in a fashion that is consistent with a functioning, efficient market that can provide adequate signals for market participants for adjusting demand or redirecting supplies. This is important, since due to the capital intensity of liquefaction, under normal circumstances LNG export plants run base-load. Even Qatar does not have a comparable policy to Saudi Arabia's reserve oil production capacity. As a result, any LNG market disturbance is less likely to be handled by surge production than by market adjustment. Fuel switching and pipeline imports enable some regions to reduce LNG demand while relying on efficient markets to redirect supplies to higher demand regions. As a result, policy efforts to establish LNG trading hubs that facilitate secondary trading and enable price signals which reflect gas market fundamentals, should be seen as enhancing the flexibility and resilience of the gas system.

Gas storage

Gas storage is capital intensive and is usually subject to technical limitations such as peak withdrawal rates and a winter – summer cycle. The gas storage facilities that have technical capabilities comparable to oil stockpiles, such as salt caverns and LNG tanks, are especially expensive. As a result, except for special circumstances a dedicated strategic stockpile system is generally not an attractive policy option. Nevertheless, there are legitimate debates whether market failures hinder private investment in gas storage; consequently some countries introduced regulatory incentives for private storage investment. Interconnected markets can substitute for storage capacity: geological conditions in Korea are not favourable for underground storage. Given the very high cost of LNG storage, Korea is a major buyer of spot supplies every winter, in effect relying on European storage capacities that draw down in those periods.

Combined cycle gas turbine plants can have the capability to run on jet fuel with minimal modification. This can enable countries to have safety stocks in the form of liquids with the adequate modification of their oil stockpile policies. Nevertheless, in some special cases of high infrastructure dependency and rigid demand, a dedicated gas strategic stockpile can also be justified.

Conclusions: cooperation for gas supply security

As gas markets globalise, there is room for enhanced cooperation for improving resilience and the ability to respond to shocks. The main elements could be considered:

- Improve transparency on international gas markets, especially through JODI Gas.
- Cooperate towards removing contractual rigidities and regulatory barriers that hinder efficient trading markets.
- Maintain a supportive investment framework for gas infrastructure, including new transit pipelines and LNG.
- Encourage international cooperation to take advantage of the best storage potentials.
- Cooperate on the deployment of clean coal technology to preserve the energy security contribution from coal.
- Share best practice in electricity transmission policy and wholesale market design in order to enhance gas demand side flexibility.

Electricity security

Electricity security of supply is critical in modern societies. It is essential for modern industry and for communications as well as maintaining health and order in society. All other subsystems of energy supply such as oil and gas are dependent on electricity for their pumps or compressors. In the past decade several societies with widely different income levels suffered electricity supply interruptions or shortages. The electricity sector is currently facing new challenges: the quick spread of wind and solar power, the need to become more resilient to climate change, and to aging networks and generation infrastructure in OECD. This led to a fully justified policy interest in electricity security, and this was the motivation for the IEA Electricity Security Action Plan that was delivered to and adopted by the 2013 IEA Ministerial.

Electricity is the most rapidly growing segment of the energy system. Global power demand is growing at a rate equivalent to the German power system every year. Electricity represents around half of the total investment needs of the energy system in the coming decades, driven by demand growth in non OECD countries, by aging power generation and networks in OECD, as well as by the deployment of capital intensive low carbon sources almost everywhere.

Several governments have explicit policy objectives to reduce CO_2 emissions from power generation. At the moment, the most carbon intensive source, coal fired power generation, is the backbone of electricity supply with a 40% share, and has been the biggest source of growth in the past decade. Given that its primary fuel, coal, is abundant and geopolitically well distributed and that coal plants are a dependable, well understood technology, the policy drive for decarbonisation unavoidably generates new electricity security challenges. While some renewables, especially wind and solar, experience technological improvements and rapid deployment they will remain a minority of the mix for decades to come. In addition, due to their weather dependent nature, wind and solar deployment over a minimum level requires system adjustments.

To ensure security of supply, an electricity system needs to be able to satisfy two dimensions: It needs adequate power generation capacity and networks to meet demand as well as sufficient flexibility to deliver the electricity to consumers and respond to variations in demand and supply. If the second dimension fails, a region can have a blackout even if sufficient power generation capacity is available.

The most likely cause of a generation capacity adequacy problem is systematic underinvestment in power plants due to regulatory problems or flaws in the market design. This can range from price regulation that prevents power plants from recovering their investment costs to licensing regimes that hinder the construction of economically viable power plant projects. Implicit subsidies in the form of maintaining retail electricity prices at below cost level are especially harmful since they hinder demand side energy efficiency and power plant investment at the same time.

Creation of wholesale markets and unbundled generation-supply businesses create measurable efficiency gains. Nevertheless, real life electricity markets also tend to suffer from market imperfections that increase investment risk. The rapid growth of low marginal cost renewable (wind and solar) production while desirable from a climate change point of view, also created additional investment risks for conventional power generation. In most countries renewable producers don't recover their investment cost from wholesale markets, and since their low marginal cost production depresses wholesale prices they cut into the investment recovery of existing conventional plants. This is a potentially serious threat for electricity security. Indeed, despite the technological improvements in smart grids and electricity storage the production flexibility provided by conventional power plants remains an essential component for electricity supply security. Consequently flexible power generation has to be economically viable. Some policy elements that governments might consider to achieve this are the following:

- Renewable support schemes should be structured in a way that provides incentives for a "system friendly" deployment minimising technical and financial disruption. A technology-neutral balancing regime is especially important in providing operational incentives.
- Integrating electricity markets over wide geographic areas improves electricity security and reduces costs of renewable deployment. Nevertheless it also requires adequate coordination and real time communication to prevent cascading system problems.
- The market design needs to remunerate flexibility in an adequate manner while providing efficient incentives for the deployment of new technological solutions such as demand side response and electricity storage.
- Capacity mechanisms or long term contracting could be considered as a safety net mechanism.

A core component of electricity security is a resilient and well operated network with adequate capacities. Given the state of play in electricity storage technologies the deployment of distributed generation such as PV does not make the network redundant. On the contrary, the importance of and the reliance on a strong network increases: people don't consume their own electricity from the rooftop, but feed into the network in some periods while buying in others. In practically every country the electricity network is riddled with bottlenecks, and network upgrades lag behind the aspirations of energy policy. Given that electricity networks are always regulated assets, the first priority should be to establish and maintain a regulatory framework in which network investments are not only financially viable, but also feasible from a licensing and permitting point of view. Nevertheless, given the real life constraints on network investment, it is very likely that network capacity will remain scarce in most regions.

Consequently there is a strong interest in the technically and economically efficient utilisation of network capacity. A broad application of modern IT and monitoring and control tools on network management can ensure a better utilisation of already existing wires; and more efficient demand side management can similarly substitute for physical networks to a certain degree.

The most important element to ensure the economic efficiency of network utilisation is to introduce price signals that reflect the location- and time-dependent nature of electricity. Integrating electricity trading and network capacity allocation as well as unifying system operation could significantly increase the effective capacity of the physical network to support commercial transaction in important regions.

Electricity security requires a real time system balance. In addition to the longer term dimensions of supply security maintained by investment and efficient regulation, countries should ensure a flexible and resilient system operation that has adequate information and coordinating authority over system users. Given that synchronized systems operate as one physical unit regardless of borders, coordination of adjacent system operators and reliability regulations is essential.

Given the regional nature of electricity a global mechanism for supply security is not practical. On the other hand due to the similarity of the technical and economic problems encountered, there is room for enhanced cooperation in exchanging regulatory and policy experience and sharing best practice.

Global energy trends to 2035

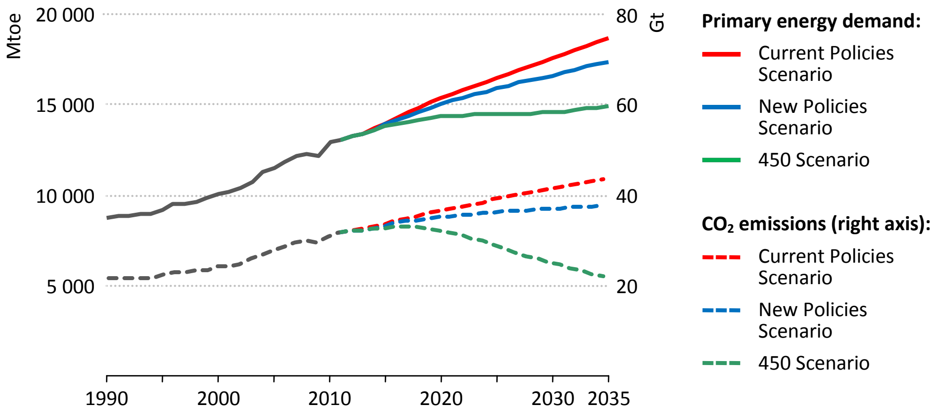
Many of the long-held tenets of the energy sector are being rewritten. Major importers are becoming exporters, large exporters are becoming large consumers and previously small consumers are becoming the dominant source of global demand. These changes emerge as the energy sector acts and reacts to broader global trends, such as shifts in economic growth, demographic change, industrialisation, electrification, efforts at decarbonisation, technological breakthroughs and divergent regional energy prices. The energy sector itself is innovating at a rapid pace: unlocking unconventional oil and gas supplies, enhancing supply flexibility with liquefied natural gas (LNG), integrating larger shares of variable renewable supply into the power sector and increasing energy efficiency.

The IEA's *World Energy Outlook (WEO-2013)* seeks to put the latest developments into perspective and explore their implications for global energy security, economic development and the environment. *WEO-2013* takes 2011 to 2035 as its *Outlook* period and considers three scenarios based on differing policy assumptions; the results vary significantly. The New Policies Scenario – the central scenario – takes account of existing policies and the anticipated impact of the cautious implementation of declared policy intentions. The Current Policies Scenario takes account only of policies enacted as of mid-2013, providing a baseline of how global energy markets would evolve if established trends continue unabated. The 450 Scenario illustrates an energy pathway compatible with a 50% chance of limiting the long-term increase in average global temperature to 2 degrees Celsius (°C).

A growing global population and expanding economy will continue to push primary energy demand higher, but government policies will play an important role in dictating the pace (Figure 1). In the New Policies Scenario, global primary energy demand increases by one-third between 2011 and 2035, reaching around 17 400 million tonnes of oil equivalent (Mtoe). Demand rises more quickly in the Current Policies Scenario, ending nearly 45% higher than 2011, equivalent to adding the combined energy demand of the world's three largest consumers today (China, the United States and India). In both cases, energy demand grows most rapidly in this decade and moderates after 2020. Energy demand grows much more slowly in the 450 Scenario, increasing by only 14% over the *Outlook* period, and just 0.3% per year after 2020, which, given historical rates of global energy growth, would represent a massive and extremely challenging change in trajectory.

There is a growing disconnect between the greenhouse-gas emissions trajectory that the world is on and one that is consistent with the 2 °C climate goal. The energy sector accounts for more than two-thirds of global greenhouse-gas emissions and, in 2012, we estimate that energy-related carbon dioxide (CO_2) emissions increased by 1.2% to 31.5 gigatonnes (Gt). The scenarios have a significantly different impact on the level of future emissions. By 2035, global energy-related CO_2 emissions are projected to increase to 37.2 Gt in the New Policies Scenario and 43.1 Gt in the Current Policies Scenario, but they decrease to 21.6 Gt in the 450 Scenario (Figure 2). In the absence of additional policies, as in the Current Policies Scenario, CO_2 emissions would be twice the level in the 450 Scenario in 2035, while the cautious implementation of announced policies, as in the New Policies Scenario, achieves nearly 30% of the cumulative savings needed to be on a trajectory consistent with limiting the average global temperature rise to 2 °C.

Figure 2. World primary energy demand and related CO_2 emissions by scenario



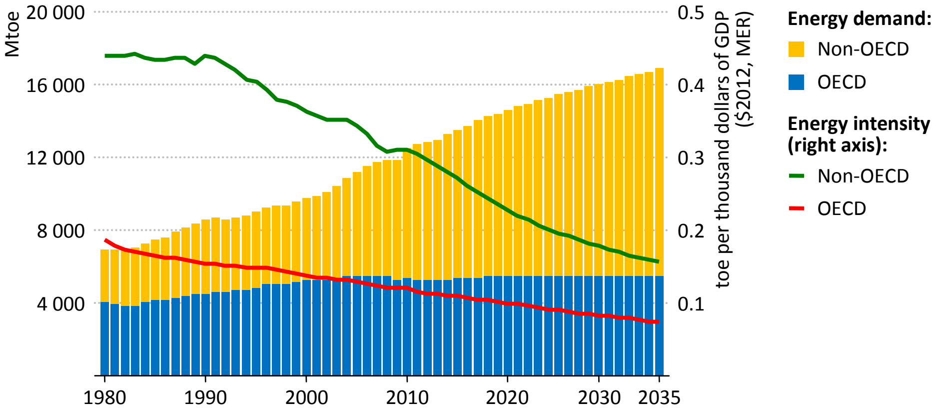
Note: Mtoe = Million tonnes of oil equivalent; Gt = gigatonnes.

Energy trends in the New Policies Scenario

In the New Policies Scenario, global energy demand grows by 1.6% per year on average to 2020 and then gradually slows to average 1% per year thereafter, reaching around 17 400 Mtoe in 2035 (Figure 3). Associated with this 33% increase in energy demand over the projection period, the global population grows by around one-quarter and the global economy more than doubles. Energy demand growth slows primarily as a result of a gradual slowdown in economic growth in certain countries, particularly the largest rapidly industrialising developing economies, and as recently announced energy policies (targeted at increasing energy security, improving efficiency and reducing pollution) are implemented and have a greater effect over time.

The New Policies Scenario incorporates continued support for renewables and efficiency, an expansion of carbon pricing and a partial removal of fossil-fuel subsidies. Even after taking these factors into account, energy-related CO_2 emissions increase by nearly 20%, to 37.2 Gt, in 2035. Nonetheless, there is an acceleration in the divergence between emissions and economic growth, so that expanding the economy by one unit of GDP in 2035 emits nearly 50% less CO_2 than similar economic expansion today. The New Policies Scenario points to an increase in the greenhouse-gas concentration in the atmosphere, from 444 parts per million (ppm) in 2010 to over 700 ppm by 2100. This would correspond to an increase in the long-term global average temperature of 3.6 °C, compared with pre-industrial levels (an increase of 2.8 °C from today, adding to the 0.8 °C that has already occurred).

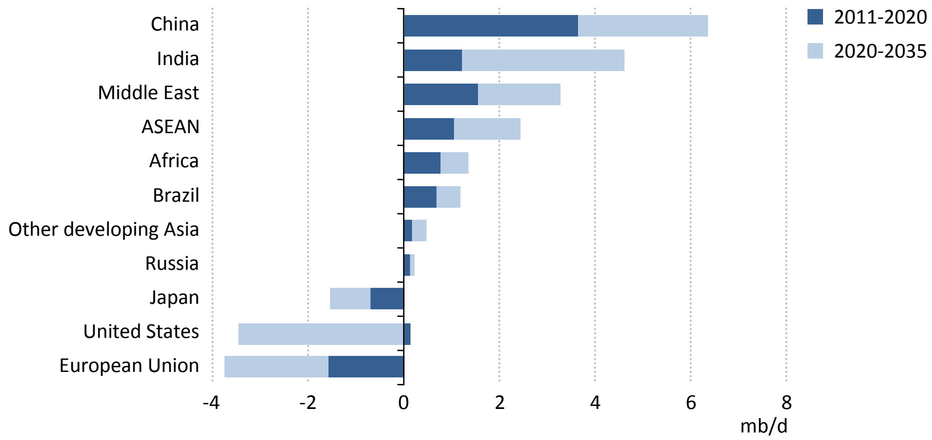
Figure 3. Primary energy demand and energy intensity in the New Policies Scenario



Note: toe = tonne of oil equivalent; MER = market exchange rate.

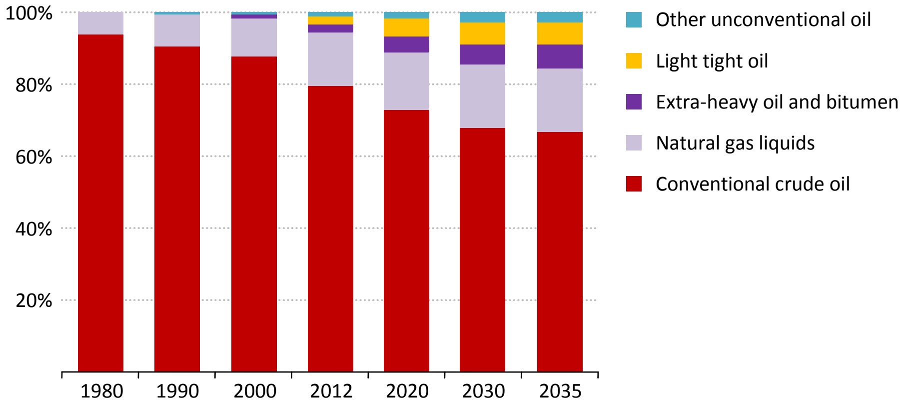
Global demand for oil increases from 86.7 mb/d in 2011 to reach 101.4 mb/d in 2035. The average pace of demand growth slows over the period, from around 1.1% per year to 2020 to just 0.4% per year thereafter. Oil continues to be the largest single component of the primary energy mix, but its share declines from 31% to 27%. While global oil demand grows, the overall change is the net result of decreasing demand in many OECD markets and increasing demand in many non-OECD markets, particularly in Asia and the Middle East (Figure 4). The combination of rapidly increasing oil demand in China and decreasing demand in the United States (after 2020), results in China overtaking the United States as the world's largest oil consumer around 2030.

Figure 4. Change in oil demand in selected regions in the New Policies Scenario



Oil supply is projected to reach 101 mb/d in 2035 in the New Policies Scenario, a rise of 12 mb/d from 2012. Key components of the increase are unconventional oil (up by 10 mb/d) and natural gas liquids (NGLs) accompanying the increase in global gas output (up by 5 mb/d) (Figure 5). They fill the gap between increasing global demand and conventional crude oil production; the latter's share in total oil production falls, from 80% in 2012 to two-thirds in 2035, despite rising offshore deepwater output. The role of OPEC in quenching the world's thirst for oil is temporarily reduced over the next ten years, due to rapid growth of supply from LTO in the United States, from oil sands in Canada, from deepwater production in Brazil and from NGLs from all over the world, but the share of OPEC countries in global output rises again in the 2020s, as they remain the only large source of relatively low cost oil. Iraq is the single largest contributor to global production growth.

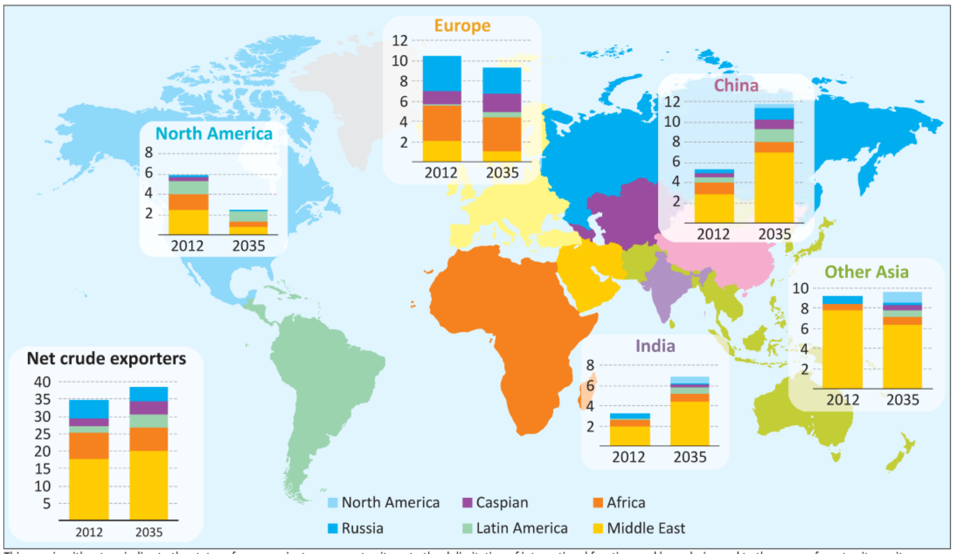
Figure 5. Shares of world oil production by type in the New Policies Scenario



Major changes in the composition of oil supply and demand confront the world's refiners with an ever-more complex set of challenges, and not all of them are well-equipped to survive. Rising output of natural gas liquids, biofuels and coal- or gas-to-liquids technologies means that a larger share of liquid fuels reaches consumers without having to pass through the refinery system. Refiners nonetheless need to invest to meet a surge of more than 5 mb/d in demand for diesel that is almost triple the increase in gasoline use. The shift in the balance of oil consumption towards Asia and the Middle East sees a continued build-up of refining capacity in these regions; but, in many OECD countries, declining demand and competition in product export markets intensify pressure to shut capacity. Over the period to 2035, we estimate that nearly 10 mb/d of global refinery capacity is at risk, with refineries in OECD countries, and Europe in particular, among the most vulnerable.

The new geography of demand and supply means a re-ordering of global oil trade flows towards Asian markets, with implications for co-operative efforts to ensure oil security (Figure 6). The net North American requirement for crude imports all but disappears by 2035 and the region becomes a larger exporter of oil products. Asia becomes the unrivalled centre of global oil trade as the region draws in – via a limited number of strategic transport routes – a rising share of the available crude oil. Deliveries to Asia come not only from the Middle East (where total crude exports start to fall short of Asian import requirements) but also from Russia, the Caspian, Africa, Latin America and Canada. New export-oriented refinery capacity in the Middle East raises the possibility that oil products, rather than crude, take a larger share of global trade, but much of this new capacity eventually serves to cater to increasing demand from within the region itself.

Figure 6. Crude oil imports by region and source in the New Policies Scenario (mb/d)



This map is 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.

Coal remains a cheaper option than gas for generating electricity in many regions, but policy interventions to improve efficiency, curtail local air pollution and mitigate climate change will be critical in determining its longer-term prospects. Policy choices in China, which has outlined plans to cap the share of coal in total energy use, will be particularly important as China now uses as much coal as the rest of the world combined. In our central scenario, global coal demand increases by 17% to 2035, with two-thirds of the increase occurring by 2020. Coal use declines in OECD countries. By contrast, coal demand expands by one-third in non-OECD countries – predominantly in India, China and Southeast Asia – despite China reaching a plateau around 2025. India, Indonesia and China account for 90% of the growth in coal production. Export demand makes Australia the only OECD country to register substantial growth in output.

Market conditions vary strikingly in different regions of the world, but the flexibility and environmental benefits of natural gas compared with other fossil fuels put it in a position to prosper over the longer term. In the New Policies Scenario, the absolute growth in primary demand for natural gas outpaces that of any other individual fuel, and increases by more than the growth in demand for oil and coal combined from 2011 to 2035. Growth is strongest in emerging markets, notably China, where gas use quadruples by 2035, and in the Middle East. But in the European Union, gas remains squeezed between a growing share of renewables and a weak competitive position versus coal in power generation, and consumption struggles to return to 2010 levels. North America continues to benefit from ample production of unconventional gas, with a small but significant share of this gas finding its way to other markets as LNG, contributing – alongside other conventional and unconventional developments in East Africa, China, Australia and elsewhere – to more diversity in global gas supply. New connections between markets act as a catalyst for changes in the way that gas is priced, including more widespread adoption of hub-based pricing.

Nuclear power generation increases by two-thirds in the New Policies Scenario, reaching 4 300 terawatt-hours (TWh) in 2035. Demand is driven heavily by expansion in just a few countries: China accounts for around half of the global increase; Korea experiences the next largest increase over the projection period, followed by India and Russia. Overall, non-OECD economies see their share of global demand for nuclear power jump from less than 20% to nearly 45% in 2035. While prospects for nuclear power at the global level are now less uncertain than they were two years ago, there are still key issues that remain unclear. These include the possibility of further changes in government policy, implications of the ongoing safety upgrades for plant economics and public confidence, and the impact of increased competition from shale gas.

The New Policies Scenario incorporates continued support for renewables and efficiency, an expansion of carbon pricing and a partial removal of fossil-fuel subsidies. Even after taking these factors into account, energy-related CO2 emissions increase by nearly 20%, to 37.2 Gt, in 2035. Nonetheless, there is an acceleration in the divergence between emissions and economic growth, so that expanding the economy by one unit of GDP in 2035 emits nearly 50% less CO2 than similar economic expansion today. The New Policies Scenario points to an increase in the greenhouse-gas concentration in the atmosphere, from 444 parts per million (ppm) in 2010 to over 700 ppm by 2100. This would correspond to an increase in the long-term global average temperature of 3.6 °C, compared with pre- industrial levels (an increase of 2.8 °C from today, adding to the 0.8 °C that has already occurred).

Global demand for energy from renewable sources grows by nearly 80% in the New Policies Scenario. This masks differences in the fortunes of different renewable products. Demand for traditional forms of bioenergy declines, while demand for modern renewable energy — including hydropower, wind, solar, geothermal, marine and bioenergy — rises almost two-and-a-half times from 2011 to 2035. Government policies and incentives, higher fossil fuel prices and technology-driven cost reductions all help to increase the attractiveness of renewable technologies, especially in the power sector.

Renewables continue to beat expectations

Despite a difficult economic context, policy uncertainty in some countries and turbulence in industry, at the global level the rapid growth of renewables continues to beat expectations, in particular in the power sector, and is a bright spot in an otherwise bleak assessment of global progress towards a cleaner and more diversified energy mix. According to the IEA Medium-Term Renewable Energy Market Report 2013, Renewable power generation grew 5.5% annually from 2006-13, and is expected to rise by around 40% up to 6850 Terawatt hours (TWh) in the next five years. By 2018 the share of renewable electricity will account for a quarter of the global power mix, up from 20% in 2011. By 2016 global renewable electricity generation will overtake that of gas and be twice that of nuclear, making renewables the second most important source of electricity after coal.

Figure 7. Total Renewable Annual Capacity Additions 2012-2018, by region (GW)

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Two key trends drive this positive outlook. First, renewable power deployment continues to expand geographically. Notably, investments and renewable deployment are accelerating in emerging markets, mainly driven by fast-rising electricity demand, energy diversification needs, and local pollution concerns, while contributing to climate change mitigation. China alone accounts for nearly 40% of expected global growth. In addition to strong deployment in a range of non-OECD markets, such as Brazil, India and South Africa, significant development is seen for the first time in the Middle East, based on compelling economics and long-term targets. This rapid deployment in these regions is expected to more than compensate for slower growth and smooth out volatility in other areas, notably Europe and the US (Figure 7).

Second, in addition to the well-established competitiveness of hydropower, geothermal and bioenergy, more renewables are becoming cost competitive versus fossil fuels in a wider set of circumstances. For example, wind competes well with new fossil fuel power plants in several markets, from Brazil, to Turkey to New Zealand. Where long-term power purchase agreements are possible, renewables emerge as a competitive option to hedge risk of fossil fuel prices. Moreover, solar is increasingly becoming attractive in markets with high electricity peak prices, for instance if these are set by oil-fired generation. Finally, generation costs of decentralized PV have become lower than retail electricity prices in a number of countries, including Italy, Spain, Australia, California, but also Denmark and Southern Germany. This "socket parity" is expected to increasingly become an additional driver for investment where and when self-consumption of PV is possible, provided that measures are put in place to recover fixed costs of electricity distribution networks.

System flexibility is key

In terms of technologies, wind and solar PV will have a major role to play. But those technologies also bring a number of issues related to their variable and not fully predictable nature. The main question is whether and to what extent wind and solar PV can be integrated in grids in reliable and cost-effective way. This has been the focus of one of IEA's most recent publications, *The Power of Transformation – Wind, Sun and the Economics of Flexible Power Systems.* The publication emphasizes that the share of variable renewables that can be integrated in a power system critically depends on the overall system flexibility. A major result of this study is that it is possible to integrate very large shares of variable renewables cost-effectively, but this calls for a change of perspective. Rather than simply adding variable renewables on top of an existing system, an overall transformation of the power system as a whole is required. IEA detailed modelling shows that in the long term a fully transformed power system with 45% of wind and solar – i.e. about 10 times what we see today in average - is only about 15% more expensive than a system with no variable renewable energy at all. And that small cost increase is using today's technology and assumes a moderate carbon price of 30 USD per tonne.

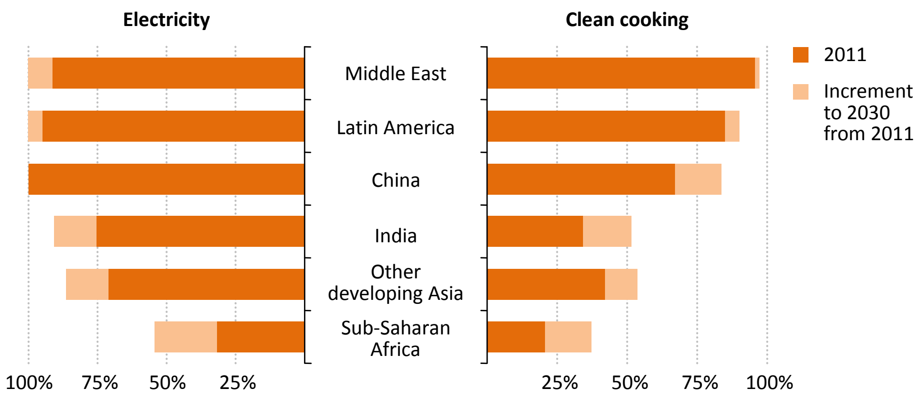
Such a cost-effective transformation of power systems can be achieved with a three-pillar strategy. First, through a system-friendly deployment of variable renewables. Traditionally, the role of variable renewables has been perceived as causing trouble. But in a transformed system, variable renewables become part of the solution, if a well balanced portfolio of state-of-the art wind and PV technologies is applied. The second pillar is making better use of markets and operations. That means a better operation of balancing areas, systems and markets - e.g. with intraday market bidding and the introduction of location specific (nodal) pricing – and increased coordination with neighbour countries. The IEA analysis shows that there is vast potential for low-cost, no regret, operational improvements in all markets. Only then, comes the third strategy pillar, i.e. additional investments in flexibility resources. This includes investing in more flexible power plants, developing more robust, smarter, and inteconnected grids, using storage where cost-effective, and unlocking the potential of demand-side integration.

Energy Efficiency: from "hidden fuel" to "first fuel"

Recent analysis of a sub-set of 11 IEA countries has shown that taken over the longer term, energy savings from energy efficiency measures exceed the output of any single fuel source. The "hidden fuel" has become the "first fuel". Meanwhile, energy productivity is already improving more rapidly. The amount of energy used to produce a unit of GDP declined by 1.5% in 2012, compared with an average annual decline of just 0.4% between 2000 and 2010. The New Policies Scenario envisages *additional* investments of $3.4 trillion in energy efficiency through to 2035 compared with the Current Policies Scenario. This increased investment could generate cumulative savings in energy expenditures of $6.1 trillion, including a reduction in household energy bills of $2.6 trillion. The benefits of energy efficiency are multi-faceted. Energy efficiency can contribute to economic growth in situations where energy is in short supply as well as contributing to energy security. Energy efficiency also brings a range of non-energy benefits including improved health and job creation.

There is growing recognition that modern energy is crucial to achieving a range of social and economic goals relating to poverty, health, education, equality and environmental sustainability, and this recognition is reflected in a number of new initiatives. However, modern energy for all is far from being achieved. We estimate that nearly 1.3 billion people, or 18% of the world population, did not have access to electricity in 2011. Sub-Saharan Africa and developing Asia account collectively for more than 95% of the global total. Furthermore, we estimate that more than 2.6 billion people, or 38% of the global population, relied on the traditional use of biomass for cooking in 2011. Developing Asia accounts for around 70% of the global total and includes seven of the ten largest populations without access to modern cooking facilities.

Figure 8. Shares of population with access to electricity and clean cooking facilities by region in the New Policies Scenario



In the New Policies Scenario, the number of people without access to electricity is projected to decline by one-fifth to around 970 million in 2030, or 12% of the global population.[1] Around 1.7 billion people are expected to gain access over the period to 2030 but, in many cases, these gains are offset by population growth. While there is an improving global picture, the regional trends are very diverse (Figure 8). Developing Asia sees the number of people without access to electricity decline by around 290 million between 2011 and 2030. China is expected to achieve universal access within the next few years. India sees a significant improvement: its electrification rate rises from 75% today to around 90%, but the country still has, in 2030, the largest number without access to electricity in any single country. In sub-Saharan Africa, the number of people without access to electricity in 2030 is projected to reach 645 million, 8% more than in 2011. The number of people relying on the traditional use of biomass for cooking is projected to drop slightly, to just over 2.5 billion in 2030 – around 30% of the global population at that time – linked to economic growth, urbanisation and clean cooking programmes.

[1] While the *Outlook* period for *WEO-2013* is 2011 to 2035, analysis in this section is based on the period 2011 to 2030, so as to be consistent with the timeframe of the SE4All initiative.