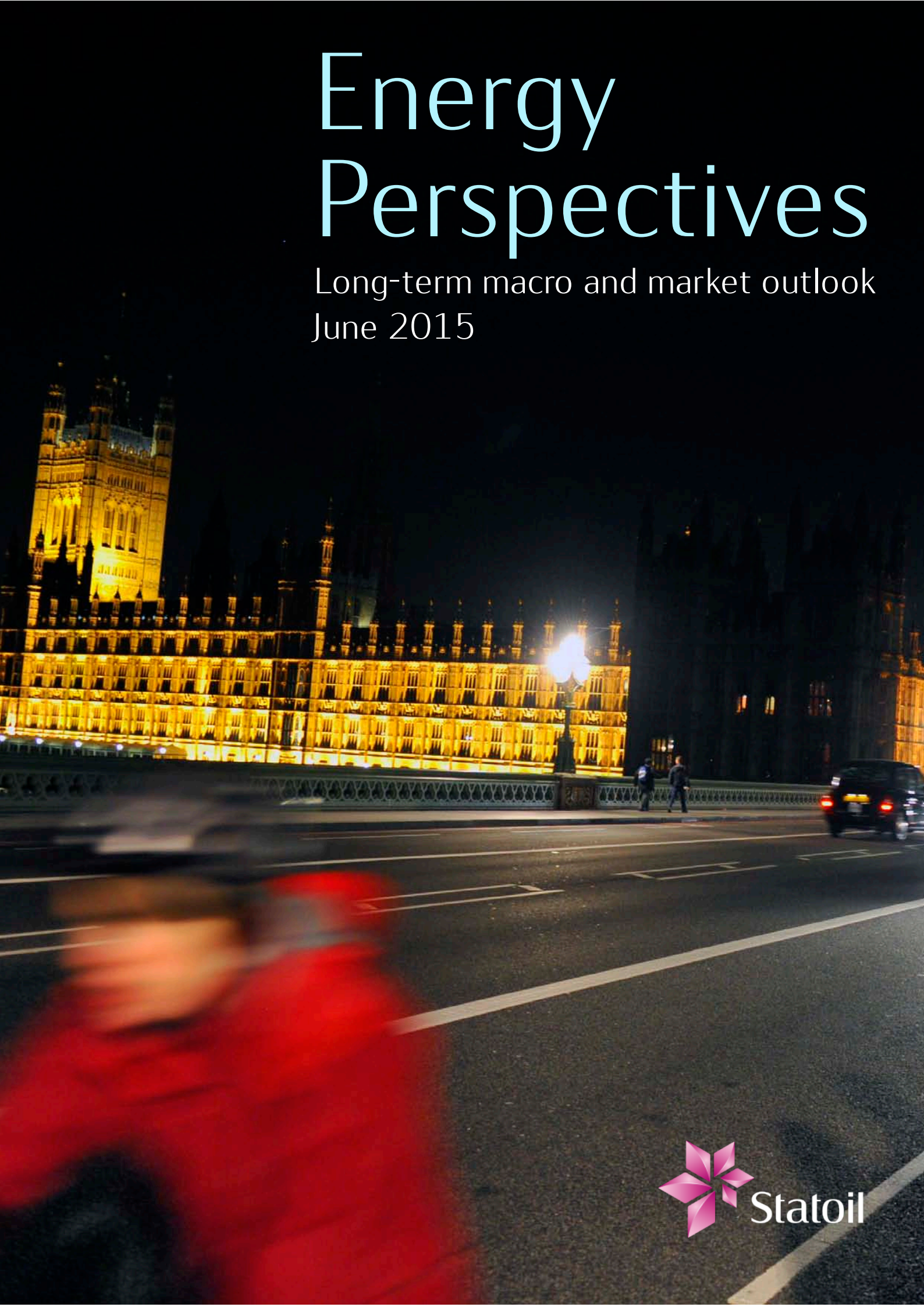
Energy Perspectives

Long-term macro and market outlook

June 2015



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Acknowledgements

The analytical basis for this outlook is long-term research on macroeconomics and energy markets undertaken throughout the Statoil organisation during the winter and spring 2014/2015.

The research process has been coordinated by Statoil's unit for Macroeconomics and Market Analysis, with crucial analytical input, support and comments from various parts of the company.

Joint efforts and close cooperation in the company have been critical for the preparation of an integrated and consistent outlook for total energy demand and for the projections of future energy mix.

We hereby extend our gratitude to everybody involved.

Editorial process concluded 1 June 2015.

Front page photo: Harald Pettersen, Statoil

Energy Perspectives 2015

2015 is an important year. It will give signals about global decision makers' ability to agree on an effective climate policy that might lead to real progress, or not. We might see Western sanctions against Iran lifted. Relations between Cuba and its northern neighbour seem to be rapidly improving. On the other hand, relations between Russia and the West are cold and might not improve any time soon. China is fighting to reduce the most negative effects of its polluting energy mix, while trying to restructure its economy and avoid a rapid slowdown in growth - a tremendous challenge. Prospects for economic and investment reform in India look good. USA is considering allowing crude oil exports on the back of a tremendous increase in its shale oil production. The new king in Saudi Arabia is putting his mark on political priorities, and the new strategy of watching Opec's market share in crude oil markets is having profound effects on global markets. The situation in Libya, Syria and to some extent Iraq seems locked and critical. Terrorists are creating havoc in several countries in Africa, from Nigeria to Kenya. Ebola is reportedly eradicated in Liberia. Brazil is struggling between the World Cup and the Olympics, tarnished by corruption. Growth is picking up in Spain, Germany struggles to handle the consequences of its Energiewende, and Greece is going from cash crisis to cash crisis. The UK is considering its long-term relationship to EU. Uncertainties prevail, as usual, with some developments going in the right direction, others in the wrong, and with more muddy geopolitical demarcation lines than we are used to.

Drawing the picture of future macroeconomic development, energy demand, fuel mix, economic development, and CO_2 emissions in the light of these developments is an exciting and necessary, but difficult task. In this year's Energy Perspectives, we discuss uncertainties in important drivers behind energy markets and climate change that may lead to highly different development paths and outcomes. By presenting three different sets of assumptions we get three alternative scenarios for, or stories about, the future. With a 25-year time horizon, it is important to keep in mind that we can only hope to sketch a possible area of likely development for energy demand and fuel mix for different regions and sectors. The actual development will most likely take place within the boundaries of the area defined by our scenarios.

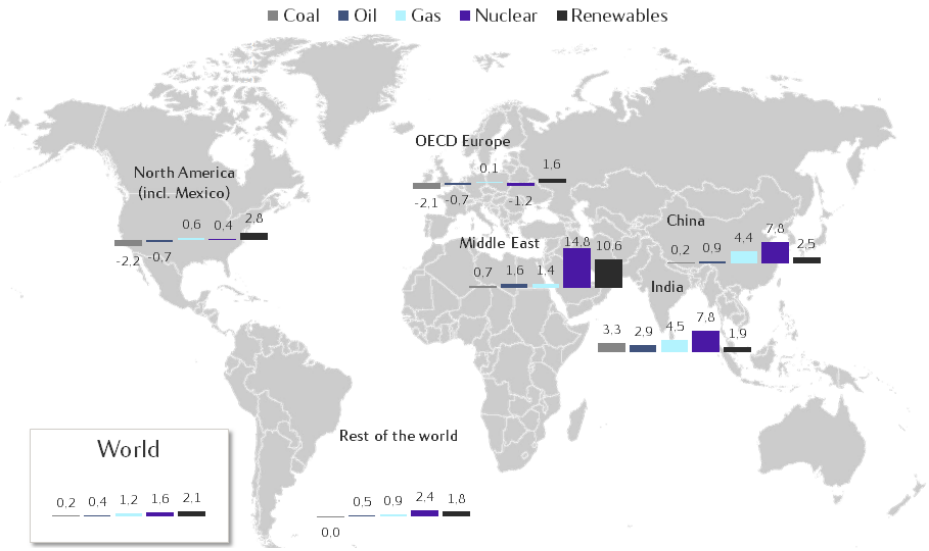
The trajectories in this report describe developments in the scenarios labelled *Reform*, *Renewal* and *Rivalry*. *Reform* is a story about gradual development towards an energy future defined by tightening of energy and climate policies, emission standards and other framework conditions as signalled by governments leading up to the climate conference in Paris. It portrays a significant and by historical standards sharp improvement in energy efficiency, gradually increasing carbon prices and rapid increase in renewable energy. However, the energy related CO_2 emissions remain significantly higher than prescribed by the 2-degree target on global warming. The consequence of this is gradually increasing costs of climate change, which we have taken into account through a reduction in the economic growth rates towards the end of the period. *Renewal* is a story about a rapid, green energy transition driven by global consensus and action to achieve the 2-degree target through energy efficiency, reduced coal consumption, growth in no- and low-carbon sources of energy, and transformation in transport and electricity generation, driven by increasing carbon prices and energy and climate policies. It is a world where we hardly use more energy than today in 2040, in spite of being more than twice as rich, and where the global energy use is on a sustainable path. *Rivalry* is a story about continued geopolitical conflict and power struggle, with sanctions, slower economic development, less trade and focus on security of supply instead of on globally efficient solutions to common challenges. On the energy arena, this dampens energy demand, but also leads to focus on domestic energy sources and therefore higher global carbon intensity.

The outcome space defined by these scenarios indicates an average economic growth from 2012 to 2040 at between 2 and 2.9% per year, respectively. Total primary energy demand grows between 0.2 and 0.9% per year, reflecting improvement in global energy intensities of between 1.3 and 2.7% annually. Oil demand will grow between -0.6 and 0.4%, while gas demand is expected to take market share in all scenarios and grow between 0.6 and 1.2%. The outcome space for coal is very wide and indicates the following range for growth rates: -2.4% to 0.8%. Nuclear energy is expected to grow between 0.8 and 2.8% per year. New renewable energy is expected to grow significantly in all scenarios, between 5.9% and 11.1% annually. In *Renewal*, growth in solar energy equals 15.7% per year, leading to a 59-fold increase in electricity production from this energy source. CO_2 emissions in 2040 will be between 61% and 114% of the level in 2012, the lower of these consistent with the 2-degree target.

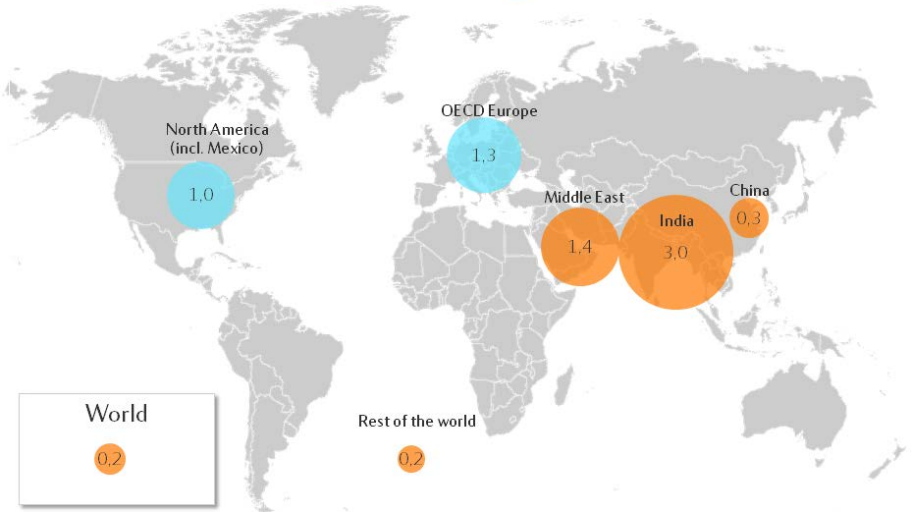
Hoping to contribute to a fact based discussion on future developments in global energy markets,

Eirik Wærness
Chief economist

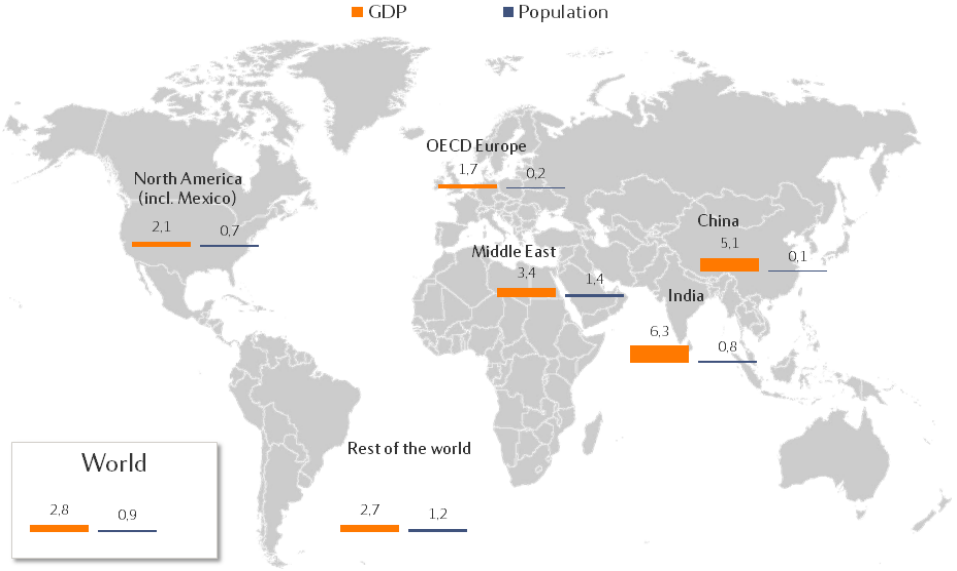
Regional growth in energy demand 2012-2040 in the Reform scenario
CAGR, %



Regional growth in CO_2 emissions 2012-2040 in the Reform scenario
CAGR, %



Regional growth in GDP and population 2012-2040 in the Reform scenario
CAGR, %



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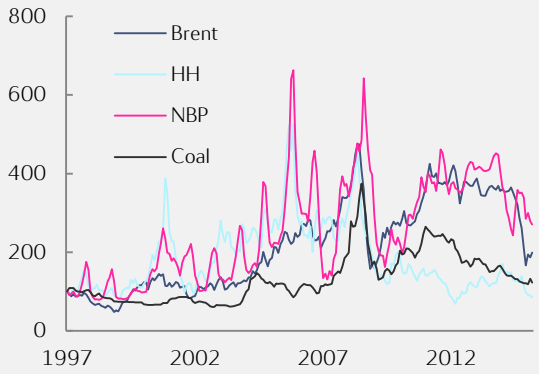
Context and uncertainties

Commodity prices

Real Apr 2015, index, Feb 1997=100

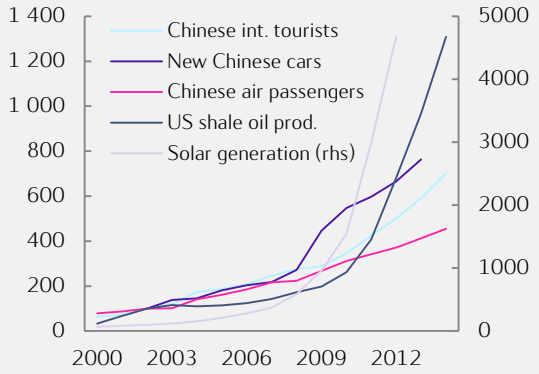


Source: Thomson Reuters Datastream

Uncertainty around geopolitics, policy, sustainability, technological progress and economic growth

Supply and demand factors

Index, 2002=100



Source: DOE, CEIC, IEA

Reform: Not business as usual, but insufficient progress to avoid climate change

The scenarios in Energy Perspectives build on assumptions for economic development, energy intensity and energy mix over a period of 25 years. Obviously, no one can predict exactly what will happen in 2030 or 2040, or along the way. But acknowledging the uncertainties, it is important to describe what the future can look like and to understand possible consequences. The energy business is by nature long-term, and industry decisions will have impact for many decades to come – on shareholder values and revenues for the companies, on production, and on stakeholder welfare. Hence, it is a prerequisite for economic and social responsibility to try to understand and describe the most important underlying factors for development in energy markets, such as:

- *Geopolitics*: Will the unravelling of a US-dominated post-Cold War order and transition toward a more multipolar world, lead to a more volatile future? Will cooperation and coordination prevail, or will rivalry and conflict dominate the development?

- *Policies,* in particular energy and climate policies: Developments in national, regional and global energy and climate policies will affect profitability of investments in different energy sources and impact demand for different fuels.

- *Sustainability,* with climate change at the centre of our attention: In the long term, climate change will impact the operating environment for all businesses, unless decision makers are able to agree on sustainable climate policies.

- *Technological progress* can impact energy efficiency, long-run marginal costs for energy supply, transportation patterns, consumer behaviour and various other supply and demand factors.

- Econ*omic growth* is driving energy demand. Economic stability and progress may increase willingness to accept decisions that balance short-term welfare with sustainability over generations. Unemployment, excessive income inequality and poverty may threaten political stability and limit willingness to take a long-term perspective on investments in energy. In the long run, demography, structural policies to improve economic efficiency and markets, and also impact from climate change, will determine the global growth potential. Productivity growth, globalization and infrastructure investments are other examples of drivers that will determine the long-term global economic development.

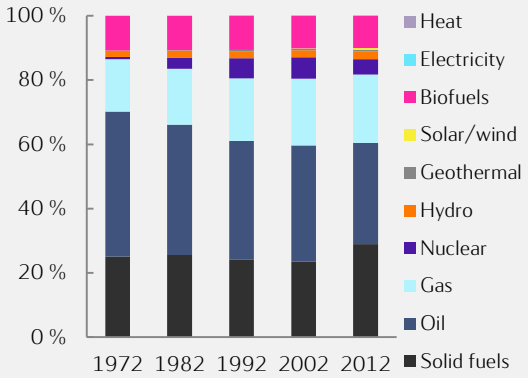
In this report the uncertainties are illustrated by presenting three different futures, building on three different sets of assumptions, under the scenario headlines *Reform*, *Renewal* and *Rivalry*. None of these scenarios are a prolongation of Business As Usual.

- *Reform* assumes the gradual, but significant change in policies, efficient regulation, economy and technology that has been presented by different governments. Examples include EU's energy and climate ambitions toward 2030 or the US-China joint statement on climate change. Still, the increasing global population and continued growth in global GDP outweigh the effects of stronger decline in energy intensity, so that energy demand continues to grow, albeit moderately. Fuel switching is too slow to stabilize and reduce CO_2 emissions

Renewal: What it will take to limit CO_2 emissions within a 2-degree target

Rivalry: Greater unpredictability, with unrestrained geopolitical rivalry and conflicts

Total final energy demand



Source: IEA

Key parameters for each scenario

2012-2040 average growth per year (%)	Reform	Renewal	Rivalry
GDP	2.8	2.9	2.0
Total primary energy demand	0.9	0.2	0.7
Energy intensity	-1.9	-2.7	-1.3
Coal	0.2	-2.4	0.8
Oil	0.4	-0.6	0.2
Gas	1.2	0.6	0.7
Nuclear	1.6	2.8	0.8
Hydro	1.3	2.1	1.6
Biomass	0.6	1.0	0.5
New Renewables	7.8	11.1	5.9

Global energy mix (fuel shares in%)	2012	2040		
		Reform	Renewal	Rivalry
Coal	29	25	14	30
Oil	31	27	24	27
Gas	22	23	24	22
Nuclear	5	6	10	5
Hydro	2	3	4	3
Biomass	10	9	13	10
New Renewables	1	7	11	4

CO_2 emission growth, total 2012-40 (%)	7	-39	14

significantly during the forecast period. Therefore, *Reform* is not a sustainable scenario in the long run, neither for societies nor companies, in terms of global warming and consequences of climate change. To underline and illustrate the gradual negative economic impact as a result of increasing climate costs, we assume that GDP growth declines towards 2040.

- *Renewal* shows what it will take to reach CO_2 emission levels consistent with a 2-degree target. It portrays a green transition within power, transport, energy, housing and city planning. In this scenario the energy related CO_2 emissions are about 40% lower in 2040 than they were in 2012, which is equivalent to the emission reduction paths in the corresponding IEA and IPCC scenarios. Such a development requires significant and consistent changes in energy policies worldwide, unprecedented improvements in energy efficiency, higher levels of renewable and low-emission energy, as well as substantial investments in new energy technology.

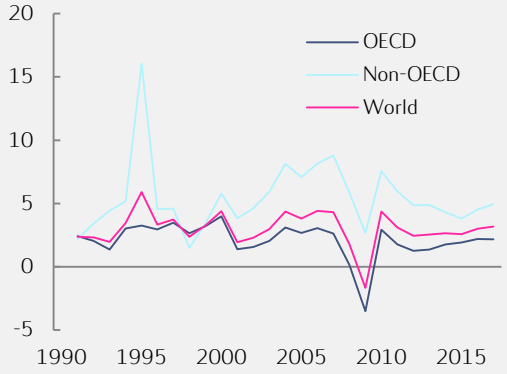
- *Rivalry* highlights the risk of greater unpredictability, with unrestrained geopolitical rivalry and conflicts as important elements in a more multipolar and disorderly world. As competing powers begin to assert their influence, values that have been regarded common erode. The global governance framework that was conceived and built after World War Two becomes outdated. Regionalism supersedes globalisation as states withdraw into the safety of narrower security and economic blocs. Like the *Reform* scenario, *Rivalry* does not describe a sustainable path. Lower economic growth contributes to lower energy demand and CO_2 emissions, but on the other hand the world is not able to agree on coordinated and forceful measures against climate change. Also the ability to finance green technology and growth in renewables is weaker and it is assumed that coal, partly because of security of supply concerns, maintain a higher share in the energy mix.

In the *Reform* scenario chapters, we analyse the fundamental factors behind energy demand, describe the oil and gas markets in some detail, and discuss other energy carriers. In the *Renewal* and *Rivalry* scenario chapters we highlight the main characteristics for these trajectories without repeating elements that are common for all three scenarios. In some of the chapters we also present boxes that aim to highlight topics, countries or developments of particular interest in order to understand individual markets or scenario.

The report does not assign probabilities on individual development paths. The purpose of presenting different scenarios is to contribute to understanding on how different assumptions for the energy market drivers can deliver very different outcomes. Hopefully this can contribute positively to the important discussion on energy and climate.

GDP growth 1990-2017

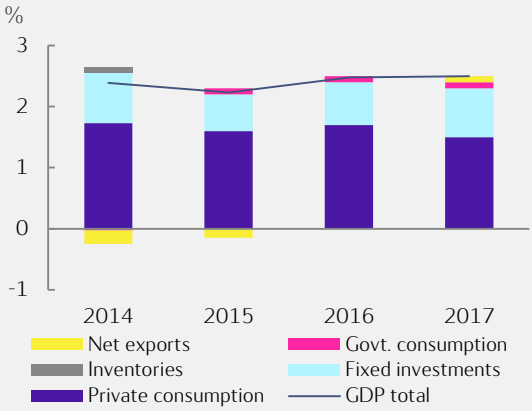
Annual % change at market exchange rates



Source: IHS Connect (history), Statoil (projections)

Both short-term shocks and long-term trends are shaping the global economy's medium-term growth trajectory

Contribution to change in annual US GDP



Source: Thomson Reuters Datastream, Statoil (projections)

The US economy will grow close to historic trend growth, driven by solid household consumption

Reform – insufficient progress

The global economy

Medium-term outlook: it's complicated

Several major forces are at work in the world economy. Short-term shocks like the oil price plunge, large exchange rate movements and the impact of geopolitical unrest, but also trends of a more long-term nature, are affecting economic activity and shaping the medium-term growth trajectory.

The low oil price is beneficial for global economic growth and will contribute positively over the next two years or so, notwithstanding the loss of real income for oil producers. The US economy has developed stronger than its peers. As a result US interest rate expectations have increased, while monetary policy will remain very expansive in most other advanced economies. The dollar has consequently strengthened relative to most other major currencies. A weaker exchange rate provides a competitive advantage, and together with the lower oil price and low interest rates this gives the Eurozone and Japan an opportunity to get back to somewhat stronger growth rates. India is set to grow faster than China, where growth is slowing and stabilizing below the official target of around 7%. These developments are however being offset to some extent by decelerating activity in many other emerging economies. Oil and commodity exporters such as Brazil and Russia are facing recessions mainly caused by lower prices, but also due to internal challenges in Brazil and economic sanctions in the case of Russia.

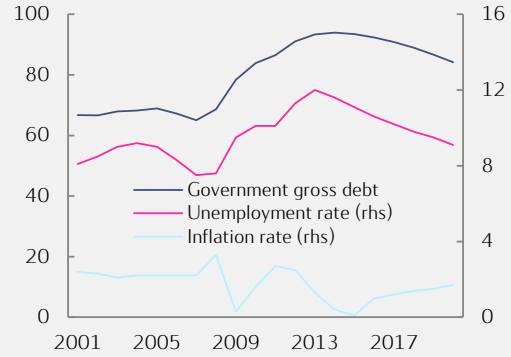
The world's long-term economic growth potential is discussed below. It is however important to note that the slowdown seen since the onset of the financial crisis also can be attributed to long-term trends like an aging population and declining productivity growth. Some of these trends will be reversed as economic conditions improve and activity recovers, whereas others will continue to play a role. The US, European countries and Japan are all greying at unprecedented rates, resulting in a demographic cost that will continue to dampen economic growth. In emerging markets much of the decline is attributable to slower productivity growth, which is likely to decrease further in the medium term under current policies. To raise economic speed limits, structural economic policies that encourage innovation, promote investment in productive capital, and counteract the negative impetus from aging will be key.

US medium-term outlook: solid and subjective to oil

The underlying economic growth in the US is solid, helped by robust household consumption. Cheaper fuel, job growth and an improved financial situation pave the way for further progress. Development in salaries has been muted, but as the slack in the labour market diminishes, more pressure will come on both wages and inflation. The Federal Reserve has ended its quantitative easing program and is expected to gradually tighten monetary policy, but overall it is likely to remain relatively accommodative for quite some time. Corporate investments are decent, but lower shale oil activity and the strong dollar will curb the outlook somewhat. Average annual growth over 2015-17 is forecasted at 2.4%, close to the historical growth rate. Downside risks are linked to fiscal policy deadlock and the impact of monetary tightening.

Eurozone debt, unemployment and inflation

% of GDP, % (rhs)

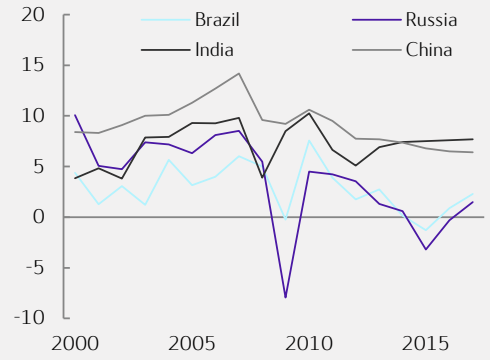


Source: International Monetary Fund

Eurozone activity lifted by oil price and QE, but reform and investments crucial to make the recovery sustainable

BRICs GDP growth

Annual % change at market exchange rates



Source: IHS Connect (history), Statoil (projections)

China medium-term growth to remain moderate due to industrial overcapacity, but no hard landing

Eurozone medium-term growth: a window of opportunity

Legacies from the crisis still weigh on spending and growth in the Eurozone. A lower oil price and additional liquidity injections by the European Central Bank therefore provide a much-needed opportunity to avoid a prolonged period of stagnant real incomes, weak labour markets, and too low inflation. In addition to lowering long-term interest rates, the shift to a more aggressive monetary policy, while the US moves closer to raising policy rates, has brought about a substantial depreciation of the euro, boosting the Eurozone's net exports. Higher import prices will also offset some of the effect of the energy price decline on consumer prices and help to move inflation back up towards target. Eurozone average annual growth is projected to accelerate from 1.5% in 2015 to 1.7% in 2017. Productive investments and structural reform will however be crucial to raise productivity growth and make the cyclical recovery sustainable. The rise of anti-establishment political movements in many Eurozone member countries, particularly Greece, Spain, and Italy, may lead to more uncertainty on what policies will be pursued over the medium to long term.

Japan's consumer spending continues its rise despite moderate wage growth and unemployment edging down. Monetary easing should continue albeit at a slower pace as inflation remains positive. Further weakening of the yen and exports boost can be expected. Nevertheless, recovery of capital expenditure will remain weak until a significant lift in corporate profits and an initiation of favourable structural reforms. The government's ability to control the fiscal balance to cope with the debt is key to sustainable growth. Growth is likely to improve in 2015-16 to an average of 1.1% until consumption tax hike effect kicks in during 2017.

Emerging economies medium-term growth: sluggish engines

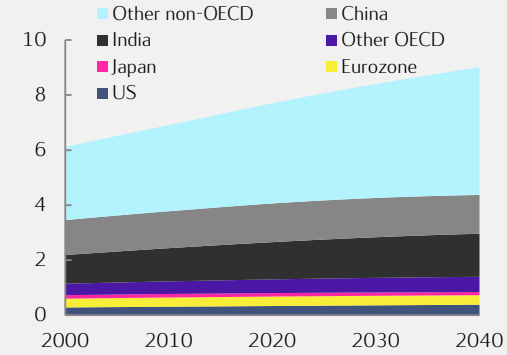
The halt in high and rising commodity prices, inflationary pressure and corruption are taking their toll on the supply constrained **Brazilian** economy. This combined with a twin deficit on the current account and government budget point towards muted economic progress the next couple of years. **Russia** is hit by low oil prices, sanctions, corruption and lack of reforms - all sending the economy into contraction mode. How the Ukraine-crisis develops will be decisive for Russia's near term economics. Efforts made to strengthen the domestic production and to grow ties with Asia are probably not enough to counteract the decline.

In **India**, less price pressure will continue to support private consumption, corporate profitability and export. Ongoing efforts to boost infrastructure are translating into a gradual pick-up in investments. A reversal of foreign capital inflows and returning balance-of-payments pressures remain key risks for the rupee in the near-term. Lower commodity prices and easing inflation will boost investment and growth could pick up to 7.6% in 2015-2017 as infrastructure develops and deregulation gathers pace.

Despite both structural reform and stimulus efforts gathering pace in **China**, economic growth will remain moderate in 2015 due to excess capacity and sluggish organic engines of growth. Industrial overcapacity constrains the government's ability to implement more aggressive stimulus, but more easing could be expected to reduce funding costs, increase fiscal investment and recover property sales. The Chinese economy is expected to continue to slow in the medium-term and post an average growth rate of 6.6% over 2015-17.

World population

Billions of persons

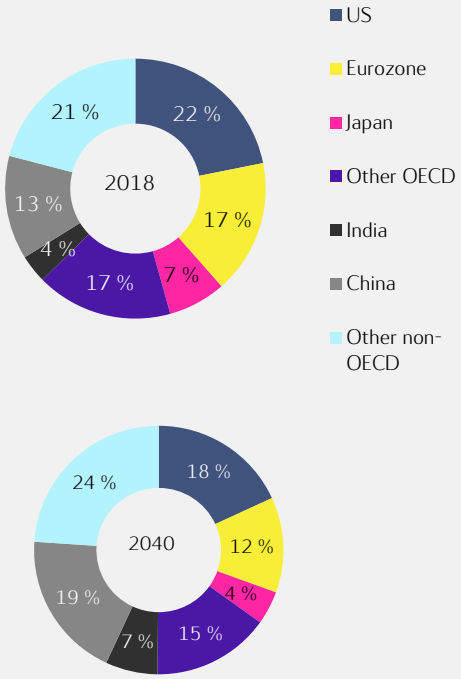


Source: IHS Connect

Global growth the next 25 years will be close to the average of the previous 30 years, but the composition will change

Composition of global GDP

2010 USD at market exchange rates



Source: Statoil

Long-term economic growth: it's all about productivity

Approach

Compared to the demand-side focus of short- to medium-term forecasting of economic activity, the long-term approach shifts attention to the supply side; and thus the production potential of individual economies. Our economic growth framework is based on a production function which splits economic output growth into components associated with changes in input factors such as labour and capital and a residual that reflects production efficiency, Total Factor Productivity (TFP). Population growth and the size and quality of the labour force are variables taken into account to calculate the impact from labour on GDP growth. The contribution from capital has been decomposed into capital accumulation and capital efficiency. While the former is a stock variable capturing changes to capital investments, the latter is an attribute that describes how effective capital markets will support channelling of savings to productive investments. Similarly, elements such as globalization, regulation and reforms, research and development (R&D) and technological progress are used to forecast contribution from TFP on economic growth prospects.

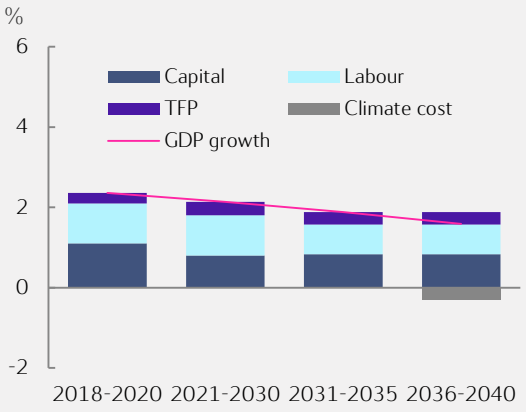
A key assumption behind our forecast is convergence between economies. The idea is that developing countries will grow at faster rates than advanced countries because they can replicate technologies and production methods instead of generating them from scratch – resulting in convergence with the average OECD per capita income over a given time span. In this framework this so called catch-up effect is evident in higher TFP growth in non-OECD than in OECD countries. The pace of catch-up growth declines gradually over time however, as the less advanced economies move closer to the technological frontier.

Key trends in major regions and countries

Global economic growth is expected to moderate gradually from 3.3% in 2017-20 to 3.1% in the 2020s. Slower population growth, diminishing catch-up potential in non-OECD economies, and slowing productivity growth are foreseen to further moderate global growth to 2.7% in 2031-35. In the period 2036-40 economic impacts of climate change in the *Reform* scenario are expected to become visible and reduce the average global growth rate to 2.3%. Climate costs are expected to have the largest impact in communities that face other stresses, e.g. since poor communities are more vulnerable to more extreme weather.

OECD economies are foreseen to expand much slower than the global average. Growth here is foreseen at 2.2% over the 2017-20 period and 1.9% in the 2020s. OECD growth is expected to slow further to 1.7% in 2031-35 and to 1.5% in the last five years of the forecast horizon. This moderating pattern is also evident in the outlook for non-OECD economies, which are foreseen to grow at an average rate of 5.2% for the latter part of this decade before moderating to 4.7% in the 2020s, 3.9% in 2031-35 and 3.1% after that, respectively. Although both OECD and non-OECD economies experience moderating growth, higher growth in non-OECD will gradually add to their combined share of the world economy. Consequently, global growth the next 25 years is expected to be close to the average of the previous 30 years.

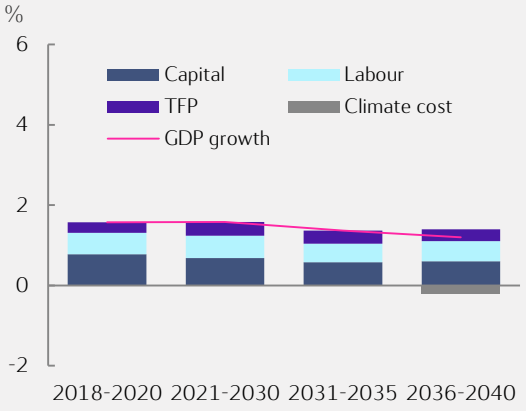
USA GDP growth by source



Source: Statoil

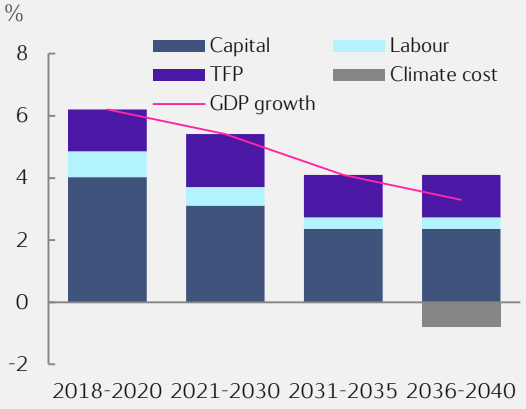
Long-term economic growth potential depends on structural economic policies

Eurozone GDP growth by source



Source. Statoil

China GDP growth by source



Source: Statoil

Energy demand growth in the long term will largely stem from emerging Asia

USA is likely to remain one of the two largest economies over the forecasting period. A growing population secures a sound basis to grow the labour force, but on the other hand the old-age dependency burden will rise. Capital investments are expected to add about as much as labour, helped by the energy sector. As a mature economy, with relatively weak innovation and moderate productivity growth, the US is not assumed to have any catch-up growth potential. Hence the US is over the forecasting period expected to deliver an average annual growth rate of 2.0% - compared to 2.5% over the last 25 years. Increased inequalities, the impact of monetary tightening and unsustainable public finances will have to be dealt with to secure healthy long-term growth.

Eurozone economic growth is expected to log 1.5% on average between 2018 and 2040, compared with 1.6% since 1990. The medium-term windfalls of lower oil price and loose monetary policy together with progress on sovereign debt and financial system issues will maintain a growth of 1.6% until 2020. In the 2020s dividends from labour market reforms and investments in R&D and more productive capital are expected to materialize. But, in the 2030s long-term challenges like poor demographics, generous retirement and slowing capital investments will pull growth down. **Japanese** growth will decelerate as the boost from trade and investment (due to QE and a weakening yen) is offset by an increasing debt to GDP ratio. Some structural reforms will improve capital efficiency, but a shrinking population constrains the growth potential. The economy is expected to grow 0.6% on average towards 2040, compared with 0.9% since 1990.

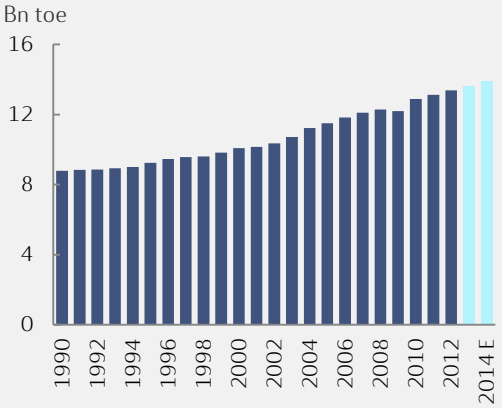
Higher infrastructure spending and structural reforms are necessary to eradicate bottlenecks and harvest on **Brazil's** huge resource base and favourable demographics. Assuming prudent policies, a 3.0% growth is foreseen on average from 2018 to 2040. **Russia's** geographic closeness to both Europe and Asia and its abundance of natural resources give the country a solid growth potential. But demanding demographics, slowing investments and the need for innovation and diversification curb Russia's long-term growth forecast to an average rate of 2.0%. **India's** favourable growth path also critically depends on implementation of sustainable reforms. Structural reforms in the private sector will continue to outpace those in the public sector, boosting capital efficiency and reducing poverty levels. The economy is expected to grow at an average annual rate of 6.6% towards 2040, mainly driven by its large catch-up potential and huge demographic dividend.

Over the long term, **China's** economic prospects depend on the government's continued effort to rebalance and liberalize the economy. A successful financial reform will facilitate the shift from an investment driven economy towards more consumption. Enhancement of capital efficiency and technological progress will be the key to growth, while an aging population carries some loss of momentum. China's GDP is likely to move to a more sustainable growth averaging 6.2% from 2018 to 2020, before moderating to 5.4% in the 2020s and 4.1% in the 2030s.

These trends imply that even though growth rates in emerging countries are slowing, they will still increase their economic weight relative to the OECD economies. This, combined with the structure of economies at such levels of development, imply that virtually all growth in energy demand will stem from emerging economies, and mostly so from Asia.

Overall energy market outlook

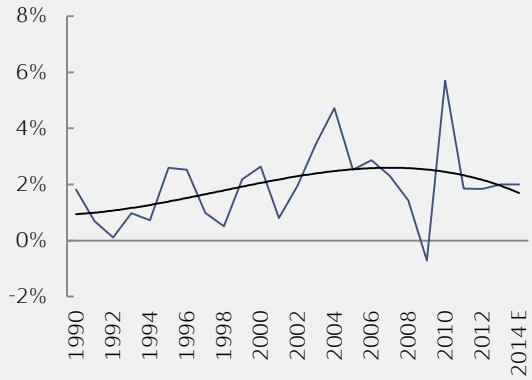
Global primary energy demand



Source: IEA (history), Statoil (projections)

Global primary energy demand up by 1.9% per year between 1990 and 2014, by an estimated 2.7% per year since 2009

Annual growth in global primary energy demand



Source: IEA (history), Statoil (projections)

Recent developments

According to IEA estimates, world primary energy demand – that is, world coal, oil, gas, nuclear electricity, hydroelectricity, other renewable electricity, and other renewable energy consumption – increased by 1.8% in 2012. BP suggests 2.0% for 2013. By end May 2015, there were no estimates for world energy demand growth in 2014 in the public domain.

One key driver of global energy demand growth, namely economic growth, was a bit stronger in 2014 than in 2013 – 2.6% against 2.5%. Another driver operating mainly in the short term is temperature fluctuations. These always differ from region to region. In Continental Europe and in China the winter months (January-March and October-December) were on balance warmer in 2014 than in 2013. In the US the situation was the opposite. A third driver, changes in energy prices, may have moderately affected energy demand in 2014, with the oil price collapse stimulating oil and eventually oil-linked gas demand, though the full impact of cheaper oil will become visible only over the longer term.

Yet other important drivers – changes in the structure of economies, technological evolution and energy efficiency policies – are of a gradual, longer term nature. However, the dampening impact on world energy markets of the transformation of the Chinese economy is already visible. Wood Mackenzie estimates that a 7.4% growth in China's GDP in 2014 was accompanied by a mere 3.8% increase in Chinese electricity consumption and declines in coal and diesel demand.

All things considered, world energy demand growth in 2014 was probably roughly in line with the estimates for 2012 and 2013.

Energy demand outlook

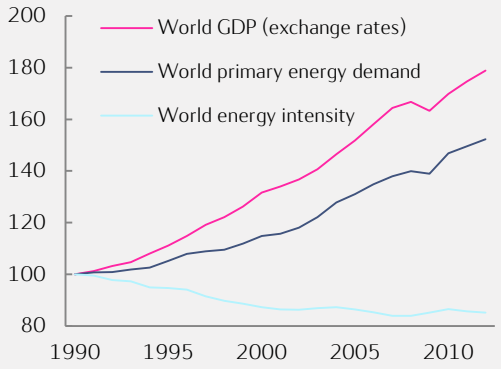
Energy demand growth no longer tracks economic growth one-to-one. Today a one per cent increase in value added typically generates only a fraction of a per cent growth in the demand for coal, oil products, gas and electricity – or no growth at all. Between 2007 and 2013 OECD primary energy demand declined by 5% in spite of an almost 4% growth in the area's GDP. This is partly because of energy efficiency improvements and partly because of changes in the structure of economies, with an increasing share of the value creation taking place in low-energy intensity economic sectors.

With respect to energy efficiency, new technology is being introduced at breakneck speed, and market incentives and policy pressure in the form of e.g. efficiency standards ensure that technology developers are indeed prioritizing the target of lowering the amounts of fuel input per unit of energy services provided. Mounting concerns about energy security, local air quality and global warming have accentuated this trend.

Energy efficiency improvements are not easily measured at aggregate levels. Instead we measure energy intensity changes, i.e., how the amount of energy required for the production of one unit of GDP has evolved. This is a proxy with weaknesses since it captures the combined impact of energy efficiency improvements, structural changes and more random energy demand drivers, but it is handy for benchmarking purposes.

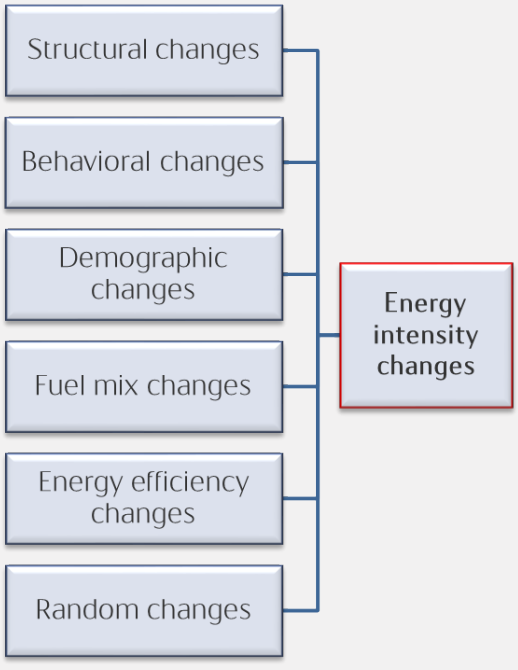
World GDP, energy demand and energy intensity evolution 1990-2012

Index, 1990=100



Source: IEA

Global primary energy demand has increased at a slower pace than global GDP...



...but this decline in energy intensity was faster before than after the turn of the century

Between 1992 and 2012 world primary energy consumption increased by 51%, while world GDP (measured at market exchange rates) increased by 73%. By implication, the energy intensity of the world economy declined by an average of 0.7% per year. All regions apart from the Middle East took part in this decline. Decline rates varied from -0.2% per year in OECD Pacific to -3.6% in China. Though regional energy intensities are becoming more similar, those of the non-OECD regions remain on balance almost four times higher than those of the OECD regions.

The energy intensity of the world economy could in principle decline at the same pace, or faster, or slower, in the years to 2040 than in the past. Policy independent technology developments could slow if developers run out of "low hanging fruits" and find themselves left with only costly options for making cars or buildings even more energy efficient, or accelerate if developers manage to crack previously unsolved technology challenges. Policy attention to energy efficiency could fluctuate in the future as it has done in the past. Moreover, even if we could forecast policy decisions, the impacts of given policies can never be predicted with full certainty. Changes in views on the future availability of energy supply will affect real fuel and energy prices and thereby the incentives to prioritize energy efficiency.

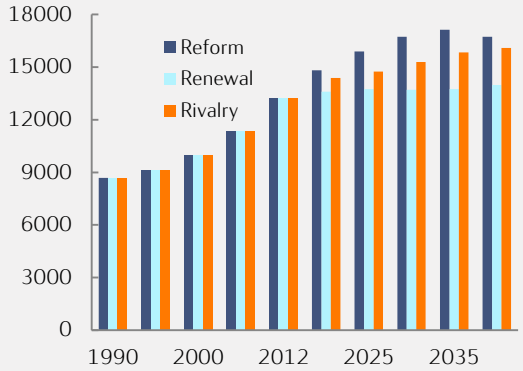
There is however no reason to expect energy intensities to level out on a sustained basis any time soon. As the IEA and other institutions point out, there are large gaps between the energy efficiencies of the best technologies, and those of average technologies, in use in vehicles, buildings, heating and lightning systems, refrigerators, air conditioners, etc. Over time the average equipment in use will become more like today's most efficient equipment, at the same time as the most efficient equipment in use becomes even more efficient, sustaining the improvement process. .

In the *Reform* scenario, the energy intensity of the world economy declines by an average of 1.8% per year between 2012 and 2040. We thus assume significantly higher decline rates for the coming years than the world experienced between 1990 and 2012. At the regional level average annual decline rates vary from -1.4% for the Middle East to -3.2% for China. The OECD regions' annual decline rates also vary, from -1.5% for OECD Asia Pacific via -1.9% for OECD Europe to -2.3% for OECD North America.

We base our assumptions on several core beliefs. We assume that structural changes will dampen energy demand growth in regions that have seen explosive growth in the recent past, especially in China. We assume that environmental issues in general and the global warming threat in particular will remain on top of most regions' policy agendas, and sustain interest in energy efficiency. We believe that continued rapid technology development will make energy intensity decline rates physically and economically possible, and that tighter policy frameworks will ensure that the possibilities are exploited. We assume that policies will have more bite in the *Renewal* scenario, but we believe that they will play a major role in shaping energy demand also in the other scenarios. In this context we assume both in the *Reform* and *Renewal* scenarios that the subsidisation of fossil fuel use going on in many non-OECD countries will be sharply reduced or eliminated. In line with these beliefs we do not

Global primary energy demand

Mtoe



Source: IEA (history), Statoil (projections)

Box 4.1: The rebound effect

Today's generally optimistic estimates of the scope for energy efficiency improvements could be on the high side due to underestimation of the impact of the so-called rebound effect. This effect refers to the observation that efforts to reduce the consumption of some good, for example energy services, typically lower the market price of the good, which in turn leads consumers to demand more of it. Also, when energy services get cheaper, consumers get richer in real terms and demand more of everything including goods and services that represent "embodied" energy. Thus, the rebound effect has both a direct (price) and an indirect (income) dimension.

The rebound effect is universally accepted as real and capable of diluting the initial impact of energy efficiency measures. However, while some research indicates that the effect is significant and could wipe out perhaps half of initial savings (there is even evidence to suggest that rebound can exceed 100%, i.e., that energy efficiency measures could boost rather than reduce energy use), other studies conclude that energy demand seldom bounces back by more than a few per cent and that the rebound effect does not weaken the case for ambitious energy efficiency targets and tough policy measures.

Its existence should however make us think twice before jumping from the engineering based estimates of energy savings opportunities on which many optimistic scenarios are built, to the conclusion that exploiting these opportunities and ensuring increased efficiency is only about pushing the right buttons.

see the global energy intensity curve flattening before 2040; we rather see the pace of energy efficiency improvement building towards the end of the scenario period.

Evidently there is downside risk to our assumptions – the pace of energy efficiency improvement could get stuck on technological inertia or failures to agree and implement adequate policies. Also, we could underestimate the so-called "rebound" effect of energy efficiency improvements. Judging by other institutions' recent scenarios there is however also a significant upside. ExxonMobil suggests in its latest "Outlook for Energy: A View to 2040" an average annual global energy intensity decline rate of 1.9% per year. In BP's most recent outlook covering the period up to 2035, the energy intensity of the world economy declines by 2.0% per year. And the 2014 version of the IEA's New Policy scenario suggests a 2.2% yearly decline in world energy demand per unit of GDP produced, between 2012 and 2040.

Our energy intensity assumptions result in a 0.9% yearly growth in world primary energy demand between 2012 and 2040, with the OECD area and Russia experiencing negative yearly growth rates between -0.1 and -0.7%, and the other non-OECD regions positive growth rates in the 0.9-2.9% range.

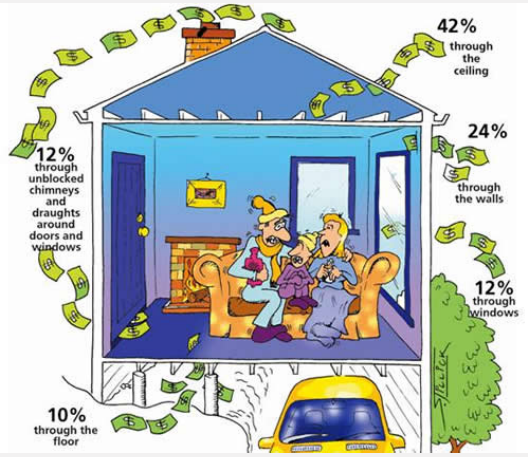
Fuel mix outlook

In 1990 oil consumption made up 36.2% of world primary energy consumption, with coal in second place (25.6%) and gas in third place (19.2%). The biofuels, nuclear and hydro shares were 10.4%, 6.0% and 2.1%, respectively. The so-called new renewables – mainly wind power, solar power and geothermal energy – contributed a miniscule 0.4% to global primary energy supply. By 2012 oil was still in first place, but its share had shrunk to 30.6%, however within an overall energy demand that had grown by an estimated 52% over the period. In spite of many years of attention to global warming, the coal share had increased to 29.3%, reflecting a 74% increase in global coal use over the 22-year period. Gas use had also become more widespread, making up 21.5% of total energy use. While the nuclear share had dropped to 4.9%, the new renewables share had more than doubled, but was still, at 1.1%, tiny compared to the fossil fuel shares. In terms of final energy consumption, the main development between 1990 and 2012 was that the electricity share increased from 13.7% to 18.8%.

While the global fuel mix is indeed changing, the change is gradual and also affected by the fact that overall energy demand is increasing. As many have pointed out, it took time to turn the Titanic. And, had Titanic grown in size during the attempts at turning it, it would have taken even longer.

In *Reform* oil will become increasingly marginalized in all sectors except the transport sector, and is under mounting pressure from substitutes in the road and maritime transport sub-sectors as well. Oil has certain advantages in its remaining strongholds that will prevent or at least slow its demise from the energy scene. However, battery performance and cost developments have boosted the attractiveness of electric light-duty

Major energy – and monetary – savings opportunities in better insulation of buildings…

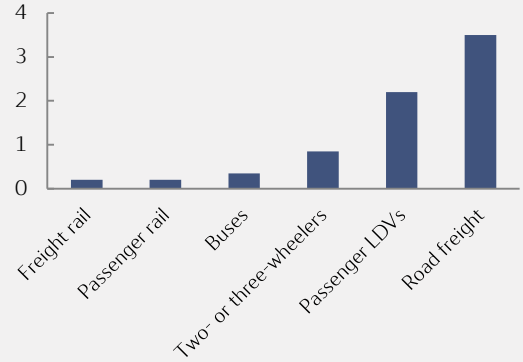


Source: green.wikia.com

… and in switching between transportation modes

Global average energy use in 2010

MJ/pkm or MJ/tkm



Source: IEA Energy Efficiency Market Report 2014

vehicles, and major car manufacturers claim that fuel cell improvements spell a bright future for hydrogen powered vehicles as well. How environmentally superior today's most luxurious unconventional cars really are, is a moot point, but that will become less decisive for their marketability the more they come to be seen as competitive on the normal criteria – design, comfort, driving range, speed, acceleration, reliability and ultimately costs.

Oil will likely do best under *Reform* scenario conditions. In a more carbon conscious world (*Renewal*) as well as in a politically fragmented world with international trade falling apart (*Rivalry*), the pressure from energy efficiency measures and from substitutes to gasoline and diesel will build.

Gas is widely expected to gain ground in most regions thanks to its effectiveness and relative cleanness as a power sector fuel, its potential as a truck and maritime transportation fuel and its relative abundance – if, that is, the shale gas revolution sustains in North America and spreads to other parts of the world. Another precondition is that gas retains its competitiveness. Effective carbon pricing would help a lot in this respect.

Further gasification is however not a universally accepted target. Coal-to-gas switching across the regions leaning most heavily on coal for their power supply would reduce local air pollution and CO_2 emissions, but not deliver the cuts recommended by the IPCC. Sustainability as defined by the this forum would require carbon capture and storage and/or the replacement further out in time of many gas power plants with renewables based power plants. Reflecting such considerations – in addition to geopolitical and fuel supply security concerns – the European Union's long term energy scenarios see a restricted long-term role for gas.

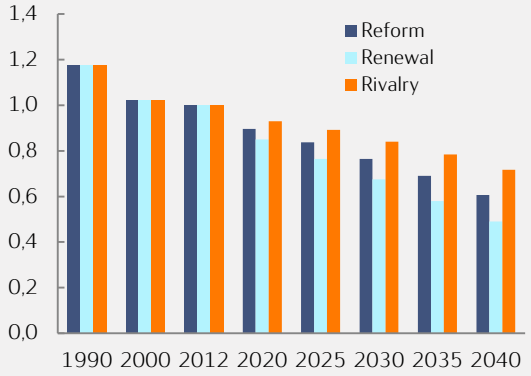
In a politically fragmented world, gas resource rich countries would likely seek to step up gasification while the import dependent parts of the world would go in the opposite direction.

Coal looks set to lose market share due to its dirtiness – there is hardly a major coal burning country left that does not see its coal dependence as a problem. The most important of the countries to watch in this respect is China, which accounts for more than half of world coal consumption. Between 2002 and 2012 Chinese coal use increased by 10% per year. In 2014 it declined. Lower electricity demand growth and mounting competition from nuclear, renewables and gas based power have raised concerns that many of the coal power plants that the Chinese are continuing to build, will become stranded assets. To the extent Chinese and other coal demand contraction leads to lower coal prices, we could however come to see the rebound effect in action.

Nuclear energy, whose share of global power generation had plummeted from 17.5% in the mid-1990s to only 11% in 2012, remains a key plank of China's, India's and select other developing economies' energy

Global energy intensity assumptions

Index, 2012=1,0

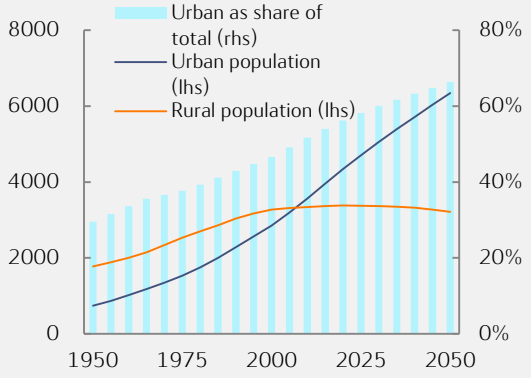


Source: IEA (history), Statoil (projections)

Energy intensity declines by 41% in *Reform*, 53% in *Renewal* and 31% in *Rivalry*

The UN's world urbanization outlook

Mill persons, and % share urban



Source: UN

strategies. Cost, safety and radioactive waste disposal issues are currently preventing a nuclear revival in the developed parts of the world, but a major world-wide push to contain global warming as we assume in the *Renewal* scenario could set the scene for a change of heart for nuclear also in the OECD regions.

The new renewables – wind, solar and in the future perhaps wave power, plus geothermal energy – seem assured of a bright future as they play up to all the concerns that are expected to drive the global fuel mix, and as the costs especially of solar power are coming down. See separate chapters for more detail on these energy carriers.

In the *Reform* scenario, the fuel substitution processes observed since 1990 continue, but at a fairly moderate pace. The main development is that new renewables increase their combined share of world primary energy supply and demand from 1% to 7%. The oil and coal shares decline from 31% and 29% to 27% and 25%, respectively. The biomass share holds up at 10%. The gas share increases from 21.5% to 23%, the nuclear share increases from 5% to 6% and the hydro share edges up by half a percentage point to 3%.

Box 4.2: Urbanization and energy consumption

Everywhere people are moving from the countryside to cities. By 1980 some 39% of the global population lived in cities. By 2010 the share was 52%. By 2040 it will, the UN believes, be 63%. The trend is most pronounced in the developing countries but it has not come to an end in the developed world either. Urbanization is recognized as a key determinant of global energy demand and of the global fuel mix. Urbanization is widely seen to facilitate both energy efficiency improvements and mostly desirable fuel switching in the developing countries. People are moving closer together enabling joint use of energy services. Energy inefficient space heating, cooking and lighting equipment is left behind and replaced by modern equipment. Traditional, non-commercial fuel use goes down, modern fuel use – first kerosene, then maybe LPG and eventually electricity consumption – goes up.

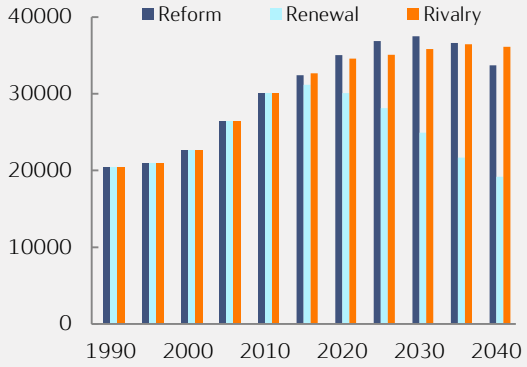
In the developed word the "smart city" concept is gaining traction. Smart cities will be dominated by compact, "vertical" living. Asian and European big cities are arguably closer to the new ideal than US cities built for drivers. Smart cities will call for smart mobility, with public transportation, bicycles and (small) electric cars playing key roles. Buildings will be made nearly or fully self-sufficient in energy through smart designs, smart materials, solar panels and extensive computerization.

The transition will be neither easy nor painless. The booming, chaotic, polluted and crime ridden cities of the developing world will not look much like the vision of smart cities any time soon. Moving into them still seems to hold more promise to hundreds of millions of immigrants than continued rural life.

The exact impact of urbanization on energy use varies across locations and over time, reflecting differences in circumstances. Forecasts of this impact should therefore be taken for what they are – assumptions driven and tentative. That being said, if we in our modelling with our assumptions had kept the rural and urban shares of the Chinese population constant at their 2010 levels rather than adopting the UN's urbanization projection, Chinese residential energy use by 2040 would in the *Reform* scenario have been some 30% higher.

Global energy related CO_2 emissions

Mt



Source: IEA (history), Statoil (projections)

Global CO_2 emissions up 1.9% per year between 1990 and 2014, declined only in 2009 as a result of the financial crisis

Box 4.3: Methane emissions from gas supply

Methane is a highly potent greenhouse gas. In a 20-year time frame the GWP – a measure of the capacity of a gas to trap heat in the atmosphere – of methane is 72 times the GWP of CO_2. Methane does not last as long as CO_2, so in a 100-year time frame the GWP ratio is down to 25 to one. This is still more than enough to warrant attention to the methane emission leakage issue.

The US Environmental Protection Agency (EPA) estimates that energy related methane emissions in 2013 amounted to 264 million tons CO_2 equivalent. In comparison US CO_2 emissions totalled 5332 mt. The methane emission problem was thus 5% of the CO_2 emission problem. Of total methane emissions the gas industry accounts for about 60%, with the coal industry contributing most of the remainder. EPA data also show that gas industry methane emission fell by 12.5% between 2005 and 2013, i.e., over a period when US gas production increased by about 35%.

Different studies have yielded different estimates of the level of methane emissions from gas value chains.

But, evidence suggests that methane leakages from gas chains can be greatly reduced through proper regulation ensuring more consistent use of so-called green well completions and transmission and distribution pipeline reinforcement. Hence methane emissions seem an altogether more manageable challenge than CO_2 emissions.

We do not in our scenarios try to account explicitly either for the emission of greenhouse gases other than CO_2 or for possible sinks such as reforestation.

Greenhouse gas emission outlook

World CO_2 emissions related to fossil fuel consumption increased by 1.9% per year on average between 1990 and 2012. OECD area emissions were up by 0.3% per year and non-OECD emissions by 3.2% per year. Global emissions increased more than three times faster in the second half of this period – by 3.0% per year – than in the first (0.8% per year). This acceleration was due to a formidable spurt in non-OECD emissions. The pace of OECD area emission growth dropped from 0.9% per year in the first half of the 1990-2012 period to minus 0.3% per year in the second. The reasons for these opposite developments were:

- The Chinese economic boom based primarily on investments in infrastructure and heavy industry, fuelled in particular by coal
- The financial crisis which capped economic and energy demand growth in the West
- Governments' energy efficiency and renewables policies
- The relocation of energy intensive industry from Europe and North America to countries like China

Thus the OECD regions' success in reducing their CO_2 emissions has contributed in no small amount to the explosive growth in the non-OECD regions' emissions. A related observation is that the OECD regions' success in making their production less CO_2 intensive has not at all been replicated on the consumption side – they have merely switched from domestically produced CO_2 intensive goods to imported CO_2 intensive goods. Hence, replicating the front-runners' accomplishments on a global scale may not be easy.

In IEA's 450 scenario, world CO_2 emissions drop by 39% between 2012 and 2040. The 450 scenario is tailored to be consistent with IPCC's estimate of what it will take to ensure a 50% probability of global warming staying below 2 degrees Celsius. The 450 scenario is supposed to be technically and economically feasible, but how to share the costs and handle the distributional consequences of its implementation has not yet been worked out. Political support for tough action seems to be building, but whether and when enough countries will be ready to commit to and actually deliver on targets in line with the IPCC's descriptions remains to be seen.

In our *Reform* scenario, world energy-related CO_2 emissions increase from 31.6 Gt in 2012 to a peak of 37.9 Gt in 2030, before declining to 34.2 Gt in 2040. Emissions at the end of the period are thus 8.2% above their 2012 level. The *Renewal* scenario is designed to be sustainable as defined by the IPCC, to deliver broadly the same 39% decline in global emissions between 2012 and 2040 as IEA's 450 scenario, if not necessarily the same regional emission trajectories and not necessarily on the basis of the same mix of targets, measures and driver developments. Lower economic and energy demand growth ensures that global CO_2 emissions increase more slowly to 2030 in the *Rivalry* scenario than in *Reform*, but in the *Rivalry* case they do not peak until mid-2030s and decline very slowly during the remainder of the scenario period so that growth between 2012 and 2040 totals 14.2%.

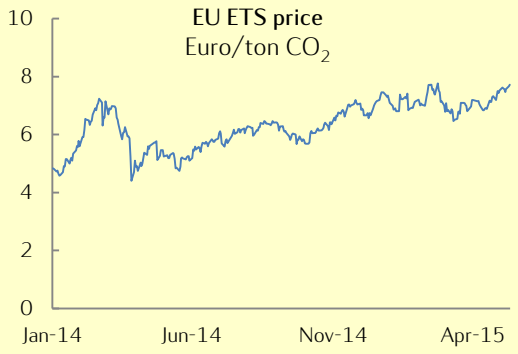
Box 4.4: Outlook for the EU ETS price

The EU ETS price remains depressed, but some observers see light at the end of the tunnel. According to Thomson Reuters Point Carbon, 2014 was the first year since 2008 when the EU CO_2 emissions covered by the ETS exceeded the supply of new emission allowances. Consequently, 2014 was also the first year since 2008 when the cumulative oversupply of allowances went down.

Optimism is slowly taking hold also because of last year's agreement to reduce EU CO_2 emissions by 40% between 1990 and 2030, in response to the "backloading" arrangement whereby 900 million emission allowances will not be auctioned on schedule, but held back until 2019-20 at the earliest, and due to signs that the planned "market stability reserve" (MSR) will become reality sooner rather than later. The MSR is supposed to ensure that the EU ETS market is kept in balance by removing excess allowances when needed and releasing them back into the market in the event of signs of unwanted tightness. It was planned to take effect in 2021, but some countries have lobbied for earlier implementation, and in early May this year the European Council agreed to introduce the reform in 2019.

It was also tentatively agreed that the 900 million backloaded allowances will go straight into the MSR rather than back into the market, an outcome that might have had disastrous consequences for the ETS price.

It is not expected that the ETS price will reach levels where it would actually start driving power plant dispatching choices and incentivizing investments in renewable energy any time soon. It will take time to work off the current oversupply of allowances in the market, estimated at more than 2 billion tons. But the fraying of the image of the ETS as the European Union's flagship measure to accomplish CO_2 emission reductions may have been halted - at least for now.
In our *Reform* scenario we assume the EU ETS price to increase to USD 50/ton by 2040. In our *Renewal* scenario the price goes to USD 140/ton, and in the *Rivalry* scenario where climate policy receives comparatively little attention it levels out at some USD 25/ton.



Source: Thomson Reuters

Box 4.5: State of CCS

Carbon capture and storage (CCS) remains a key plank of most green scenarios. A negative outlook for CCS would force scenario builders to step even harder on the energy efficiency and renewables pedals that already receives plenty of pressure.

CCS is edging forward, though not at the speed envisioned a few years ago. The Global CCS Institute reports that by the beginning of this year 13 large-scale CCS projects were operating around the world, with another 42 projects under construction or at various stages of planning. Of the projects up and running, only one has post-combustion capture, the others handle CO_2 from gas processing plants or industrial processes. 9 are in North America, 2 in Europe, 1 in South America and 1 in Africa. Statoil is well represented - the two European projects are Sleipner and Snøhvit, the one in Africa is the In Salah CO_2 reinjection project.

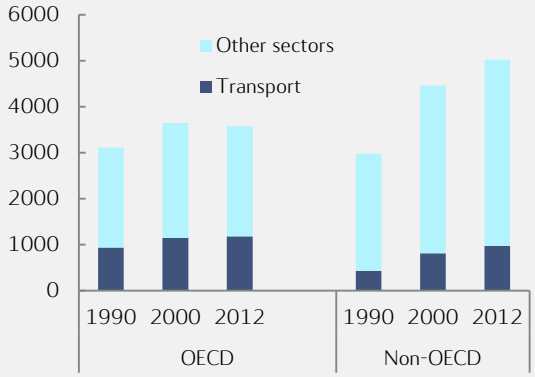
2014 marked a break-through for CCS applied to coal-fired power generation with the October start-up of the Boundary Dam project in Saskatchewan in Canada. A similar project, the Kemper County IGCC project in Mississippi, USA, will likely commission during 2015. Both projects have sales contracts for their CO_2 with nearby enhanced oil recovery (EOR) projects. Kemper County has suffered long delays and major cost overruns, but Boundary Dam was delivered on time and within budget and indicates that the combination of CCS and EOR with policy support in the background can be a winner.

Elsewhere in the world where EOR opportunities are scarce, financing CCS remains a hurdle. In Europe many projects that received support under the European Union Economy Recovery Plan have since been cancelled as no one has been prepared to put up the additional money needed. How financing is to be arranged for projects in the countries that will need CCS for their coal power plants the most - China and India - remains an open question.

In the *Renewal* scenario we assume a breakthrough for CCS in the relatively near future and a rapid roll-out of this solution for remaining fossil fuel based power plants and heavy industry during the late 2020s and 2030s. By 2040, approximately 1.6 Gt of CO_2 will be captured, transported to safe deposits and stored worldwide. This corresponds to roughly 1600 Boundary Dam or Sleipner projects, but is still way below the 3-4 Gt of CO_2 emissions assumed to be removed through CCS in the 2DS scenario in IEA's Energy Technology Perspectives 2015.

Final energy consumption

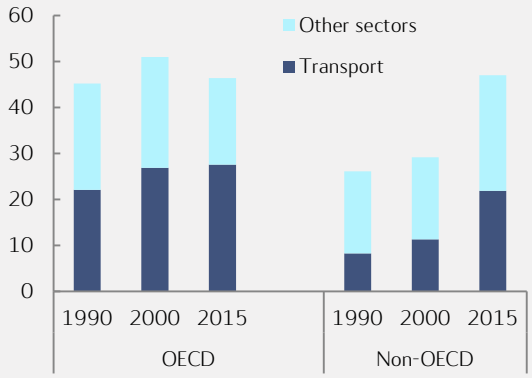
Mtoe



Source: IEA

Global oil demand

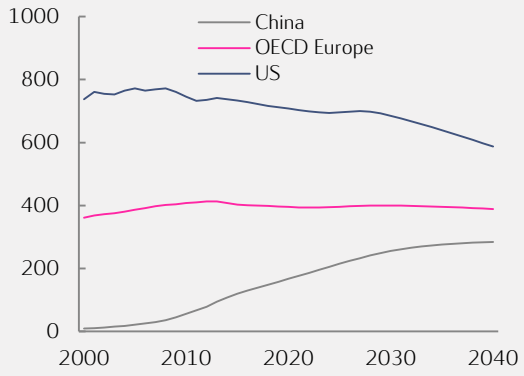
Mbd



Source: IEA (history), Statoil (2015)

Car density

Cars per 1000 people



Source: IEA (history), Statoil (projections)

Rising energy demand in transport – with oil's monopoly situation threatened

Transport accounts for 28% of energy demand and is on the rise

In 2012 total energy consumed in the transport sector was almost 2.2 billion toe, which represented an annual average increase of 2% since 1990 and accounted for 25% of the world's total final energy demand (TFE). Driven by rising demand for individual mobility and goods transport, energy use in the transport sector has increased in both advanced and emerging economies. However, after 2000 efficiency improvements and saturation effects in transport and other sectors in the OECD regions have led to stagnation in energy use. With more than 90% of the energy use consumed by cars, buses, trucks and two-wheelers, *road transport* is the dominant transport mode. In 2012 passenger cars accounted for 77% of the total passenger energy use in OECD countries and 56% in non-OECD countries. Public transport modes (road and rail) represented 4% and 17%, respectively of total transport energy demand in OECD and non-OECD. For freight transport, road represented 67% of the total energy use to move goods, and trucks accounted for almost three quarters of the total. Oil products have traditionally had a monopoly position in the road sector, in domestic and international aviation and in marine transport, while coal and electricity have had significant market shares in the rail sector.

Strong megatrends shape the structure of future energy demand

Four strong megatrends will shape the development and structure of global energy and oil demand over the longer term:

- Continued *economic growth,* in all regions, which stimulates demand for mobility and for goods transportation.
- The impact on energy demand will increasingly be constrained by *urbanization*, which contributes to increasing congestion and reduces the advantage of using cars, especially if lifestyle and preferences of coming generations change.
- Policy responses to rising and increasingly severe *environmental challenges*; local air pollution, pressure on water resources and the growing awareness of climate change.
- Technology developments in general, and *battery technology* in particular. Cost reductions are continuing. Plug-in hybrids (PIH) and full electric vehicles (EVs) looks set to significantly improve their competitive position compared with cars with combustion engines.

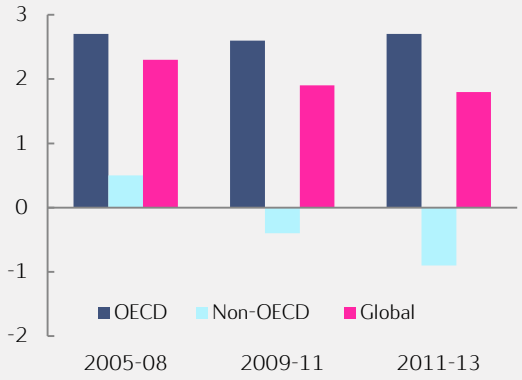
Most of these megatrends directly and indirectly drive the key variables of the energy model that shapes our projections – for total energy use in the sector and for inter-fuel competition.

Car ownership meets resistance and car licence rates are falling

As long as the car gives individuals flexibility and relative travel costs are competitive, the attractiveness of cars remains high. However, rising congestion means that the car option increasingly fails to deliver on choice of route, arrival time and convenient parking. Furthermore, there is a growing list of acceptable alternatives, both virtual and physical, and awareness of individuals' health suggests that walking and cycling will

Recent trends in fuel efficiency

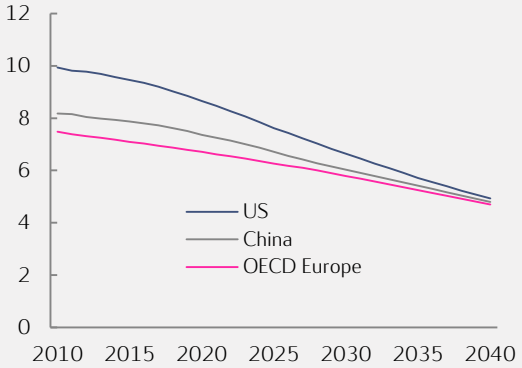
Annual average improvements, %



Source: IEA and Global Fuel Economy Initiative, 2014

Fuel efficiency

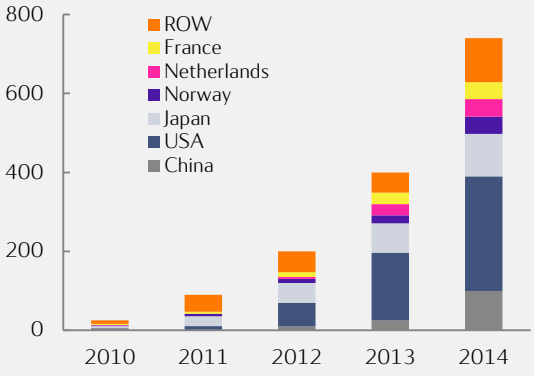
Light duty vehicles, l/100 km



Source: IEA (history), Statoil (projections)

Plug-in electrical vehicle fleet

Start of the year, thousands



Source: IEA

be more common. While car ownership has continued to grow in cities in emerging economies since 2000 (driven by income and status effects), ownership rates have fallen in several cities in the OECD area. These are signposts that the traditional link between income and car ownership and car use (distance travelled) weakens once saturation levels are reached.

The future of cars in China – one of the wild cards

The trends towards rising traffic congestion and deterioration of local air quality have been particularly evident in China. In many large cities and regions, where smog levels have moved far above acceptable health standards, local governments have introduced licence plate restrictions to regulate car ownership and car use. Looking ahead, private ownership and distances travelled per vehicle should potentially continue to drive energy demand in transport. While the US and Europe have private car ownership of 700 and 550 vehicles per 1000 inhabitants, respectively, China will on a national basis, more likely see ownership rates level out at 250-300 vehicles during our forecasting period, dependent on the overall rural and urban structure, per capita income levels, type of transport network between cities as well as air quality trends and other wider policy objectives. The same drivers will probably lead to lower distance travelled per vehicle over the next decades – from the current level of 12000 kms per year to 7000-9000 kms.

Fuel efficiency gains are driven by efficiency standards

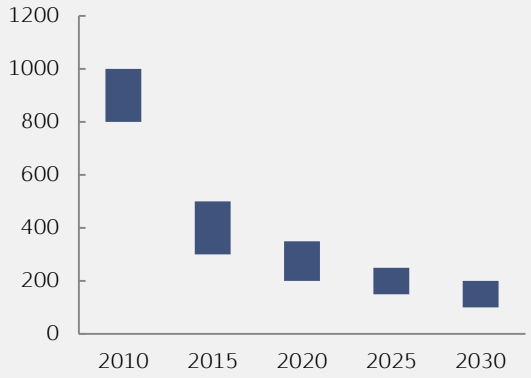
In most OECD countries fuel efficiency and emission standards for passenger light duty vehicles (PLDVs) have been significantly tightened since the middle of the last decade. Outside the OECD area the introduction of efficiency standards has been slower. China has gradually tightened its standards, and Brazil, India, Mexico and Saudi Arabia have in recent years adopted similar standards. An updated study (2014) on PLDV fuel efficiency improvements (2005-2013) by IEA and the Global Fuel Economy Initiative (GFEI) shows that there is a clear relationship between the rate of efficiency improvements and the timing and tightness of efficiency standards, While the annual efficiency improvement for the OECD countries were 2.6%, improvements in non-OECD countries slowed and stagnated during the period. In emerging economies the combined effects of a preference for larger vehicles (as income grows) and a lack of standards have not surprisingly prevented fuel efficiency improvements. In 2012-2013, Japan and the major EU economies have experienced accelerating gains, of 4.7% and 3.3-4.8%, respectively, which suggests a potential for significant future improvements worldwide. Given the belief that sustainability issues will be given higher priority in most regions of the world, tightening efficiency standards for both PLDV and heavy trucks are expected to drive fuel efficiency improvement further.

Strongly rising sales of "green vehicles" in several markets

Governments, local authorities and businesses increasingly recognize electric mobility as one of the key elements of a sustainable transport sector. Globally, hybrid electric vehicle sales reached 1.57 million cars last year, with over 1 million sold in Japan. This represented a 20% growth from 2013. In 2014 new sales of plug-in hybrids (PIHs) and full electric vehicles (EVs) grew by 0.32 million to a total number of 0.74 million on the roads. Although new sales have risen sharply in absolute terms, the market shares in most markets are still very low, typically between 0.5

Estimated battery cost range

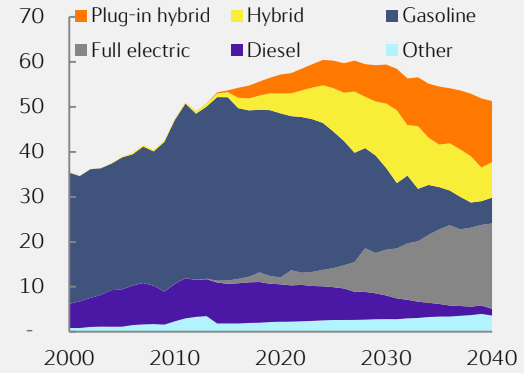
USD/kWh



Source: Nykvist and Nilsson, Stockholm Environment Institute, 2015 and Statoil

New car sales in main regions

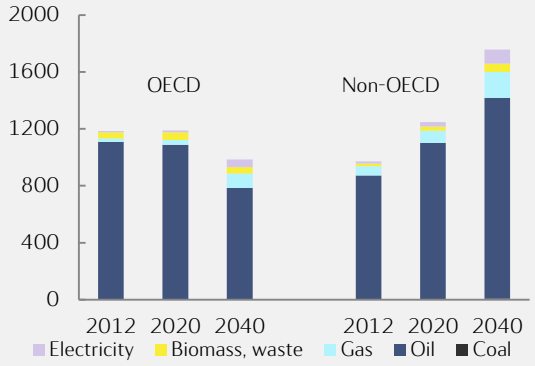
North America, China, OECD Europe, India, million cars



Source: IEA (history), Statoil (projections)

Energy use in the transport sector*

Bn toe



*Excluding international bunkers

Source: IEA (history), Statoil (projections)

and 2%. In the Netherlands, and particularly in Norway, the market shares of PIHs and EVs combined reached impressive 4% and 12.5%, respectively, but these strong gains were driven by tax credits, subsidies and other incentives to promote sales.

Battery costs and overall costs of EVs are coming down

Despite falling battery prices, payback calculations for hybrids and electric vehicles show that most of these cars are still not fully cost competitive relative to vehicles with internal combustion engines. However, a study by Stockholm Environment Institute (Nykvist and Nilsson, 2015) indicates that battery costs for leading electric car models have been reduced from 1000 USD/kwh in 2007 to around 300 USD/kWh in 2014. The cost reductions realized over the last few years appear to have been larger than previously expected. Based on learning curves from other lithium-ion battery applications and comprehensive ongoing research by automotive companies, studies suggest that battery costs can come down towards the 150-200 USD/kwh level by 2030, and potentially lower. This, together with cost reductions arising from the mass production of EVs, implies that smaller EVs, with a 300 km range, will probably become cost competitive with similar conventional engines.

Rising attractiveness should lead to higher market shares of EVs

Generally, consumers' preferences for vehicles with different engine technologies eventually depend on their cost-benefit assessments, including end-user prices affected by possible financial incentives and preferences given to EVs, and uncertainties about driving range and lifetime of batteries. Based on the outlook for relative cost reductions and lower uncertainty about EVs' overall performance, it is likely that the attractiveness of PIHs and EVs will rise over time. In the *Reform* scenario we have assumed that that world-wide market shares of the new sales of PIHs and EVs increase to 14% (28% in total) by 2030 and further to 25% and 30% respectively by 2040.

The *Renewal* scenario is based on the assumptions that battery costs will decline towards the lower end of the cost range and that regulations will be supportive. This will boost penetration rates of PIHs and EVs, with full EVs as the dominant technology.

On balance, rising mobility compensates for higher efficiencies

Towards 2040 the net effect of all these forces and trends leads to a continued, although decelerating growth in the energy demand of the transport sector. China and generally the emerging markets will experience the strongest growth, driven by rising incomes and demand for mobility and a continued preference for passenger vehicles. More aggressive regional policies with comprehensive regulations and efforts to redirect travel from road to rail and to public means of transportation, and the enhanced efficiency, are as a rule in the *Reform* scenario not sufficient to arrest the underlying income driven growth. However, due to the increasingly stronger penetration of alternative vehicle technologies, oil demand in the transport sector is projected to reach a peak around 2030.

The global oil market

2014-2016 – strategy shift and rebalancing

Saudi Arabia makes a historic strategy shift

Supported by low commercial oil stocks and concern about oil supplies, Brent prices fluctuated around 110 USD/bbl during the first half of 2014. However, the further acceleration in US shale oil production and the sharp slowing of oil demand growth in mid-2014 apparently convinced Saudi Arabia that its traditional strategy of price defence had run its course and that further attempts at price defence would only lead to an unfair balance between Opec and non-Opec production. Following increasingly strong signals from the Saudis, on 27 November 2014 Opec made a historic decision to keep production unchanged and to leave it to the market to find a new equilibrium oil price. Given the underlying momentum of oversupply and an outlook for further growth in commercial stocks in the coming quarters, crude oil prices dropped sharply during 4Q14 before prices levelled out around 50 USD/bbl in January. The consistent decline in the US rig count and signs that US shale production is close to a peak have created hope in the market that a rebalancing is not far away, which in recent months has led to a tentative price recovery.

Price drop, but small effect on the pumps – and on oil demand

Since prices started to fall last autumn there have been expectations for a positive effect on products demand. However, a strong US dollar and higher taxes or lower subsidies on oil products have moderated the fall in end user prices in most regional markets outside the US. While crude prices tumbled by more than 50%, end-user prices in the 1Q15 had only fallen by 10-15%. Since short-term price elasticities are rather low, this suggests that the demand response to the sharp crude price drop will be modest in most regions. The moderate price recovery seen in recent months only strengthens this conclusion.

Hope for stronger demand growth

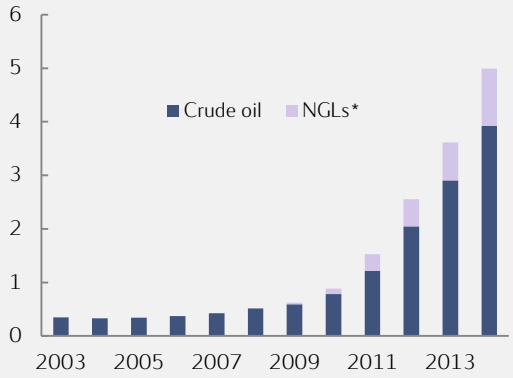
The outlook for stronger economic growth in OECD through 2015 and 2016, an exceptional 30% fall in US pump prices and colder than normal weather in 1Q15, entail that OECD oil demand, led by the US, may swing from a 0.5 mbd decline in 2014 to moderate growth in 2015. The mixture of slowing economic growth in China, but accelerating growth in the Indian economy, suggests that non-OECD Asian oil demand on balance may increase by almost 0.7 mbd, which is in line with historical trends. However, Brazil, Russia, and many oil producing countries of the Middle East are currently facing strong headwinds. Thus, oil demand in most non-OECD regions excluding Asia will probably grow more slowly than normally. Overall, global oil demand is bound for a growth of 1.0-1.2 mbd in 2015 and 2016, unless the world economy develops significantly differently than expected.

Sharp investment cuts and stagnant non-Opec production

Mainly helped by an impressive 1.6 mbd gain in US oil production, total non-Opec production rose by a record 2.1 mbd in 2014. However, the sharp fall in prices has forced the industry to make large cuts in upstream investments. For 2015, investments appear to be reduced by up to 40% and several companies have already signalled further cuts in 2016. Since the peak in US rig counts in October 2014, the number of

US shale production

Mbd

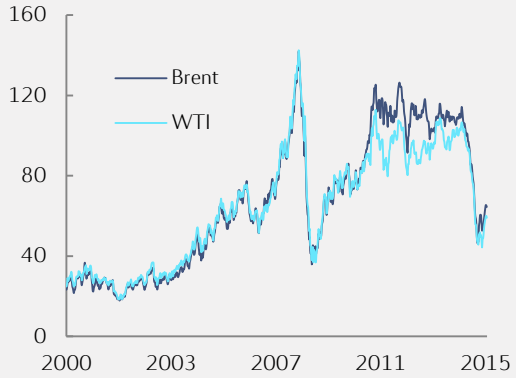


*Estimate

Source: US EIA, March 2015

Crude oil prices

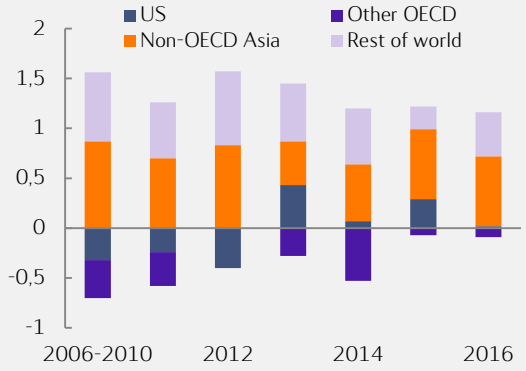
USD/bbl



Source: GDM

Global oil demand

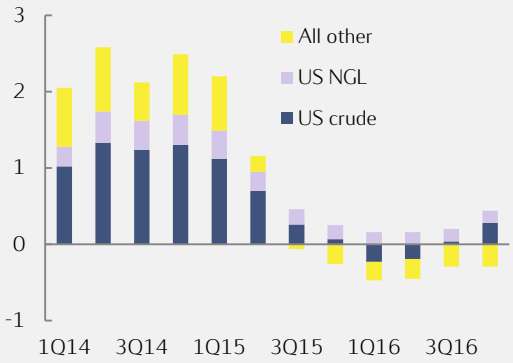
Annual change, mbd



Source: IEA (history), Statoil (projections)

Non-Opec production

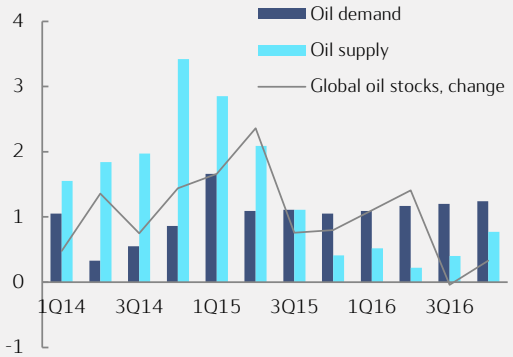
YoY change, mbd



Source: IEA (history), Statoil (projections)

Global oil balance

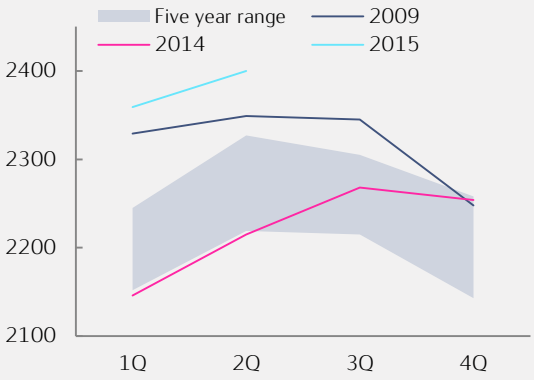
YoY change, mbd



Source: IEA (history), Statoil (projections)

OECD commercial oil stocks

Million barrels



Source: PIRA Energy

drilling rigs has fallen by more than 50% and shale production is now in a phase of levelling out, and expected to decline during the second half of 2015. This will reduce shale related crude oil production growth from 1.2 mbd in 2014 to 0.4-0.5 mbd this year. A stagnant picture is likely for most of 2016, but a tentative price recovery may trigger an early drilling recovery. The cuts in oil companies' investments are also affecting regions outside the US. Lower investments will increase the depletion rates of existing fields and slow the development of smaller projects. After a couple of years with quite strong production growth, non-Opec production outside the US will most likely decline in both 2015 and 2016.

Commercial oil stocks are on the rise

During 2014 the unbalanced development of oil demand and total oil supply led to a global oversupply of 1.0 mbd. While most of the surplus in 4Q14 appeared to have flowed into new infrastructure, strategic stocks and floating storage, a large part of the counter- seasonal rise in global oil stocks in the first five months of 2015 has moved into the price-influential commercial oil stocks in the main OECD markets. Based on data up to May 2015 total crude and product stocks in these markets are now reaching record high levels. Furthermore, in March, Saudi Arabia lifted its crude production by 0.5 mbd to more than 10 mbd and now seems to keep production at this level. This increase has effectively brought total Opec production up to around 31 mbd. If Opec keeps production at this level through the year, OECD commercial stocks will increase substantially, with rotation toward rising product stocks.

Strategy change and implication for the market equilibrium

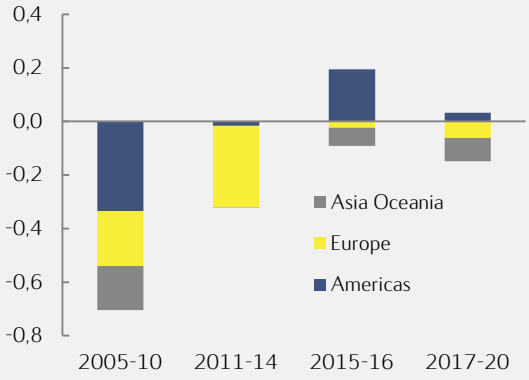
Lower prices and slowing non-Opec production is the first phase of the new market equilibrium dynamics following from Saudi Arabia's strategy change. In the old regime, Saudi Arabia and Opec traditionally played the role as swing producer and adjusted production volumes up or down in order to balance the market and defend a "fair price level". In the new regime where Saudi Arabia gives priority to Opec's market shares and own production – and provides base volumes – the market clearing process is effectively turned upside down. To achieve market balance, for a given level of Opec market share, non-Opec producers have become the suppliers of the balancing barrels. When prices tumble, US shale production – due to its special production profile and cost structure – takes most of the hit, but shale producers are at the same time well positioned to re-start drilling when prices recover above a certain level, It appears that the market thinks this level is about 60-65 USD/bbl WTI.

Removal of excess oil stocks and price volatility

If global oil demand continues to grow by about 1 mbd in 2016, non-Opec production remains stagnant, and Opec production is kept around 31 mbd, supply and demand is brought roughly in line. However, the excess commercial oil stocks, which emerged in 2014-2015, must be eliminated before the market is fundamentally balanced. The price recovery in the spring of 2015 – ahead of a clean up of excess stocks – illustrates the normal forward-looking nature of the market. However, a too fast discounting of the future rebalancing may run the risk of incentivizing a recovery in US shale production and eventually lead to a setback in the rebalancing process. Thus, it seems that the new market regime inherently contains a new source of price volatility.

OECD oil demand

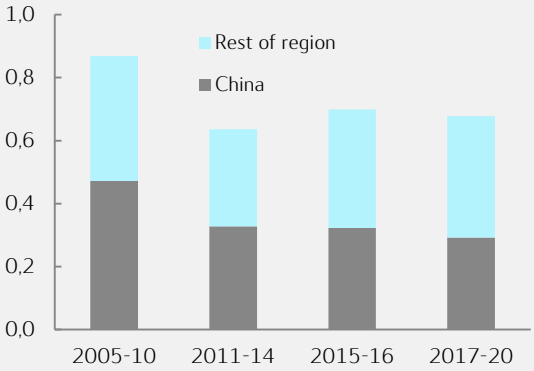
Annual average change, mbd



Source: IEA (history), Statoil (projections)

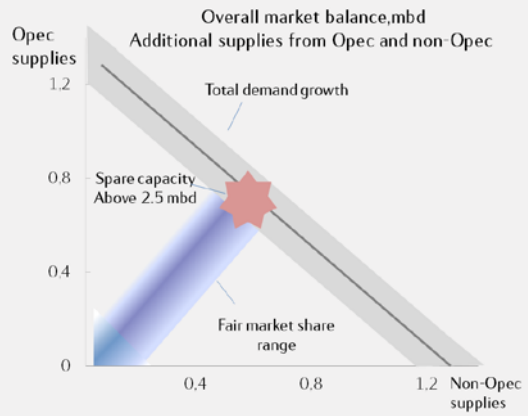
Non-OECD Asia oil demand

Annual average change, mbd



Source: IEA (history), Statoil (projections)

Complex equilibrium process



Source: Statoil

The next cycle (2017-2020)

Stagnant and declining OECD demand

The outlook for OECD oil demand (2017-2020) is based on the view that the main economies grow relatively healthy along their long-term trend. However, existing and new policy-induced efficiency gains and moderate losses of market shares mainly in the power sector continue to restrain overall demand growth. In the US, these drivers lead to a mixed picture for the various products, and gradually to stagnation in total products demand. In the other OECD regions, oil demand nearly consolidates in 2015-2016, but falls back into decline in the subsequent years, typically affected by efficiency driven losses in gasoline demand and substitution from residual fuel to other fuels.

Uncertain Chinese demand growth, Indian demand strengthening

Driven by hectic investment intensive economic growth between 2002 and 2012, Chinese oil demand increased on average by almost 0.5 mbd per year and was the main engine behind the growth in global oil demand. In recent years, slower economic growth and a shift towards a more consumption oriented economy have contributed to a moderation of oil demand growth to about 0.3 mbd. The outlook for further slowing of the Chinese economy and weaker expansion of the energy intensive sectors, in combination with the government's stronger emphasis on environmental standards, suggest that Chinese oil demand will continue to rise relatively moderately around 0.3 mbd per year. A scenario where oil demand only grows by 0.2 mbd per year for some years also looks plausible. On the positive side, the stronger outlook for the Indian economy has led to an upward revision of the country's oil demand growth. In aggregate oil demand in non-OECD Asia is projected to rise annually by almost 0.7 mbd, which is in line with the historical aggregate.

Headwinds slow demand growth in other emerging economies

Oil demand trends in Latin America, the Middle East, Africa and FSU are currently affected by several restraining forces; economic challenges, geopolitical constraints, political unrest and lower oil revenues. Many of these headwinds will probably moderate over the next few years, but the macroeconomic outlook is hampered by structural imbalances and other impediments. However, after some years with below trend growth, oil demand growth will most likely accelerate from 2017.

A complex oil supply structure

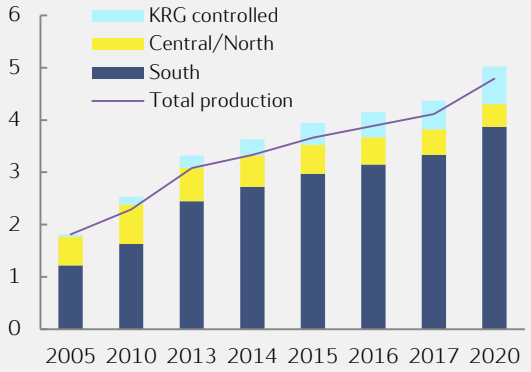
In aggregate, global oil demand is projected to grow by about 1.1 mbd annually and reach 99 mbd in 2020. Total oil supplies needed to cover additional final demand and allocations to new infrastructure and strategic storage will generally come from three sources:

- Low cost Middle East oil, mainly from Iraq and Iran, which have ambitious expansion programs, and from Saudi Arabia, which still has ambitions to influence the market.
- The relatively low cost, but highly price sensitive US shale oil.
- All other non-Opec supplies, including supplies from the traditionally high cost areas.

The volume split between these sources will mainly be determined by Opec's market share ambitions. A supply mix where additional supplies of crude and NGLs from Opec and non-Opec are split relatively equally may be seen as "fair". That allows for an annual growth in Opec crude

Iraqi capacity and production

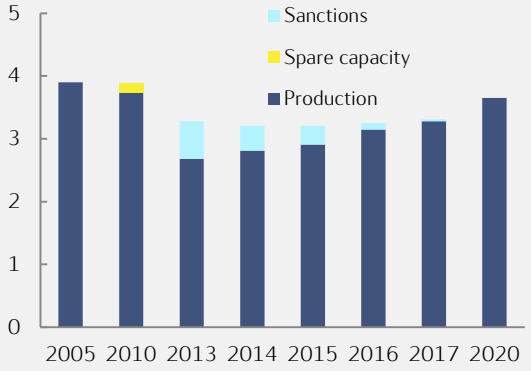
Capacity by region, mbd



Source: IEA (history), Statoil (projections)

Iranian oil production

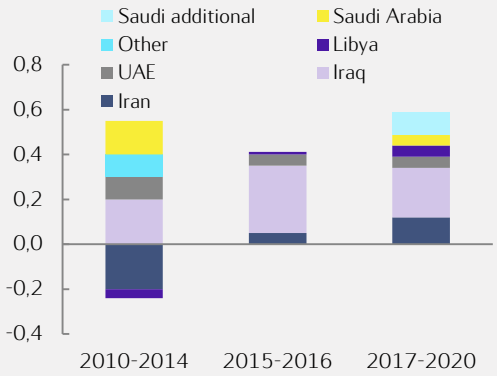
Mbd



Source: IEA (history), Statoil (projections)

Opec capacity additions

Annual average change, mbd



Source: IEA (history), Statoil (projections)

production in the order of 0.4-0.5 mbd, and takes total Opec crude production to 32.5-33.0 mbd by 2020. However, what really counts for Saudi Arabia and all member countries is oil revenues. This means that Opec will continue to keep at least one eye on oil prices. History suggests that it is not straightforward for Opec to attain its oil revenue targets. Among the many challenging trade-offs Saudi Arabia will be facing is the fine-tuning of its capacity to avoid excessive price development. The market's price signals and the relative cost development will be critical for the split between US shale oil and the traditional non-Opec production. A low to moderate price level will favour relatively low cost US shale, while expectations of rising prices may also encourage producers operating in high cost areas to expand production.

Amid political fragmentation, can Iraq deliver?

The ongoing political transformation of the Middle East, which has reinforced the sectarian conflicts in Iraq and other parts of the region over the last few years, has made it even more challenging to manage Iraq and develop the country's oil sector. Despite the huge political challenges, the industry has successfully developed new capacity, both in the main oil province in the south and in the semi-autonomous Kurdish region. Driven by a significant contribution from the area under Kurdish control, total Iraqi oil production may rise by 0.3-0.4 mbd this year. Supported by the governments in Baghdad and Erbil the oil companies have plans for further expansions over the coming years. However, the hostile business climate with lack of coordination, lower oil prices and potential terrorist attacks from IS obviously raises questions about the country's ability to deliver. Based on historical experience since the mid-2000s, total production is projected to rise by 0.2-0.3 mbd per year between 2015 and 2020, but with large downside risk.

How fast can Iran bring its oil industry up to speed?

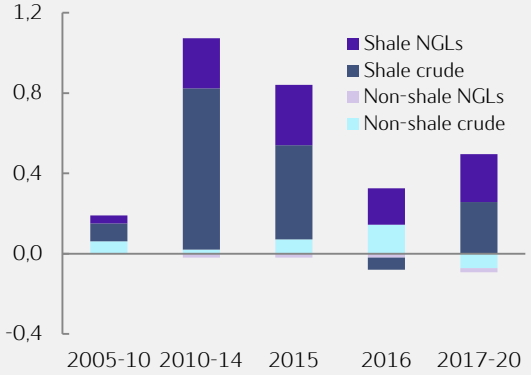
With the outlook for the lifting of economic sanctions related to the nuclear program, Iranian oil production is bound for a gradual rise over the next few years. The Iranian government is currently preparing an ambitious reactivation and expansion program for the country's upstream sector. A successful implementation is probably dependent on active engagement and support from the international oil industry, but oil companies' willingness to participate depends on the attractiveness of the economic terms of the new petroleum contracts and the potential hurdles that the remaining sanctions related to Iran's regional role may represent. Most likely, it will take some time to agree on the commercial terms and sort out all political issues, which suggest that the capacity expansion up to 2020 will be moderate, at least during the first part of this period.

Small capacity additions from the rest of Opec

The outlook for capacity additions from other Middle East countries are more limited, but smaller capacity additions may come in UAE and potentially in Kuwait. In Libya, where oil production is restrained by the civil war, the political situation may, however, improve in a three- to five-year perspective and allow for a moderate recovery. Based on the capacity outlook that also includes the rest of Opec, Saudi Arabia probably has to add net capacity in order to realize its market share ambition and to keep its spare capacity at sufficient levels.

US oil production*

Annual average change, mbd

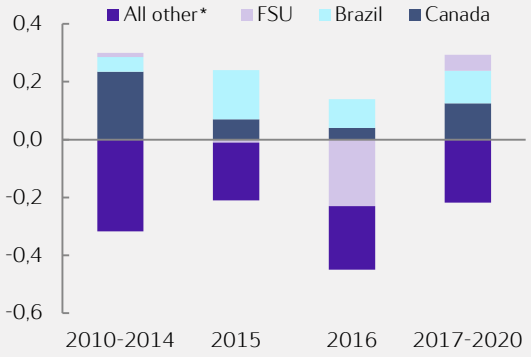


* Excludes bio-fuels and processing gains

Source: US DOE (history), Statoil (projections)

Non-Opec production, excluding the US

Annual average change, mbd

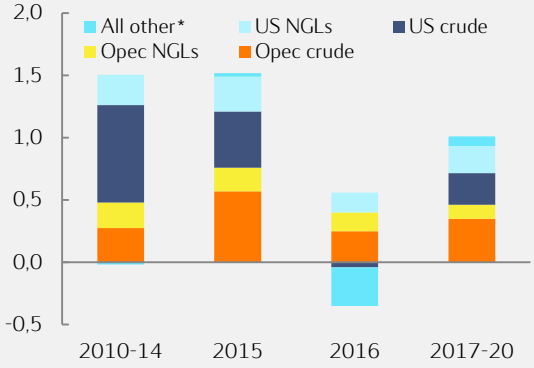


* Rest of non-Opec production outside the US

Source: IEA (history), Statoil (projections)

Total supply

Annual average change, mbd



*All other non-Opec production, excl. USA

Source: IEA (history), Statoil (projections)

The IOCs are positioning for a lower price level

In order reduce overall costs, most companies are currently undertaking comprehensive cost reductions and efficiency programs, which include the search for smarter solutions, efforts to enhance efficiency in all parts of the operations and negotiations with suppliers to improve cooperation and secure cheaper deliveries. Concepts and plans for many projects are sent back to the drawing board. The investment cuts themselves have already lead to significant softening of the supplier markets, which in aggregate could push the industry's cost level down by 20-30% over the coming years. Although some of these gains could be cyclical, the industry that recovers from the 2014 price shock will probably be slimmer, more efficient and more competitive than prior to the shock.

When prices recover, how fast will US shale production expand?

Prior to the price fall break-even prices for US shale plays were seen in a wide range between 45 and 85 USD/bbl (WTI) with a sensitive level, where large changes in the total drilling activities are triggered, around 70 USD/bbl. However, lower drilling rates, continued learning and efficiency gains, and relocations to more prospective formations, have pushed this "sensitive price level" lower, perhaps into the 60-65 USD/bbl range. Given that new drilling can be financed by easy access to capital, which was the case prior to the price collapse, shale production should start growing when prices move above this level. If oil prices settle, but fluctuate within the 70-85 USD/bbl range over the medium term, US crude production from shale plays may increase annually by 0.2-0.5 mbd. The robust expansions in 2012-2014 suggest that there is an upside to this projection, but arguments that debt financing could become a limiting factor for some companies point to the lower part of the range. On top of this comes the steady rising production of NGLs, which is projected to grow by typically 0.2 mbd per year.

Consolidation, sanctions and an industry scandal hit non-Opec

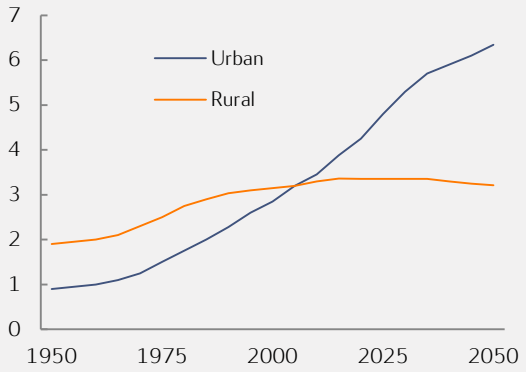
Outside the US, non-Opec production was on a rising trend in 2013 and 2014, helped by strong gains in Canada, Brazil and Russia. The industry's investment cuts in 2015-2016 will, however, generally slow new field developments and probably raise the depletion rate of fields in production. Most vulnerable are projects in an early development phase and unsanctioned projects in high cost areas. The economic sanctions towards Russia and the Petrobras scandal that has hit the entire Brazilian oil industry come on top of price driven consolidations. Russian oil production is expected to fall moderately, while the expansion in Brazil production will be slowing. Thus, in aggregate non-Opec production outside the US will only rise modestly during 2017-2020.

Towards a volatile market balance

Aggregation of the bottom-up supply projections, based on prices in the 70-85 USD/bbl range, shows that a balanced market – with fair market shares and with an acceptable level of spare capacity – is within reach. However, the vulnerability of the Middle East supplies, the uncertainty about the price sensitivity of US shale production and the effects of the industry consolidation, clearly suggest that the medium-term market can go in different directions. Obviously potential underinvestment can trigger a new upwards price cycle, but the economics of US shale production suggests that additional shale supplies relatively quickly may dampen excessive price fluctuation. The market is heading towards a new type of price volatility.

Population growth

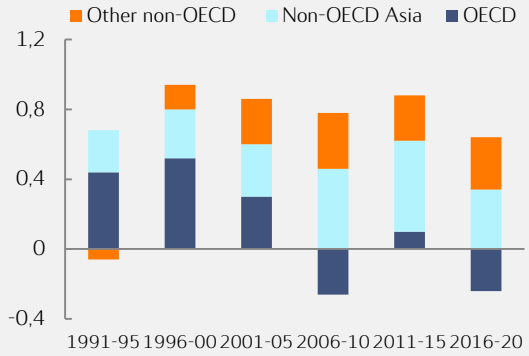
Billion



Source: UN

Oil demand in transport

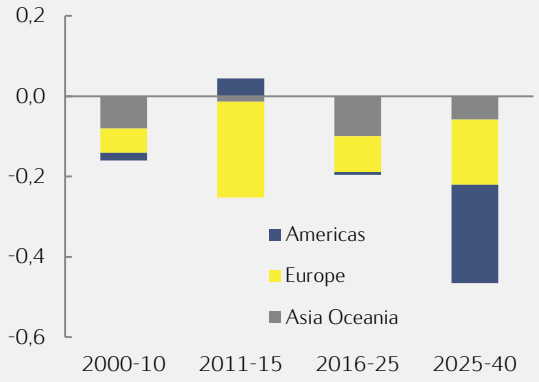
Annual average change, mbd



Source: IEA (history), Statoil (projections)

OECD oil demand

Annual average change, mbd



Sources: IEA (history), Statoil (projections)

The long-term outlook – towards intensified competition

Strong megatrends shape global oil demand

Three strong megatrends will shape the development of global energy and oil demand over the longer term;

- Slowing economic growth, partly driven by demographics, and a development towards a larger services sector in many of the larger emerging economies
- Continuation of the historical trend towards urbanization, with a growing number of megacities
- Political response to the environmental challenges and gradually higher priority given to sustainability issues

Especially China, but also other emerging economies, has successfully lifted income levels and the demand for electricity, individual mobility, and goods and services. But as a negative side effect – and exacerbated by the underlying urbanization – the air quality in many cities has deteriorated to unacceptable levels and generally created rising pressure on local resources. These trends are not sustainable. The Chinese government is currently giving environmental issues a higher priority. As stressed in previous chapters – as various sustainability issues are expected to move to the forefront of policies in practically all regions – it is assumed that comprehensive and more increasingly more aggressive energy and climate policies are adopted and implemented.

The megatrends are strongly affecting transport

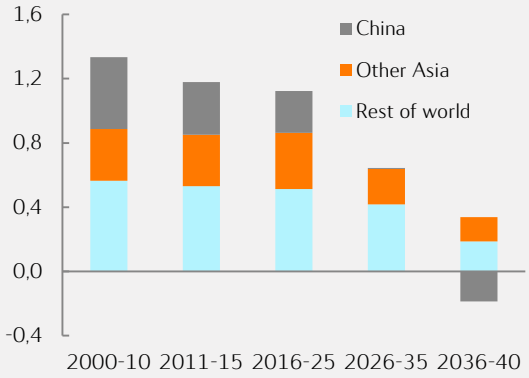
Transport has for decades been the backbone of the oil market. Oil products have had a near monopoly position in this sector, and more than 50% of global oil demand is consumed in transportation. Thus, how the trends play out in transportation will be critical for the development of oil demand in all regions. Further urbanization is generally expected to affect the demand for mobility and particularly the demand for the various modes of daily travel, including the use of own vehicles. Lifestyle and preferences of younger generations in the urbanized parts of the world may suggest that the demand for car ownership and use of cars may grow less than previously expected. Furthermore, a steady tightening of efficiency standards and other regulation of mobility and transport activities are expected. From an oil demand point of view the timing of the penetration of plug-in hybrids and full electric vehicles (EVs) represents the largest uncertainty, and different assumptions on market shares of engine technologies will shape the outlook for oil demand. Alternative scenarios for the use of EVs and the other driving forces are discussed in the separate chapter on the transport sector.

Global oil demand reaches a peak around 2030

The underlying projections for the transport sector to a large extent explain the overall outlook for global oil demand. As described in the chapter on transport, steady tightening of fuel efficiency standards and further progress in hybrid and battery technologies, which make alternative technologies more competitive, contribute to the overall slowing of oil demand growth in all regions. Also in other sectors lower GDP growth, the continued improvement of energy and oil efficiency, and substitution away from oil lead to slowing demand. OECD oil demand, which is currently around 46 mbd, is expected to fall steadily through the coming decades and to reach 37 mbd in 2040.

Non-OECD oil demand

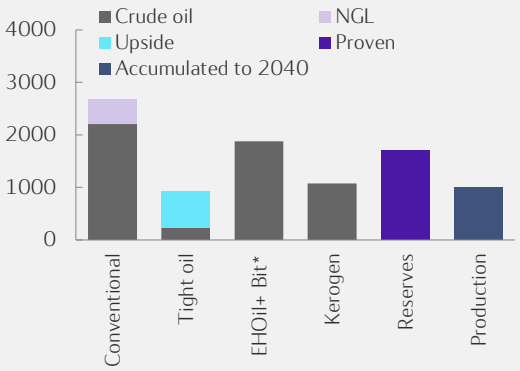
Annual average change, mbd



Sources: IEA (history), Statoil (projections)

Recoverable oil resources

Bn barrels

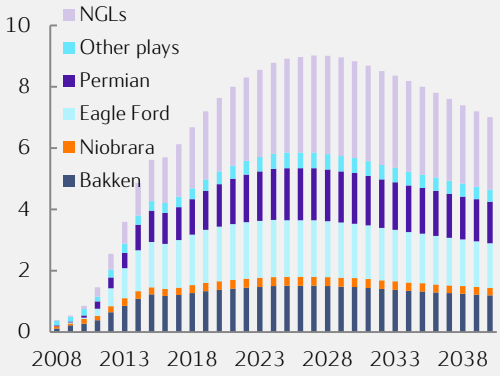


* Extra Heavy Oil and Bitumen

Source: IEA, Statoil

US shale oil by source

Crude oil and NGLs, mbd



Source: IEA (history), Statoil (projections)

In China, the annual demand growth will slow from 0.3 mbd in the early 2020s towards stagnation around 2030, before it moves into steady decline in the 2030s. In other emerging economies the restraining drivers are generally weaker, which means that demand will continue to rise, but increasingly by a slower rate. In aggregate, global oil demand, including bio-fuels, grows from 99 mbd in 2020, levels out at 106 mbd around 2030, and then falls slowly to103 mbd in 2040. This forecast is mainly in line with the projections in the last editions of *Energy Perspectives*.

The three fundamental supply issues

Given these prospects for oil demand, three key main questions arise:

- Can the remaining recoverable oil resources cover the accumulated demand up to 2040 and beyond?
- How much of total supply will be covered by low-cost conventional Middle East oil?
- At which cost levels can the additional oil that comes from other regions, mostly non-Opec volumes, be developed?

Recoverable resources are sufficient

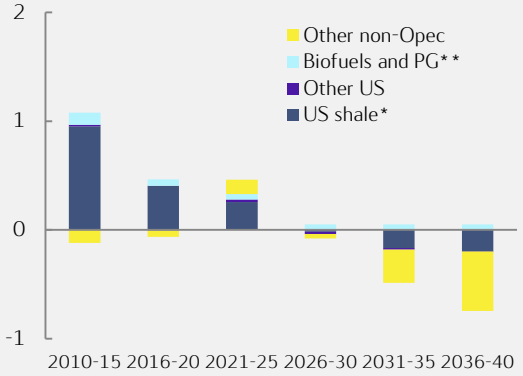
The assessments of the US Geological Survey are the key source for several institutions' estimates of the remaining recoverable resources of various types of oil liquids. In WEO 2014 IEA estimates that the total remaining recoverable conventional resources of crude, condensate and NGLs are 2615 billion barrels. The three main categories proven reserves, reserve growth and undiscovered (yet to find) resources amount about 1700, 700 and 300 billion barrels, respectively. The 2014 estimate represents an upward revision of 42 billion barrels compared with the 2013 assessment. IEA believes that the remaining recoverable resources of US shale oil (light tight oil) and other unconventional resources are about 345 and 2950 billion barrels, respectively. Compared with the assessment of several consultants, IEA's estimate of shale oil and NGL reserves from shale gas are conservative. In aggregate, IEA's estimate of total remaining recoverable oil resources amounts to almost 6000 billion barrels, of which 1700 are proven reserves. The estimates and perceptions of the size of the future reserve growth and yet-to-find resources, which are quite controversial, tend to fluctuate with upgrading and exploration performance. However, even if a lower, very cautious estimate (P95) is applied, the total remaining oil resources are sufficient to cover our projected accumulated oil supplies of approximately 1000 billion barrels up to 2040.

US shale production remains a key source

The long-term outlook for US shale production remains crucial to the overall market balance and Saudi Arabia's market strategy. Despite the price-triggered setback in shale production in 2015-2016, several consultants have revised the resource estimates and production outlook for the longer term further upwards. Given that most of these resources are economic at prices below 80-90 USD/bbl, we expect that total crude oil production from all plays will rise steadily from 4.3 mbd in 2015 towards almost 6.0 mbd in the second half of the 2020s. This level is in the middle of a range of forecasts from consultants, the US Department of Energy and IEA. Up to 2025 most of the growth is expected to come from the three main plays; Bakken, Eagle Ford and the Permian. Beyond 2025 declining Eagle Ford production will partly be met by moderately rising production from the Permian, but in aggregate total shale production will most likely decline moderately through the 2030s.

Non-Opec production by main source

Annual average change, mbd

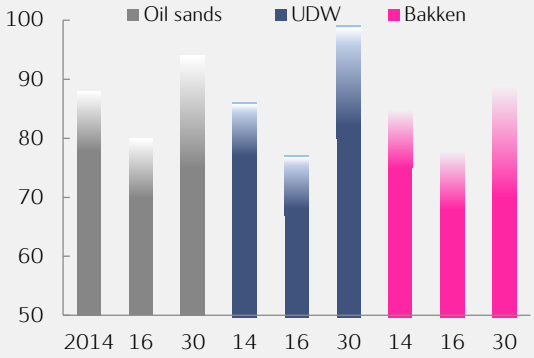


* Crude and NGLs ** Processing gains

Source: US EIA (history), Statoil (projections)

Supply cost of expensive non-Opec supplies

FCC cost range*, 2015 USD/bbl

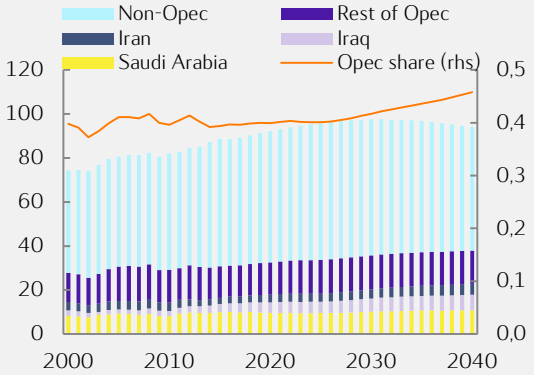


*Range for FCC of marginal projects

Source: Statoil and various market information

Total supply and Opec share of supply

Mbd and share



Source: US EIA (history), Statoil (projections)

Compared with conventional production, the implicit recovery rate is still very low and below 10%. Further technological advances in the future could lift this rate and production profile, especially in the 2030s. In addition to the crude oil production comes a steady growth in NGLs mainly from shale gas, implying that total US oil production, excluding biofuels, rises from 12.6 mbd in 2015 to almost 16 mbd in 2030, before production declines moderately during the 2030s.

Less room for additional high-cost non-Opec production

The combined outlook for decelerating oil demand growth, robust US shale production and a potentially strong expansion of Iranian and Iraqi oil production suggests that Opec, led by Saudi Arabia, will continue to give priority to market share defence, and gradually seek higher shares as it becomes more evident that oil demand faces stagnation and decline. There are obviously many uncertainties related to the underlying forces, but the main implication is that there will be less room for expansion of the most expensive non-Opec production than previously expected. Despite the lower call for high cost non-Opec production, a large number of new oil fields must be developed in order to replace the exhausted capacity of existing fields. The depletion rates of the rising share of deep water production will become increasingly more important for the supply picture.

At which cost can new oil resources be developed?

Full cycle cost (FCC) of marginal projects in various high cost areas like oil sands and ultra-deep waters were prior to the 2014 price collapse assessed to be in the USD 80-90 USD/bbl range. As mentioned, the lower prices have probably pushed the FCC of these projects significantly lower, at least in the short- to medium-term. The cost level of the next generations of projects – to be developed over the coming decades – will still be driven by reservoir complexity, technology improvements and prices in the supplier markets. The continuation of the current trends toward development of smaller fields and reservoirs that are more complex will drive costs upwards, while technological improvement could offset at least some of the cost increases. The longer-term trend of unit prices is driven by supply and demand for skilled and experienced people in engineering and other segments. While the price fall clearly leads to downsizing and lower engineering capacity, the trend towards more standardized concepts potentially reduces the long-term demand for skilled people. In many resource-rich countries the cost level will also be influenced by policies that affect upstream competition and local content requirements. In this world of uncertainty most driving forces suggest that the upstream cost level will rise over the longer term.

Overall supply picture – steadily rising Middle East oil is in the cards

Given the underlying behaviour and development described above, Opec crude production is projected to rise steadily from 32-33 mbd in 2020 to 38 mbd in 2040, with a parallel increase in Opec's market share. Most of the additional Opec supplies is expected to come in the three Middle Eastern countries which hold the largest oil resources; Saudi Arabia, Iraq and Iran. The assessments above also imply that non-Opec production outside the US will fall steadily during the 2030s. The relative cost position of new supplies from oil sands, ultra-deep water and other high cost sources determines the split between supplies. The lower call for high cost oil suggests that only limited parts of the shale resources outside North America will be developed over the coming decades.

The global gas market

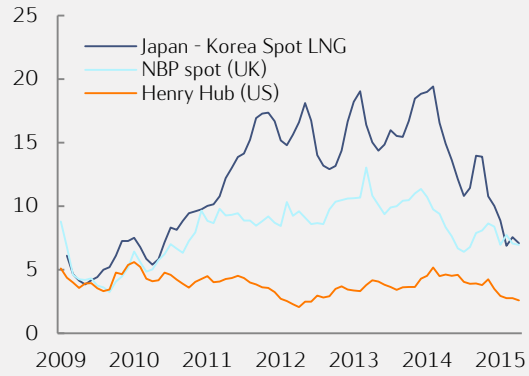
Setting the gas scene – what are the issues?

The fall in oil prices and natural gas

The plunge in crude oil prices during the second half of 2014 has implications for global gas markets and the industry in wider terms. Lower gas prices should as such underpin demand, but prospects for gas penetration into some new segments as transportation is actually challenged by more competitive oil. Contract prices linked to oil is still common in the industry, one example being the recently concluded sales agreement between Gazprom and CNPC. Lower oil prices make it harder to lift new gas projects, although costs are reportedly coming down, also as a consequence of the price-induced contraction in the industry. Although gas price formation in Europe takes place at liquid market places, gas sourced under oil-linked contracts constitutes a source of supply in the market. Contract prices typically follow oil prices with a time lag. The same goes for most LNG contracts in Asia.

Regional gas price markers

Jan 2009 - April 2015, USD/MMBtu



Source: EnergyScope

The plunge in oil prices has profound impact in the gas market

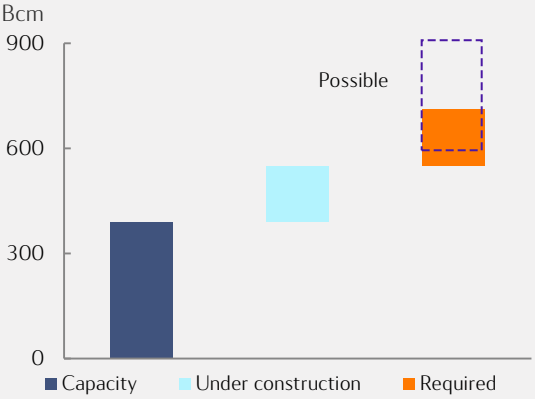
The cyclical nature of global LNG

The global LNG market is exposed to boom and bust cycles. The Qatari volumes were absorbed partly by the Fukushima disaster in 2011. Around 160 bcm of liquefaction capacity is currently under construction. Although a large share of these volumes is sold under contracts, the LNG market is expected to be well-supplied mid-term. A number of LNG projects are targeting project sanction; our list includes some 60 projects with 500 bcm of annual capacity. This has raised concerns of a 'long lasting surplus. However, the fall in oil prices is coinciding with an impasse in contractual negotiations over pricing terms. This suggests an alternative narrative of a return to market tightness in the 2020s. Companies are failing to take LNG projects to FID due to elevated price uncertainty, tougher capital budget constraints and project-specific issues.

Potential LNG buyers see an abundance of new supplies coming to the market and are reluctant to conclude longer-term contracts in the current price environment. Most LNG project developers are targeting oil-indexed sales contracts whereas Asian buyers are – or actually were – eager to supplement existing oil-indexed LNG contract portfolios with LNG purchased under alternative price formation mechanisms, including prices linked to Henry Hub. This contractual impasse has been exacerbated by the recent fall in oil prices. Some holders of US LNG even want to off-load exposure to Henry Hub-prices as the discount to traditional oil-indexed pricing terms has evaporated.

LNG liquefaction capacity by 2030: surplus or deficit?

Bcm



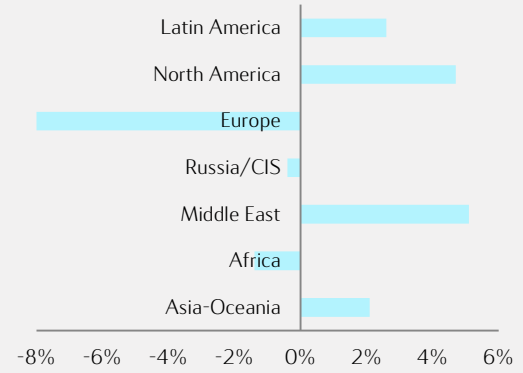
Source: Statoil (compiled from open sources)

Russia's fallout with the West and pivot to the East

Moscow's interference in Ukraine is weakening the standing of natural gas in Europe with detrimental impact on the future role of gas in Europe. In 2014 EU launched an initiative to improve energy efficiency. Focus is on buildings, a segment with high market shares for gas. The objective is to curb the growth in gas imports to the EU. The Commission's own analysis suggests that higher energy efficiency could result in 100 bcm/yr lower gas imports by 2030 compared to a business-as-usual scenario. In Russia, the fallout with the West has triggered a turn to Asia, and pipeline exports to China could constitute a significant share of Russian gas exports by 2030. Sanctions are however making it more complicated for Russia to realize its ambitions in global LNG.

Russia is reshaping its gas strategy

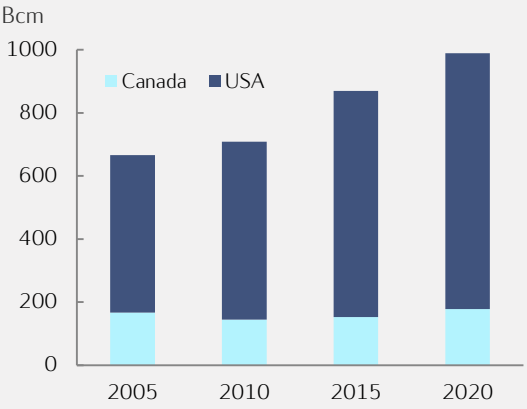
Change in gas consumption from 2013 to 2014



Source: Cedigaz

The strong growth in US shale production expected to continue

US and Canadian gas production



Source: Statoil

Outlook to 2020

Continued high growth rates globally

The international association for natural gas CEDIGAZ estimates global gas consumption growth at 1.1% in 2014, up from 0.8% in 2013. Although most emerging markets continue to show strong growth in gas consumption, growth rates weakened to 8% in China and actually turned negative in India. Total Asia Oceania gas consumption grew by 2.1%. European gas use was down 8% due to a particularly mild winter, while gas consumption in North America was up 4.7%.

The US may become net gas exporter by 2020

The shale revolution has transformed the supply side of the North American gas market. Despite challenging economics, US dry gas production is expected to grow from 690 bcm in 2013 to more than 800 bcm in 2020 (EIA). The emphasis is on the most economic shale and unconventional supply. The winners are the Marcellus/Utica area and liquids rich supplies near the coast (with an eye on export markets), notably the Eagle Ford area. More output from Marcellus will require infrastructure expansions in order to ensure outlet to markets to the west and south. The US is on its way to become a net exporter of gas, driven by LNG exports and higher pipeline exports to Mexico.

The bulk of US gas demand growth has so far come from the electricity sector as stricter environmental regulations and competitive gas prices incentivize generators to turn to gas to satisfy underlying load growth and for coal replacement. Industrial gas demand has also grown. Energy-intensive plants have been built in the US to capitalize on favourable gas prices, but the rising dollar is now hurting their competitiveness. North America is the only OECD region expected to show material growth in gas demand towards 2020, but growth rates will significantly slowdown from those observed in recent years. Thus, LNG exports out of the region will be crucial to balance the North American gas market.

Four liquefaction plants were by early May under construction in the US; combined they will add 60 bcm of capacity to the market. In the middle of May, Cheniere Energy taken FID on its Corpus Christi liquefaction project; a project that had contracted most of its planned output before the market turned. In general LNG projects face strong headwinds. Contracting for supplies has come to a halt, and without contracts projects cannot get financing. In the US and Canada, some projects are cancelled or deferred.

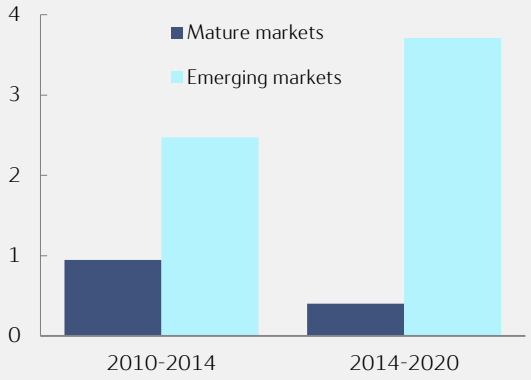
Muted gas demand in Europe, comeback for LNG

In 2014 European gas consumption was 100 bcm below 2008 pre-crisis level, but a quarter of this can be attributed to seasonally mild weather. European gas demand is expected to remain at current (temperature adjusted) levels until 2020. Continental Europe power gas demand should remain weak as carbon and coal prices stay low. UK gas-fired generation has regained its competitiveness towards coal thanks to the additional carbon tax through the carbon price support. In general renewables and lower-than-expected demand for electricity are making inroads in the need for thermal power plants in Europe. A somewhat brighter outlook for the Eurozone for the last half of this decade is not expected to translate into the same growth in industrial gas demand.

Gas demand growth concentrated in emerging markets

Gas demand

Annual growth rates in % (CAGR)

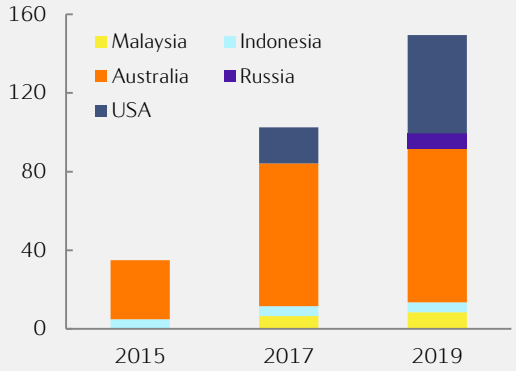


Source: Statoil

Sharp increase in global LNG capacity by 2020

Indicative LNG capacity additions

Bcm, cumulative addition at year end vs. 2014



Source: Statoil (compiled from open sources)

Since 2008 indigenous gas production in Europe has fallen by almost 60 bcm/yr or by 28%. UK gas production will remain at current levels for some years as new fields come on stream. Following an increase in the frequency of earth tremors in the Groningen region, Dutch authorities have on a number of occasions been forced to impose tighter caps on production. Norwegian gas production is expected to stay around 100 bcm per year for the rest of the decade. North African gas exports could strengthen from historically low levels. LNG imports to Europe were roughly halved over the last 3-4 years, but should now bounce back. Europe needs more LNG, and the window for commercial arbitrage for re-exporting LNG to Asia has been closed.

Russia has a significant surplus production capacity, and this is expected to last for some time. Gazprom is ramping up production from the giant Bovanenkovo field on the Yamal Peninsula in the Arctic, but less than planned due to weak domestic demand, low exports to Ukraine and higher production from the so-called independent producers. Gas exports to Western Europe have fluctuated around 150 bcm/yr over the last decade, reflecting variations in seasonal demand and the availability of LNG.

Asian gas demand growth is slowing down

Gas demand in OECD Asia will depend on the prospects for nuclear generation. Japanese utilities are preparing restart of some of the plants closed after the Fukushima disaster, but are challenged in courts. South Korea (and Taiwan) will add new nuclear plants. Growth in Chinese gas demand slowed down to around 8% last year, attributed to major price reforms (higher end user prices) and a general slowdown of the economy. The underlying growth in other emerging Asia gas demand is strong, reflecting the strength of the economies, energy shortages, penetration of gas into new areas or market segments, and rising concerns for local pollution due to extensive coal burning. Security of supply concerns have long impacted the willingness to drive gasification in Asia, but a broader set of LNG suppliers could improve the situation somewhat.

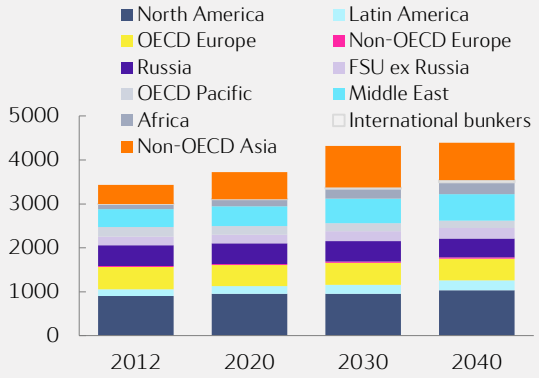
World gas demand is expected to increase by around 1.3% p.a. in the 2014 - 2020 period. Non-OECD Asia, the Middle East, Africa and Latin America are delivering growth rates above this rate, whereas Russia and all OECD regions below - or even decline.

The global LNG market is up for change

In 2014 two LNG projects commenced operation, one in Papua New Guinea and the first of the Australian liquefaction projects based on coal-bed methane. At least 160 bcm of annual new LNG liquefaction capacity is currently under construction with expected start-up before 2020; a few more may be added. Significant uncertainty is attached to start-up for some projects. However, some existing LNG producers are facing feed-gas shortage, most notably in Egypt, a country that will start importing LNG in 2015. Indonesia, a major LNG exporter, is diverting more and more LNG from exports to domestic use. The first US Gulf of Mexico LNG project is expected to commence operation in the upcoming winter, adding new dynamics and price linkages into the market.

Gas demand development

Bcm

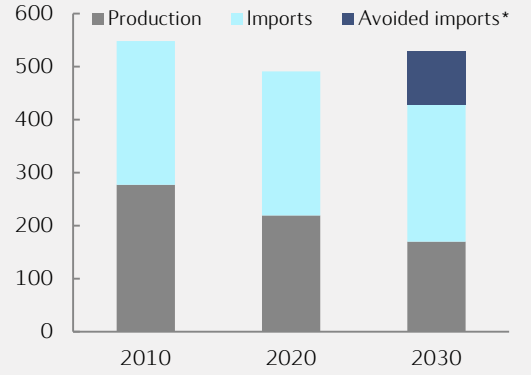


Sources: IEA (history), Statoil (projections)

North American LNG exports will increase

EU gas import requirements

Bcm



*Avoided gas imports by EU 27% energy efficiency proposal

Source: EU, Statoil, IHS CERA

The long-term outlook

Abundant North American supplies boost exports

North American gas demand is on a long-term growth trajectory due to a comparatively healthy US economy, growing and competitive gas supplies and more stringent regulatory restrictions on thermal power generation. Nevertheless, growth rates are expected to remain rather modest in the forecast period. Gas may be playing a more prominent role as fuel for heavy duty trucks.

The shale gas revolution has not run its course, and resource updates show that even more gas seems to be producible at moderate prices. Thus resources are available to ensure feed-gas for additional liquefaction projects, both in the US and in Canada. The authorities have also received a large number of requests for LNG export permits. Despite a difficult situation today, we believe that some of these projects will be developed as Non-OECD Asia and other import regions face growing import requirements. US brownfield projects are cost competitive, but gradually more costly greenfield projects need to be developed. In Canada, the front-runners are deferring FID due to high costs, falling oil prices (despite improved fiscal conditions in British Columbia), and First Nation issues. North American LNG export capacity could reach 150 bcm per year in the forecast period.

European gas remains highly politicized

The new European Commission has put a potential Energy Union on the agenda, building on existing policies and goals. 2014 saw a potentially significant shift in EU energy policies when the EU leaders in October added an energy efficiency target of 27% by 2030 to complement the 40% carbon reduction and the 27% renewable targets put forward in January 2014. The Commission's own analysis suggests that gas demand in such a scenario would be slashed by a quarter by 2030 compared with a business-as-usual scenario. Most observers believe that Europe will increasingly rely on imported gas, and imports from sources outside OECD Europe could be expected to grow by 100 bcm p.a. from current levels already by 2030. The actual gap will depend on how much indigenous gas production will fall and gas demand developments. The prospects for growing import requirements has long been a security of supply concern in Brussels, but Russia's fallout with the West on Ukraine have turned it into an urgent issue.

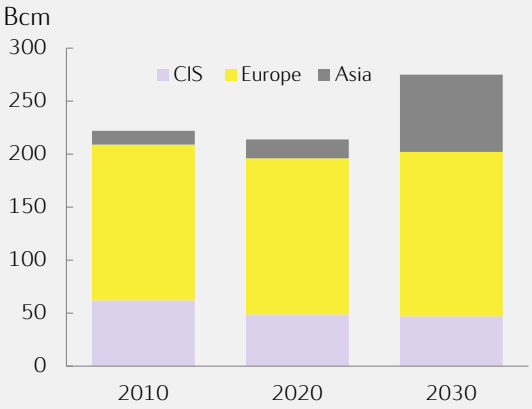
Reforms of the EU ETS carbon market could improve the competitive position of gas versus coal in power generation, but apparently restrictions on the actual use of coal-fired generation, as currently being debated in Germany, may turn out to be more decisive and provide some sort of support for the use of natural gas for power generation. This is one reason to expect modest growth in European gas demand in the 2020s. However, EU gas demand will probably not return to 2008 levels. The interest in shale gas developments waned in 2014, despite some regulatory efforts in some countries.

Russia is shifting priorities away from Europe

Russia's pivot to the East gained momentum in 2014. The Eastern Gas Program was launched back in 2007 to promote gasification of East Siberia and the Russian Far East, but progress has been modest. Today gas exports are limited to Sakhalin LNG, but the conclusion of a 38

Russia's pivot to the East will come at a significant cost

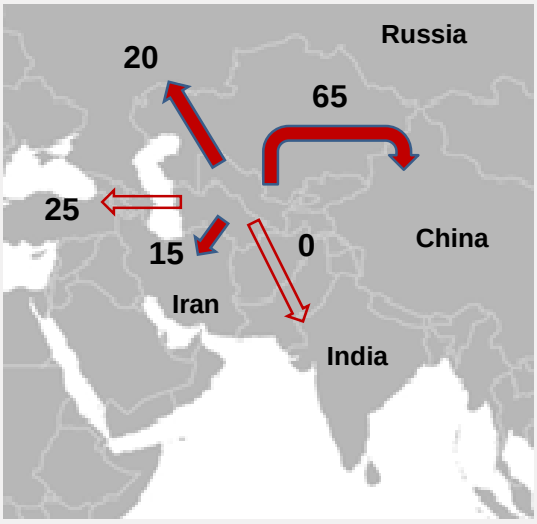
Russian gas exports to 2030



Source: CEDIGAZ (2014), partly based on ERI at the Russian Academy of Sciences

Central Asia is exploring new export options, China remains main market

Central Asia gas exports and options
Indicative 2030 exports



Source: IHS CERA

bcm/yr gas contract between Gazprom and CNPC in 2014 will be a catalyst for an entirely new gas region in Eastern Siberia. This export route will be centred around a new pipeline - Power of Siberia. Initial volumes will come from the Chayanda field, later from the Kovykta and adjacent fields. Russian oil and gas companies have large LNG ambitions, but these are now likely to be scaled down or moved out in time. As an example, Vladivostok LNG on the Pacific Coast is expected to become victim to Western sanctions, a more uncertain outlook for the global LNG market, and priority to pipeline exports to China. Instead, Gazprom is pushing forward the so-called Altai pipeline, which would bring gas to China from existing and new production areas in Western Siberia. Gas contract prices are reported to be linked to oil prices; thus another example on how low oil prices increase uncertainty.

Russia possesses the resources to cover domestic demand, establish itself as a key supplier to China (Power of Siberia, Altai pipeline and even from Sakhalin) and step up gas exports to Europe. Natural gas covers more than 50% of Russian energy needs, one of the highest in the world. There is however large scope for energy efficiency improvements and the current economic difficulties suggests that Russian gas demand may level out and even contract sometime in the future.

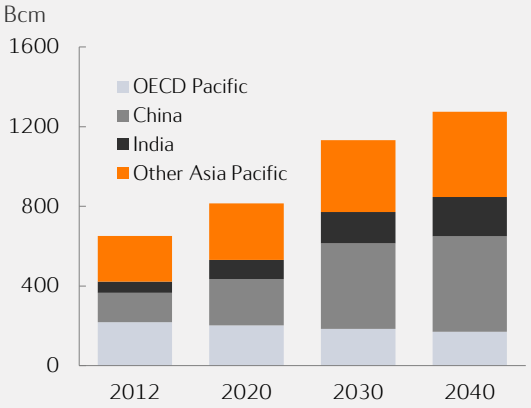
Nevertheless, Gazprom will have to develop new fields on the Yamal Peninsula or elsewhere in order to replace falling output from the legacy fields in Nadym-Pur-Taz. Legacy production is expected to fall by several hundred bcm until 2030. Reflecting the economic situation, one may ask if Russia actually does possess the financial resources, the industrial capacities and the political will to develop the required gas assets to also cater for a significant step-up in the country's gas exports to Europe. In this context, Russian and EU policies, or at least realities, may be more aligned than often perceived.

Caspian gas to Europe and Central Asian gas to China

Gas producers in the Caspian Region and in Central Asia would like to contest Russia's hegemony. Shah Deniz gas will flow through a Southern Corridor to Southeast Europe and Italy by the end of this decade. Iraqi Kurdistan has made gas discoveries, but a complicated political setting will defer developments. Eventually, political risks could abate, allowing for new trade routes. This may be the case for Iran if sanctions are lifted, but future export levels is uncertain as domestic demand is soaring, boosted by population growth. Priority is also on oil.

Central Asian producers, once an integral part of the Soviet gas system, exported close to 30 bcm to China in 2014. Chinese companies have a leading role in the development of the giant Galkynysh field in Turkmenistan, and also in construction of pipelines. China is expected to import around 60 bcm of gas from Central Asia the early 2020s. Turkmen gas may in principle reach Europe or the Indian Sub-Continent, but unresolved legal disputes over Caspian Sea territorial boundaries and a difficult political situation in and around Afghanistan constitute major hurdles.

Asian gas demand



Source: IEA (history), Statoil (projections)

Different narratives for the global LNG market in the 2020s are perceivable

East African LNG well position to serve import markets

Source: Oxford Institute for Energy Studies

Asian gas demand drives global gas markets

Asia consumed around 650 bcm of natural gas in 2014, a fifth of the world total. Gas demand in OECD Asia Pacific is expected to contract over the long term, whereas Non-OECD Asia (primarily China, India and Southeast Asia) is expected to show strong growth rates of 3.5% (CAGR) for the period from today until 2040 for reasons outlined above. Total gas demand in Asia Pacific is expected to almost double by 2040, approaching 1300 bcm or around 28% of the world total.

The role of gas in China's energy mix is growing, albeit from low levels. Gas penetration is supported by a diversified supply mix: domestic conventional and unconventional gas, pipeline imports from Central Asia and Russia, and LNG contracted from various suppliers. Actually, Beijing is inclined to foster all supply sources, thereby maintaining the balance between them. This contrasts the outlook for Indian gas supply. Domestic gas production has disappointed, and lack of infrastructure and adequate gas price reforms are hampering India's imports of LNG. Eventually, gas demand should ramp-up to substantial levels, creating a promising market for LNG imports. Southeast Asia, traditionally the second largest supply region of LNG behind Qatar, is expected to turn to net imports by around 2030. One example is Indonesia, which redirects more and more LNG to local usages.

List of new LNG projects far exceeds the needs

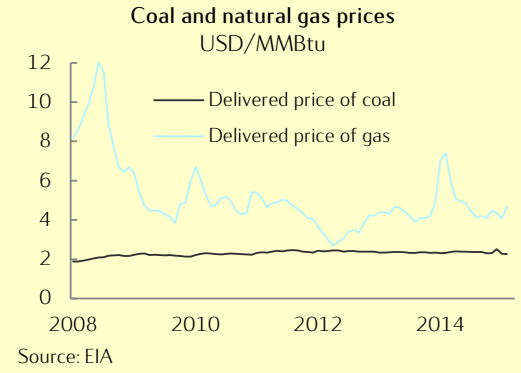
The oil and gas industry is facing a wide range of challenges when progressing new LNG liquefaction projects. The most important is the volume challenge: the capacity of projects proposed far exceeds realistic demand. The developers have long been facing spiralling costs, and the oil price uncertainty now takes centre-stage. Although today's market prices ought to have minimal relevance to investments in new LNG liquefaction capacity, companies will find it difficult to invest against the business cycle, at a time of high capital budget discipline. Eventually, stricter cost disciple and falling costs due to lower industry activity will ensure that some projects go ahead. However, investment decision on one LNG project erodes the prospects for remaining projects. This will particularly be the case for competing projects from one supply region as many (Asian) buyers are seeking supply diversification.

Most LNG projects for the 2020s and 2030s are located in Canada, the United States, Russia, Australia and East Africa – with additional projects in West Africa, the Middle East and Southeast Asia. North America and Russia have been addressed above. In Australia, the industry apparently awaits start-up of projects currently under construction – and the verdict of the market – before embarking on expansion (brownfield) projects. Papua New Guinea may become host for more LNG projects. With legislation and framework in place, East African LNG is perceived to be reasonably cost competitive despite lack of local infrastructure and skilled workers. Further to enabling Asian contract buyers to diversify supply, East Africa is well located to serve Europe, South America and Asian markets, and to generate value from geographical arbitrage.

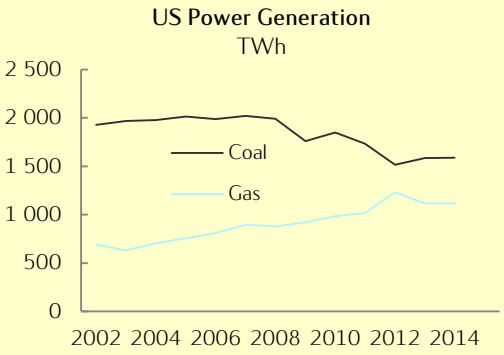
Box 6.1: The competition between gas and coal in the United States

A coal miner in the US might want to turn back the clock to the spring of 2008. The market for coal had been trending up for years, the cost of competing fuels, natural gas and oil, were much higher and rising, and environmental restrictions were costly, but manageable. Spot sales of coal were being made for more than USD 5 per MMBtu. It would be easy to imagine a rosy future of continuing growth and prosperity. That rosy future never materialized.

The coal industry in North America has declined dramatically since then and the prospects for the future are poor. Lower cost renewables, notably wind and solar power, began to capture market share in the power sector, halting growth of fossil fuel generation. Environmental regulation has added more costs to coal miners and coal burners. But most significantly, natural gas became much cheaper and took market share from coal on the basis of price. Power generation from coal was down 21% in 2014, compared with 2008. Over the same time period, the price advantage of coal over natural gas fell from USD 6.8 per MMBtu in 2008, to USD 2.7 per MMBtu in 2014. It should be noted that natural gas is more efficient than coal in power generation and less polluting, so the price of gas can be higher than coal and still gas is a less costly power generation fuel.



Source: EIA



Source: EIA

Over the next five years, the nature of coal-gas competition will shift in a more permanent way as the power generation infrastructure changes. Almost no new coal-fuelled power plants (less than 1 GW) are under construction, while over 33 GW of new natural gas units are expected to be built (EIA). According to IHS CERA, at least 39 GW of coal-fired power plants in the US will be retired at the same time. These changes in the power generation fleet will make permanent the switching between coal and gas that has been made on a tactical basis in recent years. At the end of five years, the Clean Air Plan (carbon emission reduction regulation) is scheduled to begin, adding a penalty to coal relative to gas that will likely make the 2020s even more advantageous for natural gas relative to coal.

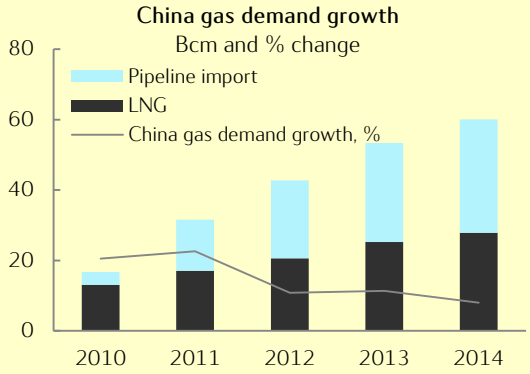
Box 6.2: Recent Chinese gas demand challenges

In 2012 China surpassed Iran to become the third largest gas consuming country after Russia and the US as a result of years of relentless pace of growth. However, gas demand growth slowed down to around 8% in 2014, the slowest pace in the last ten years. A range of underlying factors were behind this slowdown. Weaker GDP growth, falling oil prices, mild winter weather, hydro outperformance, and an ongoing price reform resulting in higher end-user gas prices.

With gas already a premium fuel, the economic slowdown constrained investments in the gas sector that would have expanded the gas demand growth. Lower oil prices have narrowed the price margin between oil products and gas used for transportation. Besides competition from rapidly developing nuclear power, the long distance power transmission of hydro and coal-fired power to coastal demand centres have also challenged the gas-fired power use. A move towards oil-indexed city-gate netback pricing for gas over the past three years has also caused some demand destruction amidst economic slowdown and infrequent adjustment of prices to reflect the collapse of oil prices.

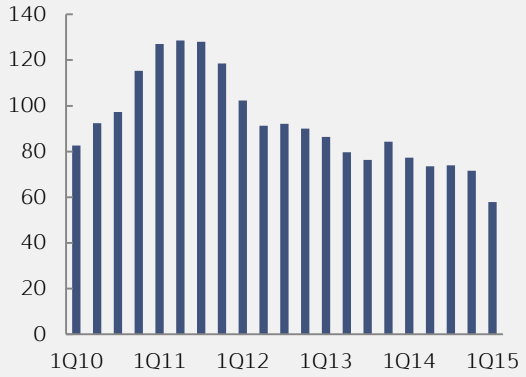
A new oil and gas price environment will reduce energy import bills and help China to absorb the surge in contracted pipeline and LNG gas volumes. However, even with lower import prices, it takes time for the import price to pass through to end users and also develop new usages. Domestic end users will have opportunities to negotiate for better supply deals if the accessibility is accelerated. Indeed, Chinese NOCs have started to rent out part of their LNG facilities to non-NOC gas distributors and utilities. However, the relationship remains delicate between the NOCs and other companies, and more regulations to cater for third party access would be needed.

Going forward, market liberalization such as direct negotiation between large industrial users and gas suppliers, bypassing city-gate regulated prices, will be crucial in enhancing the role of gas prices in reflecting the fundamentals of demand and supply. Establishment of a competitive domestic gas price formation for various geographical regions that depend on a diverse cost of supply will be critical to foster a sustainable level of demand besides reinforcing the environmental drive, economic rebalancing and fuel mix policies.



North-West Europe steam coal import price

Quarterly averages, 2013-USD/metric ton



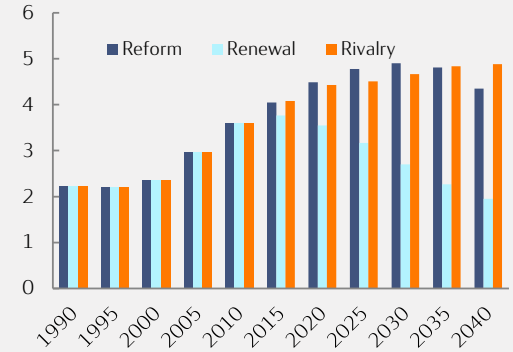
Source: IHS

Steam coal prices down 55% since 2011; outlook uncertain due to stagnant Chinese demand

Air pollution problems in the big Chinese cities have driven the authorities to clamp down on coal

World coal consumption

Mtoe



Source: IEA (history), Statoil (projections)

Other energy carriers

The coal market – status and outlook

Coal consumption in 2012 made up some 29% of world total primary energy consumption, with shares varying from close to zero in the Middle East and 4% in Latin America, to 42% in India and 68% in China. Most regions aim to wean themselves off coal, due to concerns about local air pollution as well as global warming. It will take time, but there are signs that a reduction in coal consumption could happen faster than assumed only a couple of years ago.

A striking feature of coal market developments since 2000 has been a sharp increase in non-OECD consumption in both absolute and relative terms. This increase has been driven mainly by the uptick in Chinese economic growth based on energy intensive industrialization, and by the relative abundance and cheapness of coal across the Non-OECD Asian countries. China's share of world coal demand – slightly above 50% – will make this country's economic and energy policies crucial for global coal consumption and CO_2 emission developments.

2014 provided important clues to the future in this respect. Chinese economic growth dropped to 7.4%, electricity demand growth plummeted from an average of 12% between 2002 and 2012 to 3.8%, to some extent reflecting rapid changes in the structure of the Chinese economy, and – most strikingly – Chinese coal demand contracted by 2.9%. Apparently coal use has continued to decline with Greenpeace research suggesting a 7.7% drop in January-April this year compared to the same period last year. Though a rebound in consumption cannot be ruled out, it seems clear that China will no longer be *the* engine of the global coal market. On the contrary, forecasters see not only a steep decline in Chinese coal imports, but also the possibility of the Chinese coal industry – which keeps adding capacity due to decisions made when everybody were still expecting boom conditions – turning to exports.

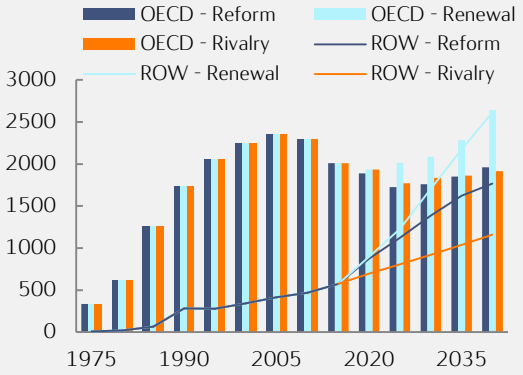
Coal is under mounting attack in the developed world as well. In the US the Environmental Protection Agency has just started implementing its new Mercury and Air Toxic Standards (MATS) rule, and will submit revised emission thresholds for existing fossil fuel fired power plants later this year, Both measures aim to force either costly pollution control investments or early coal plant retirements. In Germany, the government in 2014 realized that the country was not on track to deliver on its 2020 CO_2 emission reduction target – the "Energiewende" intended to boost renewables based power generation has also lifted coal use. German leaders responded in March this year by proposing a cap on power plant CO_2 emissions and penalties for non-compliance.

The internationally traded coal market is understandably depressed. The CIF price of steam coal imported into Northwest Europe declined by 23% between April 2014 and April 2015, and is less than half of what it was four years ago. Textbook economics would suggest a rebound effect – that lower prices will reignite coal demand growth – but most observers see structural forces and policy dampening such a response.

In *Reform*, global coal consumption increases by 12.3% between 2012 and 2040 or by an average of 0.4% per year. In *Renewal,* demand plummets by almost 50%, or by 2.4% per year. Finally, in *Rivalry,* where supply security and local availability issues take precedence over sustainability issues, coal use increases by 26%, or by 0.8% per year.

Nuclear power generation

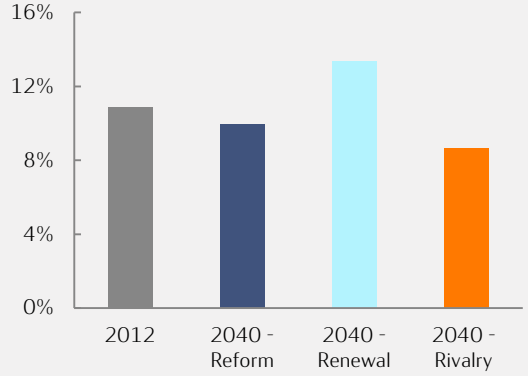
Thousands GWh



Source: IEA (history), Statoil (projections)

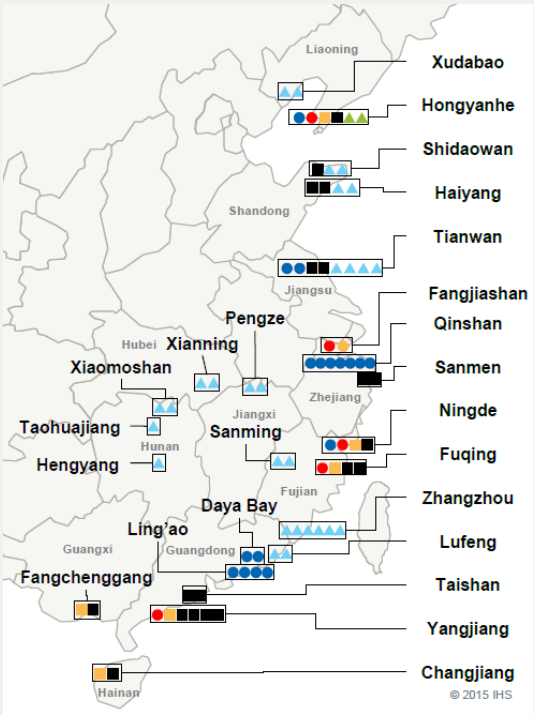
OECD nuclear power generation likely to decline, but assumed to recover from the mid-2020s

Nuclear share of global power generation



Source: IEA (2012), Statoil (projections)

China's operating and under construction nuclear power stations



Source: IHS

Nuclear energy – status and outlook

The outlook for atomic energy is mixed. 67 new reactors are under construction or awaiting construction start-up, but one country – China – accounts for 24, or 36%, of them. And many of the 43 reactors under development outside China have suffered significant delays and face an uncertain future.

The nuclear industry faces multiple challenges. The first, which affects the entire power industry, is the outlook for stagnant or declining electricity demand in most developed economies. The second is also common to the utilities sector and refers to the pressure on today's dominant revenue model in a market influenced by low or zero marginal cost renewables. The third is that, in spite of assurances that new "passive" designs have solved the safety problems of nuclear power generation that surfaced with the Fukushima disaster, NIMBY – "not in my backyard" – attitudes to nuclear power plants prevail. In Japan it remains an open question how many of the mothballed plants will ever be restarted. In Germany the decision to shut down the last of the country's nuclear power plants by 2022 enjoys continued support. Increased concerns about safety have also complicated permitting, delayed projects and boosted capital costs.

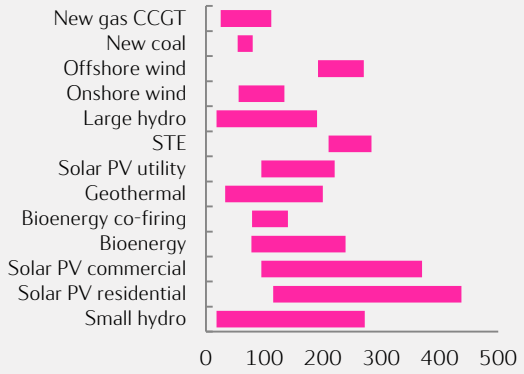
World nuclear electricity generation dropped by almost 7% in 2012 due mainly to the shutting down of Japanese plants. 2013 saw a 1% recovery, however, and 2014 another 1-2% growth in world generation with China, South Korea and France increasing output by 19, 17 and 12 TWh respectively.

For the OECD area we expect comparatively low economic growth, energy and electricity efficiency improvements, safety concerns and cost challenges to result in another lost decade for nuclear. In North America the outlook is clouded also by the impact of the shale revolution on gas and electricity prices. Five new reactors are under construction in the US, but these are all in states with regulated electricity markets. However, we do not foresee a demise of OECD nuclear power generation. It is difficult to see the developed world turning its back to an important zero carbon power generation technology, and a key piece in many countries' power sector diversification puzzle as well, on a permanent basis. The UK, Turkey, Poland and South Korea are examples of OECD members that have ambitious plans for newbuilds. The Abe administration reportedly aims for a 20-22% nuclear share of Japanese power generation by 2030, down from the 50% target adopted before Fukushima, but still requiring perhaps 25-30 GW of running capacity.

Outside the OECD area, where electricity demand is booming and local pollution problems are escalating, interest in nuclear remains strong. Fuel switching from coal to renewables or gas, and investments in energy efficiency, may be the ideal solutions, but governments typically look for as many solutions as possible to their challenges. Besides China, India, Russia and some Middle Eastern and Latin American countries pursue very ambitious nuclear targets.

In *Reform*, global nuclear power generation is about 50% higher in 2040 than in 2012, and in *Renewal* it is more than twice as high. If, however, another Fukushima type accident occurs, which cannot be ruled out, all bets will be off for nuclear, in the OECD countries and probably also in many developing countries.

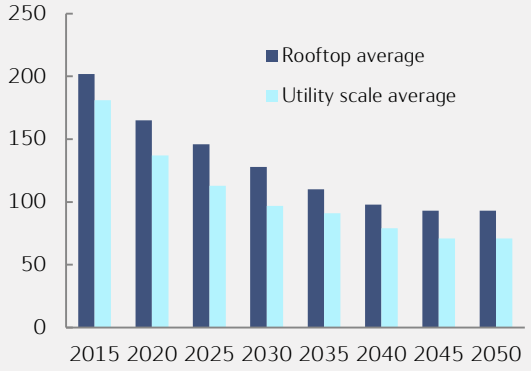
Levelized cost of electricity range estimates
2014 USD/MWh



Source: IEA: Energy Technology Perspectives 2015

Well located solar PV facilities can already compete

IEA's assumptions on the levelized cost of solar PV electricity for its 2 degrees scenario
USD/MWh



Source: IEA: Energy Technology Perspectives 2014

IEA sees the levelled cost of solar PV electricity dropping by 50-55% towards 2040

Renewables in power generation

New renewables[1] based power generation is booming in a number of countries, and the outlook is for further rapid growth in capacities and generation. Some of the countries which led the way struggle to sustain the momentum, but other countries – in particular China – are picking up the slack. Bloomberg New Energy reports that after 7% and 9% declines in 2012 and 2013, global investments in new renewable power generation capacity bounced back by 16% in 2014.

Preliminary numbers indicate a 16% or 51 GW growth in installed wind power capacity in 2014 against a 12.5% growth in 2013. China alone added 23 GW of capacity – 85% more than Europe and 3.2 times more than North America. China is rapidly closing in on Europe as the centre of gravity of the global wind power industry. Preliminary numbers also indicate a 30% or 41 GW increase in installed solar photovoltaic capacity in 2014 against a 38% growth in 2013, with China accounting for 10.6 GW, Japan for 9.6 GW, Europe for 7 GW and the Americas for about the same. Europe remains comfortably in the lead in terms of solar PV capacity, with a share of nearly 50% but that lead will likely not last very long.

In 2013 global *investments* in new renewables based and fossil fuel based power generation capacity was split 42 to 58. However, by 2012 *total installed* new renewables based and fossil fuel based capacity was split 12 to 88, and actual new renewables and fossil fuel based *power generation* was split more differently still – 4.7 to 95.3 – due to much lower capacity factors for wind and solar. It will thus take some time, regardless of growth rates, for new renewables based power to approach parity in generation terms with fossil fuel based power.

Investments in wind and solar power dropped in 2012-13 for two reasons. One was positive – the prices of key components, in particular solar photovoltaic system, came down, giving investors more bang for their bucks. The costs of solar panels have dropped very rapidly and will probably continue to decline, if not necessarily as rapidly in the future as in the past. The other was more disturbing from the point of view of the renewables industries – the financial support arrangements that had underpinned the ascension of renewables in Europe and the US showed signs of crumbling. Governments signalled cuts in subsidies and in some cases implemented retroactive adjustments. The result was uncertainty about the future and investment delays.

The uptick in investments in 2014 suggests that confidence in the future is growing stronger again. Though big parts of the variable renewable power industry still needs feed-in tariffs, green certificates, contracts for difference or other types of support, recent levelled cost of electricity (LCOE)[2] comparisons show well located onshore wind power plants to

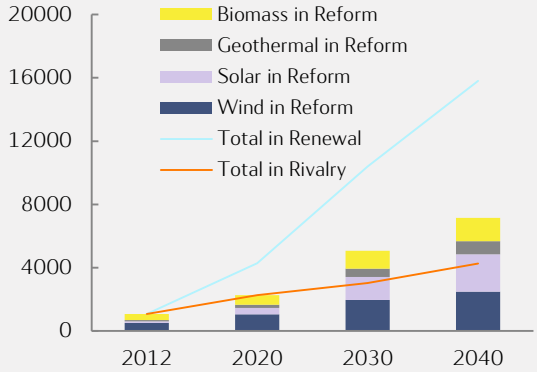
[1] The «new renewables» term refers to all renewable sources of energy apart from large scale hydro, biomass and waste.
[2] The LCOE of a given power plant means the present value of the capital, fuel (where relevant), carbon (where relevant) and operating and maintenance costs of building and running the plant divided by the amount of electricity assumed to be generated by the plant over its lifetime.

The 550 MW Desert Sunlight solar PV power plant in California's Mojave desert - reportedly the biggest in the world

Source: Time Magazine

New renewables based power generation

Thousands GWh



Source: IEA (history), Statoil (projections)

Global new renewables based power generation assumed to grow eight-fold in *Reform*, and 19-fold in *Renewal*, between 2012 and 2040

have attained competitiveness, without subsidization, with both new coal power plants and new gas CCGT power plants. Utility scale solar PV power generation remains on balance more expensive than fossil fuel based generation, but the solar PV industry claims that it is already the best option in sunny places and close to competitiveness in many more locations.

The renewables side adds to this that levelled cost comparisons are skewed from the start since the negative externalities of fossil fuel based power generation are not adequately priced – not in Europe with the EU ETS price at Euro 7-8/ton CO_2 and certainly not in the majority of countries where emissions have no costs at all. On the other hand, the facts that time of year, time of day and weather dependent electricity typically has a lower market value than dispatchable electricity, and that renewables inevitably need backup capacity – either other sources of electricity or storage solutions – make it difficult to adequately establish and compare the economics of the different options. See text box 7.1.

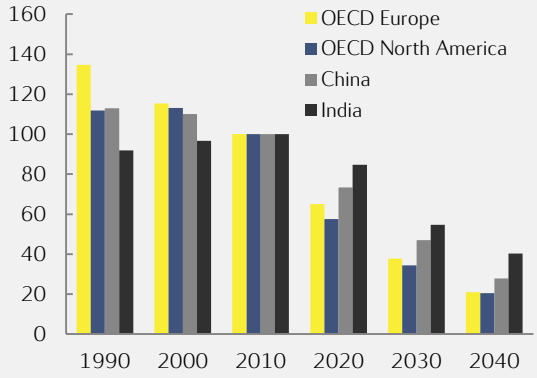
In *Reform*, global wind and solar power generation increases by averages of 5.7% and 11.9% respectively between 2012 and 2040. Growth rates decline over time, in the case of wind power from 9.2% per year between 2012 and 2020 to 6.5% per year in the 2020s and 2.4% per year in the 2030s, and in the case of solar power from 19.2% in the first of these sub-periods to 13.4% in the second and 5% in the third. This is because of slower economic, energy and electricity demand growth, in addition to the normal challenges of sustaining a given pace of growth as the growth base becomes bigger. Moreover, investments will increasingly need to be split between maintaining and replacing existing capacity and adding capacity. Annual increments keep growing through the 2020s. Growth is expected to be faster in the non-OECD than in the OECD countries simply because the developing world apart from China starts from relatively low levels of new renewable power generation.

In *Renewal,* global wind and solar generation increases by averages of 9.2% and 15.7% respectively between 2012 and 2040. By 2040 wind, solar and geothermal power generation make up some 15% of total world power generation in *Reform*, and 33% of total world power generation in *Renewal*. According to IEA statistics the share was about 3% in 2012. Hence both scenarios – though of course in particular *Renewal* – assume far-reaching changes in the structure of electricity supply.

Though wind and solar power may hold more promise for the future, the world's rivers and waterfalls remain the biggest renewable source of electricity generation by a wide margin. Hydropower generation makes up around 15% of world total power generation – a bit more in years with above average rainfall in the regions relying most heavily on this option, a bit less in dry years. In the OECD area the scope for growth in hydropower generation is limited – the bulk of resources have already been developed. Outside the OECD area the situation is different. The World Energy Council estimates that only 33% of the potential in Latin America, 22% of the potential in Asia and 7% of the potential in Africa is being exploited. Big hydropower schemes have always been controversial, however, for aesthetic and increasingly for social and environmental

CO_2 emission intensity of power and heat generation

Index 2010=100



Source: IEA (history), Statoil (projections)

CO_2 emissions per amount of electricity and heat generated are assumed to decline sharply

reasons. Recent projects in China and Latin America have drawn much criticism. The apparently powerful combination of undeveloped resources and a worldwide craving for electricity not based on fossil fuels is therefore no guarantee for a mushrooming of projects.

In *Reform,* world hydropower generation increases by an average of 1.6% per year between 2012 and 2040. OECD generation is assumed to grow by 0.6% per year, Chinese and other non-OECD generation by averages of 2.2% and 2.0% per year, respectively. In the *Renewal* scenario, world hydropower generation increases by 2.1% per year.

Box 7.1: Limits to growth in variable renewable power?

The ongoing growth in the shares of wind and solar power in total power generation begs the question whether there are limits to this growth, and where those limits might go.

The LCOE concept provides only part of the information needed to assess the viability of high shares of variable renewable power in total power supply. The LCOE refers to plant level costs only. It does not include the system costs of integrating power supply that cannot be dispatched according to requirements, but inevitably fluctuates with wind speed and solar radiation.

The system costs of integrating variable renewable power include maintaining back-up dispatchable generation capacity, strengthening transmission and distribution grids to be able to more easily route electricity from surplus areas to deficit areas, providing electricity storage opportunities to be able to handle short-term fluctuations, and enabling increased demand side flexibility. Ensuring that investments in system flexibility are made in a timely manner faces the additional challenge that high shares of wind and/or solar power with very low variable costs in total power supply tend to erode the economics of conventional power generation and make utilities unable to play their parts.

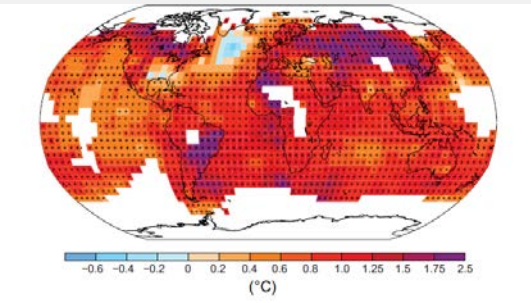
Recent reports indicate however that the challenges should not be exaggerated. The US DoE's National Renewable Energy Laboratory (NREL) and MIT have a couple of years ago found that US renewable energy resources could supply 80% of total US electricity generation in 2050, and that variable renewable power – mainly wind and solar PV electricity – could make up almost 50% of total supply by 2050.

Last winter, the US DoE presented a separate US wind power study. In the most aggressive of the scenarios investigated in the study, the share of wind power in total US power supply increases to 10% by 2020, 20% by 2030 and 35% by 2050. The study estimate that the economic benefits of helping the wind power industry to achieve this growth would outweigh the costs, and see no fundamental hurdles either in the form of system integrity problems or related to the capacity of component manufacturers.

IEA in 2014 concluded that variable renewable power shares of 25-40% are technically achievable and that levels above 50% will be possible if wind and solar power generators can be persuaded to curtail generation from time to time in order to limit variability. A 50%+ share of variable renewable power presupposes however that power system planners take a holistic view and provide for transformation of the entire system. If things are done correctly, variable power generators will eventually be able to provide most of the system balancing services they now need from others, themselves.

The NREL, US DoE and IEA results indicate that our assumptions in the *Renewal* scenario are below the levels of solar and wind power generation where system integrity issues could put irremovable spanners in the wheel. However, they offer little support for assuming that such technologies alone could account for 80-90% of total power supply. The totality of zero carbon options could likely reach this proportion, but then hydro, biomass, geothermal, concentrated solar and probably nuclear power would have to weigh in too.

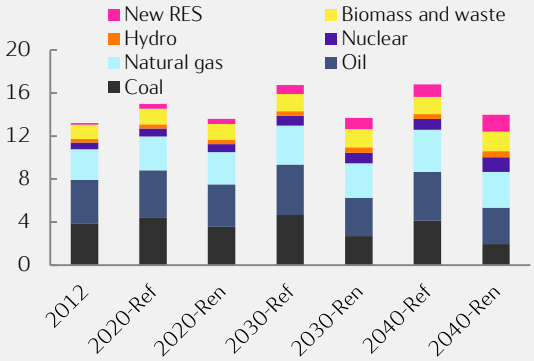
Observed change in surface temperature 1901-2012



Source: IPCC (2013)

Renewal represents *one* possible route towards a sustainable energy system

World TPED by fuel in *Reform* and *Renewal* scenarios
Bn toe



Note: Ref = *Reform* scenario, Ren = *Renewal* scenario
Source: IEA (history), Statoil (projections)

Source: United Nations

Renewal – a green energy transition

Sustainable energy development

In order to prevent the most dramatic effects of climate change the average global temperature increase by 2100 must be limited to a maximum of 2 °C above pre-industrial levels. According to the IPCC and IEA this will require substantial and sustained cuts in global energy related greenhouse gas emissions. Science suggests a need for at least a 60 % reduction from 2012 to 2050, on the way to practically zero emissions by the end of the century.

The *Renewal* scenario describes a mix of policy, regulatory, behavioural and ultimately technology developments consistent with a 40% decline in energy related CO_2 emissions between 2012 and 2040. Such a decline is what the 2 °C scenarios from IPCC and IEA call for. Reductions of this magnitude will require a radical renewal of the energy systems of the world, with strong improvements in energy efficiency, significant and consistent changes in energy policies worldwide, much higher levels of renewable and low-carbon energy, and substantial investments in new technology.

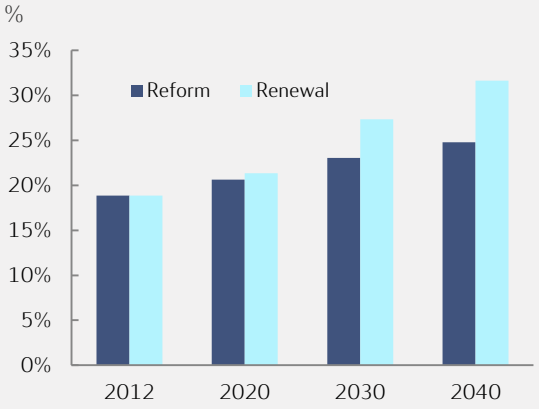
The *Renewal* scenario represents *one* possible route towards bringing about the targeted decline in CO_2 emissions. It describes a challenging way forward. Clearly the scenario could have been based on other combinations of assumptions delivering the same emission reductions. None of the alternatives would however have been significantly less challenging.

Emission reduction targets achieved

In the *Renewal* scenario countries achieve all the emission reduction targets they submit to the COP21 climate negotiations in Paris in 2015. Building on the COP21 results, targets and plans going beyond the ambitions indicated so far are quickly established, with consequences for global emissions already from around 2020. Compliance to national targets comes under regular UN review, and countries and regions succeed in implementing strong and effective regulations in the power, transport, and residential sectors. A regulatory framework allowing for cross-border reduction efforts is ensured, and global mechanisms for pricing carbon (trading schemes, taxes) are developed. The G20 countries agree on a gradual phase-out of fossil fuel subsidies, and countries outside the G20 follow suit. This also contributes to the financing of new and sustainable energy systems.

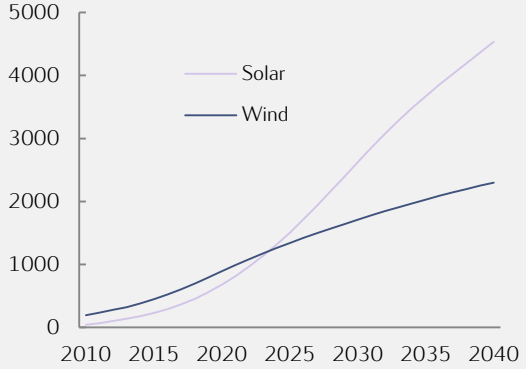
Strict climate targets and the application of strong policy regulations create a basis for substantial public and private investments in new low carbon energy production and infrastructure. This will reduce GDP growth somewhat until 2030, compared with the *Reform* scenario. In the long term, costs related to adapting to the physical impact of climate change are smaller in the *Renewal* scenario compared to the *Reform* and *Rivalry* scenarios. This contributes to lifting GDP growth between 2030 and 2040 somewhat in *Renewal* relative to the assumptions in in the other two scenarios. If the analysis in this report was extended beyond 2040 and towards the end of the century, it would show a significant and increasing difference between the scenarios, with negative climate change related economic consequences in a *Reform* or in a *Rivalry* world compared to a *Renewal* world.

Electricity share of global final energy consumption



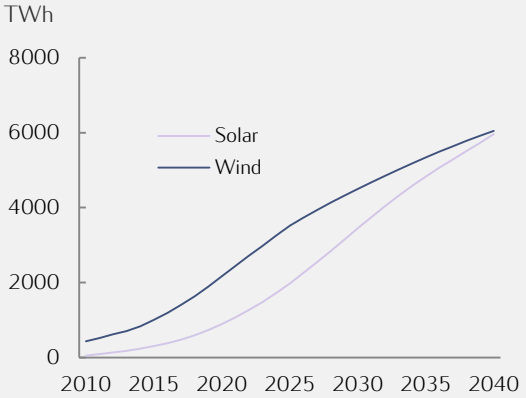
Source: IEA (history), Statoil (projections)

Capacity new renewables in *Renewal*



Source: Statoil

Electricity generation new renewables in *Renewal*



Source: Statoil

Google's self-driving car

Source: Google

The new energy architecture

In *Renewal* the world has a completely different energy architecture by 2040. For instance, large parts of world households produce their own electricity locally (mainly by solar panels), and electricity is more widely used in all sectors of society, including in transport. Traditional centralized utilities have faced the challenge of adapting to a new reality, and have to a large extent been replaced by smart, decentralized, efficient and consumer centric infrastructures.

New technology renews the way we produce, distribute and consume energy. Electricity represents more than 30% of final energy consumption in 2040, up from 19% today. Cost efficient energy storage, sensors, improved software, applied artificial intelligence, improved housing, big data and other rapidly improving technologies connect a highly complex and distributed electricity supply side with real-time information on the demand side.

The decarbonized power sector

By 2040, the *Renewal* world has a much higher penetration of renewable energy in the power sector, 57% compared to 21% today. Conversely, the share of fossil fuels in power generation is reduced from 67% to 30% in 2040. Cost improvements, technological innovation as well as new business models and regulatory measures to balance the grid contribute to make this possible. Solar and wind power become almost universally competitive on costs and the challenges of the intermittency of wind and solar power are being overcome. This is mainly achieved by global deployment of cost efficient energy storage solutions, smart-grids and the use of fast natural gas turbines as swing producers.

The global share of coal in electricity generation is reduced from today's 40% to 10%. This significant reduction is made possible by strong unilateral measures and wider access to alternative energy in big emerging economies that are well endowed with domestic coal, such as China and India. In China, coal use in power generation is reduced from almost 80% to 16%. The reduction in India over the same period is from almost 70% to 35%.

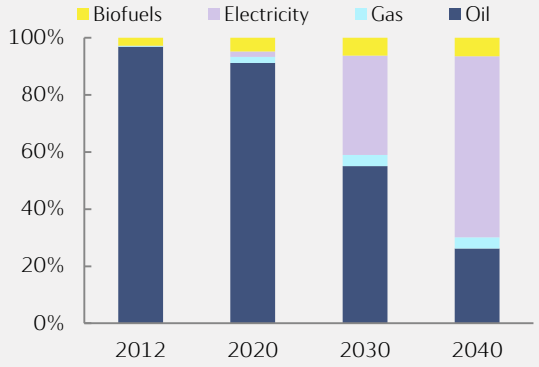
In *Renewal,* nuclear power remains an essential part of the non-fossil contribution to base-load power generation. In 2040, the nuclear energy share of the world power generation is 13.3%, compared to 11% in 2012.

Transformed private transport

Strong population growth and rapid urbanisation have huge implications for the transport sector, and road traffic. By 2040 increased congestion and local pollution are significantly reducing the use of private cars in the central areas of many big cities.

Extensive electrification, supplemented by other new technologies, is significantly reducing emissions from the transport sector. Due to cost reduction and improved capacity of batteries, electric cars become competitive even on retail price with equivalent fossil fuel powered cars. Sustainable biofuel technologies demonstrate improvements in cost efficiency and enable the use of biofuels in aviation as a part of the low-carbon operation for airlines.

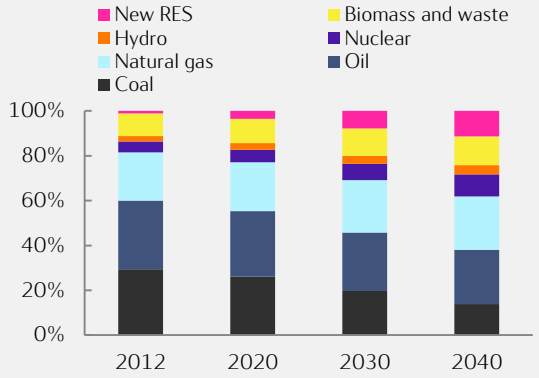
OECD Europe: Fuel shares in private road transportation – *Renewal*



Source: IEA (history), Statoil (projections)

Oil share in private road transport dramatically reduced by 2040

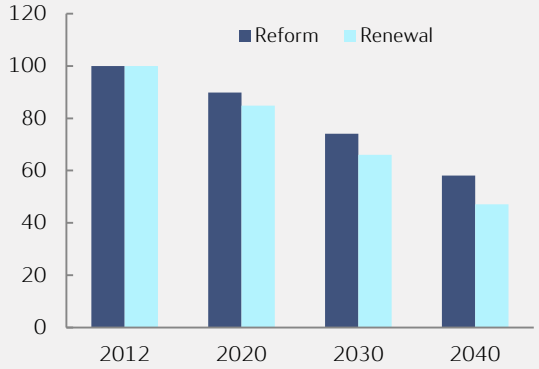
World TPED fuel mix – *Renewal*



Source: IEA (history), Statoil (projections)

World energy intensity evolution

Index, 2012=100



Source: IEA (history), Statoil (projections)

The share of oil in private road transport is dramatically reduced by 2040. The combined share of electric cars and other alternative car technologies, for example hydrogen, has increased correspondingly, with electric vehicles dominating the unconventional car market. In key regions such as OECD Europe and OECD North America this share grows to around 60%, while the share of oil falls to less than 30%. This trend also applies for Asia, even though the shares of oil in private road transport in China and India are still more than 50%.

Carbon capture and storage (CCS) delivers on expectations

Although renewables have a significant share of the global energy mix in 2040, there is still a need for fossil fuels in power production and industry. In *Renewal*, about 8% of remaining energy related CO_2 emissions are handled by CCS by 2040. Government incentives are put in place by 2020, and CCS turns into an option for large scale emission reductions towards the end of the 2020s. Significant reductions are made in the total cost of CO_2 capture, and business models and regulatory frameworks effectively support development of large scale CO_2 transport and storage infrastructure for multiple emitters. Less expensive applications in other industries such as petrochemicals, fertilizers, refining and metals work as first movers with CO_2 used for Enhanced Oil Recovery (EOR) paving the way for CCS in a profitable development of the necessary CO_2 infrastructure.

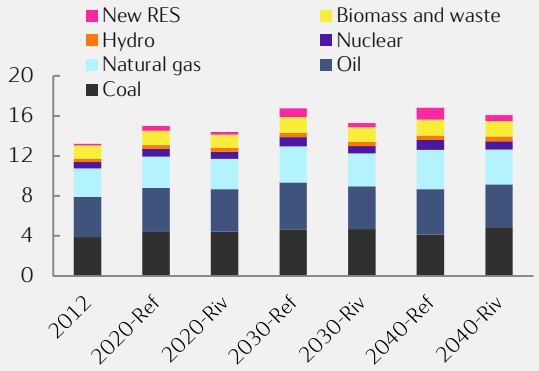
Summary – *Renewal*

In *Renewal* total primary energy demand grows on average by only 0.2 % per year between 2012 and 2040, despite population and economic growth. This is made possible through radical energy efficiency improvements and by replacing existing technologies and infrastructure with new energy solutions in all sectors. These investments enable an average annual decline in the global energy intensity of 2.7%, and significant changes in the global fuel mix – away from coal and to some extent oil, and towards more renewable energy. The oil and coal shares of world primary energy use drop to 24% and 14%, respectively, within a much lower overall energy demand level. The gas share increases to 24%, the nuclear share increases to 10% and the new renewables share increase more than tenfold to above 11%. In this scenario solar power generation grows almost 16% per year between 2012 and 2040, while wind power generation grows by more than 9% per year.

In sum, *Renewal* rests heavily on a few key assumptions:

- A high level of mutual trust and cooperation between key countries in policy and technology development efforts to combat climate change.
- A complete transformation of power systems and transportation systems worldwide, including a much needed step-up of investments in new infrastructure, also driven by changed consumer preferences.
- A continued development of cost-efficient low carbon energy technology across a wide range of areas – from all forms of renewable energy to CCS.
- A radical improvement of energy efficiency – crucial in order to keep emissions under control. Progress within technological development, regulations, city infrastructure and consumer patterns are examples of contributing factors that lead to strong improvements in energy efficiency across all sectors.

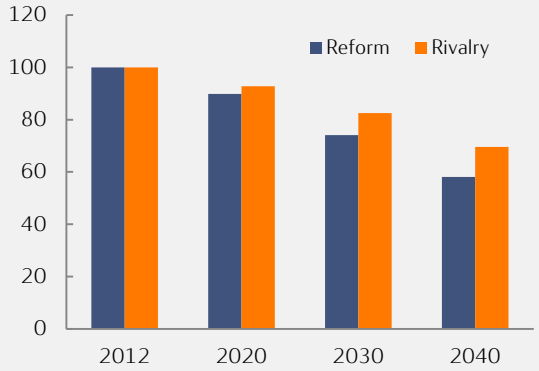
World TPED by fuel in *Reform* and *Rivalry* scenarios
Bn toe



Note: Ref = *Reform* scenario, Riv = *Rivalry* scenario
Source: IEA (history), Statoil (projections)

Transition to a more multi-polar world ends with rivalry, conflict and limited ability to solve common challenges

World energy intensity developments
Index, 2012 =100



Source: IEA (history), Statoil (projections)

Rivalry – a more volatile world

Geopolitics and energy interlinked

The multiple links between energy markets and geopolitics are important, and developments may follow different routes than in the *Reform* or *Renewal* scenarios. The *Rivalry* scenario outlines a future where the transition towards a more multi-polar world ends with rivalry, conflicts and less will to collaborate in order to solve common challenges.

An orderly transition to a multipolar world...

The world as we have known it for almost a generation is changing. The certainty, the familiarity, the casual acceptance of a US-dominated post-Cold War order is unravelling. The world is now in a process commonly referred to as the relative decline of the West, and the rise of the rest.

Retrenchment of the US' relative influence is one factor. The US political model has come to be regarded as less successful and attractive owing to a multitude of domestic political and structural factors. There is, obviously no single explanation for this and to suggest one would do disservice to the changes that are unfolding.

While the old order is decaying, it is uncertain what will replace it. What seems certain is that we are moving towards a more multipolar world, which will be different from the world that we have seen over the last 25 years. However, whether the current period of disorder becomes a transitional phase or permanent feature remains unclear. While some regard this as a more unstable and conflict prone world, others see movement towards a new equilibrium, with a more even distribution of power as both inevitable and desirable for progress.

Even in the multipolar world depicted in this scenario there are many examples of international cooperation and coordination. More inclusive institutions such as the G20, and the creation of new collaborative structures, act as a brake on the destabilising potential of power struggles and conflicts. There are challenges from revisionist powers and the sporadic outbreak of conflicts. But no transition, not even the most orderly process imaginable, will be able to prevent this.

...or the alternative scenario, *Rivalry*

In the *Rivalry* scenario disorder continues to develop as competing powers fuel greater instability and volatility into the future. Greater unpredictability and potential for conflict characterise the *Rivalry* world. Among the key attributes of this mounting disorder are push-back against, and erosion of, global norms, competition for influence over regional and global governance structures, and a slowdown in globalization as a result of increased confrontation and conflict.

Expanding on the elements of this scenario:

- Erosion of global norms

As rivalry and competition for influence begin to dominate, values that have been regarded common – respect for human rights, freedom of expression, the right to assembly, responsibility to protect – are challenged, if not altogether eroded with the emerging powers coming to see these norms as not accommodating their rise.

Source: The Economist

Box 8.1: Russian Revisionism

Where post-Cold War Russia adopted a *status quo* posture and quietly went about its business of revitalisation, a revisionist mind-set has now become dominant, challenging what it perceives to be Western encroachment into its backyard. Trade and economic relations with the West are, therefore, likely to suffer, pushing Russia in parallel to seek diversification of energy partnerships with several Asian countries, notably China. The reliability of Russian gas to Europe will factor ever more urgently into European policy discussions as will the severe cause for concern over Russia's ambitions.

Box 8.2: Chinese Ascendancy

Economic expansion in China has happened at high speed. It is already among the world's leading importers of raw materials and it is hungry for energy. With this China has sought to expand its global footprint as its economic and trade relations with Asia, Africa, the Middle East and Americas have ballooned. As its international expansion accelerates, other regional and global actors may get unsettled. This comes as China is increasingly seeking to redefine the rules and institutions of global governance. Moreover, the prospects for China's peaceful rise are also closely tied to the pace and process of internal reform and development. The recent recalibration of growth targets to a 'new normal' demonstrate the internal challenges, emanating from a slowing and maturing economy, growing environmental challenges and unfavourable demographics. Resolving these internal challenges will also have impact the country's external engagement

- Outdated global structures

The global governance framework that was conceived and built after World War Two is increasingly regarded out-dated. New countries and regions grow in importance and perceive that their needs and demands are not met by existing structures. In the absence of reform, the old international institutions and organisations lose relevance and therefore also their ability to fill their roles.

- A slowdown in globalisation

Regionalism replaces globalisation as states withdraw into the safety of narrower security and economic blocs. Meanwhile, the interplay between regional economic cooperation and security alliances does not flow smoothly. As such, economic interdependence as a contributor to peace and stability is likely to serve less as a check on conflict. International trade is reduced, contributing to lower economic growth.

Geopolitical hotspots

This world of disorder is already playing out across various geographies with potential for spillover. This includes a world in which non-state actors and terrorist groups proliferate; the Middle East is beset by political and security challenges fuelled by sectarian crises.

The emergence of a more revisionist Russia, its role towards neighbouring countries and the use of economic sanctions from Europe and the US, may indicate a transition into the *Rivalry* scenario.

China's approach to globalisation will be important. Along with its growing overseas interests and influence, its ambitions and role globally and in Asia will be important. The maritime territorial disputes in the East and South China Seas and the tension on the Korean peninsula are conflicts with potential to overshadow regional and global cooperation and to trigger major international conflicts.

Thus, in this scenario a self-perpetuating cycle of instability is created: more unrest and instability which further threaten global stability. Given the increased volatility, a lack of relevant conflict handling institutions or framework and the fracturing of international relations, states seek to resolve conflicts through the formation of ad hoc 'coalitions of the willing'. Direct conflict may be avoided, but the era of benevolent global cooperation is likely to be over.

Weaker economy and not sustainable

In *Rivalry,* economic growth is lower than in the past decades, and also lower than in the other two scenarios. This reflects constraints on international trade and technology exchange, and also channelling of political and economic resources to lesser productive purposes.

There is interest in energy efficiency and in renewable energy sources also in *Rivalry*. Neither the global warming threat nor the local pollution problems that are causing millions of premature deaths especially in the developing economies, die away. Also, interregional tensions and incidents of interregional energy flow interruptions boost interest in replacing imported energy with indigenous solutions of which energy efficiency and wind and solar power are prime examples.

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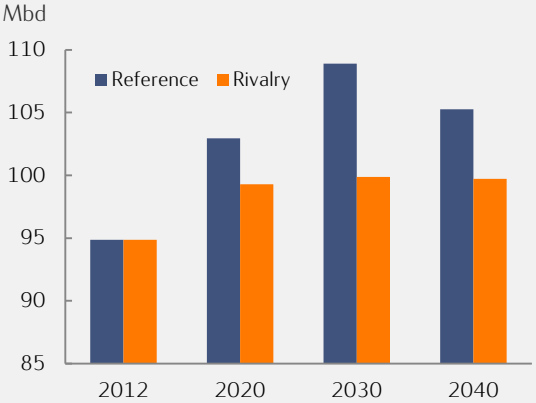
Box 8.3: Unrest in MENA

Subsumed in a security quagmire, the Middle East & North Africa region impacts energy markets like no other. Home to some of the world's leading oil and gas exporters, widening regional conflict and geopolitical contests will inevitably affect outside powers. The deep-rooted Saudi-Iran rivalry is increasingly being played out in aggressively sectarian terms as both sides seek to consolidate their power and influence across the region. Crises in Syria,
Iraq, and Yemen will remain fertile ground for Iran and Saudi to engage in proxy wars which will have unsettling implications for most, if not all, regional states. Meanwhile, the threat from non-state actors will remain intense, completing the vicious circle of failed states, sectarianism and terrorism which will continue to have regional and global ramifications

Source: The Economist

The fuel mix changes slowly and in a less green direction, with coal as a winner

Global oil demand



Source: IEA (history), Statoil (projections)

On the other hand;

- with governments having to prioritize security issues there is less political focus on sustainability and challenging energy transformation targets;
- with economic growth dropping there is less money available for costly solutions;
- with constraints on cross-border technology exchange, importing the best solutions available is not always an option, complicating leap-frogging;
- with international agreements on climate change mitigation targets and measures remaining ineffective, governments do not need to account for their policy choices to the global community.

For these reasons the energy intensity of the global economy declines by only 1.2% per year in *Rivalry*, which is a more moderate pace than in *Reform*, not to mention in *Renewal*.

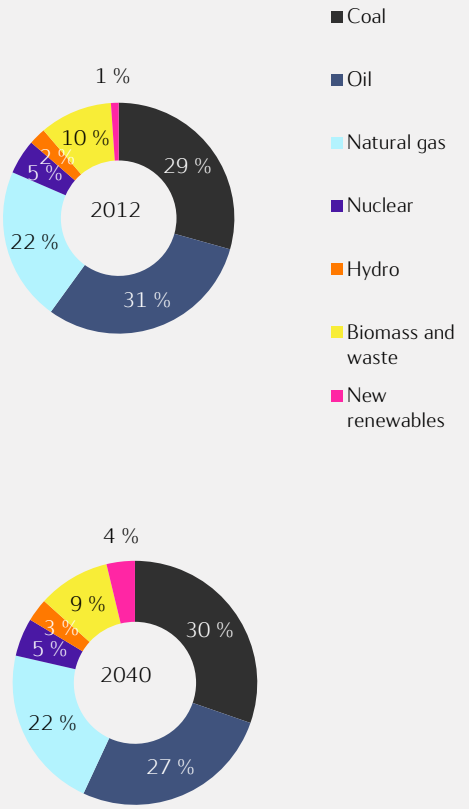
Energy demand grows by 0.7% in *Rivalry* - more slowly than *Reform* because of lower economic growth, but more rapidly than in *Renewal* because of less improvement in energy efficiency.

The global fuel mix changes also in *Rivalry*, but more slowly and in a less green direction than in *Reform* and *Renewal*. On a global scale power generation based on wind, solar and geothermal energy increases by some 400% between 2012 and 2040 or by an average of 5.9% per year. The share of new renewables based power generation in total power generation increases from slightly above 3% to about 10%. The share of wind, solar and geothermal energy in total primary energy supply increases from around 1% in 2012 to barely 4% by 2040.

Coal as an ample, mostly indigenous and relatively cheap energy source gains market share in *Rivalry* from 29% in 2012 to 30% in 2040. The countries that suffer the most from coal related pollution, e.g. China, manage to reduce the coal share of their primary energy supply somewhat, but put more emphasis on simpler "solutions" such as moving coal power plants further away from the biggest cities and transporting electricity back into the urban areas. Other regions with indigenous coal resources to support growth in consumption and with lower levels of public frustration with air pollution, increase coal use faster than overall energy use.

Oil demand increases by an average of 0.2% per year, implying a loss of energy market share. The oil share of total primary energy supply declines in nearly every region of the world - the marginalization of oil in all sectors except for the transport sector is a robust trend with only the pace of change, not the direction of change, varying across scenarios. Car fleets become electrified also in *Rivalry*, but the process starts much later and has not come very far by 2040. Globally the oil share goes from 31% to 27%.

Global fuel mix in *Rivalry*



Source: IEA (history), Statoil (projections)

The gas share of total primary energy demand declines in some import dependent regions such as OECD Europe, but holds up in regions where gasification is seen as a feasible and comparatively cheap air pollution clean-up measure, and increases in regions with significant indigenous resources, such as OECD North America. Changes are however a lot less dramatic in *Rivalry* than in *Renewal* and also less pronounced than in *Reform*, with many other issues outperforming the fuel mix in the battle for public attentions. Globally gas demand increases by 0.7% per year. The gas share remains at 21-22% throughout the scenario period.

Nuclear power generation increases by an average of 0.8% per year between 2012 and 2040, implying a further decline in the nuclear share of total power generation from 11% to some 8.5%, and stagnation in the nuclear share of global primary energy supply at around 5%. Nuclear is held back not so much by continued safety concerns as by continued difficulties competing on costs in a low growth scenario. .

There is in *Rivalry* neither money for, nor interest in, pursuing the technology break-troughs required to develop carbon capture and storage (CCS) beyond a handful of projects – mainly in developed economies – linked to EOR opportunities. The CO_2 volumes handled by CCS in this scenario are too small to show up in our statistics. On the same note there is limited appetite for introducing carbon pricing. Only the EU ETS plays a role by 2040, and that role is limited – the CO_2 price is less than half of what it is in *Reform* and less than one sixth of what it is in *Renewal*.

Global CO_2 emissions increase by 14% between 2012 and 2040 against 7% in *Reform*. Growth is slower in the early part of the scenario period in *Rivalry* due to lower economic growth, but whereas emissions peak around 2030 before going into fairly steep decline in *Reform*, they peak only in 2035 before going into only gentle decline in *Rivalry*.

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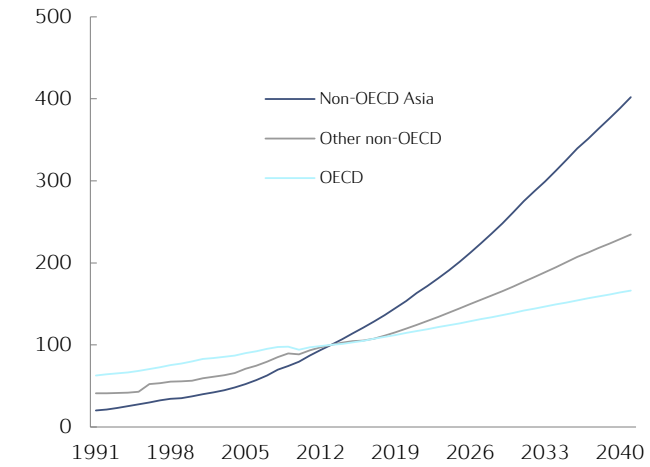
Chart appendix

Economic growth – *Reform*

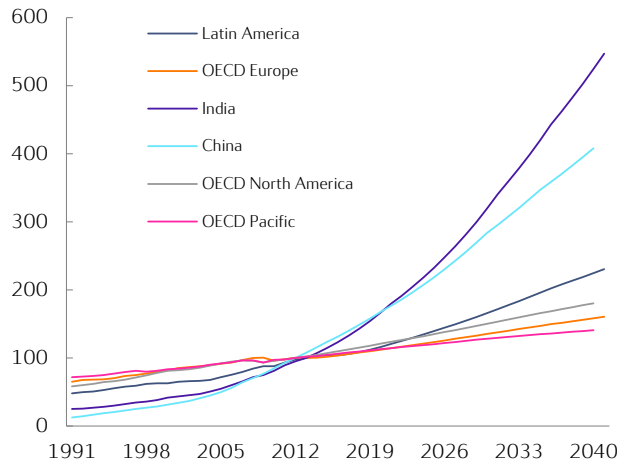
World GDP levels 1991-2040

Real, index, 2012 = 100



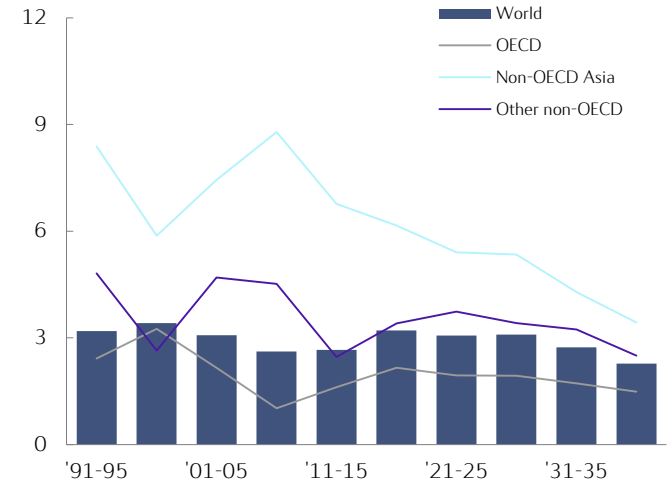
World GDP levels 1991-2040

Real, index, 2012 = 100



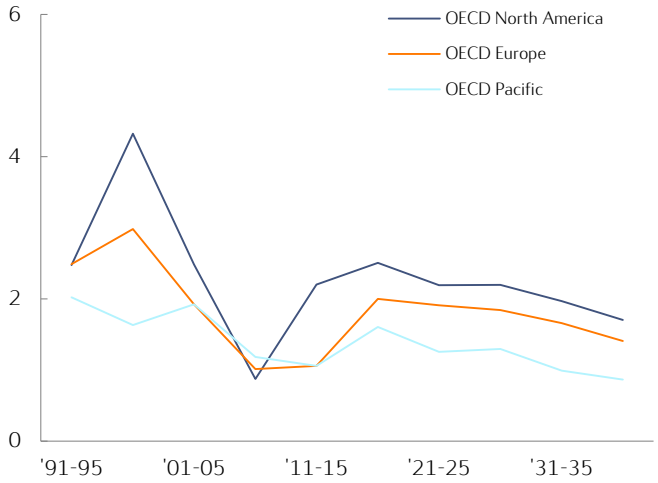
World GDP 1991-2040

5-year annual growth rate (CAGR), %



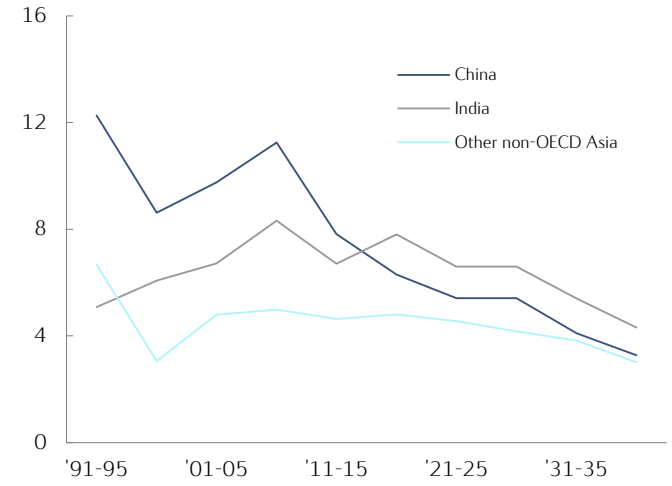
OECD GDP 1991-2040

5-year annual growth rate (CAGR), %



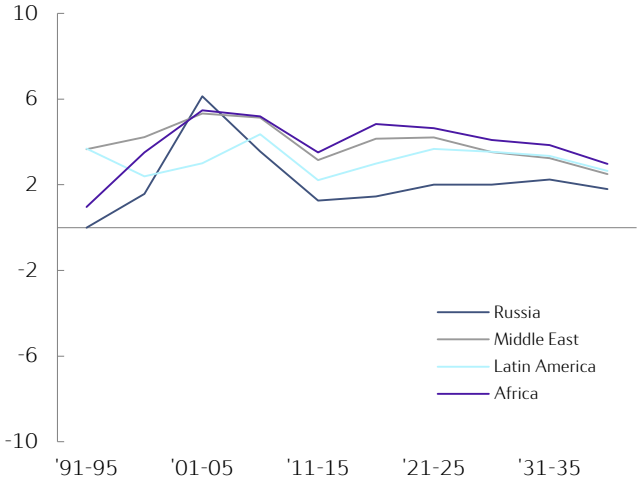
Non-OECD GDP 1991-2040

5-year annual growth rate (CAGR), %



Other countries/regions GDP 1991-2040

5-year annual growth rate (CAGR), %

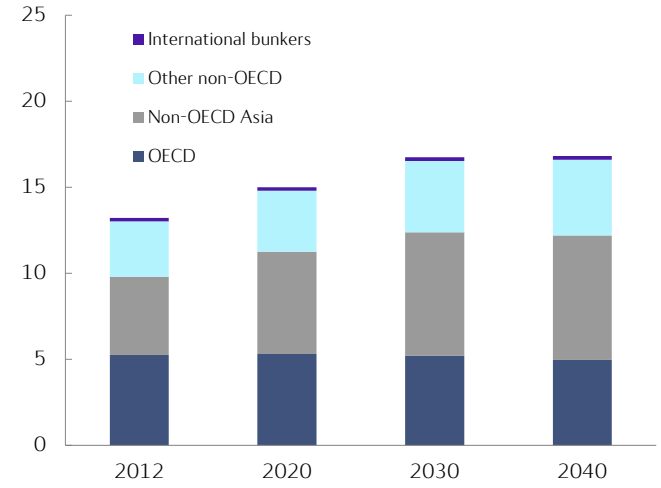


Source: IHS Connect (history), Statoil (projections)

Global and regional energy demand – *Reform*

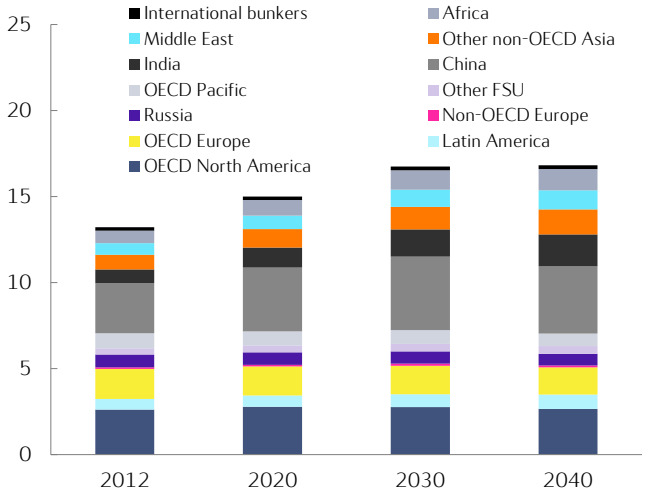
World energy demand 2012-2040

TPED, bn toe



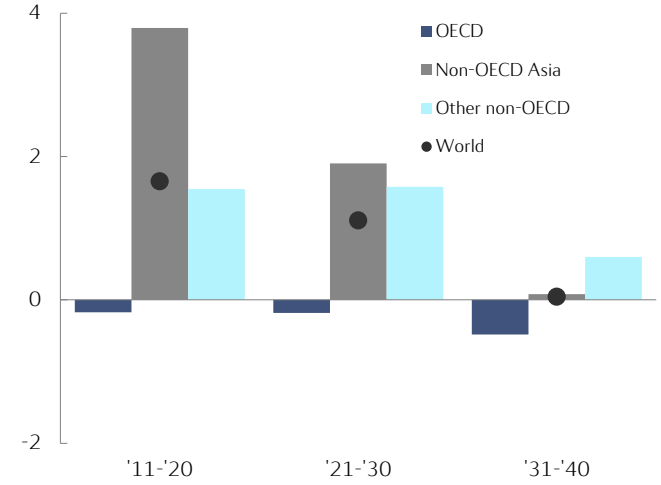
World energy demand 2012-2040

TPED, bn toe



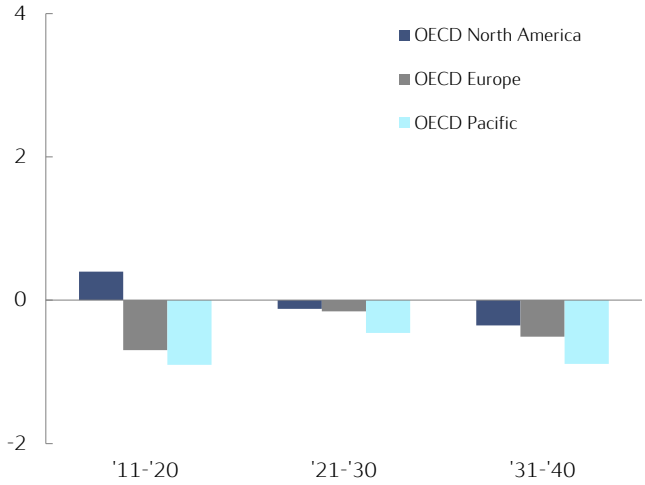
World energy demand 2011-2040

10-year annual growth rate (CAGR), %



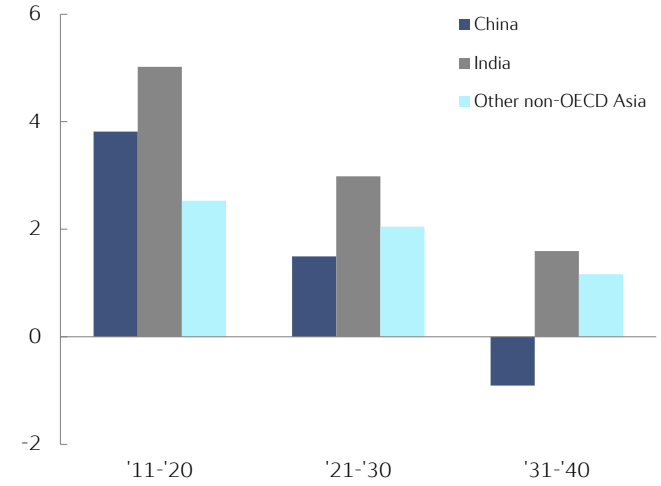
OECD energy demand 2011-2040

10-year annual growth rate (CAGR), %



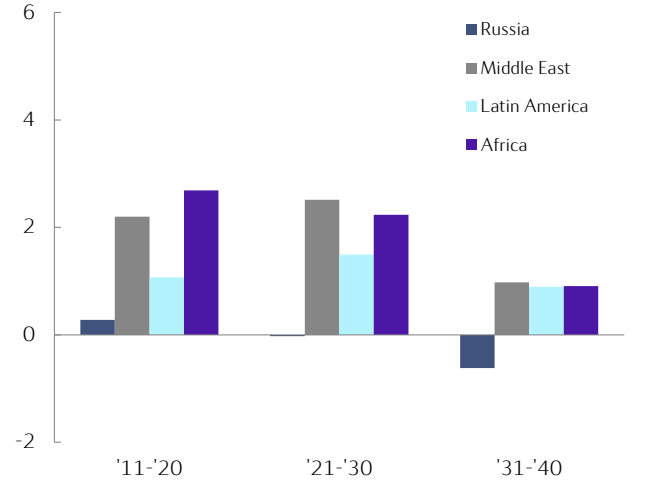
Non-OECD Asia energy demand 2011-2040

10-year annual growth rate (CAGR), %



Other countries/regions energy demand 2011-2040

10-year annual growth rate (CAGR), %

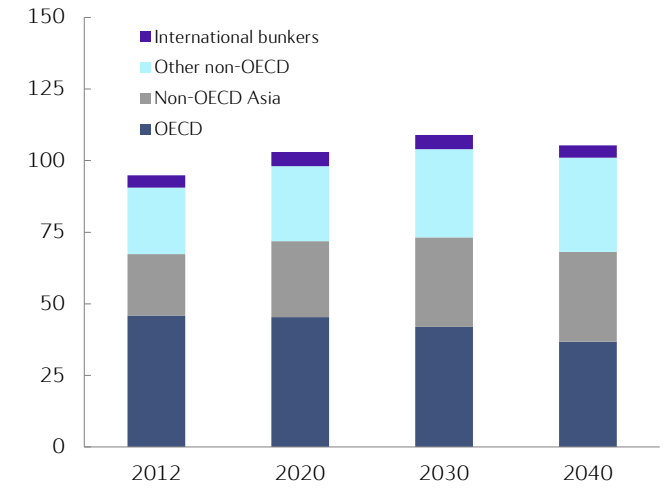


Source: IEA (history), Statoil (projections)

Global and regional oil demand (excl. bio-fuels) – *Reform*

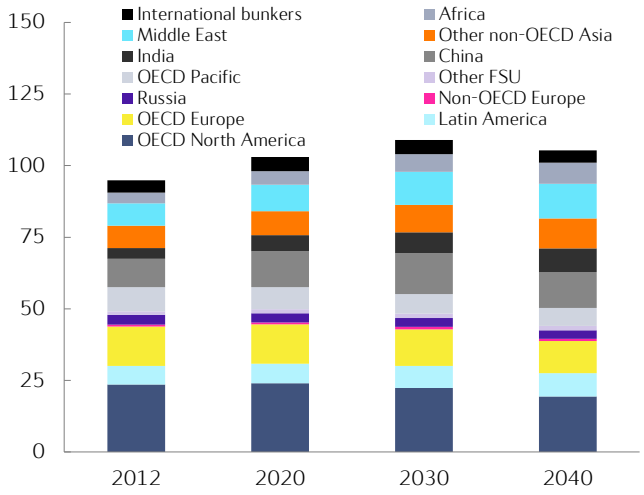
World oil demand 2012-2040

Million barrels per day



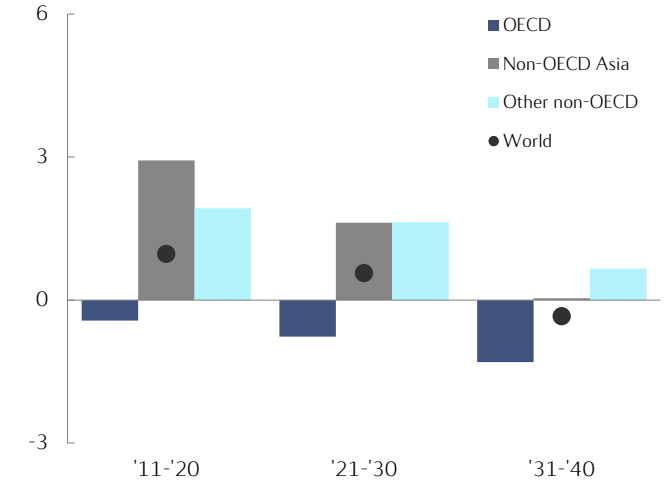
World oil demand 2012-2040

Million barrels per day



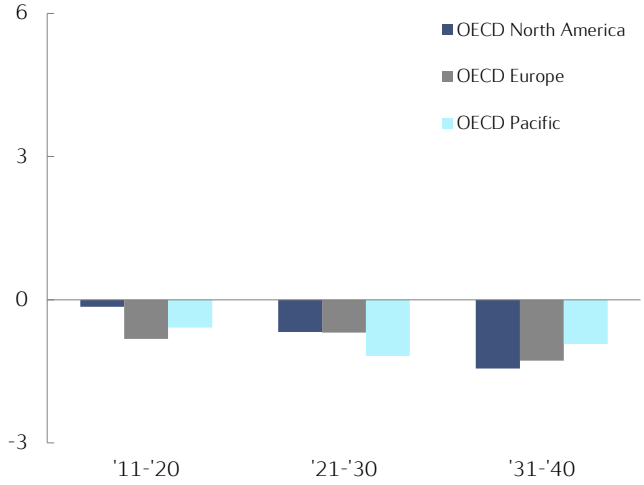
World oil demand 2011-2040

10-year annual growth rate (CAGR), %



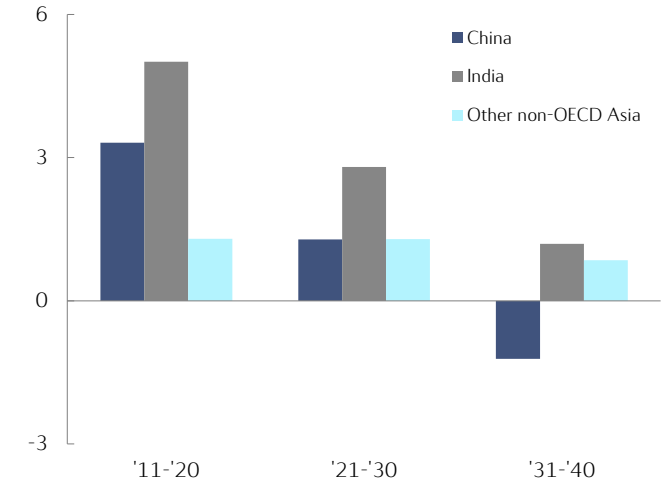
OECD oil demand 2011-2040

10-year annual growth average (CAGR), %



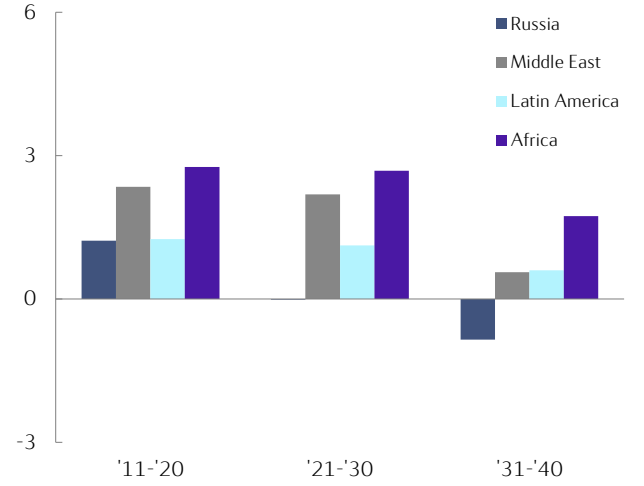
Non-OECD Asia oil demand 2011-2040

10-year annual growth average (CAGR), %



Other countries/regions oil demand 2011-2040

10-year annual growth average (CAGR), %

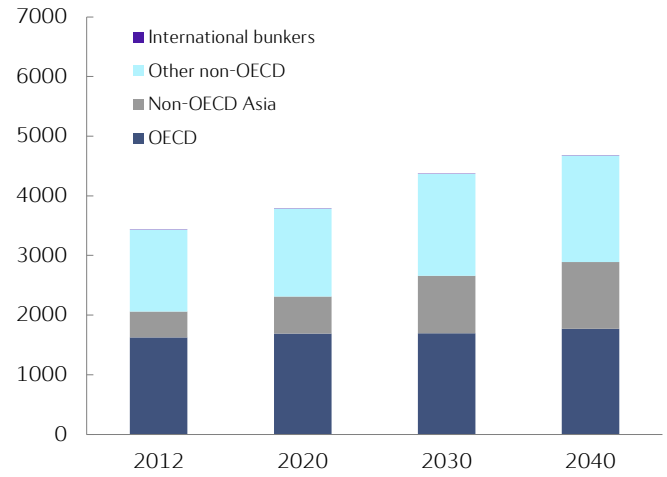


Source: IEA (history), Statoil (projections)

Global and regional gas demand – *Reform*

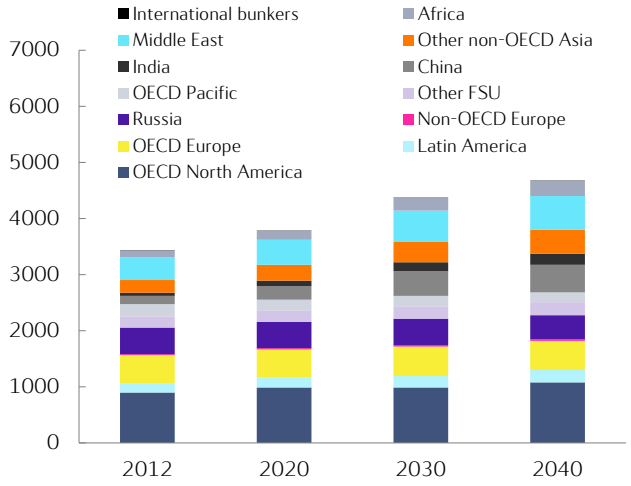
World gas demand 2012-2040

Bcm



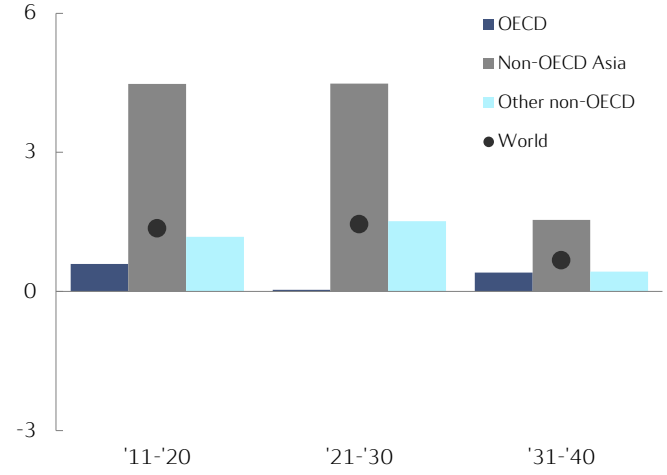
World gas demand 2012-2040

Bcm



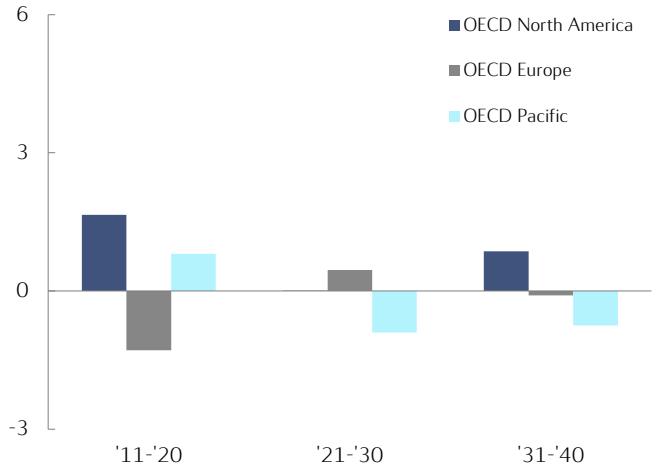
World gas demand 2011-2040

10-year annual growth average (CAGR), %



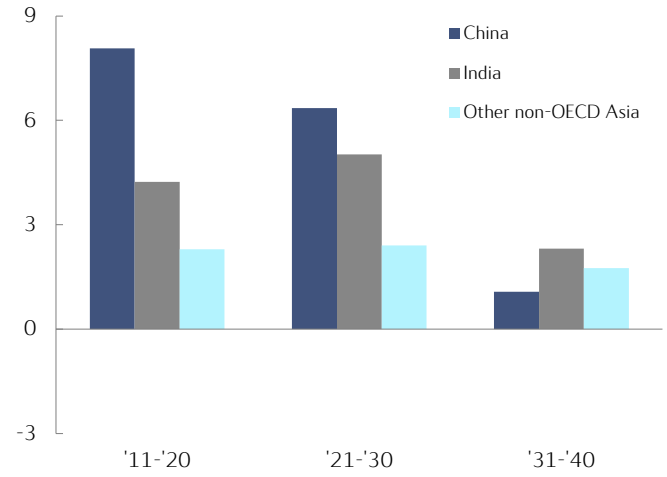
OECD gas demand 2011-2040

10-year annual growth average (CAGR), %



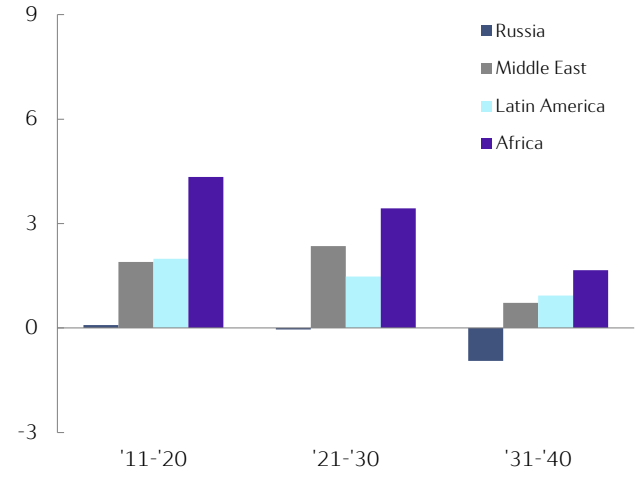
Non-OECD Asia gas demand 2011-2040

10-year annual growth average (CAGR), %



Other countries/regions gas demand 2011-2040

10-year annual growth average (CAGR), %

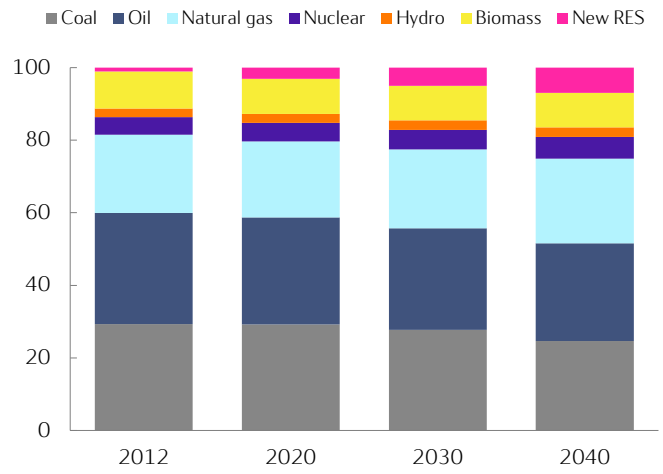


Source: IEA (history), Statoil (projections)

Global and regional energy mix – *Reform*

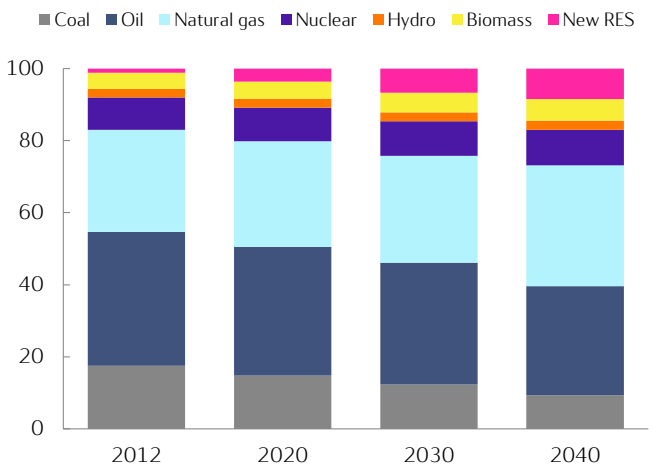
World energy mix

Share of total energy demand (TPED), %



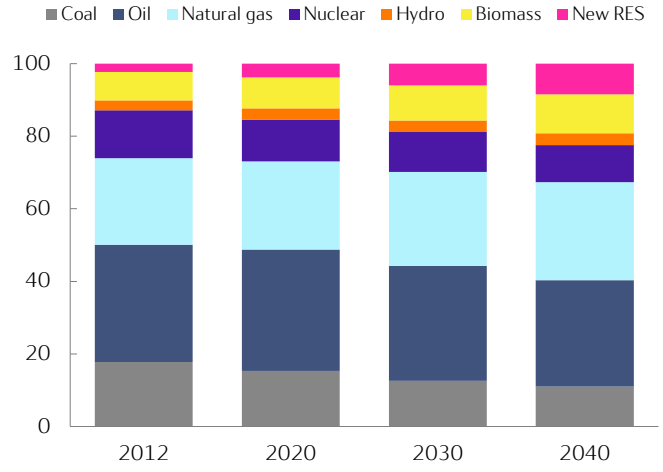
OECD North America: Energy mix

Share of total energy demand (TPED), %



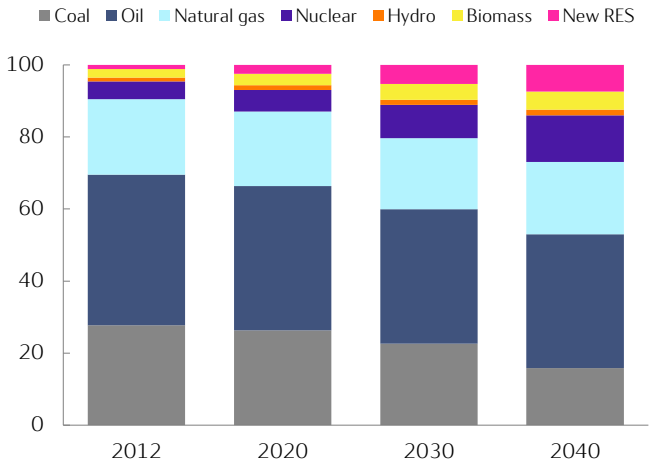
OECD Europe: Energy mix

Share of total energy demand (TPED), %



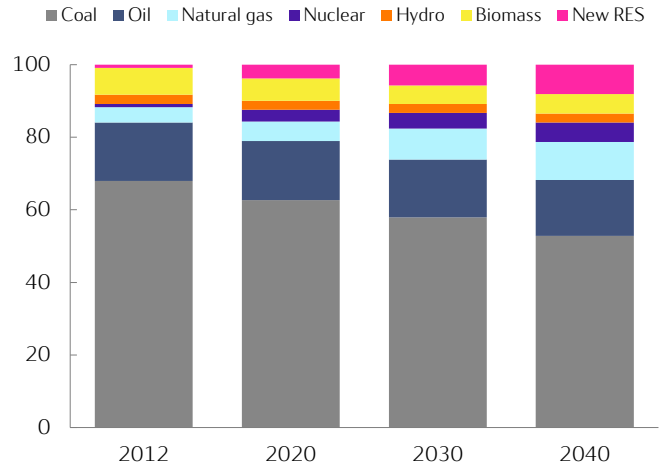
OECD Pacific: Energy mix

Share of total energy demand (TPED), %



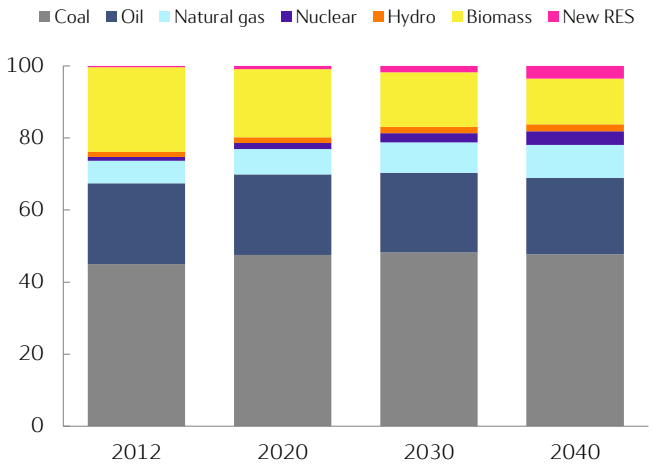
China: Energy mix

Share of total energy demand (TPED), %



India: Energy mix

Share of total energy demand (TPED), %

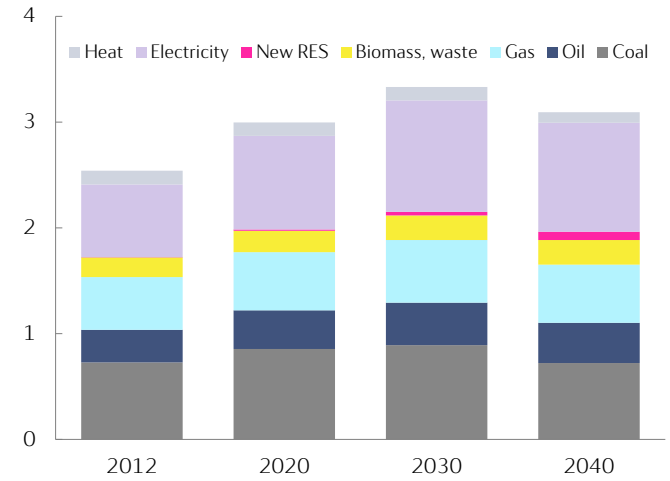


Source: IEA (history), Statoil (projections)

Sectorial energy mix – *Reform*

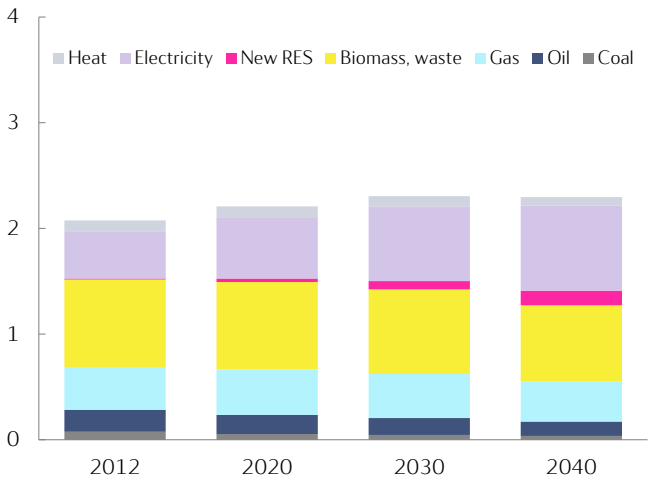
Industry

Bn toe



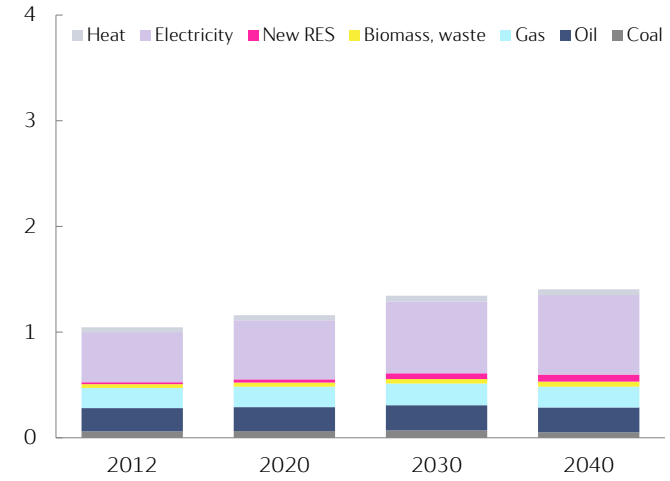
Residential

Bn toe



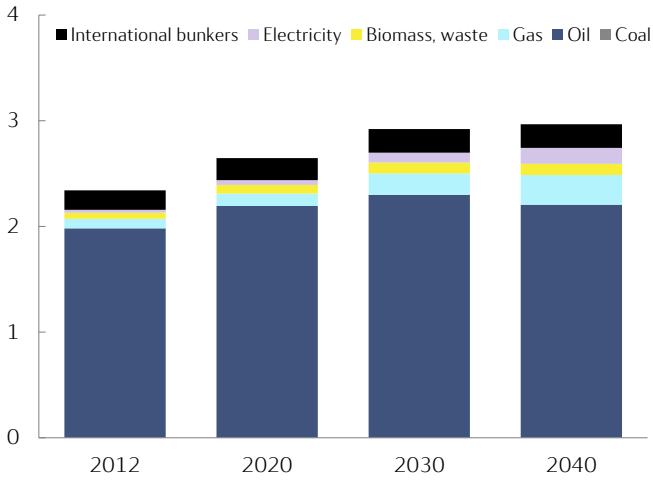
Other stationary

Bn toe



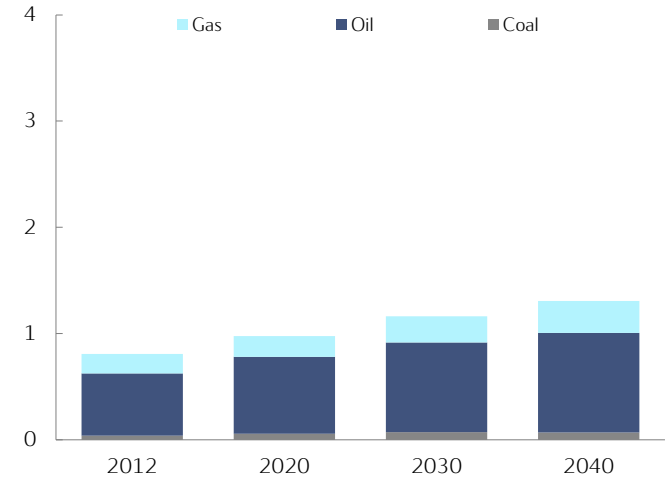
Transport

Bn toe



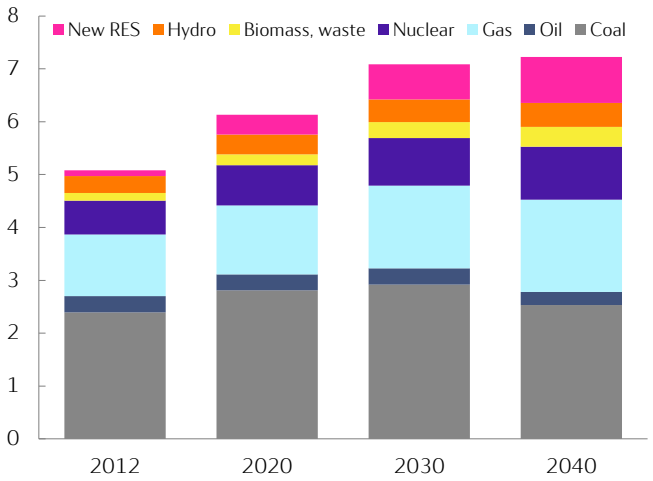
Non-energy

Bn toe



Power

Bn toe

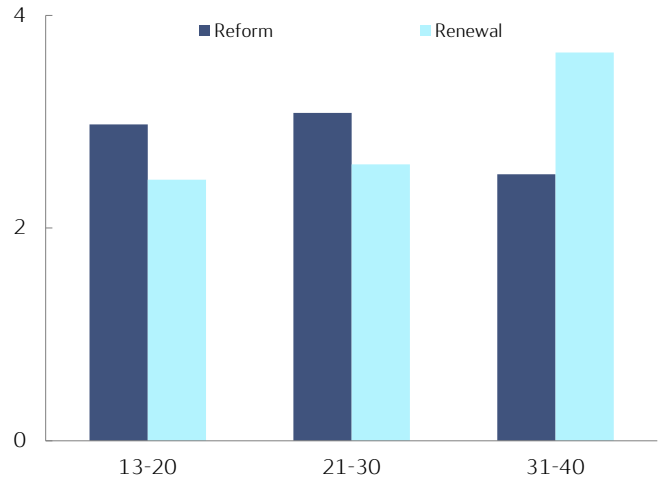


Source: IEA (history), Statoil (projections)

Renewal scenario

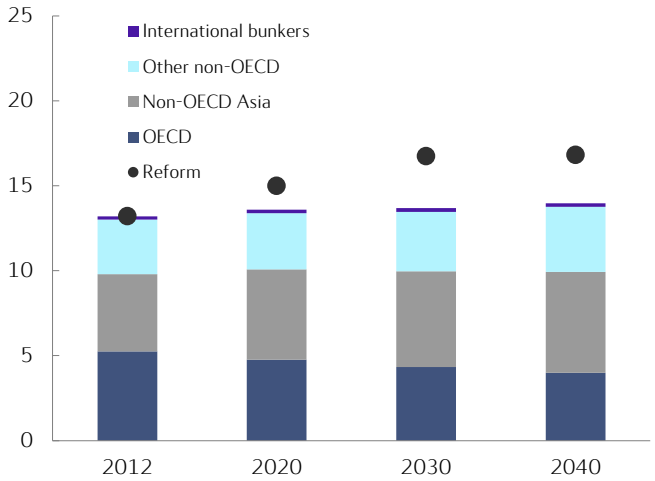
World GDP growth rates

10-year annual growth average, %



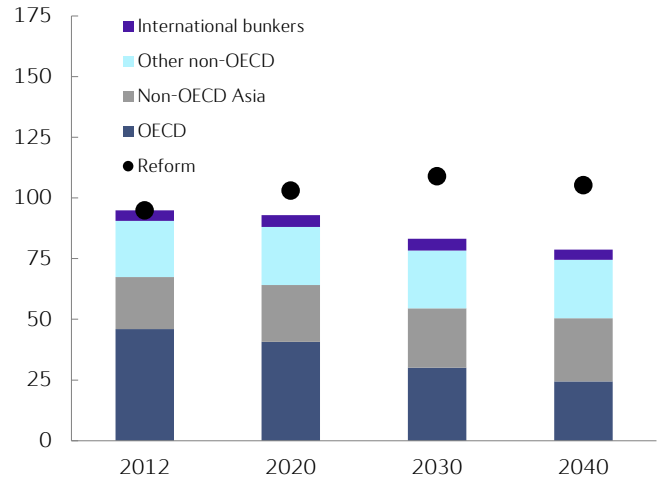
World energy demand 2012-2040

TPED, bn toe



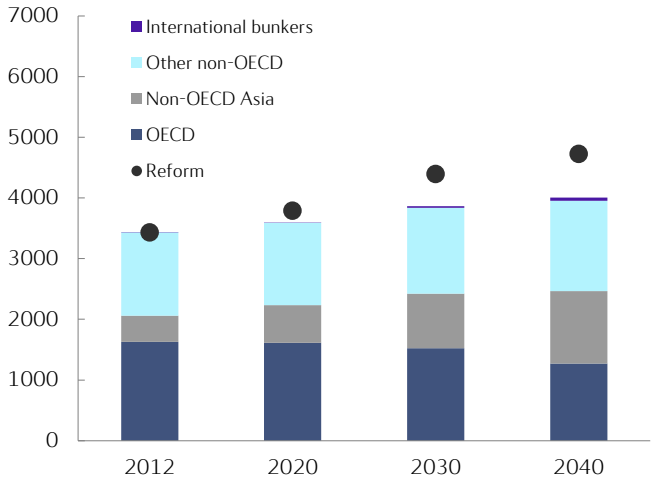
World oil demand 2012-2040

Million barrels per day



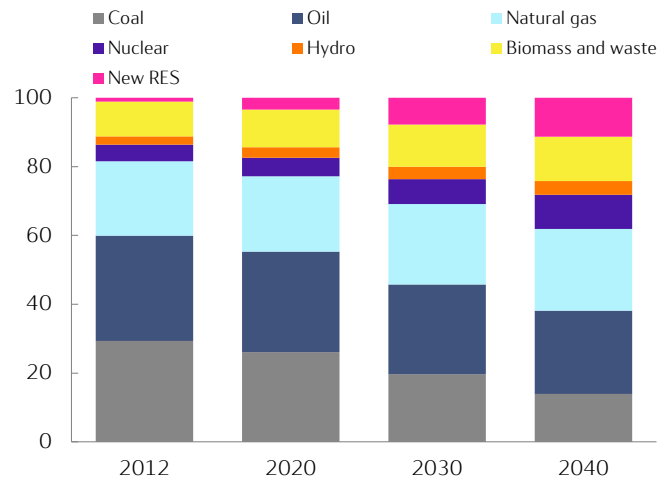
World gas demand 2012-2040

Bcm



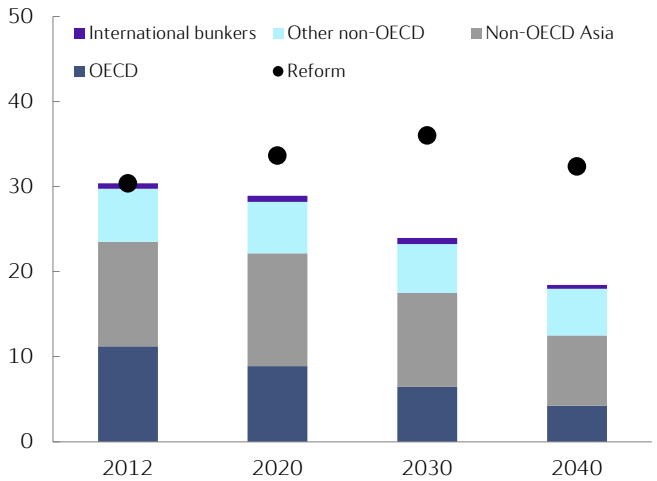
World energy mix

Share of TPED, %



CO_2 emissions

Bn t

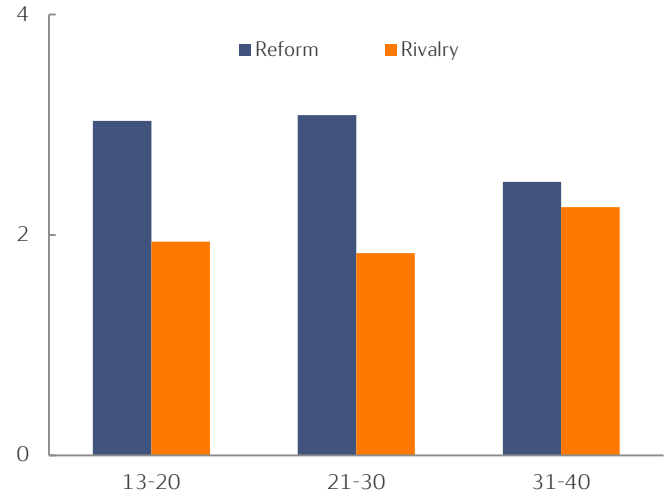


Source: IEA (history), Statoil (projections)

Rivalry scenario

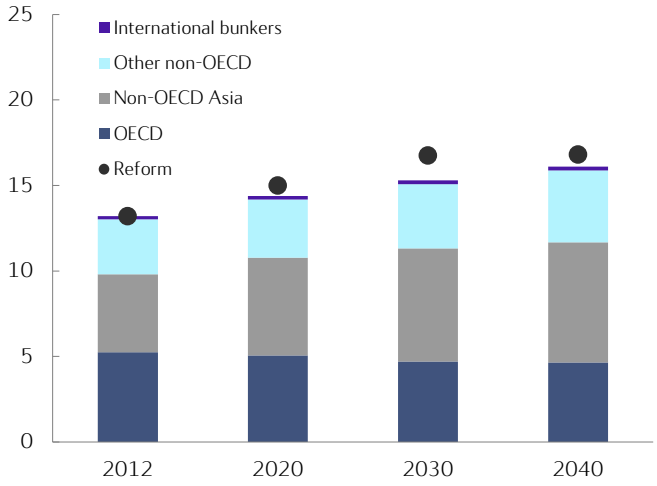
World GDP growth rates

10-year annual growth average, %



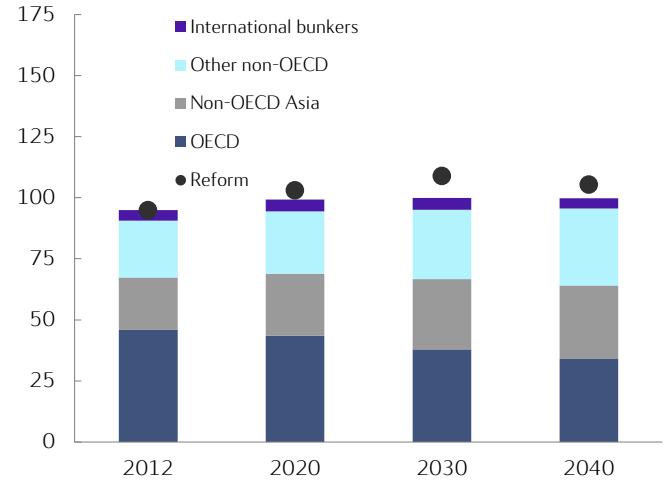
World energy demand 2012-2040

TPED, bn toe



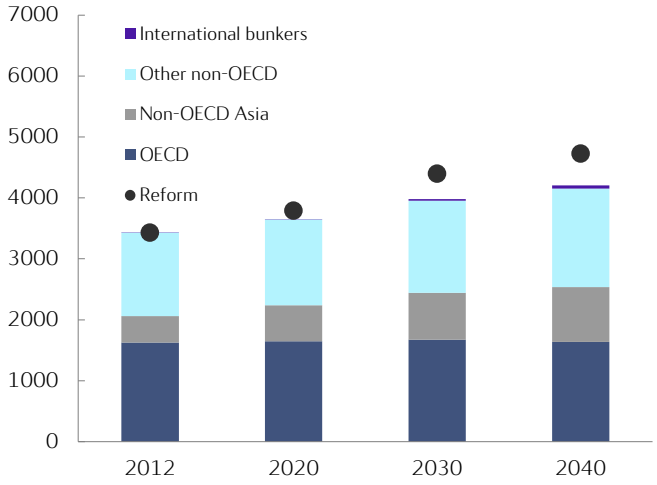
World oil demand 2012-2040

Million barrels per day



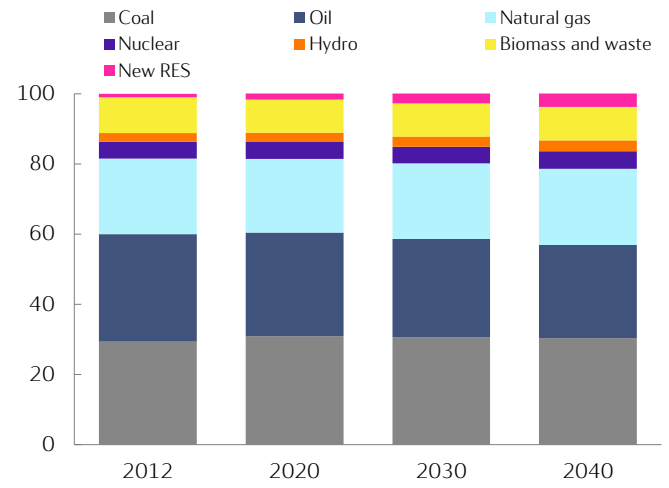
World gas demand 2012-2040

Bcm



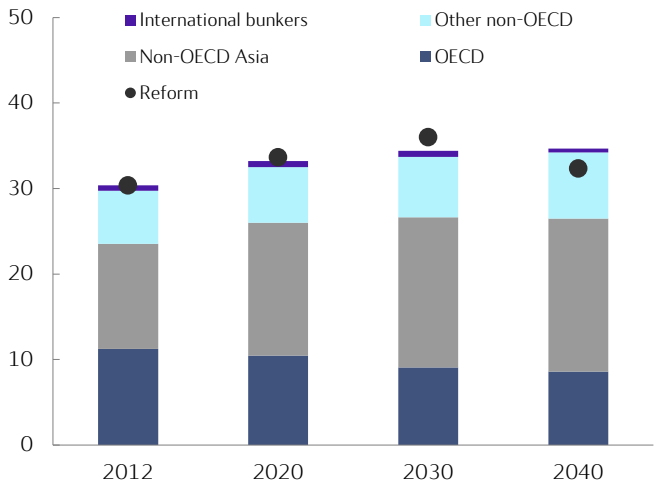
World energy mix

Share of TPED, %



CO_2 emissions

Bn t



Source: IEA (history), Statoil (projections)

Energy Perspectives 2015

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