BP Energy Outlook
2016 edition

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Unless noted otherwise, data definitions are based on the BP Statistical Review of World Energy, and historical energy data up to 2014 are consistent with the 2015 edition of the Review. Gross Domestic Product (GDP) is expressed in terms of real Purchasing Power Parity (PPP) at 2010 prices.

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Welcome to the 2016 edition of BP's *Energy Outlook*.

Our industry remains focussed on the continuing weakness in the oil market. There are clear signs that the market is adjusting and that it will gradually rebalance. But the adjustment process is likely to be painful, and energy companies need to adapt to weather the storm. That is what BP has been doing over the past year and will continue to do.

But in order to adapt successfully, we must have a clear sense of where we are heading, so that we not only emerge from the current weakness leaner and fitter, but do so better equipped to meet the longer-term challenges facing our industry.

That is the role of the *Energy Outlook*: to help lift our focus from the here-and-now and consider how the energy landscape might evolve over the next twenty years. With that in mind, three key features of this year's *Outlook* stood out for me.

First, energy demand will continue to grow. Put simply, as the world economy expands, more energy will be needed to fuel the higher levels of activity and living standards. The growth in energy will be curbed by faster gains in energy efficiency. And there is of course considerable uncertainty as to exactly how quickly global GDP will grow. Even so, it seems clear that significantly more energy will be required over the next twenty years to enable the world economy to grow and prosper.

Second, the fuel mix continues to shift. Fossil fuels remain the dominant source of energy powering the world economy, supplying 60% of the energy increase out to 2035. Within that, gas looks set to become the fastest growing fossil fuel, spurred on by ample supplies and supportive environmental policies. In contrast, the growth of global coal consumption is likely to slow sharply as the Chinese economy rebalances. Renewables are set to grow rapidly, as their costs continue to fall and the pledges made in Paris support their widespread adoption.

Third, the outlook for carbon emissions is changing significantly. In particular, the rate of growth of carbon emissions is projected to more than halve over the Outlook period relative to the past twenty years. That reflects both faster gains in energy efficiency and the shift towards lower-carbon fuels. Despite this, carbon emissions are likely to continue to increase, indicating the need for further policy action. In BP, we believe carbon pricing has an important part to play as it provides incentives for everyone to play their part.

2016 looks set to be another tough year for our industry. But we have faced similar episodes in the past and we know that the market will eventually rebalance. We need to respond to the near-term challenges, but we mustn't lose sight of the longer-term role of our industry in providing the energy the world needs to grow and prosper, and doing so in a safe and sustainable manner. We hope that this edition of the BP *Energy Outlook* can make a useful contribution to informing discussions about future energy needs and trends.

Bob Dudley
Group chief executive

Executive summary

- The Energy Outlook considers a base case, outlining the 'most likely' path for energy demand by fuel based on assumptions and judgements about future changes in policy, technology and the economy, and develops a number of alternative cases to explore key uncertainties.
- In the base case, world GDP more than doubles, but unprecedented gains in energy efficiency mean that the energy required to fuel the higher level of activity grows by only around a third over the Outlook.
- Fossil fuels remain the dominant form of energy powering the global expansion: providing around 60% of the additional energy and accounting for almost 80% of total energy supplies in 2035.
- Gas is the fastest growing fossil fuel supported by strong supply growth, particularly of US shale gas and liquefied natural gas (LNG), and by environmental policies.
- The oil market gradually rebalances, with the current low level of prices boosting demand and dampening supply.

Executive summary (continued)

- Oil demand increases by almost 20 Mb/d over the Outlook, with growing use in Asia for both transport and industry. Tight oil continues to grow, although at a gradually moderating pace.
- The continuing reform of China's economy causes growth in China's energy demand to slow sharply. This slowing weighs heavily on global coal, which grows at less than a fifth of its rate over the past 20 years.
- Renewables grow rapidly, almost quadrupling by 2035 and supplying a third of the growth in power generation.
- The rate of growth of carbon emissions more than halves relative to the past 20 years, reflecting gains in energy efficiency and the changing fuel mix. But emissions continue to rise, suggesting the need for further action.
- The uncertainty around the base case is explored in three alternative cases: slower global GDP growth; a faster transition to a lower-carbon world; and shale oil and gas having even greater potential.

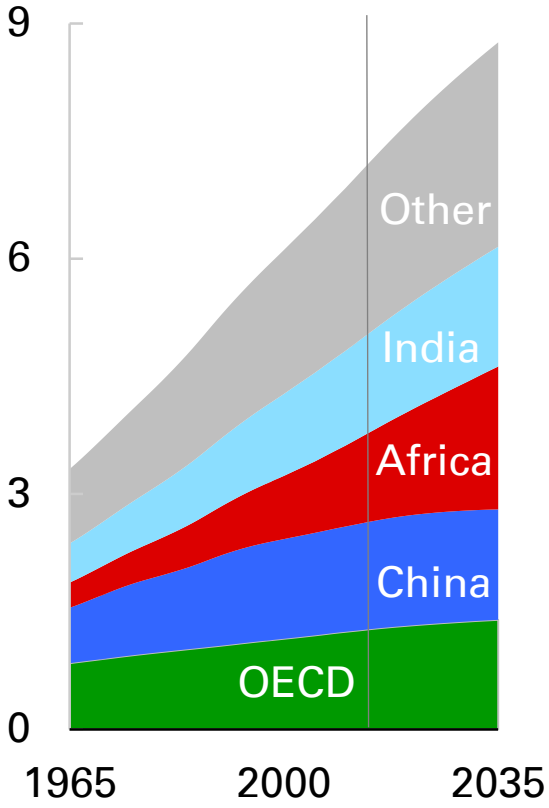
Base case

Primary energy

Global GDP is expected to more than double…

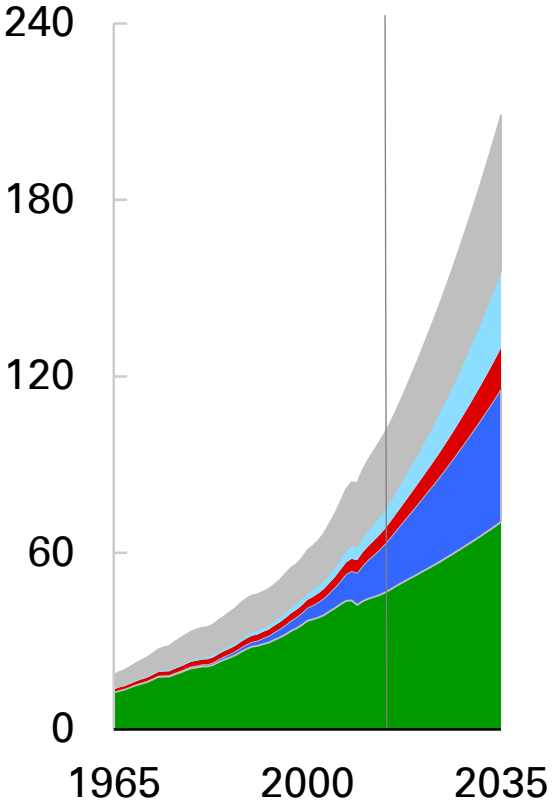
Population

Billion



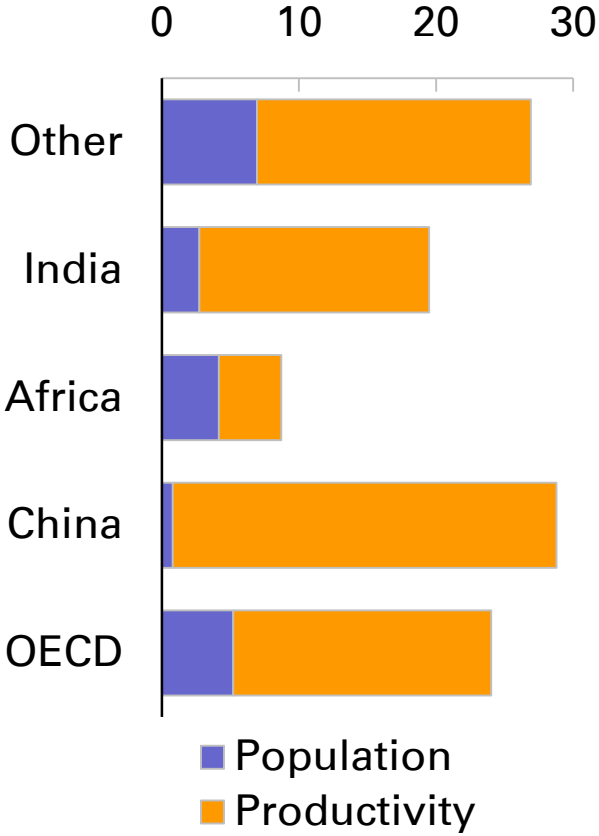
GDP

Trillion, $2010



Contribution to GDP growth 2014-35

Trillion, $2010

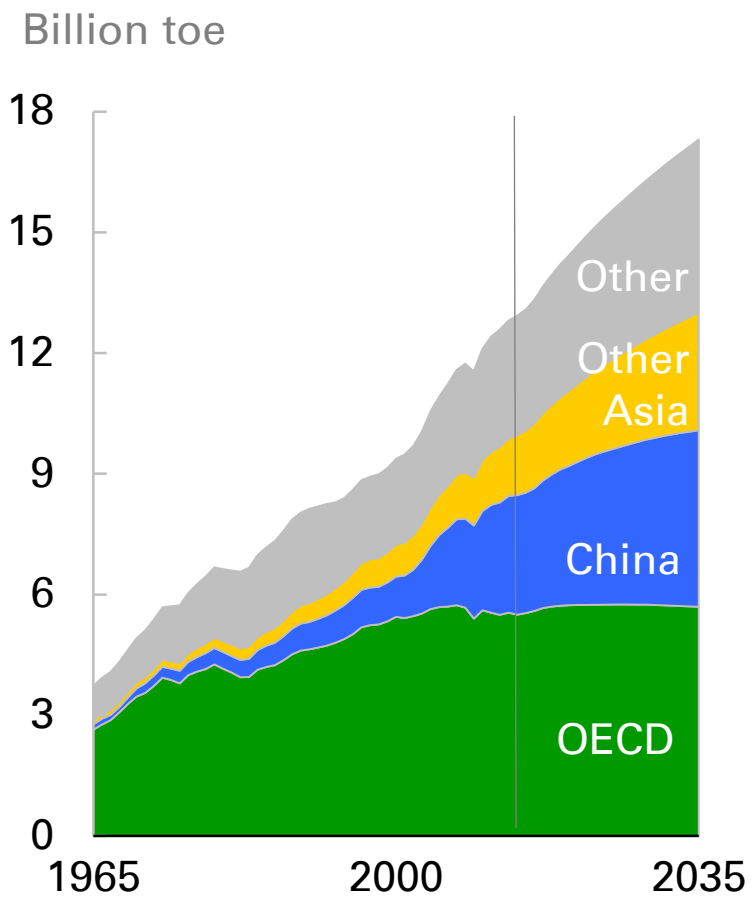


…driven by strong growth in emerging Asia

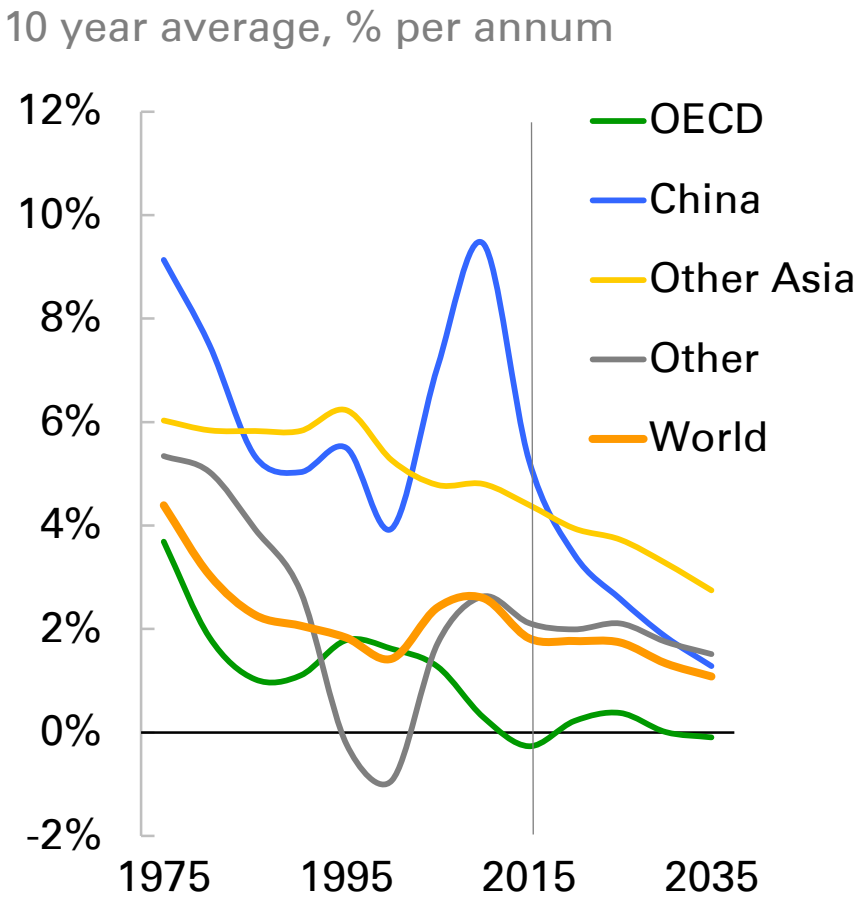
- Population and income are the key drivers behind growing demand for energy.
- The world's population is projected to increase by around 1.5 billion people to reach nearly 8.8 billion people by 2035.
- Over the same period, GDP is expected to more than double; around one-fifth of that increase comes from population growth and four-fifths from improvements in productivity (i.e. GDP per person).
- China and India together account for almost half of the increase in global GDP, with OECD economies accounting for around a quarter.
- Africa accounts for almost half of the increase in the world's population, such that by 2035 it is projected to have 30% more people than China and 20% more than India. Yet Africa accounts for less than 10% of the increase in both global GDP and energy consumption over the Outlook.

Growth in the world economy requires more energy…

Consumption by region



Consumption growth by region

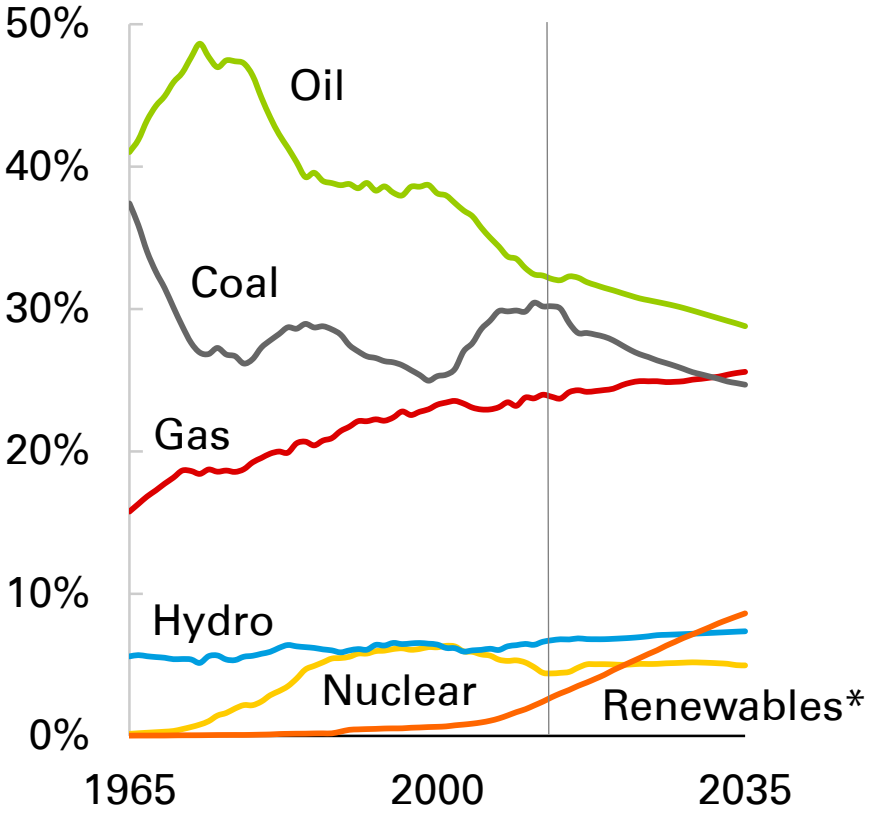


…largely consumed by fast-growing emerging economies

- The growth in the world economy means more energy is required; energy consumption increases by 34% between 2014 and 2035.
- Virtually all of the additional energy is consumed in fast-growing emerging economies; energy demand within the OECD barely grows.
- The growth of energy is slower than in the recent past – 1.4% per annum (p.a.) versus 2.3% p.a. in 2000-14 – reflecting significantly faster falls in energy intensity (energy used per unit of GDP).
- China's energy demand growth slows as its economy rebalances, towards a more sustainable rate. By the final decade of the Outlook, China contributes less than 30% of global energy growth, compared with nearly 60% over the past decade.
- The sharp slowing in China's energy demand growth is partially offset by a pickup in other developing countries. India accounts for more than a quarter of the growth in global energy demand in the final decade of the Outlook, double its contribution over the past decade.

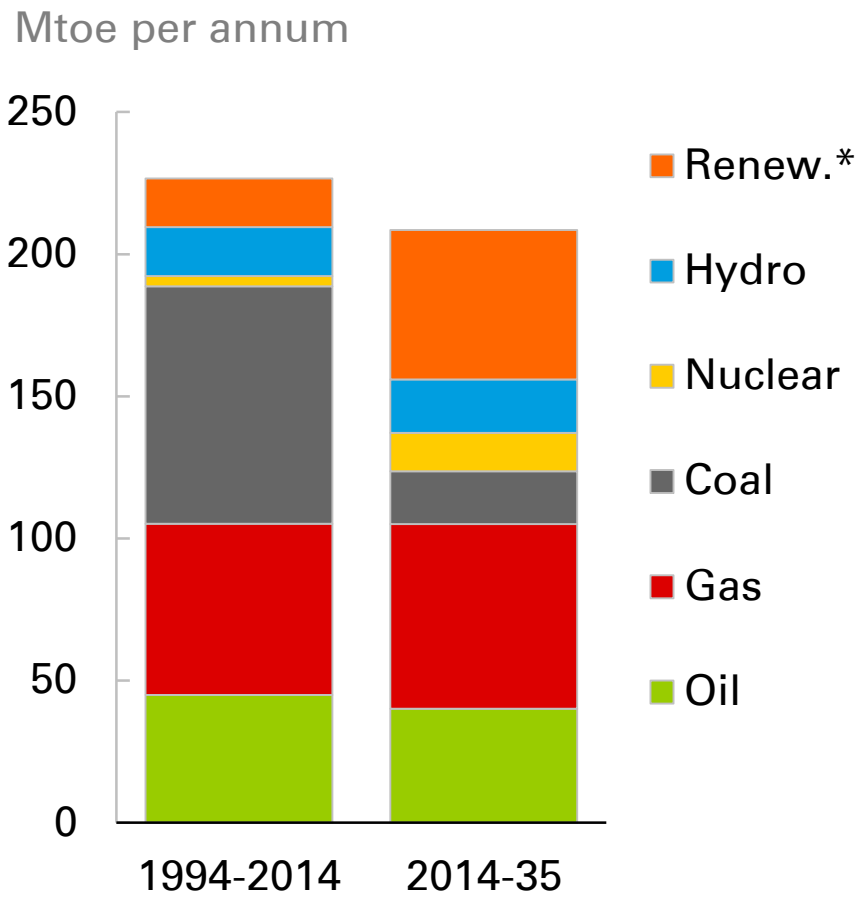
The fuel mix is set to change significantly…

Shares of primary energy



*Includes biofuels

Annual demand growth by fuel

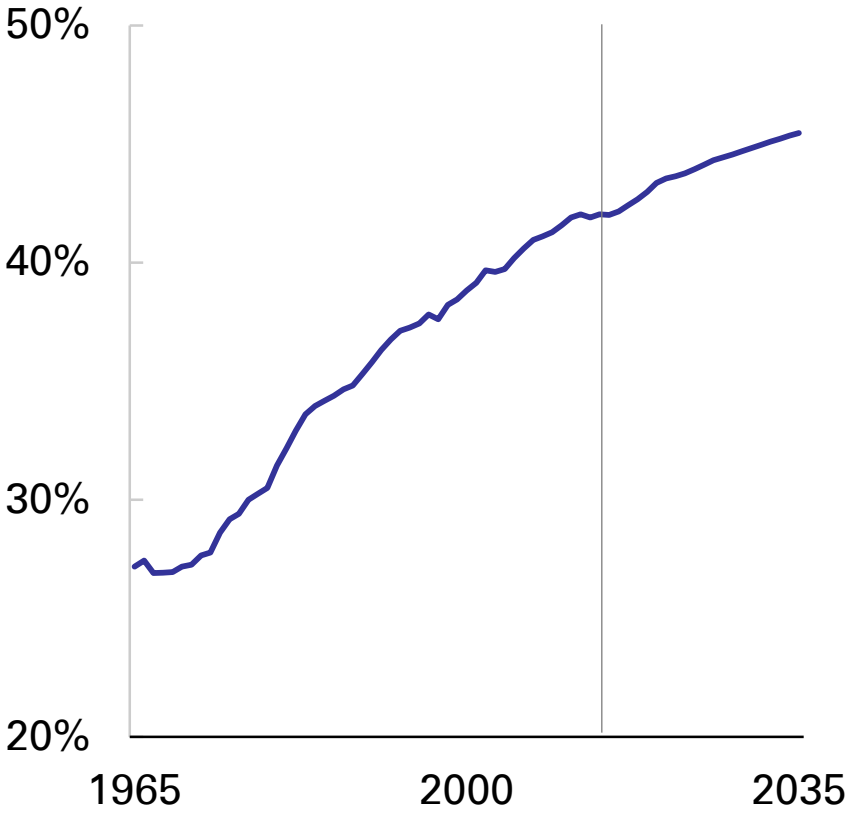


...although oil and gas remain key sources of energy growth

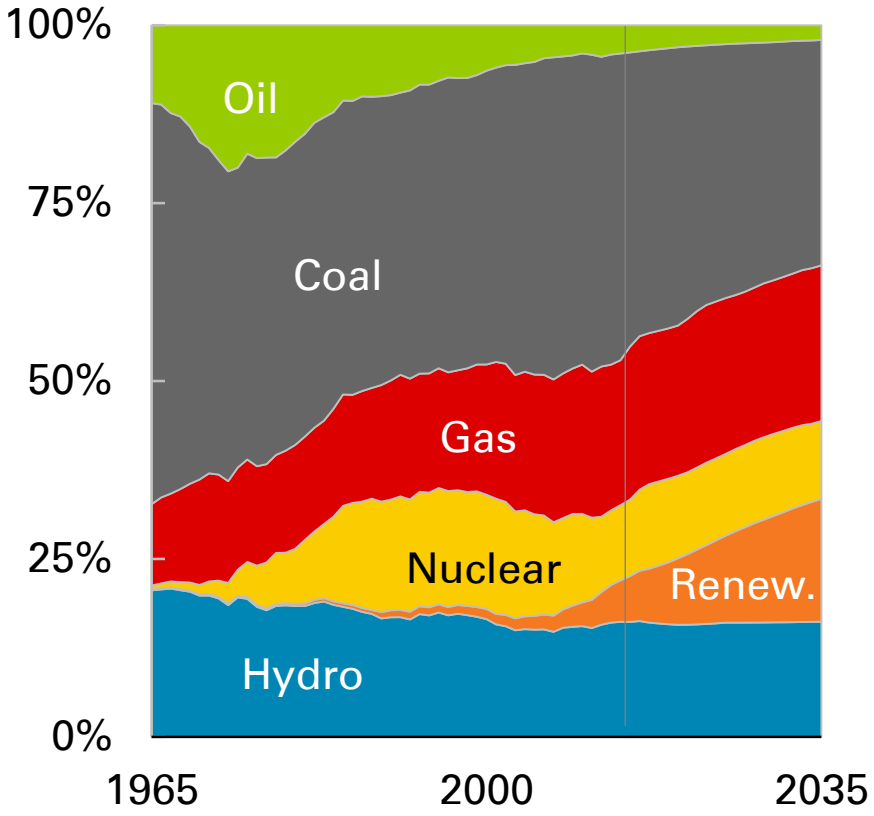
- Fossil fuels remain the dominant source of energy powering the global economy, providing around 60% of the growth in energy and accounting for almost 80% of total energy supply in 2035 (down from 86% in 2014).
- Gas is the fastest growing fossil fuel (1.8% p.a.), with its share in primary energy gradually increasing. Oil grows steadily (0.9% p.a.), although the trend decline in its share continues.
- The combined increase of oil and gas over the Outlook is similar to the past 20 years.
- In contrast, coal suffers a sharp reversal in its fortunes. After gaining share since 2000, the growth of coal is projected to slow sharply (0.5% p.a.), such that by 2035 the share of coal in primary energy is at an all-time low, with gas replacing it as the second-largest fuel source.
- Among non-fossil fuels, renewables (including biofuels) grow rapidly (6.6% p.a.), causing their share in primary energy to rise from around 3% today to 9% by 2035.

Much of the growth in energy is used for power generation…

Inputs to power as a share of total primary energy



Primary inputs to power



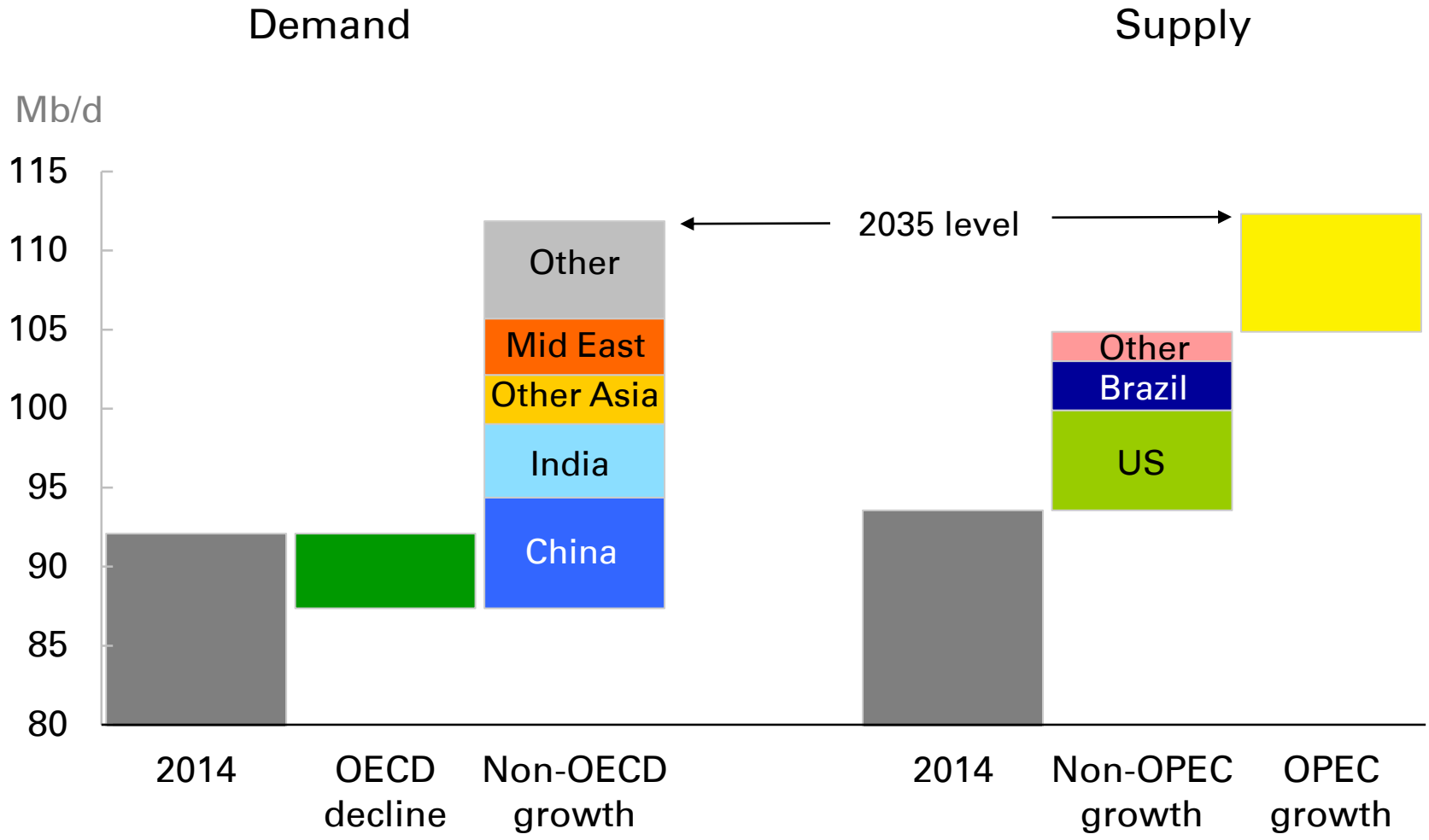
…as the trend towards global electrification continues

- More than half of the increase in global energy consumption is used for power generation as the long-run trend towards global electrification continues: the share of energy used for power generation rises from 42% today to 45% by 2035.
- More than a third of the growth in power generation takes place in regions where a large part of the population lack adequate access to electricity – India, other developing Asia (excluding China), and Africa.
- Power generation is the main sector where all fuels compete and so it plays a major role in the evolution of the global fuel mix, with renewables and gas gaining share relative to coal.
- The outcome is a more balanced and diversified portfolio of fuels for power generation. The share of coal declines from 43% in 2014 to around a third in 2035. In contrast, the share of non-fossil fuels increases, reaching nearly 45% by 2035.

Base case

Fuel by fuel detail

Strong growth in Asia drives increases in oil demand…

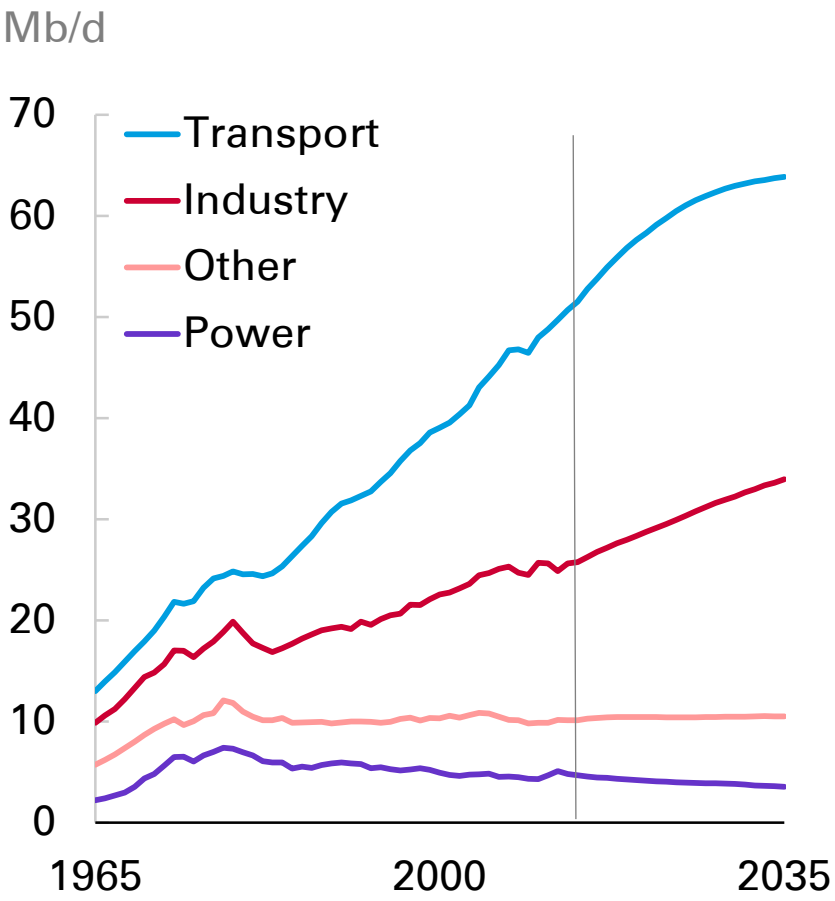


…met by increased supply from the Americas and OPEC

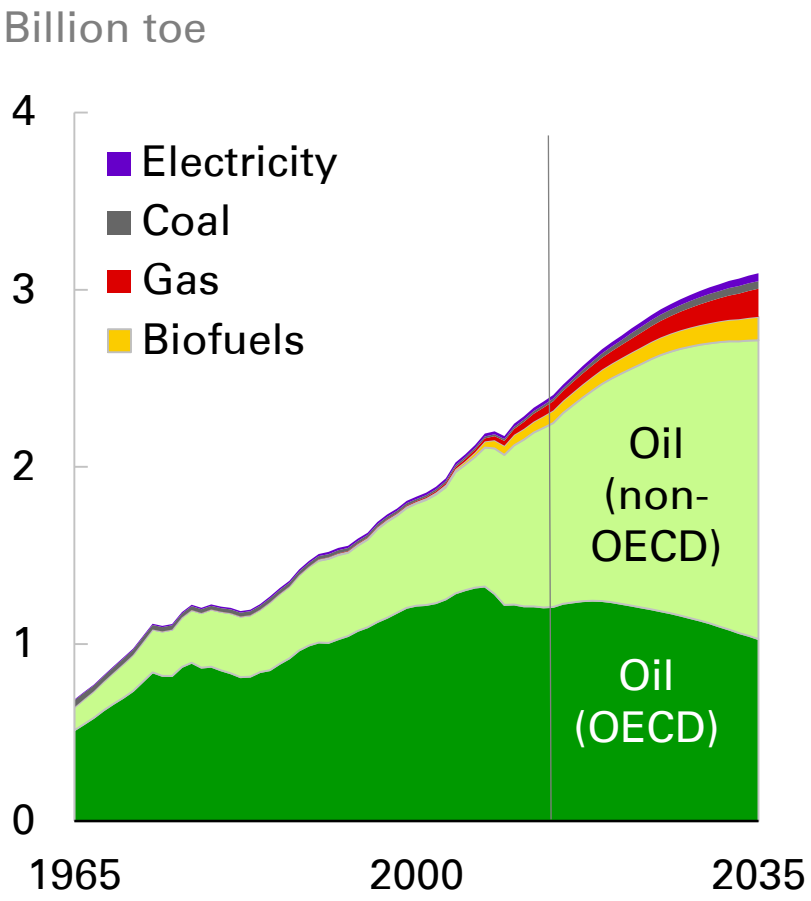
- The oil market gradually rebalances, with the current low level of prices boosting demand and dampening supply.
- Global liquids demand (oil, biofuels, and other liquids) increases by around 20 Mb/d, to reach 112 Mb/d by 2035.
- All of this increased demand comes from emerging economies, with China and India accounting for over half of the increase. In contrast, oil consumption in OECD economies continues its secular decline (-5 Mb/d).
- Non-OPEC supply accounts for the majority of the supply increase, growing by 11 Mb/d, while OPEC increases by 7 Mb/d. All of the net increase in non-OPEC supply comes from the Americas: US shale, Brazilian deepwater and Canadian oil sands.

Growth in liquids demand is driven by transport and industry…

Liquids demand by sector



Transport demand by fuel



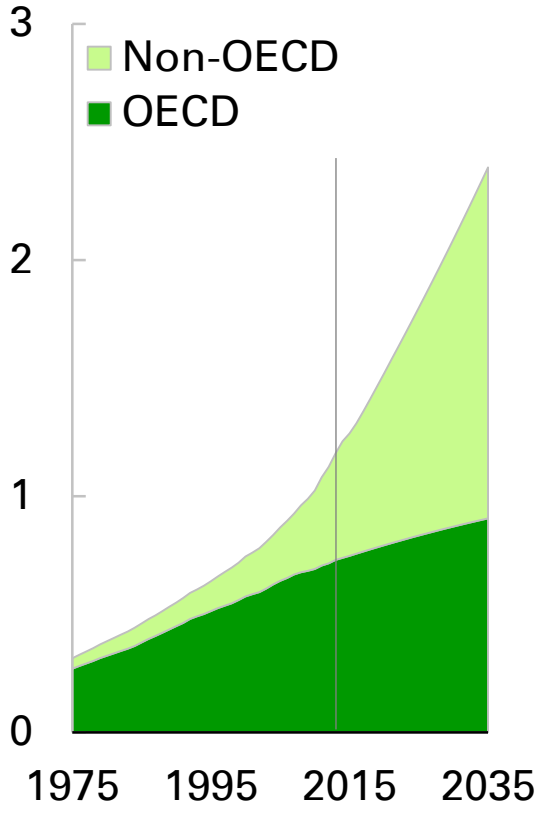
…helped by limited competition from alternative fuels

- The growth in the global consumption of liquid fuels is driven by transport and industry, with transport accounting for almost two-thirds of the increase.
- The growth in transport demand reflects rapid increases in vehicle ownership in emerging economies, partially offset by sustained gains in vehicle efficiency, which slow the sector's growth post-2025.
- Transport fuel continues to be dominated by oil (88% in 2035). The share of non-oil alternatives increases from 7% in 2014 to 12% in 2035, with natural gas the fastest growing transport fuel (6.3% p.a.).
- The other major source of demand growth for liquid fuels is industrial use, especially in petrochemicals, which is the fastest growing source of demand.
- Growth in industrial use of oil is aided by the relatively limited scope for efficiency gains and fuel switching. Moreover, over 40% of oil used in industry is not combusted and so is less affected by climate policies.

The global vehicle fleet more than doubles…

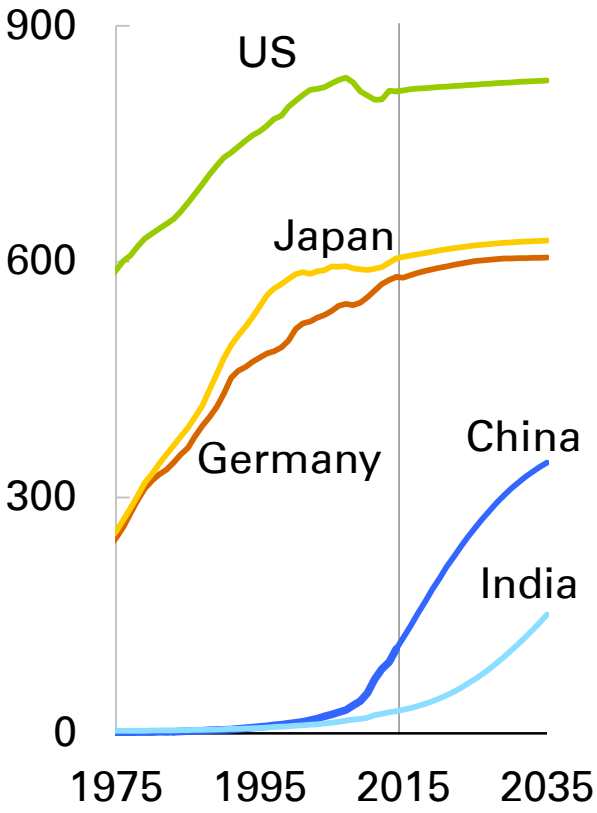
Vehicle fleet

Billion vehicles



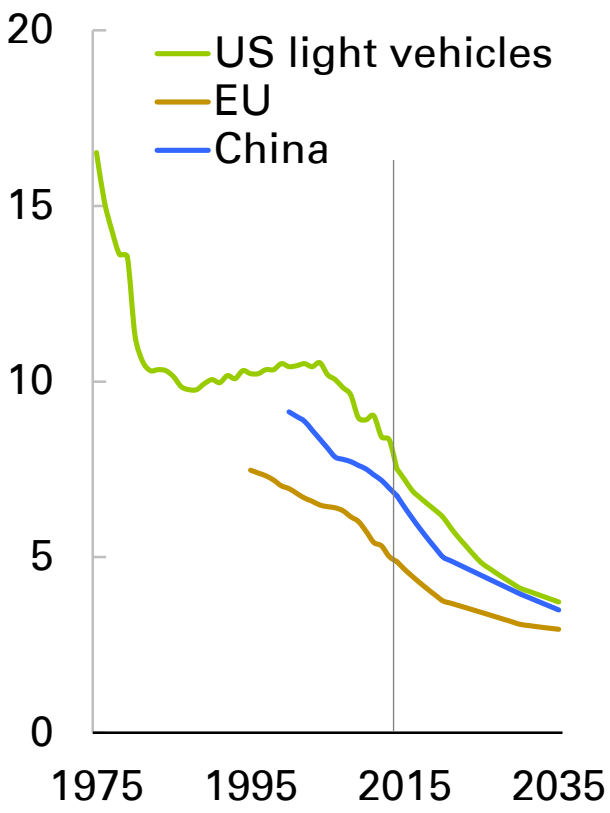
Vehicle ownership

Vehicles per 1000 people



Fuel economy of new cars

Litres per 100 km

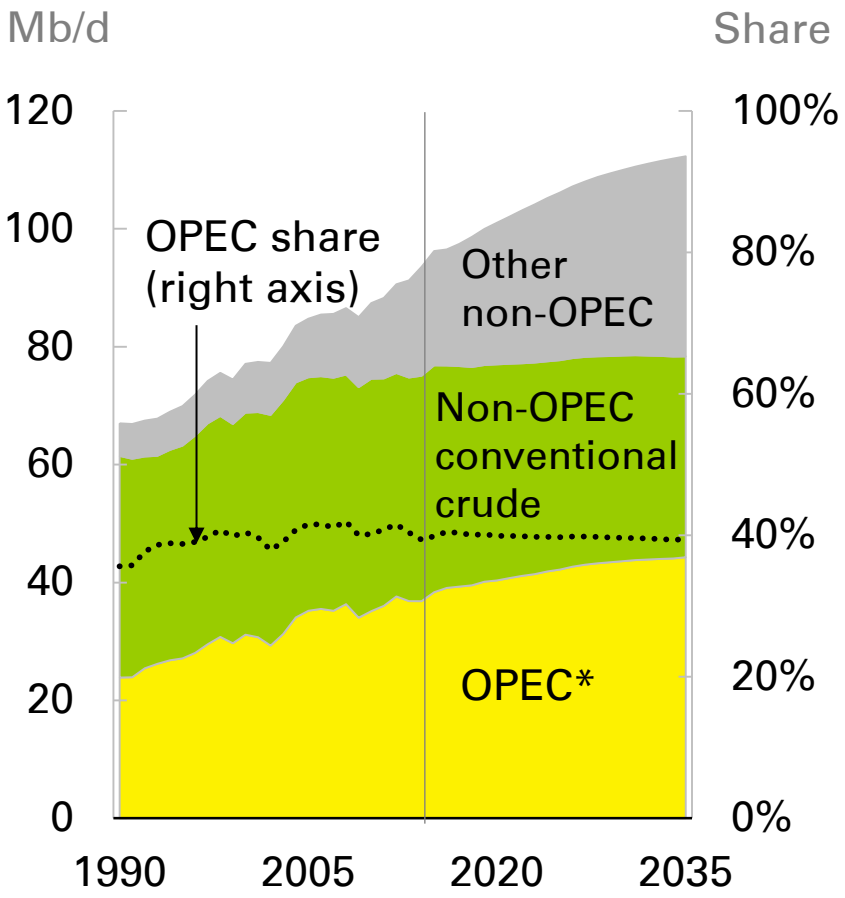


…as vehicle ownership in emerging economies grows rapidly

- The global vehicle fleet (commercial vehicles and passenger cars) more than doubles over the Outlook, from around 1.2 billion today to 2.4 billion by 2035.
- Almost all of that growth is in emerging economies: the non-OECD vehicle fleet more than triples from about 0.5 to 1.5 billion over the Outlook, overtaking the OECD in the early 2020s.
- Growth in mature economies is much slower, as markets such as the US and Japan are close to saturation levels in terms of vehicle ownership.
- The efficiency of the vehicle fleet increases substantially over the Outlook, improving by 2-3% p.a. compared with 1.5% p.a. over the past decade.
- As a result, in 2035, an average passenger car is expected to achieve 50 miles per gallon, compared with only 30 miles per gallon today.

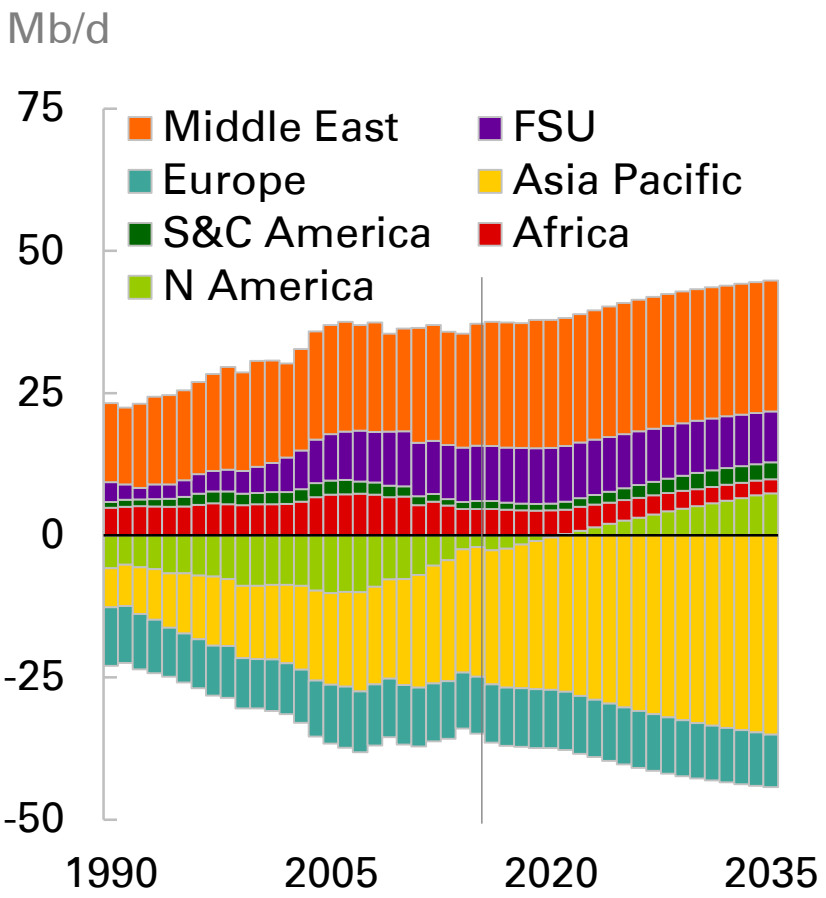
Non-OPEC is the largest source of supply growth...

Liquids supply by type



*Includes crude and natural gas liquids (NGLs)

Regional net balances

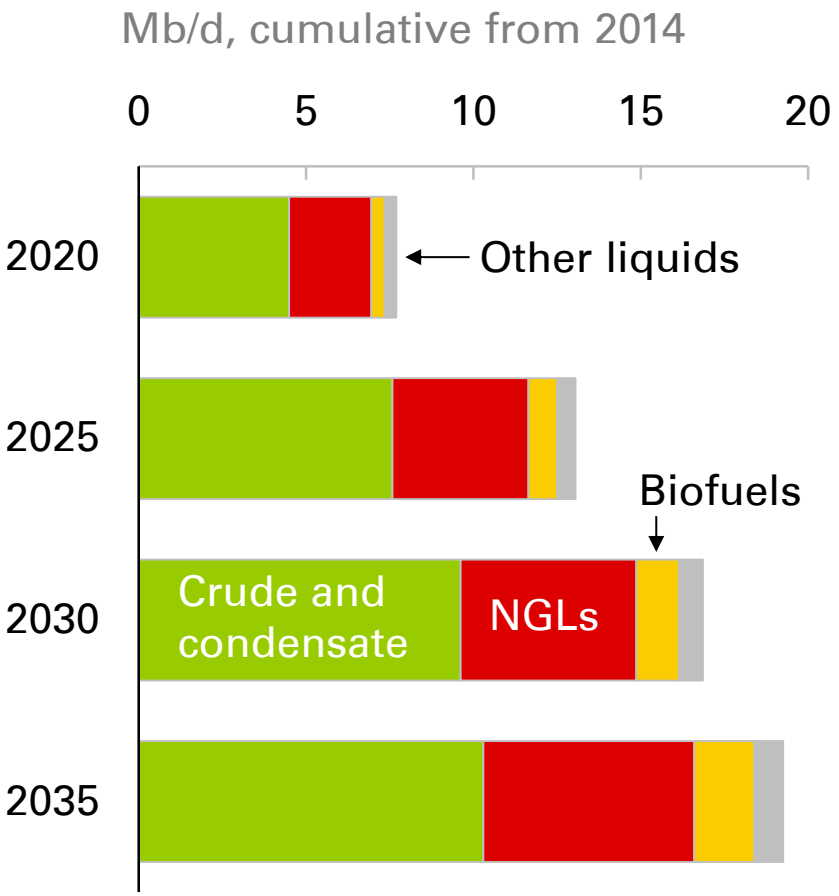


…shifting the pattern of supply and regional trade

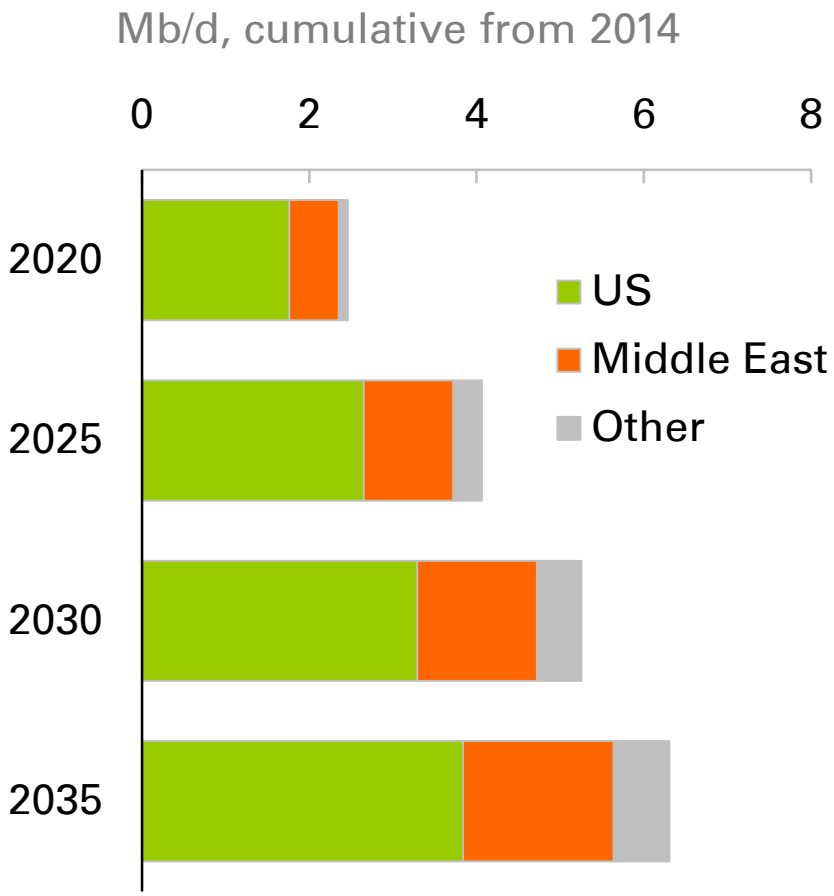
- Global liquids supply expands by nearly 19 Mb/d by 2035, led by growth in non-OPEC supply. US shale (crude and NGLs), tight oil elsewhere, Brazilian deepwater, Canadian oil sands and biofuels together grow by 16 Mb/d, accounting for around half of non-OPEC production in 2035.
- We assume that OPEC acts to maintain its market share of around 40%, increasing output (crude and NGLs) by 7 Mb/d to 44 Mb/d by 2035.
- The shifting pattern of demand and supply cause regional oil imbalances to shift and become more concentrated.
- In particular, the increase in tight oil production, coupled with declining demand, further reduces North America's reliance on oil imports, with the region set to become self-sufficient in oil over the next few years. The removal of the US crude export ban helps this adjustment process.
- In contrast, Asia's dependence on oil imports increases significantly, accounting for virtually all of the growth in global imports over the Outlook and for nearly 80% of inter-regional net imports by 2035.

Refiners are challenged by spare capacity…

Global liquids supply growth



NGLs production growth

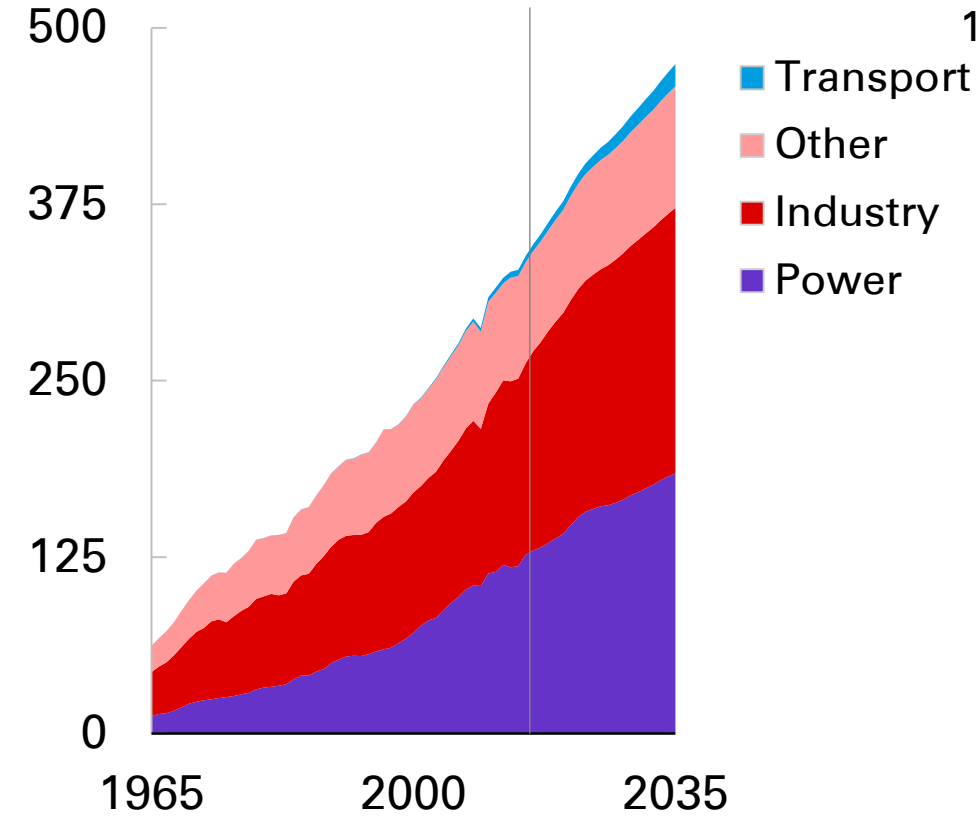


…and alternative supplies, particularly from NGLs

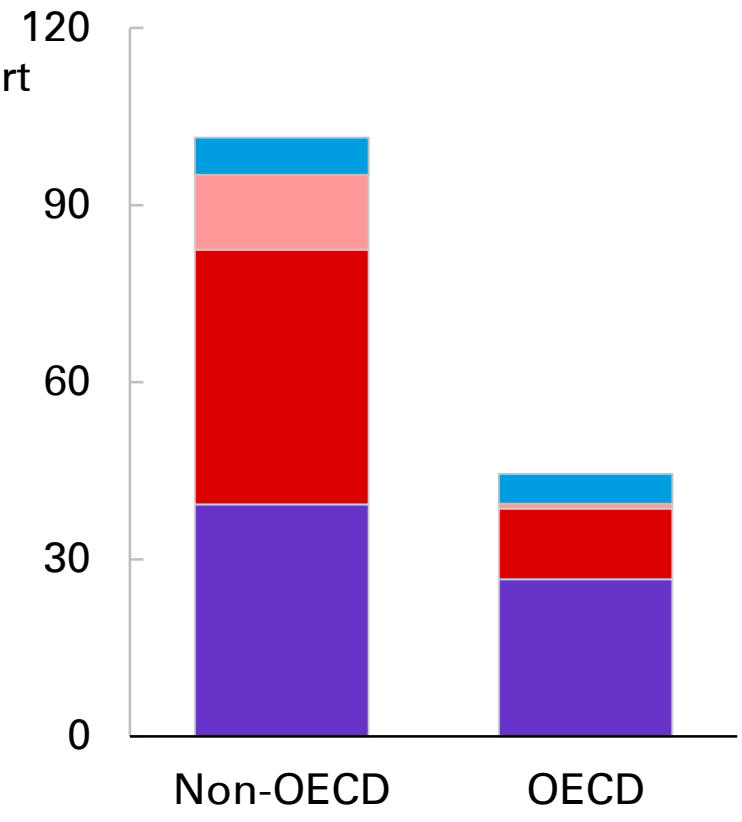
- Of the 19 Mb/d projected growth in supplies of liquids, almost half (9 Mb/d) is expected to be accounted for by NGLs, biofuels and other liquids that do not require refining.
- Current spare refining capacity plus planned refinery additions over the next five years is already enough to meet the incremental growth in crude and condensate supplies projected over the next two decades (10 Mb/d).
- Assuming growth regions, such as China and India, continue to invest in refining capacity, our Outlook implies a long period of volatile margins, with capacity reductions required in disadvantaged refining centres.
- NGLs provide the largest increment of non-refined liquids, expanding by more than 6 Mb/d to 2035 and supporting the growth in petrochemicals demand.
- Growth is driven by the US (4 Mb/d) and the Middle East (2 Mb/d), with the US expected to become a major exporter of LPG, to both Europe and the Asia Pacific markets.

Demand for natural gas grows strongly…

Demand by sector



Demand growth by region

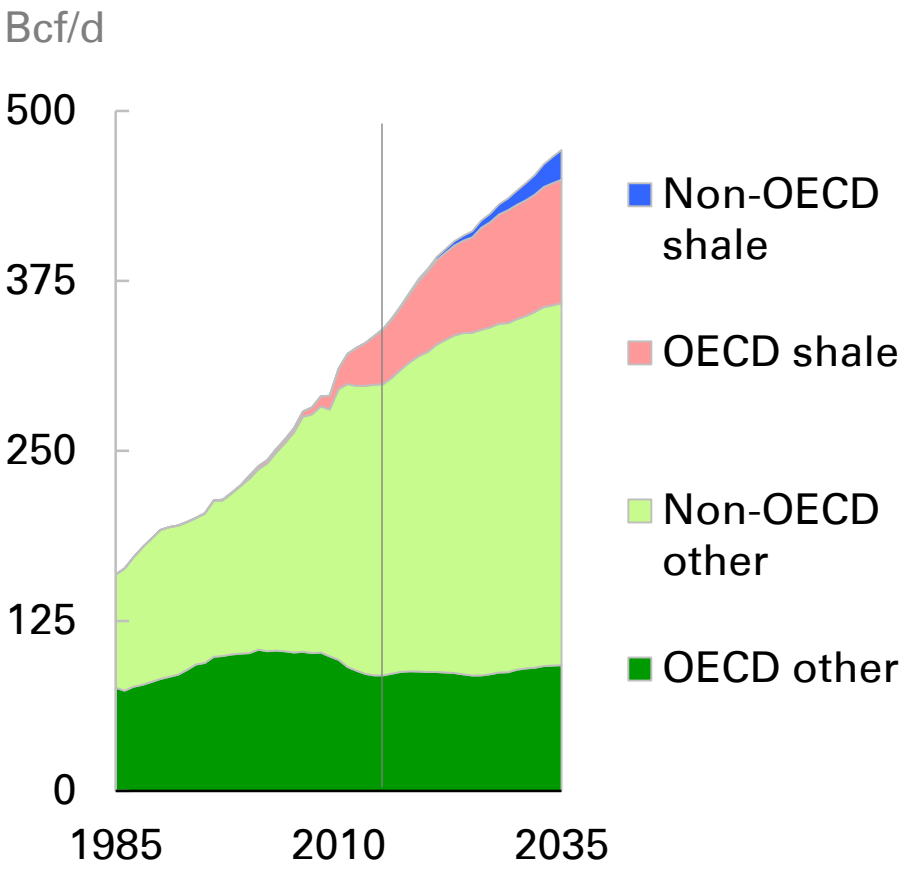


…driven by increasing consumption in emerging economies

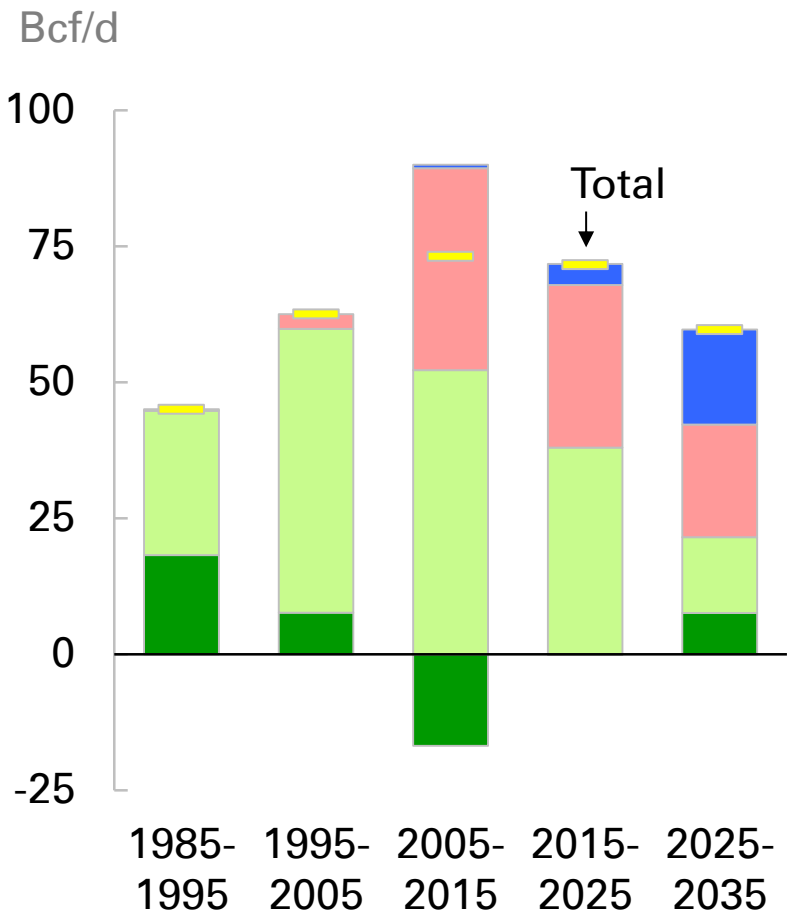
- Demand for natural gas grows by 1.8% p.a., making it the fastest growing fossil fuel. This robust growth is helped by ample supplies and supportive environmental policies.
- The majority of the increase in demand comes from emerging economies, with China and India together accounting for around 30% of the increase and the Middle East over 20%.
- The increased use of gas in emerging markets is fairly evenly split between use in the industrial sector, as these economies continue to industrialize, and use for power generation.
- In contrast, growth in OECD gas consumption is more concentrated in the power sector.

Global supplies of natural gas grow robustly…

Gas production by type and region



Ten year increments

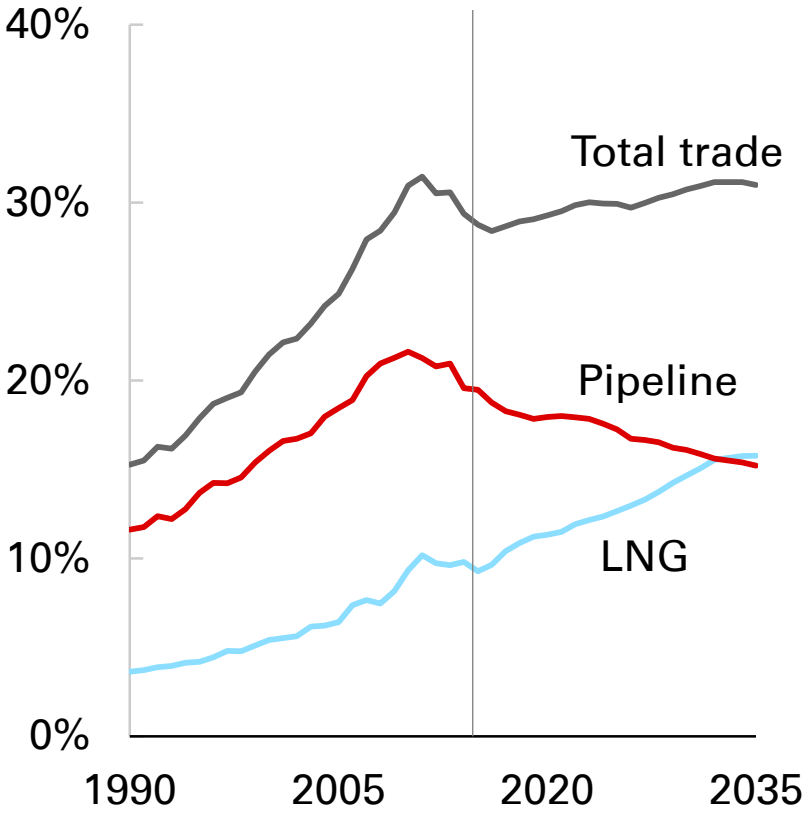


…underpinned by increases in shale gas around the world

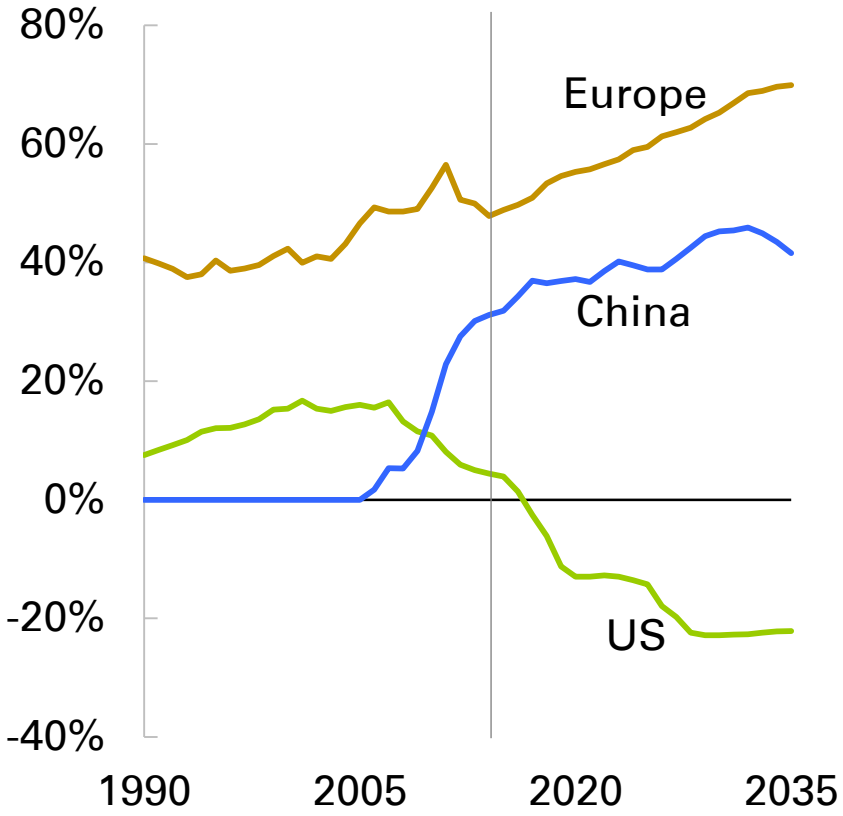
- The increase in global gas supplies is roughly evenly split between increases in conventional production and shale gas.
- Much of the increase in conventional production comes from non-OECD countries, with marked increases in the Middle East, China, and Russia.
- Shale gas grows strongly (5.6% p.a.) throughout the Outlook, with the share of shale gas in total production increasing from just over 10% in 2014 to nearly a quarter by 2035.
- In the first half of the Outlook period, almost all of the growth in shale output stems from the US. Further out, growth in China's shale gas production increases, such that by 2035, China is the largest contributor to growth in shale gas production.

Trade in gas grows broadly in line with global consumption…

Trade as share of global consumption



Imports as share of consumption

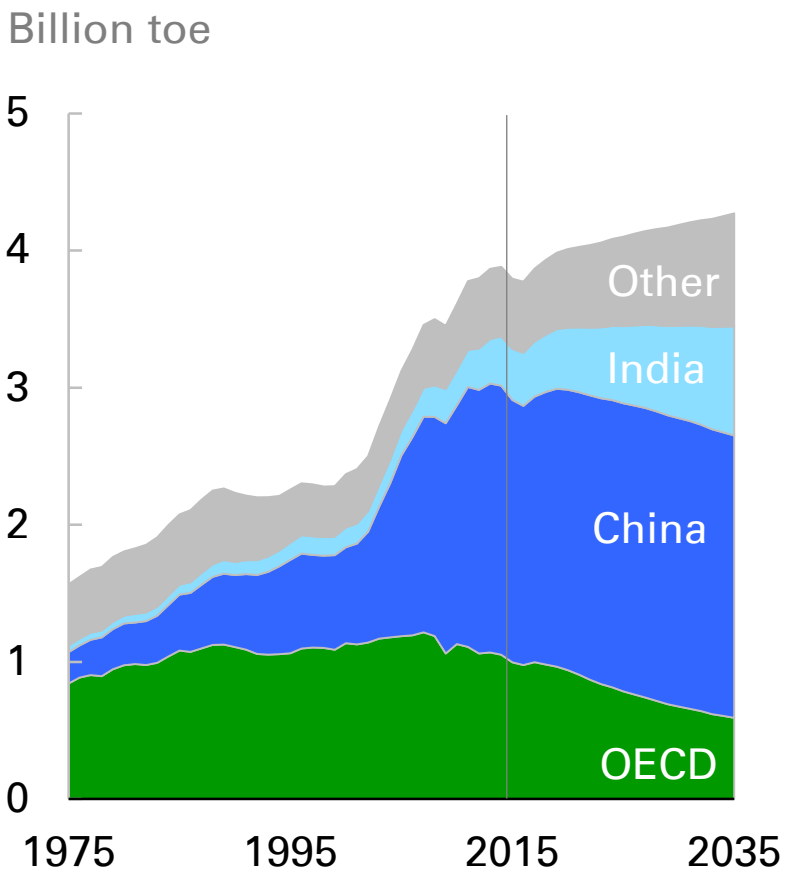


…with LNG playing an increasingly important role

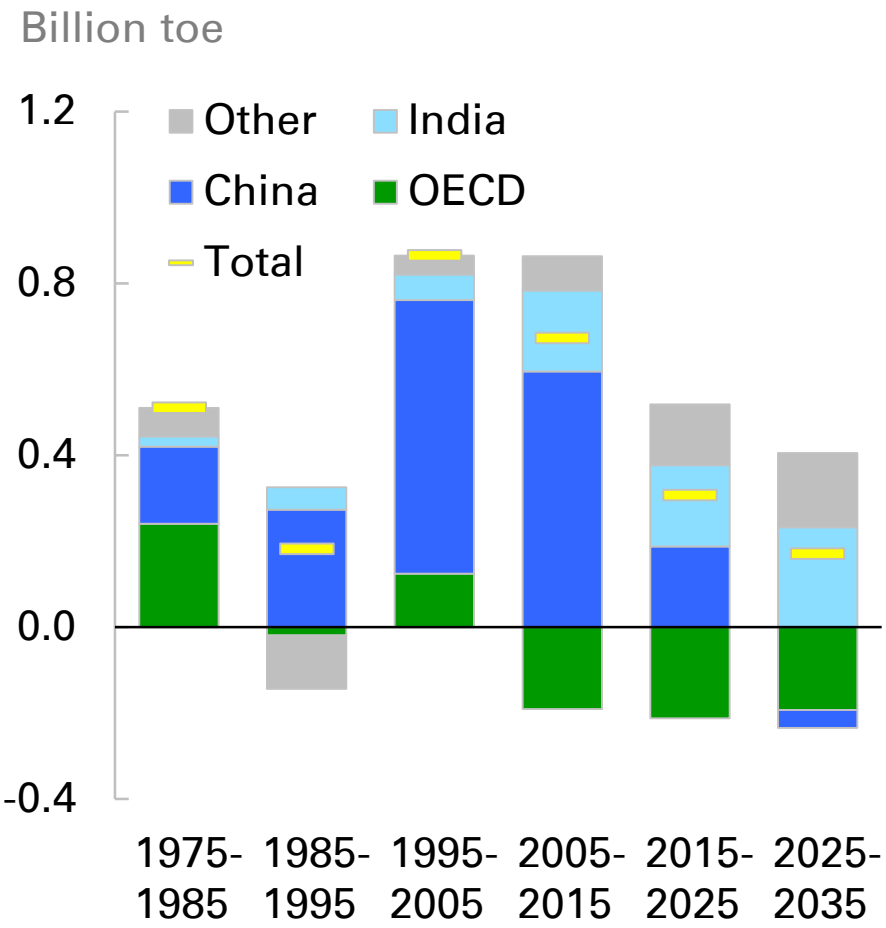
- International trade in gas grows broadly in line with global consumption, such that the global trade share of gas remains around 30%.
- But within that, LNG trade grows twice as fast as consumption, with LNG's share of world demand rising from 10% in 2014 to 15% in 2035.
- Over 40% of the increase in global LNG supplies is expected to occur over the next five years as a series of in-flight projects are completed. This equates to a new LNG train coming on stream every eight weeks for the next five years.
- By 2035, LNG surpasses pipeline imports as the dominant form of traded gas. The growing importance of LNG trade is likely to cause regional gas prices to become increasingly integrated.
- The growth in LNG coincides with a significant shift in the regional pattern of trade. The US is likely to become a net exporter of gas later this decade, while the dependence of Europe and China on imported gas is projected to increase further.

Growth in global coal demand slows sharply…

Coal consumption by region



Ten year increments by region

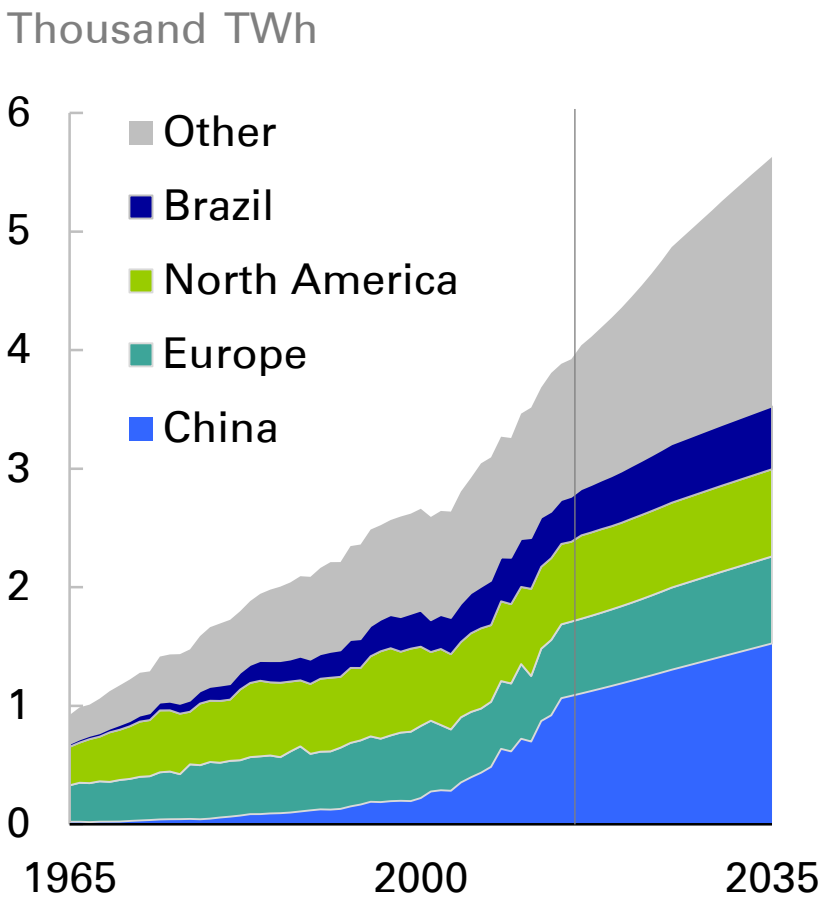


...driven by China's changing energy needs

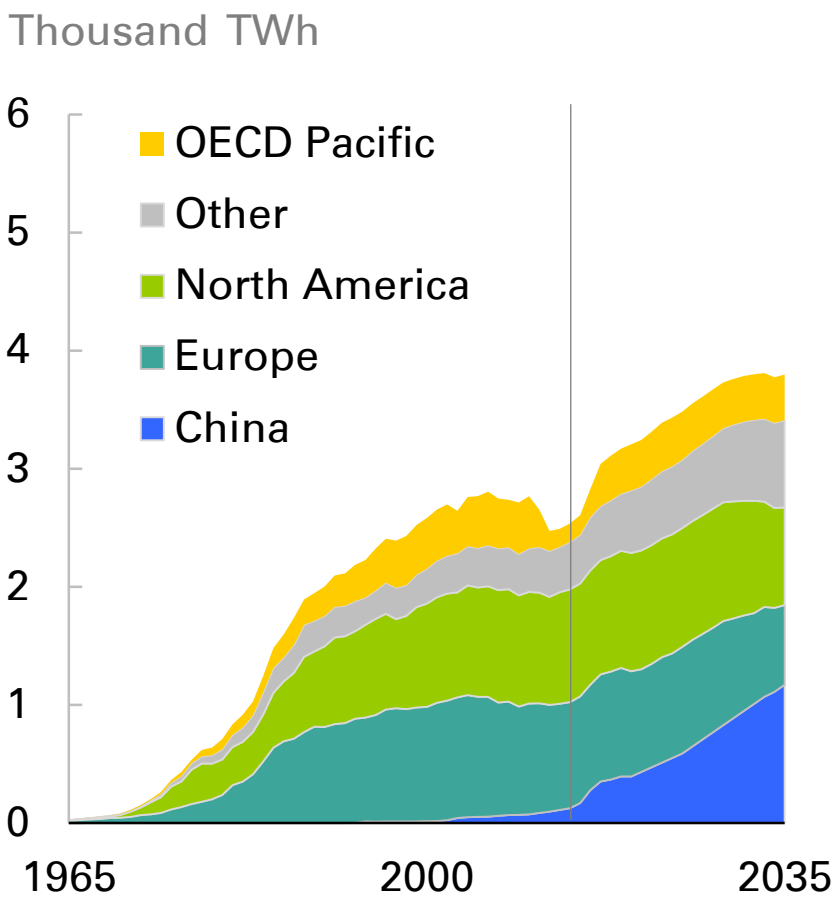
- Growth in global coal demand is expected to slow sharply, growing by just 0.5% p.a. over the Outlook compared with almost 3% p.a. over the past 20 years.
- This slowdown can be largely accounted for by the deceleration in China's coal consumption as its economy rebalances. China's demand for coal grows by just 0.2% p.a. over the Outlook, down from over 8% p.a. during 2000-14, and by 2030 it is in decline.
- Even so, China remains the world's largest coal market, consuming almost half of global coal supplies in 2035. India shows the largest growth in coal consumption (435 Mtoe), overtaking the US to become the world's second biggest consumer of coal. Over two-thirds of India's increased coal demand feeds into the power sector.
- Coal demand is projected to fall by more than 50% in both the US and OECD Europe, driven by plentiful supplies of gas, the falling cost of renewables, and stronger environmental regulation.

Hydro and nuclear generation are set to grow steadily…

Hydro generation by region



Nuclear generation by region

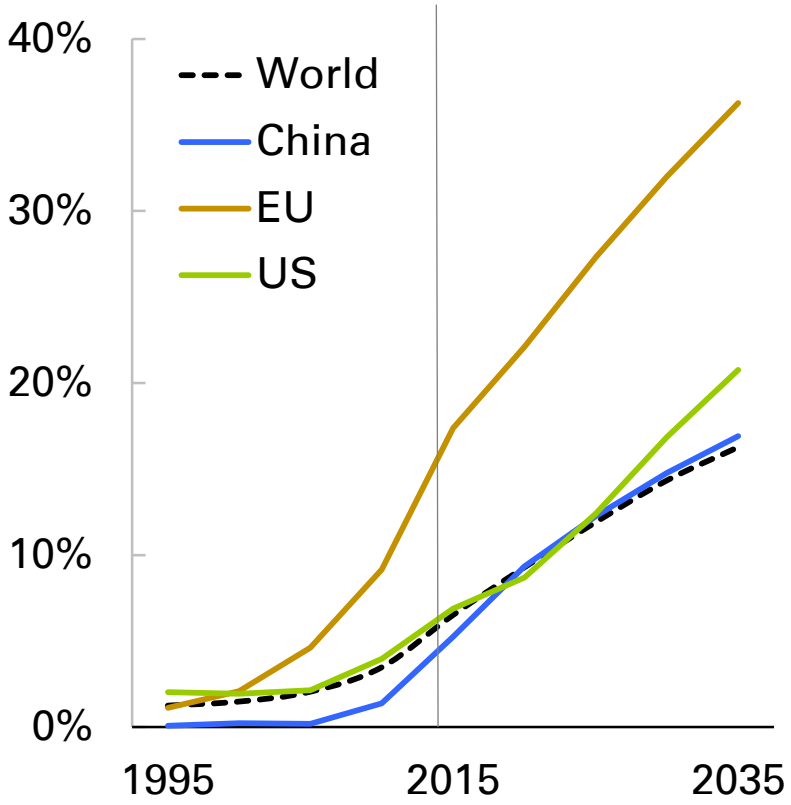


…mostly driven by increases in Asia

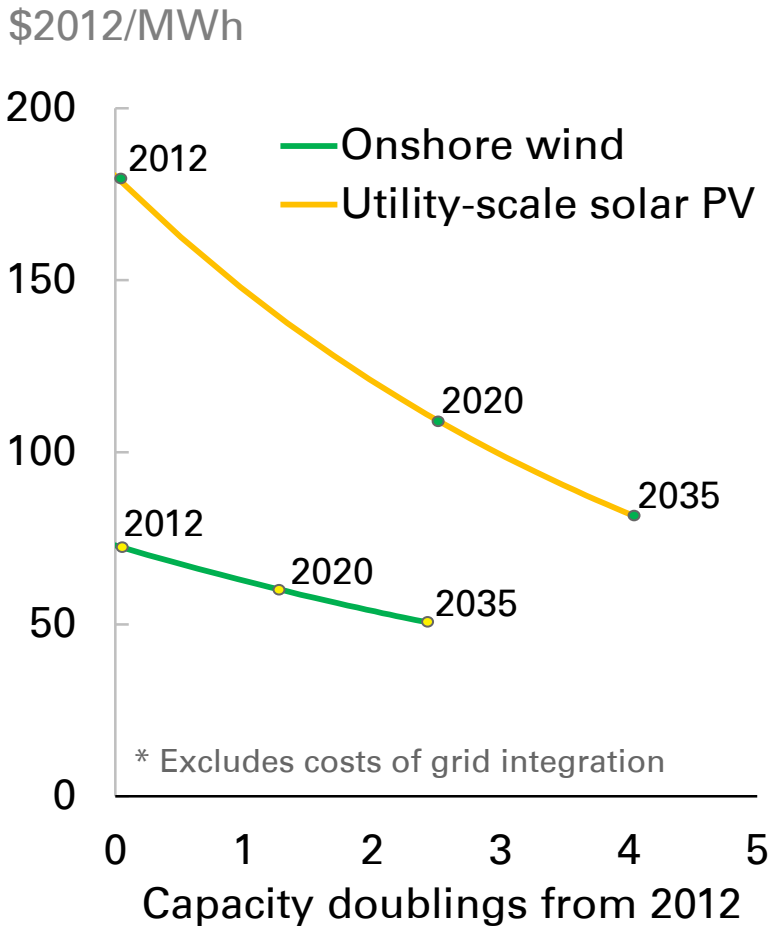
- Both hydroelectric and nuclear energy are projected to increase steadily, growing at 1.8% p.a. and 1.9% p.a. respectively.
- The period of unprecedented growth of hydro in China is coming to an end: China hydro is expected to grow at 1.7% p.a. over the Outlook, compared with almost 10% p.a. over the previous two decades.
- Brazil supplies the second largest increase in hydro power (after China), overtaking Canada to be the world's second largest hydro producer.
- China's nuclear output increases rapidly (11.2% p.a.) over the Outlook – a faster pace of growth than China's hydro power over the past 20 years – more than doubling by 2020 and increasing nine-fold by 2035.
- Nuclear output declines in the EU (-29%) and North America (-13%), as ageing plants are gradually decommissioned and the economic and political challenges of nuclear energy stunt new investments.
- Japanese reactors are expected to restart over the next five years to reach 60% of their 2010 levels by 2020.

Renewables continue to grow rapidly…

Renewables share of power generation



Levelized cost* of electricity in North America



…supported by significant cost reductions

- Renewables are projected to be the fastest growing fuel (6.6% p.a.), almost quadrupling over the Outlook.
- Renewables account for over a third of the growth in power generation, causing their share of global power to increase to 16% by 2035.
- The EU continues to lead the way in the use of renewable power. However, in terms of volume growth to 2035 the EU is surpassed by the US, and China adds more than the EU and US combined.
- By 2035, the penetration of renewables in some OECD markets is expected to reach levels where the challenge of integrating intermittent sources into the power grid becomes an increasing constraint: for example, renewables are expected to account for more than a third of EU power generation by 2035.
- The rapid growth in renewables is supported by the expected pace of cost reductions: the costs of onshore wind and utility-scale solar PV are likely to fall by around 25% and 40% over the next 20 years.

Base case

Key issues

What drives energy demand?

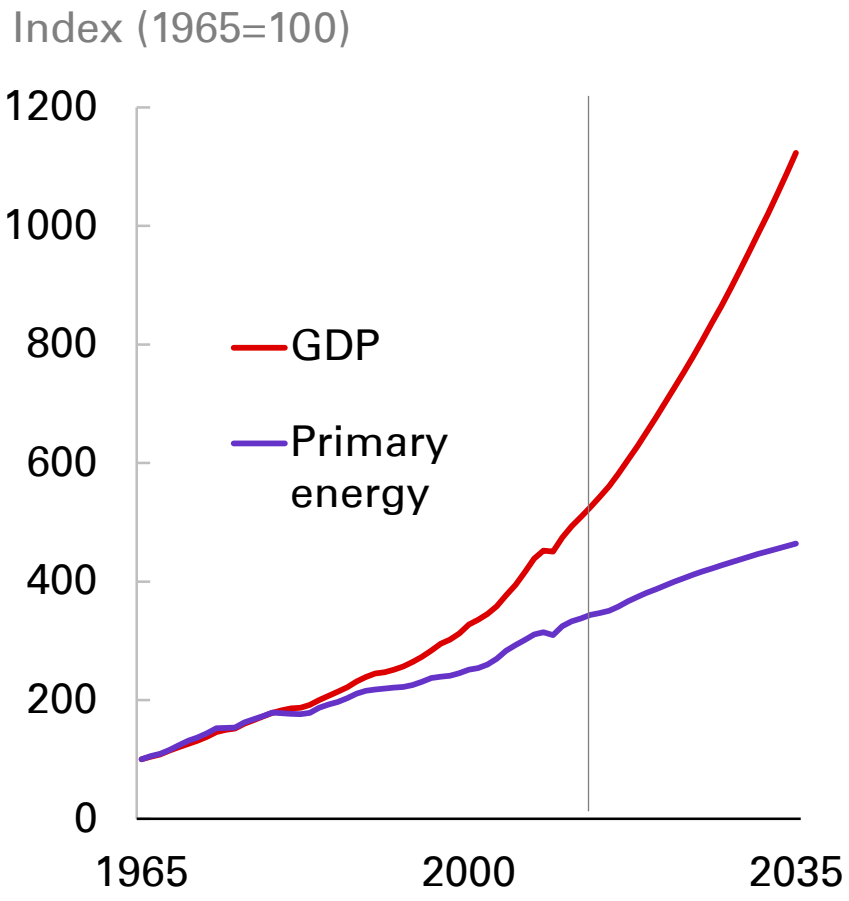
The changing outlook for carbon emissions

What have we learned about US shale?

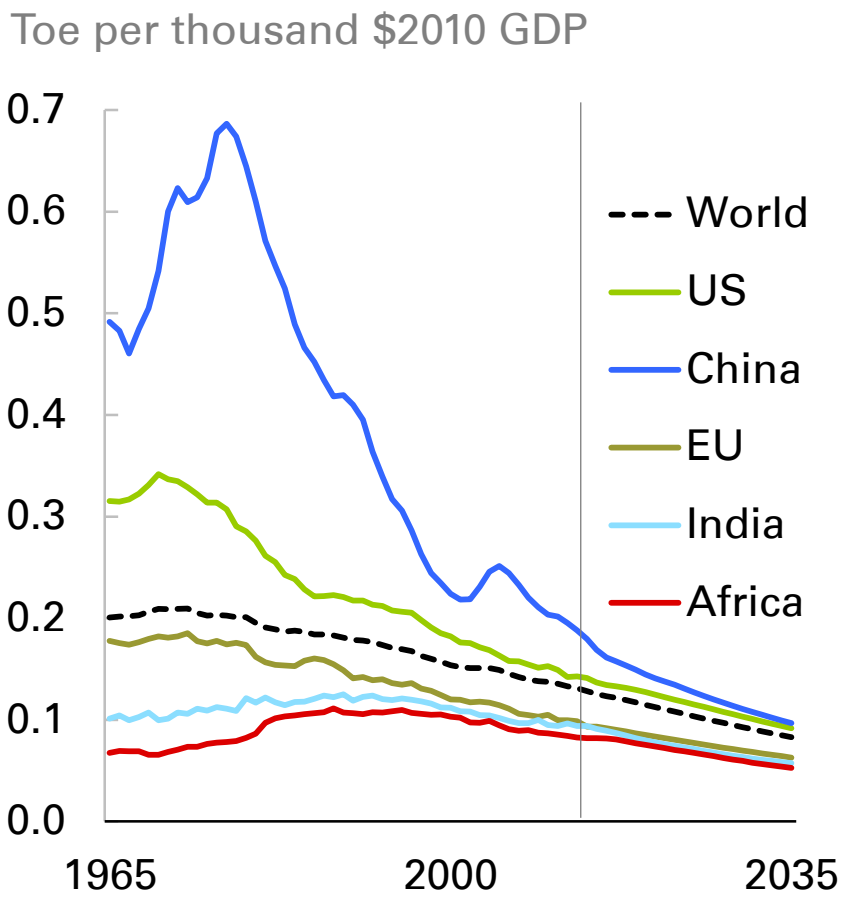
China's changing energy needs

Increases in energy demand are driven by economic growth…

World GDP and energy demand



Energy intensity by region

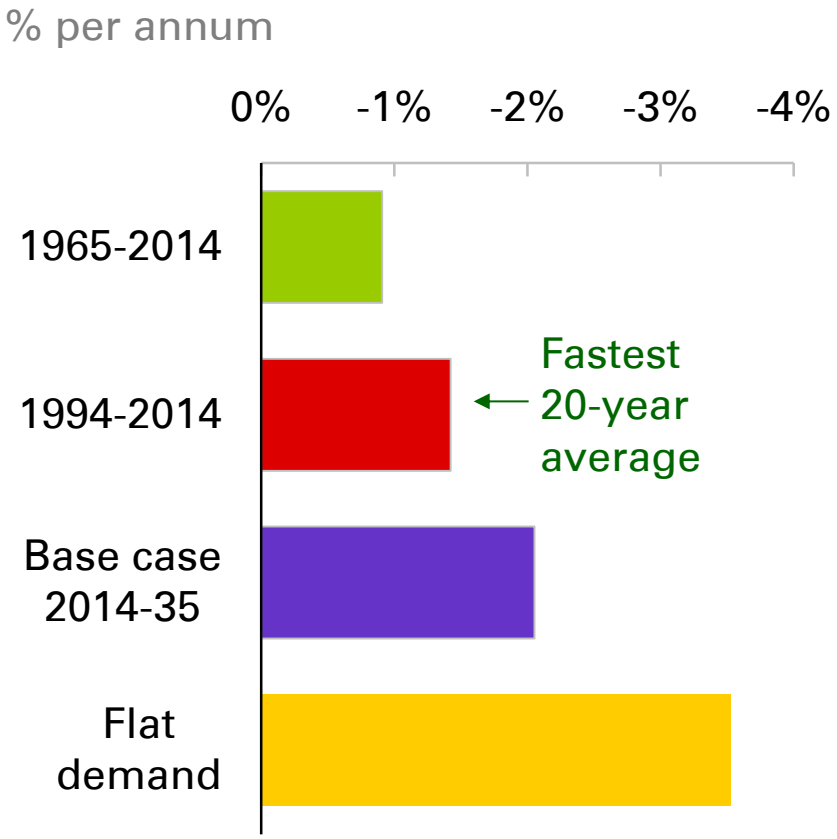


…offset by significant improvements in energy intensity

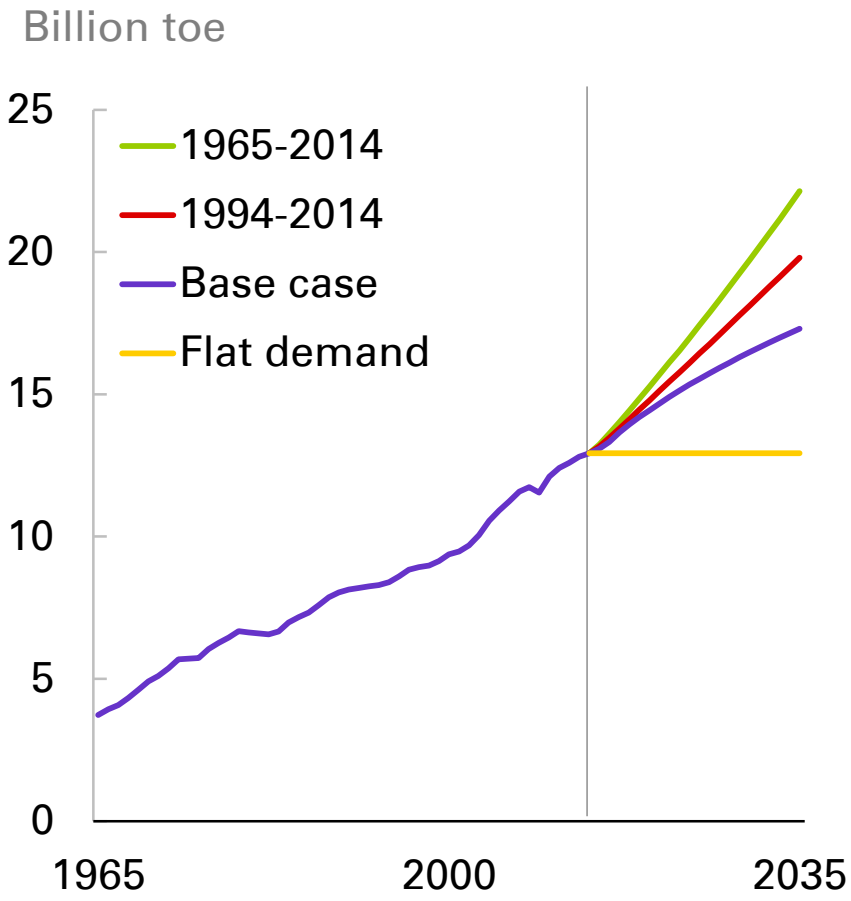
- As the world economy grows, more energy is required to fuel the increased level of activity.
- However, rapid improvements in energy intensity – the amount of energy used per unit of GDP – mean that energy demand grows far less quickly than global GDP: 34% versus 107%.
- Global energy intensity is projected to decline by 2.1% p.a. over the forecast period. This is faster than in any 20-year period in history since our data begins in 1965, and significantly quicker than the 1.5% p.a. average rate of decline seen over the past 20 years.
- OECD energy intensity declines at a faster rate than in the past 20 years, and the growing importance of China means the continuing declines in China's energy intensity have a bigger impact on the global trend.
- The energy intensity of other major non-OECD economies, including India and Africa, is projected to continue falling even as they go through the industrialization phase of their economic development.

Alternative assumptions about energy intensity…

Decline in world energy intensity



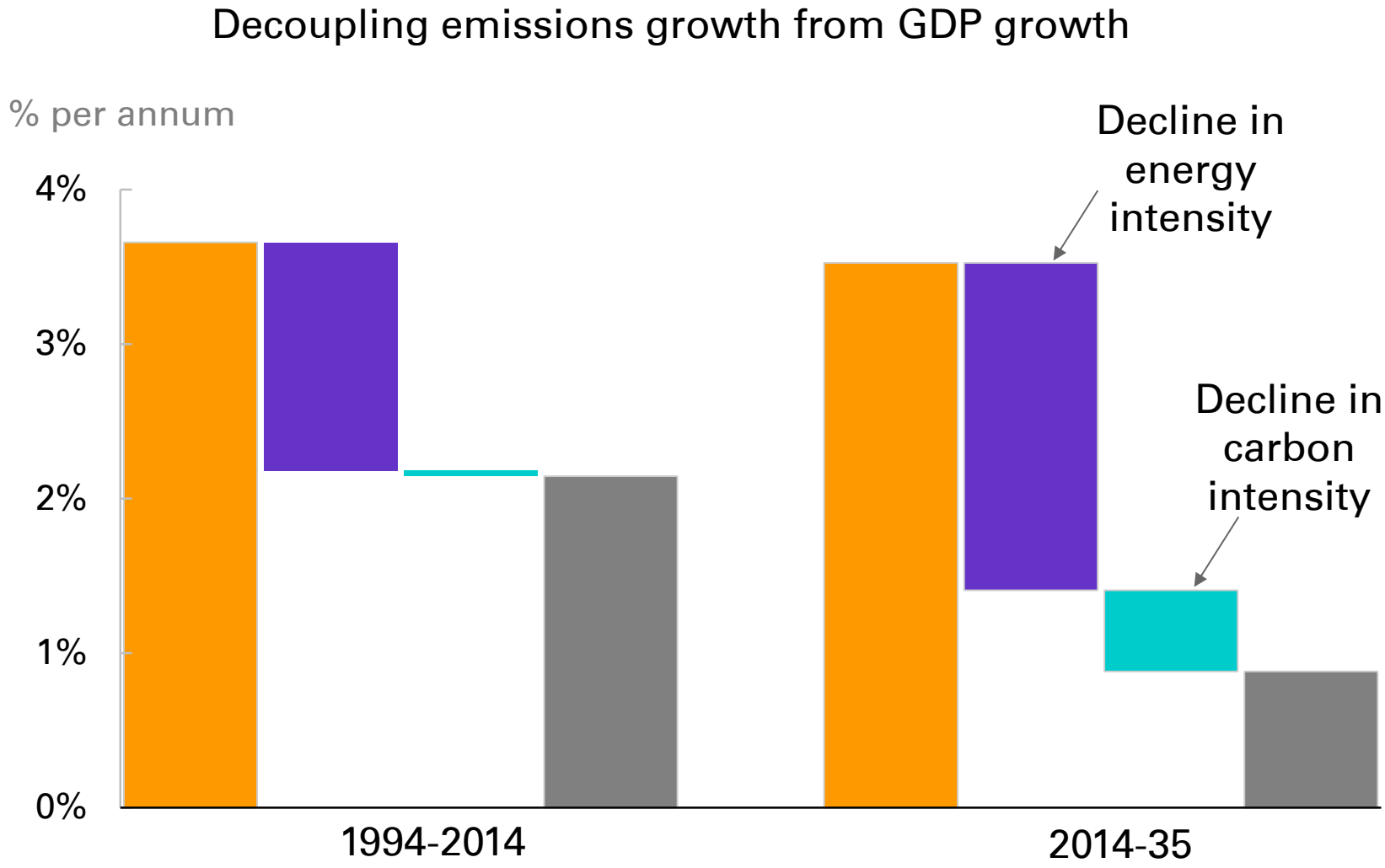
World energy demand



...can have a material impact on prospects for energy demand

- For a given GDP growth path, alternative assumptions about energy intensity can imply very different profiles for energy demand.
- For example, if energy intensity declined at its average rate over the past 50 years (-0.9% p.a.), growth in energy demand by 2035 would be around double that in the base case (71% versus 34%).
- Alternatively, if energy intensity declined at the fastest rate seen in any 20 year period since 1965 (1994-2014, -1.4% p.a.), the growth in energy demand to 2035 would be nearly 60% more than in the base case.
- In order for energy demand not to grow at all over the Outlook period ('flat demand'), energy intensity would need to decline on average by 3.5% p.a..This is far faster than any 20-year rate of decline experienced since at least 1965 (and probably far longer) and more than double the average rate of decline seen over the past 20 years.

The growth rate of carbon emissions more than halves…

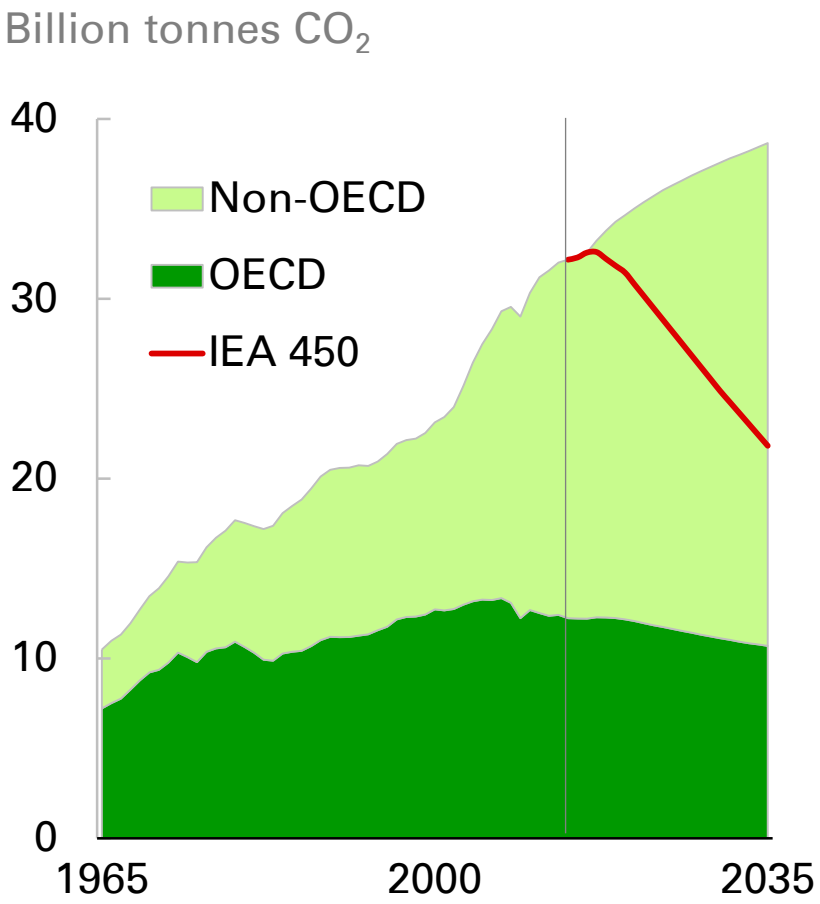


…driven by faster efficiency gains and the changing fuel mix

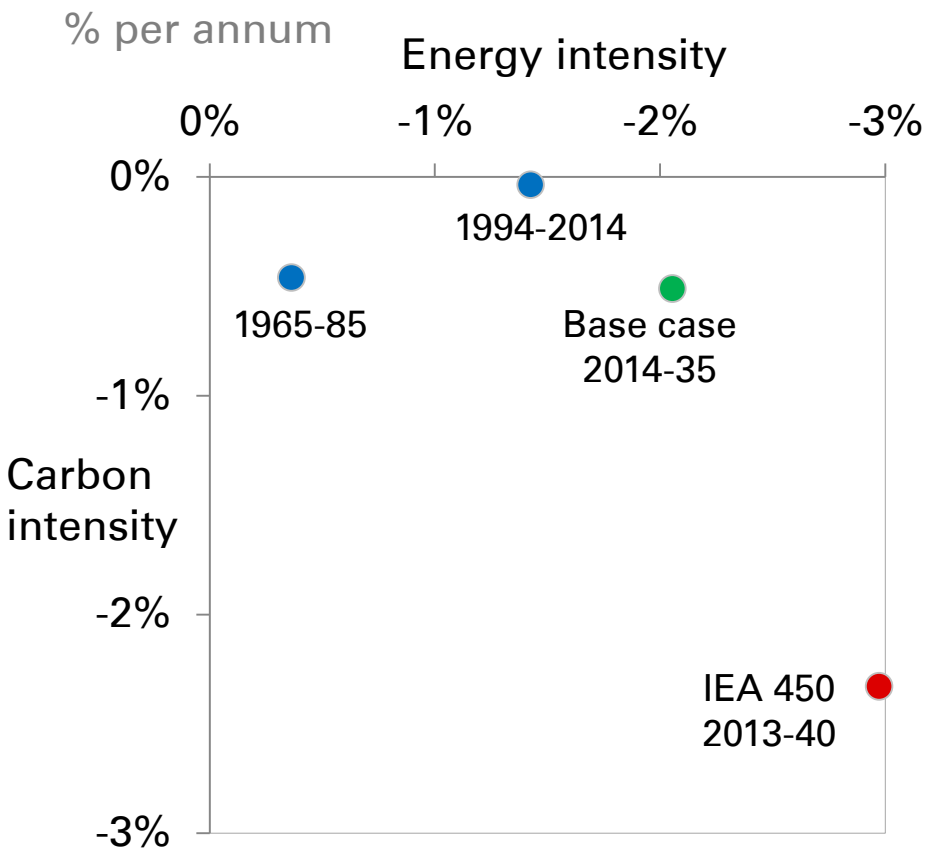
- The growth rate of carbon emissions over the Outlook is expected to more than halve relative to the past 20 years: 0.9% p.a. versus 2.1% p.a..
- Given that GDP is projected to grow only slightly slower than the historical trend, this represents a significant degree of 'decoupling' of carbon emissions from GDP.
- This decoupling reflects significant increases in the expected pace of decline of both energy intensity (energy used per unit of GDP) and carbon intensity (carbon emissions per unit of energy consumption).
- The world is embarking on a transition to a lower-carbon energy system. The pledges made by participating countries in their Intended Nationally Determined Contributions (INDCs) ahead of the COP21 meeting in Paris, and the level of agreement reached in Paris, have increased our confidence that the world will achieve this break from past trends.
- The potential impact of an even sharper break with history, and a faster transition to a lower carbon world, is explored in the alternative case described later (pages 78-81).

But carbon emissions continue to rise…

Carbon emissions



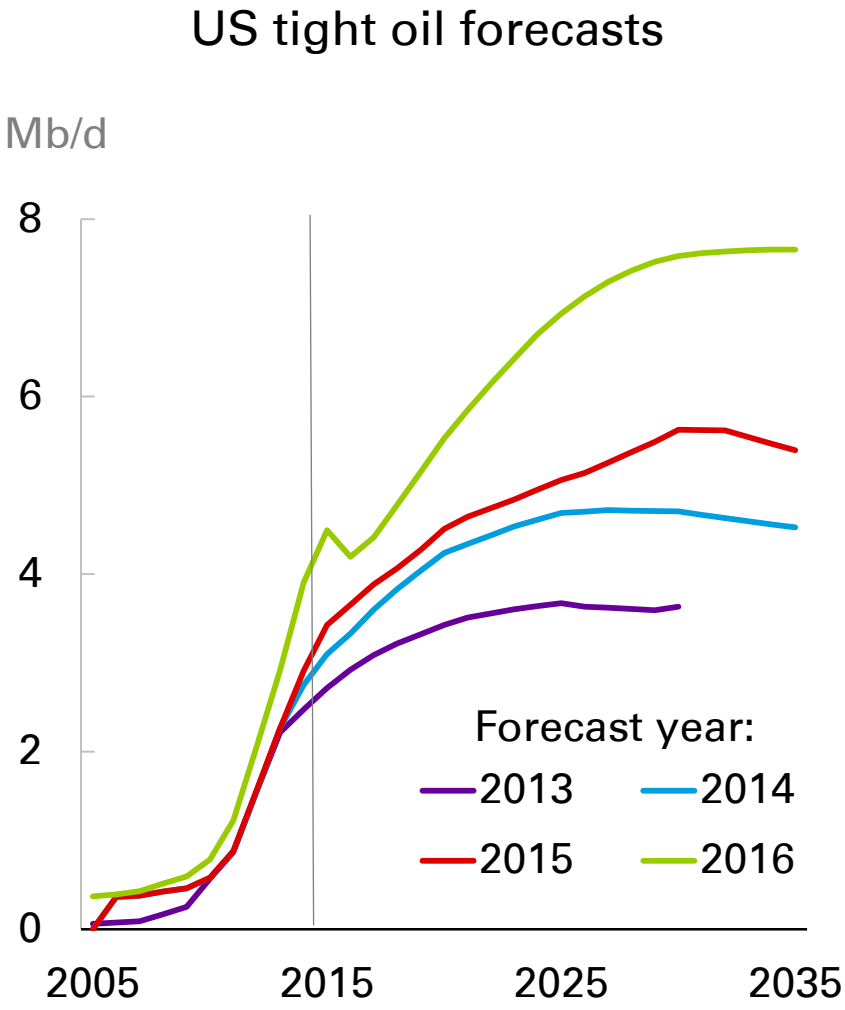
Changes in intensity

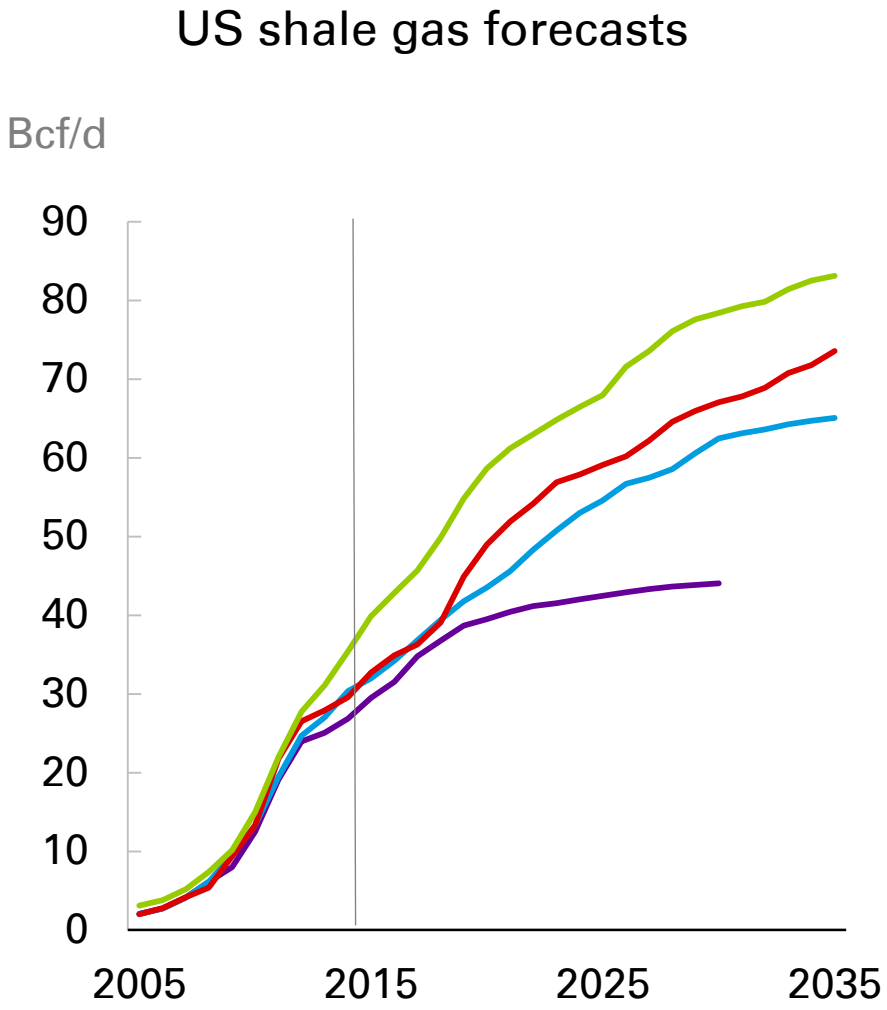


…creating pressure for more policy action

- Despite the slowdown in emissions growth, the level of carbon emissions continues to grow, increasing by 20% between 2014 and 2035.
- The widening gap between the projected path for emissions and, for example, the IEA's 450 Scenario illustrates the remaining challenge, despite the expected reduction in the growth of carbon emissions.
- Our base case already has global energy intensity declining at an unprecedented pace, and a fall in carbon intensity that matches what the world achieved 1965-85, when first cheap oil displaced coal from the fuel mix and then nuclear displaced both oil and coal.
- For the given projected path of GDP, achieving anything close to the IEA's 450 Scenario by 2035 would require an unprecedented pace of improvement in both global energy intensity and carbon intensity.
- A meaningful global price for carbon is likely to be the most efficient mechanism through which to achieve these improvements.

The outlook for US shale has been revised up repeatedly…



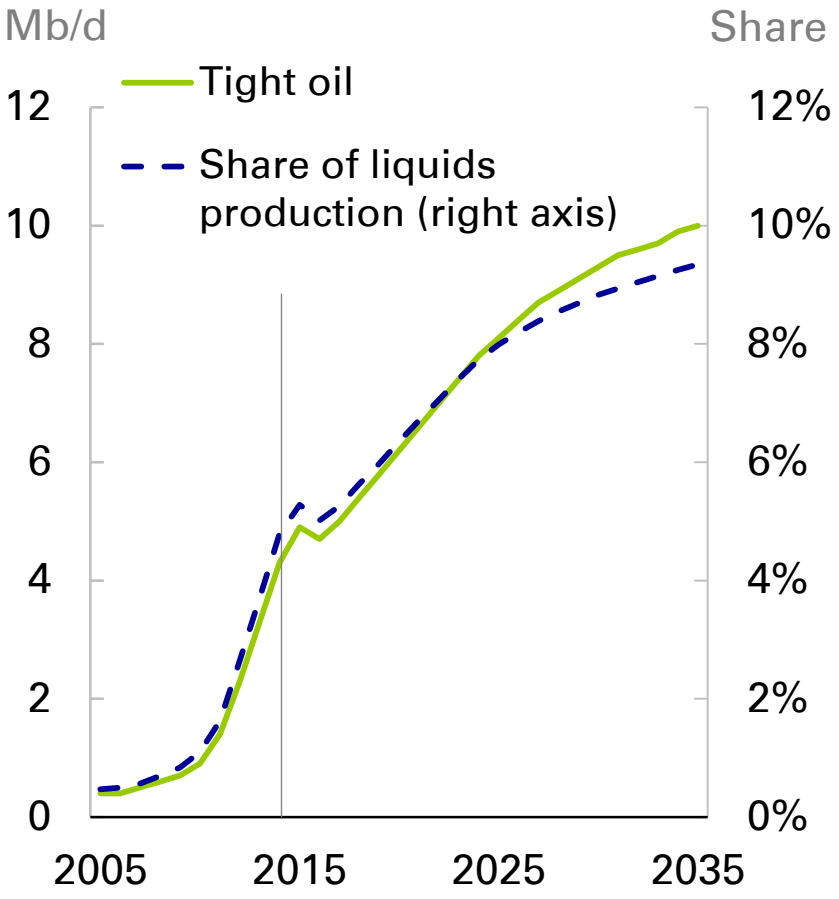


…as technology and productivity gains unlock new resources

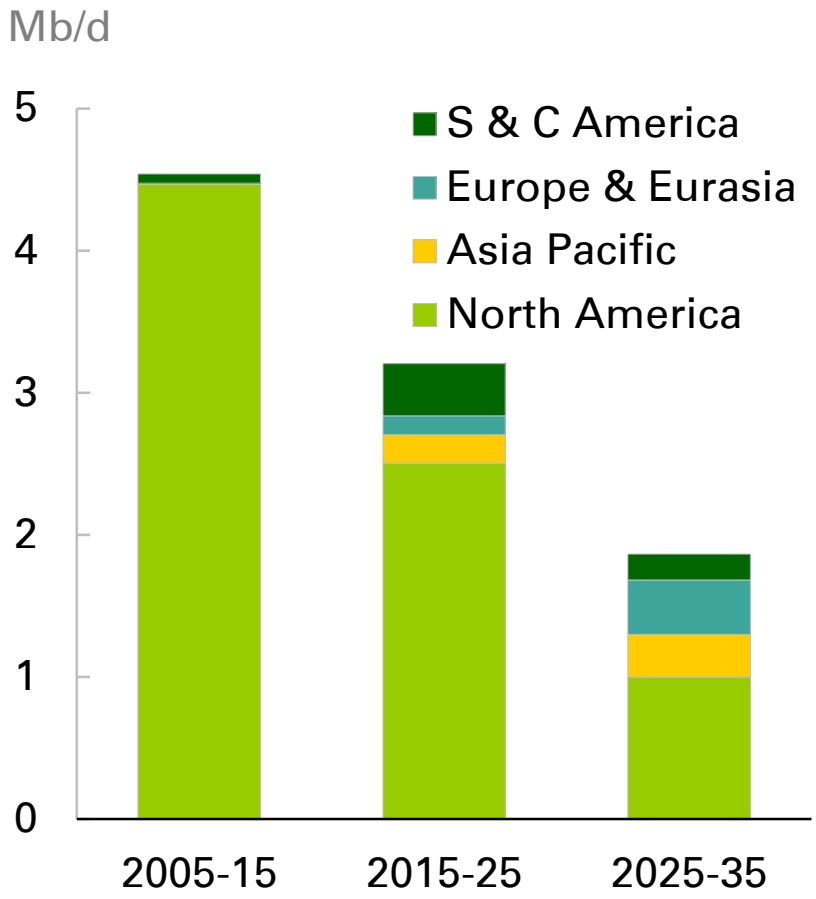
- We have been repeatedly surprised by the strength of US tight oil and shale gas. Technological innovation and productivity gains have unlocked vast resources of tight oil and shale gas, causing us to revise the outlook for US production successively higher.
- In the 2013 Energy Outlook, US tight oil was projected to reach 3.6 Mb/d by 2030 – that level was surpassed in 2014. After a brief retrenchment due to low prices and falling investment, US tight oil production is now expected to plateau in the 2030s at nearly 8 Mb/d, accounting for almost 40% of total US oil production.
- US shale gas is expected to grow by around 4% p.a. over the Outlook. This causes US shale gas to account for around three-quarters of total US gas production in 2035 and almost 20% of global output.
- The past surprises in the strength of the shale revolution underline the considerable uncertainty concerning its future growth. This uncertainty is explored later in an alternative case (pages 82-85).

The global growth in tight oil slows…

Global tight oil production



Ten year increments by region

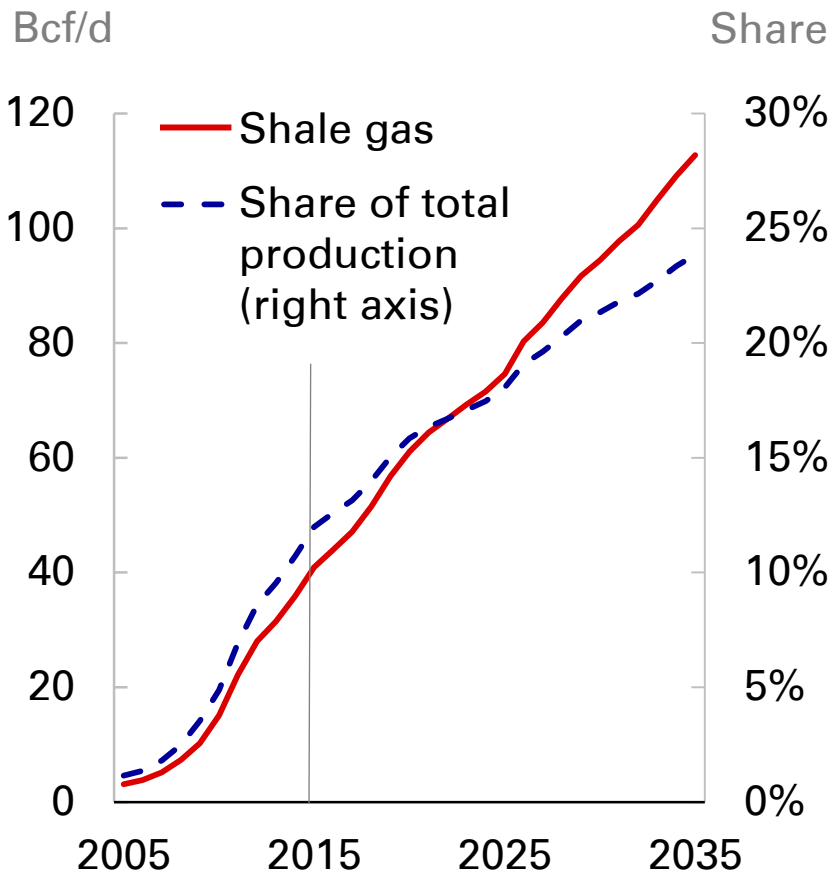


...as North American growth gradually moderates

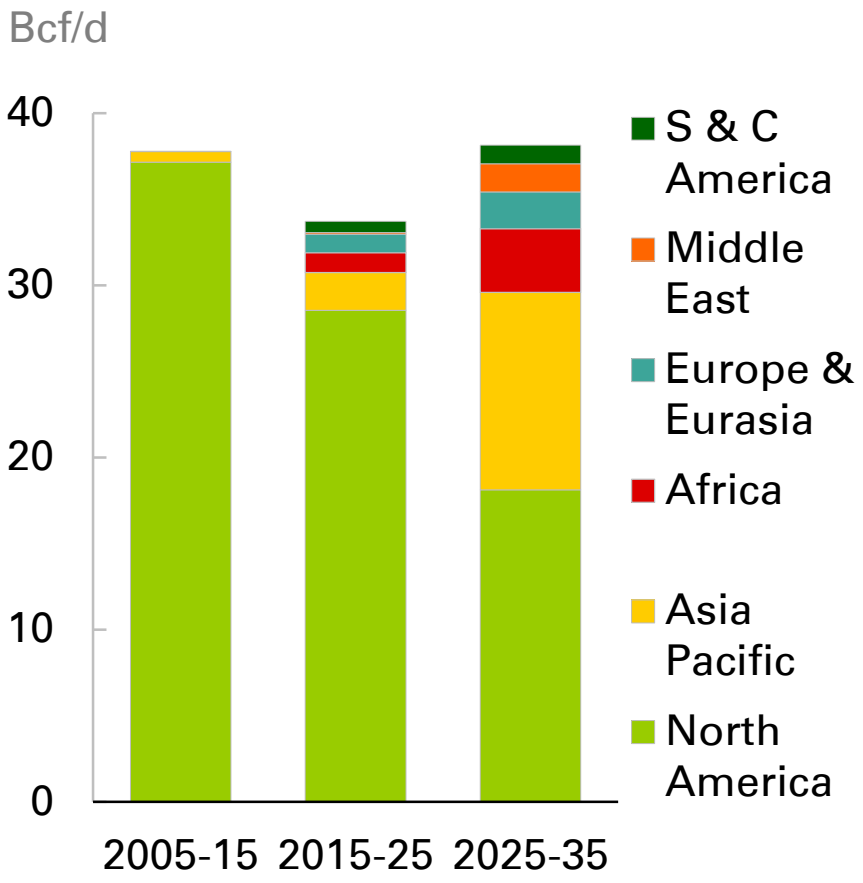
- Global tight oil production increases by 5.7 Mb/d over the Outlook to around 10 Mb/d. Despite this sizeable growth, tight oil accounts for less than 10% of all liquids production in 2035.
- Growth in North American tight oil – which has been the dominant source of growth over the past 10 years – slows gradually over the Outlook period, constrained by the size of the resource base.
- North American production is expected to grow by 2.5 Mb/d between 2015-25, and by just 1 Mb/d between 2025-35, compared with 4.5 Mb/d during the past 10 years.
- This slowing is partially offset by increased production in the rest of the world. During the final ten years of the Outlook, almost half (0.9 Mb/d) of the increase in tight oil production is from outside North America.

Shale gas production continues to expand rapidly…

Global shale gas production



Ten year increments by region

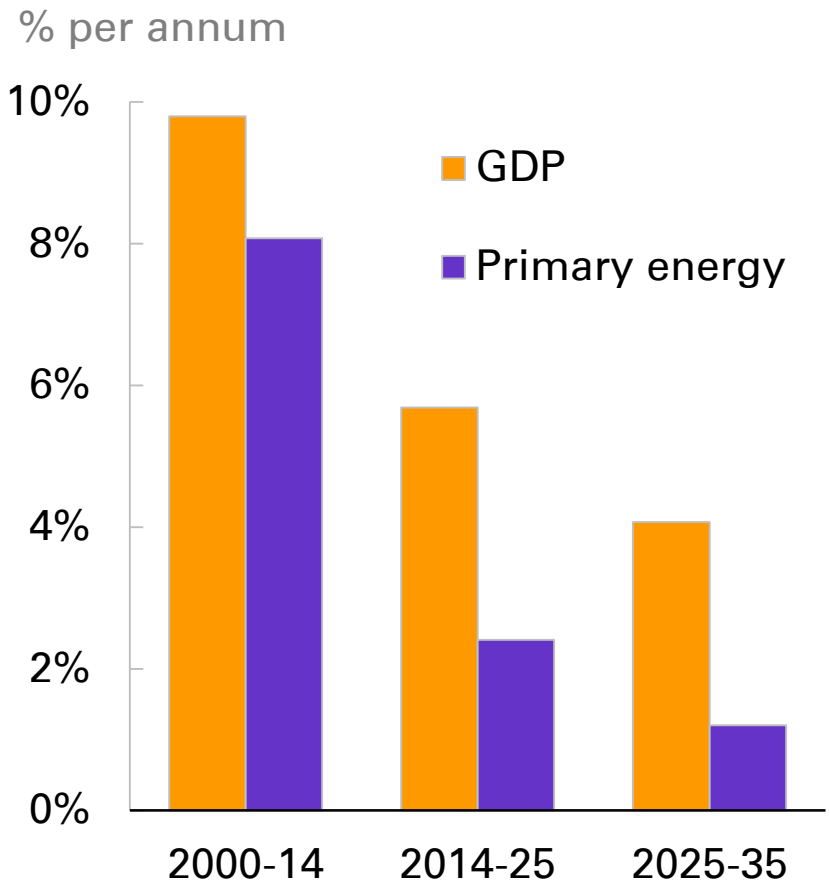


…helped by increasing production outside North America

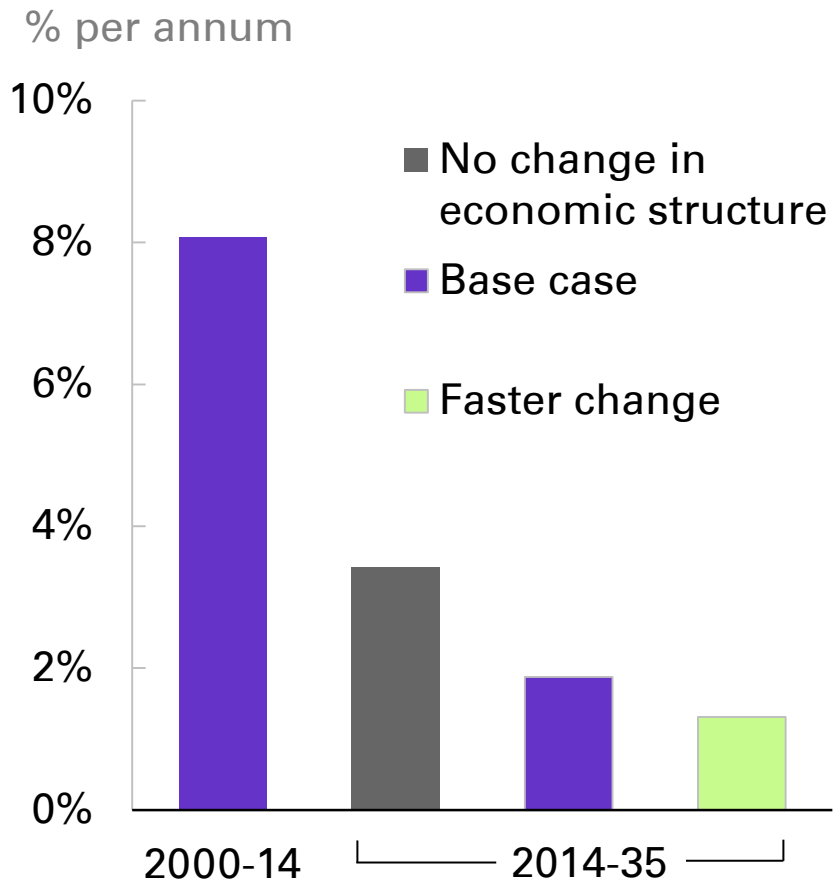
- Global shale gas is expected to grow by 5.6% p.a. over the Outlook, well in excess of the growth of total gas production. As a result, the share of shale gas in global gas production more than doubles, from 11% in 2014 to 24% by 2035.
- The growth of shale gas supply is dominated by North American production – as it has been for the past decade – which accounts for around two-thirds of the increase in global shale gas supplies.
- But over the Outlook period, we expect shale gas to expand outside North America, most notably in Asia Pacific and particularly in China, where shale gas production reaches 13 Bcf/d by 2035.
- In the last 10 years of the Outlook, around half of the increase in shale gas supplies comes from outside North America, with the Asia Pacific region accounting for over 10% of global shale gas production by 2035.

China's energy needs are changing…

GDP and primary energy growth



Primary energy growth and changing economic structure

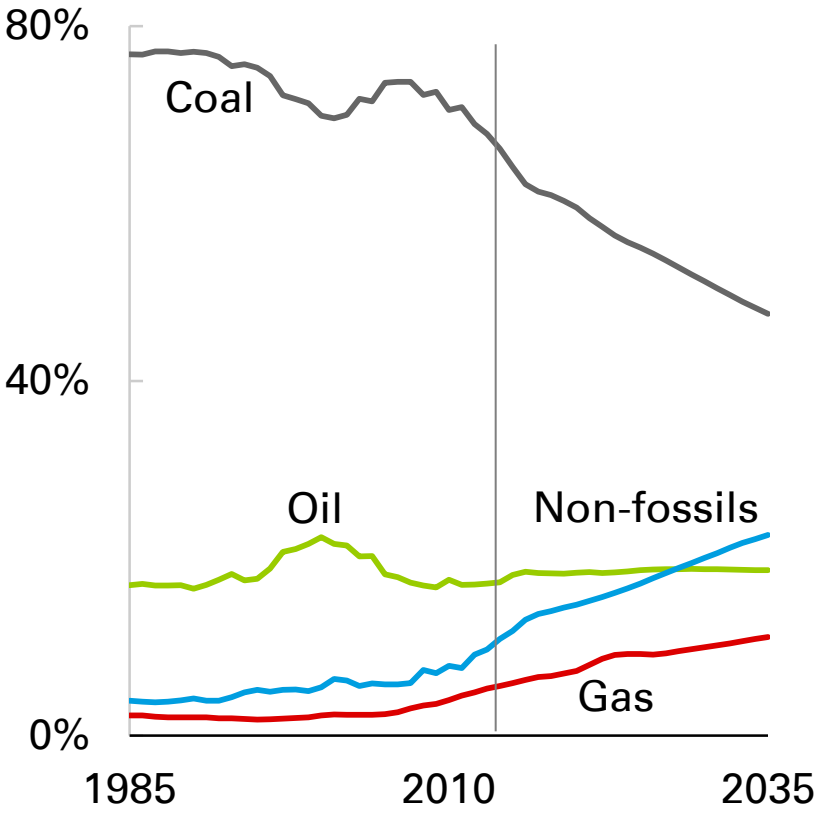


...as it adjusts to a more sustainable path

- China is the world's largest consumer of energy and has been the most important source of growth for global energy demand over the past 20 years. But China's energy needs are changing.
- China's demand for energy is expected to grow by less than 2% p.a. over the Outlook, far slower than the 8% p.a. seen since 2000.
- Part of this reduction is driven by slower economic growth: annual GDP growth is projected to average close to 5% over 2014-35, around half the average pace of growth since 2000.
- But China's energy demand growth slows by more than its GDP growth. In part this reflects improvements in energy efficiency, and in part the changing pattern of economic growth; with growth becoming less dependent on highly energy-intensive industrial sectors.
- The extent of the shift in China's economic structure will have a major bearing on China's future energy needs. If there is little change, energy demand might be stronger. But a bigger change, say to something akin to the US economy by 2035, might lead to weaker energy demand.

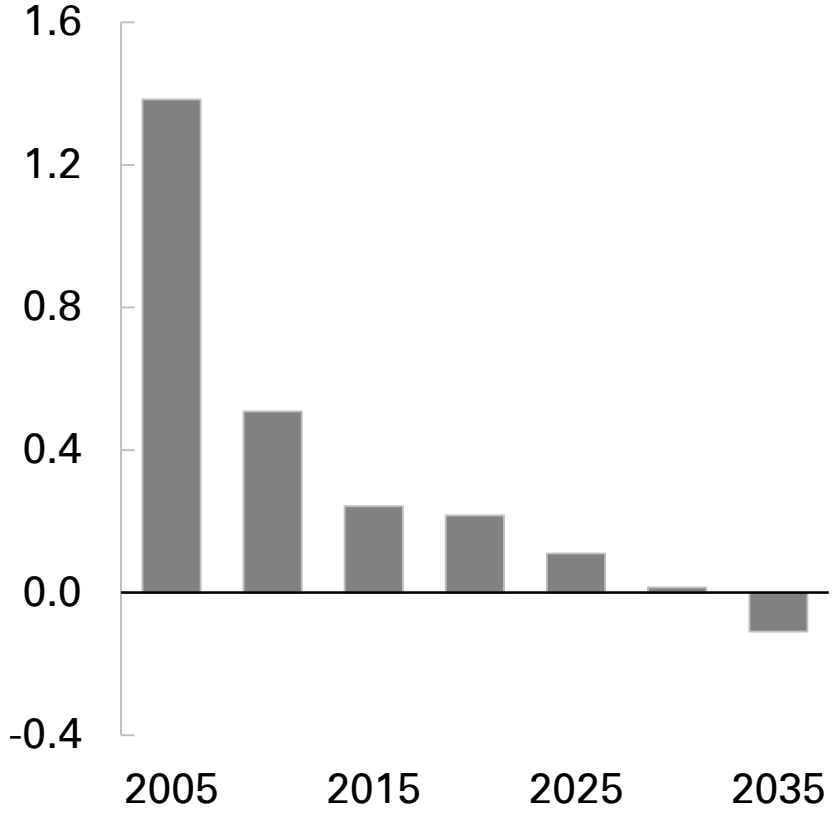
China's fuel mix is also likely to change significantly…

Shares of primary energy in China



Ratio of coal demand growth to GDP growth

Average ratio during previous five years



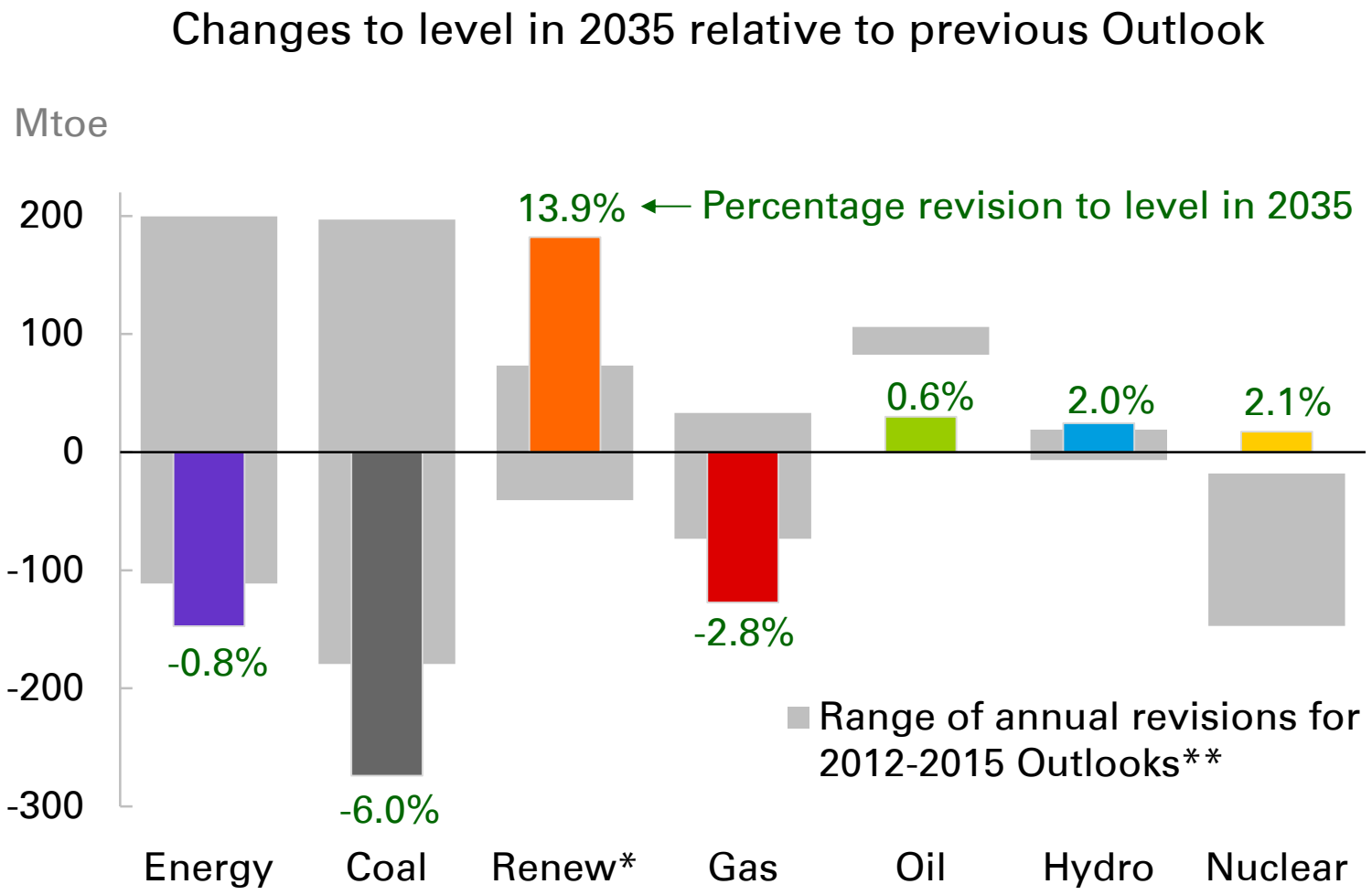
…as China reduces its reliance on coal

- China's fuel mix is also likely to change significantly, driven by its changing economic structure and environmental and climate policies.
- In particular, China reduces its reliance on coal, with the importance of coal in fuelling economic growth falling sharply: by the last five years of the Outlook coal demand falls while the economy still grows.
- Coal consumption grows by just 0.2% p.a. over the whole Outlook period, and coal's share of primary energy falls from around two-thirds in 2014 (and over 85% in 1965) to a little less than half by 2035.
- This plateauing in China's coal demand reflects a combination of: slower energy demand growth; the economy becoming less dependent on coal-intensive sectors; and policies encouraging the use of alternative fuels.
- The use of non-fossil fuels and gas are both expected to increase rapidly, with their combined share in China's energy mix more than doubling, from just over 15% today to around a third by 2035.

Base case

Main changes

Energy demand in 2035 has been revised down…



* Renewables including biofuels

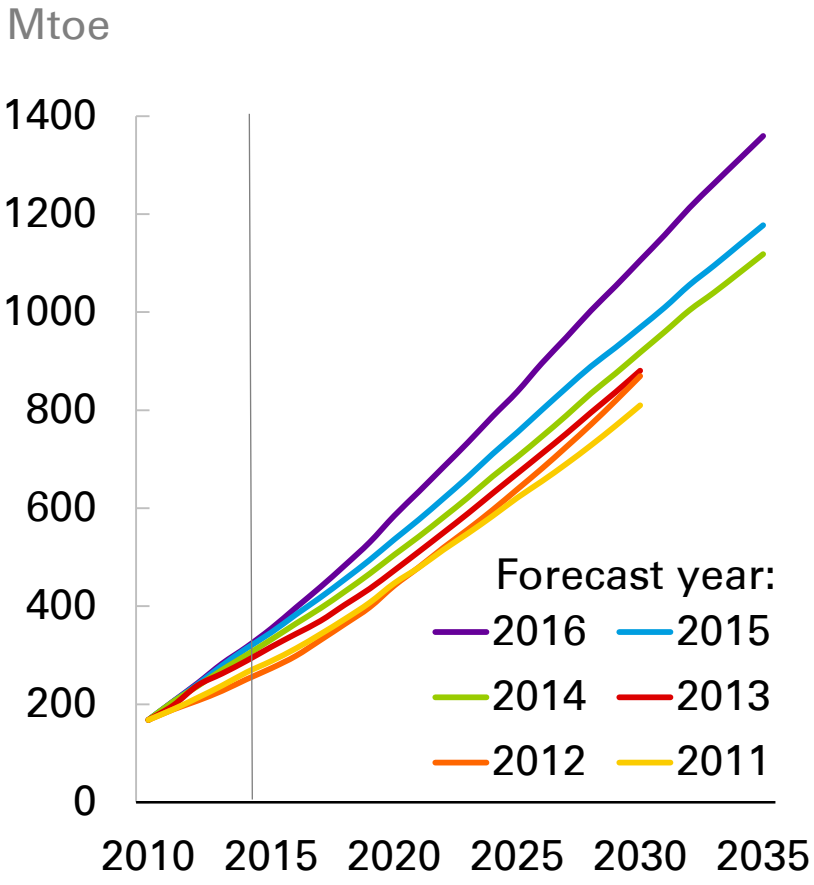
** Revision in final year of Outlook

…due to increased energy efficiency

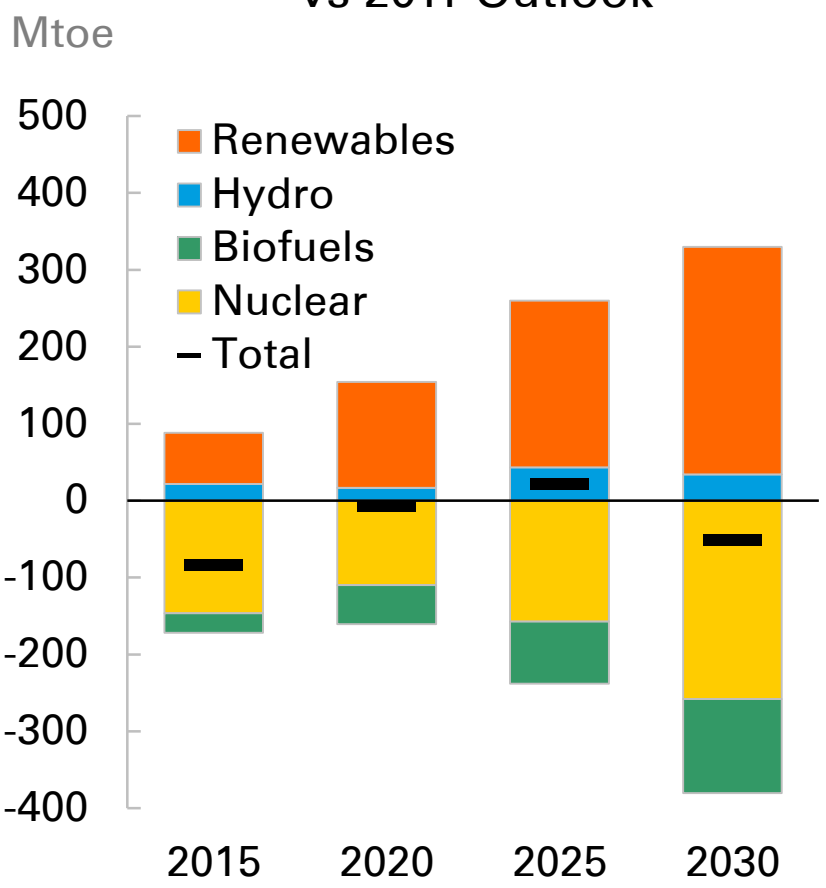
- Energy demand in 2035 has been revised down by nearly 1% (-150 Mtoe) relative to the 2015 Outlook. Compared with previous Outlooks, this represents a relatively large revision to energy demand, reflecting the judgement that energy intensity is likely to decline faster than previously thought, helped by the agreements reached at Paris COP21.
- The large downward revision to coal demand by 2035 (-6%, -270 Mtoe) reflects both a lower expected profile for Chinese economic growth, and environmental and climate policies encouraging a faster switch to lower carbon fuels.
- Renewables have been revised up by 14% (180 Mtoe) – the largest revision in percentage terms – driven by faster-than-expected cost reductions, particularly for solar, and the anticipation of more supportive environmental policy.
- Gas demand is almost 3% lower than in the 2015 Outlook (-130 Mtoe), with downward revisions in both China (-50 Mtoe) and the EU (-37 Mtoe).

Renewables have been revised up repeatedly...

Renewable power forecasts



Revisions to non-fossil fuels vs 2011 Outlook



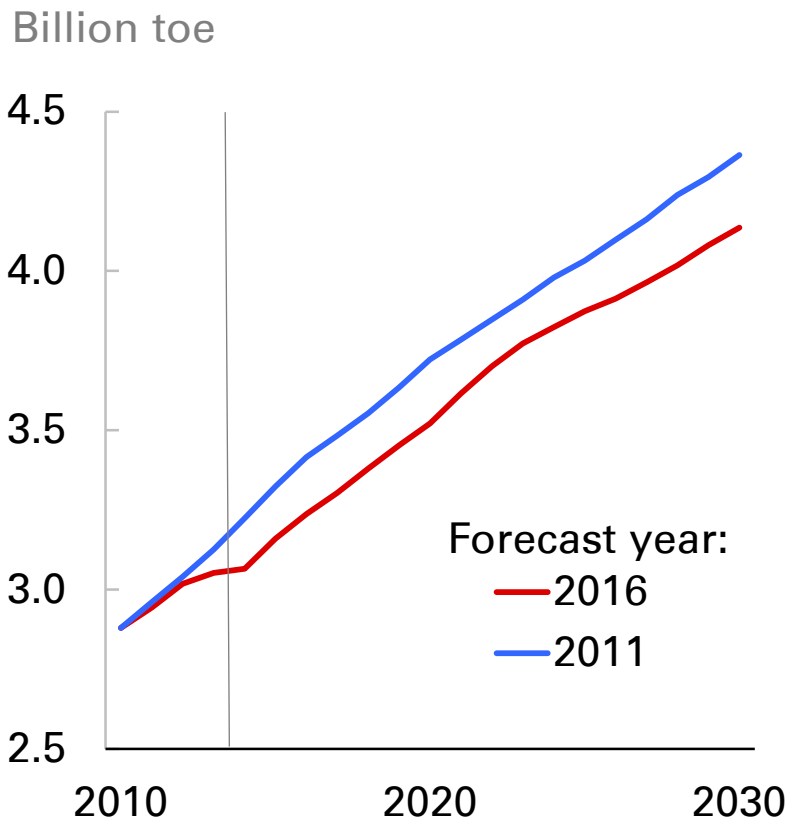
Note: Projected growth from each Outlook applied to latest 2010 data

…while other non-fossil fuels have been revised down

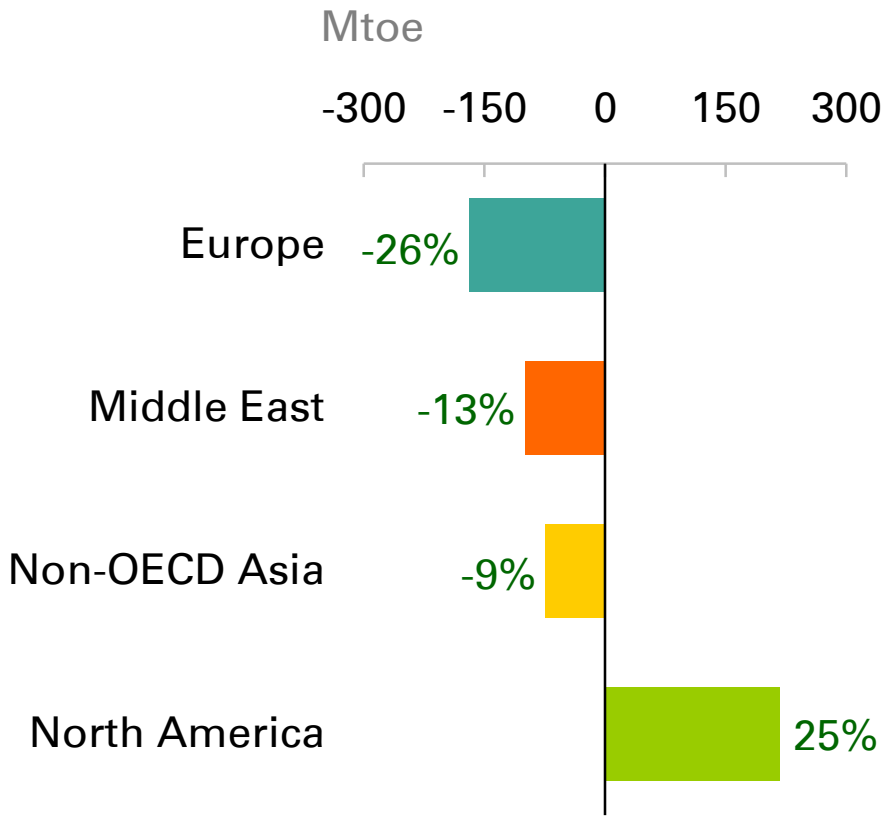
- Renewable power has been revised up every year for the past five years: renewables in 2030 are projected to be around 35% higher than expected in 2011. The upward revision in this year's Outlook is the largest to date.
- These upward revisions reflect both higher-than-forecast outturns in recent years, and our increasing confidence in future growth. Faster-than-expected cost reductions, more rapid deployment (particularly in the non-OECD), and widening policy support have all contributed to the reassessment of future growth prospects.
- Despite these upward revisions to renewable power, the expected level of total non-fossil fuels in 2030 is actually a little lower than in the 2011 Outlook, reflecting weaker prospects for nuclear energy and biofuels.
- The downward revision to nuclear energy followed the Fukushima accident, as many countries scaled back their planned use of nuclear energy. The lower profile for biofuels reflects both slower-than-expected technological progress on advanced biofuels and weaker adoption in transport fuel.

Gas demand growth has been weaker than expected…

Gas consumption forecasts



Key revisions in 2030 by region (relative to 2011 Outlook)



Note: Projected growth applied to latest 2010 data

…but this weakness is not expected to persist

- The growth of gas consumption has been weaker than expected in recent years, as gas has been crowded out by cheaper and more abundant coal and, in Europe, also by the rapid growth in renewables.
- As a result, gas consumption in 2030 is expected to be around 5% lower than in the 2011 Outlook (-230 Mtoe), with significant downward revisions to gas demand in Europe, the Middle East, and non-OECD Asia.
- But this recent weakness in the growth of gas is not expected to persist, with global gas demand projected to grow at 1.8% p.a. over 2015-30, similar to the 2011 Outlook.
- The judgement that the recent weakness in gas consumption will not persist is based on the view that strong supply growth, particularly of US shale gas and LNG, combined with stronger environmental policies, will allow gas to compete against coal in Europe and Asia, as well as in North America.

Key uncertainties

Slower global GDP growth

Faster transition to a lower-carbon world

Shale oil and gas have even greater potential

Exploring the impact of alternative assumptions…

Case 1: Slower global GDP growth

Case 2: Faster transition to a lower-carbon world

Case 3: Shale oil and gas have even greater potential

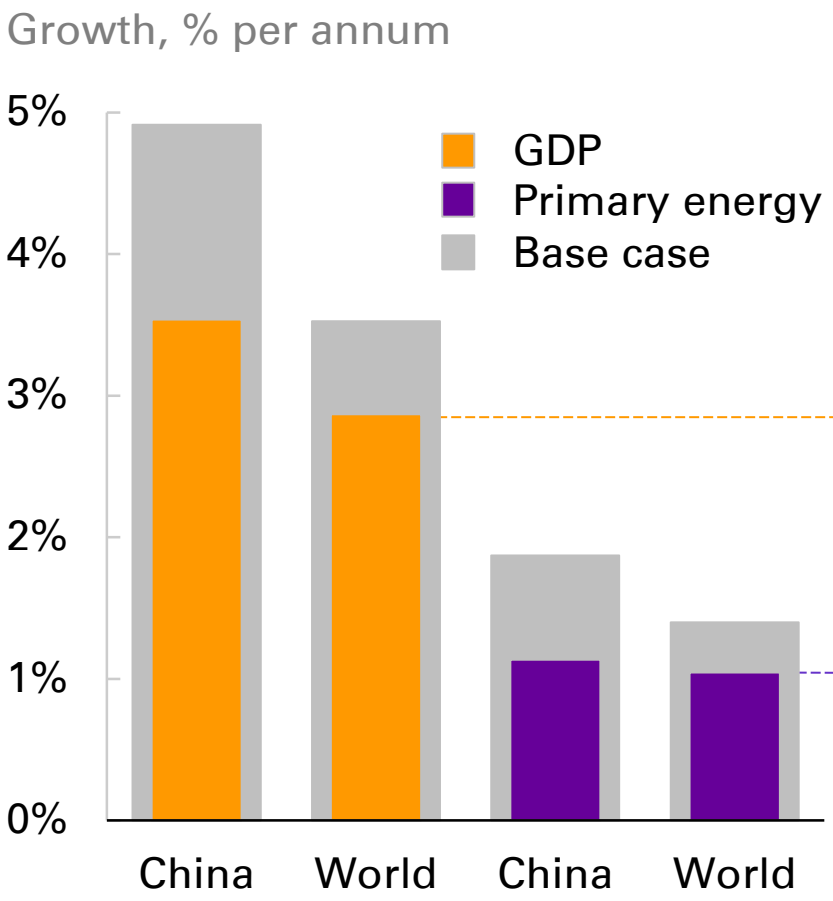
...illustrates some of the uncertainties around the Outlook

- The base case in the Outlook presents the single 'most likely' path for energy demand and the various fuels over the next 20 years. As such, it helps to highlight the main trends and forces that are likely to shape energy markets over the next two decades.
- But there are of course many risks and uncertainties surrounding the base case. It is possible to explore some of these uncertainties by varying a few of the key assumptions and judgements underpinning the base case and assessing their impact.
- We explore three key uncertainties, which are described in more detail in the following pages. This is not intended to be an exhaustive list, but these alternative cases provide useful insights into how varying some of the key assumptions might affect the projected trends.

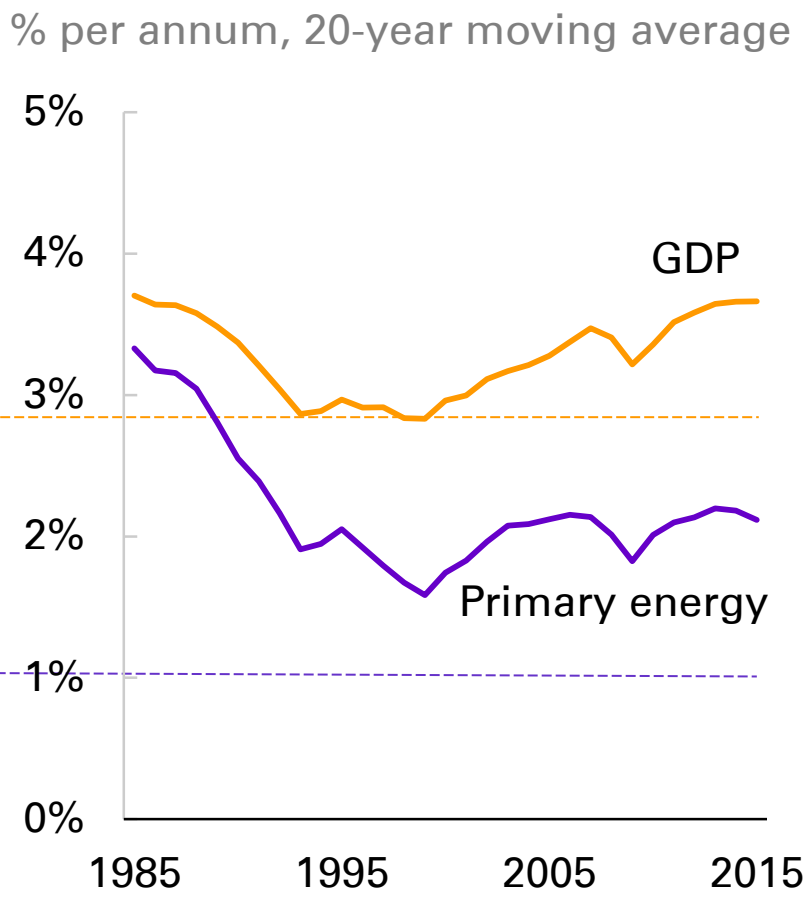
Beyond our forecasting horizon, technological advances could radically alter the choices available to us. The role of technology in shaping the energy landscape over the next 30 to 40 years is explored in the BP Technology Outlook.

Case 1: Slower global GDP growth...

Projected growth rates, 2014-35



Historical growth rates



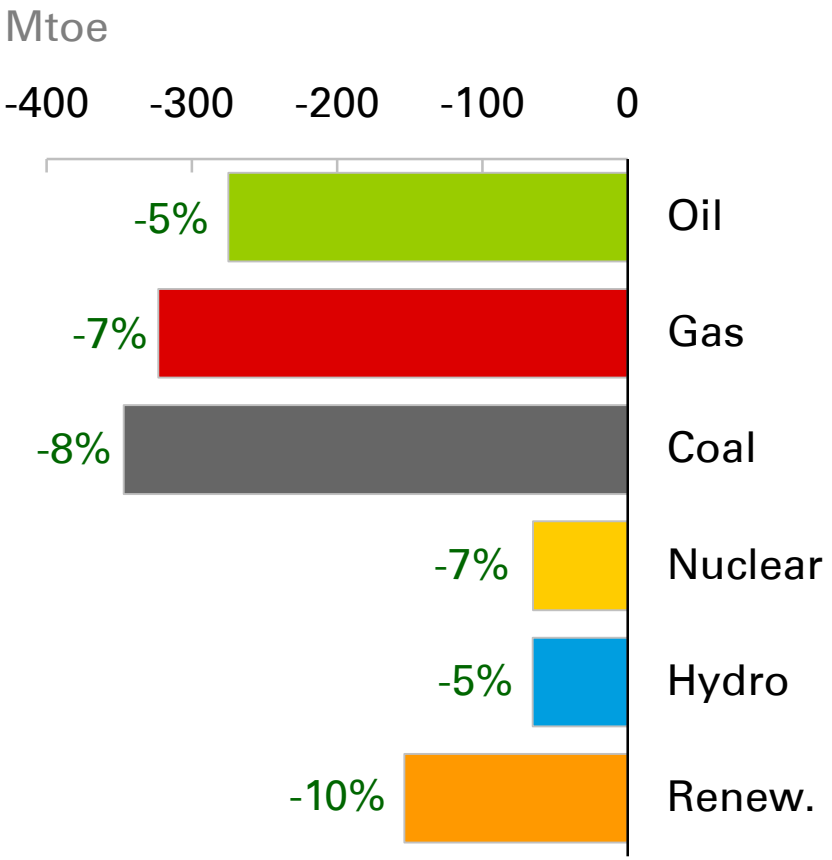
...has a significant impact on energy demand

- The pace of growth in China and other emerging economies is a major source of uncertainty for global GDP growth and hence energy demand.
- The 'slower GDP growth' case assumes that China grows at 3.5% p.a. over the Outlook, compared with nearly 5% p.a. in the base case.
- Allowing for trade and other spill-over effects, this causes world GDP to grow at a little below 3% p.a., 0.5% p.a. below the base case and comparable to one of the weakest periods of economic growth seen in recent history.
- World energy demand in this alternative case increases at just 1.0% p.a., down from 1.4% p.a. in the base. This is far slower than seen for any sustained period in recent history (reflecting the expectation that energy efficiency improves at a faster rate than in the past, so low global GDP growth translates into very low energy demand growth).
- The slower growth of global GDP reduces the overall increase in energy demand by around a third relative to the base case.

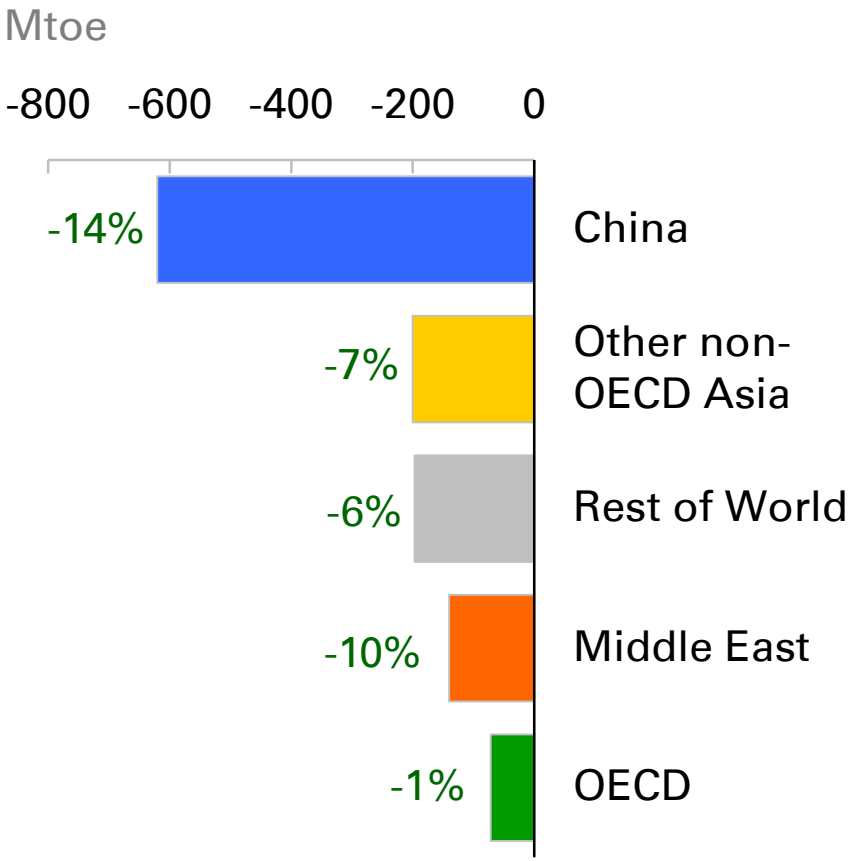
Demand growth is slower across all fuels...

Differences from base case in 2035:

Energy demand by fuel



Energy demand by region

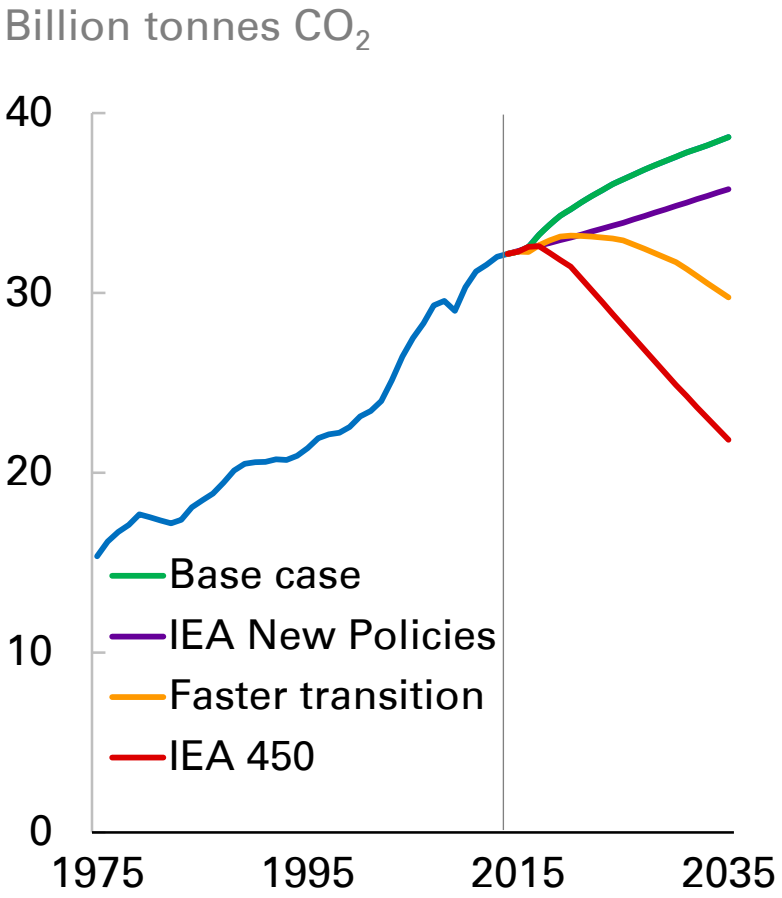


...with the main reductions concentrated in emerging Asia

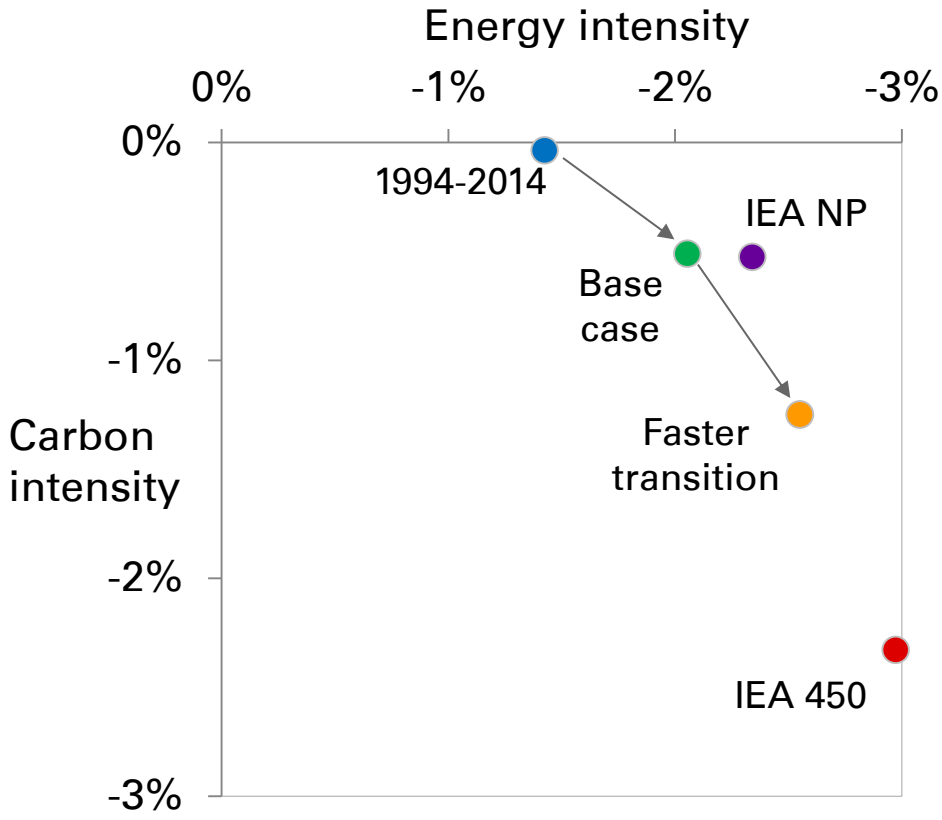
- The slower growth in GDP affects all fuels.
- Within fossil fuels, coal demand shows the largest absolute and percentage decline relative to the base case, followed by gas and then oil.
- These differential impacts largely reflect the pattern of growth of fuel use in emerging Asia (the focus of the slower economic growth).
- The lower price of fossil fuels in this alternative case, together with the lower income and wealth stemming from the slower economic growth, lead to a materially weaker profile for renewables.
- The reduction in energy demand relative to the base case outweighs the shift in the fuel mix, such that annual carbon emissions in 2035 are lower than the base case level by around 7% or 3 billion tonnes of CO_2.

The speed of transition to a lower-carbon energy system…

Carbon emissions



Changes in intensity

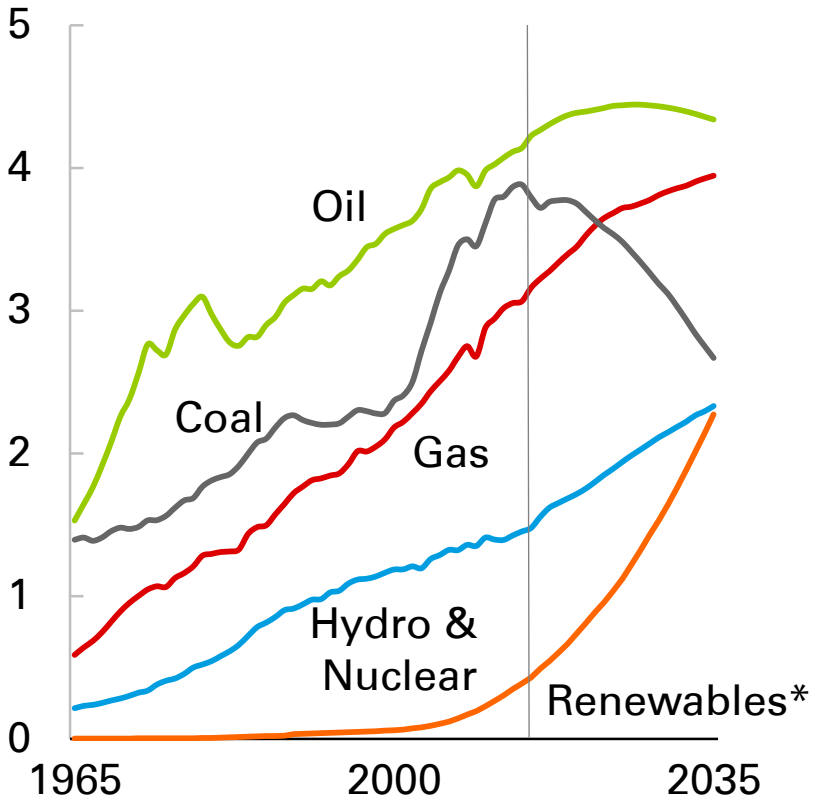


...has a significant impact on the outlook for energy

- The speed of transition to a lower-carbon energy system is a key source of uncertainty affecting the Outlook.
- The 'faster transition' case is based on:
  - a carbon price rising to $100/tonne (real $2015) by 2035 in the OECD and other leading economies, and at least $50/tonne elsewhere
  - in transport, tougher vehicle CO_2 standards, policies to encourage purchases of smaller vehicles, higher mandated biofuel blending, and improved public transport and urban planning to reduce mileage
  - measures to ensure that 80% of the estimated potential for energy efficiency gains in industry and buildings are captured by 2035.
- As a result, both global energy intensity and carbon intensity improve at unprecedented rates. Emissions peak in 2020 and by 2035 are nearly 8% below the 2014 level. That still falls short of the IEA 450 Scenario, but goes well beyond the pledges made in participating countries' INDCs at Paris (as approximated by, for example, the IEA New Policies Scenario).

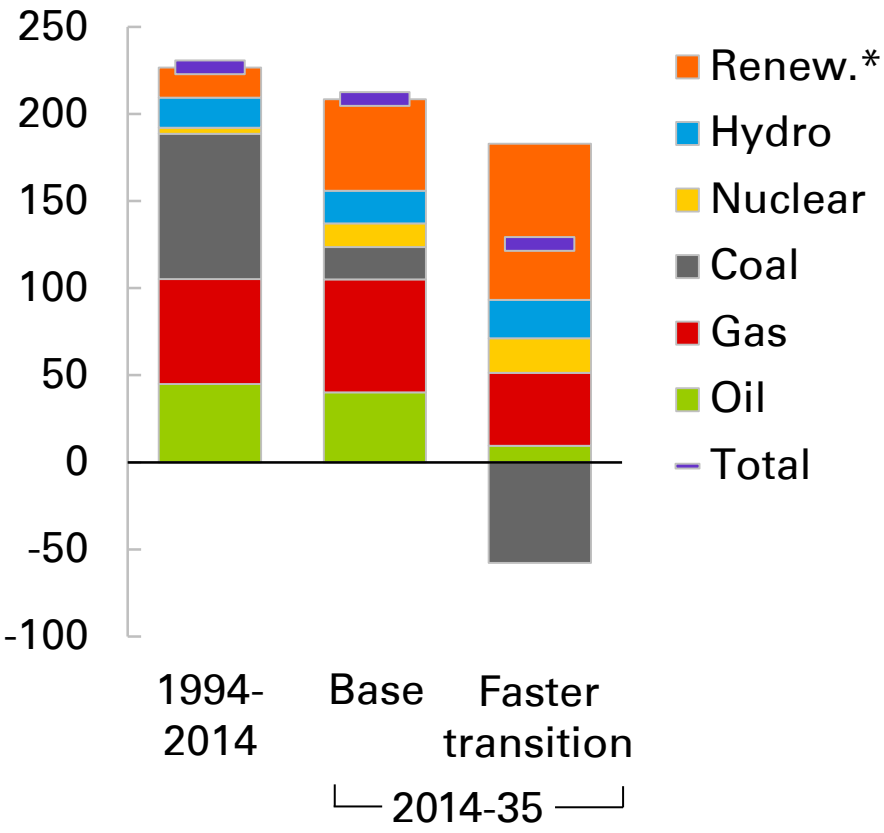
The faster transition has a significant impact…

Consumption by fuel



*Includes biofuels

Annual demand growth by fuel

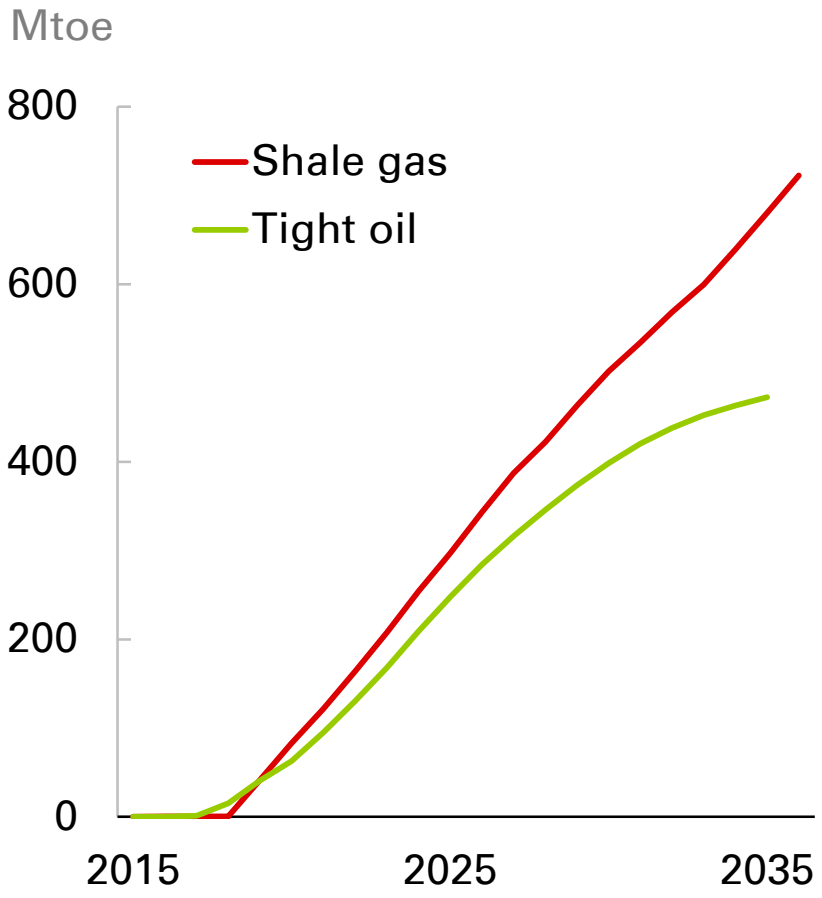


...on both overall energy demand and the fuel mix

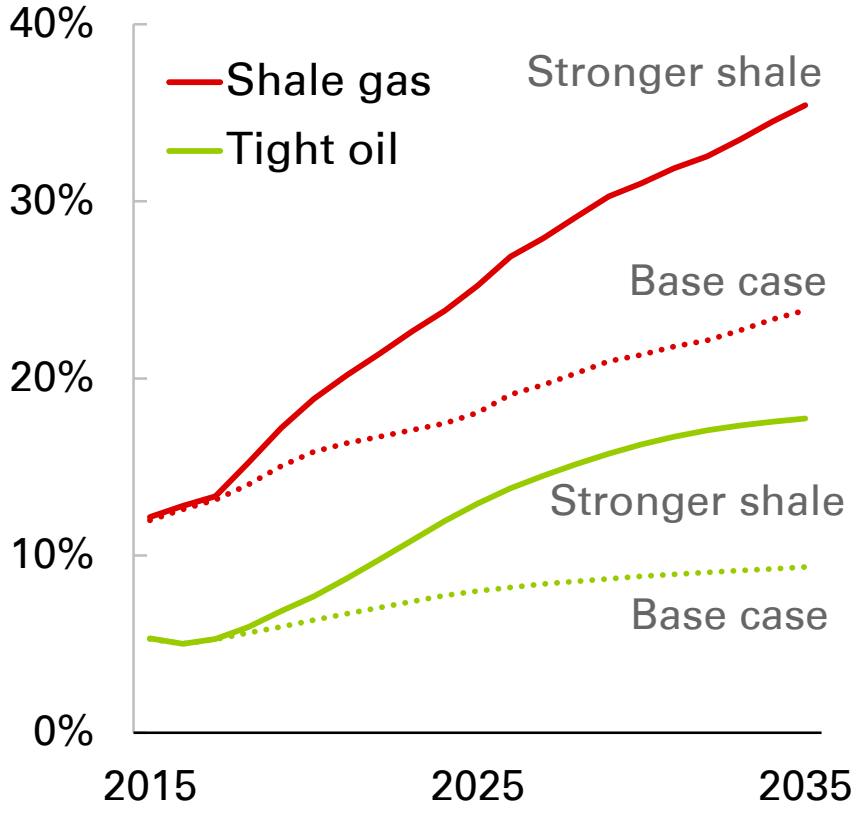
- Total energy demand still grows in the 'faster transition' case, but at a reduced pace (0.9% p.a. versus 1.4% p.a. in the base case).
- Non-fossil fuels supply all of the increase in energy. Fossil fuels decline slightly, with the share of fossil fuels in total energy falling from 86% today to around 70% by 2035.
- Natural gas and oil still increase in the 'faster transition' case, accounting for a little over half of total energy supplies in 2035, although oil demand is declining by the second half of the Outlook. Coal consumption suffers the most, falling by more than 30% to its lowest level since 2002.
- The big winner in the 'faster transition' case is renewables, with an almost six-fold increase in output (nearly 9% p.a.) and a 15% share of energy by 2035. The rate at which renewables gain share from 2020 to 2035 matches oil's gain over the 15 years of 1908-23 – years that included the Texas oil boom, the discovery of oil in the Middle East, the British Navy switching to oil, and the Model T Ford starting mass motorization.

Case 3: Tight oil and shale gas having even greater potential…

Differences in supply from base case



Shares of total oil/gas production

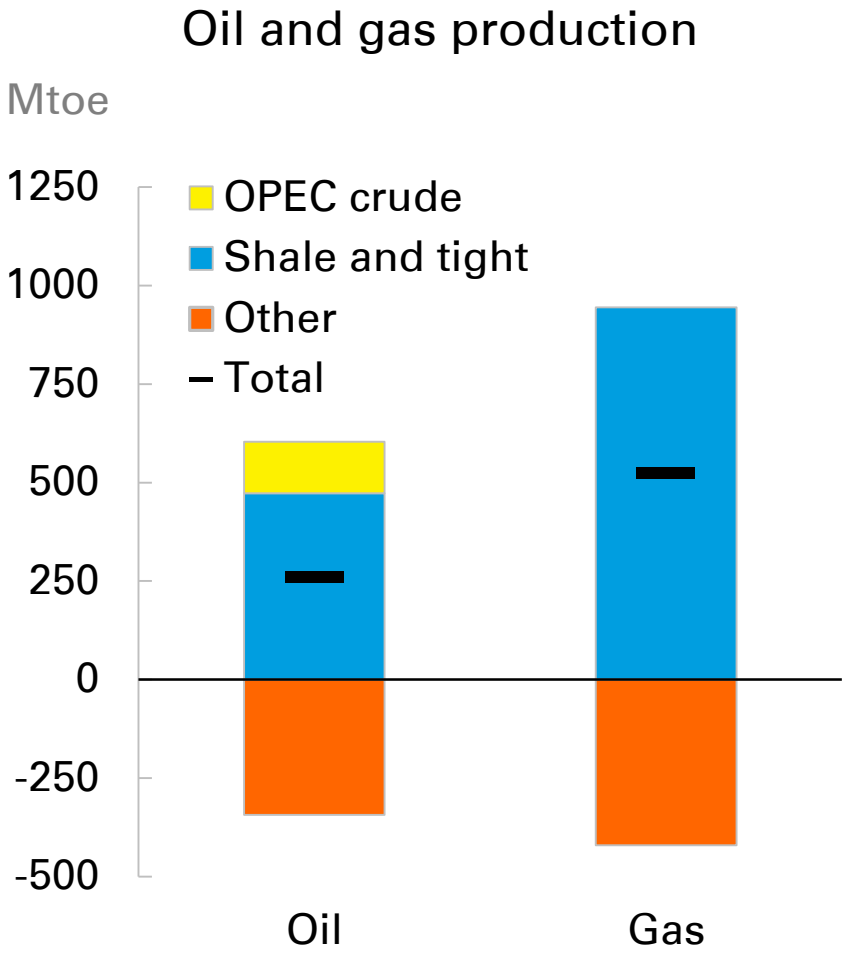


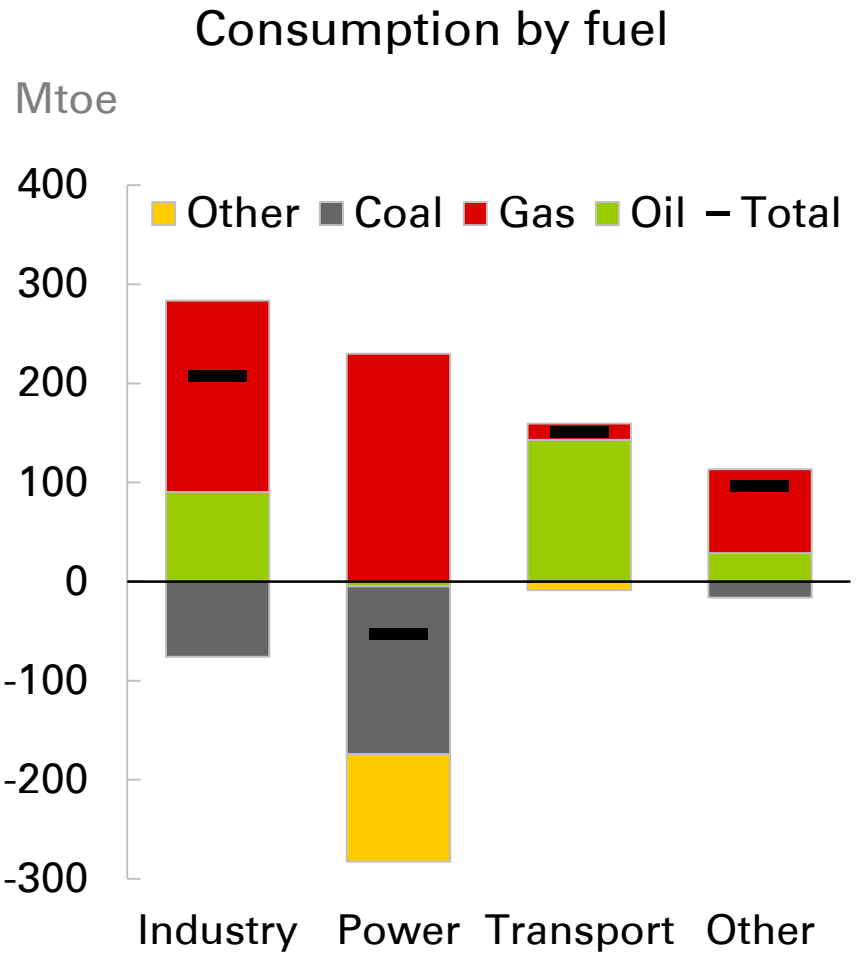
...has significant implications for global energy supplies

- The continued growth of tight oil and shale gas in the US, and the spread of shale outside North America, are key uncertainties in our Outlook.
- The 'stronger shale' case assumes global shale resources are significantly bigger than in the base case (in the US by 50% for oil and 30% for gas; elsewhere by 100% and 50%), and productivity is 20% higher by 2035.
- As a result, global supplies of tight oil and shale gas are much greater than in the base case. The higher weight of shale gas within global gas supplies, and the greater ability of gas to substitute for other fuels, means the impact is more marked for shale gas than for tight oil.
- Shale gas production is around 76 Bcf/d higher by 2035, with shale gas accounting for more than a third of global gas supplies in the 'stronger shale' case
- Global tight oil output increases to 20 Mb/d by 2035, twice its level in the base case, with its share of total liquids output reaching 18%.

Higher shale output crowds out conventional production…

Differences from base case in 2035:





...and other fuels

- The stronger growth in shale oil and gas crowds out both conventional supplies of oil and gas as well as other fuels.
- In the oil market, tight oil is around 10 Mb/d higher by 2035 than in the base case, whereas total oil production is only 6 Mb/d higher.
- OPEC is assumed to respond to the stronger growth in tight oil by increasing its own production in order to maintain its market share. As a result, the decline in non-shale supplies relative to the base case (-4 Mb/d) is concentrated within non-OPEC.
- In the gas market, shale and tight gas (included in the positive supply shock) are up by a combined 100 Bcf/d in 2035 versus the base case. Conventional gas and coal-bed methane supplies are down by 45 Bcf/d in aggregate, leaving total gas production 56 Bcf/d higher by 2035.
- Fuel substitution is most pronounced in the power sector where gas competes with all other fuels. The main casualty is coal, which is 260 Mtoe lower by 2035 than in the base case; renewables are 110 Mtoe lower.

Conclusions

Conclusions

- Global demand for energy continues to rise

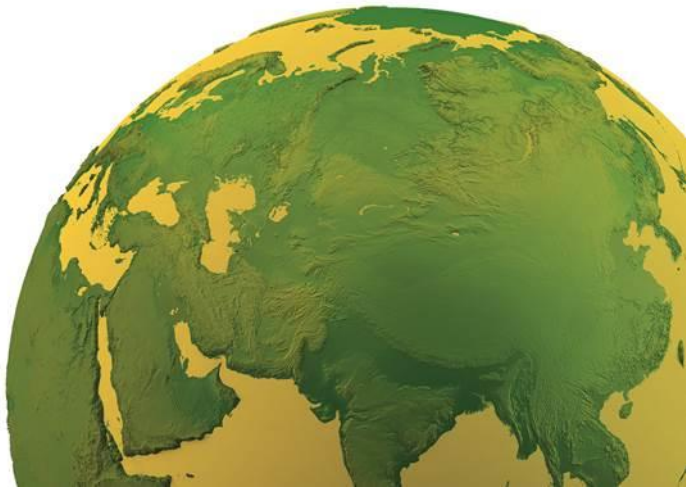
  – to power increased levels of activity as the world economy continues to grow

- Fuel mix changes significantly

  – coal losing, renewables gaining, and oil and gas combined holding steady

- Growth rate of carbon emissions slows sharply

  – but not by enough without further policy changes



Annex

Key figures and fast facts

Annual revisions in detail

Comparison with other energy outlooks

Data sources

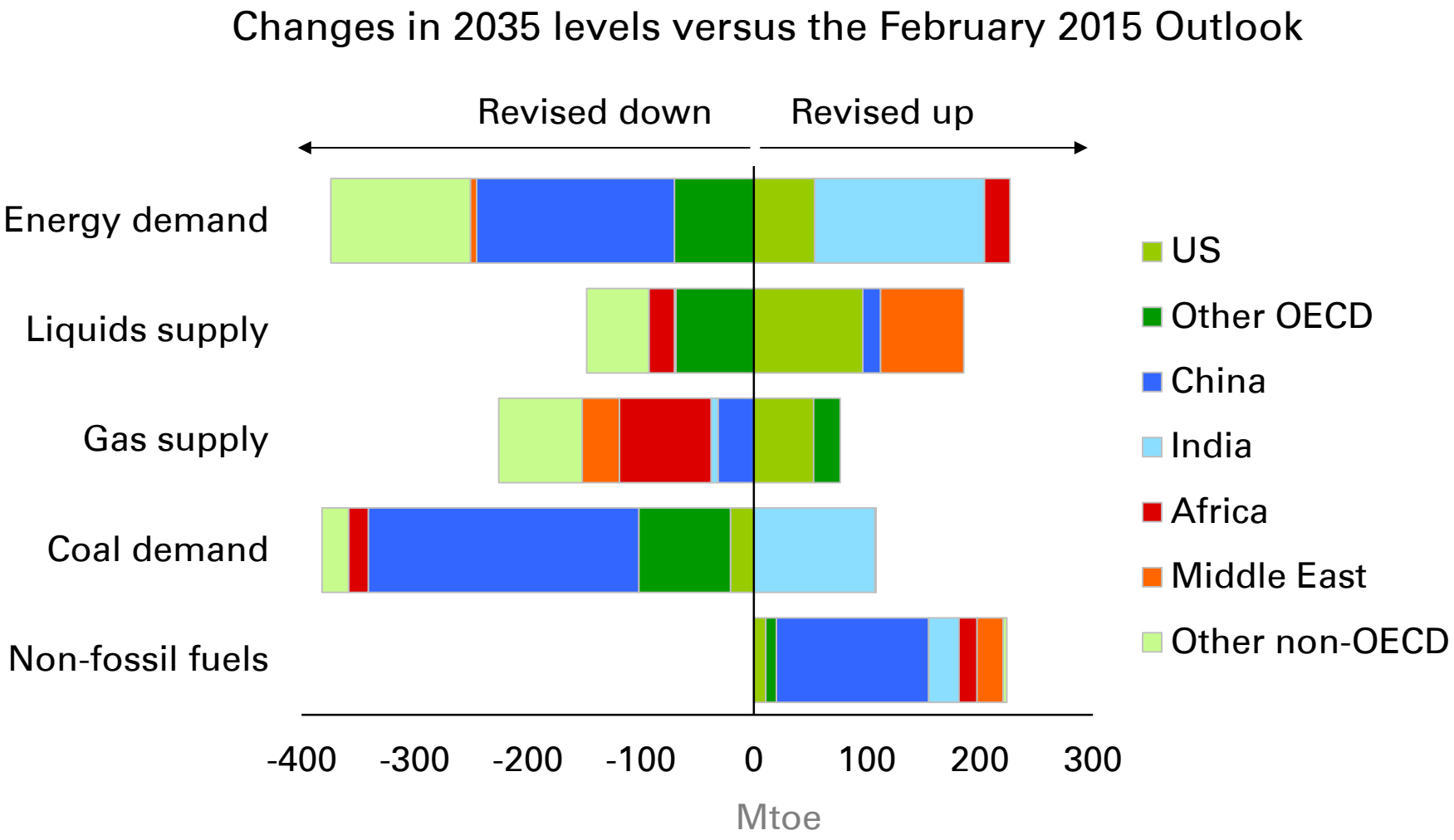
Key figures and fast facts

	Growth 2014-35 (p.a.)	Growth 2014-35 (cumulative)	2014 (share)	2035 (share)
Primary energy	1.4%	34%	100%	100%
Oil	0.9%	20%	32%	29%
Gas	1.8%	44%	24%	26%
Coal	0.5%	10%	30%	25%
Nuclear	1.9%	50%	4%	5%
Hydro	1.8%	45%	7%	7%
Renewables*	6.6%	285%	3%	9%
Population	0.9%	21%		
GDP ($2010 PPP)	3.5%	107%		
Energy Intensity	-2.1%	-35%		
CO_2 emissions	0.9%	20%		

* Includes biofuels

- Renewables account for a quarter of global primary energy growth out to 2035 and over a third of the growth in global power generation.
- EU energy demand in 2035 is back to where it was 50 years earlier, despite the economy being almost 150% bigger.
- The US achieves overall energy self-sufficiency by 2021 and oil self-sufficiency by 2030.
- China surpasses the US as the world's leading oil consumer by 2035, but per capita oil consumption will remain just 27% of the US.
- The growth of global gas consumption from 2014 to 2035 is more than the current gas production of US and Russia combined.
- By 2035 coal accounts for less than 25% of primary energy, its lowest share since the industrial revolution.
- China adds more renewable power over the Outlook than the EU and US combined.
- Spare refining capacity plus planned additions over the next five years is enough to meet the growth in crude supplies over the Outlook.

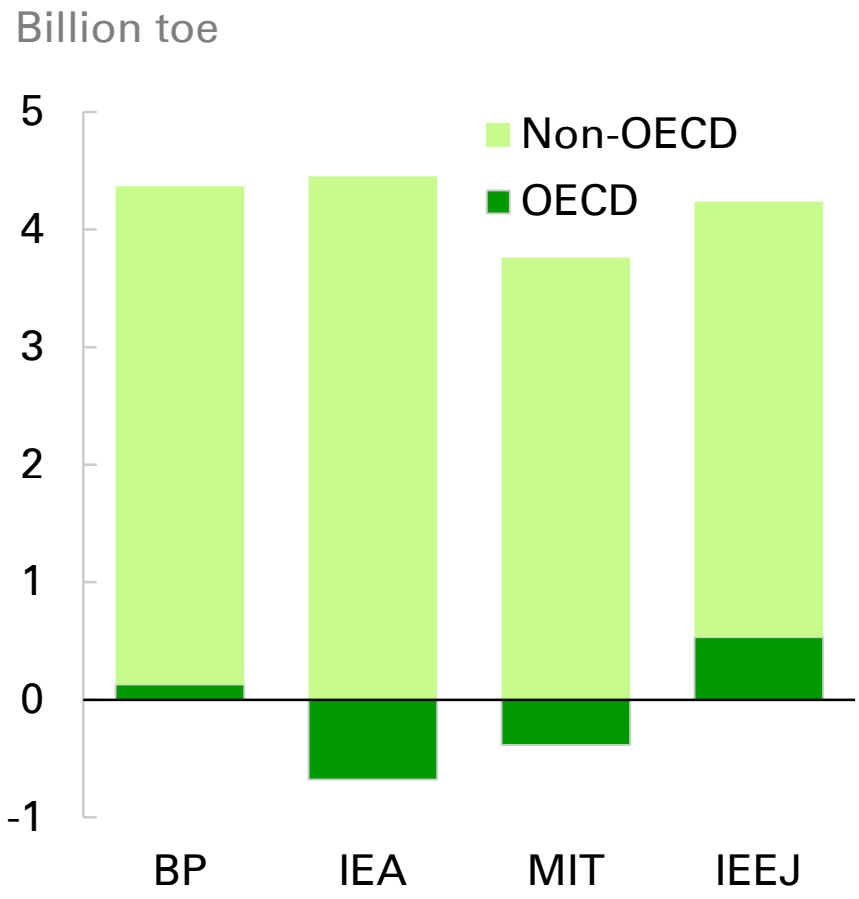
Annual revisions in detail

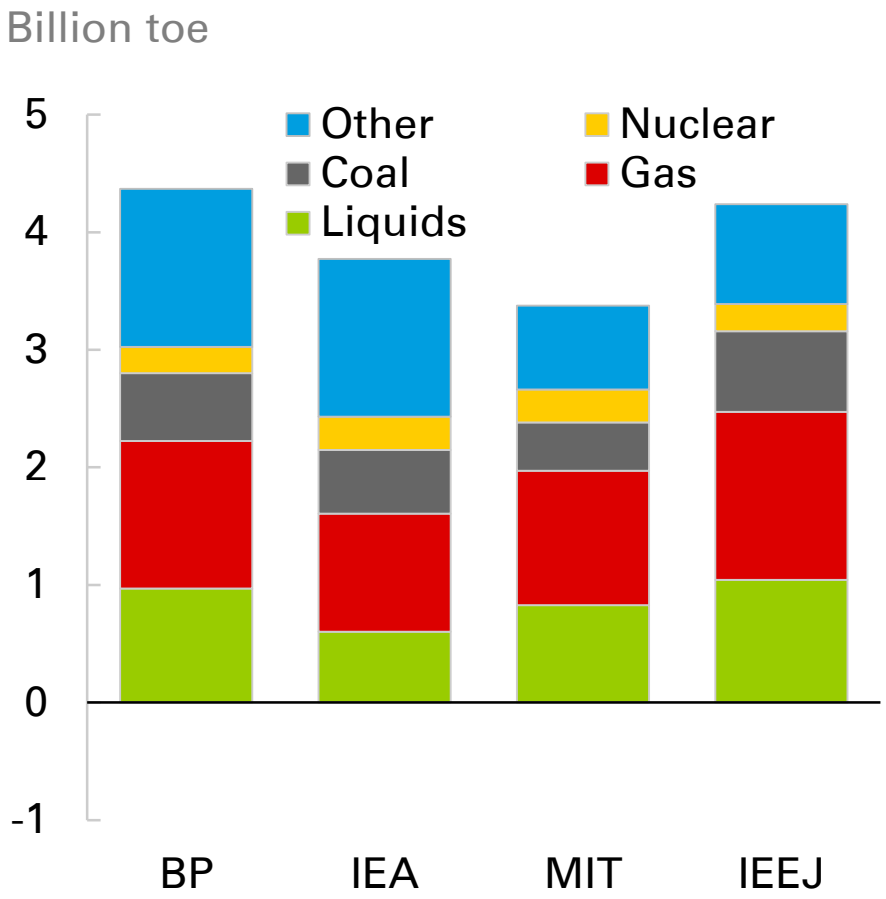


- Total primary energy has been revised down in 2035 by around 150 Mtoe (or 1%) reflecting the judgement that energy intensity is likely to decline faster than previously thought, helped by the agreements reached at Paris COP21.
- Oil supply has been revised up in the US (reflecting higher tight oil) and Iran (due to improved investment prospects), partially offset by lower output in Canada and Kazakhstan. The higher supply is largely matched by higher transport demand, helped in part by current low prices.
- Lower gas demand, combined with more US shale gas, has led to a downward revision to non-OECD gas supply, particularly in Africa.
- Coal demand has been revised down, due to a weaker profile for China GDP growth and increased environmental polices.
- Non-fossil fuels have been revised up in most regions, driven by faster technological progress in solar and more supportive environmental policy.

Comparison with other energy outlooks

Growth of energy consumption, 2010-30





- Long-run energy projections are available from several organizations. The comparison here, against some of the outlooks in the public domain, illustrates the range of views within a sample of central case projections.
- There is broad consensus on the role of emerging markets as drivers of energy consumption growth, with OECD economies showing little growth or outright declines. All the outlooks show gas as the fastest growing fossil fuel, and continuing modest growth in oil.
- Beyond that, there are some significant differences among the outlooks, at both the regional and fuel level, which reflect differences on key assumptions, such as: the availability and cost of oil and gas supplies; the speed of deployment of new technologies; the pace of structural change in China; the impact of energy and environmental policies.

Technical note: in order to facilitate the comparison, all the outlooks have been rebased to a common set of data for 2010, taken from the BP Statistical Review of World Energy.
IEA: 'World Energy Outlook 2015', New Policies Scenario.
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