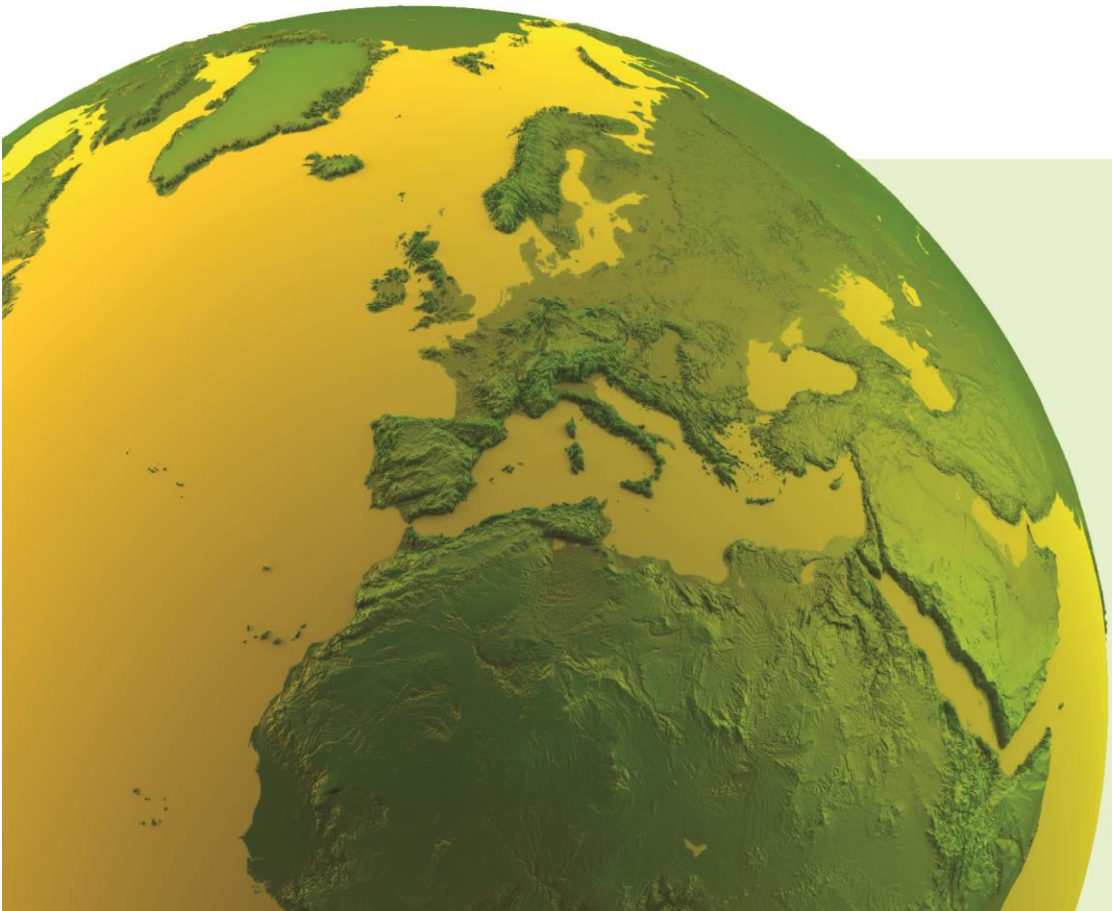
BP Energy Outlook 2035

February 2015

bp.com/energyoutlook
#BPstats



Disclaimer

This presentation contains forward-looking statements, particularly those regarding global economic growth, population growth, energy consumption, policy support for renewable energies and sources of energy supply. Forward-looking statements involve risks and uncertainties because they relate to events, and depend on circumstances, that will or may occur in the future. Actual outcomes may differ depending on a variety of factors, including product supply, demand and pricing; political stability; general economic conditions; legal and regulatory developments; availability of new technologies; natural disasters and adverse weather conditions; wars and acts of terrorism or sabotage; and other factors discussed elsewhere in this presentation. BP disclaims any obligation to update this presentation. Neither BP p.l.c. nor any of its subsidiaries accept liability for any inaccuracies or omissions or for any direct, indirect, special, consequential or other losses or damages of whatsoever kind in connection to this presentation or any information contained in it.

Contents

Welcome to the 2015 edition of BP's *Energy Outlook*.

At a time when our industry is focused on the rapid response to a dramatic fall in oil prices, it is instructive to look at events from a longer term perspective.

Today's turbulence is a return to business-as-usual. Continuous change is the norm in our industry. The energy mix changes. The balance of demand shifts. New sources of energy emerge, such as shale gas, tight oil, ultra-deepwater oil or renewables. Economies expand and contract. Energy production and consumption are affected by disruptions, from wars to extreme weather. New policies are created to address climate change or bolster energy security.

Energy companies need to adapt – as BP is doing as I write; and to build strategically for the longer term we not only need to control capital and costs, but to set a clear direction.

This Outlook is therefore valuable in giving us an insight into the most likely shape of the future energy landscape and some of the most important changes expected over the next 20 years. Three key features are particularly worth noting.

First, trade patterns are shifting. The strong growth of US tight oil in recent years has had a dramatic impact, with oil increasingly flowing from West to East rather than East to West. This is likely to continue, with strong growth in China and India driving energy demand. We also expect to see the market in gas become more global as liquefied natural gas (LNG) integrates regional markets and leads to greater congruence in global price movements.

Second, the energy mix continues to shift. Fossil fuels are projected to provide the majority of the world's energy needs, meeting two-thirds of the increase in energy demand out to 2035. However, the mix will shift. Renewables and unconventional fossil fuels will take a larger share, along with gas, which is set to be the fastest growing fossil fuel, as well as the cleanest, meeting as much of the increase in demand as coal and oil combined. Meanwhile, coal is now expected to be the slowest growing fuel, as industrialization in emerging Asian economies slows and environmental policies around the globe tighten.

That brings us to the environmental challenge. The most likely path for carbon emissions, despite current government policies and intentions, does not appear sustainable. The projections highlight the scale of the challenge facing policy makers at this year's UN-led discussions in Paris. No single change or policy is likely to be sufficient on its own. And identifying in advance which changes are likely to be most effective is fraught with difficulty. This underpins the importance of policy-makers taking steps that lead to a global price for carbon, which provides the right incentives for everyone to play their part.

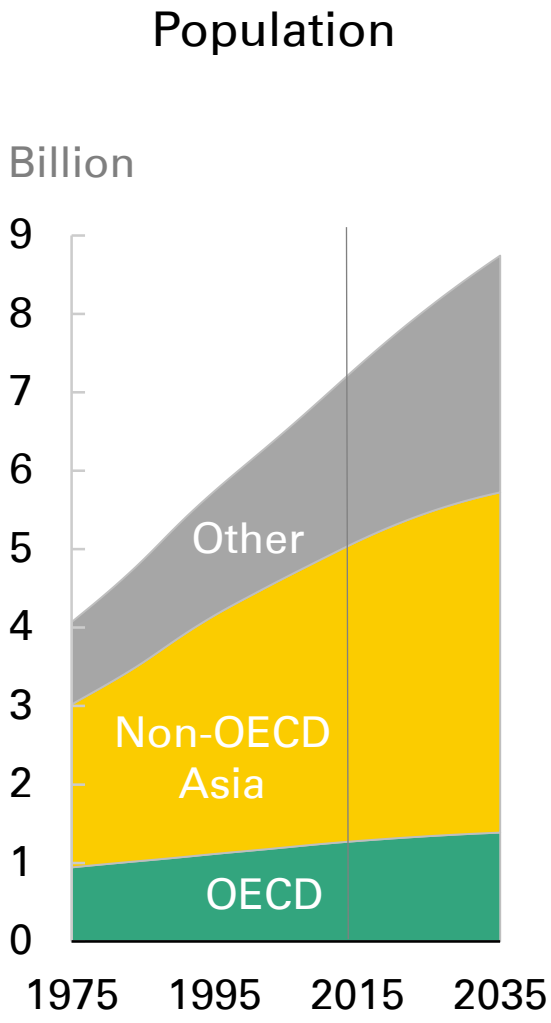
It will be a year of debate, not only on the environment, but the economy and energy in general. We hope that this year's *BP Energy Outlook 2035* can make a useful contribution to informing the discussion and shaping a future where energy is sustainable, secure and affordable.

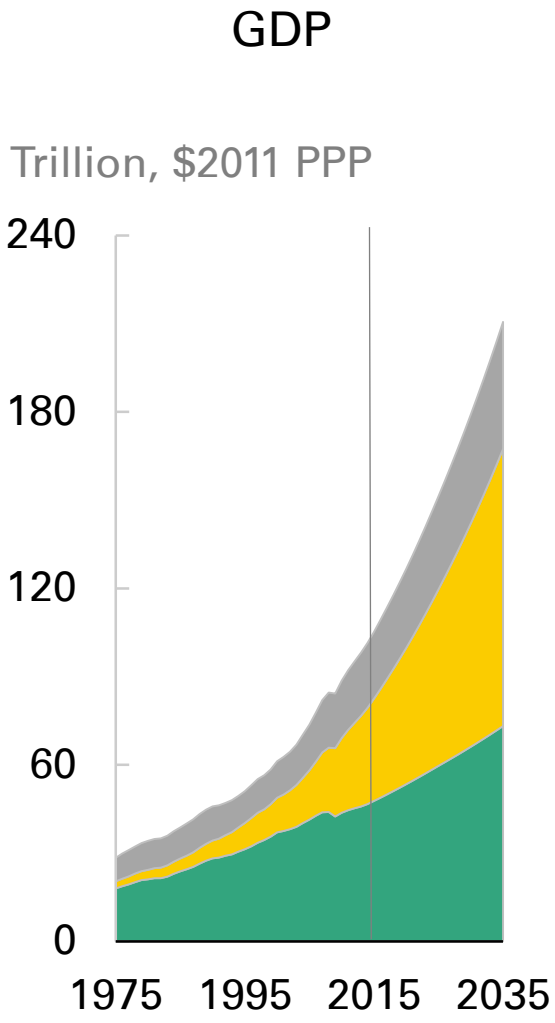
Bob Dudley
Group chief executive

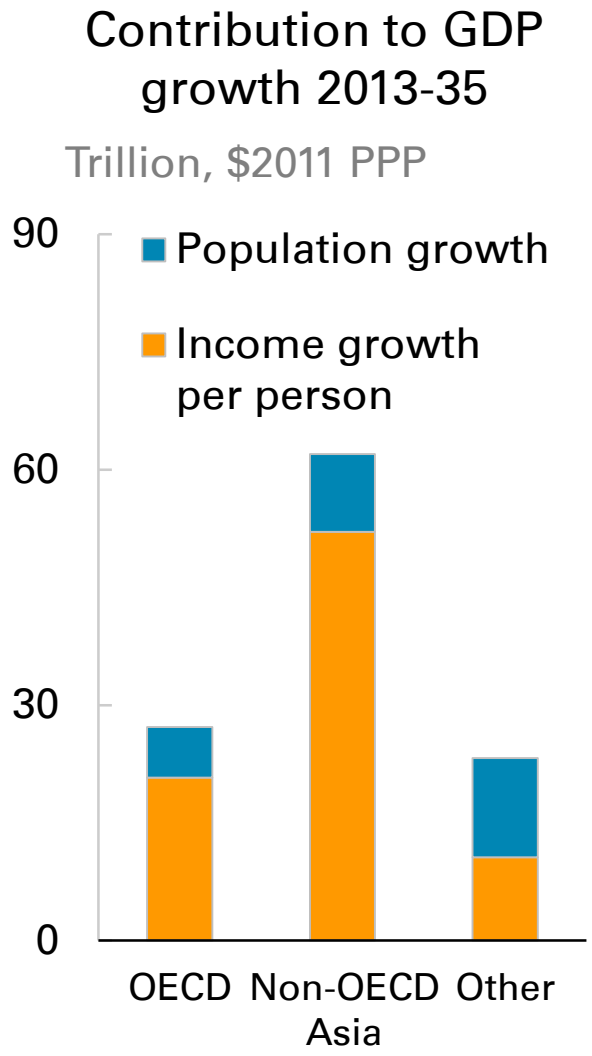
Notes on method and assumptions

- This edition updates our view of the likely path of global energy markets to 2035. The underlying methodology remains unchanged – we build a single "most likely" view based on assumptions about changes in policy, technology and the economy.
- We focus on the "most likely" base case as a basis for discussion. But there are many uncertainties surrounding the base case and in the process of building the Outlook we explore the impact of alternative assumptions. Some of those uncertainties are considered in the "Key uncertainties" section, although this discussion is by no means exhaustive.
- Unless noted otherwise, data definitions are based on the *BP Statistical Review of World Energy,* and historical energy data up to 2013 are consistent with the 2014 edition of the *Review*. Gross Domestic Product (GDP) is expressed in terms of real Purchasing Power Parity (PPP) at 2011 prices. All data sources are listed on page 98.

Global population and increases in income per person…





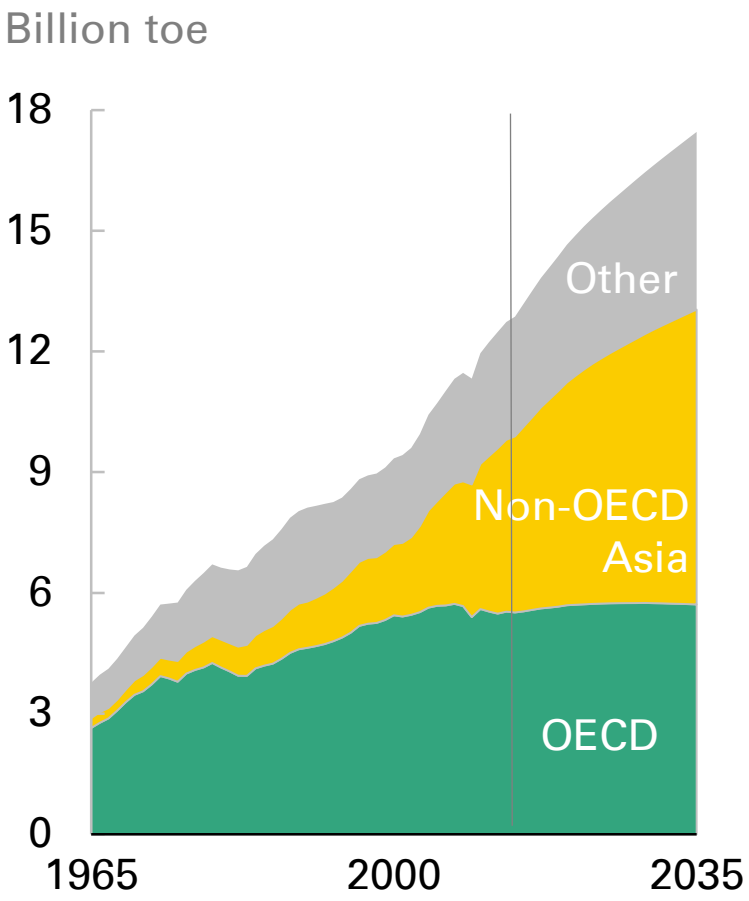


… underpin growing energy demand

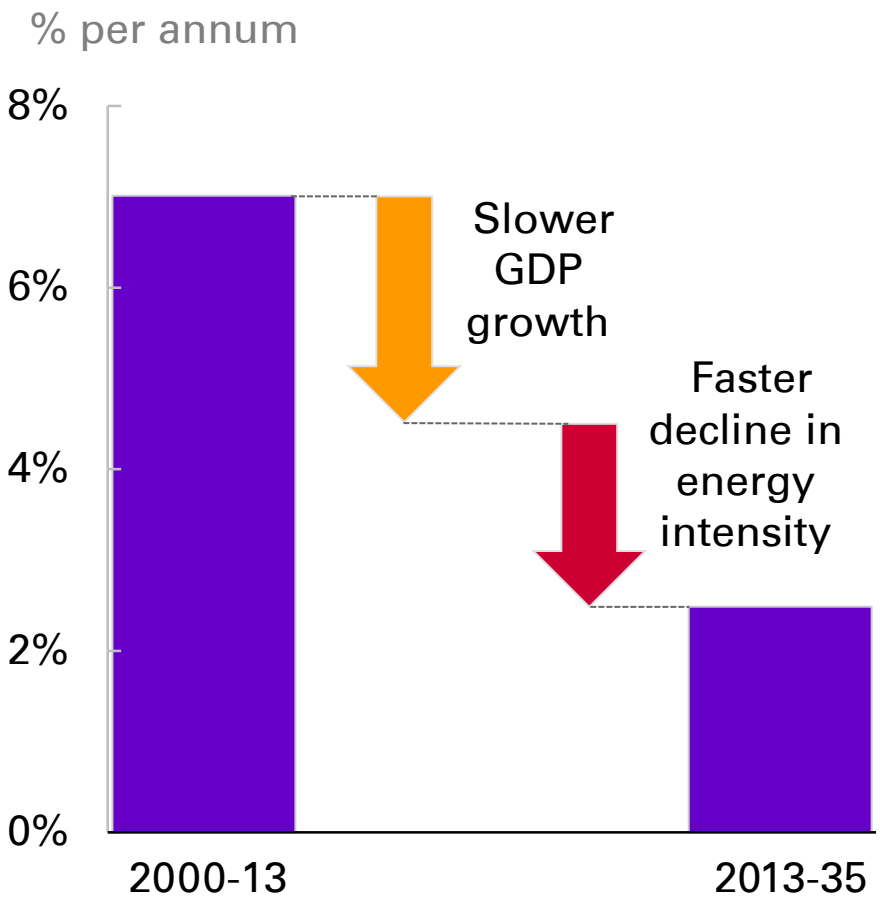
- Population growth and increases in income per person are the key drivers behind growing demand for energy. By 2035, the world's population is projected to reach 8.7 billion, which means an additional 1.6 billion people will need energy.
- Over the same period, GDP is expected to more than double, with non-OECD Asia contributing nearly 60% of that growth. Globally, GDP per person in 2035 is expected to be 75% higher than today, an increase in productivity which accounts for three-quarters of global GDP growth.
- China and India are key drivers of non-OECD growth and are projected to grow by 5.5% per annum (p.a.) between 2013 and 2035. By 2035, they will be the world's largest and 3rd largest economies respectively, jointly accounting for about one-third of global population and GDP.
- As China's level of productivity catches up with the OECD, its rate of growth is expected to slow from 7% p.a. in this decade to 4% p.a. in the decade to 2035. India's growth moderation is more gradual: slowing from 6% p.a. in this decade to 5% p.a. in the final decade.

Primary energy consumption growth slows...

Consumption by region



Non-OECD Asia energy growth



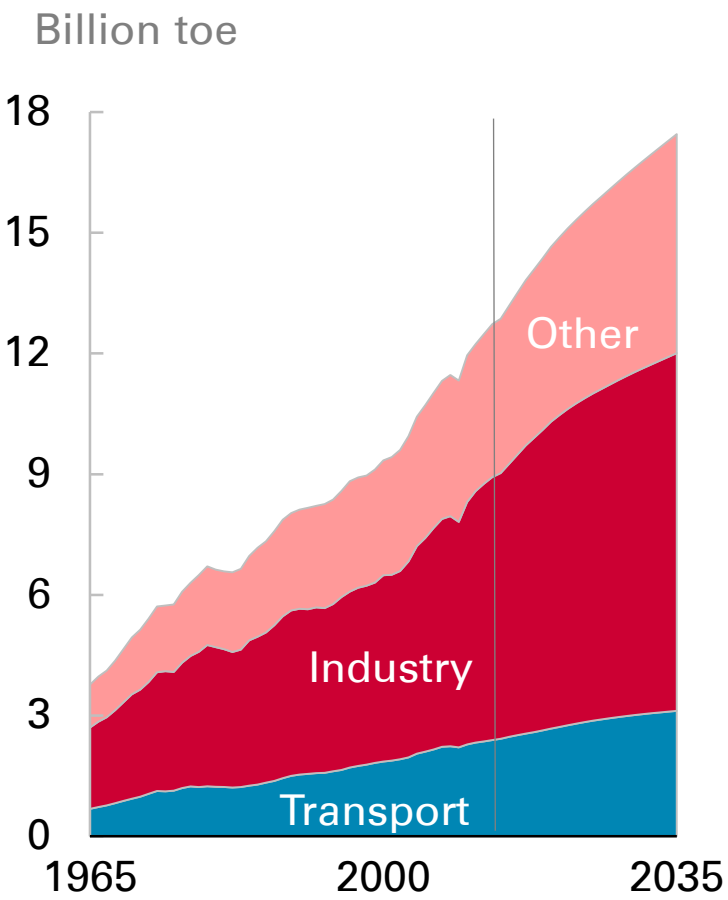
…as the impact of non-OECD industrialization weakens

- Primary energy consumption increases by 37% between 2013 and 2035, with growth averaging 1.4% p.a.. Virtually all (96%) of the projected growth is in the non-OECD, with energy consumption growing at 2.2% p.a.. OECD energy consumption, by contrast, grows at just 0.1% p.a. over the whole period and is actually falling from 2030.
- The projected growth rate of global energy consumption is significantly slower than the recent trend (2.4% p.a. for 2000-13). This slowdown is most marked in non-OECD Asia, where growth has averaged 7% p.a. since 2000 and is projected to slow to 2.5% p.a. between 2013 and 2035.
- This reflects the end of the phase of rapid growth in energy demand in developing Asia, centred on China, driven by industrialization and electrification. Slower economic growth and an accelerated reduction in energy intensity* (as economic growth becomes less dependent on heavy industry) play roughly equal parts in explaining the slowing of energy growth.

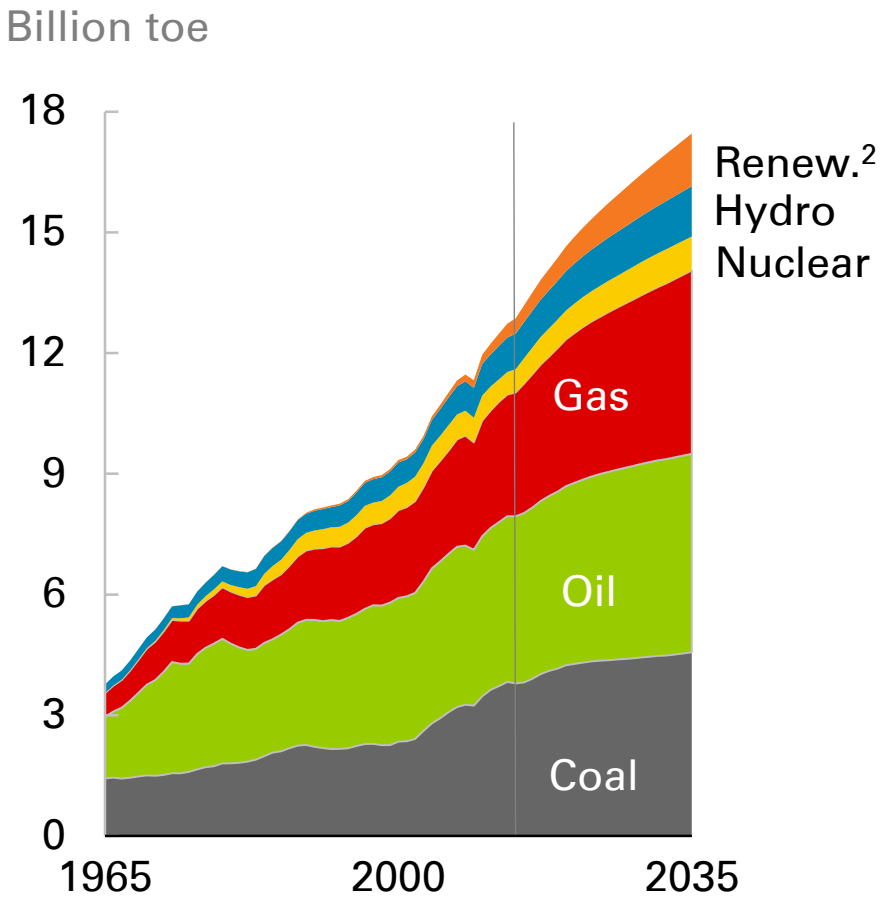
*The amount of energy used per unit of GDP

The slowdown in demand growth from industry...

Consumption by final sector[1]



Consumption by fuel



[1]Primary fuels in power allocated according to final sector electricity consumption

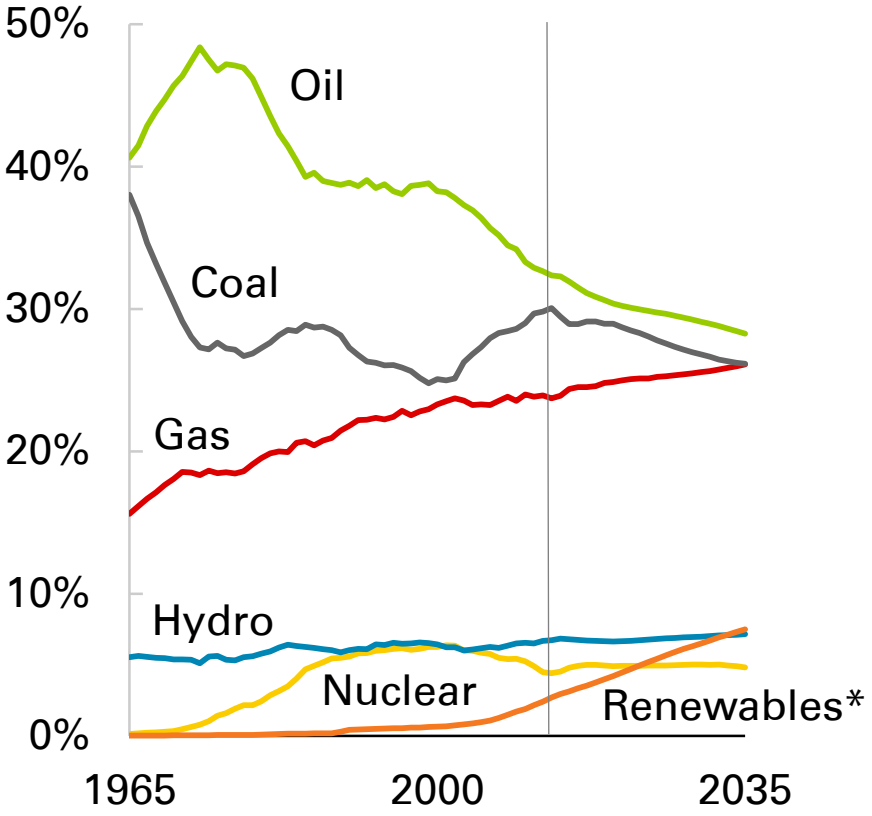
[2]Includes biofuels

…is reflected in the slower growth of coal

- The fading impact of industrialization is apparent in the split of primary energy consumption by sector. Industry has been the fastest growing sector since 2000, averaging 2.7% p.a., but projected growth slows to 1.4% p.a. The 'other' sector (residential, services and agriculture) becomes the fastest growing sector, averaging 1.6% p.a. 2013-35.
- Transport continues to play a relatively small role in primary energy growth, growing steadily (1.2% p.a.) but accounting for just 15% of total growth during 2013-35.
- Coal suffers a sharp change in fortunes, from being the fastest growing fossil fuel since 2000 (3.8% p.a.), to the slowest growing fuel from 2013 to 2035 (0.8% p.a.). This reflects the slowing of coal-based industrialization in Asia, compounded by the effects of environmental regulations and low gas prices in key markets. Natural gas is the fastest growing fossil fuel (1.9% p.a.), with oil (0.8% p.a.) marginally ahead of coal.
- The fastest fuel growth is seen in renewables (6.3% p.a.). Nuclear (1.8% p.a.) and hydro-electric power (1.7% p.a.) grow faster than total energy.

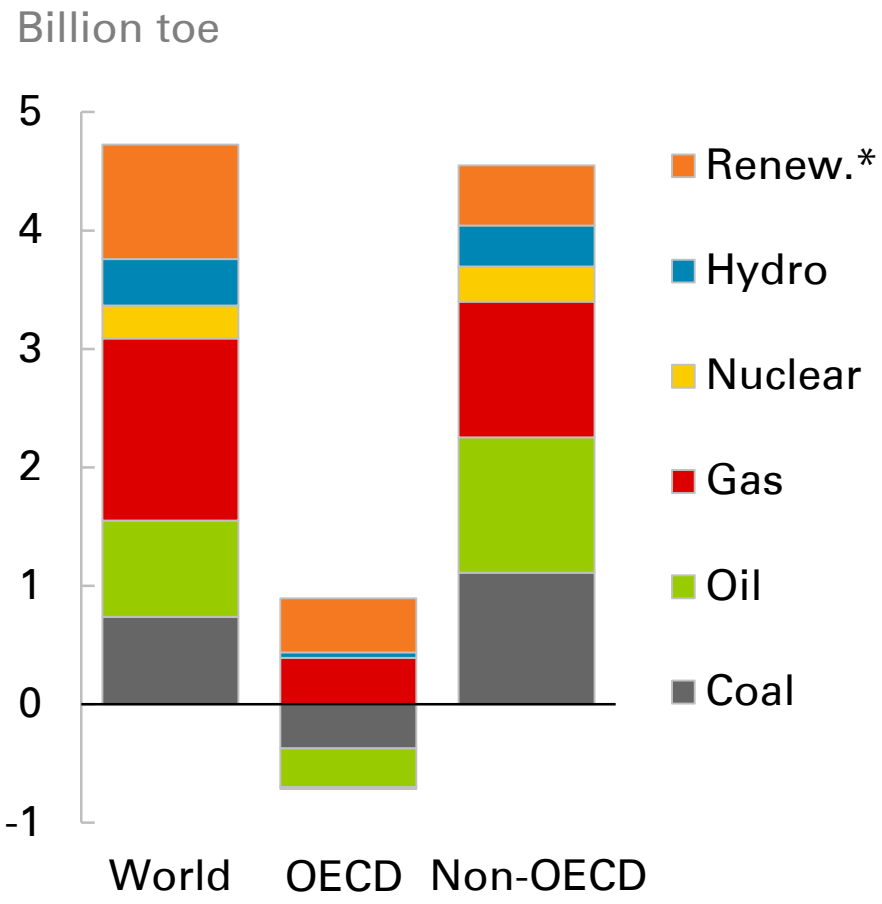
Fossil fuels continue to provide most of the world's energy...

Shares of primary energy



*Includes biofuels

2013-35 increments by fuel

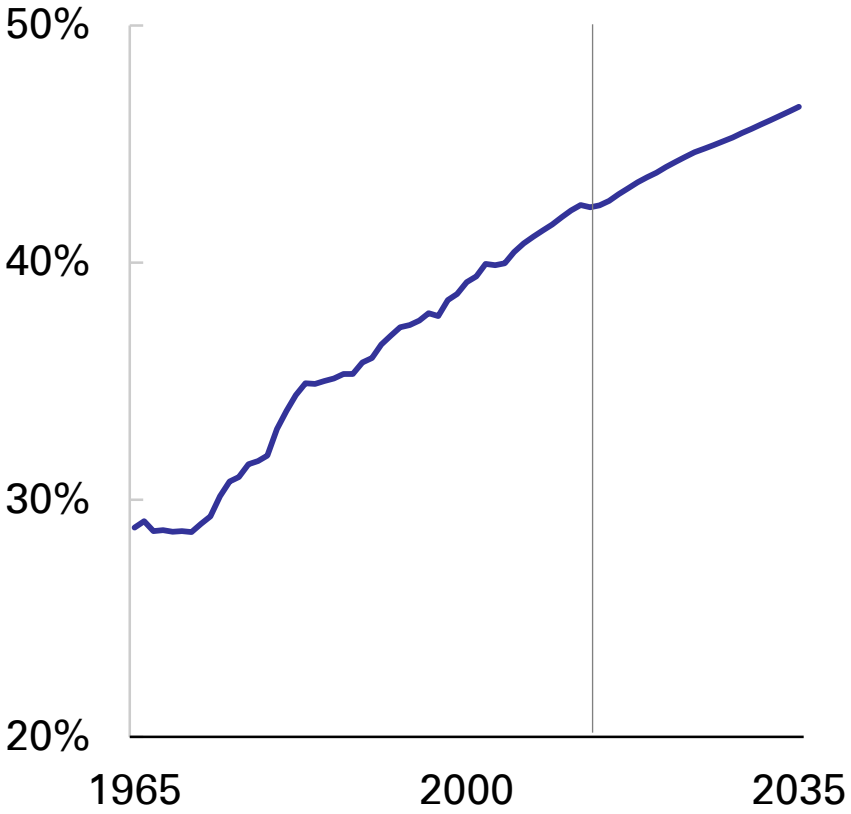


…even as the mix shifts towards lower carbon fuels

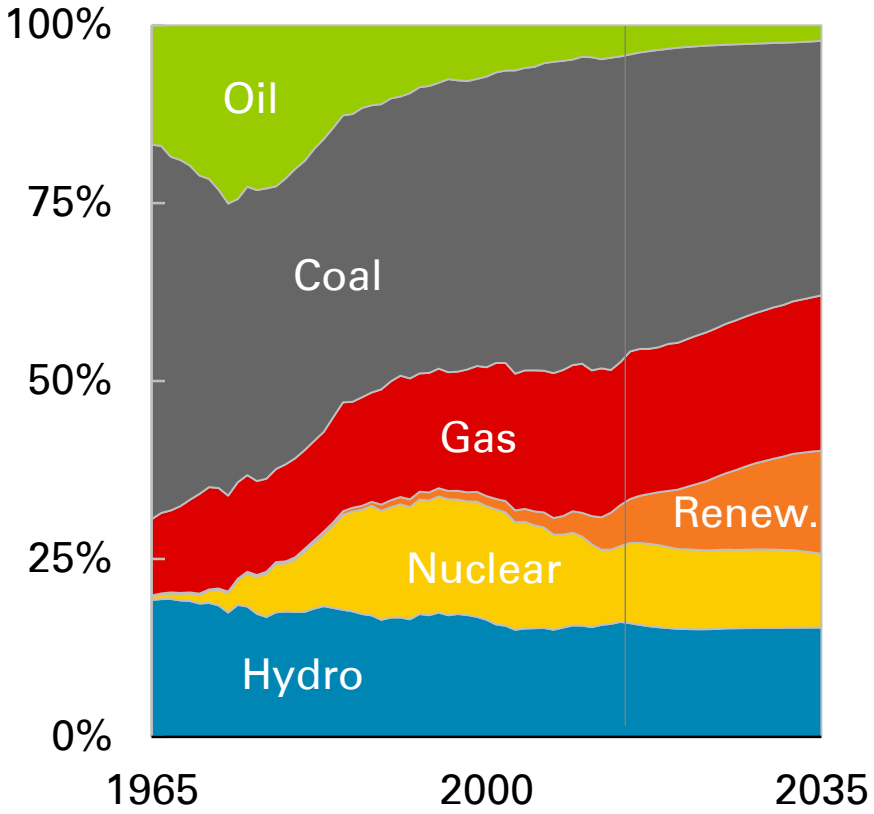
- Gas gains share steadily, while the shares of both oil and coal fall.
- By 2035 all the fossil fuel shares are clustered around 26-28% with no single dominant fuel – a first since the Industrial Revolution. Fossil fuels in aggregate lose share but remain the dominant form of energy in 2035 with a share of 81%, down from 86% in 2013.
- Among non-fossil fuels, renewables (including biofuels) gain share rapidly, from around 3% today to 8% by 2035, overtaking nuclear in the early 2020s and hydro in the early 2030s.
- Roughly one-third of the increase in energy demand is provided by gas, another third by oil and coal together, and the final third by non-fossil fuels.
- In the OECD, declines in oil and coal are offset by increases in gas and renewables, in roughly equal parts. Growth in non-OECD energy is evenly spread, with roughly a quarter each for oil, gas, coal and non-fossil fuels.

The power sector takes an increasing share of energy…

Inputs to power as a share of total primary energy



Primary inputs to power

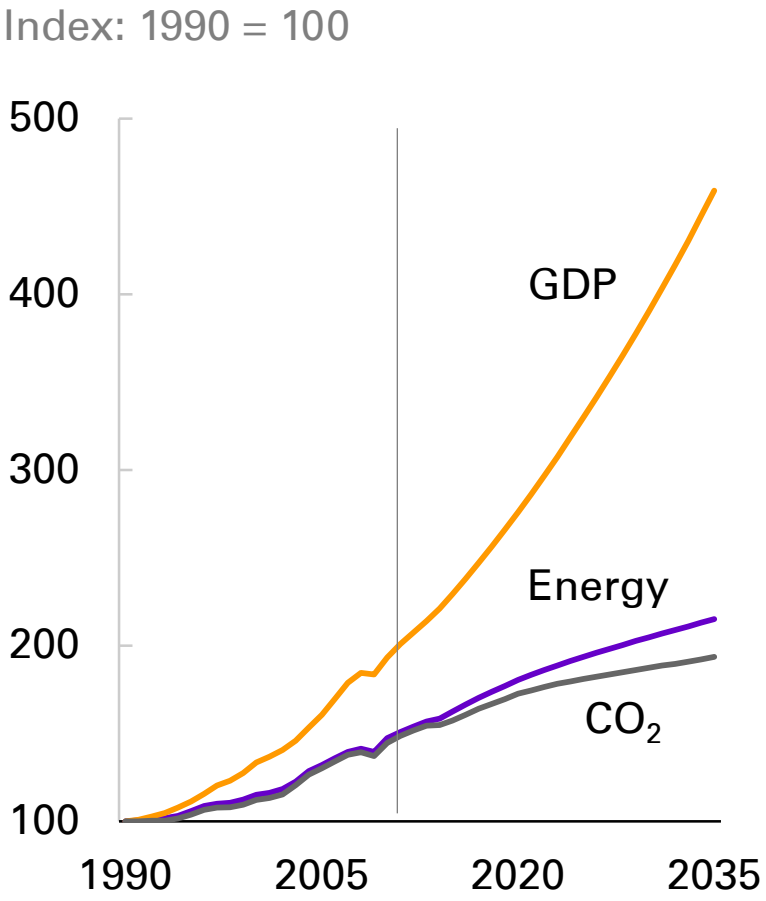


...and plays a key role in changing the energy mix

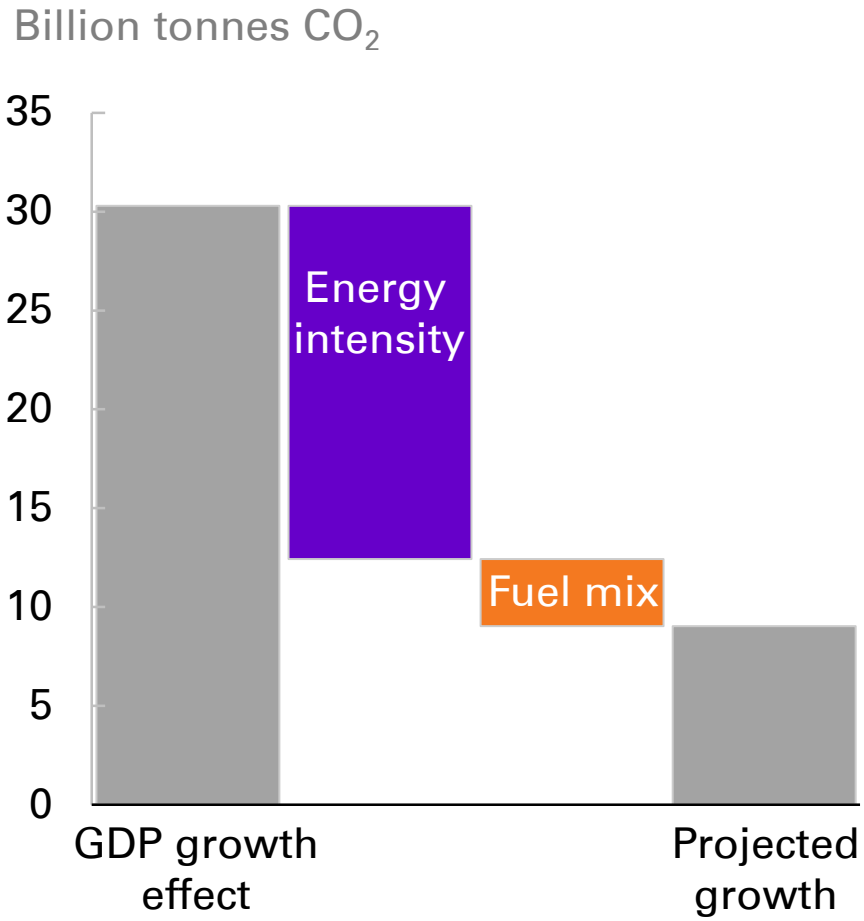
- Power generation is expected to account for an ever-increasing share of primary energy consumption as the world continues on a long-term trend of electrification: the share rises from 42% today to 47% by 2035.
- Power generation is the one sector where all fuels compete and so will play a major role in how the global fuel mix evolves.
- There have been some rapid shifts in fuel shares in power generation in the past: oil gaining in the 1960s and losing in the 1970s; nuclear picking up in the 1970s/80s and falling in the 2000s; gas rising through the 1990s and 2000s. In the Outlook, the largest shifts are the increase in the renewables share and the decline in the coal share.
- The outcome by 2035 is a more balanced and diversified portfolio of fuels for power generation. Coal remains the dominant fuel, accounting for more than a third of the inputs to power generation, but that share is down from 44% today and the gap between the shares of coal and of other fuels narrows significantly.

Energy efficiency restrains the growth of emissions…

GDP, energy and emissions



Emissions growth 2013 to 2035

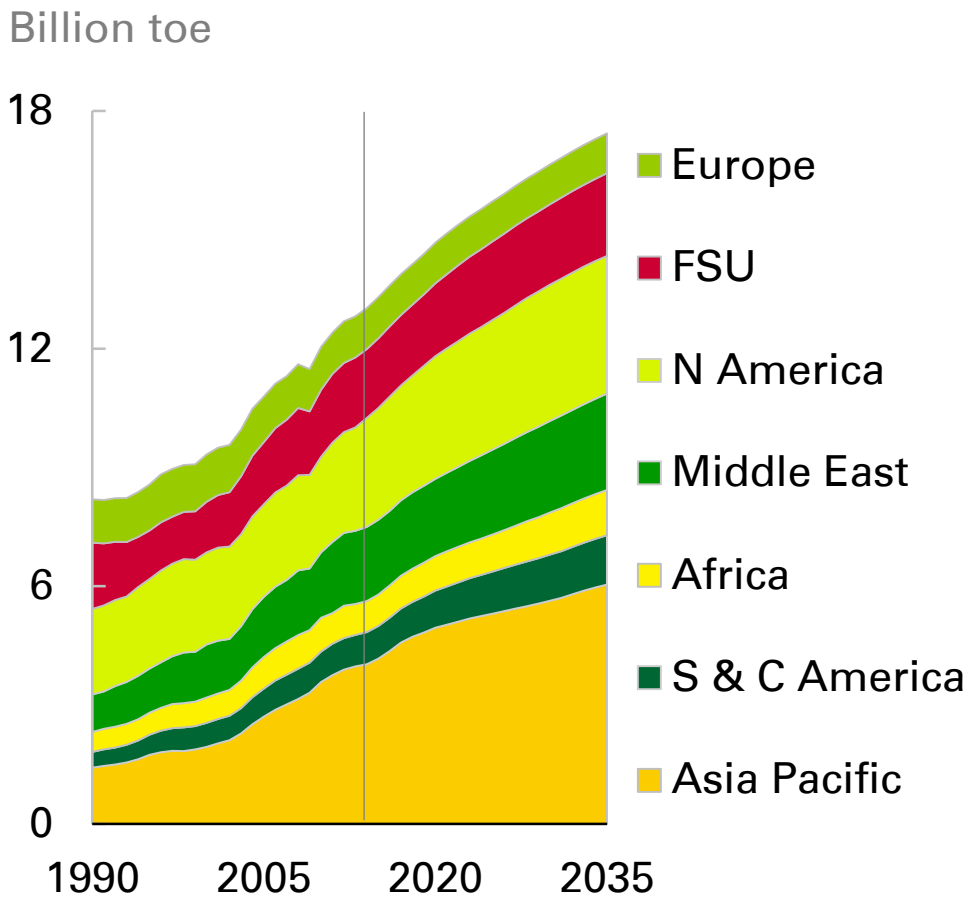


… but the changing fuel mix has only a modest impact

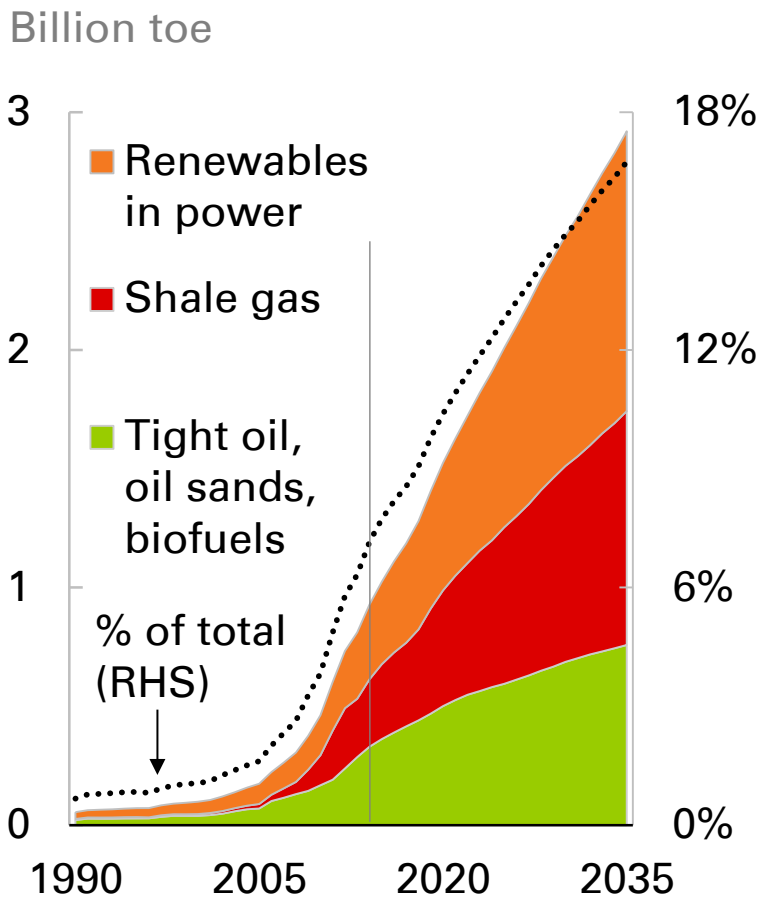
- Total carbon emissions from energy consumption increase by 25% between 2013 and 2035 (1% p.a.), with the rate of growth declining from 2.5% over the past decade to 0.7% in the final decade of the Outlook. Even so, the profile for emissions is well above that recommended by the scientific community (see pages 84-85).
- Continuing declines in energy intensity – the broadest indicator of improving energy efficiency across the economy – lead to a marked widening in the gap between GDP and energy consumption.
- Changes in the fuel mix – with the shares of gas and renewables increasing – also lead to a divergence between energy consumption and emissions, but this gap increases only gradually.
- Put differently, relative to a "no change" case: gains in energy efficiency lead to a far greater reduction in projected emissions than improvements in the fuel mix.

Energy supply is boosted by unconventional oil and gas ...

Primary energy production



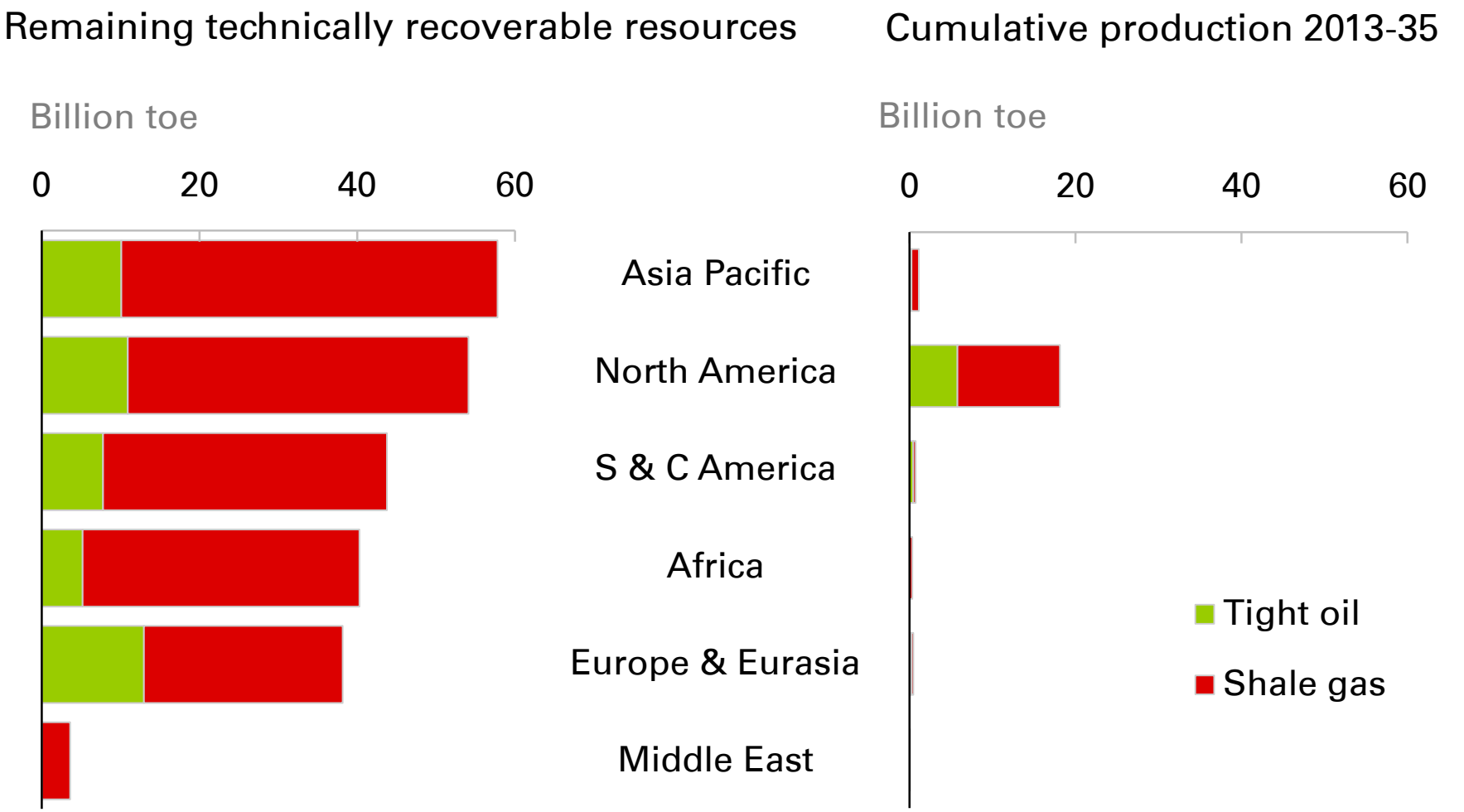
New energy forms



...and renewable power, all enabled by technology

- World primary energy production grows at 1.4% p.a. from 2013 to 2035, matching the growth of consumption.
- Growth is spread across all regions with the exception of Europe. South and Central America shows the fastest rate of growth (2.1% p.a.), while the largest increment comes from Asia Pacific, providing 45% of the increase in global energy production. North America is the second largest source of growth, and remains the second largest regional energy producer.
- New sources of energy, aided by improved technology and productivity, make a significant contribution to supply growth. Renewables, shale gas, tight oil and other new fuel sources in aggregate grow at 6% p.a. and contribute 45% of the increment in energy production to 2035.
- The growth of new energy forms has been enabled by the development of technology and underpinned by large-scale investments, and these conditions are assumed to continue over the Outlook.

Shale gas and tight oil resources are thought to be abundant…



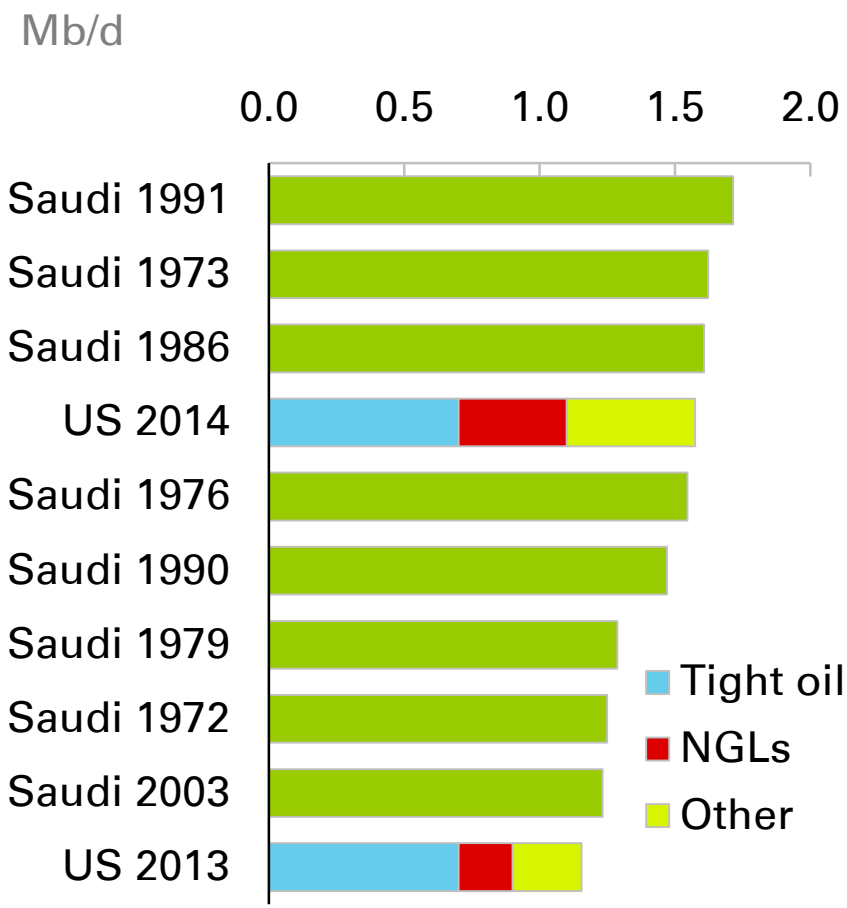
Source: Resources data © OECD/IEA 2014

…but production remains concentrated in North America

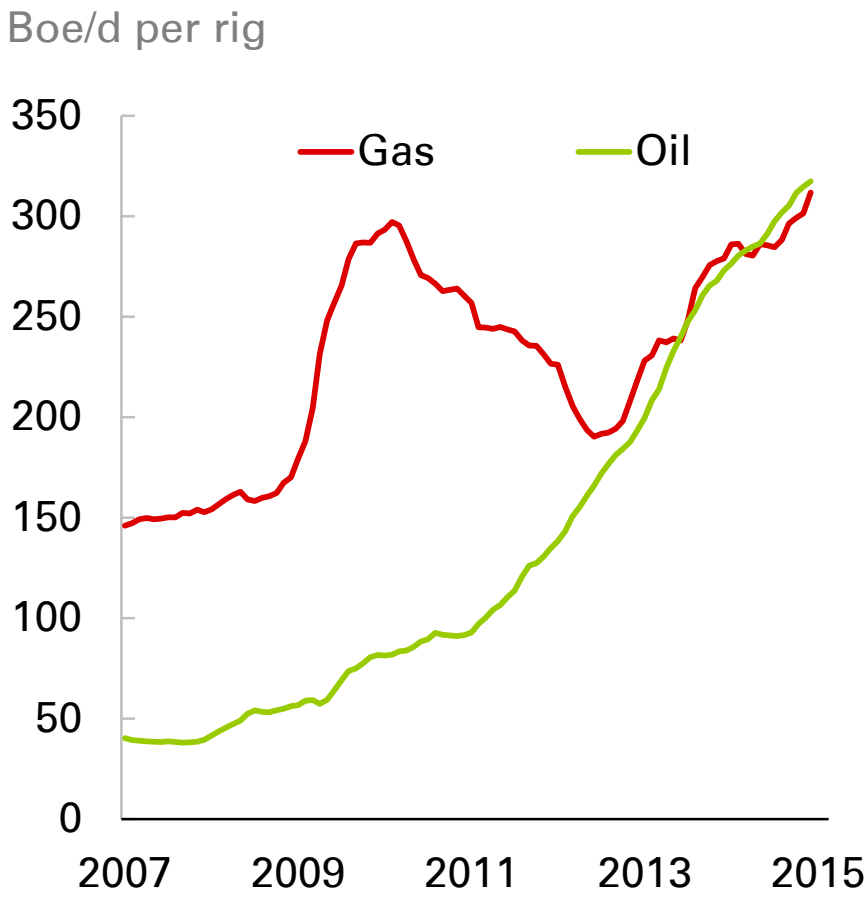
- Technological innovation and high oil prices have unlocked vast unconventional resources in North America, significantly increasing US oil and gas production and altering global energy balances.
- Technically recoverable resources are estimated to be around 340 billion barrels for tight oil and 7500 trillion cubic feet for shale gas globally. Asia has the largest resources, followed by North America.
- Although unconventional resources are spread across the globe, production is likely to remain concentrated in North America. Cumulative North American production of tight oil and shale gas between 2013-35 is roughly equivalent to 50% of tight oil and 30% of shale gas technically recoverable resources. The comparable numbers for the rest of the world are expected to be just 3% and 1% respectively.
- While production increases outside North America, the factors that have enabled the dramatic growth of North American production are unlikely to be quickly replicated elsewhere.

Drivers of tight oil and shale gas supply in the US…

Largest oil production increases



US new-well production per rig

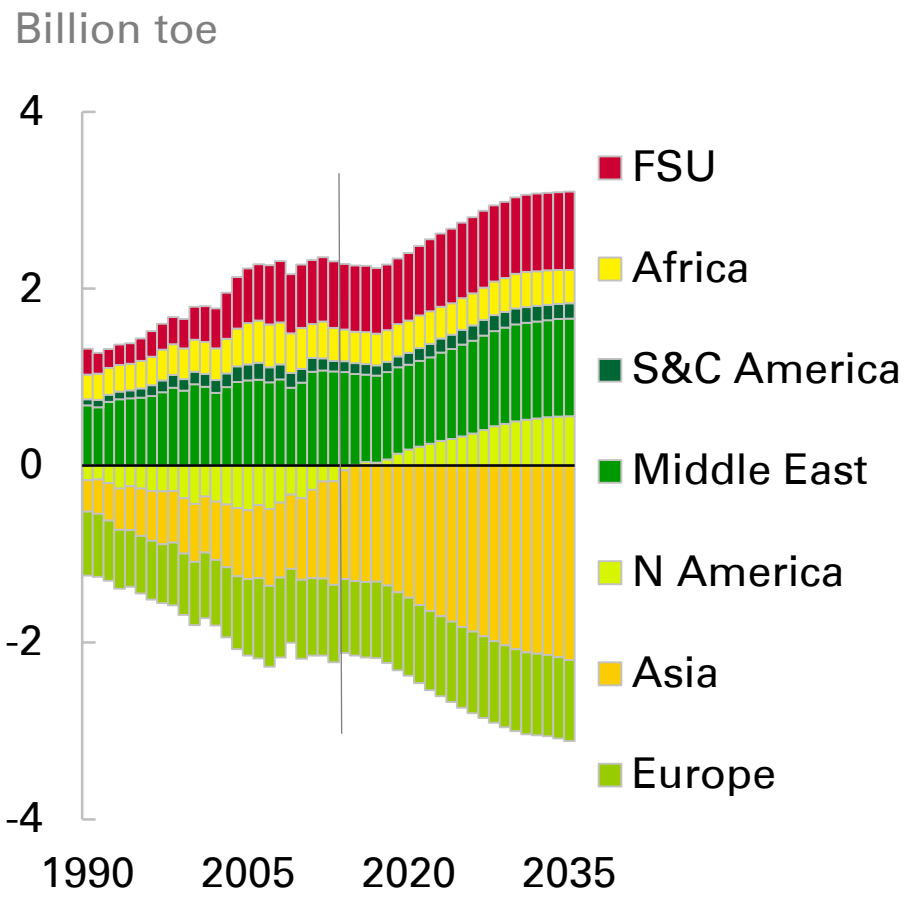


…include rapid growth of investment and significant innovation

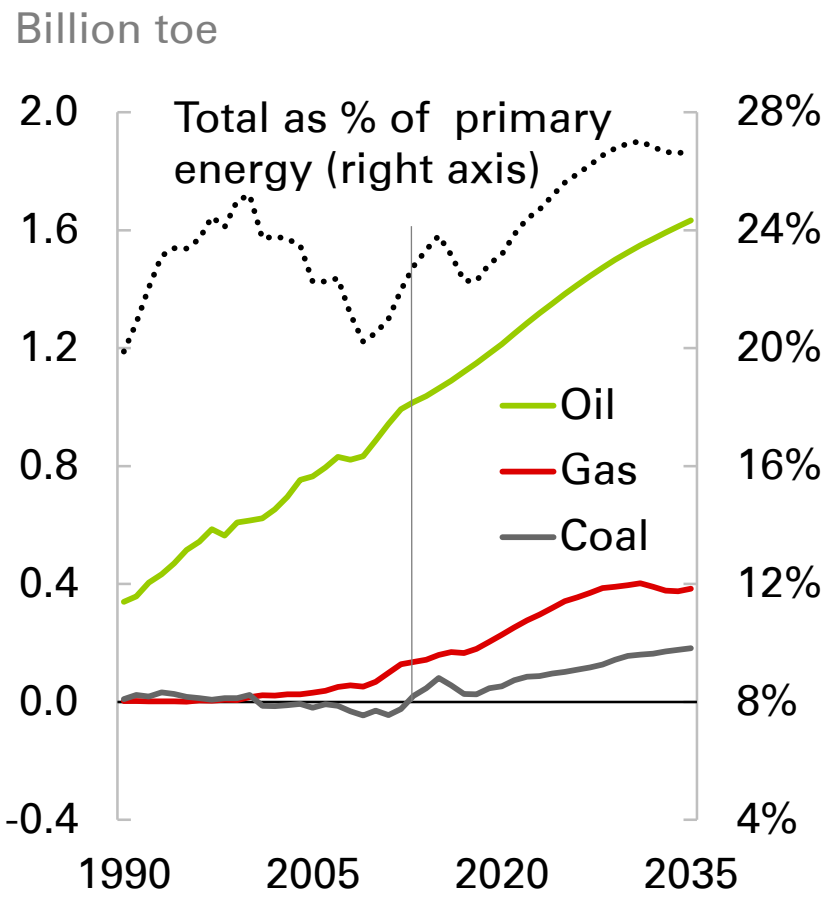
- US oil production growth in 2014 (roughly 1.5 Mb/d) was the largest in US history, driven by tight oil and NGLs (natural gas liquids). The increases in US production in recent years have been among the largest ever seen, with only Saudi Arabia recording larger annual production growth.
- Growth of US tight oil and shale gas has been supported by increasing investment and rapid technological innovation. Productivity, as measured by new-well production per rig, increased by 34% p.a. for oil and 10% p.a. for gas between 2007 and 2014.
- Growth in US tight oil is expected to flatten out in coming years, reflecting high well decline rates and less extensive resources than gas.
- In contrast, US shale gas production is expected to grow rapidly over the Outlook (4.5% p.a.), although growth rates moderate gradually.

The shifting geography of supply and demand…

Primary energy net balances



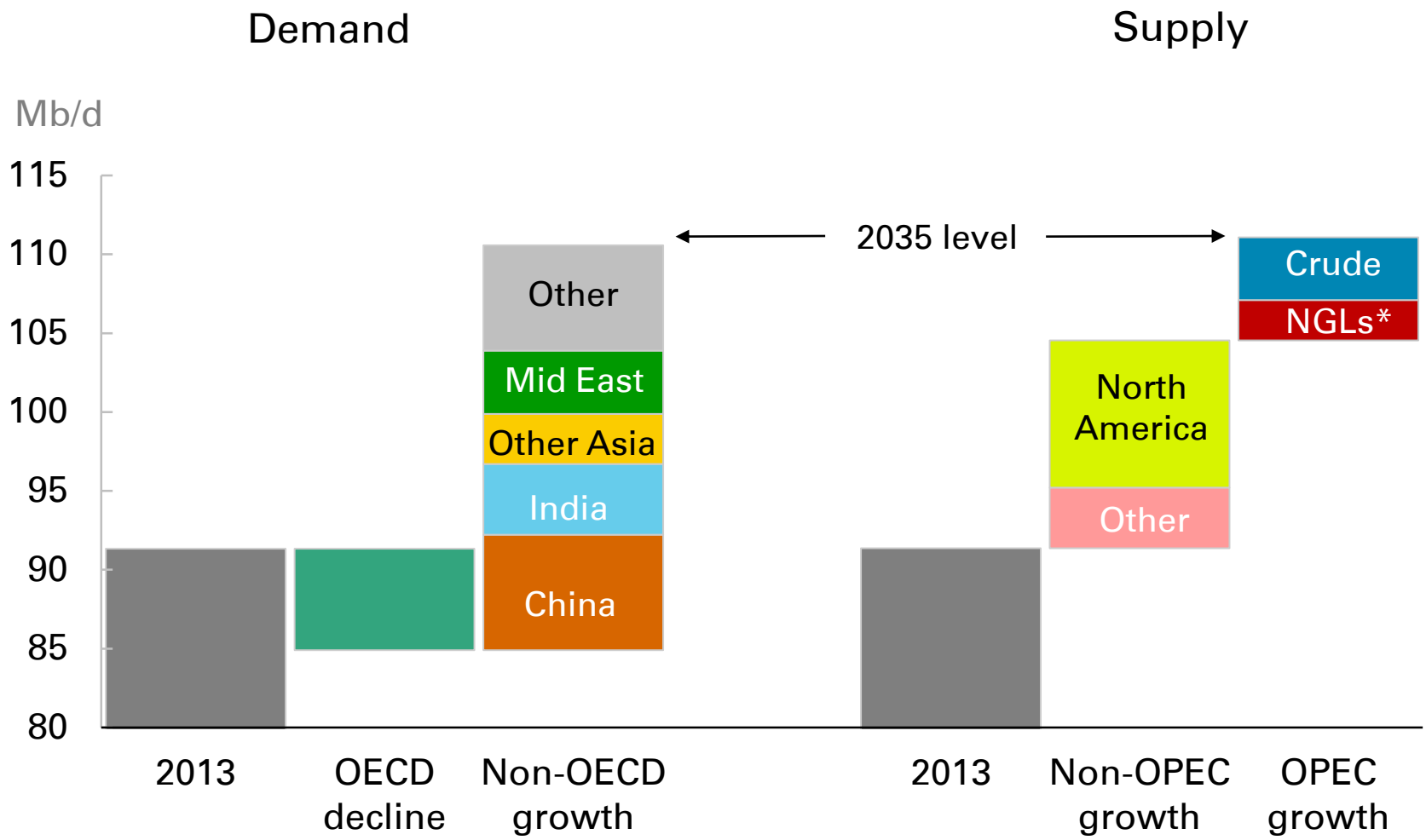
Asia's net imports of energy



...has big implications for energy trade

- Regional energy imbalances – production minus consumption for each region – are set to increase markedly over the next 20 years, with consequent implications for energy trade.
- North America switches from being a net importer of energy to a net exporter this year (2015). Asia's imports of energy continue to expand, accounting for around 70% of inter-regional net imports by 2035.
- Among exporting regions, the Middle East remains the largest net energy exporter, but its share falls from 46% in 2013 to 36% in 2035. Russia remains the world's largest energy exporting country.
- Asia's import dependency rises from 23% in 2013 to 27% by 2035. Oil accounts for 60% of that rise, with imports accounting for over 80% of Asian oil consumption by 2035. Asia's oil imports in 2035 are almost as large as OPEC's current entire oil production.

The global liquids balance reflects shifts…

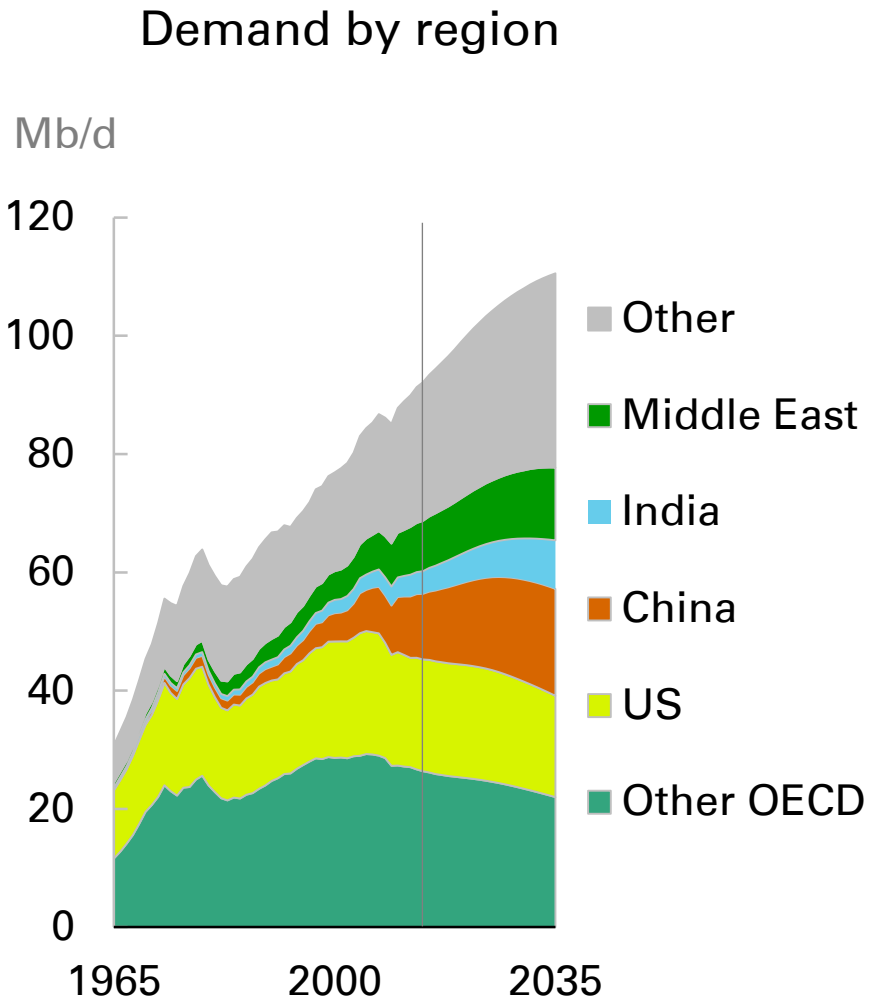


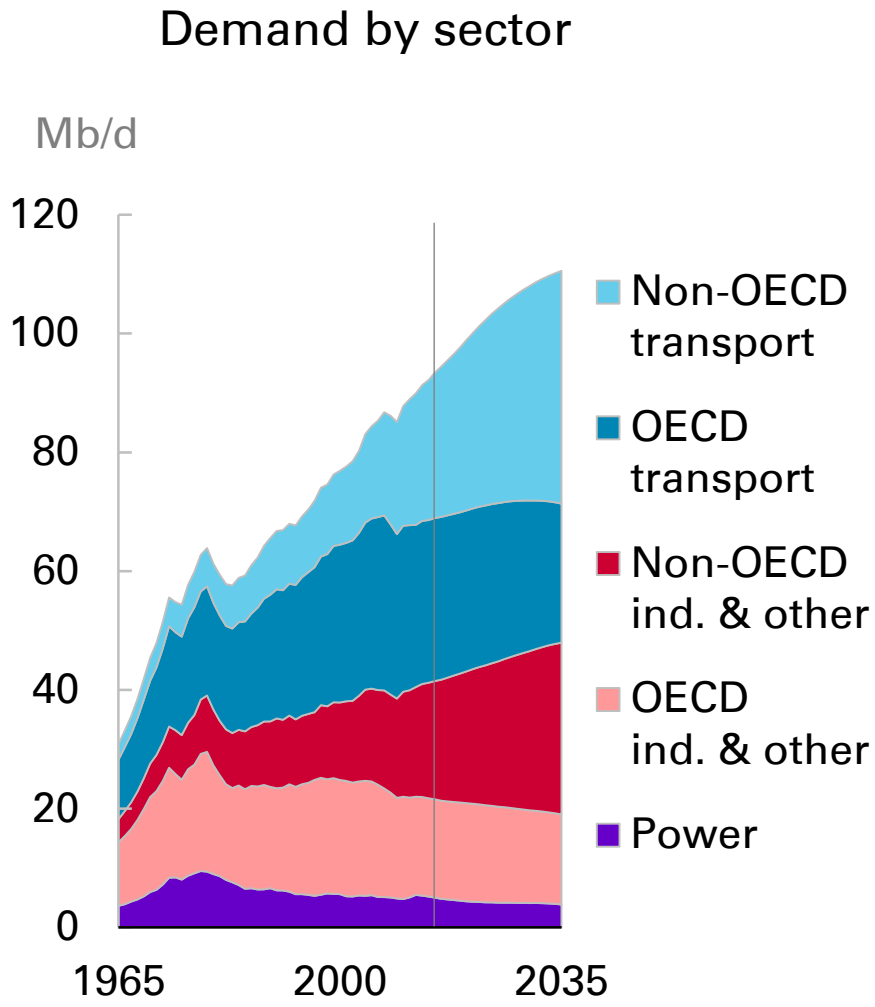
*Natural gas liquids including condensate

…in non-OECD demand and non-OPEC supply growth

- Global liquids demand (oil, biofuels, and other liquids) is projected to rise by around 19 Mb/d, to reach 111 Mb/d by 2035. Growth slows over the period: from 1.2% p.a. in 2013-20 to 0.7% p.a. for 2020-35.
- Demand growth comes exclusively from rapidly growing non-OECD economies. Non-OECD consumption reaches around 70 Mb/d by 2035 – 56% higher than in 2013. OECD demand peaked in 2005 and is expected to fall further (-6 Mb/d) to around 40 Mb/d in 2035, the lowest since 1986.
- The increased demand is met initially by supply from non-OPEC unconventional sources and, later in the Outlook, from OPEC. By 2035, non-OPEC supply is expected to have increased by 13 Mb/d, while OPEC production expands by 7 Mb/d.
- The largest increments of non-OPEC supply come from the US (6 Mb/d), Brazil (3 Mb/d), and Canada (3 Mb/d), which offset declines in mature provinces such as the North Sea. OPEC supply growth comes primarily from NGLs (3 Mb/d) and crude oil in Iraq (2 Mb/d).

Asia and the Middle East drive liquids demand growth…





Energy Outlook 2035

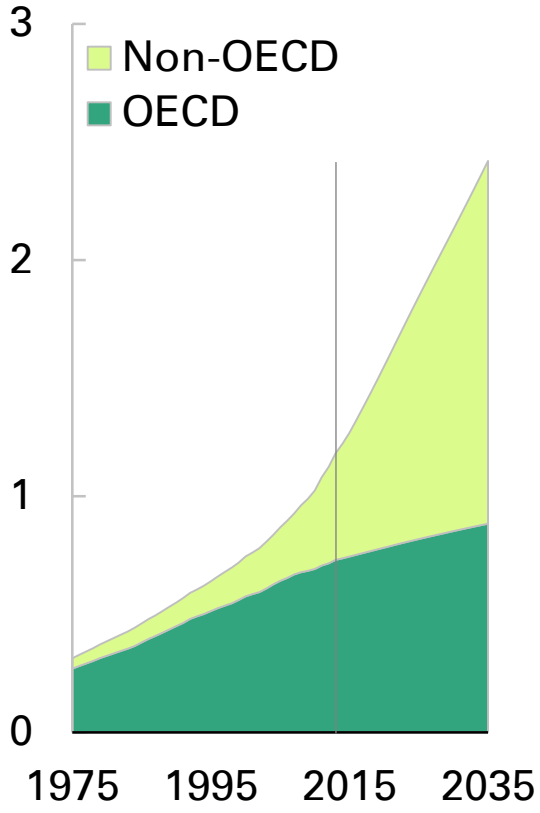
…with largest growth in transport followed by industry

- China is the largest contributor to world demand growth: growing by 7 Mb/d to 18 Mb/d in 2035, surpassing US demand (which falls by 2 Mb/d to 17 Mb/d). Even so, US consumption per capita is about 3.5 times greater than China in 2035.
- India is the second largest contributor, growing by more than 4 Mb/d, followed by the Middle East with 4 Mb/d. India overtakes China as the largest source of demand growth towards the end of the Outlook.
- Non-OECD demand growth stems primarily from transport (16 Mb/d) – reflecting a rapid increase in vehicle ownership – and industry (8 Mb/d) largely for petrochemicals. OECD consumption in both sectors declines.
- By sector, transport accounts for about 55% of total liquids demand. It contributes 64% of the total demand increment to 2035, but growth slows post 2020, due to efficiency improvements and a modest displacement by natural gas and electricity. Industry has the fastest growth rate (1.2% p.a.) driven by petrochemicals.

Vehicle numbers are likely to grow rapidly…

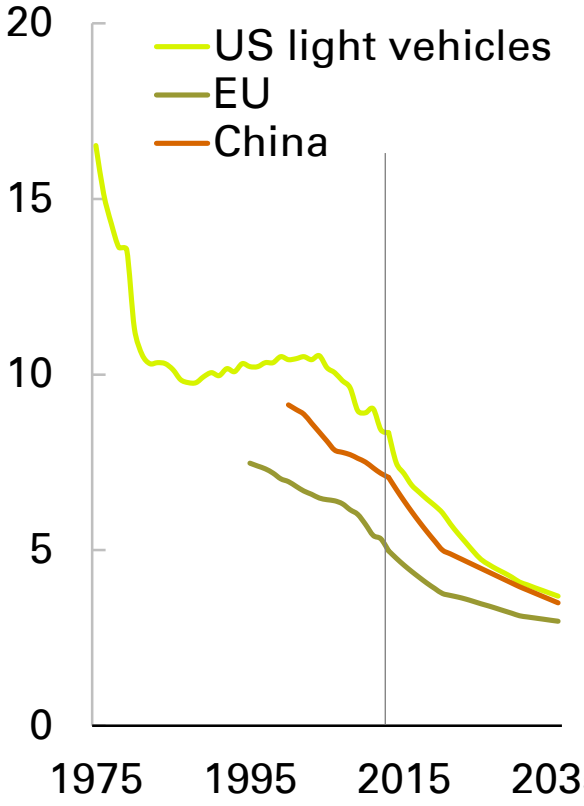
Vehicle fleet

Billions of vehicles



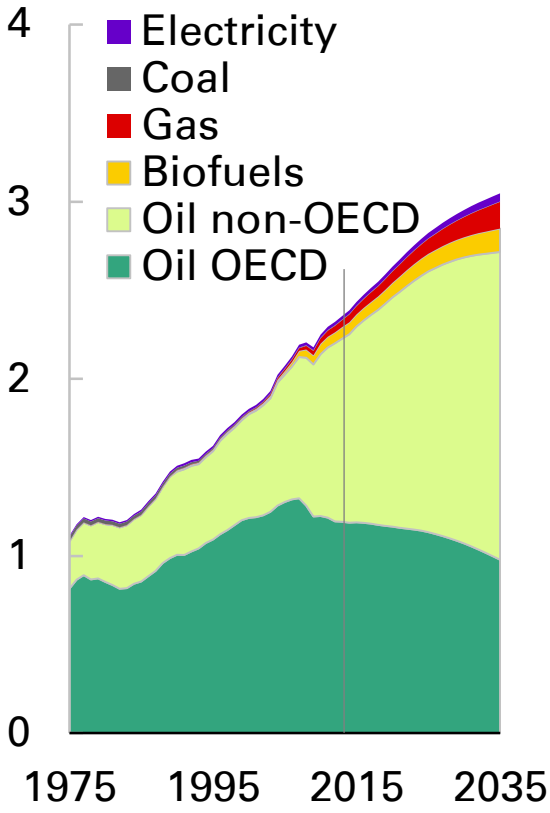
Fuel economy of new cars

Litres per 100 km*



Transport demand

Billion toe



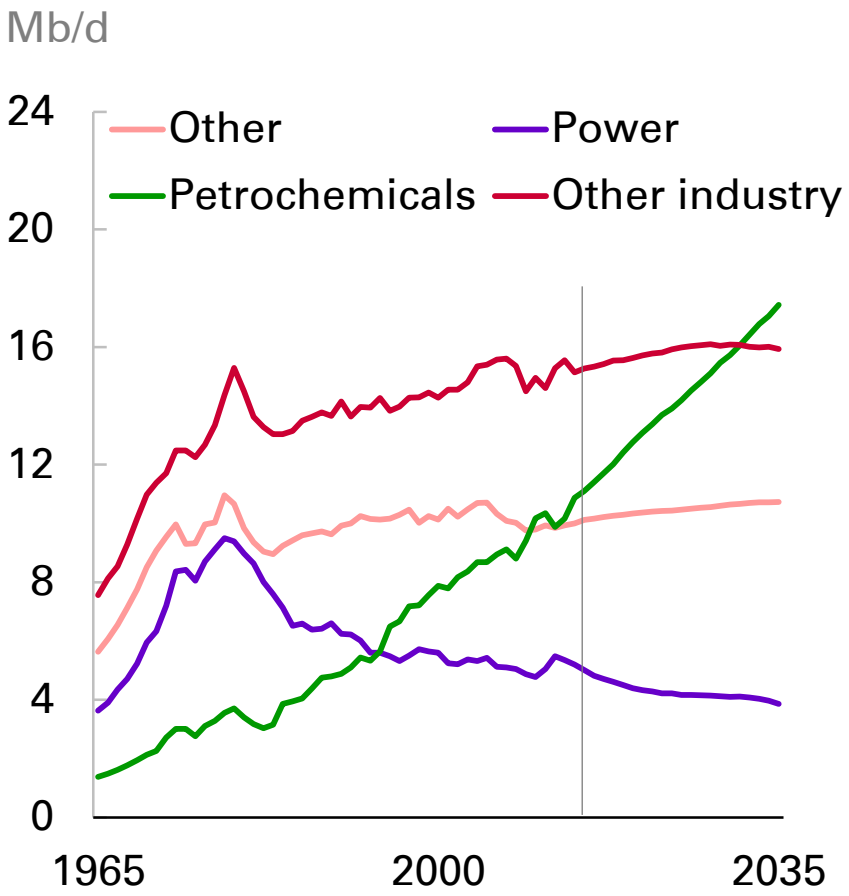
*New European Driving Cycle

…but efficiency improvements limit growth in fuel demand

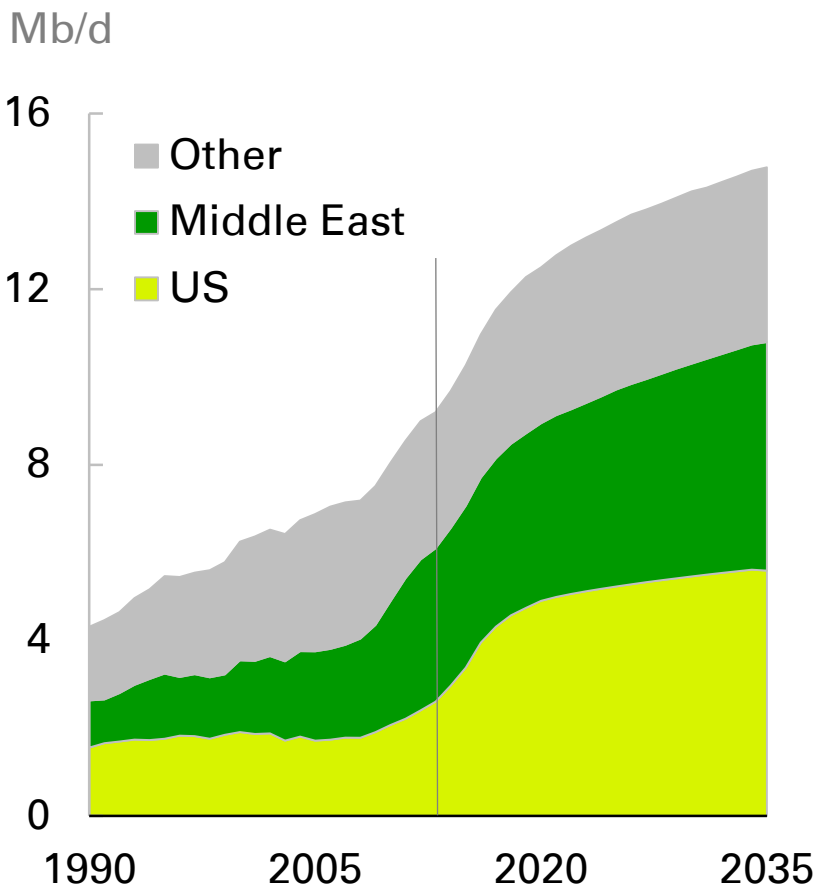
- The global vehicle fleet (commercial vehicles and passenger cars) more than doubles from around 1.2 billion today to 2.4 billion by 2035. Most of that growth is in the developing world (88%), while some OECD markets are already at saturation levels.
- Fuel economy has improved in recent years, driven by consumer choice, tightening policy (e.g. CO_2 emissions limits in Europe and CAFE standards in the US), and improved technology. Efficiency gains are likely to accelerate over the Outlook, with vehicle fleet fuel economy forecast to improve by 2.1% p.a. between 2013 and 2035, having improved by about 1.5% p.a. over the past decade.
- Efficiency gains limit growth in transport fuel demand. Transport demand rises by only around 30%, despite a more than doubling of the vehicle fleet.
- Transport fuel demand continues to be dominated by oil (89% in 2035), but the share of non-oil alternatives increases from 5% in 2013 to 11% in 2035, with natural gas the fastest growing transport fuel (6.3% p.a.).

Petrochemicals are the other key driver of oil demand…

Oil demand outside of transport



NGLs production by region

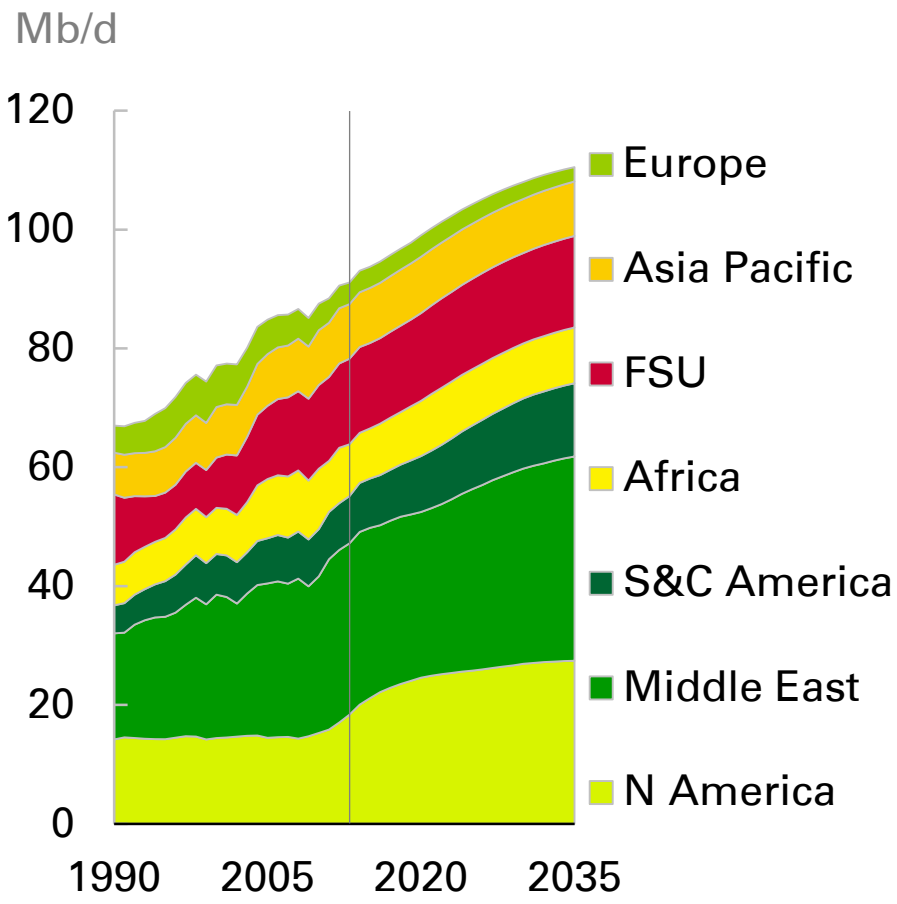


... aided by strong growth in NGLs supplies

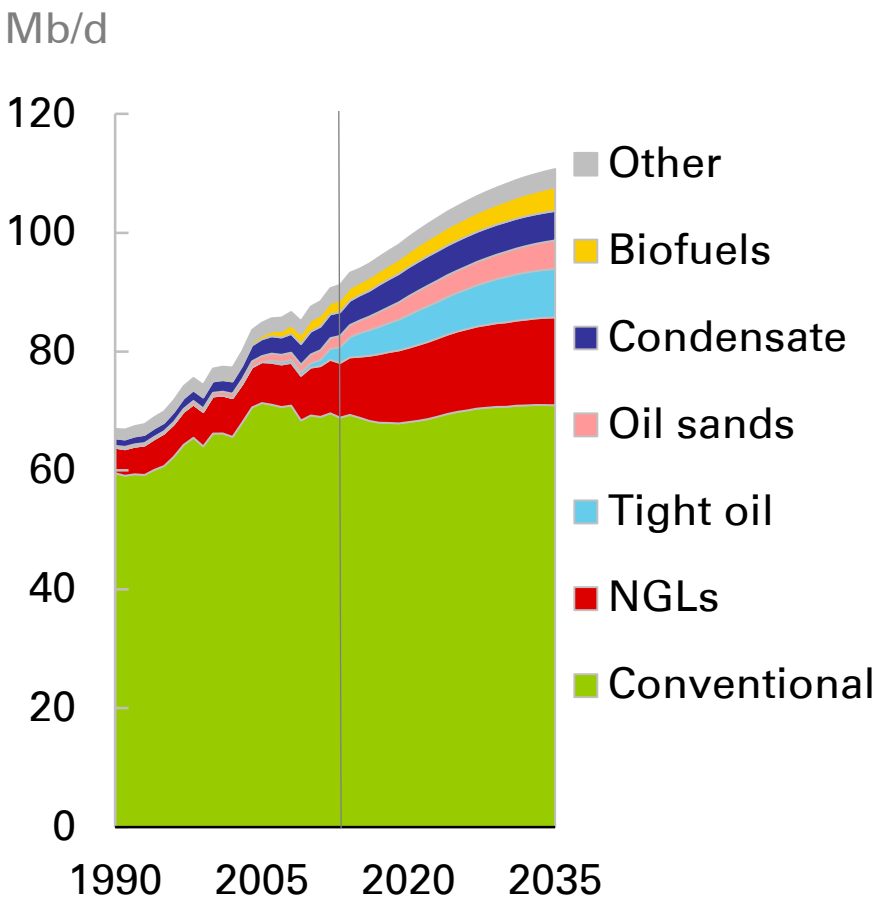
- Since the oil price shocks of the 1970s, the use of oil outside of transport has been concentrating in petrochemicals, where there is limited scope for substitution by cheaper fuels.
- Oil demand in petrochemicals increases by 2.5% p.a. (7 Mb/d) between 2013 and 2035. This continued strong growth reflects the use of oil as a feedstock, for which there are limited alternatives and little scope for efficiency gains. This is reinforced by strong growth in supplies of NGLs which are particularly well suited as a feedstock. By 2035, petrochemicals account for more than half of industrial oil demand.
- Growth in the supply of NGLs stems primarily from the US (3 Mb/d) and the Middle East (2 Mb/d). This growth is strongest in the next decade, prompting a surge in petrochemicals demand in the US as well as continued growth in the Middle East and non-OECD Asia.
- Outside of petrochemicals and transport, oil demand is expected to be broadly stagnant, as the effects of GDP growth are offset by efficiency gains and displacement by relatively cheaper gas and coal.

North American supply drives growth initially…

Liquids supply by region



Liquids supply by type

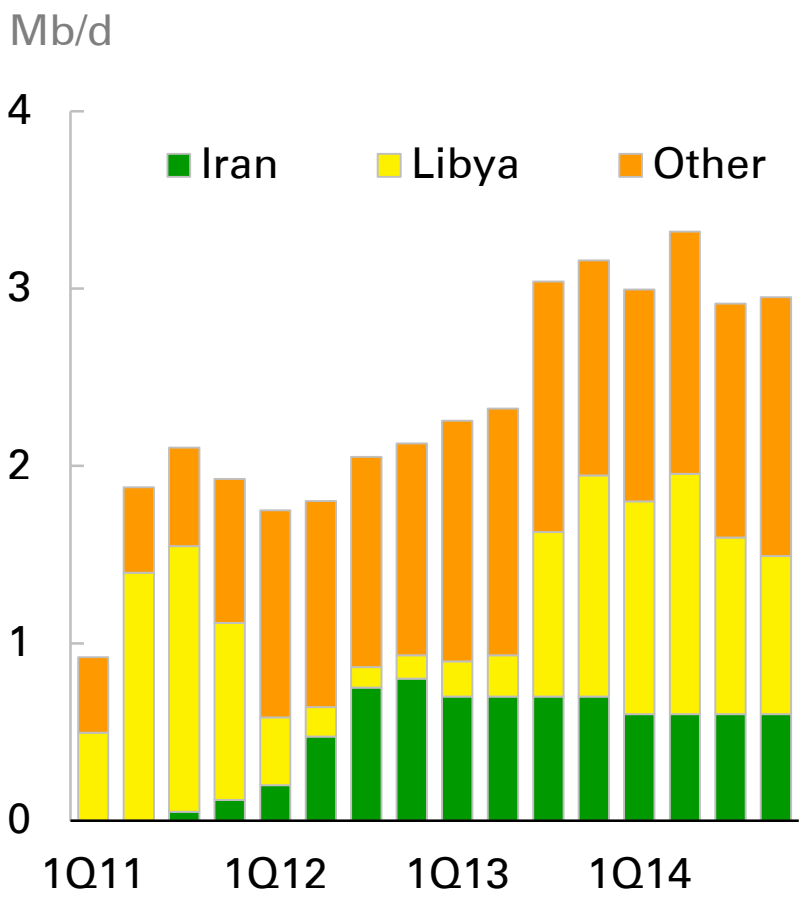


…before Middle East supply growth increases

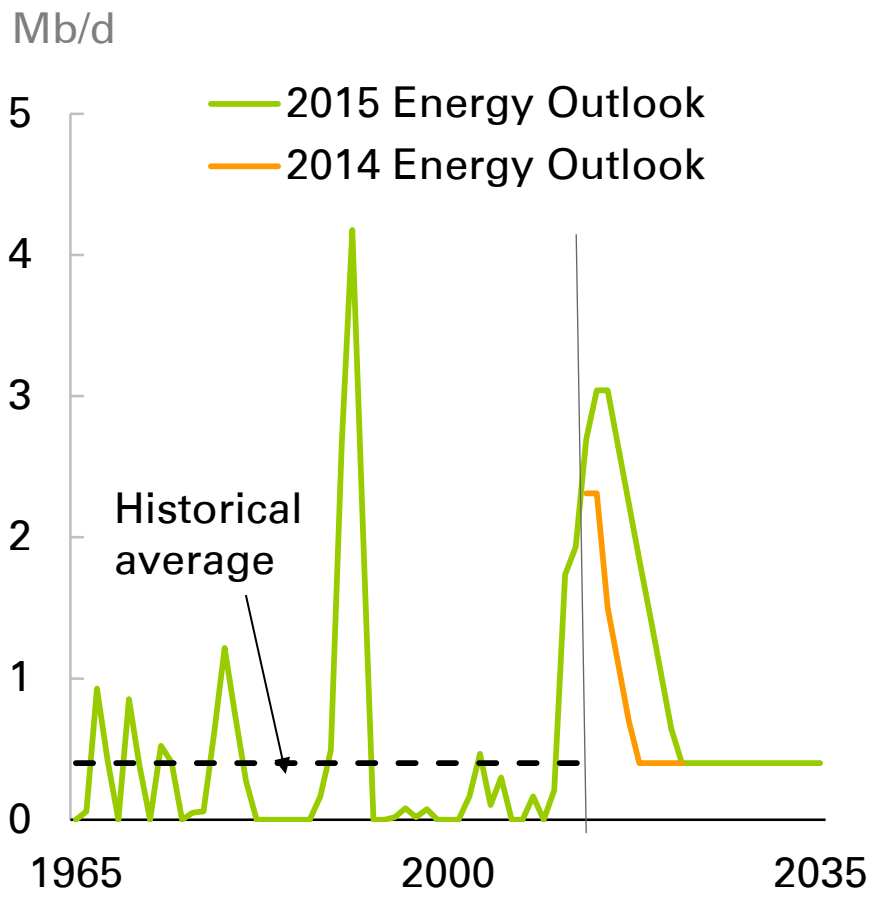
- Liquids supply expands by almost 20 Mb/d by 2035, led by growth in North America during the early part of the Outlook, before the Middle East gains ground during the latter part.
- North American production expands by 9 Mb/d by 2035, with growth concentrated in the first half of the Outlook. North American growth comes from tight oil, NGLs, and oil sands. Outside of North America, South and Central American production expands by 4 Mb/d by 2035, largely due to Brazil.
- Middle East production expands after 2020, as North American growth slows. Middle East output increases by a little over 5 Mb/d by 2035.
- Conventional crude production is broadly flat and nearly all of the growth comes from other sources (tight oil, NGLs, biofuels and oil sands). By 2035, NGLs and tight oil provide 13% and 7% of global supply, respectively.

Significant supply disruptions…

Recent supply disruptions



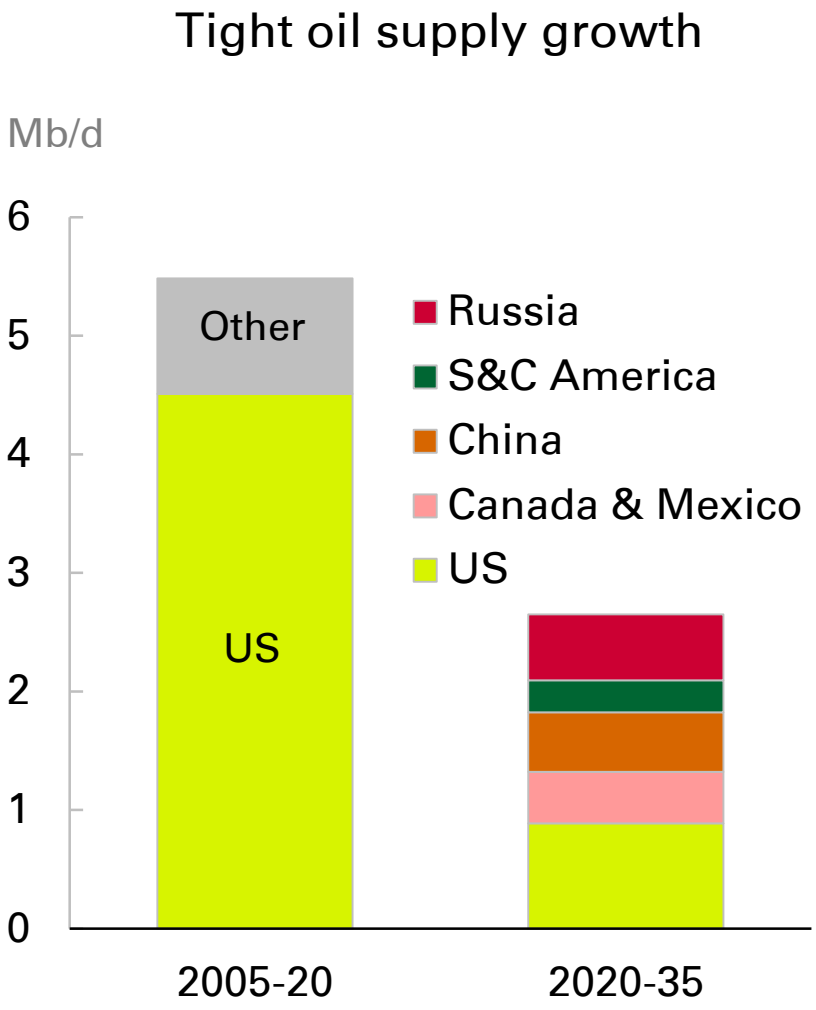
Projected disruptions

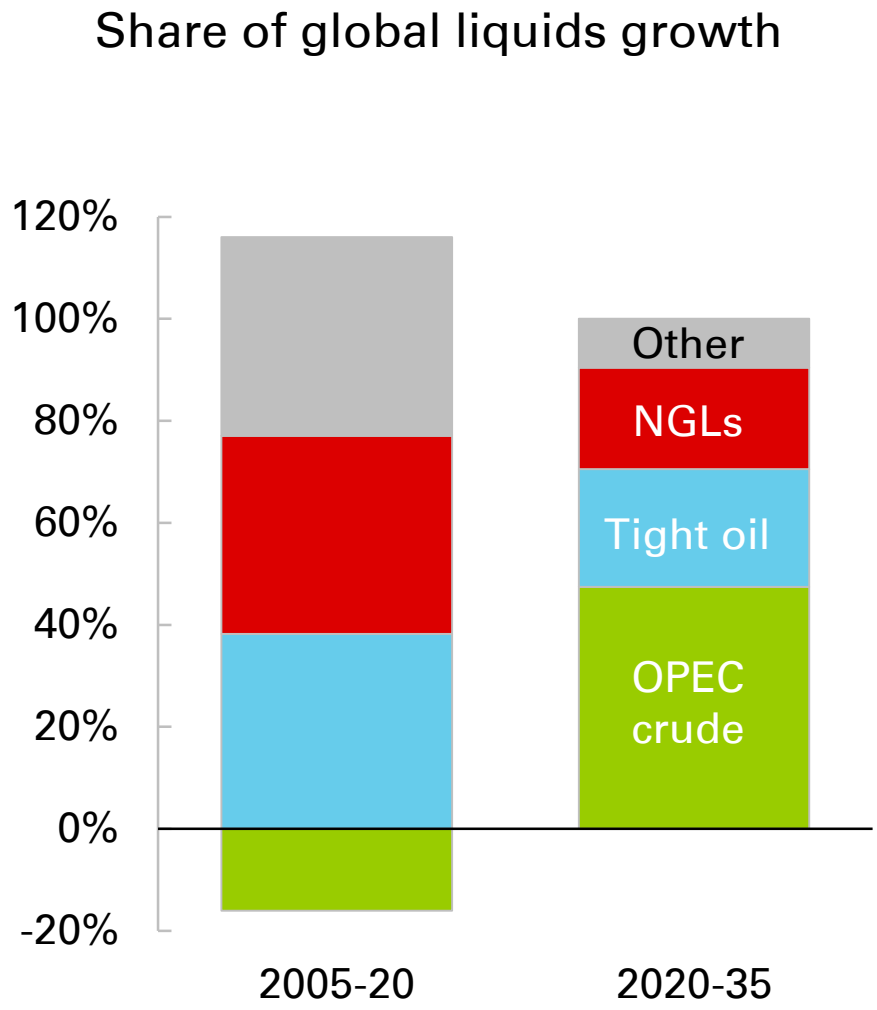


… are likely to be a durable factor

- Since the advent of the Arab Spring in 2011, supply disruptions have once again become a key feature in oil markets, reaching 3 Mb/d in 2014. Libyan production fluctuated throughout the year, civil war limited output from Syria, unrest continued in Nigeria, the Sudans and Yemen, and international sanctions on Iran limited output.
- Total supply disruptions in 2014 were well above the historical average of roughly 400 Kb/d. The historical high for supply disruptions of a little over 4 Mb/d was reached in 1991, as a result of the Iraq-Kuwait war and the collapse of the Soviet Union.
- Heightened levels of geopolitical risk and uncertainty suggest that supply disruptions may well remain elevated through the medium-term. Accordingly, we have increased the size and duration of our provision for supply disruptions compared with our previous Outlook (see also the discussion of geopolitical risks on pages 88-89).

Tight oil remains a disruptive force in the near term…



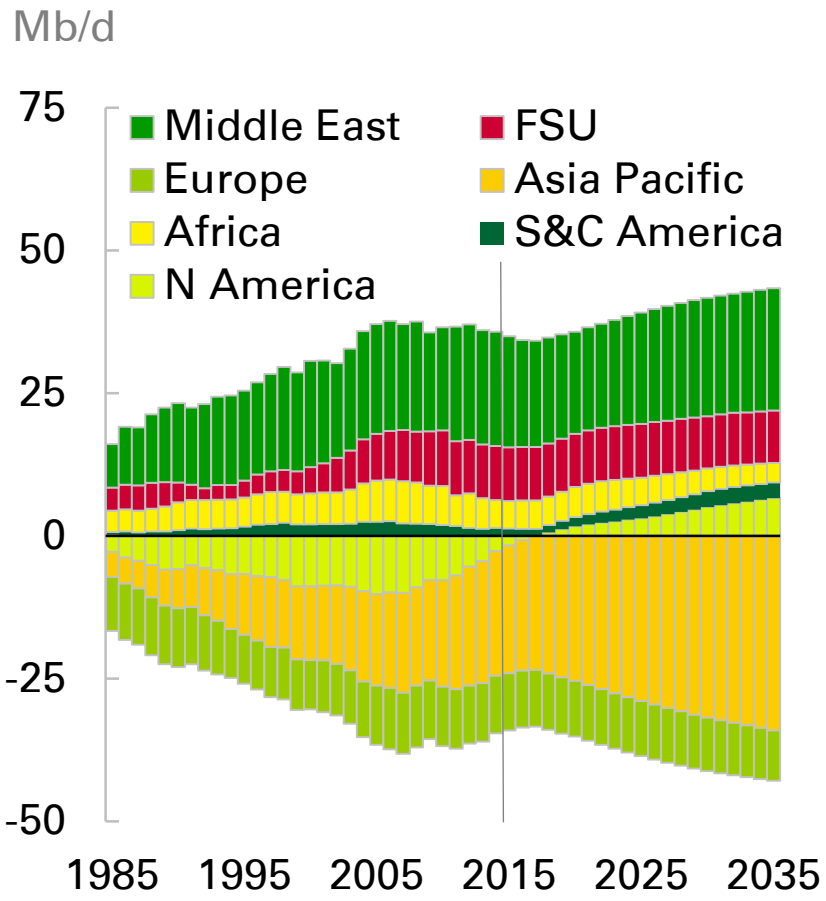


…but the market rebalances in later years

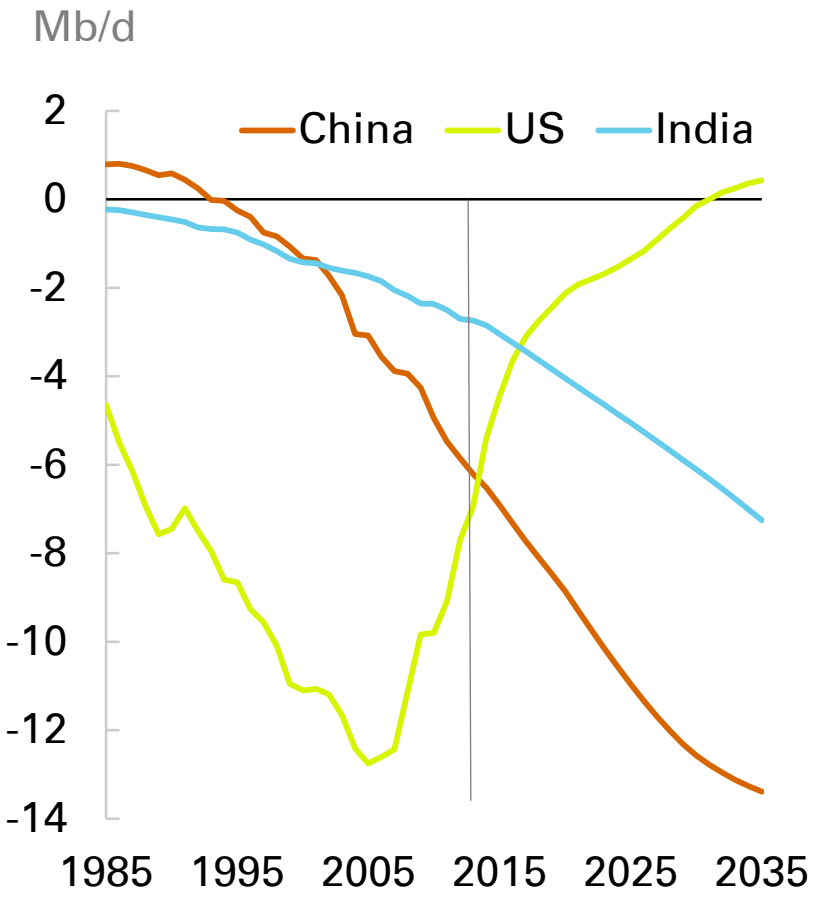
- Tight oil supply, notably in the US, continues to grow in the first part of the Outlook. US tight oil output grows by about 3 Mb/d between 2013-35 and accounts for around two-thirds of global tight oil production in 2035.
- The strength of tight oil and the relative weakness of demand have reduced the market requirement for OPEC crude in recent years. This pressure on OPEC is likely to persist in the early years of the Outlook and the response of OPEC to this reduction is a key uncertainty.
- Further out, as tight oil supply growth slows and demand strengthens, the call on OPEC crude begins to increase, exceeding the historical high (32 Mb/d in 2007) by 2030.
- OPEC's market share by the end of the Outlook is around 40%, similar to its average of the past 20 years.

Oil trade patterns change…

Regional net imbalances



Net exports



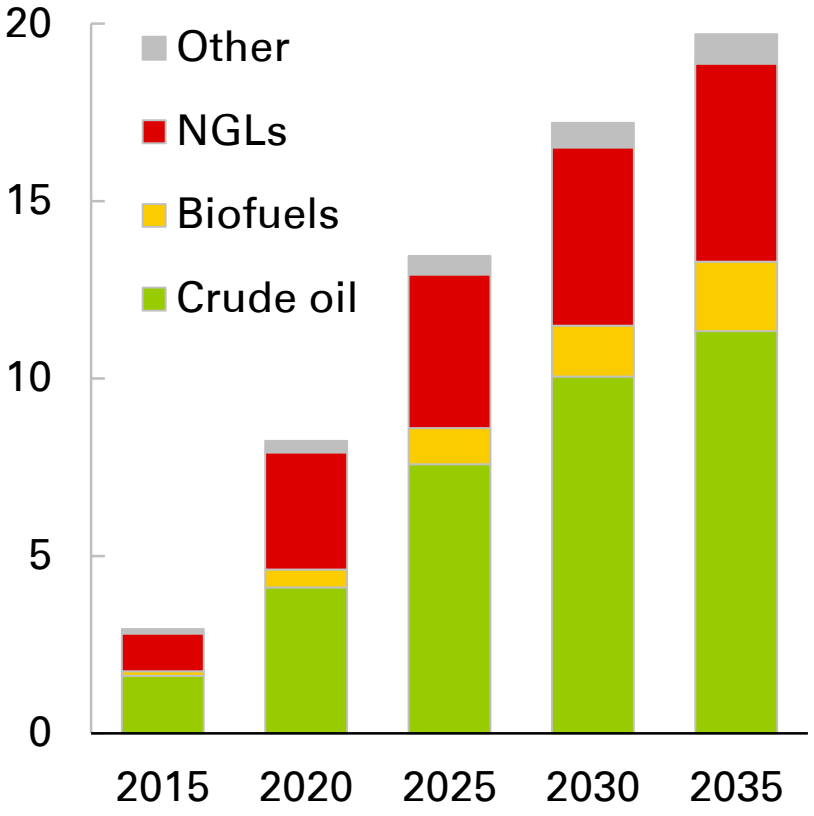
… as Asia's imports grow and the US becomes self-sufficient

- Regional trade imbalances increase and become more concentrated. In particular, Asia's imports account for nearly 80% of inter-regional net imports of oil by 2035, up from around 60% today. The Middle East's share of inter-regional net exports falls from 55% in 2013 to a touch below 50% by 2035. North America becomes a net oil exporter over the next few years.
- In the US, the increase in tight oil production coupled with declining demand transform its reliance on oil imports. Having imported well over 12 Mb/d – 60% of its total demand – in 2005, US is set to become self-sufficient by the 2030s.
- China's import requirement more than doubles to around 13 Mb/d, accounting for around three-quarters of its total oil consumption. China surpasses the US as the largest consumer of liquid fuels by the end of the Outlook.
- India's import requirements also grow rapidly, with imports accounting for almost 90% of its total oil demand by 2035.

Refiners are challenged by alternative supplies…

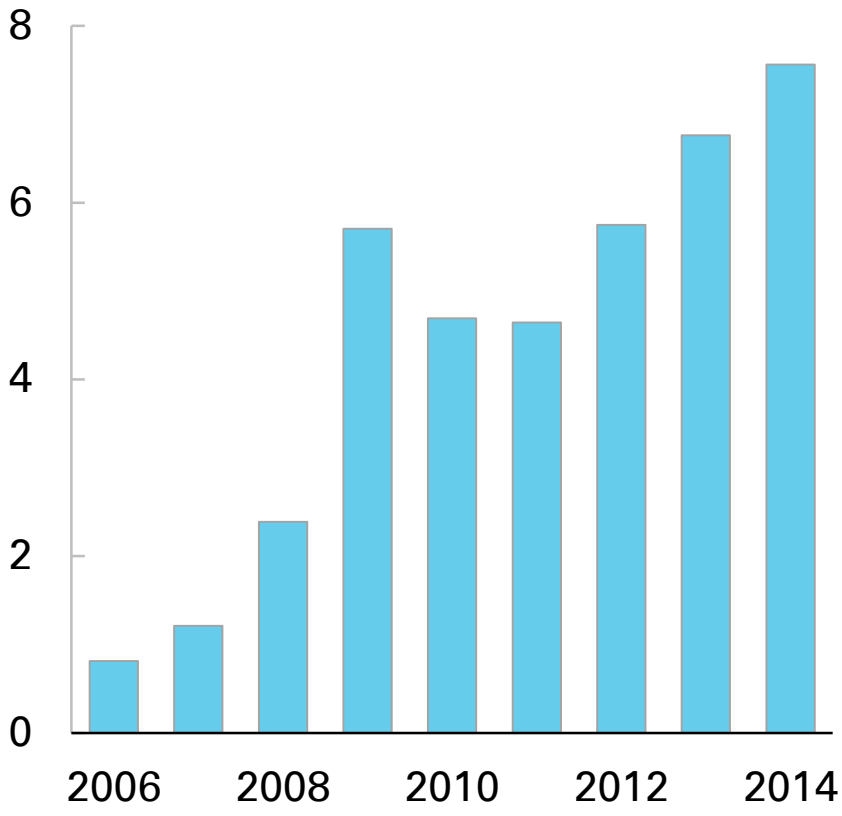
Global liquids supply growth

Mb/d, cumulative from 2013



Growth in refining spare capacity

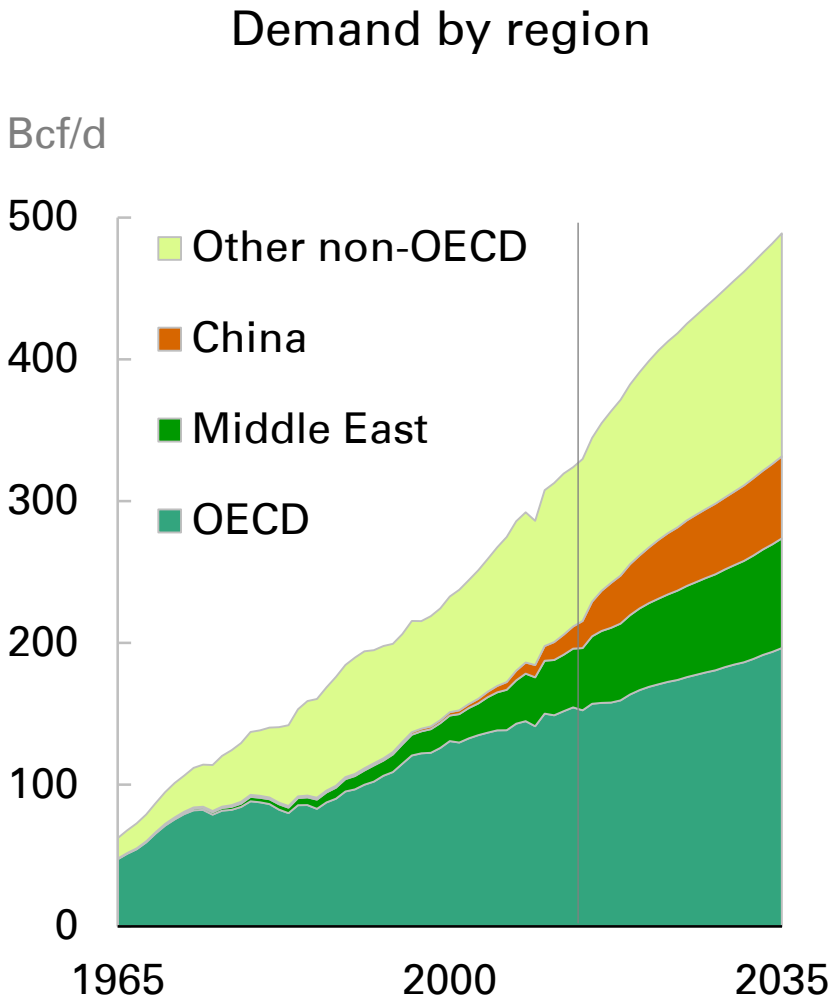
Mb/d, cumulative from 2005

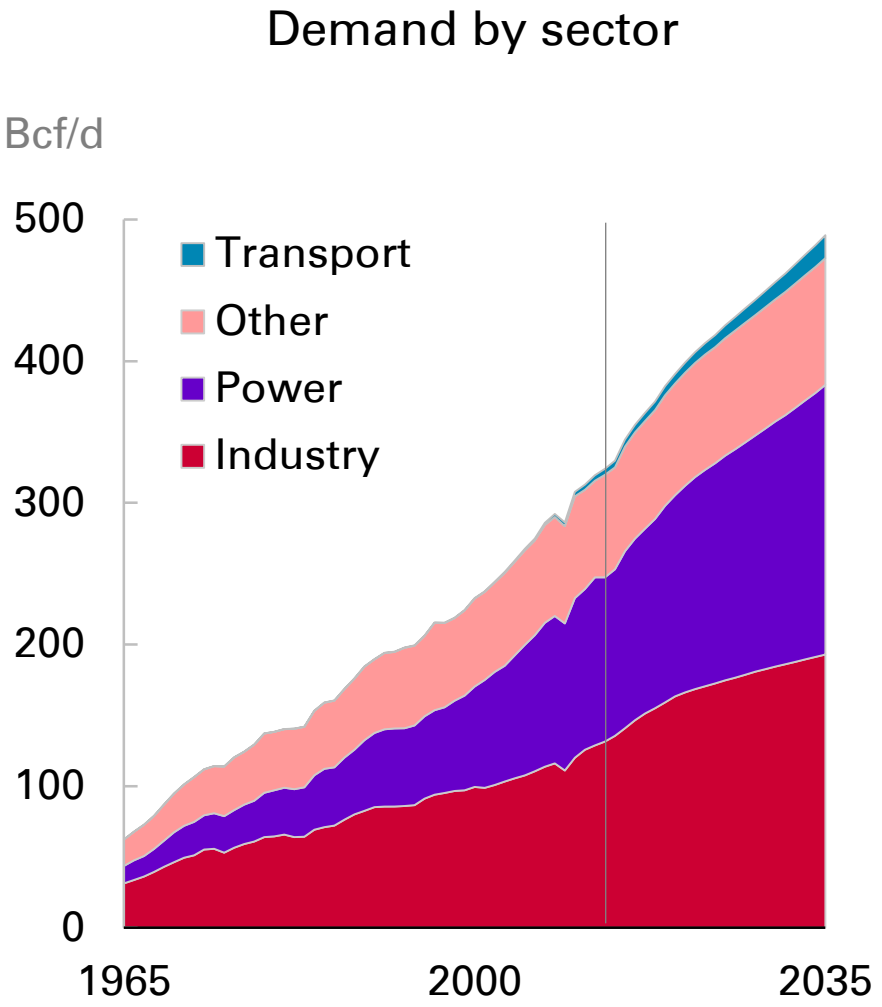


... and already ample spare capacity

- Of the 20 Mb/d increase in the supply of liquids to 2035, about 8 Mb/d comes from NGLs, biofuels and other liquids that do not require refining.
- China's demand for liquids grows by 7 Mb/d to 2035. If they follow the pattern of the past two decades, Chinese crude runs will grow by a similar amount, leaving crude run growth outside China of only 4 Mb/d over more than 20 years.
- Global spare refining capacity is already 7 Mb/d above its recent low (2005) and, in recent years, a net 1 Mb/d additional capacity has been added each year.
- This Outlook therefore suggests a long period of volatile margins, with large capacity reductions required in disadvantaged refining centres.

Non-OECD leads the growth in natural gas demand…



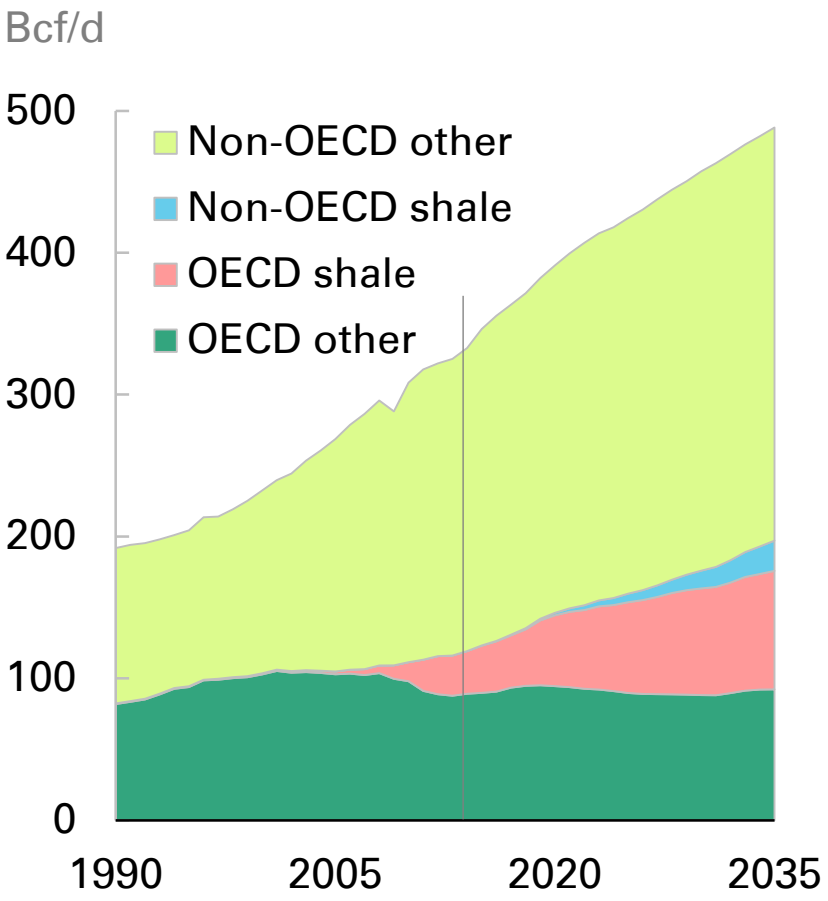


…with increasing usage in power and industrial sectors

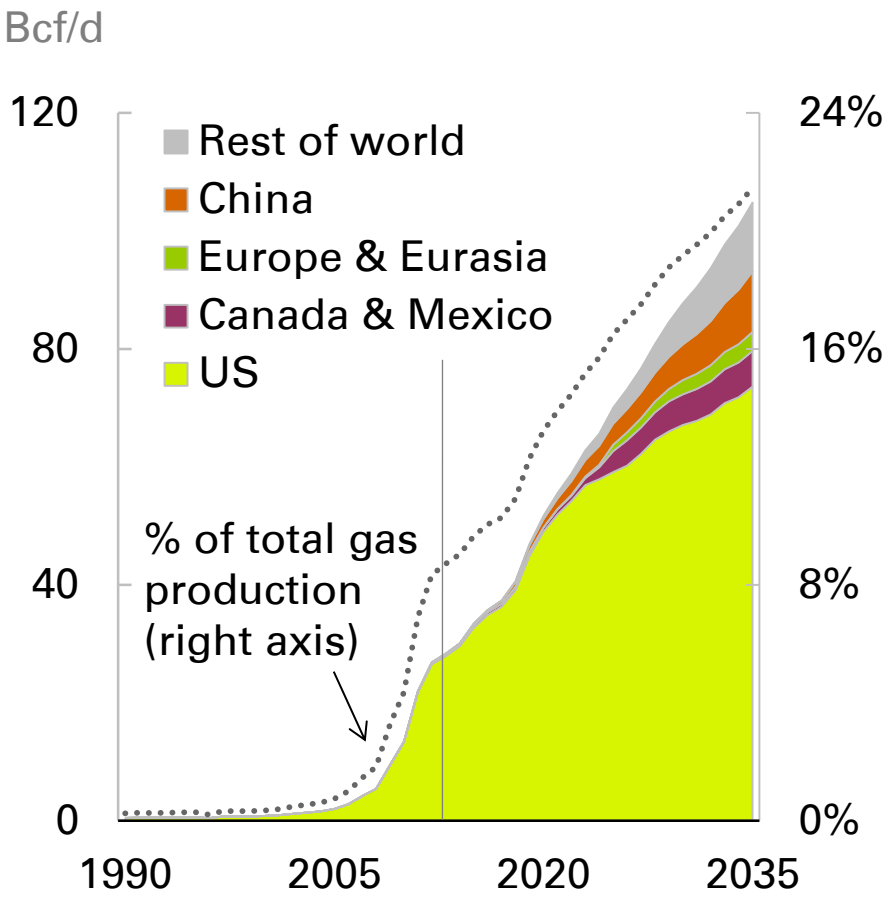
- Global natural gas demand is expected to grow by 1.9% p.a. over the Outlook, reaching around 490 Bcf/d by 2035.
- Growth is driven by non-OECD demand, which grows 2.5% p.a., adding 123 Bcf/d. OECD grows more modestly (1.1% p.a.), adding 42 Bcf/d.
- Increased usage by the power and industrial sectors account for over 80% of total demand growth, with power showing the largest gain of 75 Bcf/d (2.3% p.a.), followed by industry (61 Bcf/d, 1.8% p.a.).
- In the non-OECD, power and industry add almost 50 Bcf/d each to demand. In the OECD, growth in power sector demand (25 Bcf/d) is more than twice that of industry (12 Bcf/d).
- Transport is the fastest growing sector, albeit from a very small base, with its share of total natural gas consumption rising to 3% by 2035.

Non-OECD also provides the largest supply increment…

Gas production by type and region



Shale gas production

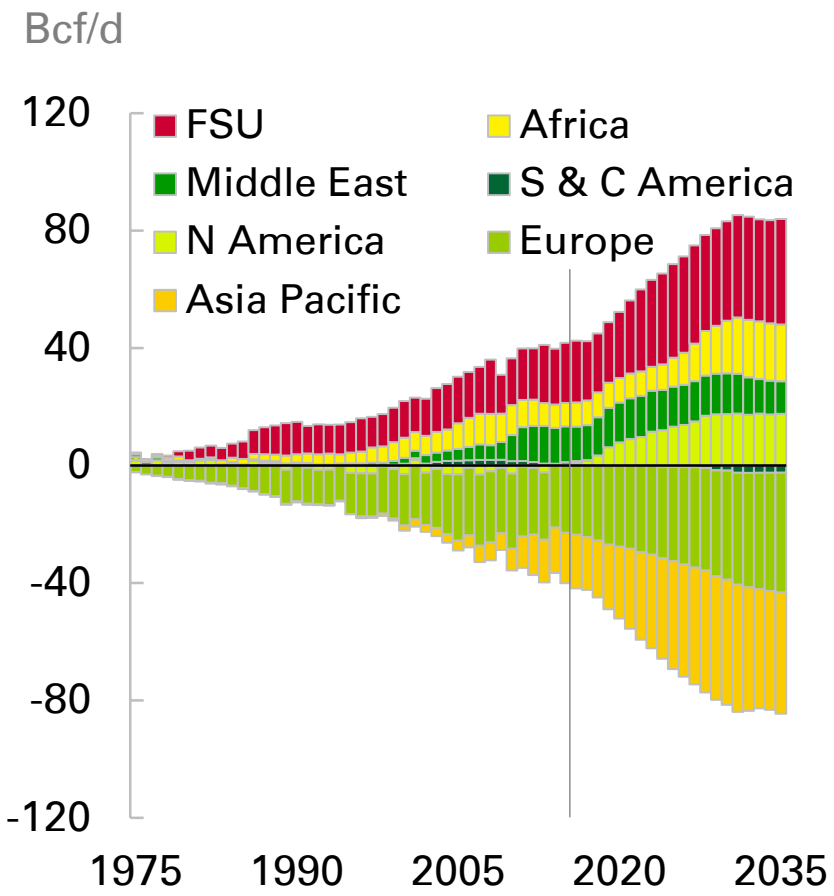


…while OECD shale gas has the fastest growth

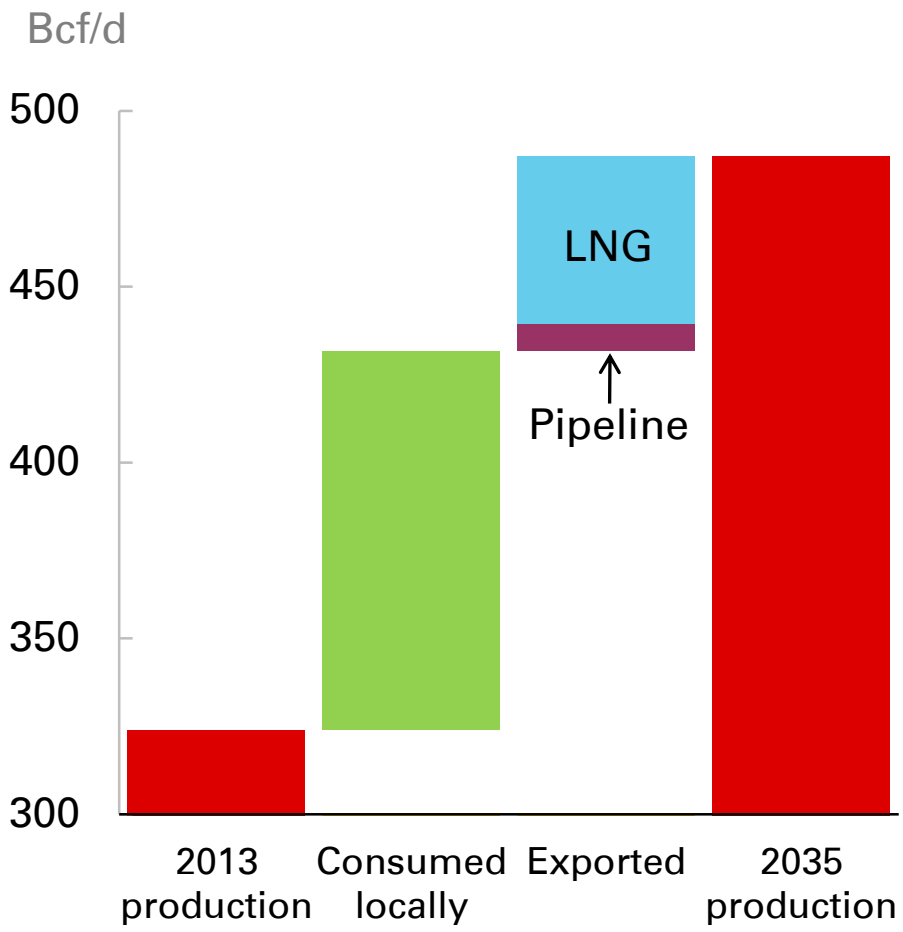
- Around half of the increase in global gas supply comes from non-OECD conventional gas (82 Bcf/d or 1.5% p.a.), driven in particular by the Middle East and Russia. Almost 80% of non-OECD growth is from non-shale sources.
- OECD shale gas grows much faster at 5% p.a., adding 52 Bcf/d and accounting for around a third of the increase in global gas supply to 2035.
- Shale gas production is dominated by North America, which currently accounts for nearly all of shale gas supply and continues to account for around three-quarters in 2035.
- However, growth in shale gas outside North America accelerates and by the 2030s overtakes North American growth (in volume terms). China is the most promising country outside North America, accounting for 13% of the increase in global shale gas. By the end of the Outlook, China and North America account for around 85% of global shale gas production.

Regional imbalances increase significantly…

Regional net imbalances



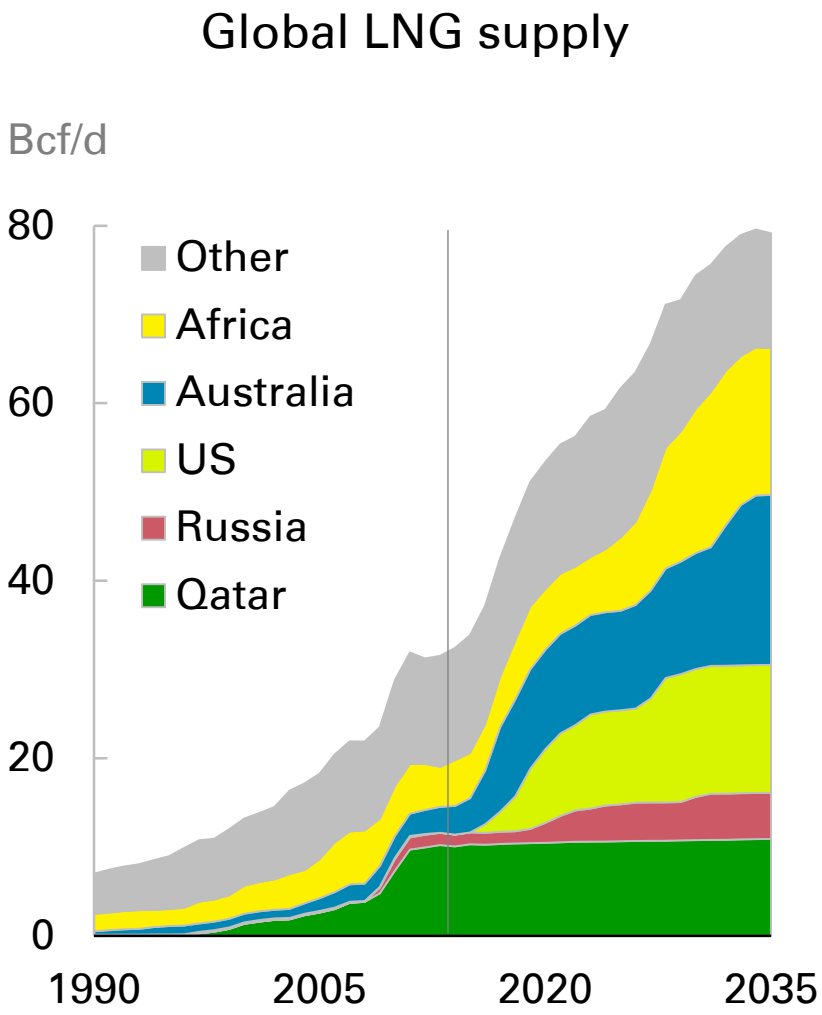
Production and trade growth

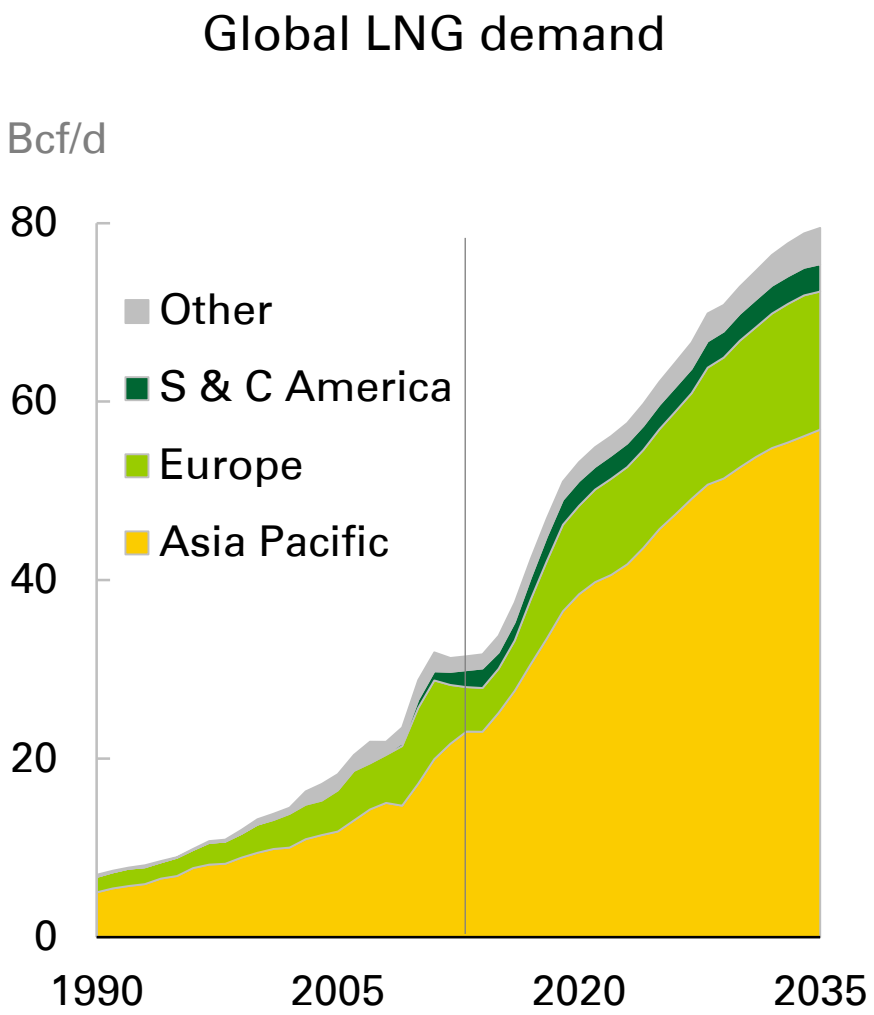


…with Asia overtaking Europe as the key importing region

- Net inter-regional imbalances more than double by 2035. Growth in gas traded across regions accounts for around a third of the increase in total gas consumption.
- The expansion of trade is driven by Asia Pacific, where net imports nearly triple and account for almost 50% of global gas net imports by 2035. Asia Pacific overtakes Europe as the largest net importing region in early 2020s. The growth of shale gas means North America will switch from being a net importer to a net exporter in the next few years.
- A vast majority (87%) of the increase in gas traded across regions reflects increased supplies of LNG (liquefied natural gas). Pipeline supplies grow much more slowly with new pipelines being commissioned from Russia and Central Asia.

LNG supply is poised for a growth spurt…





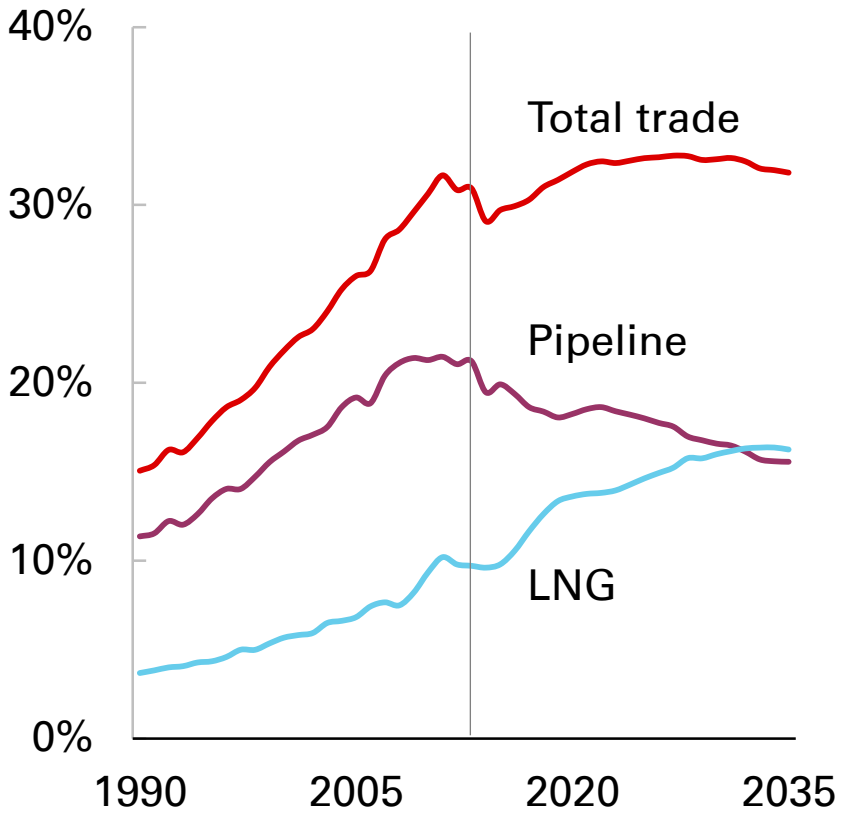
Energy Outlook 2035

…supporting the expansion of Asian imports

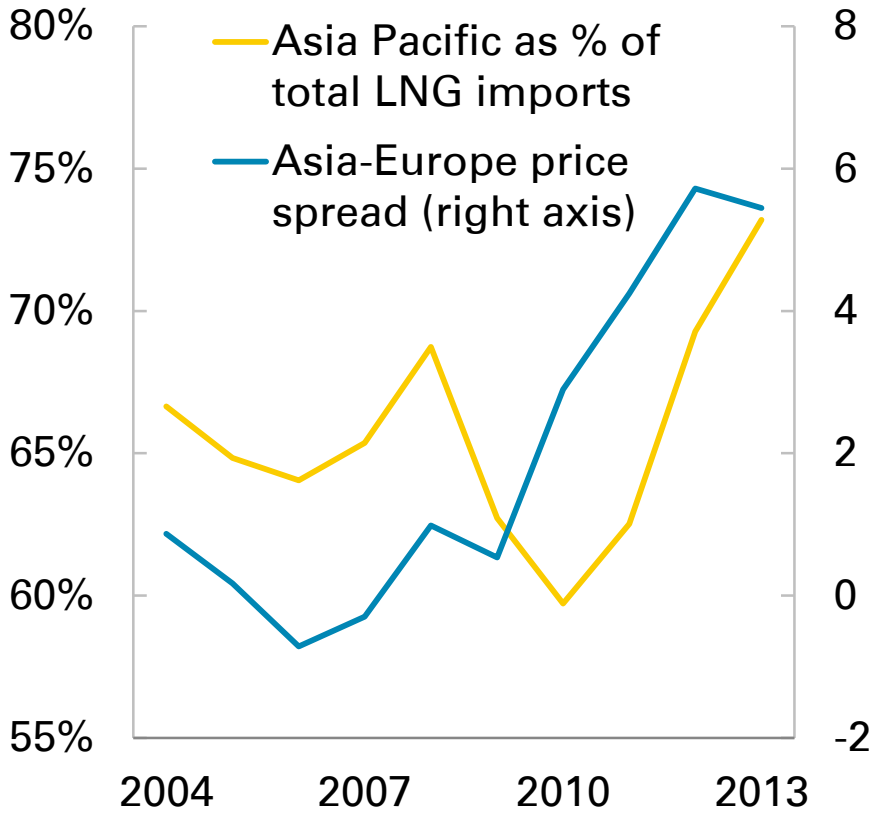
- The LNG market is poised for a growth spurt with a slew of new projects adding 22 Bcf/d by 2020. LNG supply grows 7.8% p.a. between 2013-20.
- Overall, LNG supply grows by 48 Bcf/d by 2035, with Australia (16 Bcf/d) and the US (14 Bcf/d) each contributing around a third of that increase. African LNG supply, led by East Africa, increases by 12 Bcf/d. As a result, Qatar, which has the largest market share today, is overtaken by Australia (24% share of the market by 2035), Africa (21%), and the US (18%).
- Asia is the largest destination for LNG, with its share in global LNG demand remaining above 70%. By 2035, China becomes the second largest LNG importer (12 Bcf/d), just behind Japan (13 Bcf/d).
- Europe's share of global LNG imports rises from 16% to 19% between 2013 and 2035, with an additional 10 Bcf/d of LNG demand.

LNG becomes the dominant form of traded gas…

Shares of global gas consumption



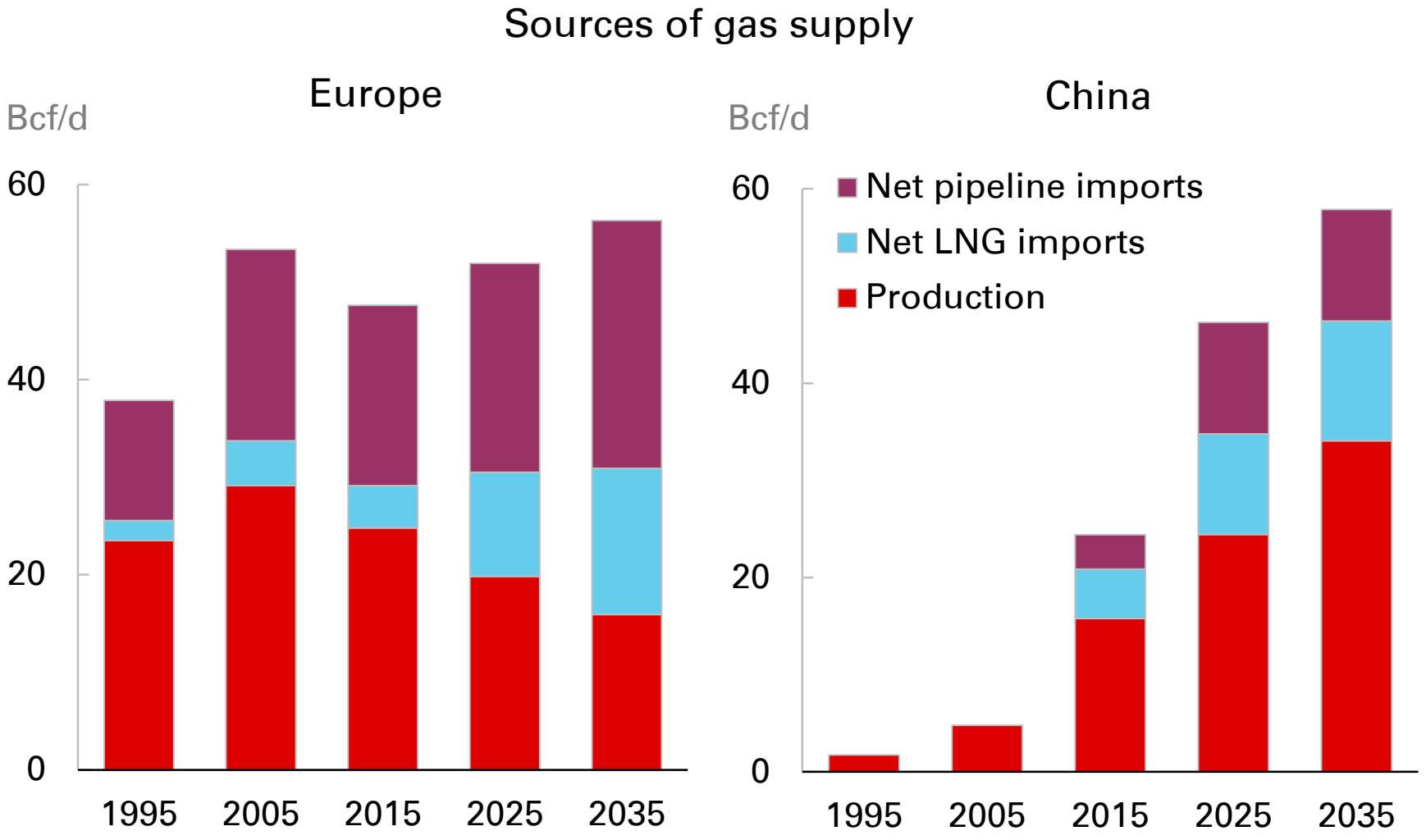
Asian LNG imports and price differential



…with supplies pivoting towards large Asian markets

- Global trade grows by 2% p.a. over the Outlook, causing the share of gas consumption supplied via traded gas to increase marginally.
- Traded gas supplied via pipelines declines as a share of consumption, reflecting the pivoting of import demand away from the US and Europe and towards Asia.
- In contrast, gas supplied via LNG grows by 4.3% p.a., more than twice as fast as total trade. As a result, LNG becomes the dominant form of traded gas by the end of the Outlook.
- The greater ability of LNG supplies to respond to varying movements in demand and supply across the world means that gas deficit regions such as Asia Pacific are able to attract larger LNG supplies by paying a premium over other markets.
- In the long run, increased LNG supplies lead to more integrated markets, with gas prices moving in greater unison across regions.

Growth in LNG leads to more diversified gas supplies …

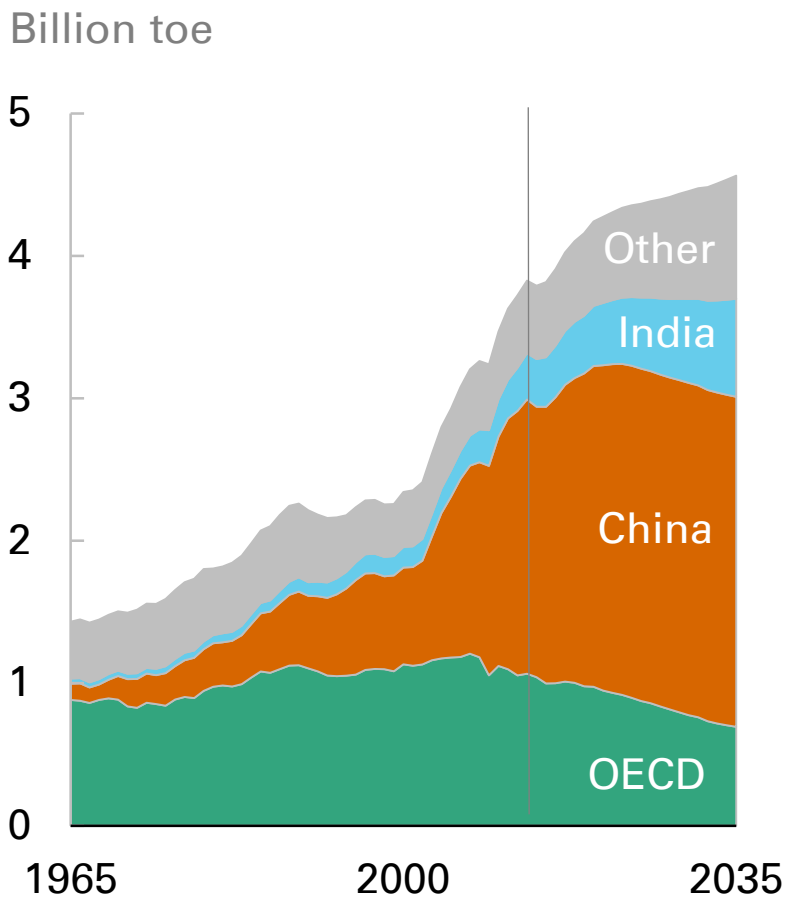


…for both Europe and China

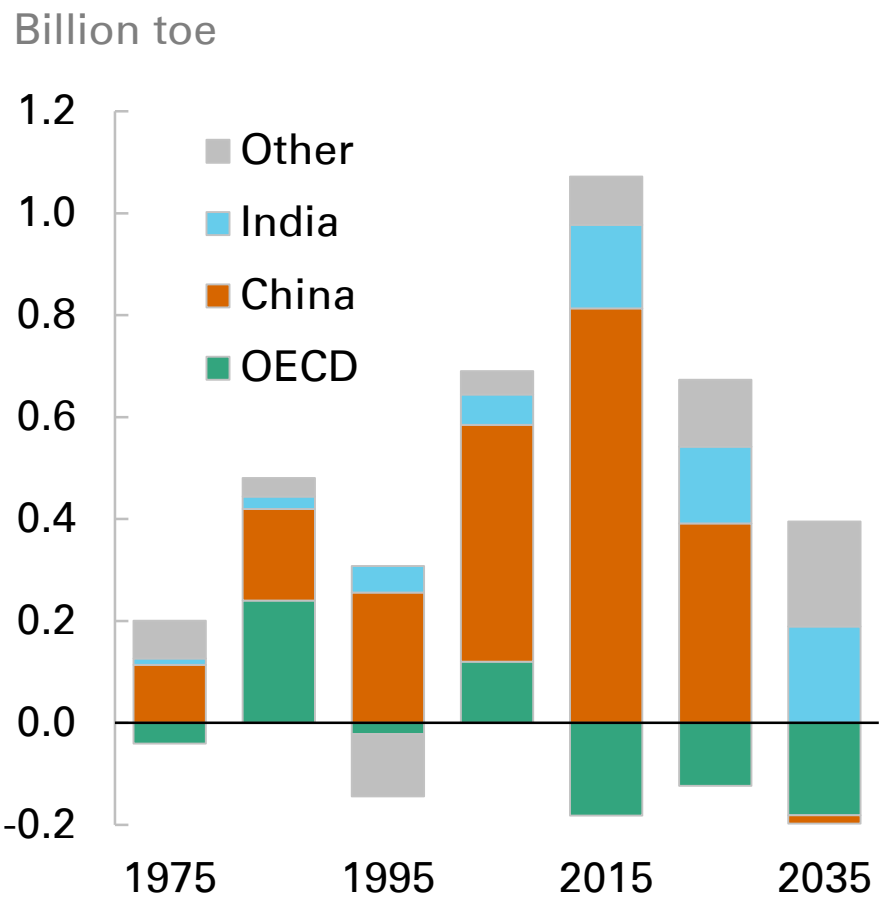
- Europe's gas imports currently account for around 50% of its total gas consumption. Over 80% of these imports are via pipeline, the vast majority of which are from Russia.
- European domestic production declines by 2% p.a. over the Outlook, so that, even with only modest demand growth (0.8% p.a.), almost three-quarters of Europe's gas needs are met by imports by 2035. Growth of LNG means these imports are more diversified, with pipelines accounting for around two-thirds of imports and LNG the remainder.
- China, by contrast, enjoys strong growth in gas production (5.1% p.a.) across all types of supply. Shale gas makes a significant contribution to growth (10 Bcf/d, 33% p.a.), with most of that increase coming in the last decade of the Outlook.
- Nonetheless, Chinese demand growth requires a rapid expansion of imports (7.6% p.a.) via both LNG and pipelines. LNG overtakes pipeline supplies as the dominant form of Chinese gas imports by the 2030s.

Growth in coal consumption slows in the non-OECD…

Consumption by region



Ten year increments by region



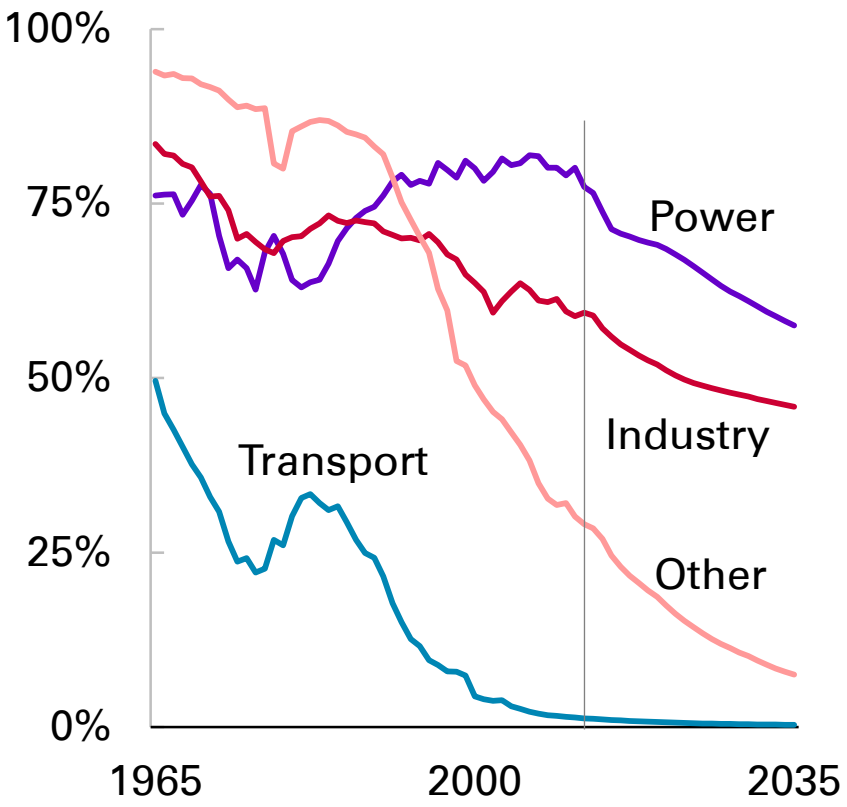
Energy Outlook 2035

…whilst OECD consumption declines

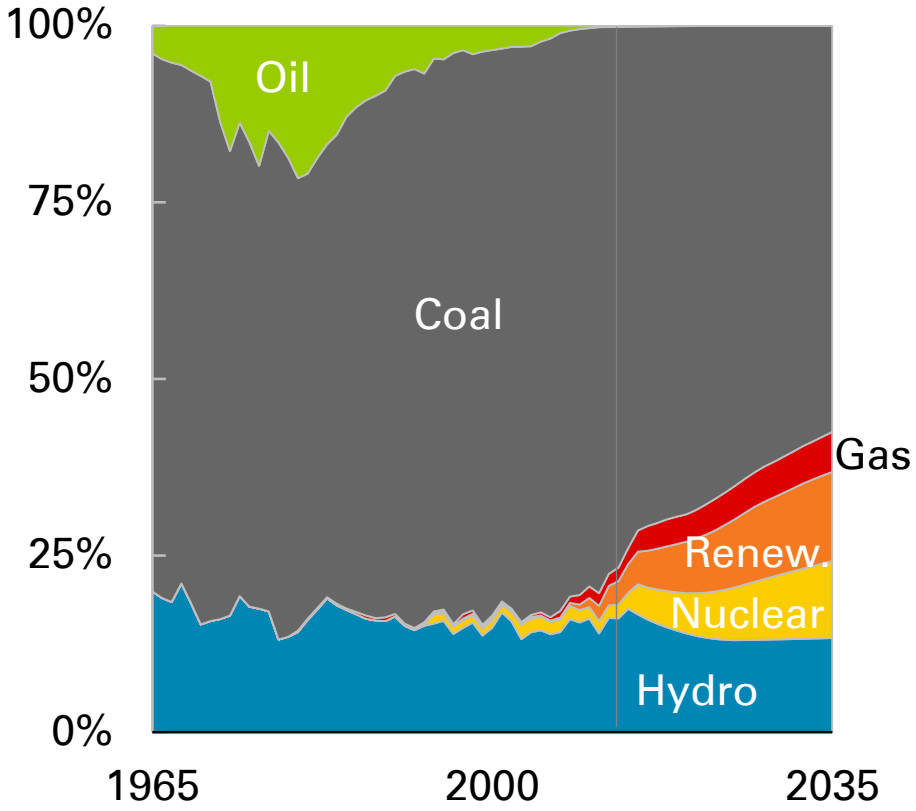
- Global coal demand grows by 0.8% p.a. between 2013 and 2035, making it the slowest growing fuel. Non-OECD consumption increases (1.1 Btoe), partially offset by declines in OECD consumption (-0.4 Btoe).
- China continues to lead the growth in consumption (390 Mtoe) even though its growth rate declines from 8.3% p.a. during 2000-13 to 0.8% in 2013-35. Chinese coal consumption peaks in 2025 and then declines slightly in the final decade of the Outlook.
- India increases coal consumption by 360 Mtoe by 2035, making it the second largest growth market. Increases in power sector demand account for almost 70% of India's consumption growth.
- The decline in OECD consumption is led by the US (-220 Mtoe) and the European Union (-150 Mtoe). This reduction is concentrated in the power sector, where environmental policies and ample supplies of gas encourage gas to displace coal.

Coal loses market share in China…

Coal share by sector in China



Inputs to power in China

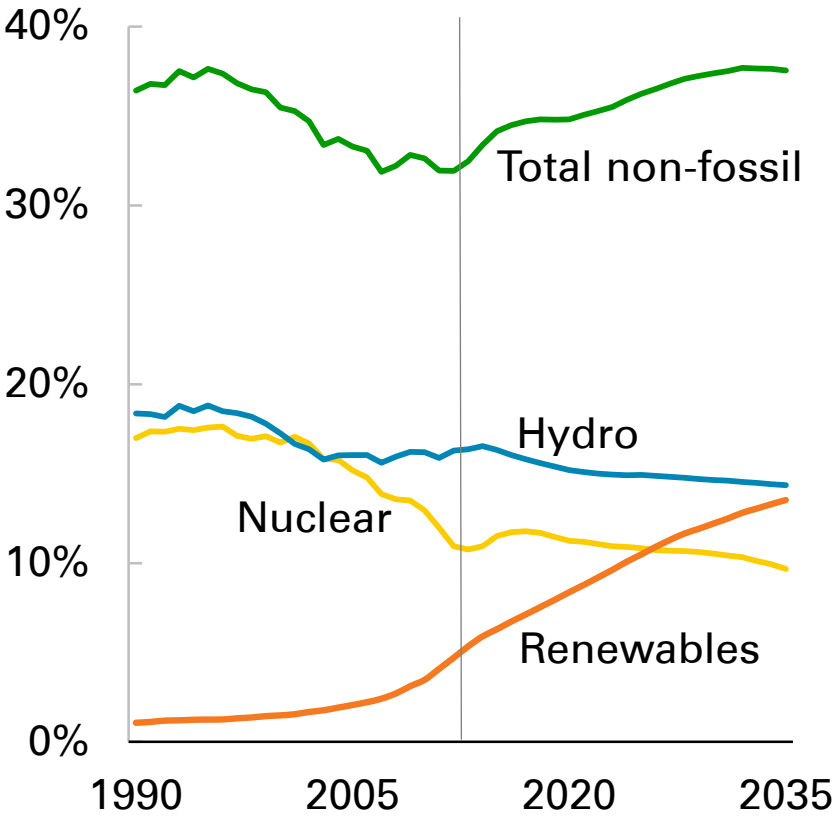


…as the country transitions to cleaner fuels

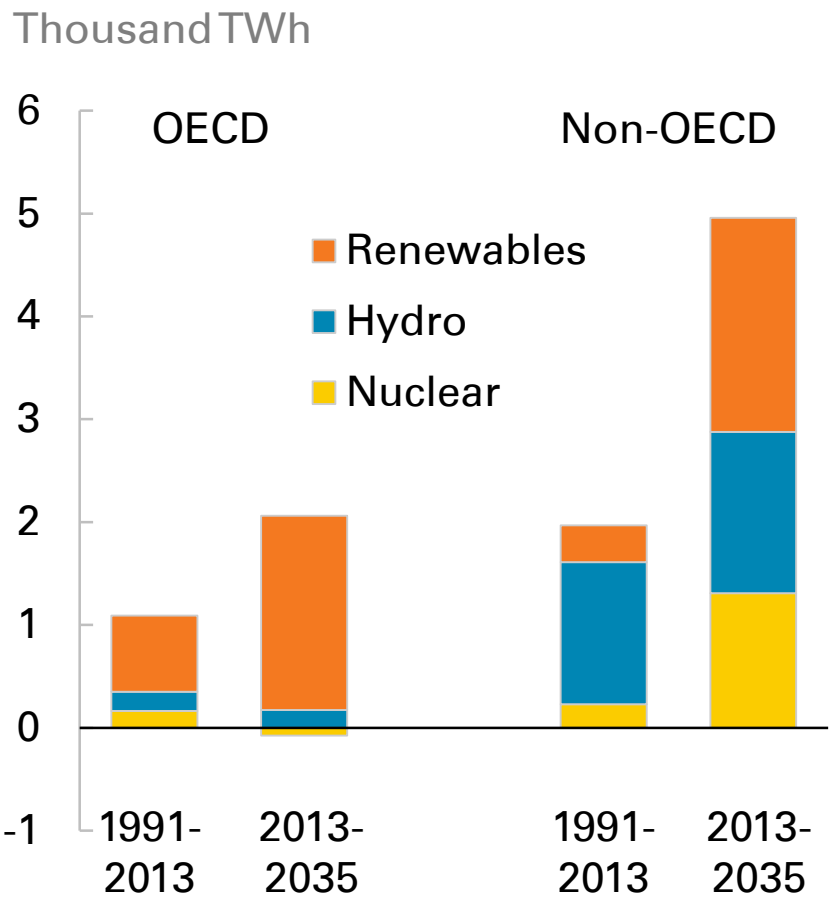
- Growth in Chinese coal consumption is led by demand in the power sector (1.4% p.a.) followed by industry (0.4% p.a.). These two sectors account for 97% of China's coal consumption by 2035.
- Growth slows considerably in all sectors, from the highs during 2000-13 when power sector consumption grew by 10% p.a. and industrial consumption by 7% p.a..
- The share of coal as a source of energy declines across all sectors in China. In power generation, the largest coal consuming sector, coal's share declines from 77% in 2013 to 58% by 2035, as renewables and nuclear gain share. The loss of market share in industry is more modest, falling from 59% to 46%.
- As a result, China records the steepest decline in the share of coal in primary energy between 2013 and 2035. Nevertheless, in 2035, China still has the highest coal share in primary energy at 51%.

The share of power generated by non-fossil fuels increases…

Share of world power generation



Growth of non-fossil power

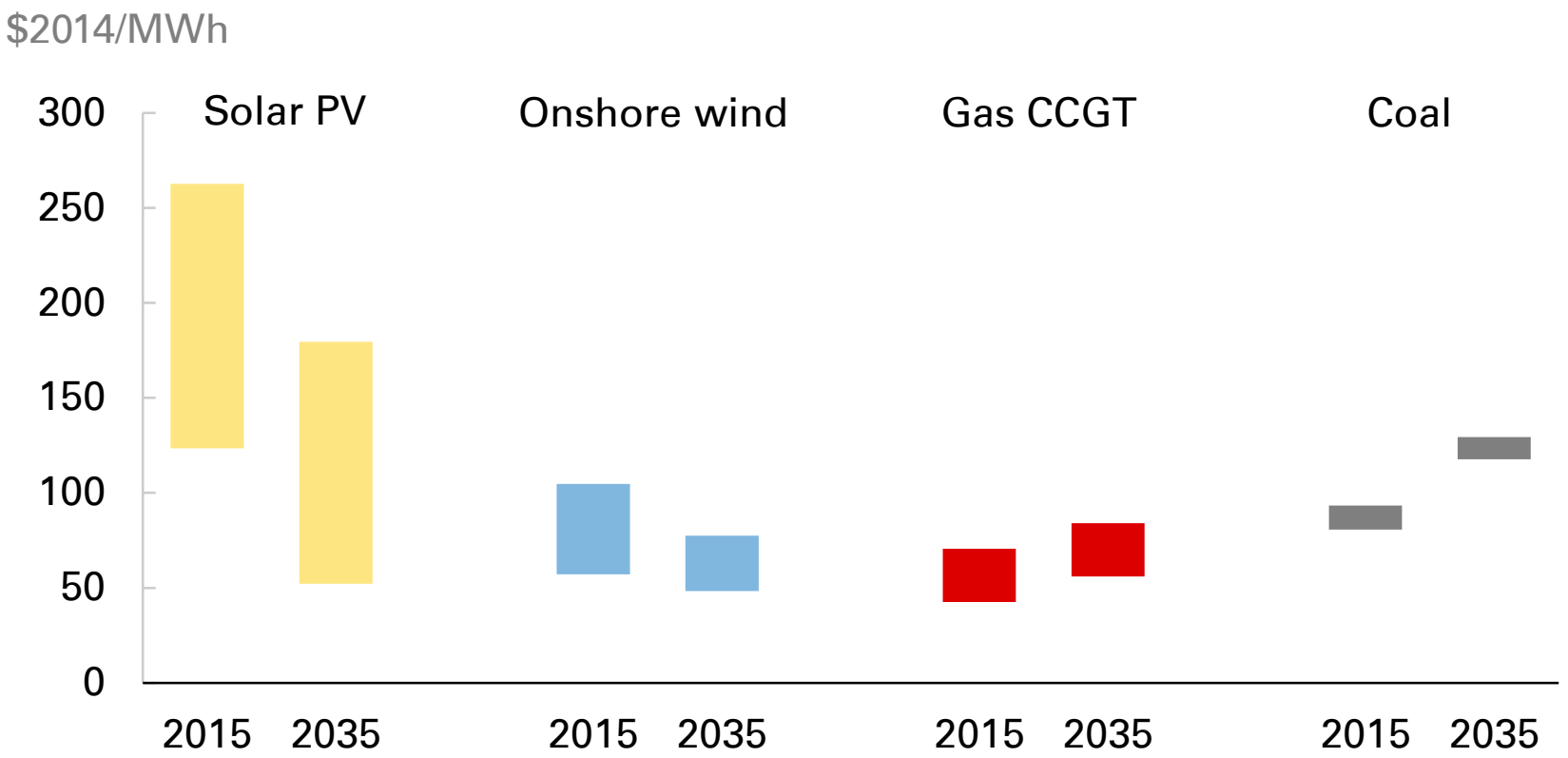


…driven by the rapid growth of renewables

- Until recently, the share of non-fossil fuels in global power generation was declining as nuclear and hydro struggled to keep pace with the growth of global power generation, and renewables were too small to make a material difference.
- Looking ahead, the shares of nuclear and hydro continue to decline, but the scaling up of renewables is sufficient to lift the aggregate non-fossil share from 32% in 2013 to 38% by 2035.
- Within the OECD, renewables dominate the growth of non-fossil power, and contribute 90% of the net growth in power generation from all sources.
- The growth of non-fossil fuels in the non-OECD is broader based. The increase in renewable power is roughly the same in volume terms as in the OECD. But there are also significant increases in nuclear and hydro. Renewables account for 16% of the growth in power generation in the non-OECD.

The falling cost of renewables…

Cost* of new grid-scale power generation, North America example



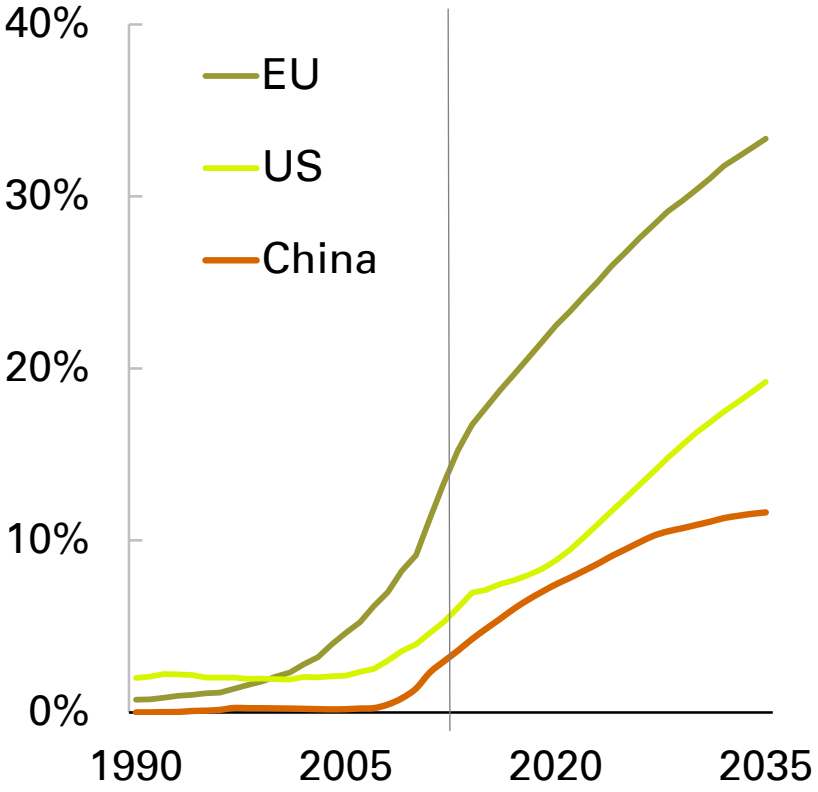
* Levelized cost per MWh of building and operating a plant over it's lifetime. Solar and wind costs exclude the cost of grid integration, and exclude any subsidies or tax incentives. Gas and coal costs in 2035 include the cost of carbon at an assumed price of $40/tonne.

…keeps a lid on the growth of the subsidy burden

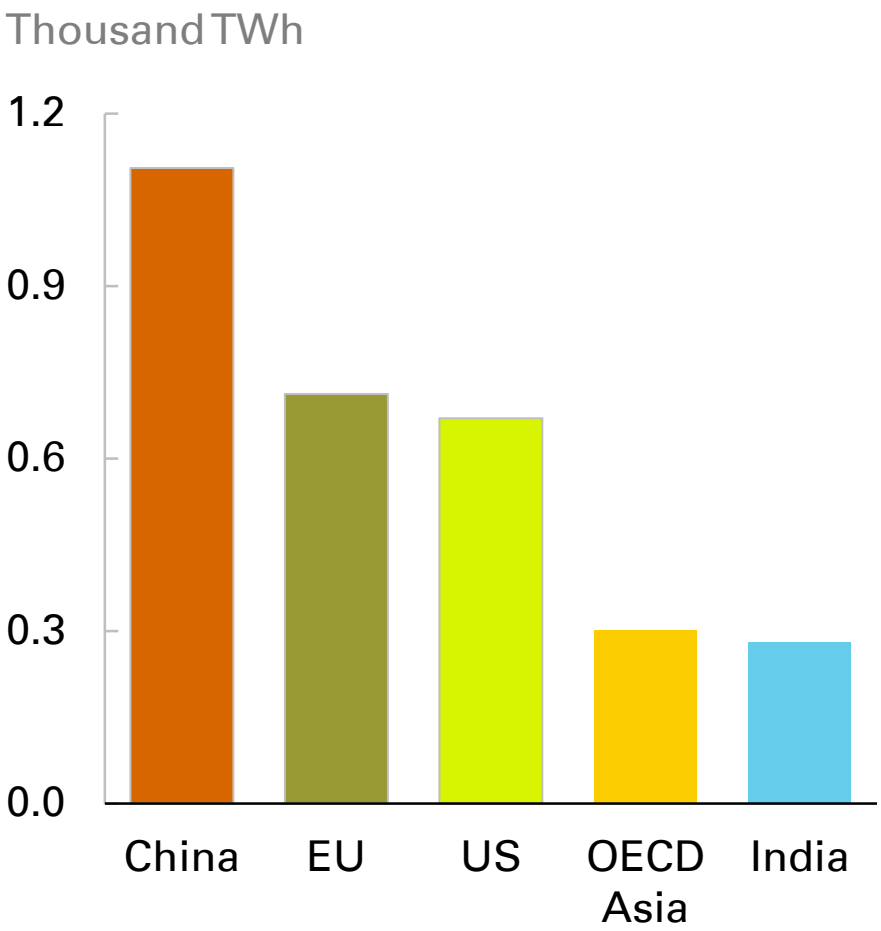
- The rapid growth of renewables currently depends on policy support in most markets, as renewables tend to be more expensive than coal or gas-fired power. As renewables grow in volume, the burden of this policy support can become a constraint on growth. To maintain rapid growth, the costs of renewable power need to keep falling, reducing the subsidy required per unit of power.
- The cost of renewables are expected to fall significantly over the Outlook, due to technological advances, learning-by-doing, and economies of scale. Both solar PV and wind appear to be following well-established learning curves, with costs falling rapidly as production increases.
- Onshore wind power in the best locations is increasingly able to compete with new conventional fossil power plants, even without subsidy and allowing for grid integration costs. Solar PV is also likely to become competitive across an increasing number of market niches. But even by 2035, grid-scale PV still requires a material carbon price to compete with efficient gas combined cycle generation.

Europe leads the way in terms of renewables share…

Renewables share of power



Renewables growth 2013 to 2035



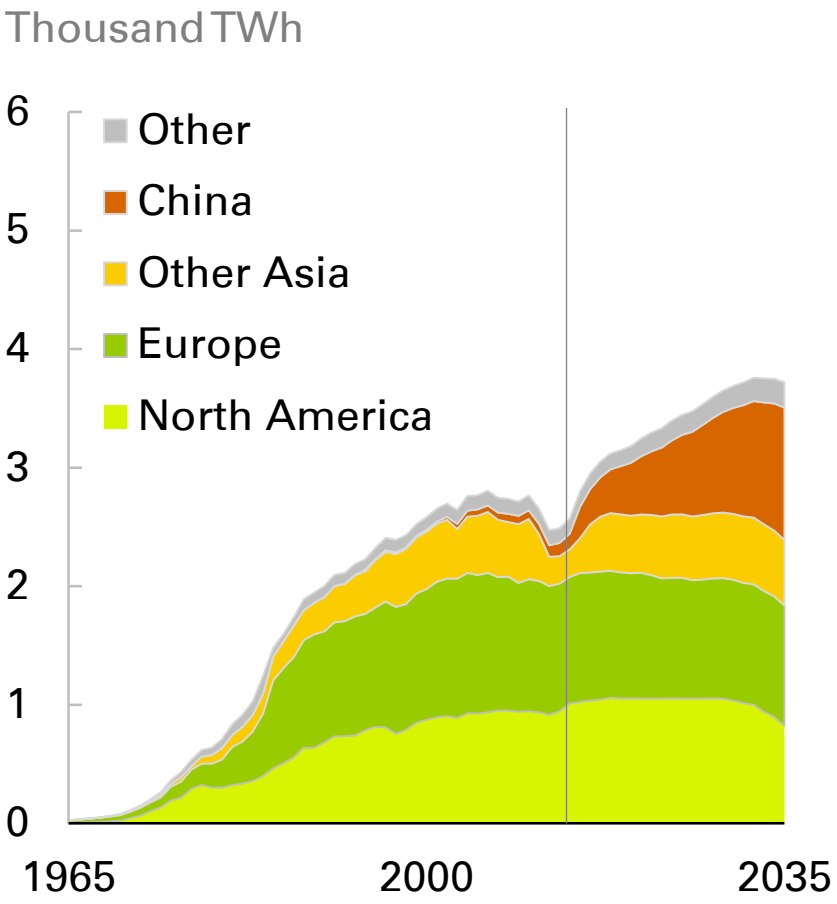
Energy Outlook 2035

…but China is the largest source of growth

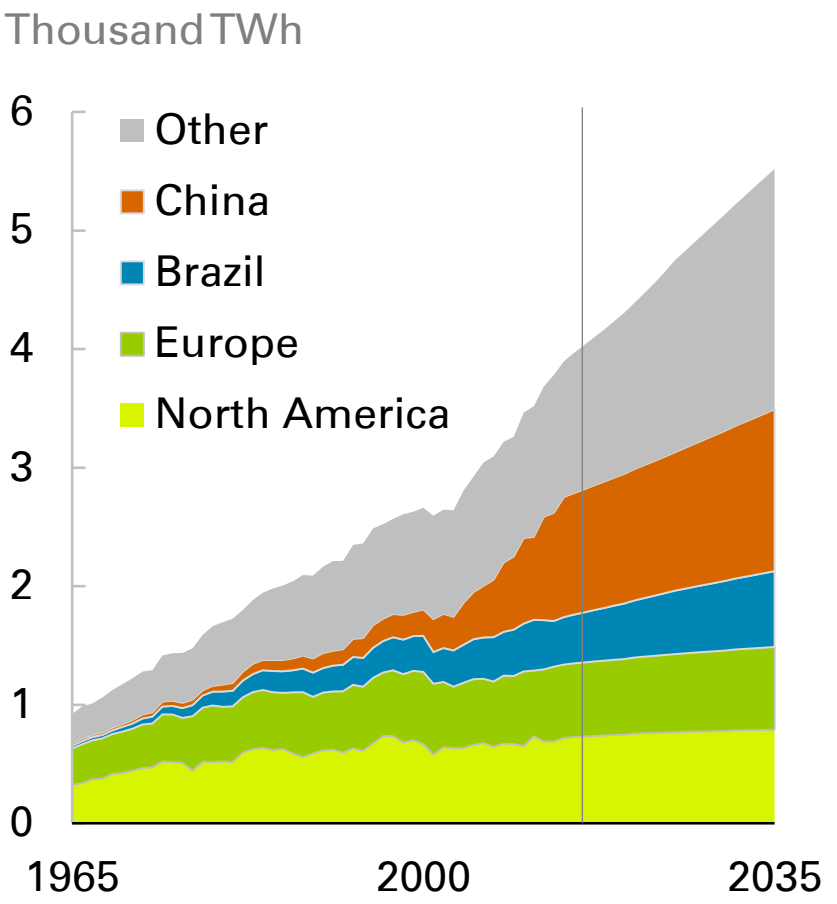
- Falling costs enable renewables to continue to gain share in Europe and encourage the spread of renewables to other regions. The European Union (EU) has led the way in promoting renewable power, but the size of the subsidy burden has become a constraint on growth in some markets. Falling costs will relax this constraint.
- By 2035, the share of renewables is likely to be stretching the ability of grid systems to handle intermittent sources of power in a number of EU markets, adding a technical constraint to the growth rate of renewables.
- Outside the EU, renewables are still scaling up – the US does not reach the current EU level of renewables penetration until 2030, and it takes even longer for China. However in terms of volume growth between 2013 and 2035, the EU is surpassed by China, and almost matched by the US.

Nuclear and hydro generation grow steadily …

Nuclear generation by region



Hydro generation by region



...led by the non-OECD, particularly China

- Despite losing share in the global power sector, nuclear and hydro are still expected to grow by 1.8% p.a. and 1.7% p.a. over the Outlook.
- Global nuclear growth is driven by China with an estimated growth rate of 11% p.a. – adding over 1000 TWh by 2035. This is an ambitious target, roughly equivalent to completing a new 1 GW reactor every 3 months for the next two decades.
- Nuclear capacity in Europe and North America declines as ageing plants are gradually decommissioned, and the difficult economics and politics of nuclear energy stunts new growth. Japan is assumed to restart its reactors gradually from 2015 but is not expected to recover to pre-Fukushima level of nuclear power generation by 2035.
- Global hydro growth is also driven by the non-OECD, with China and Brazil projected to grow by 450 TWh (1.4% p.a.) and 250 TWh (1.9% p.a.) respectively. Africa is the fastest growing region at 3.8% p.a., adding 150 TWh over the period.

Exploring the impact of alternative assumptions…

Low GDP growth

- what if growth in China and India slows more rapidly than assumed?

pages 80 to 83

Climate policies

- what if policymakers take more actions to reduce emissions?

pages 84 to 87

Geopolitics

- what are the implications of heightened geopolitical risks?

pages 88 to 89

China's electrification

- what if China's electricity use follows a different path?

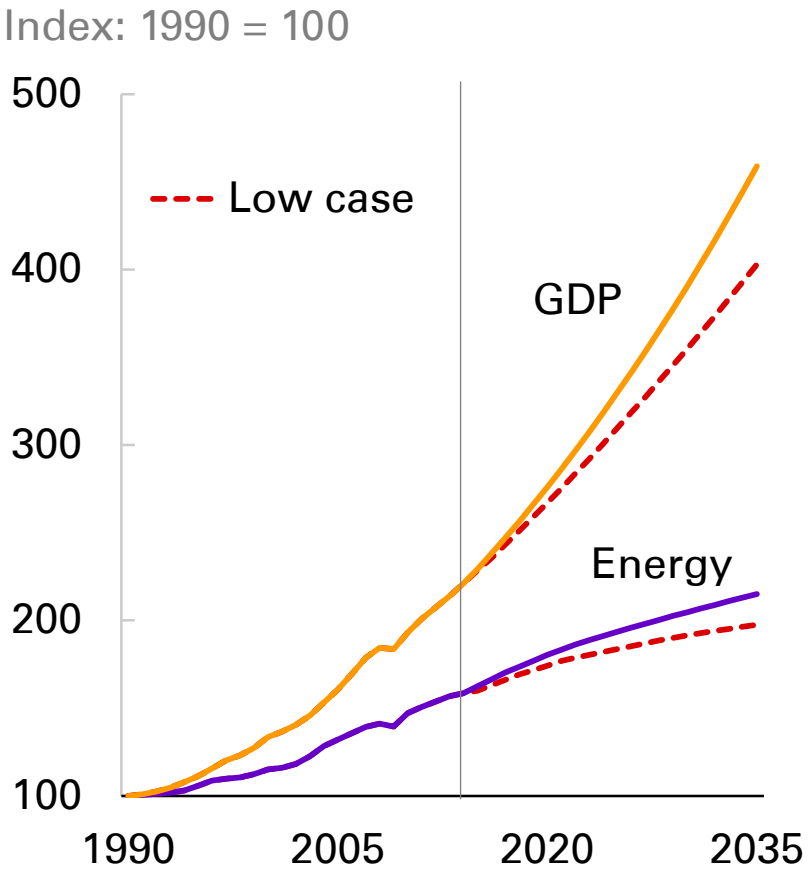
pages 90 to 91

…illustrates the uncertainties around the Outlook

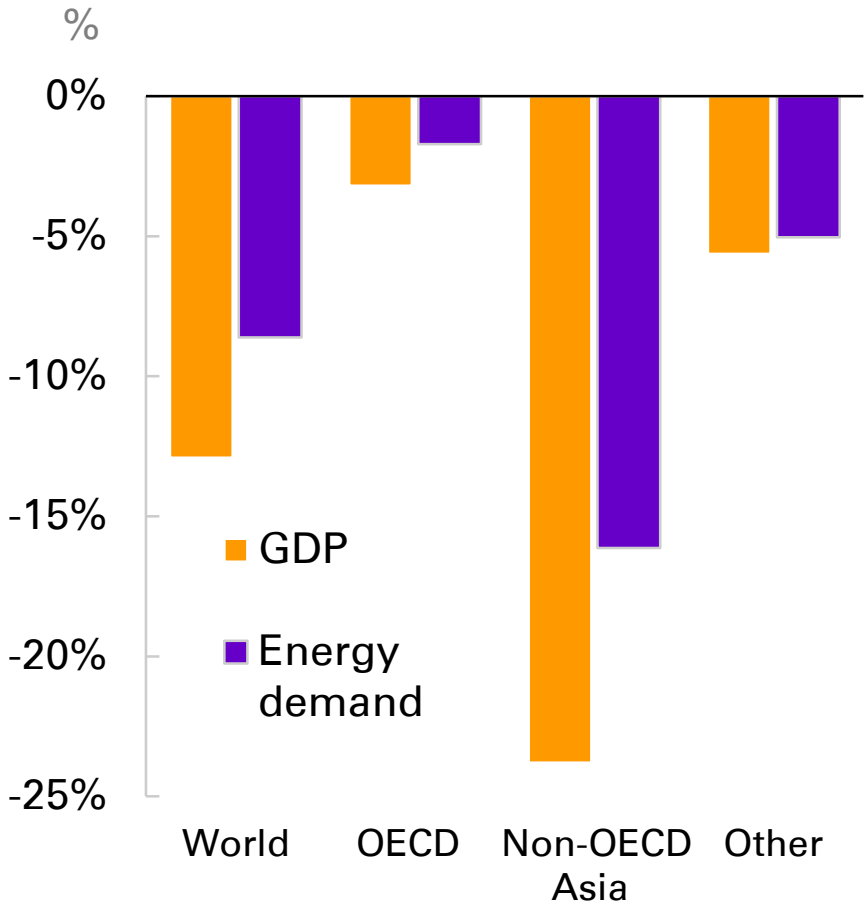
- This Outlook presents a single "most likely" view, constructed to highlight the main trends which are likely to shape energy markets over the next two decades. We believe this provides a robust basis for discussion.
- Building that single point projection necessarily requires making choices about assumptions which are inherently uncertain. By exploring the impact of alternative assumptions we can illustrate some of the uncertainties around the Outlook, adding to the richness of the debate.
- We have chosen four key uncertainties to explore here, which are described in more detail in the following pages. This is not an exhaustive list by any means – there are many other uncertainties surrounding the Outlook.

The future path of growth in non-OECD Asia…

GDP and energy demand in base and low case



Differences from base case in 2035

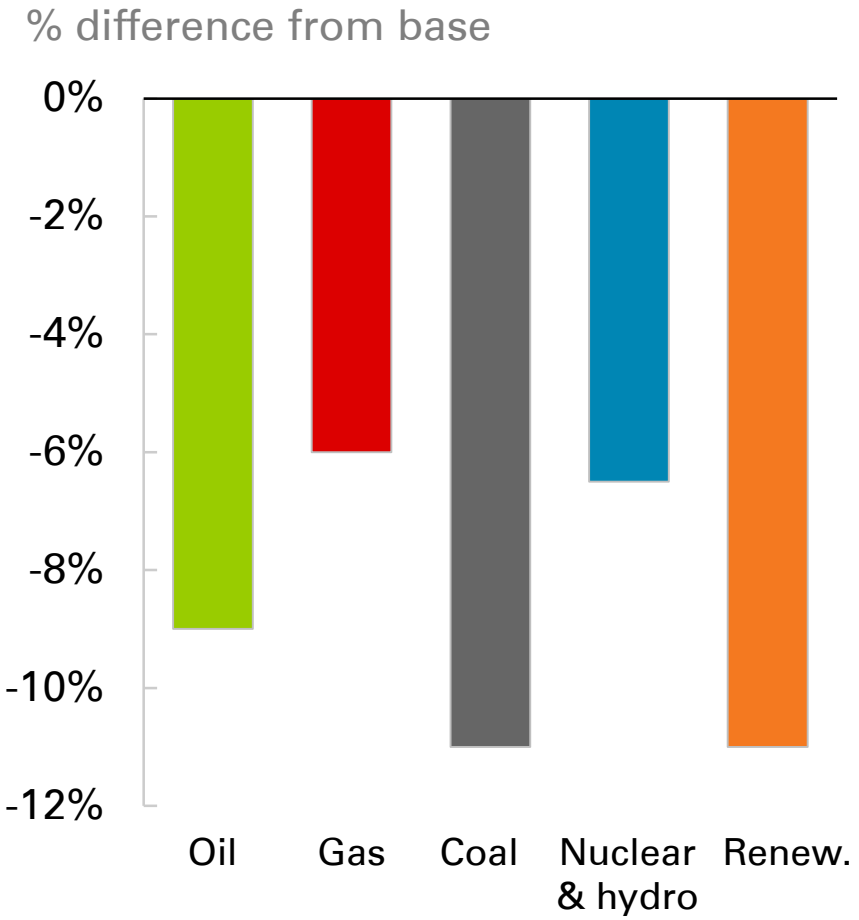


…is a major source of uncertainty for energy demand

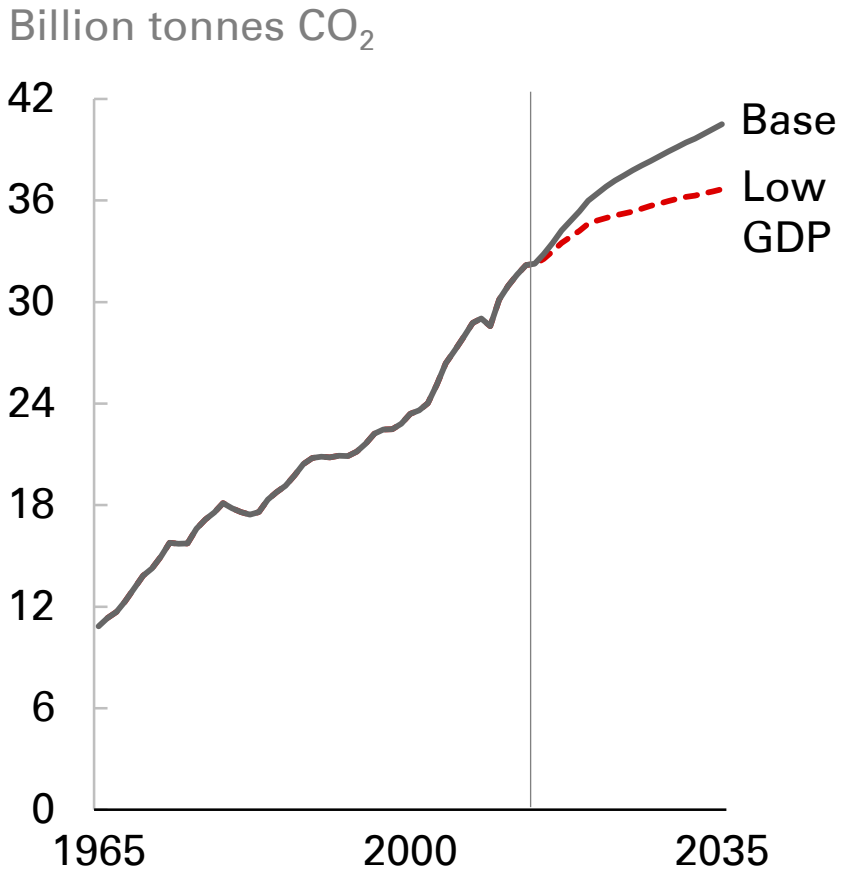
- The future growth paths of China and India represent a major source of uncertainty. Our low GDP case assumes China and India grow at an average rate of 4% p.a. over the projection period, compared with 5.5% p.a. in the base case. It also includes the trade and other spill-over effects of lower growth in these two countries on the rest of the world.
- It is based on the recognition that prolonged periods of growth above the global average are rare, and it is possible that the high growth rates seen in these countries in recent years may slow more rapidly than anticipated.
- In the low growth case, GDP in non-OECD Asia is 25% lower than in the base case by 2035, and world GDP is 13% lower. World GDP grows at a little below 3% p.a., compared with 3.5% p.a. in the base case.
- World energy consumption grows at 1% p.a. rather than 1.4% p.a. By 2035, global energy demand is 8.5% (1.5 billion toe) lower than in the base case. This is roughly equivalent to the total energy demand of the entire European Union in 2035.

Demand growth is slower for all fuels...

Energy demand by fuel in 2035



Global CO_2 emissions from energy use

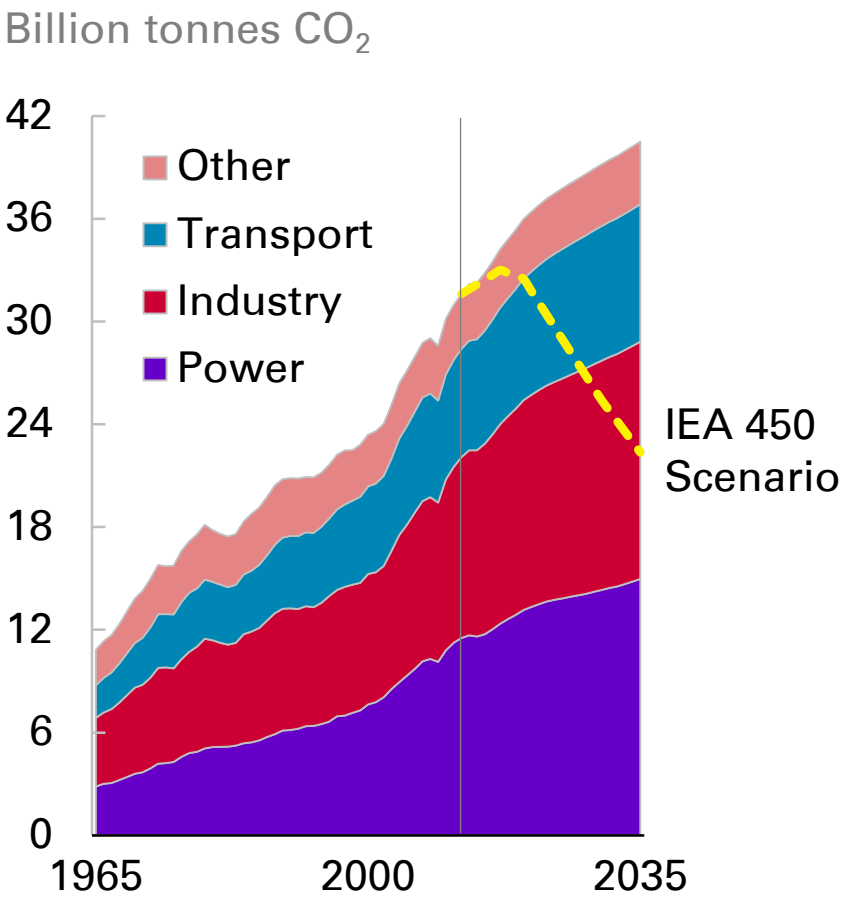


…resulting in lower carbon emissions

- Within the fossil fuels, coal demand shows the largest decline versus the base case (-11%), followed by oil (-9%) and gas (-6%). These differential impacts reflect the fuel mix in China and India (the focus of the slower grow), and assumptions about how quickly supplies would adjust.
- The lower price of fossil fuels and increased financial pressures (particularly in non-OECD Asia) that come with slower economic growth mean that the growth of renewables, nuclear and hydro also decline.
- In the low growth case, carbon emissions in 2035 are 9% lower than in the base case; equivalent to 4 billion tonnes of CO_2.
- This would still leave the path of emissions above the IEA's 450 Scenario (see following page). Indeed, the increase in financial pressures in non-OECD Asia may complicate the process of reaching a political consensus on carbon reduction policies.

Carbon emissions are rising too fast for comfort…

Emissions by sector



Options that achieve equal CO_2 emissions reductions*

Abatement option	Change required
Replace coal with gas in power (% of total power)	1%
Add CCS to coal power plants (% of total power)	0.7%
Increase renewables power generation	11%
Increase nuclear power generation	6%
Improve vehicle efficiency	2%
Improve 'other sector' energy efficiency	1%
Improve efficiency of electricity production	1%

* Normalized for a 1% swing in the coal/gas mix in power generation, equivalent to 110 Mt CO_2. Estimates are based on energy shares in 2013.

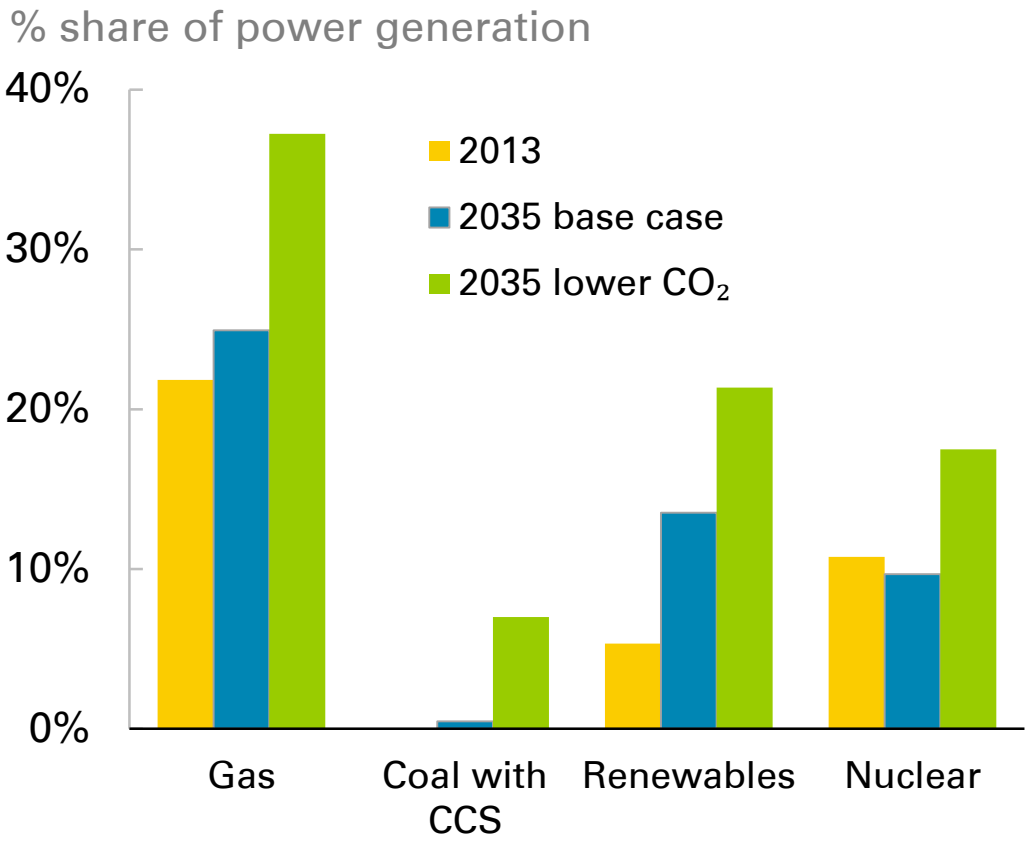
...which could trigger additional abatement policies

- Global CO_2 emissions from energy use grow by 25% (1% p.a.) over the Outlook. Emissions remain well above the path recommended by scientists, illustrated by the IEA's "450 Scenario". In 2035, CO_2 emissions are 18 billion tonnes above the IEA's 450 Scenario.
- The projections are based on our view of the most likely evolution of carbon related policies, but future climate policies are a key uncertainty in the Outlook. There are a number of options open to policy makers if they decide to further abate carbon emissions.
- The table considers a list of potential options, with a comparison of the extent of change required to achieve the same emissions savings as a 1% shift in the coal/gas mix of the power sector.
- The list is not exhaustive. The options include those that: limit emissions from coal in the power sector; increase non-fossil fuel use; and improve energy efficiency.

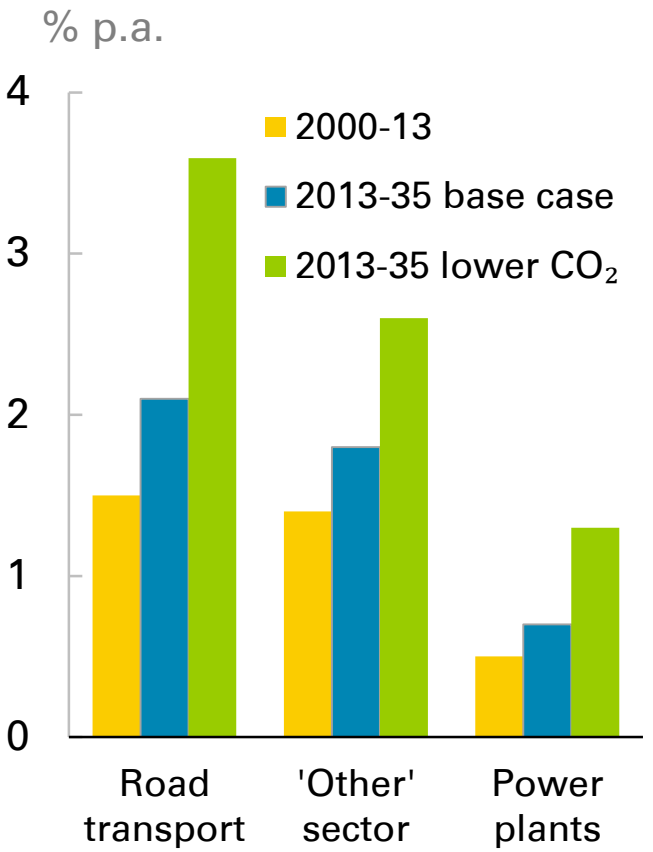
There are many ways to further mitigate carbon emissions…

Options to save 2 billion tonne CO_2 emissions in 2035 versus base case

Reducing carbon intensity in power



Energy efficiency gains



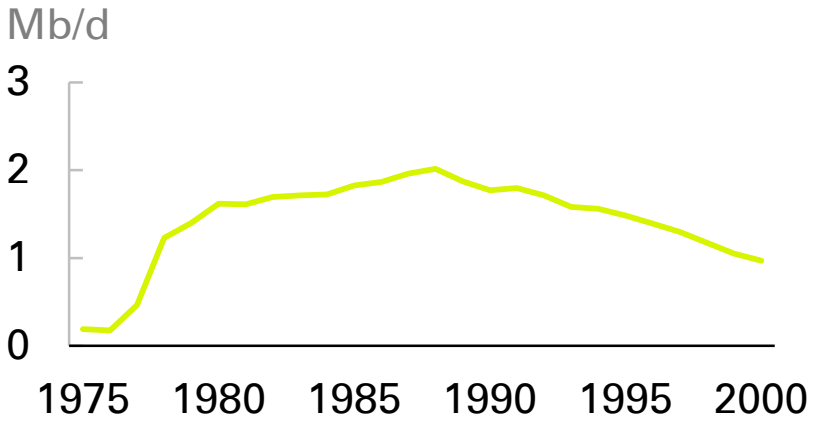
… all of which involve significant challenges

- The charts show the change required for each option to achieve a 2 billion tonne CO_2 saving in 2035 relative to the base case – roughly 10% of the gap between projected emissions and the IEA 450 Scenario in that year.
- No single change or improvement is likely to be sufficient, and none of these options are easy. The required improvement in vehicle efficiency by 2035, for example, is almost 50% more than the efficiency gain which is already in the base case. That is a considerable challenge.
- Each option has its own challenges: cost, technological limits, slow turnover of existing capital stock, the ability to implement policy globally and inertia in behavioural change. A comparison of the required change relative to recent history and to the "most likely" outcome may provide some guidance. But given the complexities, it is difficult to pick 'winners'.
- A meaningful global carbon price would provide the right incentives for the most cost-effective decisions and investments to be made.

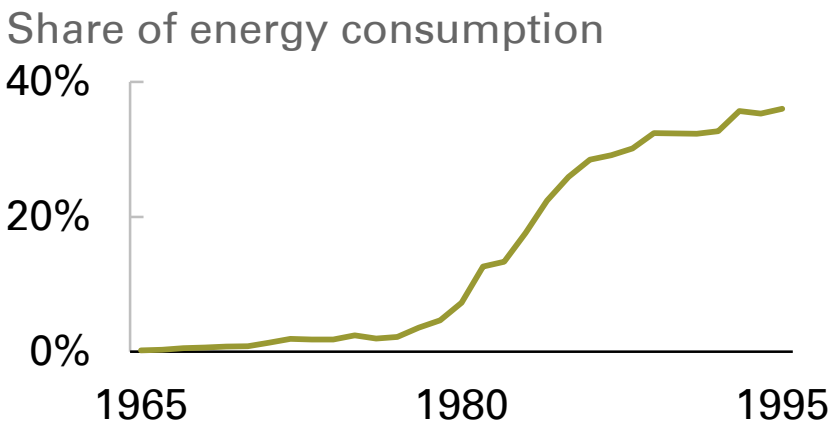
Heightened risk perceptions can have important implications...

Geopolitical risk

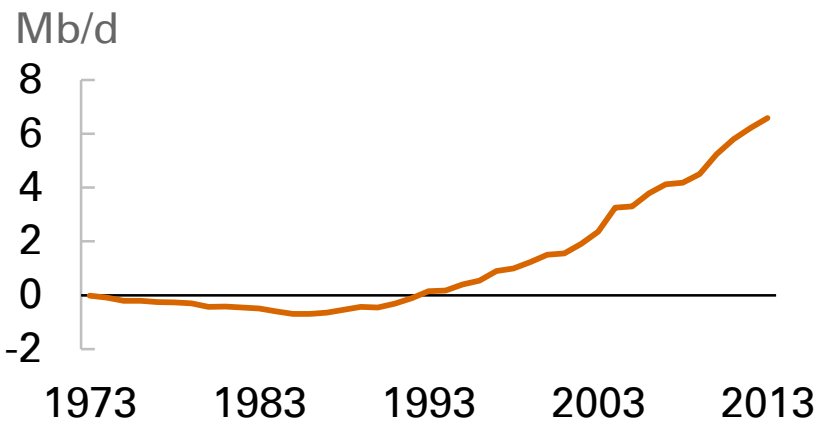
Alaska - oil production



France - nuclear power



China - oil imports

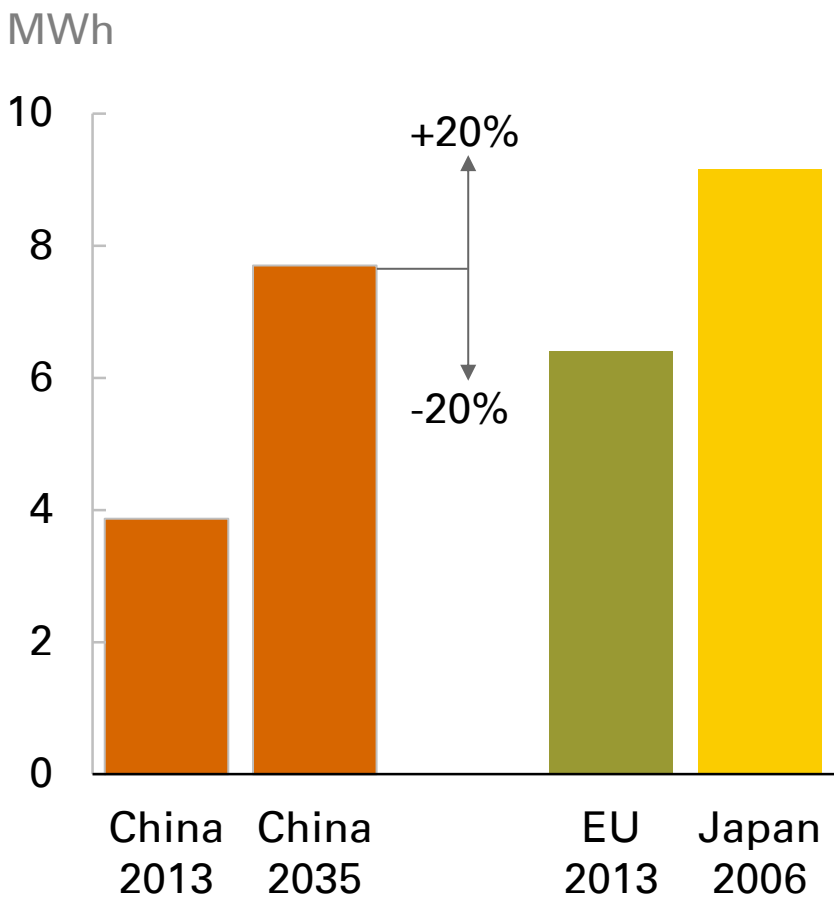


...for both energy supply and demand

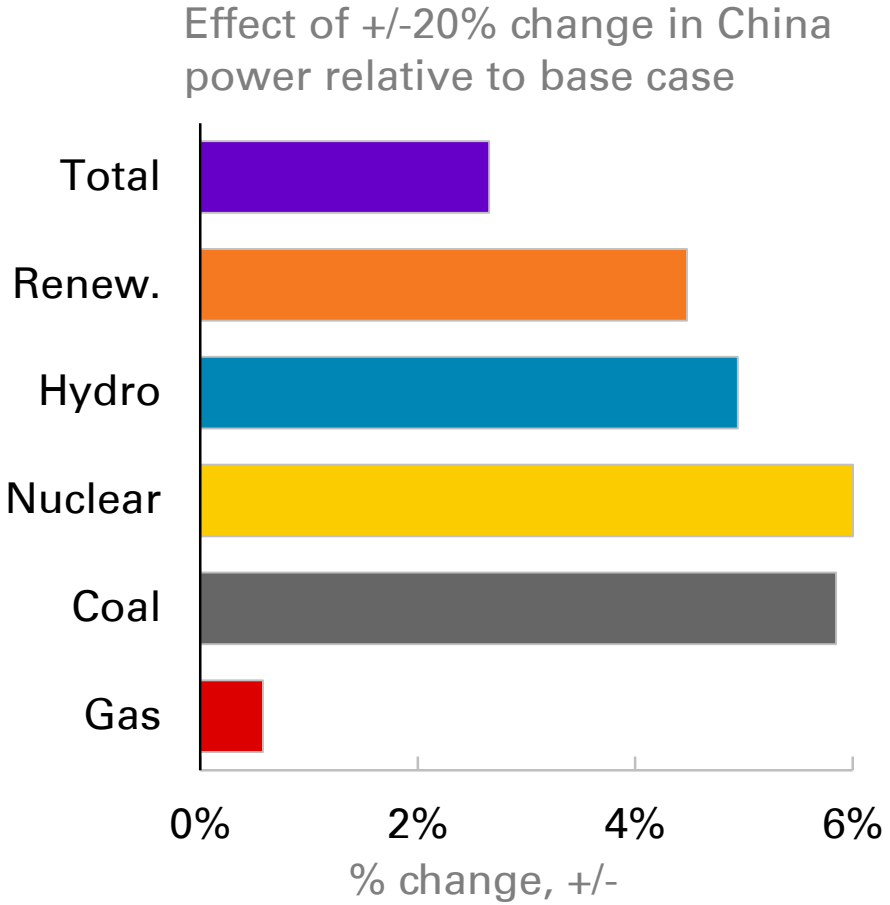
- Geopolitical risks – which on some measures have increased in recent years – have potentially important implications for energy markets.
- On the supply side, the level of disruptions to oil in recent years has been well above the historical average. We have marked up the likely incidence of supply disruptions over the medium term (see pages 40-41).
- Changing perceptions of geopolitical risks may also spur policy choices that lead to lasting changes to energy demand as well as supply. Historical examples include: the French decision to increase its dependence on nuclear energy, and the approval of the Trans-Alaska pipeline in the US (both following the early 1970s oil shocks); and China's acceptance of growing oil imports to fuel economic development (after an extended period of policy focused on maintaining self-sufficiency).
- We have built substantial evolution of both energy markets and policy into this Outlook, but heightened geopolitical risk perceptions could drive additional policy interventions beyond those anticipated.

The path of electrification in China…

Electricity consumption per capita



Impact on global fuel demand



...has significant implications for global energy

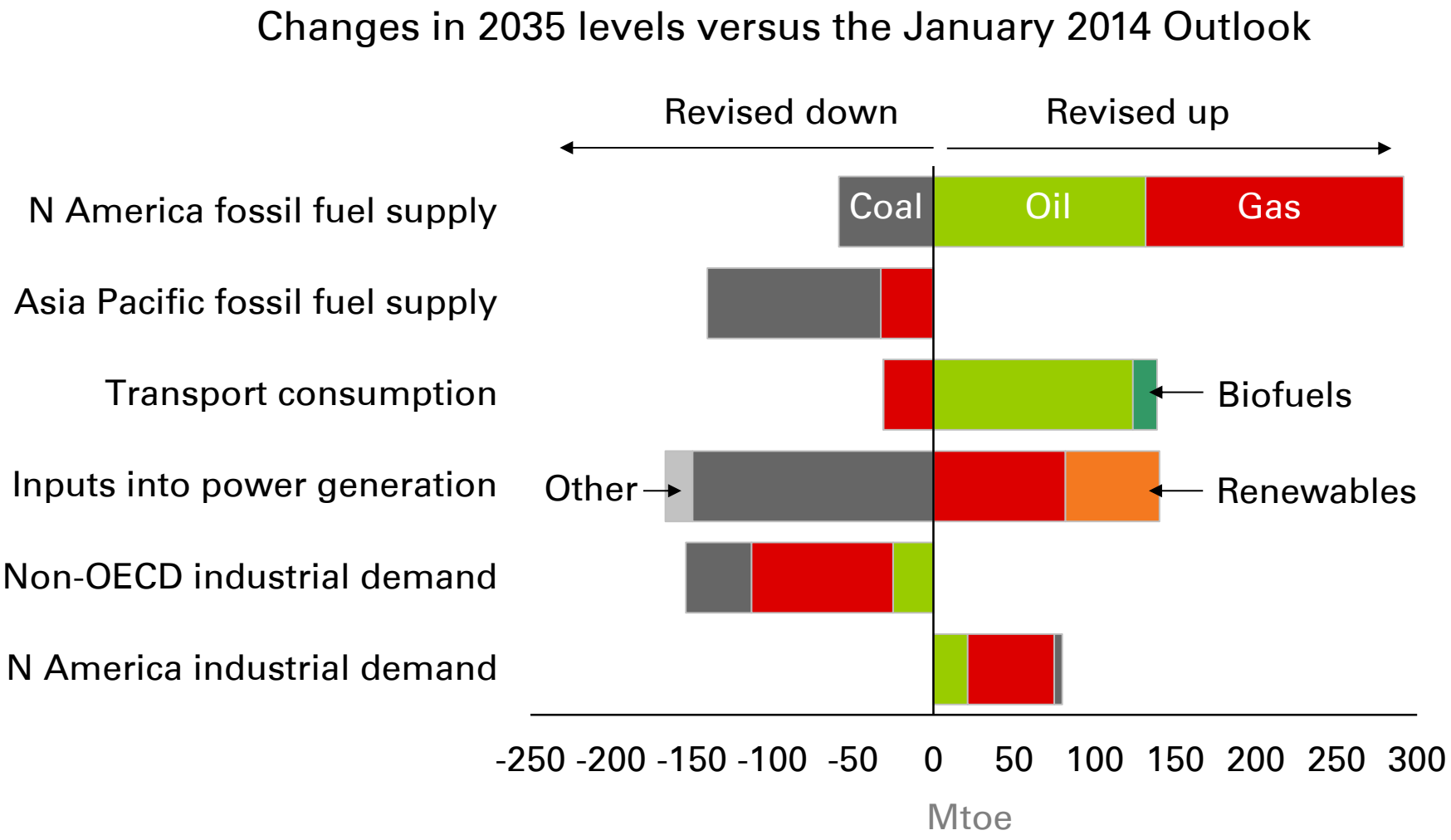
- The future path of electrification in China is a key uncertainty. China's power sector accounted for nearly 30% of global energy growth over the past decade. In our base case, China's per capita electricity consumption grows by 3.2% p.a. reaching 7.7 MWh by 2035.
- A sensitivity band around that base case can be constructed by looking at the per capita electricity consumption of the EU and Japan at the point where their GDP per capita broadly matched that projected for China in 2035 (2006 for Japan, 2013 for the EU).
- A +/-20% change in China's power generation (assuming no change in the shares of fuels in Chinese power) would change global energy demand in 2035 by +/-2.7%. That is roughly equivalent to two years of global energy growth, or an energy market the size of Japan.
- There is no impact on global oil demand and little impact on gas from this sensitivity. There is a significant impact on global coal use (+/-5.8%), and similar magnitude impacts on nuclear, hydro and renewables. The impact on carbon emissions is +/-1.6% (+/-0.7 billion tonnes of CO_2).

Conclusion

Continuous change is the norm for energy markets

- Changing energy mix
  - gas fastest growing fossil fuel, coal the slowest
  - continued rapid growth in renewables
- Changing energy trade patterns
  - increasingly flowing from West to East
- Changing the carbon emissions path?
  - no silver bullet, need action on many fronts
  - let the market pick the winners

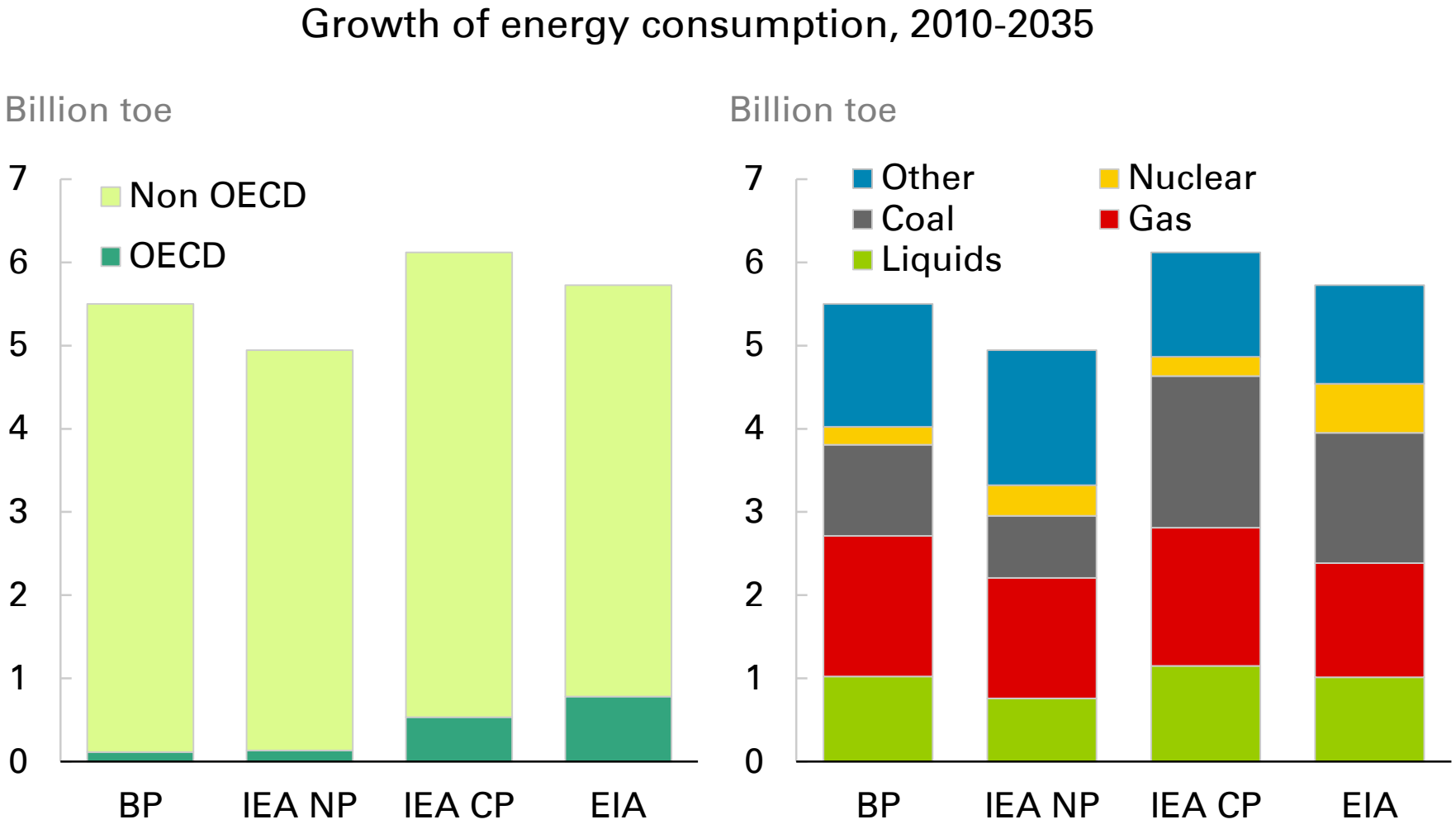
Key changes versus last year's Outlook…



…result in little net change in total energy

- Our aggregate projection for world energy demand and supply is little changed since our previous Outlook – down by about 0.6% in 2035.
- North America's oil and natural gas supply outlook has been revised higher yet again (14%) due to the continued evolving expectations for shale gas and tight oil. Increased oil supplies enable higher oil consumption, particularly in the transport sector.
- Asia Pacific fossil fuel supply is down in 2035 largely as result of slower growth of coal production in China.
- Coal consumption in the power sector has been revised down, roughly balanced by upwards revisions to gas and renewables. Fuel switching in the US and China explains the majority of the changes.
- Non-OECD industrial consumption is lower, as a result of slower economic growth and faster efficiency gains.
- North American industrial demand is higher in 2035 supported by increased availability of domestic oil and gas supplies.

Comparison with other outlooks: the key difference…



...lies in different views on non-OECD prospects

- Our Outlook is based on a "most likely" assessment of future policy trends. In that respect it differs from the energy projections published by the IEA and the EIA, which are based on specific policy scenarios and which make no judgements about the likelihood of those scenarios.
- Our policy assumptions are closest to those in the IEA's "New Policies Scenario" (NP), which assumes that announced national policy objectives are implemented. Yet our outcomes are closest to the IEA's "Current Policies Scenario" (CP) and the EIA's reference case, both of which assume no change in policy settings.
- Our Outlook shows more growth in non-OECD energy demand than the IEA NP; it also shows more growth for fossil fuels, especially for coal. This probably reflects differing views on the outlook for rapidly industrializing economies, in particular on the speed with which they can move to a less energy-intensive growth path.

Data sources

BP p.l.c., BP Statistical Review of World Energy, London, United Kingdom, June 2014

Energy Information Administration, Drilling Productivity Report, Washington, D.C., United States, 2014

Energy Information Administration, International Energy Outlook, Washington, D.C., United States, 2013

Energy Information Administration, Short-Term Energy Outlook, Washington, D.C., United States, 2014

Energy Security Analysis, Inc., Wakefield, MA, United States

Eurasia Group, New York, United States

European Environment Agency, Monitoring CO_2 from new passenger cars in the EU, Copenhagen, Denmark, April 2014

ICIS ATEC 4th Update , Vergiate, Italy, 2014

IHS Automotive, International Database World Car and Truck Data 1970-2023, Englewood, CO , United States, Dec 2014

International Council for Clean Transportation, Global passenger vehicle standards, Washington D.C., United States, 2014

International Energy Agency, CO_2 Emissions from Fuel Combustion, Paris, France, 2014

International Energy Agency, Energy Balances of Non-OECD Countries, Paris, France, 2014

International Energy Agency, Energy Balances of OECD Countries, Paris, France, 2014

International Energy Agency, World Energy Outlook 2014, Paris, France, 2014

Mitchell, B.R., International Historical Statistics 1750-2005, Palgrave Macmillan, New York, United States, 2007

Oxford Economics Ltd, Oxford, United Kingdom

UN Population Division, World Population Prospects: The 2012 Revision, New York, United States, 2013

US Environmental Protection Agency, Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 through 2012, Washington D.C., United States, March 2013

World Bank, Global Purchasing Power Parities and Real Expenditures, Washington D.C., United States, 2014