BP Energy Outlook
2017 edition

bp.com/energyoutlook
#BPstats

BP Energy Outlook

2017 edition

The Energy Outlook considers a base case, outlining the 'most likely' path for global energy markets over the next 20 years based on assumptions and judgements about future changes in policy, technology and the economy. It examines some of the key questions and issues posed by the energy transition, and develops a number of alternative cases to explore key uncertainties.

Contents

Contents (continued)

Welcome to the 2017 edition of BP's Energy Outlook.

The global energy landscape is changing. Traditional centres of demand are being overtaken by fast-growing emerging markets. The energy mix is shifting, driven by technological improvements and environmental concerns. More than ever, our industry needs to adapt to meet those changing energy needs.

In the near term, much of our focus will remain on the continuing adjustment of the oil market. Considerable progress has been made but there is still a long way to go. Oil inventories are at record-high levels and the impact on supply of the significant cutbacks in investment spending on new energy projects over the past two years has not yet been fully felt.

But our response to those near-term challenges has to be informed by our understanding of the longer-term energy transition that is taking place to ensure we are able to continue to meet the energy needs of a changing world. That is the value of the Energy Outlook: to shine a light on the key trends and forces that are likely to shape global energy markets over the next 20 years.

A central feature of the energy transition mapped out by this Outlook is the continued gradual decarbonization of the fuel mix. Rapid improvements in the competitiveness of renewable energy mean that increases in renewables, together with nuclear and hydro energy, provide around half of the increase in global energy out to 2035. Natural gas is expected to grow faster than oil or coal, helped by the rapid growth of liquefied natural gas increasing the accessibility of gas across the globe.

Oil demand continues to increase, although the pace of growth is likely to slow as vehicles become more efficient and technological improvements, such as electric vehicles, autonomous driving and car sharing, potentially herald a mobility revolution.

The overall demand for energy looks set to continue to expand, as increasing prosperity in fast-growing emerging economies lifts billions of people from low incomes. Plentiful supplies of energy enable this rise in living standards, with virtually all the growth in energy demand expected to come from outside the developed world. The extent of this increase is likely to be curbed by improvements in energy efficiency, as increasing attention around the world is devoted to using energy more sustainably.

Faster gains in energy efficiency combined with the gradual changes in the fuel mix mean the growth of carbon emissions from energy is expected to slow sharply relative to the past 20 years. Even so, the most likely path sees carbon emissions continuing to increase, indicating the need for further policy action. The timing and form of that action will have an important bearing on the nature of the energy transition. In BP, we continue to believe that carbon pricing has an important role to play as it provides incentives for everyone - producers and consumers alike - to play their part.

The energy transition underway poses a significant challenge - how to meet the world's increasing demand for energy as it grows and prospers while also reducing carbon emissions. That raises important choices and opportunities for our industry. I hope you find this edition of the BP Energy Outlook a useful contribution to discussions about the energy transition and the world's changing energy needs in the decades ahead.

Bob Dudley
Group chief executive

Executive summary

- In the base case, world GDP almost doubles over the Outlook driven by fast-growing emerging economies, as more than 2 billion people are lifted from low incomes.
- This rising prosperity drives an increase in global energy demand, although the extent of this growth is substantially offset by rapid gains in energy efficiency: energy demand increases by only around 30%.
- The fuel mix continues to adjust, although oil and gas, together with coal, remain the dominant sources of energy. Renewables, with nuclear and hydroelectric power, provide half of the additional energy required out to 2035.
- Gas grows more quickly than oil and coal, led by US shale gas; the rapid expansion of LNG is likely to lead to a globally integrated gas market, anchored by US gas prices.
- Oil demand grows throughout the Outlook, but the pace of demand slows with non-combusted use replacing transport as the main source of demand growth.
- The increasing penetration of electric cars and the broader mobility revolution will have an important bearing on future oil demand.

Executive summary (continued)

- The abundance of oil resources may prompt low-cost producers to use their competitive advantage to increase market share.
- Global coal consumption looks set to peak, as the continuing reform of China's economy causes growth in its demand for coal (and energy) to slow sharply, although China remains the largest growth market for energy.
- Renewables are the fastest growing fuel source, quadrupling over the next 20 years, supported by continuing gains in competitiveness.
- The world economy continues to electrify, with nearly two-thirds of the increase in global energy going into the power sector.
- In our base case, carbon emissions from energy grow at less than a third of the rate of the past 20 years, reflecting gains in energy efficiency and the changing fuel mix. But emissions continue to rise, highlighting the need for further action.
- The uncertainty around the base case is explored in three alternative cases: a faster mobility revolution; alternative pathways to a lower-carbon energy system; and risks to gas demand.

Key energy questions

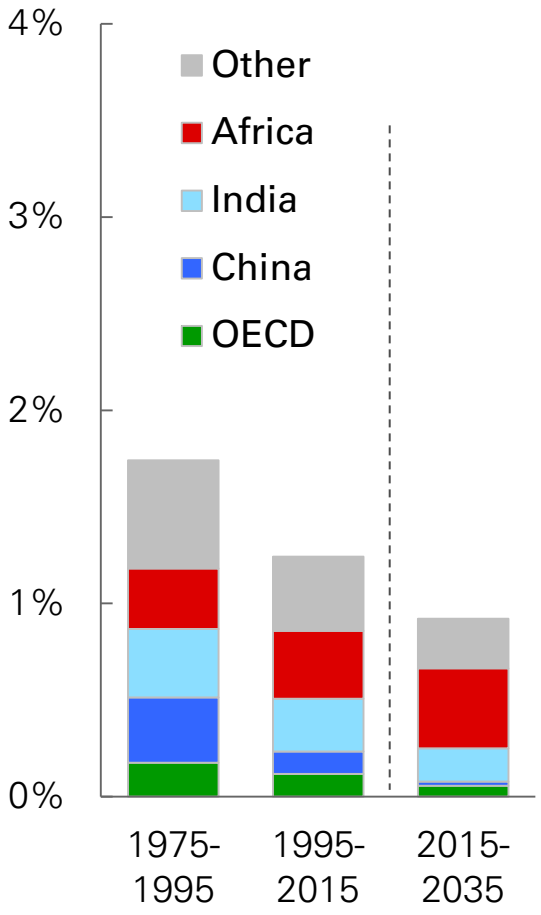
- Will global energy demand continue to increase? Has the link between economic growth and increases in energy demand been broken? (see pages 12 to 19)
- How quickly will the global energy mix evolve? (see pages 14 to 15)
- How will electric cars and new mobility technologies impact oil demand? (see pages 46 to 49, 72 to 75)
- How will the behaviour of low-cost oil producers change in a world of abundant oil resources and slowing oil demand? (see pages 50 to 53)
- How fast do we expect natural gas to grow? What is driving this and what could cause gas demand to grow less strongly? (see pages 32 to 35, 54 to 57, 82 to 85)
- Will coal demand peak in the next 20 years? (see pages 36 to 37)
- How will China's economic transition impact global energy demand? (see pages 58 to 61)
- How might a faster transition to a lower carbon energy system change global energy markets? (see pages 76 to 81)

Base case: Primary energy

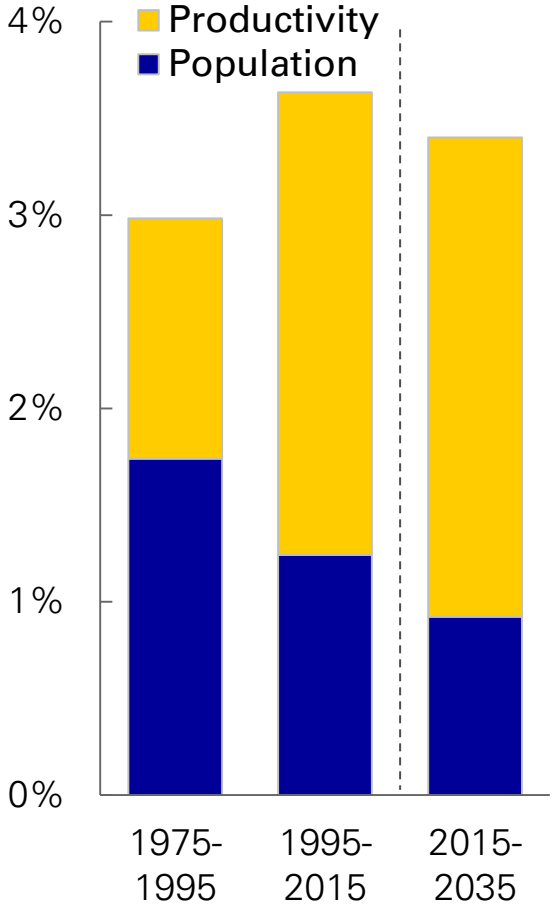
GDP is projected to almost double over the Outlook…

Population growth by region

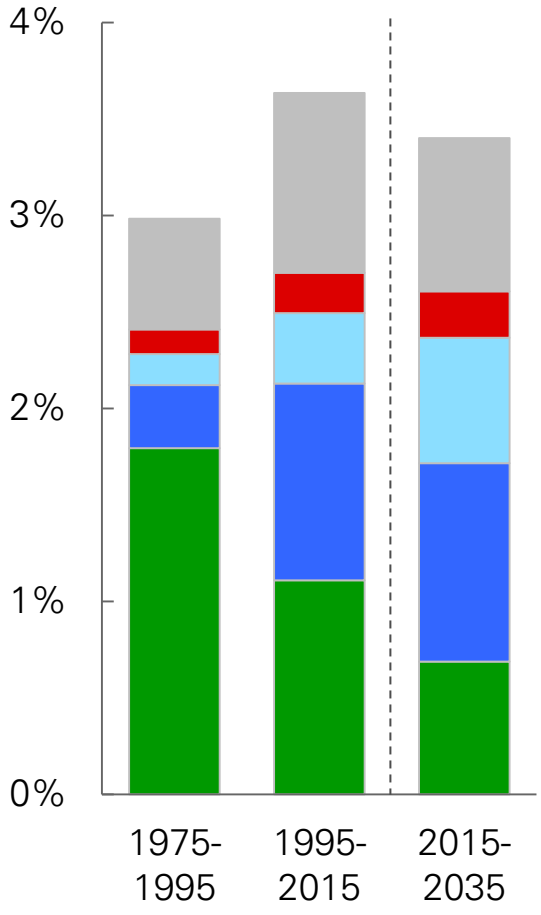
% per annum



Real GDP growth by factor



Real GDP growth by region

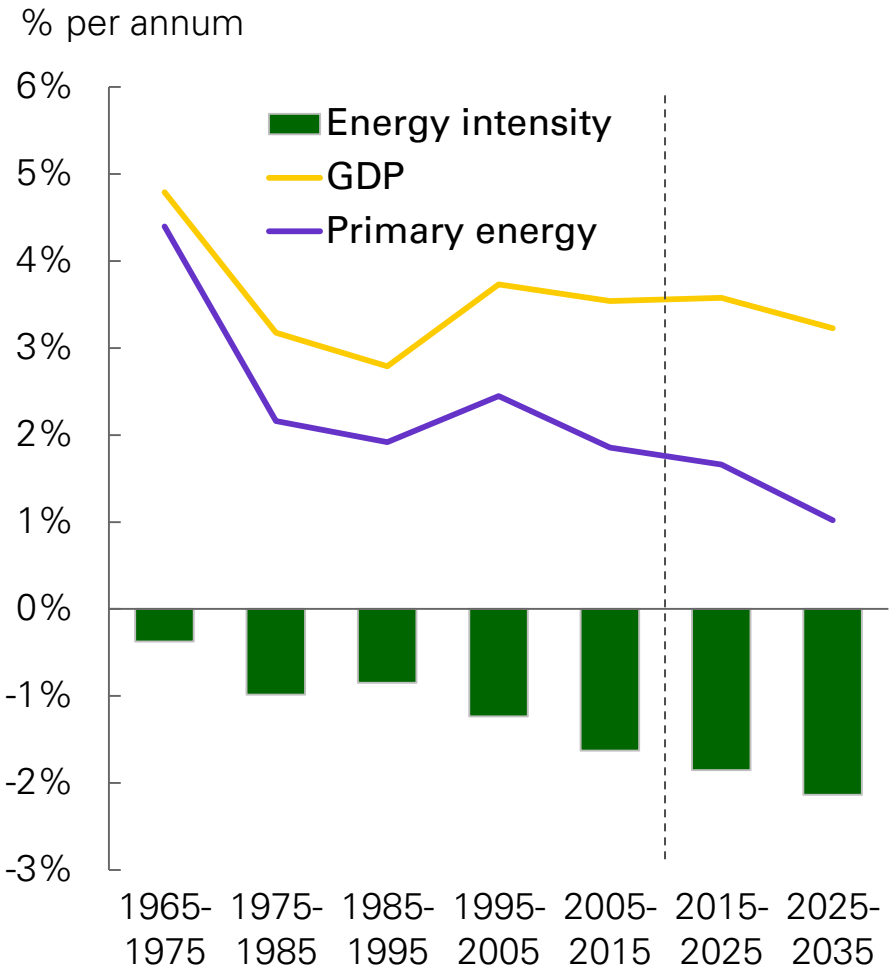


...driven primarily by productivity growth

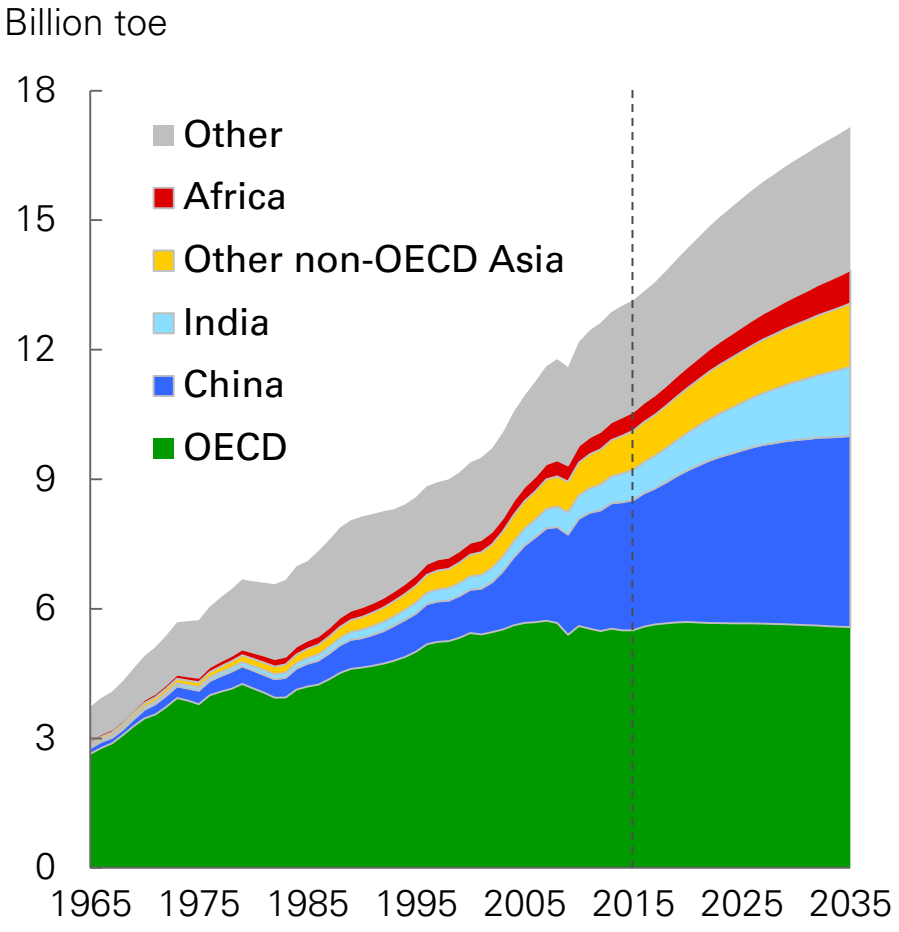
- The world economy is expected to almost double over the next 20 years, with growth averaging 3.4% p.a. (at Purchasing Power Parity exchange rates).
- Growth is largely driven by increases in productivity (i.e. GDP per person), which account for three-quarters of the growth.
- The world's population is projected to increase by around 1.5 billion people to reach nearly 8.8 billion people by 2035.
- Much of the expected growth in the global economy is driven by emerging economies, with China and India accounting for around half of the increase.
- The projected gains in productivity lead to increasing global prosperity, with more than 2 billion people lifted from low incomes.
- Africa accounts for almost half of the increase in the world's population over the Outlook, but contributes less than 10% of the expected increase in GDP. The potential importance of Africa in determining global GDP growth and energy demand beyond 2035 is considered on pages 90 to 91.

Growth in the world economy requires more energy…

Growth in GDP and primary energy



Energy consumption by region

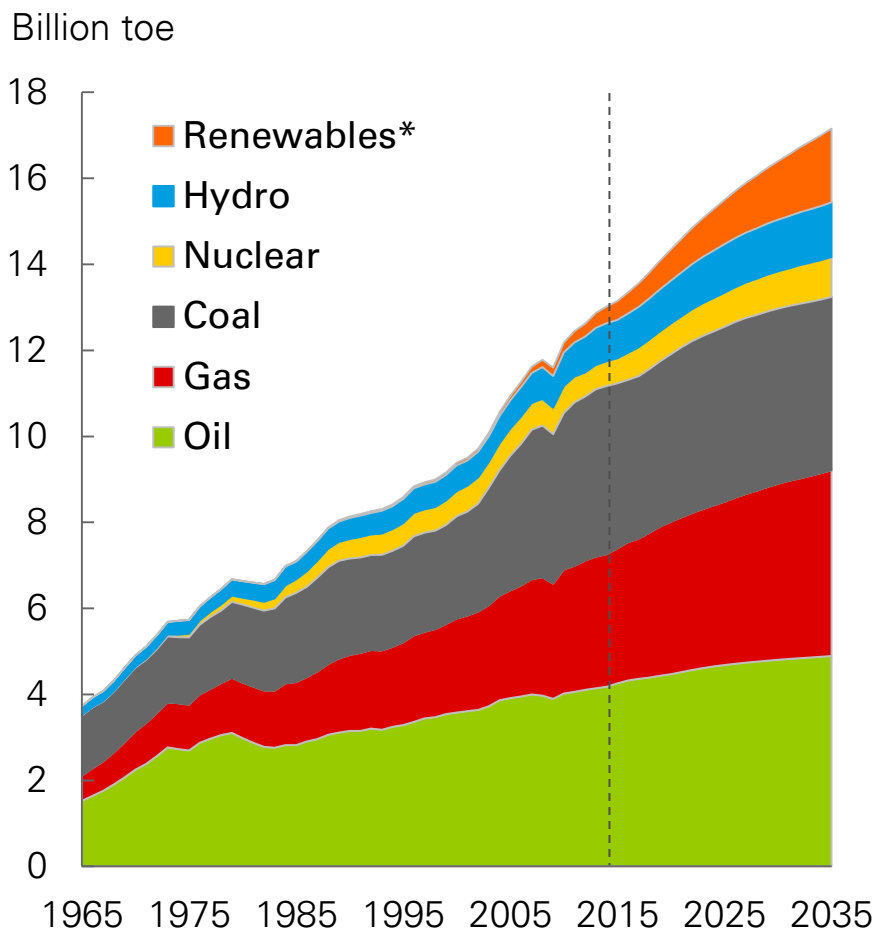


...largely consumed by fast-growing emerging economies

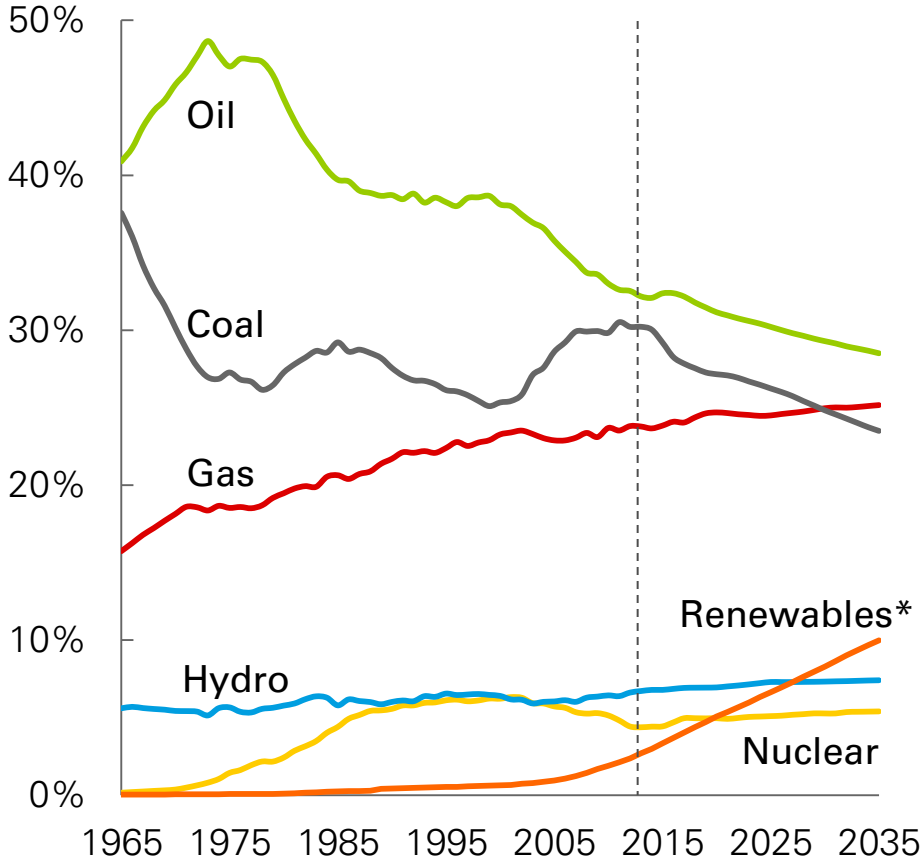
- Growth in the world economy requires more energy, although the extent of the increase is mitigated by falls in energy intensity (energy used per unit of GDP): global GDP doubles whereas energy demand increases by only 30%.
- Energy consumption is expected to grow less quickly than in the past: 1.3% p.a. over the Outlook versus 2.2% p.a. in 1995-2015.
- The pace at which global energy intensity declines is projected to increase as China's economy rebalances and more attention worldwide is focussed on improving energy efficiency.
- Virtually all of the growth in world energy demand comes from fast-growing emerging economies, with China and India accounting for over half of the increase. Energy demand within the OECD barely grows.
- China is expected to be the largest growth market for energy, although it is likely to be overtaken by India towards the end of the Outlook.

The gradual transition in the fuel mix continues…

Primary energy consumption by fuel



Shares of primary energy



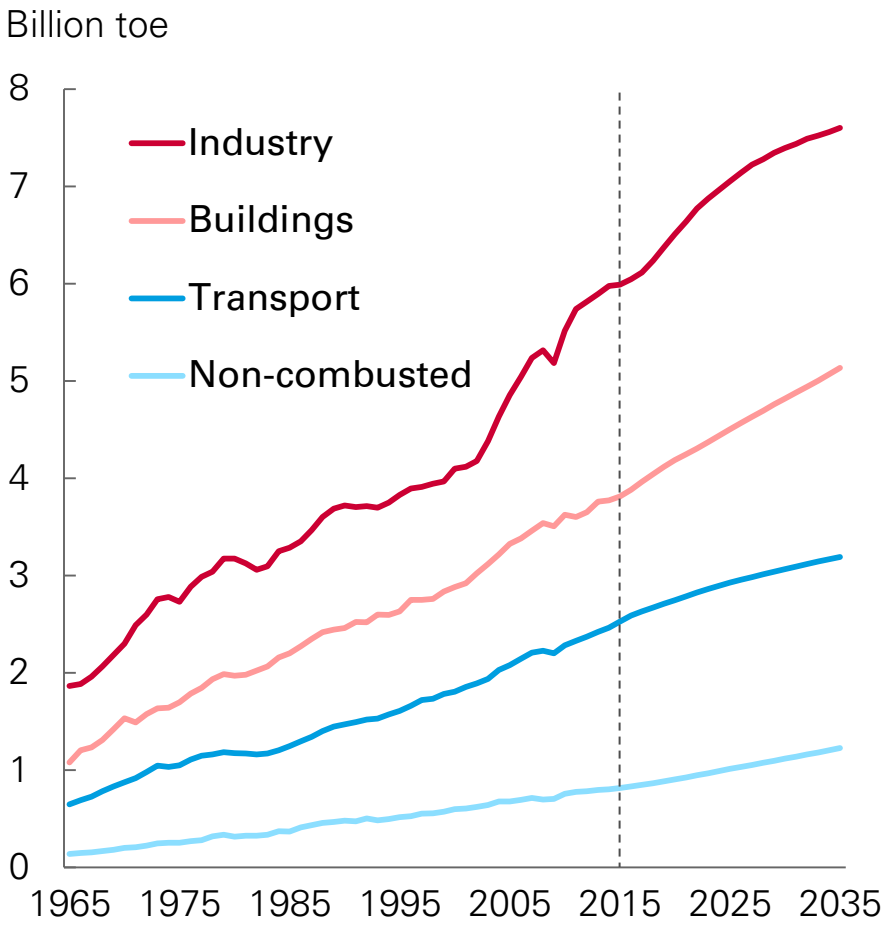
*Renewables includes wind, solar, geothermal, biomass, and biofuels

...with non-fossil fuels accounting for half of energy growth

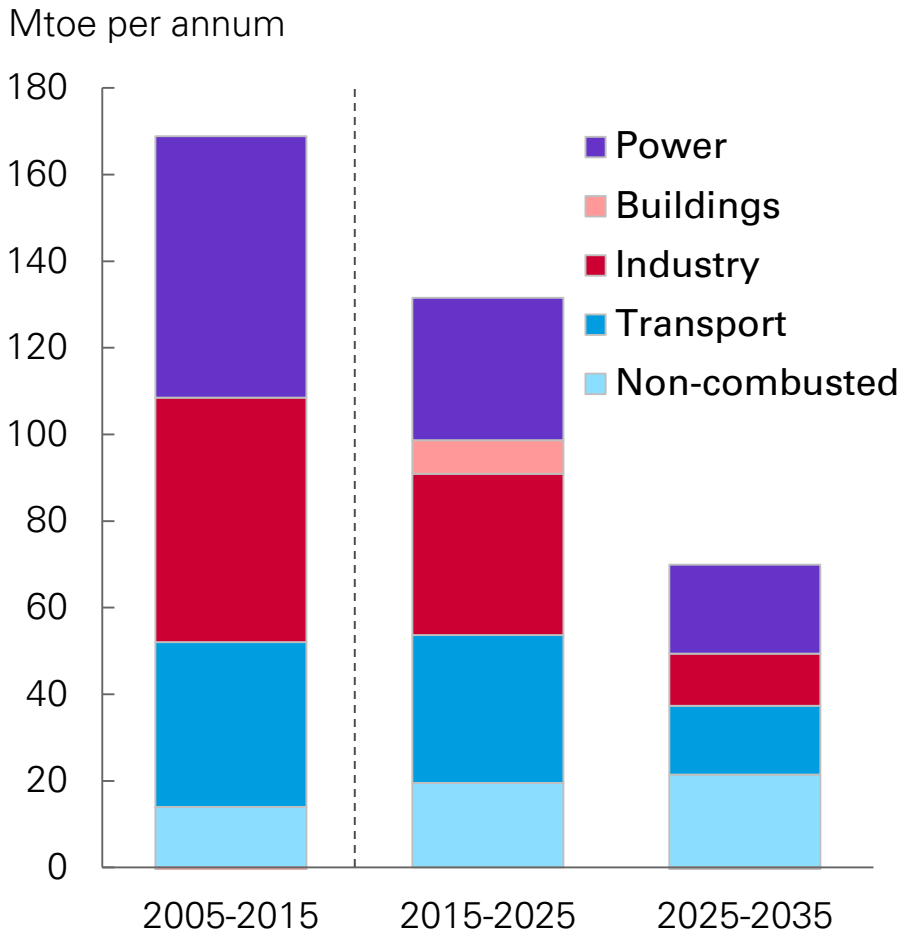
- The gradual transition in the fuel mix is set to continue with renewables, together with nuclear and hydroelectric power, expected to account for half of the growth in energy supplies over the next 20 years.
- Even so, oil, gas and coal remain the dominant sources of energy powering the world economy, accounting for more than three-quarters of total energy supplies in 2035 (down from 85% in 2015).
- Out of these, gas is the fastest growing fuel (1.6% p.a.), with its share in primary energy increasing as it overtakes coal to be the second-largest fuel source by 2035.
- Oil continues to grow (0.7% p.a.), although its pace of growth is expected to slow gradually.
- The growth of coal is projected to decline sharply: 0.2% p.a. compared with 2.7% p.a. over the past 20 years - coal consumption is expected to peak in the mid-2020s.
- Renewable energy is the fastest growing source of energy (7.1% p.a.), with its share in primary energy increasing to 10% by 2035, up from 3% in 2015.

Growth in energy demand in industry and transport slows…

Total energy consumption by final sector*



Fossil fuel demand growth by sector



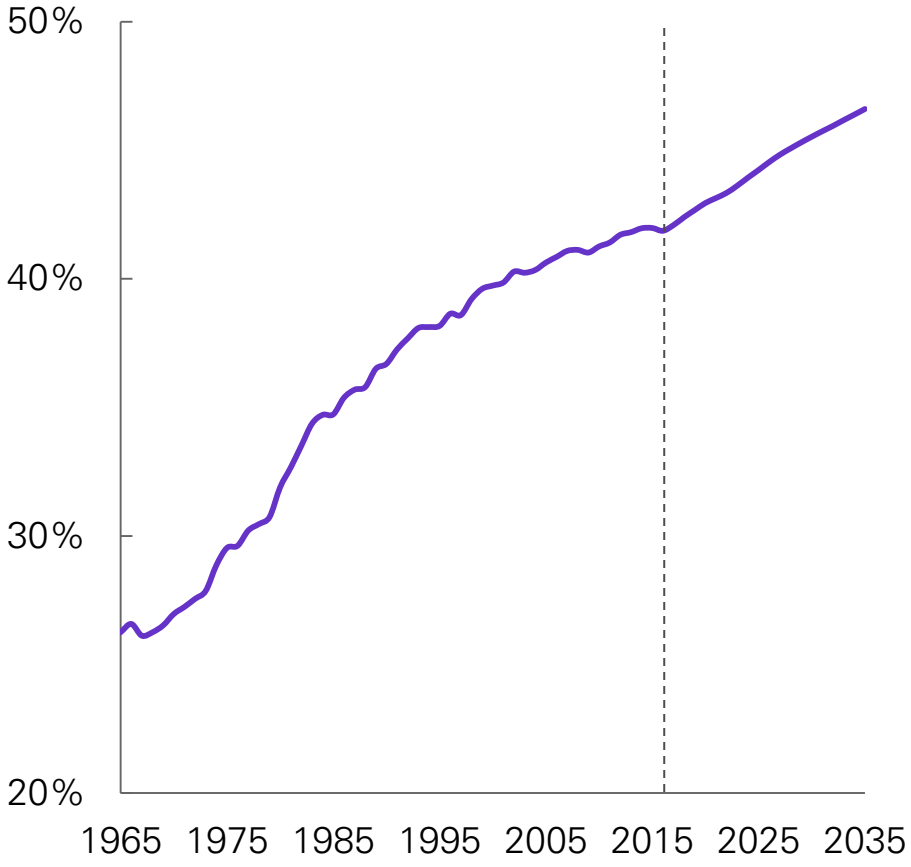
*Primary fuels in power allocated according to final sector electricity consumption

…while growth in non-combusted sector remains robust

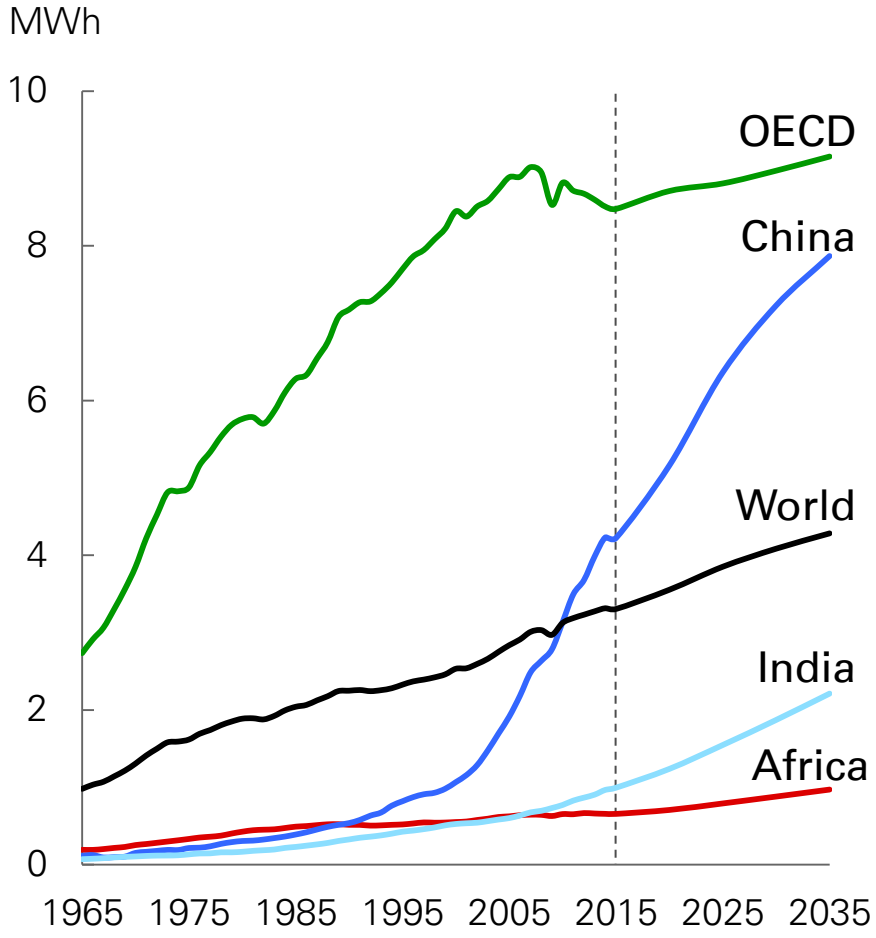
- By sector, industry and the 'buildings' sector (which also includes agriculture and other minor sectors) are the largest markets for final energy consumption and account for the majority of the growth in energy demand over the Outlook.
- However, demand growth in both of these sectors slows during the Outlook. Growth of energy use in the buildings sector slows (1.5% p.a.), driven by improved energy efficiency, while industrial growth (1.2% p.a.) is weighed down by efficiency gains and a shift away from energy-intensive sectors, particularly in China. Growth in transport consumption (1.2% p.a.) also eases as gains in fuel economy accelerate.
- In contrast, growth in non-combusted fuel use, particularly as a feedstock in petrochemicals, remains relatively robust (2.1% p.a.) in part because of its limited scope for efficiency gains.
- As a result, despite accounting for only a small fraction (6%) of current final energy use, non-combusted fuel use becomes the largest source of fossil fuel demand growth towards the end of the Outlook. Oil accounts for around two thirds of non-combusted sector's growth, with natural gas providing much of the remainder.

The power sector accounts for an increasing share of energy…

Share of power sector in primary energy consumption



Electricity consumption per capita

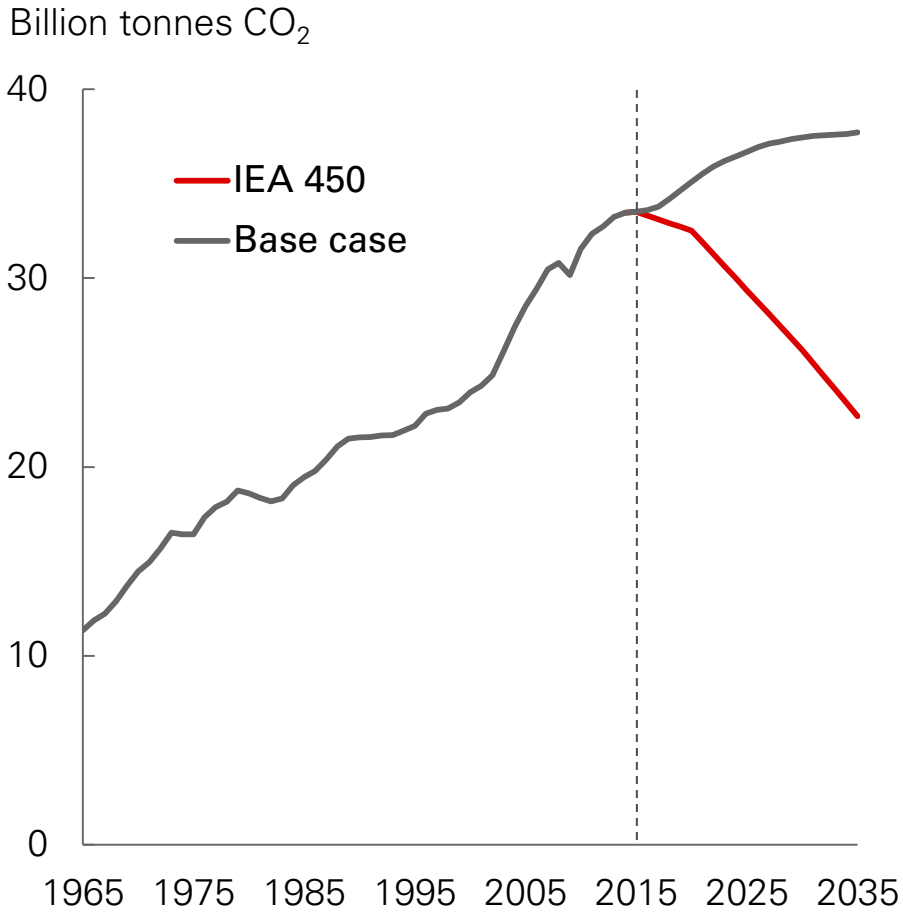


...as the world economy continues to electrify

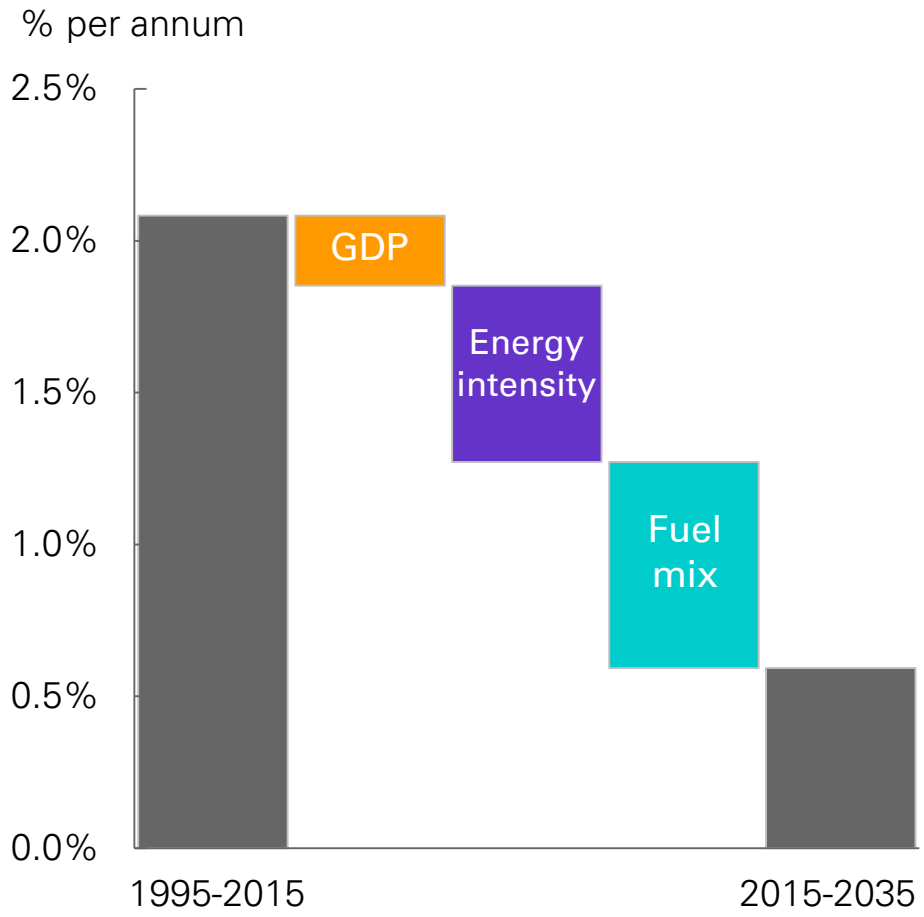
- The world economy continues to electrify: nearly two-thirds of the increase in global energy consumption over the Outlook is used for power generation.
- As a result, the share of energy used for power generation rises from 42% in 2015 to 47% by 2035.
- This rising share partly reflects a shift in consumer preferences towards electricity as a fuel that is clean and convenient at the point of use.
- It also reflects a strong catch-up process, with energy consumption per head in developing economies increasing rapidly towards OECD levels as prosperity rises.
- It is estimated that over 1 billion people currently do not have access to electricity, mainly in Africa, India and other parts of developing Asia.
- Increasing global access to energy is a key driver of energy trends over the Outlook. The potential importance of Africa in driving global energy demand post-2035 is considered on pages 90 to 91.

Carbon emissions look set to continue to rise…

Carbon emissions



Contributions to slower growth of carbon emissions



Carbon emissions have been revised to align with the updated methodology in the Statistical Review of World Energy. As such, the projection is not directly comparable to estimates in previous Energy Outlooks

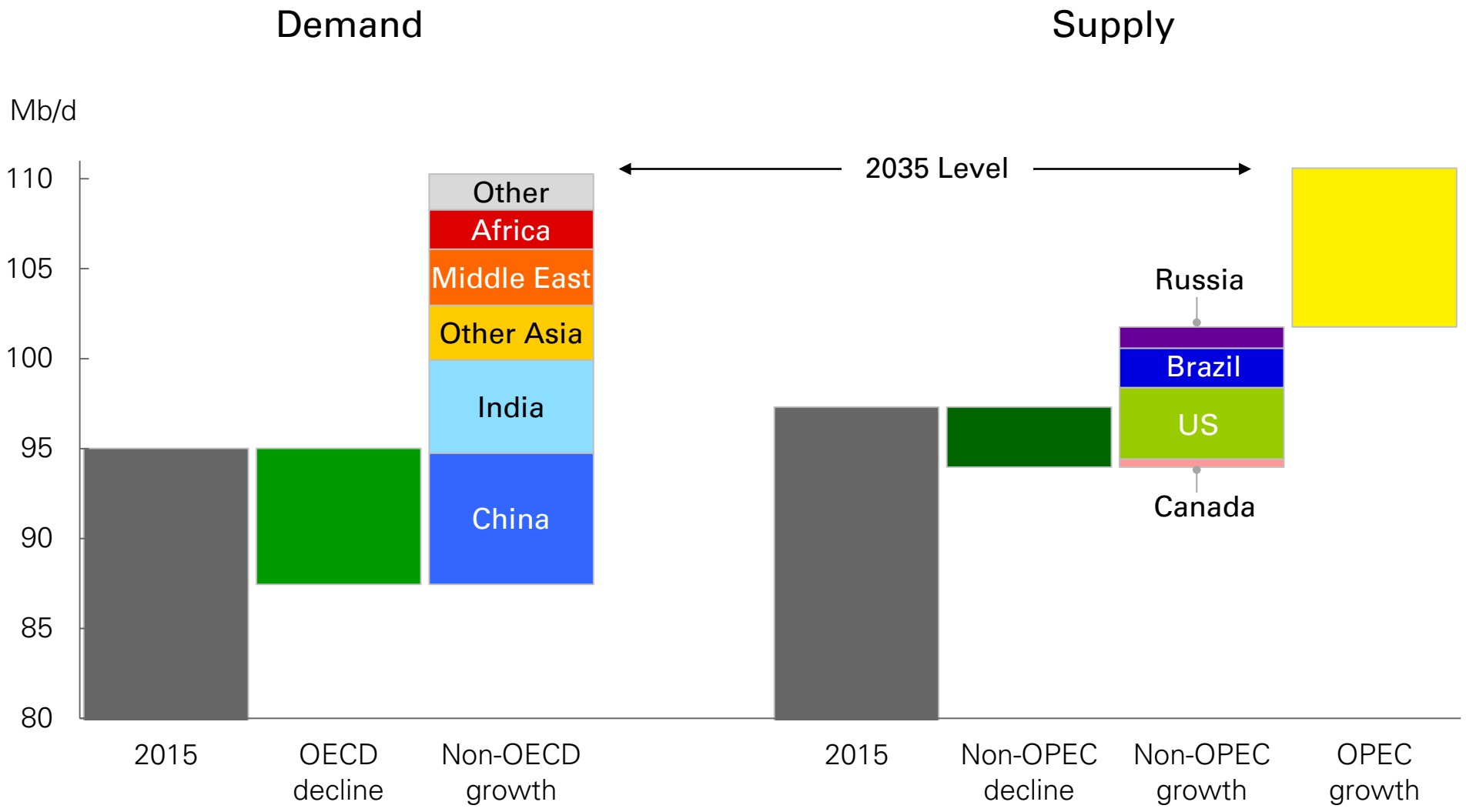
...albeit at less than a third of the rate seen in the past

- The base case implies that carbon emissions from energy use grow throughout the Outlook, rising by about 13%. This is far in excess of, for example, the IEA's 450 Scenario which suggests carbon emissions need to fall by around 30% by 2035 to have a good chance of achieving the goals set out in Paris.
- Even so, carbon emissions are projected to grow at less than a third of the rate seen in the past 20 years: 0.6% p.a. versus 2.1% p.a.. This would be the slowest rate of emissions growth for any 20 year period since our records began in 1965.
- The expected slowdown in carbon emissions growth reflects significant increases in the pace of decline in energy intensity and in the pace of change in the fuel mix, with coal consumption slowing sharply and gas - together with renewables, nuclear and hydroelectric power - supplying almost 80% of the increase in energy over the Outlook.
- The potential impact of an even sharper break with history in which carbon emissions fall materially over the Outlook is explored in the alternative cases described on pages 76 to 81.

Base case: Fuel-by-fuel detail

- Oil
- Natural gas
- Coal
- Nuclear and hydro
- Renewables

Growing oil demand in emerging economies…

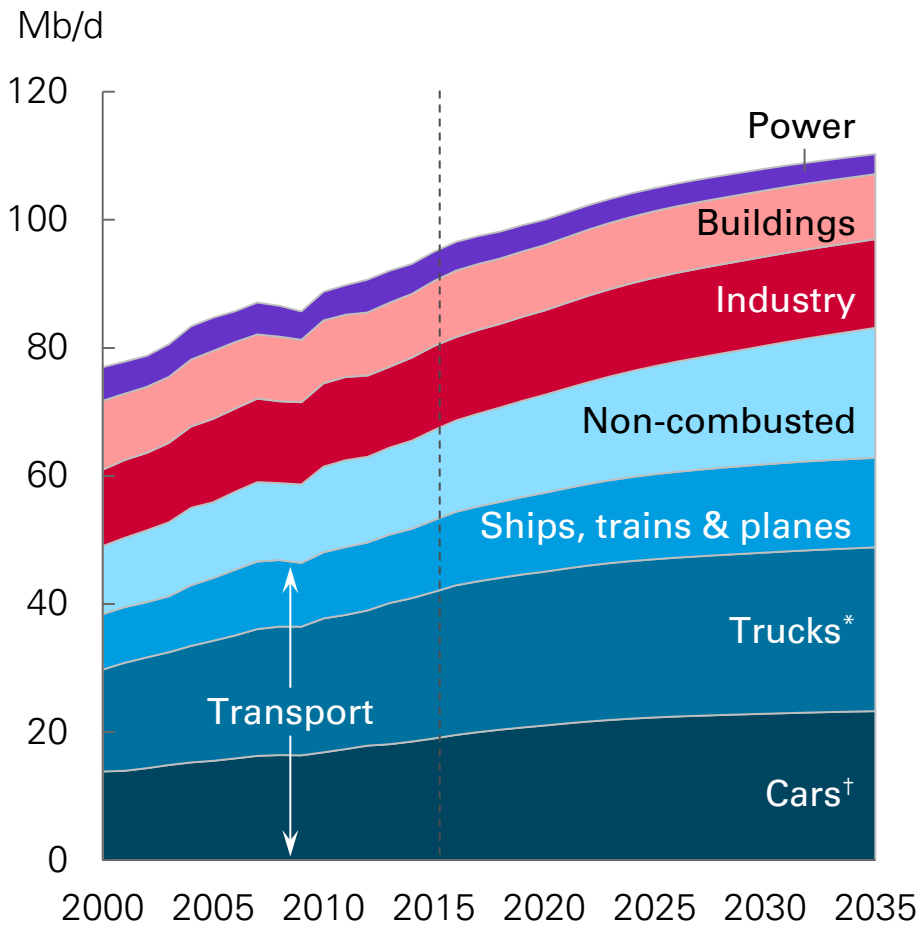


…is largely met by increased supply from low-cost producers

- Global liquids demand (oil, biofuels, and other liquid fuels) increases by around 15 Mb/d, to reach 110 Mb/d by 2035.
- All of this demand growth comes from emerging economies, as rising prosperity leads to increased oil demand, with China accounting for half of the growth. In contrast, OECD oil demand continues its trend decline (-8 Mb/d).
- Global liquids supply increases by a little less (13 Mb/d) reflecting the excess production of liquids in 2015. Supply increases are driven by holders of large-scale, low-cost resources, especially in the Middle East, US and Russia, as these producers are assumed to respond to the growing abundance of oil resources by asserting their competitive advantage.
- OPEC is assumed to account for nearly 70% of global supply growth, increasing by 9 Mb/d to 48 Mb/d by 2035.
- Non-OPEC supply grows by just over 4 Mb/d by 2035 with growth from the US (4 Mb/d), Brazil (2 Mb/d), Russia (1 Mb/d) and Canada (0.5 Mb/d) largely offset by declines in high-cost and mature regions elsewhere.

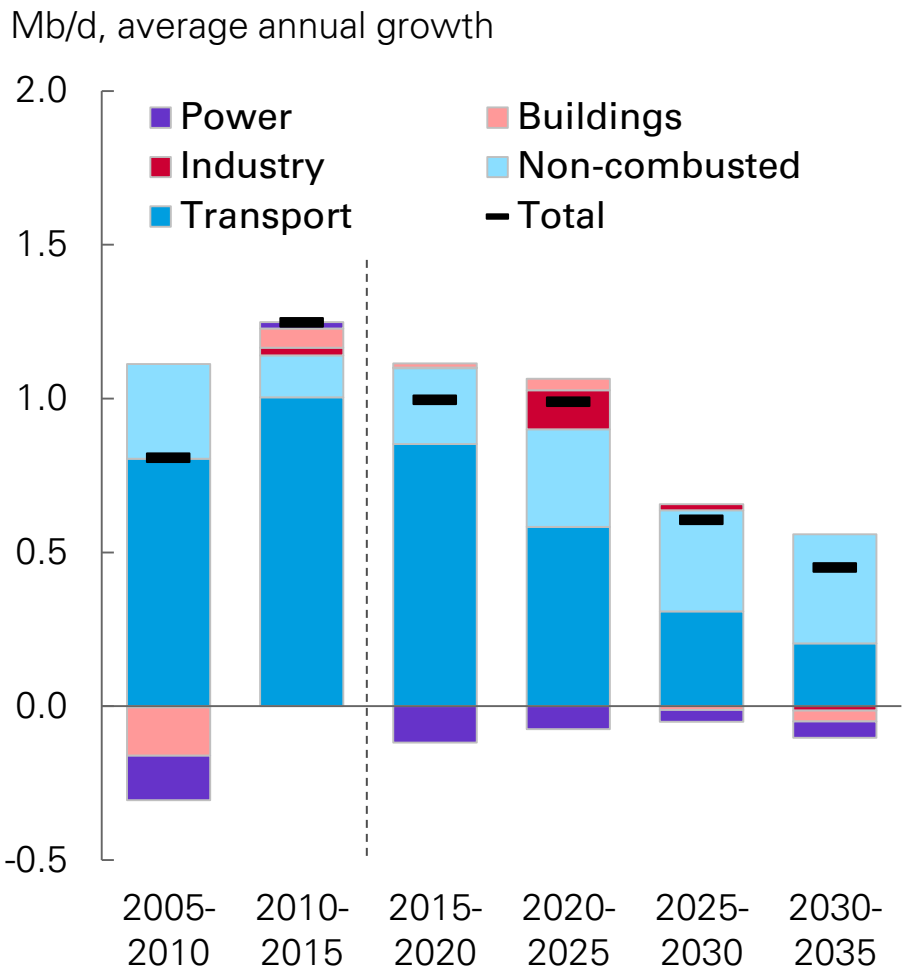
Oil demand grows throughout the Outlook...

Liquids demand



*Trucks include SUVs
†Cars include two-wheelers and other light duty vehicles

Liquids demand growth

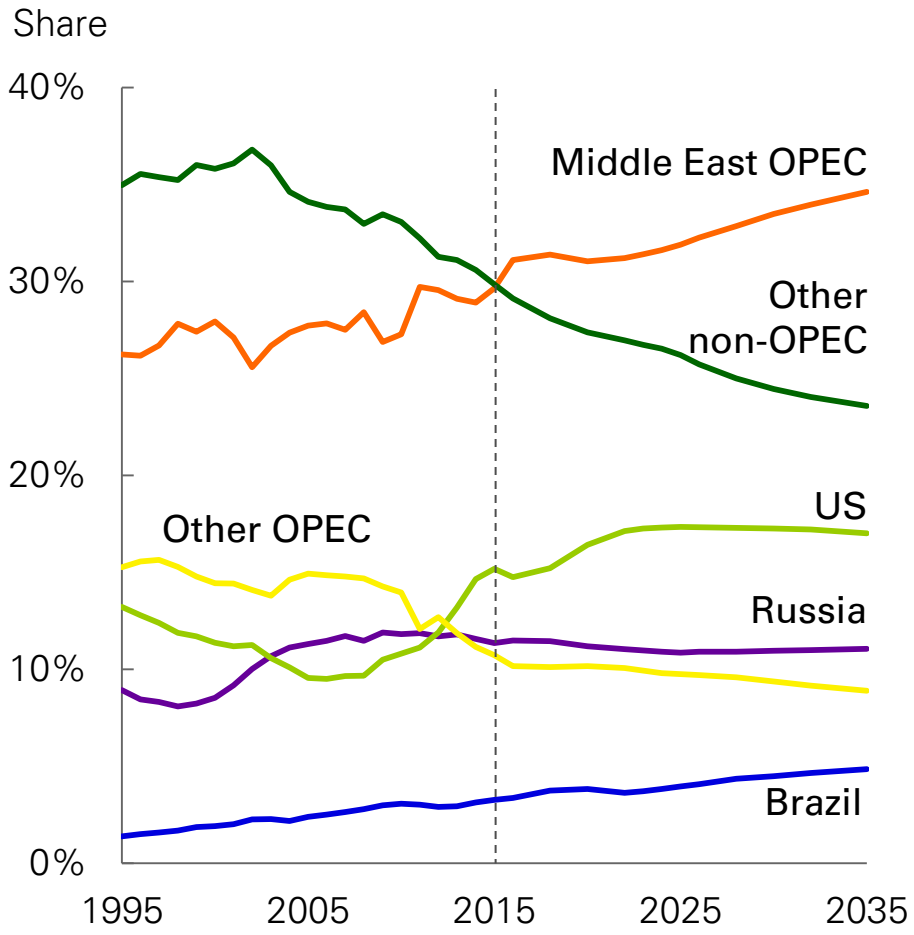


…but gradually slows as the stimulus from transport fades

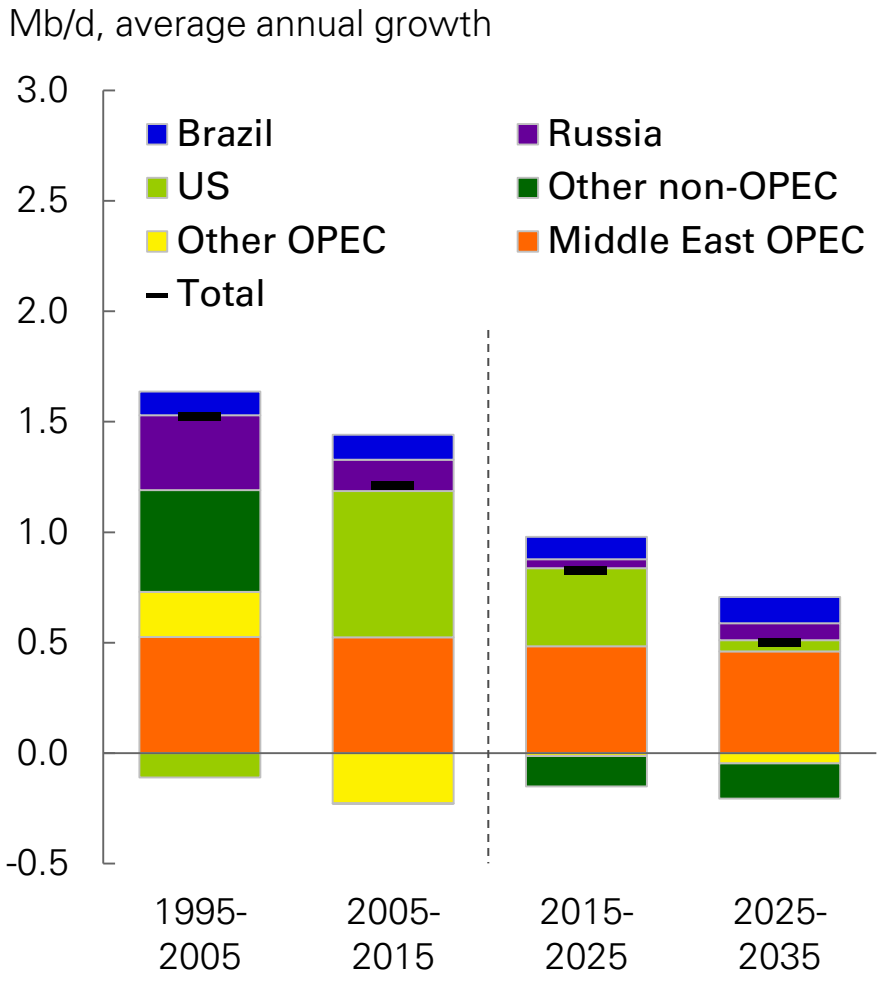
- Oil demand is expected to grow throughout the Outlook - albeit at a slower pace than in the past.
- The transport sector consumes most of the world's liquid fuel, with its share of global demand remaining just under 60% over the Outlook. Transport accounts for almost two-thirds of the growth in overall demand (10 Mb/d), with that increase split roughly evenly between: cars (4 Mb/d); trucks (3 Mb/d); and ships, trains & planes (3 Mb/d).
- But the stimulus from transport demand gradually fades, as fuel efficiency improves significantly and there is increasing penetration of non-oil fuels. Electricity, biofuels, coal and natural gas together account for 13% of transport fuel demand in 2035, up from 7% in 2015.
- Decelerating transport demand for oil causes growth in total oil demand to slow gradually, falling from around 1 Mb/d p.a. in the near-term to 0.4 Mb/d p.a. by 2035.
- Non-combusted use, especially within the petrochemicals sector, takes over as the main source of growth for liquids fuel demand by the early 2030s. Over the Outlook as a whole, demand for non-combusted use increases by 6 Mb/d.

Low-cost oil producers respond to global resource abundance…

Share of liquids supply



Growth of liquids supply

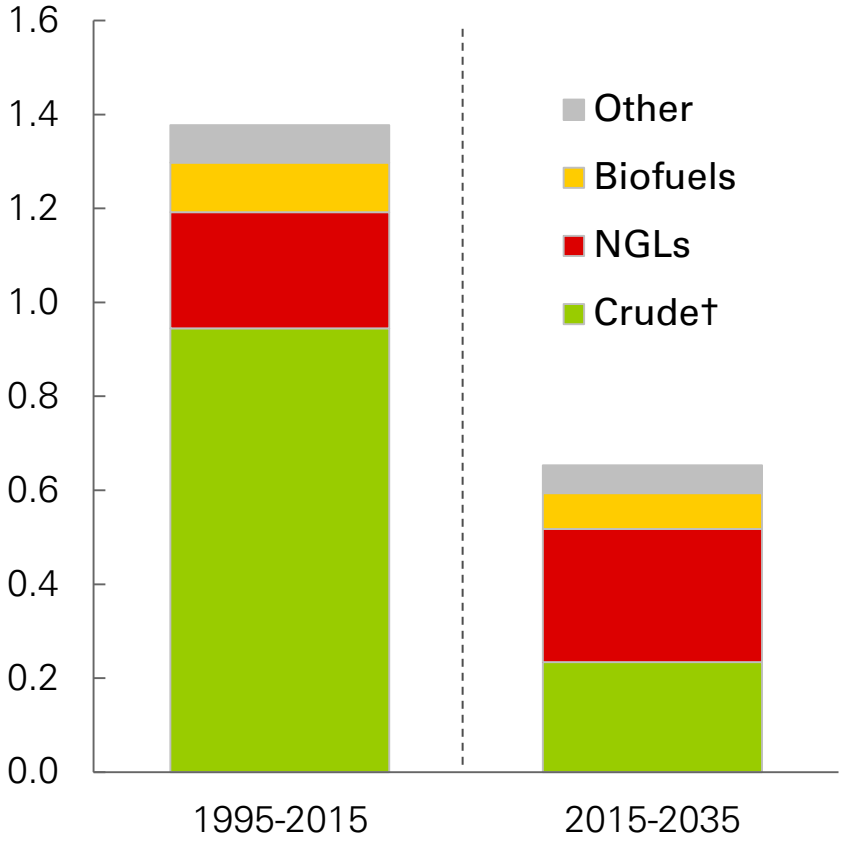


...by increasing their share of production

- The growing abundance of world oil resources is assumed to prompt a shift in the pattern of global oil supplies towards holders of large-scale, low-cost resources (see pages 50 to 53).
- As a result, the share of global liquids supply accounted for by Middle East OPEC, Russia and the US increases from 56% in 2015 to 63% by 2035.
- Middle East OPEC production increases by over 9 Mb/d over the Outlook, accounting for all the growth in OPEC production. Other OPEC production, which typically has a higher cost base, falls slightly over the Outlook, causing its share to edge lower.
- US output increases by 4 Mb/d reaching 19 Mb/d by 2035, with growth concentrated in the first half of the Outlook, driven by tight oil and NGL production. Russia's production is assumed to increase by 1 Mb/d to 12 Mb/d by 2035.
- Growing output in Brazil (2 Mb/d) stems from deepwater production. Other non-OPEC production declines, with its share in liquids production falling from 30% in 2015 to 24% by 2035 - the lowest share in our data going back to 1965.

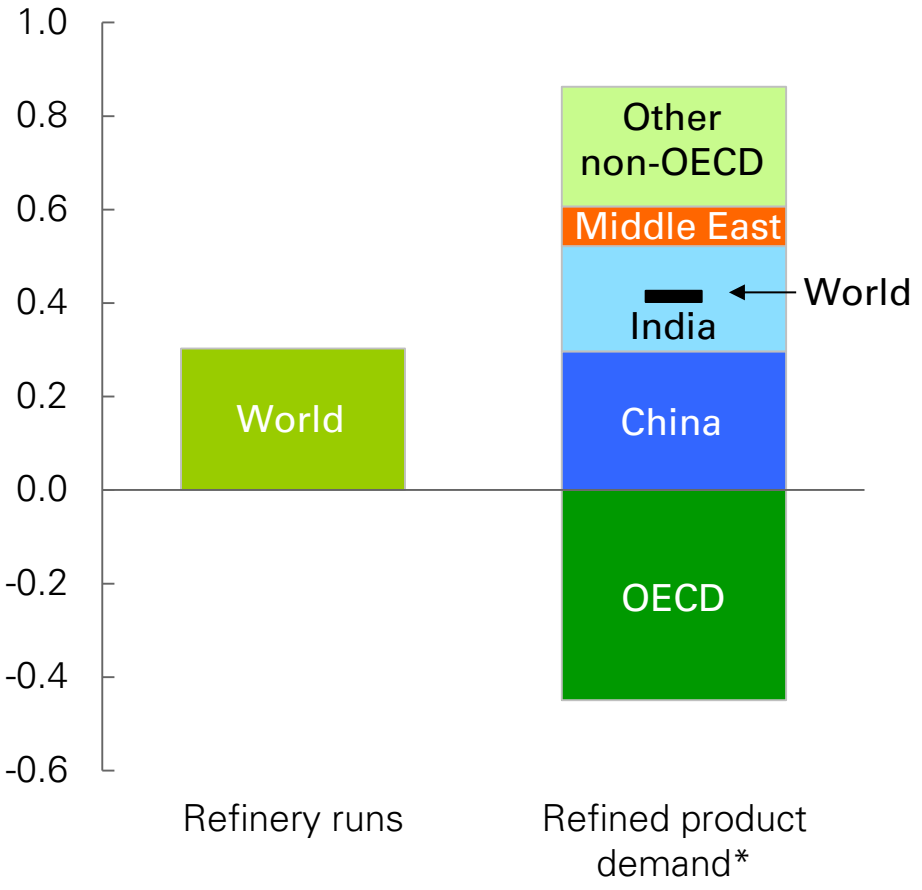
Growth in global refinery runs is limited…

Liquids supply growth by source



† Includes condensate

Refinery runs and product demand growth: 2015-2035



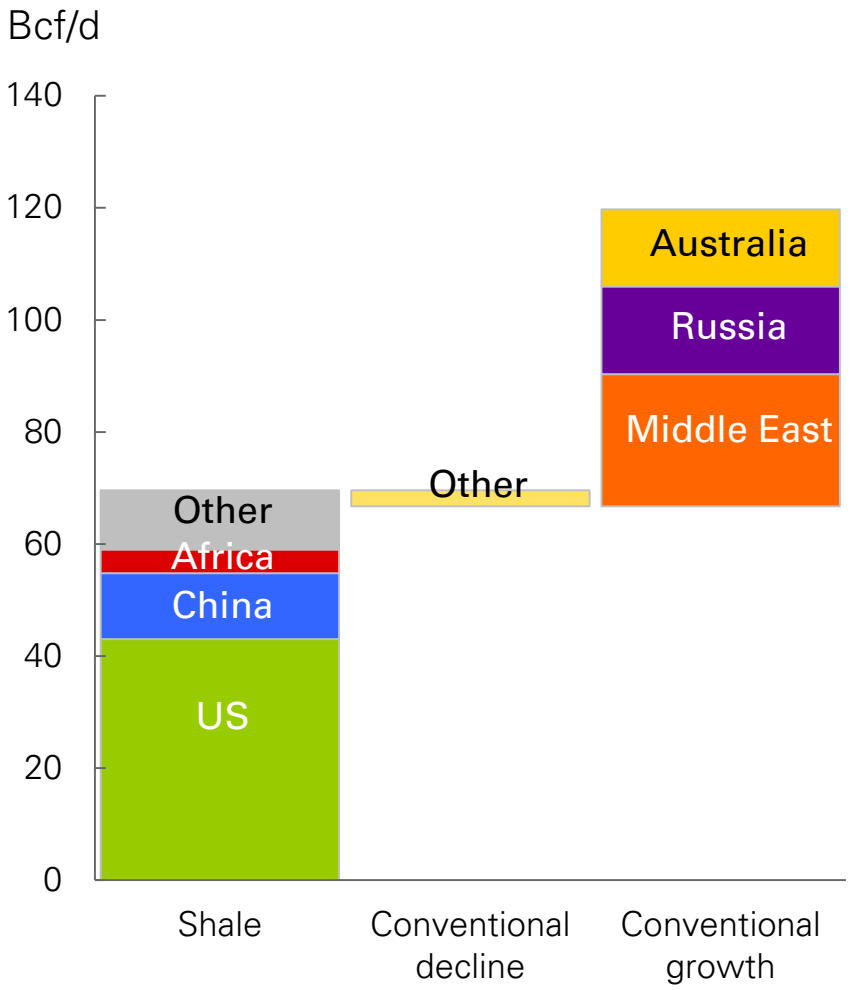
*Excludes ethane, LPG, biofuels, GTLs and CTLs

…by weak demand and abundant NGL supplies

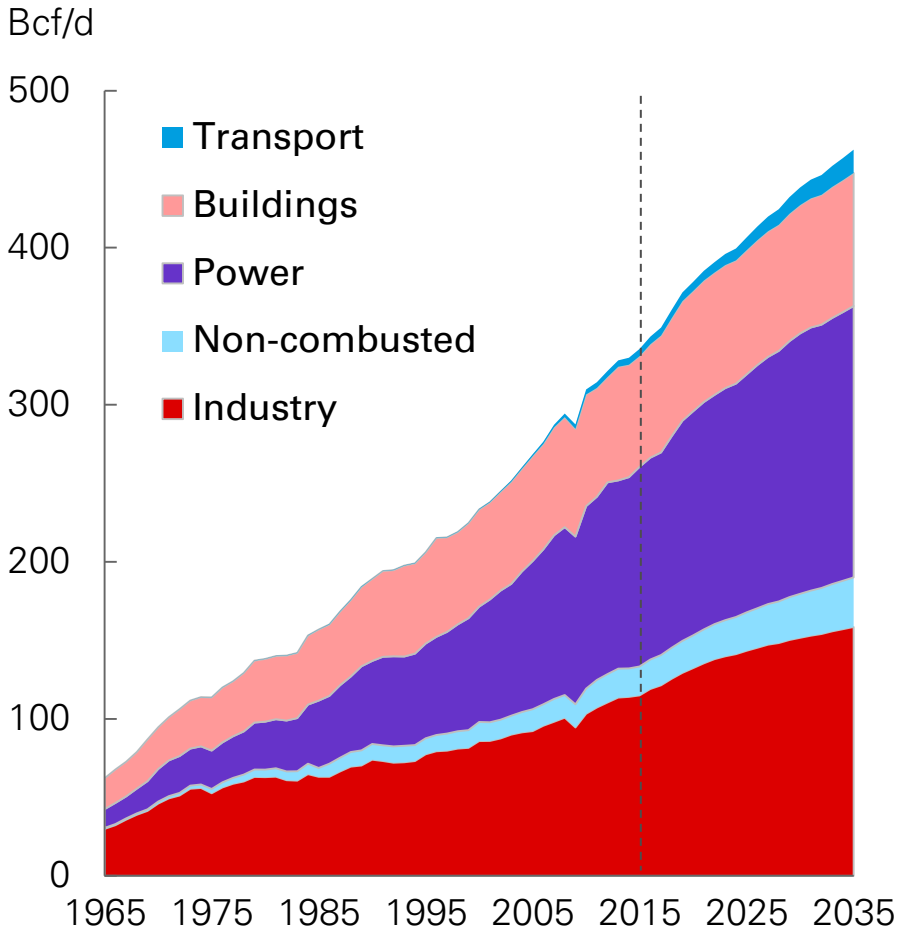
- Liquids supply increases by just 0.7 Mb/d per year over the Outlook, much slower than the 1.3 Mb/d per year growth seen over the past 20 years, reflecting the weaker outlook for demand.
- Strong gains in NGLs production (0.3 Mb/d p.a.) and continued growth in biofuels, mean global refinery runs increase by only 0.3 Mb/d per year.
- All of the growth in refined product demand stems from emerging economies, with the trend decline in OECD demand continuing. Historically, many countries and regions in the non-OECD, including China, India and the Middle East, have tended to build sufficient new refining capacity to meet (or exceed) their demand growth, rather than rely on imports. If that practice continues, this could lead to substantial refinery spare capacity and ultimately closures in mature markets such as Europe, OECD Asia and parts of North America.
- Indeed, announced start-ups and plans for new capacity between 2015 and 2020 already total around 8 Mb/d, which would be sufficient to meet the entire projected increase in refinery throughput over the next 20 years.

Strong growth in global gas supplies led by US shale...

Gas supply growth 2015-2035



Gas consumption by sector

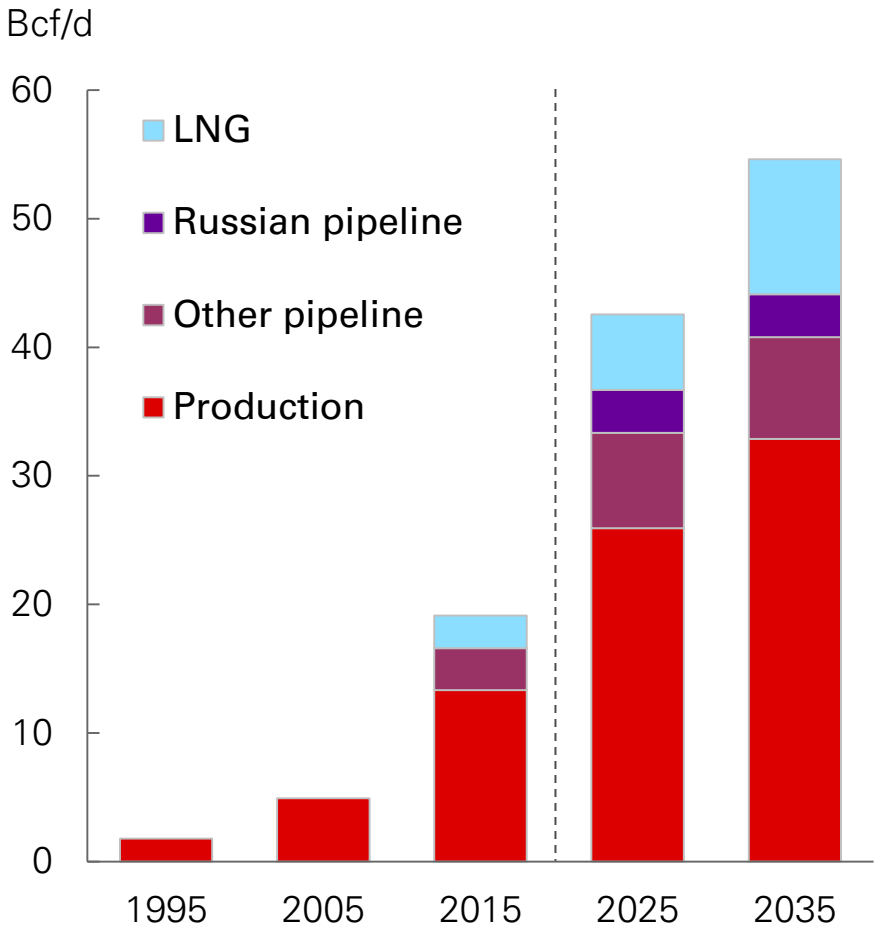


...supports increased consumption within industry and power

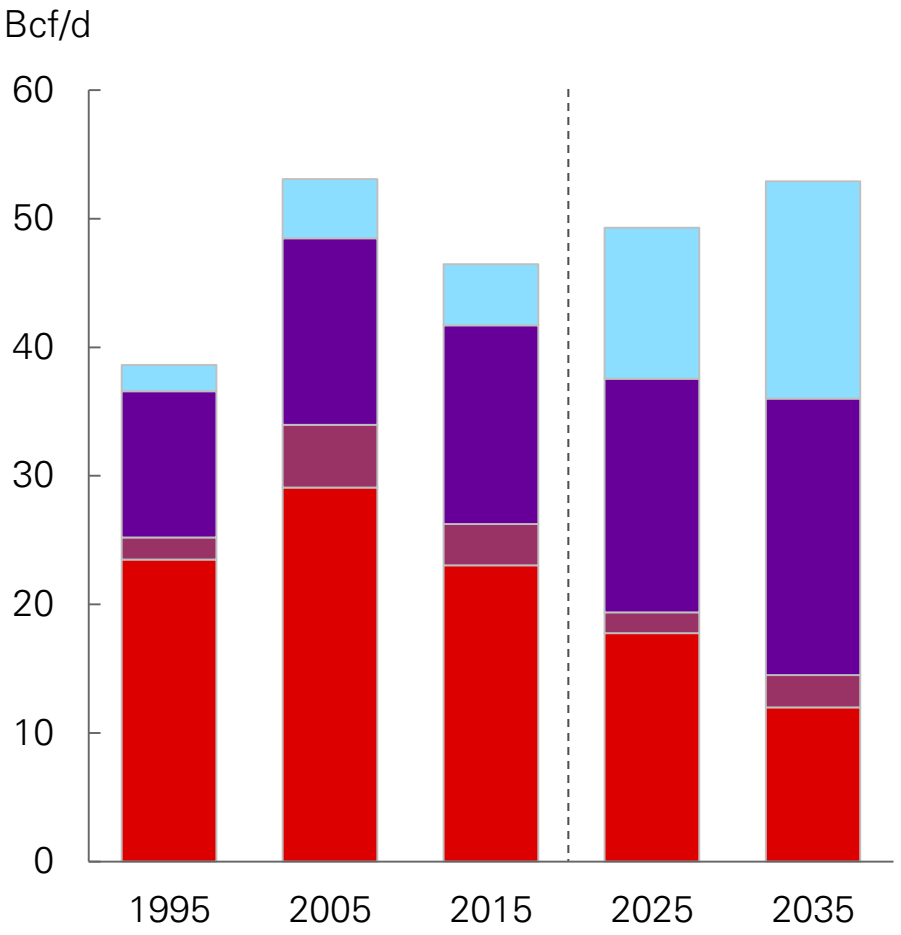
- Natural gas grows faster than both oil and coal, growing by 1.6% p.a. between 2015 and 2035.
- Shale production (5.2% p.a.) accounts for around sixty percent of the increase in gas supplies, driven by the US where shale output more than doubles (43 Bcf/d). Towards the end of the Outlook, China emerges as the second largest shale supplier. Shale gas accounts for around a quarter of total gas production by 2035.
- Increases in conventional gas production (0.7% p.a.) are led by the Middle East, Russia and Australia.
- The main centres of demand growth are: China, with gas gaining share in industry and power; and the Middle East and the US where increased availability of gas helps boost demand within the power sector.
- By sector, the largest contribution to consumption growth comes from the industrial sector (with combusted and non-combusted use together accounting for 45% of growth) followed by power (36%).

Increasing diversity of imported gas supplies…

Gas supply to China



Gas supply to Europe

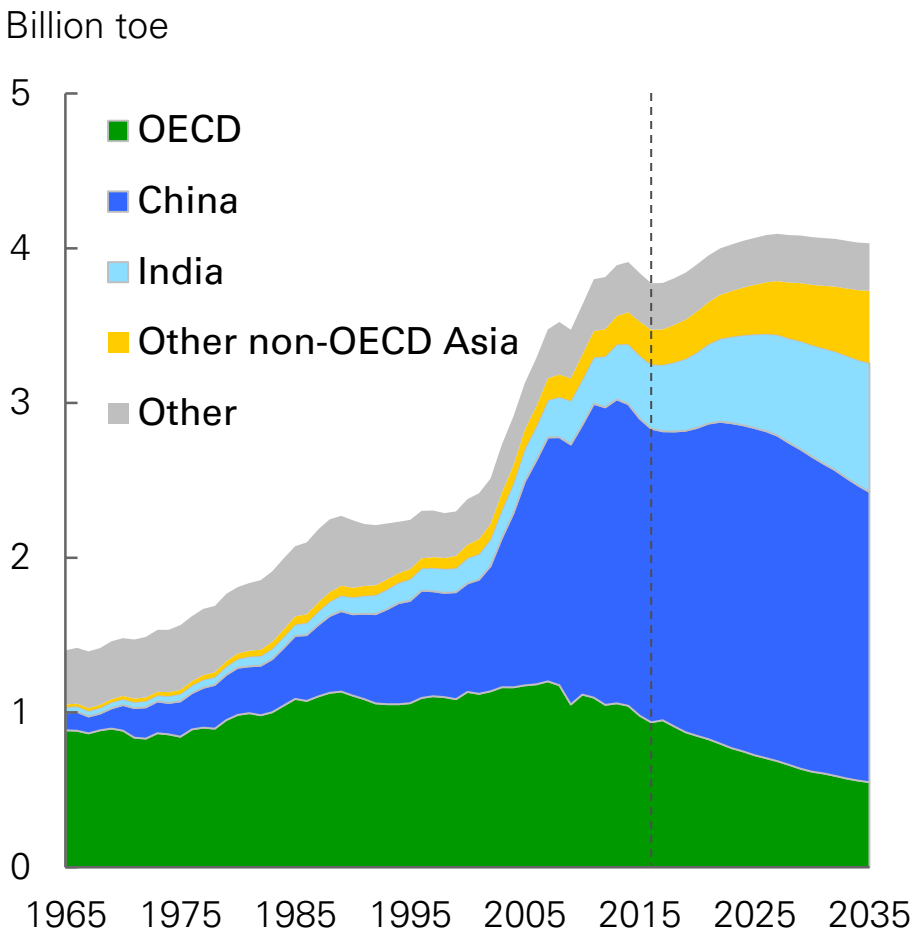


…supports gas consumption in key world markets

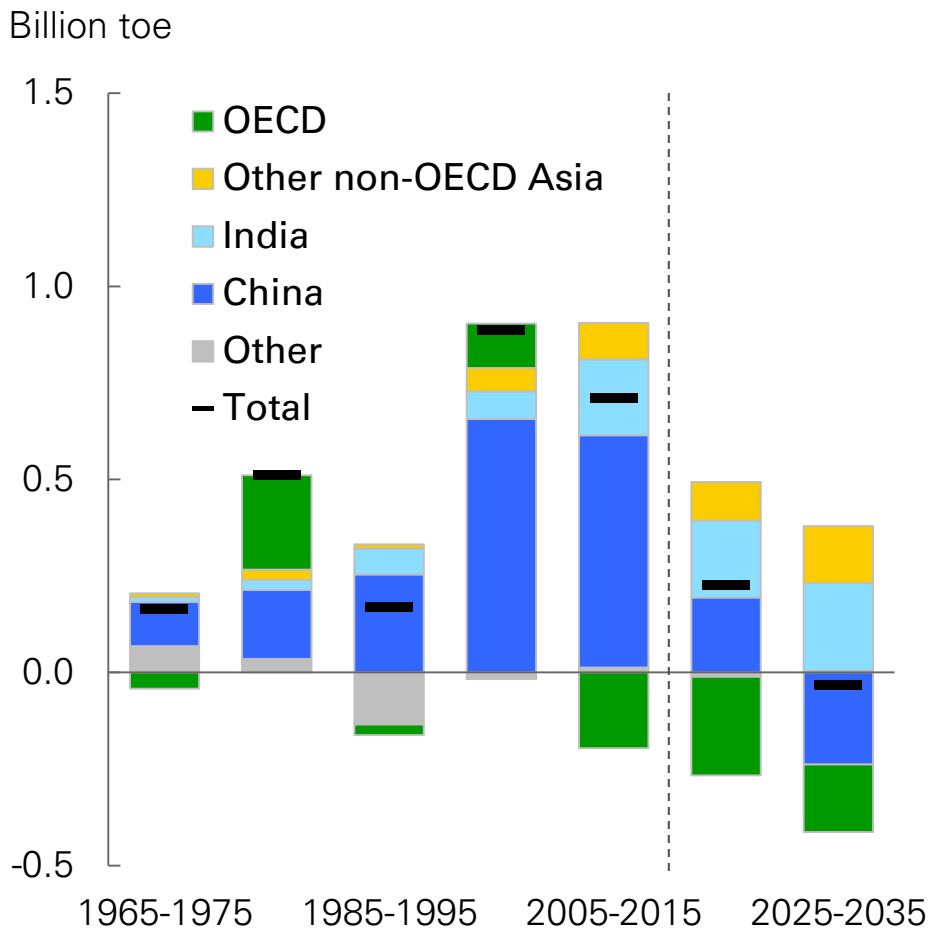
- While import dependence grows in both China and Europe, the increased diversity of supplies associated with a rapid expansion of LNG helps to support gas consumption.
- In China, growth in gas consumption (5.4% p.a., 36 Bcf/d) outstrips domestic production, such that the share of imported gas in total consumption rises to nearly 40% by 2035, up from 30% in 2015.
- Around half of these increased imports are met by LNG, with rising pipeline imports from Russia and other Commonwealth of Independent States (CIS) countries providing the remainder.
- In Europe, domestic production is set to decline sharply (-3.2% p.a.) as existing fields mature and are not replaced. As a result, the share of imported gas in total consumption rises from around 50% in 2015 to nearly 80% by 2035.
- LNG imports are expected to supply around two-thirds of the increase in imports, with rising pipeline imports from Russia providing the remainder.

Growth in global coal demand slows sharply…

Coal consumption by region



Ten-year increments by region

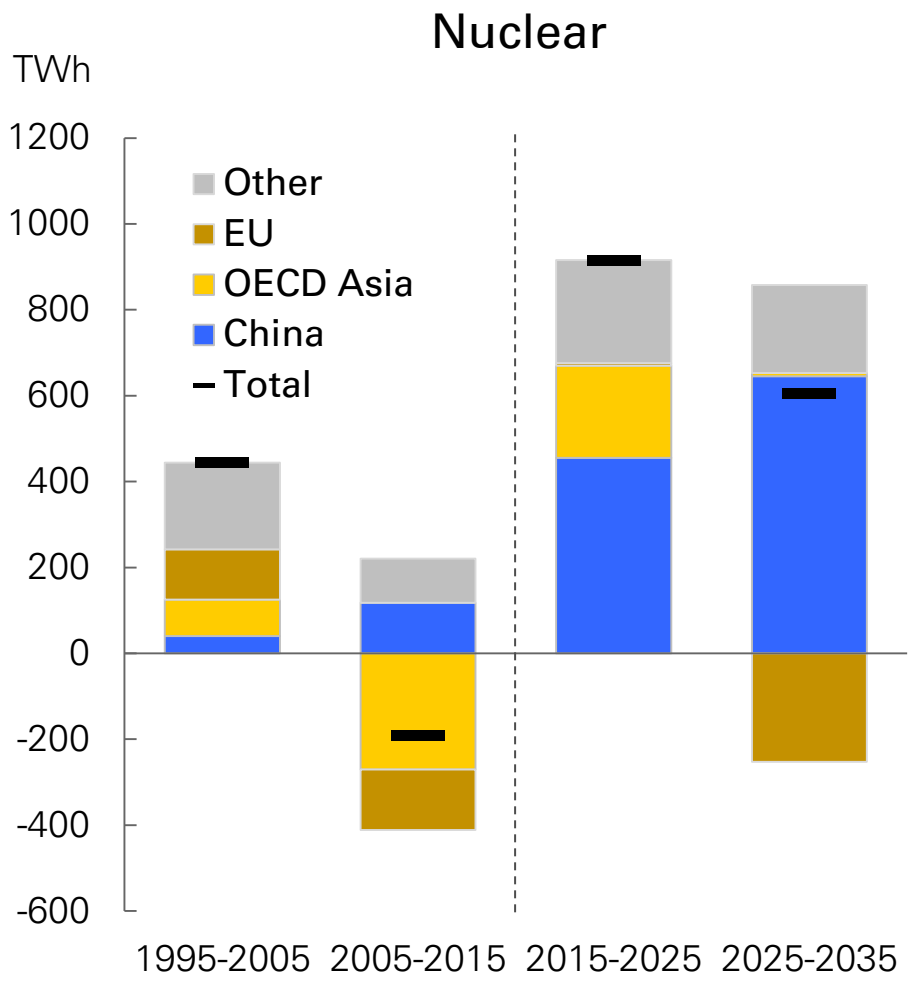


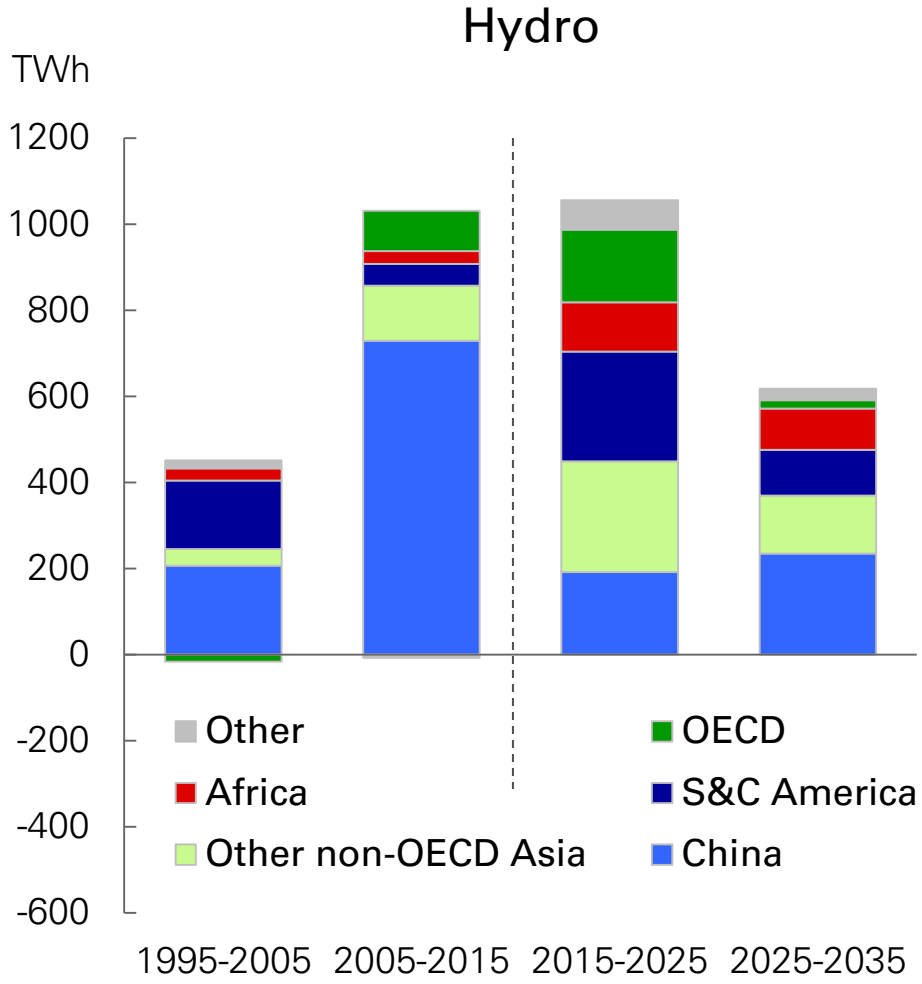
...driven by China's changing energy needs

- Growth in global coal demand slows sharply relative to the past (0.2% p.a. versus 2.7% p.a. over the past 20 years); global coal consumption peaks in the mid-2020s.
- Much of this slowdown is driven by China as its economy adjusts to a more sustainable pattern of growth and government policies prompt a shift away from coal towards cleaner, lower-carbon fuels. China's coal consumption is projected to broadly plateau over the next 20 years, in sharp contrast to the rapid, industrialization-fuelled growth of much of the past 20 years.
- Even so, China remains the world's largest market for coal, accounting for nearly half of global coal consumption in 2035.
- India is the largest growth market, with its share of world coal demand doubling from around 10% in 2015 to 20% in 2035. Over two-thirds of India's increased demand for coal is projected to feed into the power sector.
- Coal consumption in the OECD falls by over 40% as the share of coal within the power sector is crowded out by renewables and natural gas.

Nuclear and hydro generation grow steadily…

Ten-year increments in power generation by region:



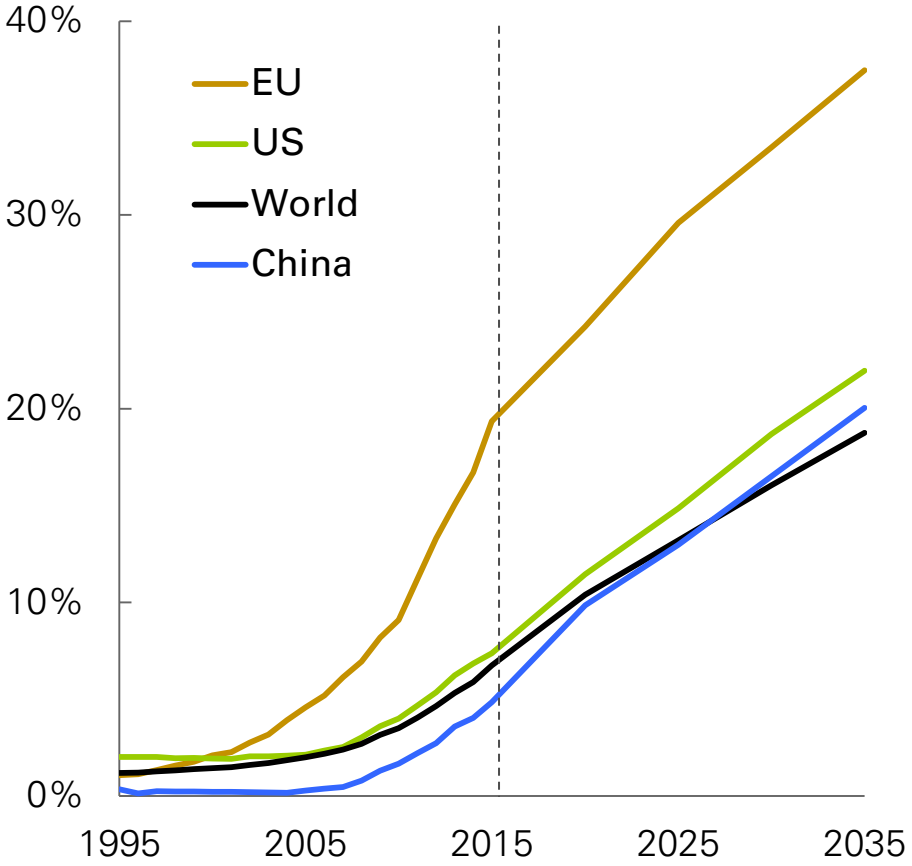


...maintaining their share within the power sector

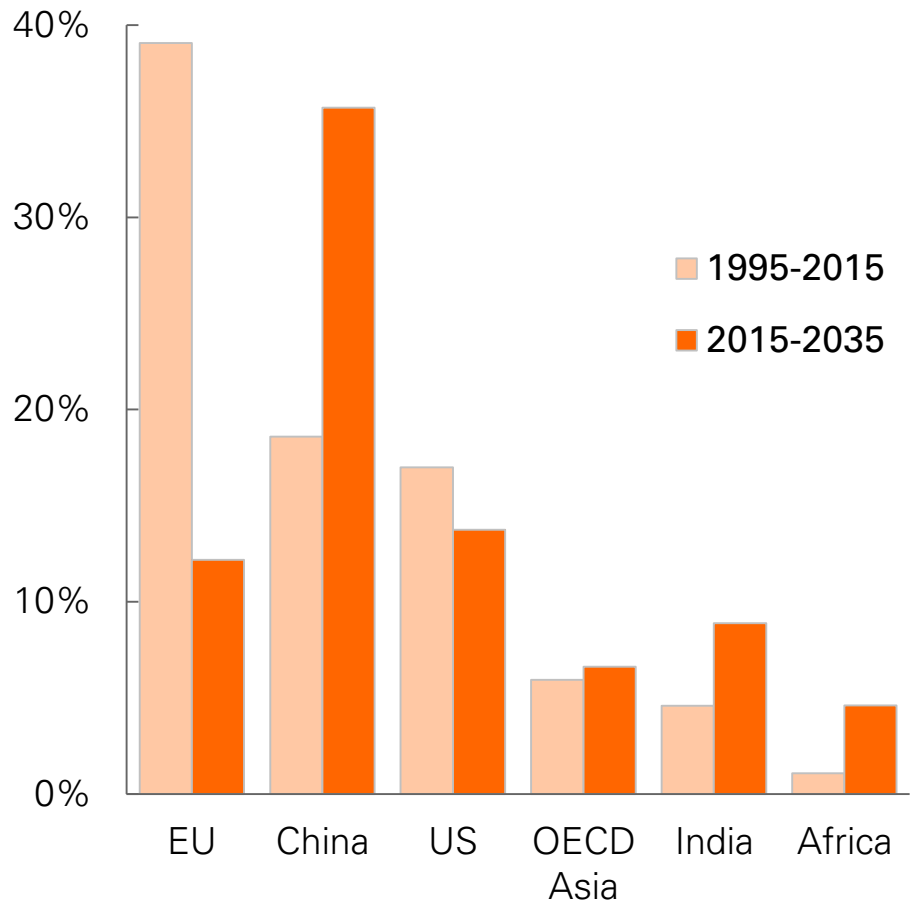
- Nuclear and hydro power generation are expected to grow steadily over the Outlook, by 2.3% p.a. and 1.8% p.a. respectively, broadly maintaining their combined share within the power sector.
- Nuclear capacity in Europe declines as ageing plants are gradually decommissioned and there is little new investment: EU nuclear power generation by 2035 is 30% lower than in 2015. Japan is assumed to restart some of its reactors gradually over the first half of the Outlook, but does not recover to pre-Fukushima levels.
- China's rapid nuclear expansion programme (11% p.a., 1100 TWh) accounts for nearly three-quarters of the global increase in nuclear generation. This is roughly equivalent to China introducing a new reactor every three months for the next 20 years.
- In contrast, growth of China's hydro power generation (430 TWh) slows sharply relative to the last decade as the availability of prime resources falls. Brazil and India make up some of the gap, with each expanding output by more than 100 TWh over the Outlook.

Renewables continue to grow rapidly…

Renewables share of power generation



Shares of renewable power growth

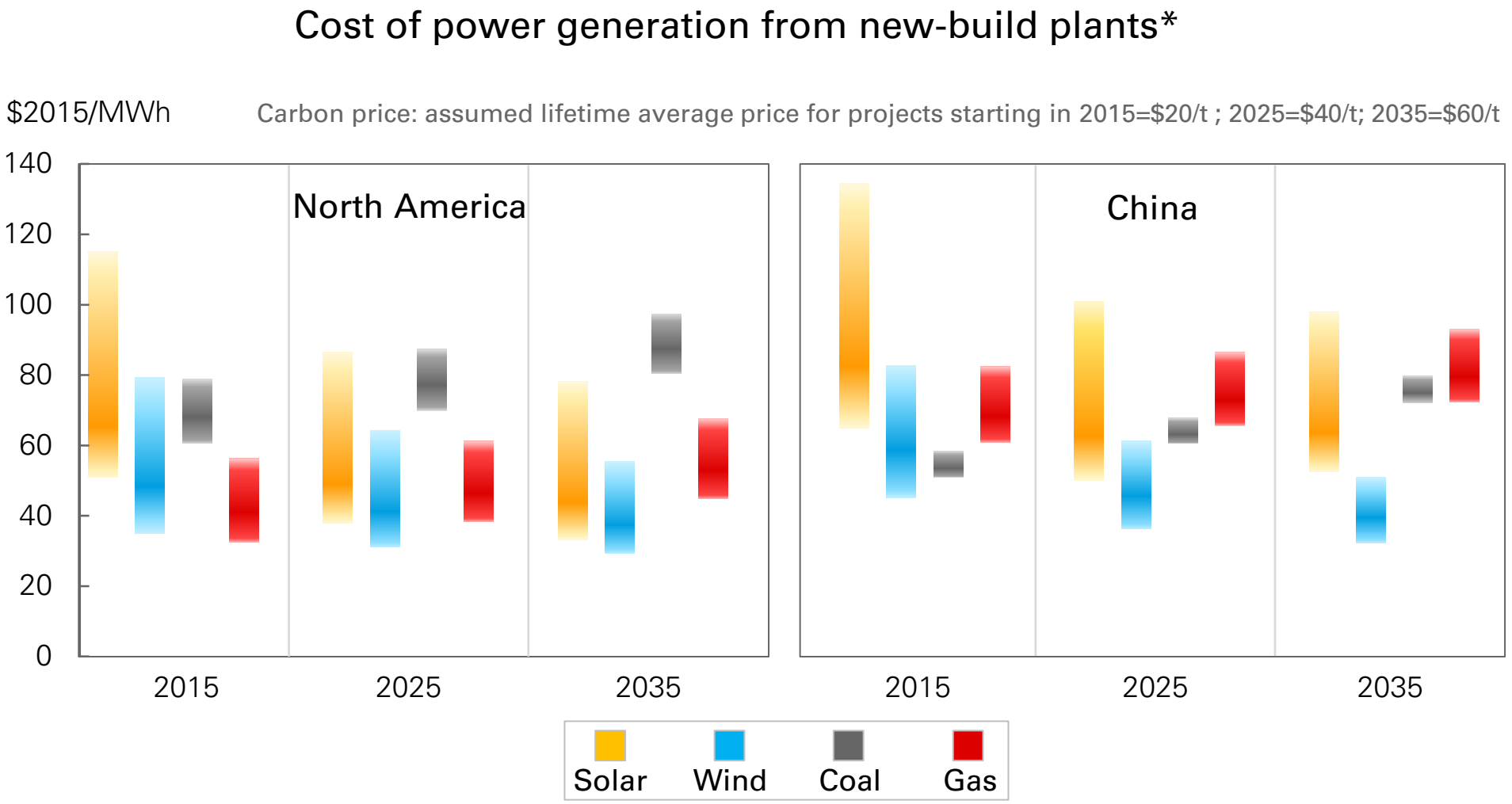


...with the weight of growth shifting towards Asia

- Renewables in power are projected to be the fastest growing fuel source (7.6% p.a.), more than quadrupling over the Outlook.
- Renewables account for 40% of the growth in power generation, causing their share of global power to increase from 7% in 2015 to nearly 20% by 2035.
- The EU continues to lead the way in terms of the penetration of renewables, with the share of renewables within the EU power sector doubling over the Outlook to reach almost 40% by 2035.
- However, China is the largest source of growth over the next 20 years, adding more renewable power than the EU and US combined.
- The strong growth in renewable energy is underpinned by the view that the competitiveness of both solar and wind power improves significantly over the Outlook. This is discussed overleaf.

Renewables growth is driven by increasing competitiveness…

Cost of power generation from new-build plants*



*Levelized cost of power over the lifetime of a plant. Ranges reflect the impact of low/high estimates for: cost of capital; load factors for solar and wind; fuel prices for gas and coal. Solar and wind include estimates of system integration costs

...as costs fall and operating efficiency of wind power improves

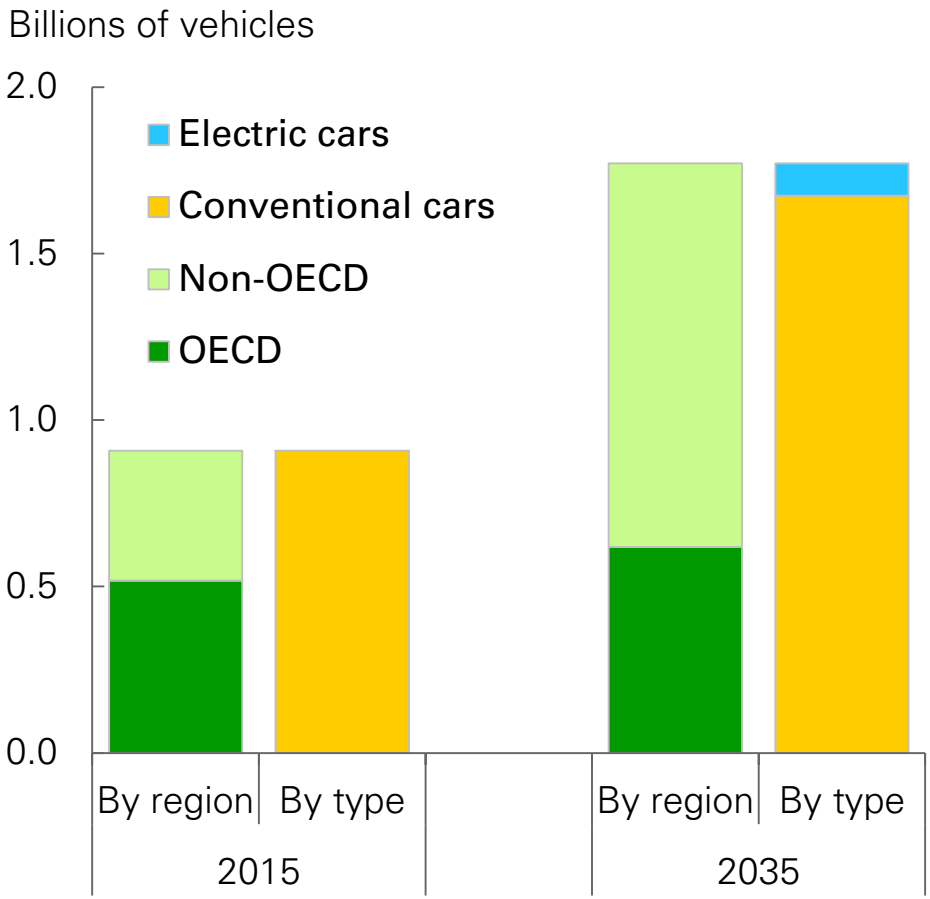
- The cost of solar power is expected to continue to fall, although the pace of that reduction slows, as the rapidly-declining PV module costs account for a decreasing share of the total installed solar costs.
- In contrast, wind power costs are assumed to fall materially throughout the Outlook, reflecting the view that there is considerable scope to improve the performance of wind turbines in harvesting the wind.
- Assessing the competitiveness of renewables needs to take into account the costs of ensuring system stability as increasing amounts of intermittent energy are added. Detailed analysis of these costs (which vary significantly across technologies and countries) indicate that they are likely to be relatively low for the levels of penetration projected out to 2035.
- Overall the analysis, including the estimated impact of system integration costs, suggests that onshore wind power will remain more competitive than solar energy in both the US and China power sectors, with gas providing the main source of competition in the US and coal in China.

Base case: Key issues

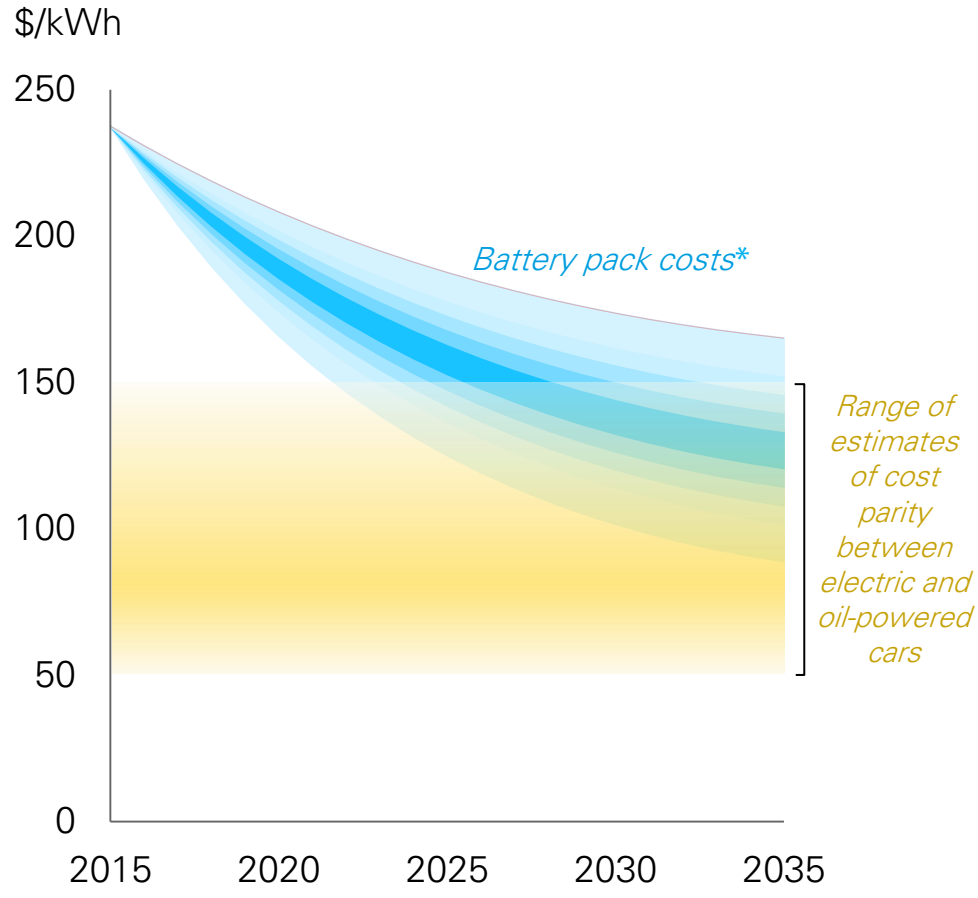
- Impact of electric cars on oil demand
- Oil supplies in a world of increasing abundance
- Implications of the growth of LNG for the global gas market
- China's changing energy landscape

Rising prosperity boosts car ownership in emerging markets…

The global car fleet: 2015-2035



Illustrative path for battery pack costs



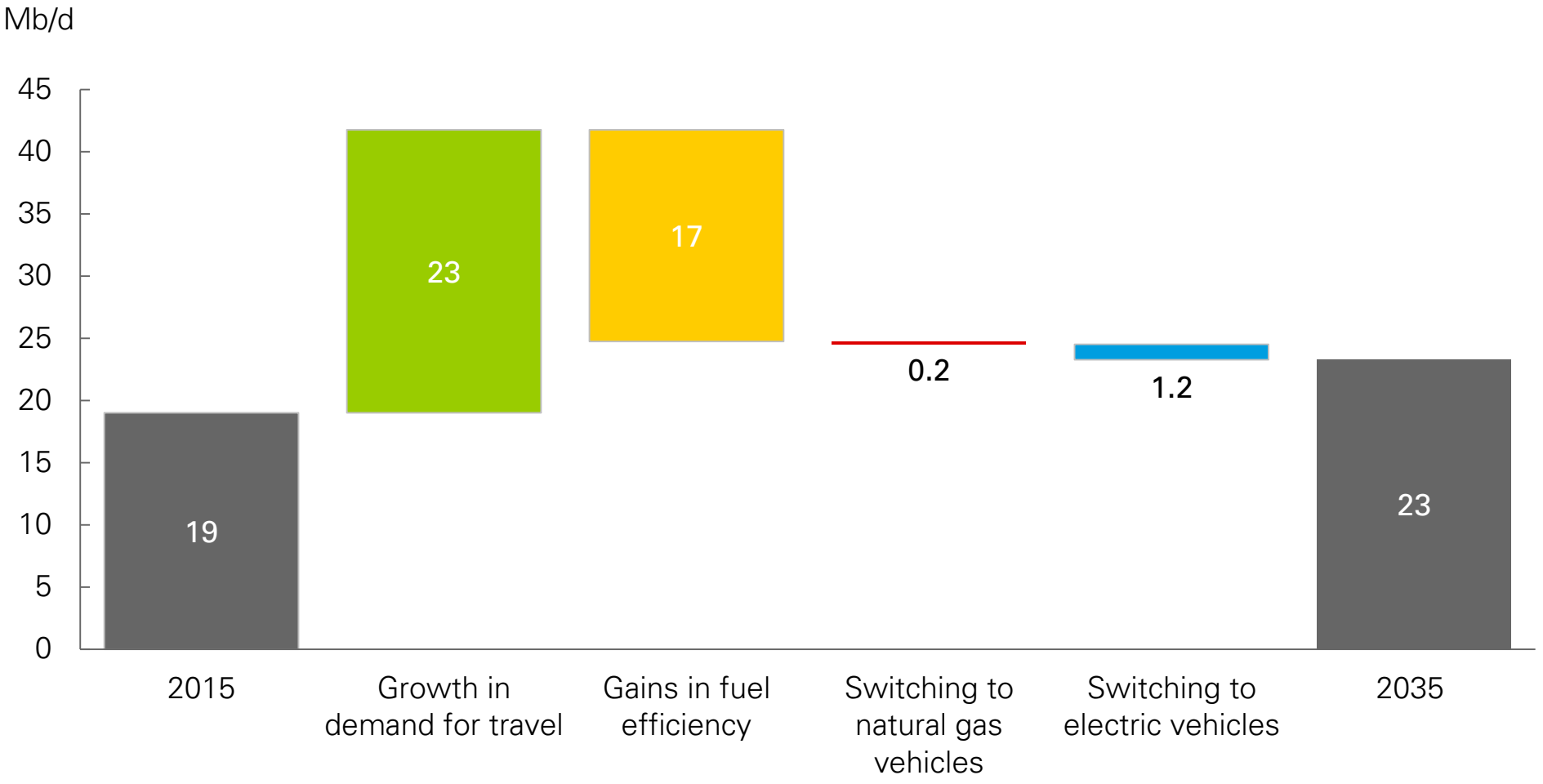
* For a Battery Electric Vehicle with a 60 kWh pack. Cost projections depend heavily on the degree of EV uptake, which is uncertain, so ranges should be treated as illustrative only. Current estimates of battery costs also vary widely, but this uncertainty is not shown

…as efficiency targets & lower battery costs spur electrification

- The global car fleet doubles from 0.9 billion cars in 2015 to 1.8 billion by 2035.
- Almost all of this growth is in emerging markets, as rising incomes and improving road infrastructure boost car ownership. The non-OECD fleet triples over the Outlook from 0.4 billion cars to 1.2 billion. Overall, global demand for car travel roughly doubles over the Outlook.
- The number of electric cars also rises significantly, from 1.2 million in 2015 to around 100 million by 2035 (6% of the global fleet). Around a quarter of these electric vehicles (EVs) are Plug-In Hybrids (PHEVs), which run on a mix of electric power and oil, and three quarters are pure Battery Electric Vehicles (BEVs).
- A key driver of the pace at which EVs penetrate the global car fleet is the extent to which fuel economy standards are tightened. But EV penetration will also depend on a number of other factors including: (i) the pace at which battery costs continue to fall; (ii) the size and durability of subsidies and other government policies supporting EV ownership; (iii) the speed at which the efficiency of conventional vehicles improves; and crucially on (iv) consumer preferences towards EVs.

Fuel demand for use in cars continues to rise…

Decomposing changes in liquids demand from cars: 2015-2035

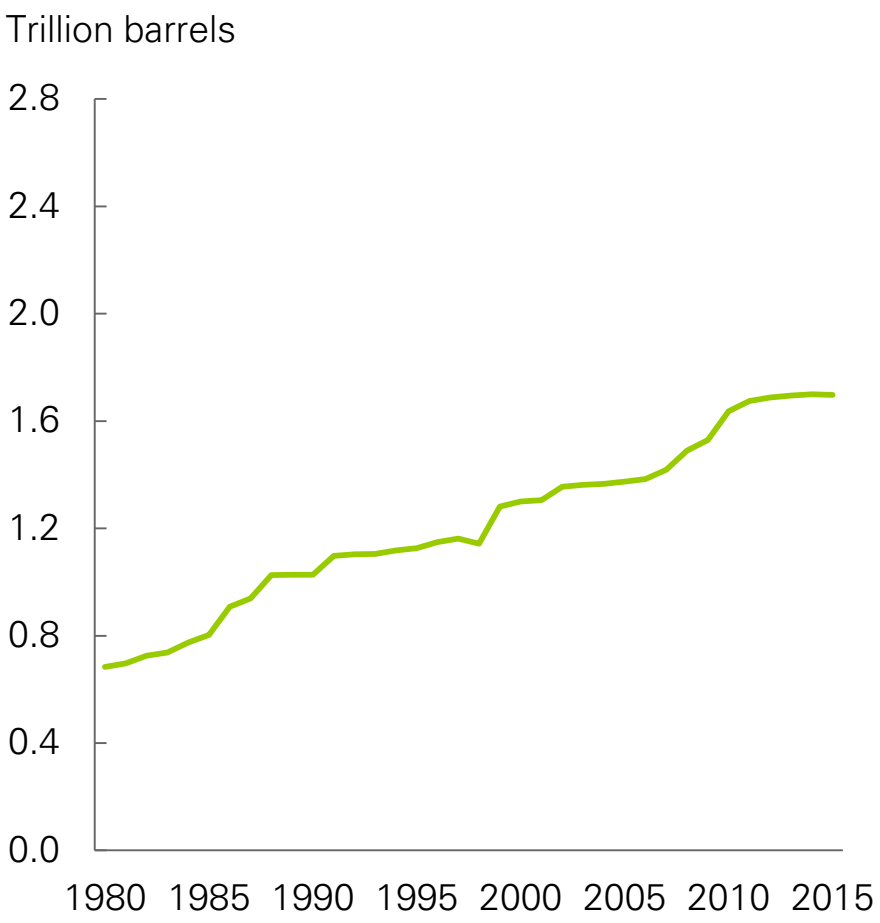


...despite efficiency improvements and EV switching

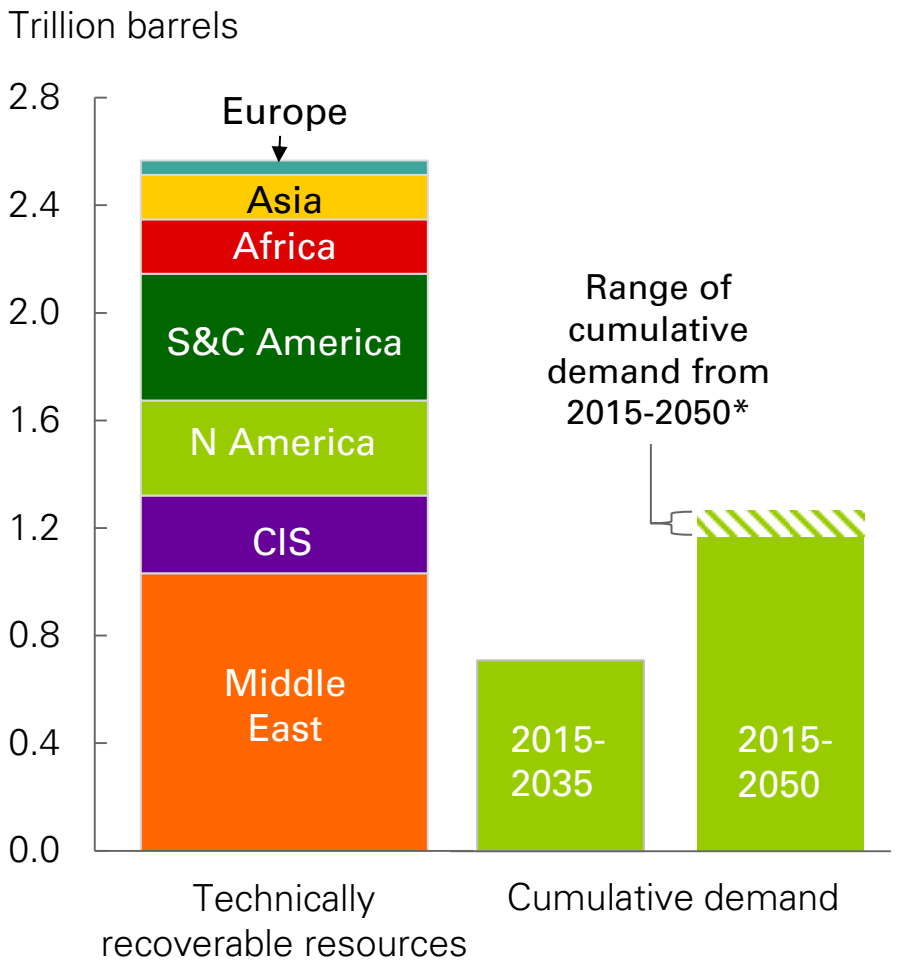
- In 2015, cars accounted for 19 Mb/d of liquid fuel demand - a fifth of global demand.
- All else equal, a doubling in the demand for car travel over the Outlook would lead to a doubling in the liquid fuel demand from cars.
- But improvements in fuel efficiency reduce this potential growth significantly (by 17 Mb/d) as manufacturers respond to stricter vehicle emission standards. An average passenger car is expected to achieve almost 50 miles per US gallon in 2035, compared with less than 30 MPG in 2015 - a faster rate of efficiency improvement than in the past.
- The growth of electric cars also mitigates the growth in oil demand, but the effect is much smaller: the 100 million increase in electric cars reduces oil demand growth by 1.2 Mb/d. By comparison, this is around a tenth of the impact of the gains in vehicle efficiency.
- Overall, the increase in demand for car travel from the growing middle class in emerging economies overpowers the effects of improving fuel efficiency and electrification, such that liquid fuel demand for cars rises by 4 Mb/d - around a quarter of the total growth over the Outlook.

There is an abundance of oil resources…

Global proved oil reserves



Estimates of technically recoverable resources and cumulative oil demand



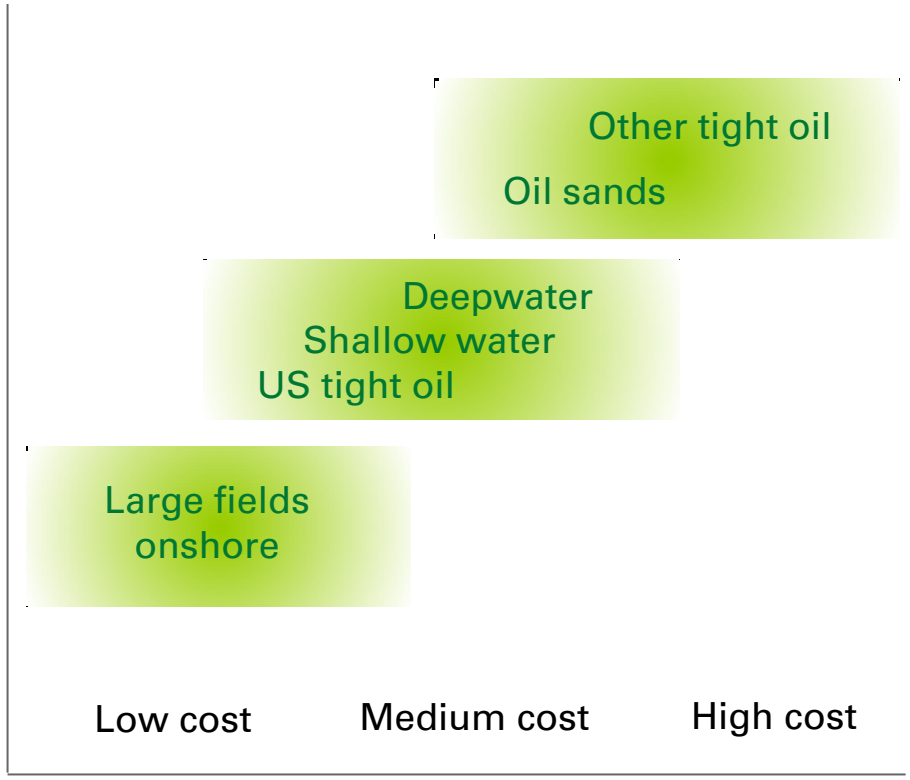
*Based on range of outcomes shown on page 88

...with known oil resources dwarfing future consumption needs

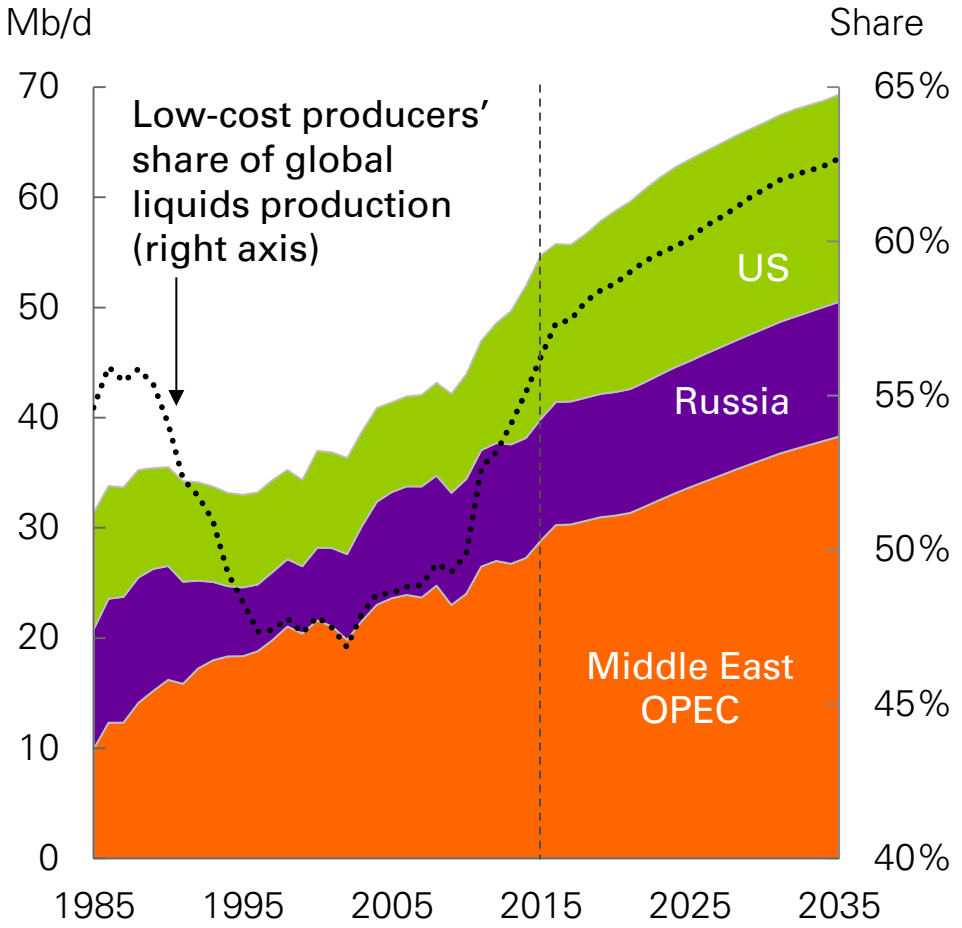
- There is an abundance of oil resources: known resources today dwarf the world's likely consumption of oil out to 2050 and beyond.
- Global proved oil reserves (the narrowest category of resources) have more than doubled over the past 35 years: for every barrel of oil consumed more than two new barrels have been discovered.
- Technically recoverable oil, a broader category which aims to measure those resources that could be extracted using today's technology, are estimated to be around 2.6 trillion barrels. Around 1.7 trillion barrels (65%) of those resources are located in the Middle East, CIS and North America.
- This abundance of oil resources contrasts with slowing growth of oil demand. Cumulative oil demand out to 2035 is expected to be around 0.7 trillion barrels, significantly less than recoverable oil in the Middle East alone.
- Looking out further to 2050, under most scenarios (see pages 88 to 89) cumulative global oil demand amounts to less than half of today's technically recoverable oil resources.

Abundance of oil resources may cause a change in behaviour…

Cost of supply (pre-tax)



Oil supply of lower-cost producers

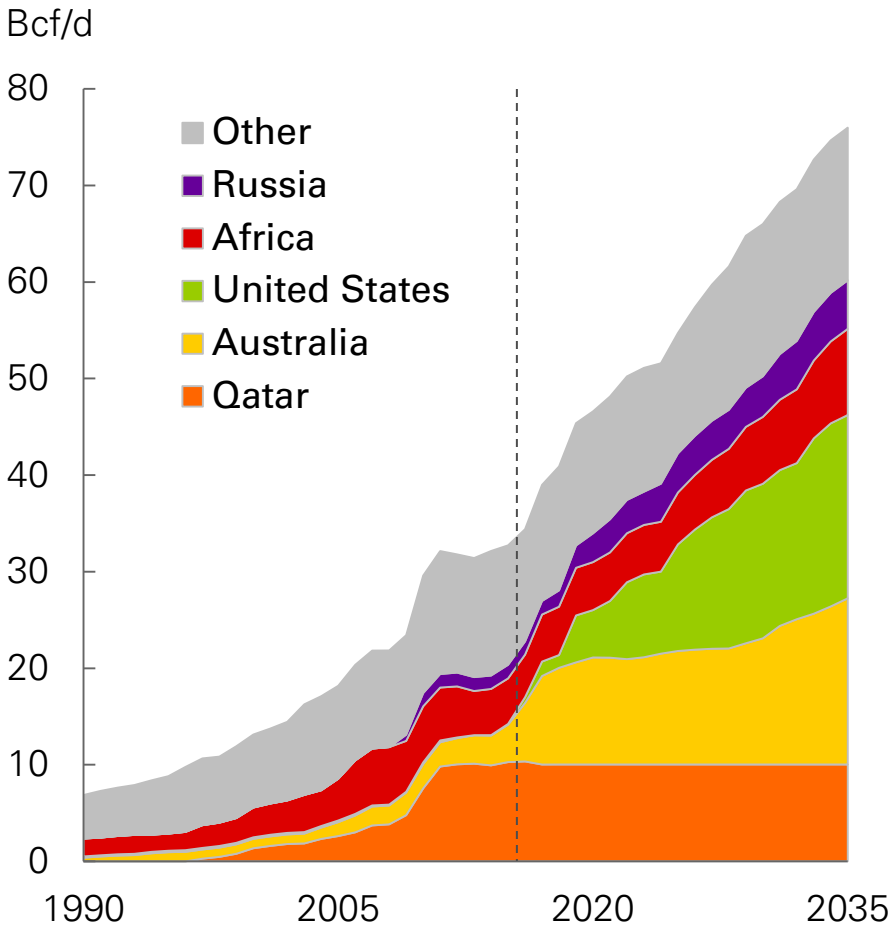


…with low-cost producers increasing their market share

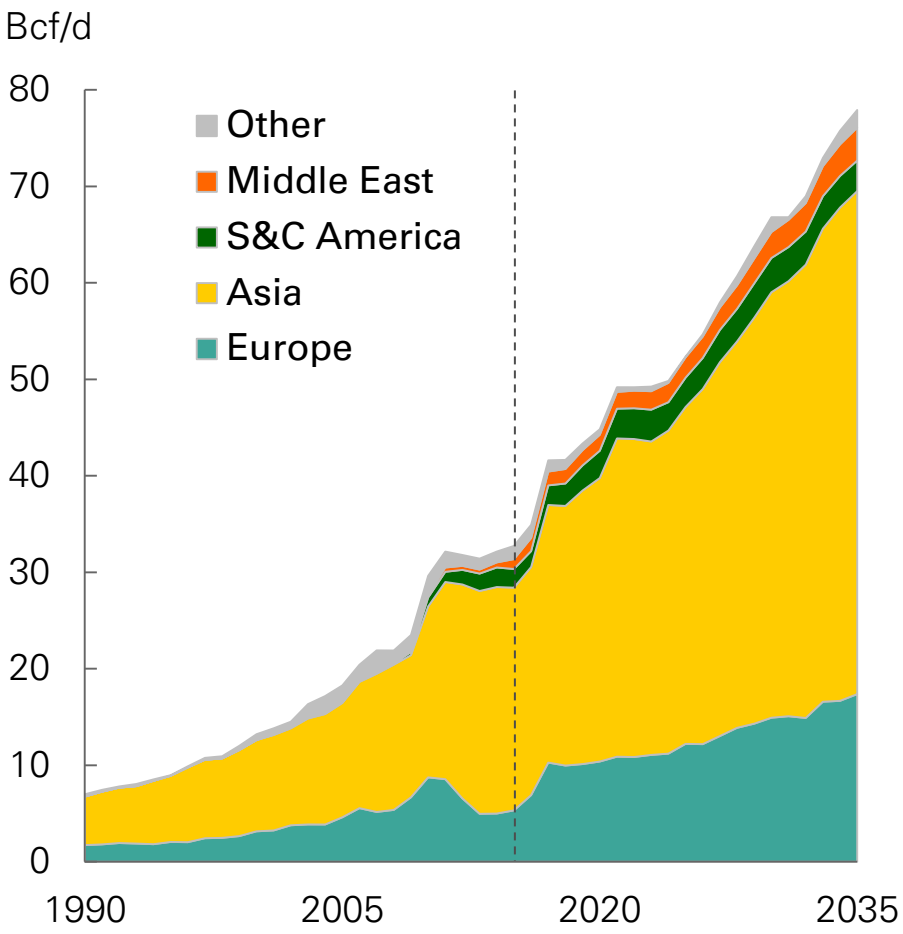
- The abundance of oil resources combined with the prospect of slowing oil demand may prompt a change in global oil supplies. In particular, low-cost producers may use their competitive advantage to increase market share.
- Although costs vary significantly within resource categories, the majority of the lowest cost resources are located in large, conventional onshore oilfields, particularly in the Middle East and Russia. This is followed by the best US tight oil plays.
- We assume the abundance of oil resources prompts a change in behaviour, such that production from Middle East OPEC, Russia and the US increases disproportionately over the Outlook, with its share growing from 56% today to 63% in 2035.
- The extent to which global supply behaviour changes is a key source of uncertainty and depends on: (i) the cost and feasibility of low-cost producers increasing supply materially over the Outlook; (ii) the extent to which prices respond to increased supplies of low-cost oil and the implications this has for producers' economies; and (iii) the ability of higher-cost producers to compete by varying their tax and royalty regimes.

LNG supplies grow strongly led by US and Australia…

LNG supply



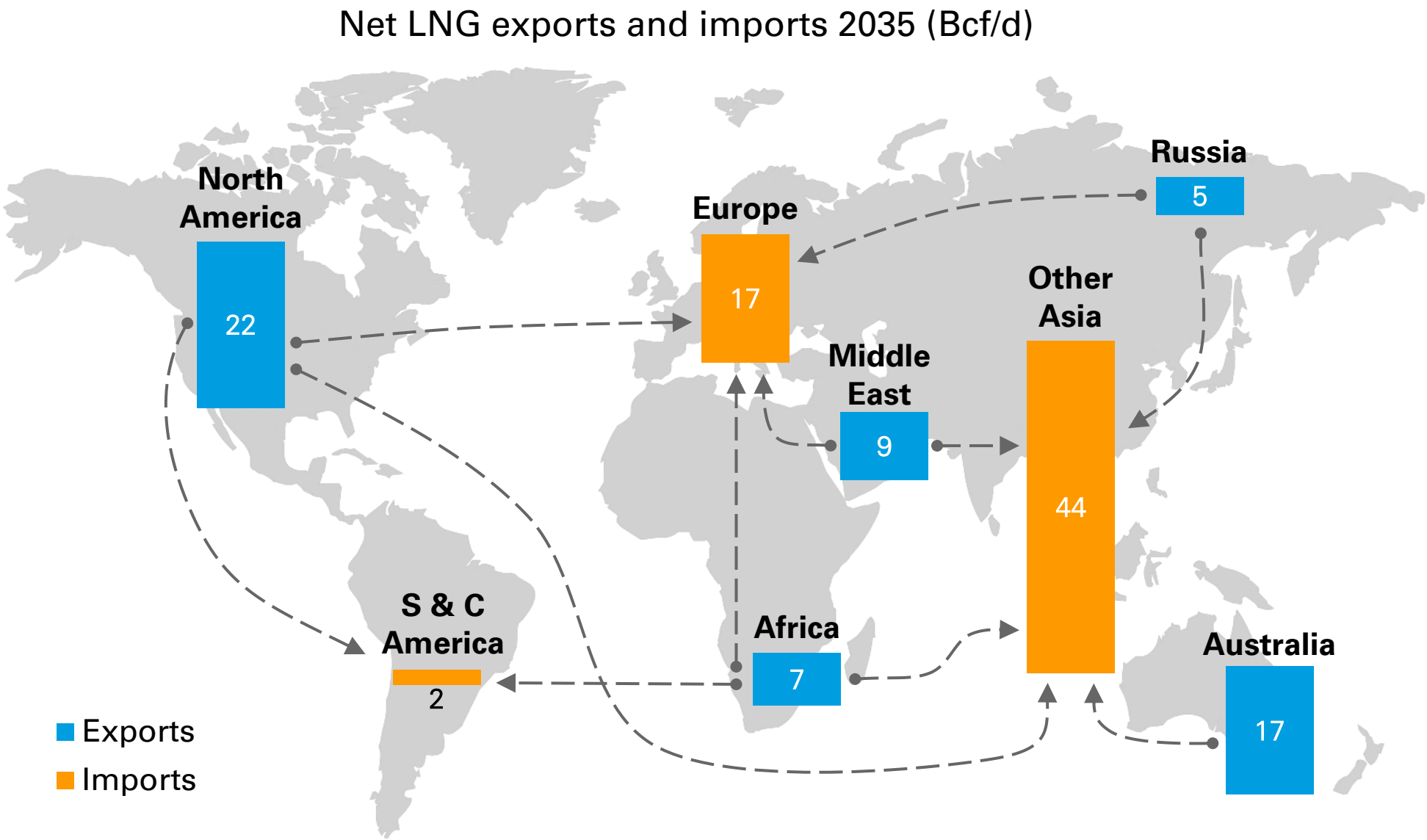
LNG demand



...with demand remaining concentrated in Asia

- Global LNG supplies grow strongly over the Outlook, led by growth in the US (19 Bcf/d) and Australia (13 Bcf/d).
- Nearly a third of this growth occurs over the first four years of the Outlook as a series of projects currently under development are completed. After a temporary lull while this initial wave of LNG supplies is absorbed, growth is assumed to resume at a more moderate pace.
- There is a risk that this second wave of LNG supply growth is slow to materialise causing a temporary period of tightness within LNG supplies.
- Asia remains the largest destination for LNG. China, India and other Asian countries all increase their demand for LNG, helping gas to grow faster than either oil or coal in each of these economies.
- Europe also makes increasing recourse to LNG to help meet the growing gap caused by declines in its domestic production (see pages 34 to 35).

LNG's share in traded gas increases sharply…

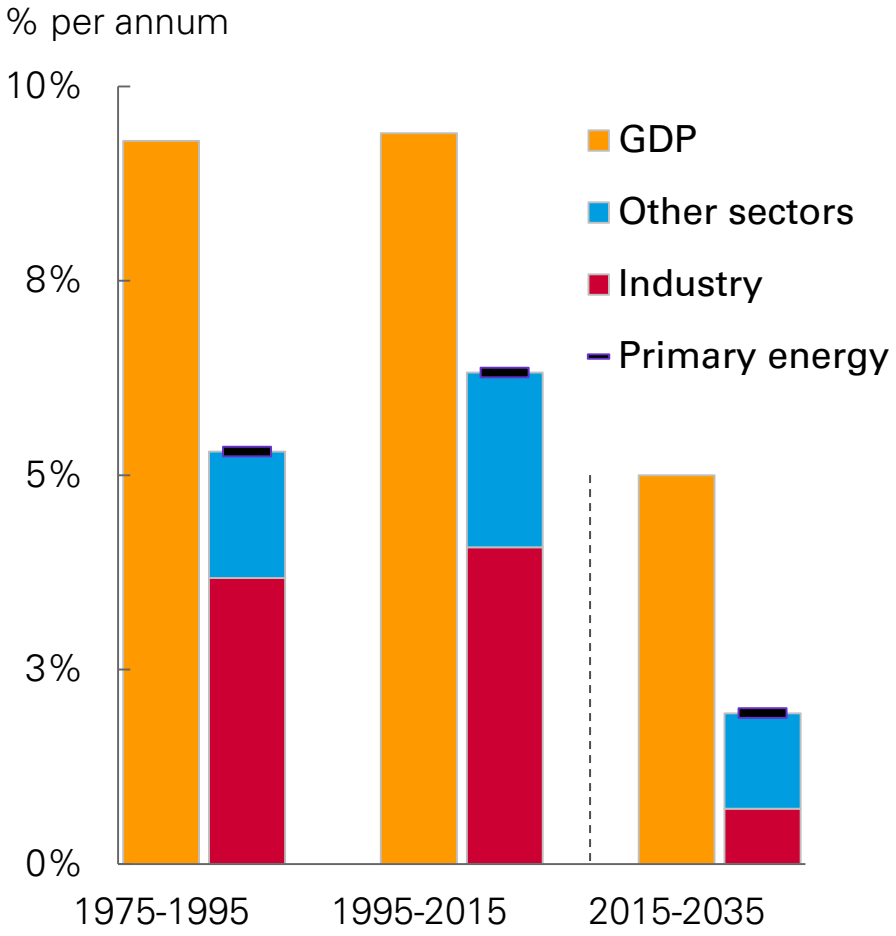


...leading to increasing integration across gas markets

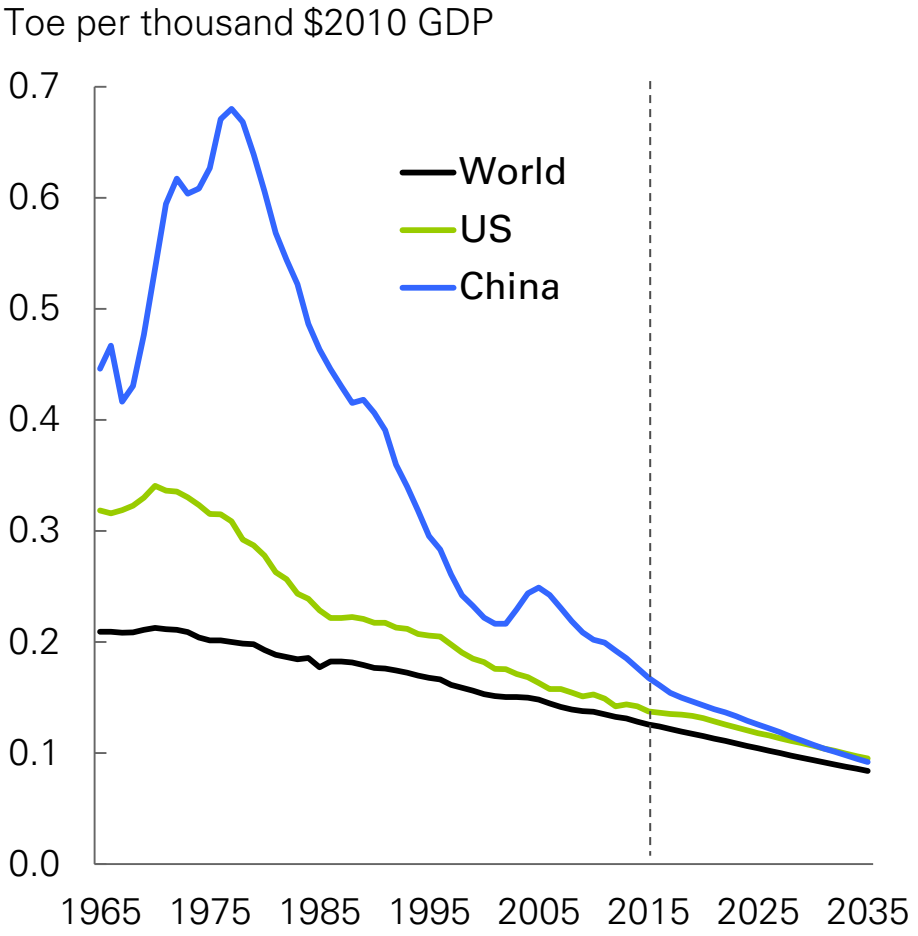
- LNG grows seven times faster than pipeline gas trade, such that by 2035 it accounts for around half of all globally traded gas - up from 32% now.
- The significance of the growing importance of LNG-based trade is that, unlike pipeline gas, LNG cargoes can be redirected to different parts of the world in response to regional fluctuations in demand and supply. As a result, gas markets are likely to become increasingly integrated across the world.
- In particular, if prices move further apart than is warranted by transportation costs, there will be an incentive for LNG supplies to be redirected until prices move back into line.
- Australian LNG supplies are normally likely to be absorbed within Asia. US LNG exports are likely to be more diversified, providing the marginal source of gas for markets in Europe, Asia and South & Central America. As such, US gas prices are likely to play a key role in anchoring gas prices in a globally integrated market.
- The development of a deep and competitive LNG market is likely to cause long-term gas contracts to be increasingly indexed to spot LNG prices.

China's energy needs are changing…

China's GDP and primary energy demand growth



Energy intensity

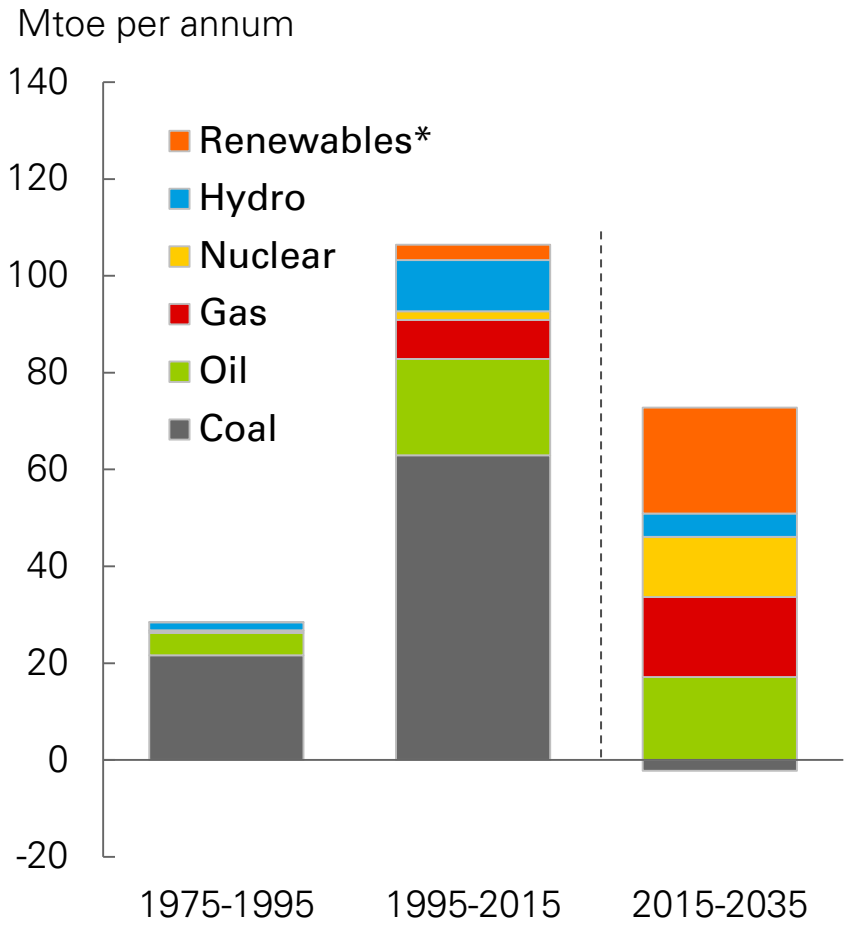


...as it adjusts to a more sustainable growth path

- China is the world's largest consumer of energy and has been the most important source of growth for global energy over the past 20 years. But as China adjusts to a more sustainable pattern of growth, its energy needs are likely to change.
- China's demand for energy is projected to grow by less than 2% p.a. over the Outlook, compared with over 6% p.a. over the past 20 years.
- Part of this slowing reflects an easing in economic growth: annual GDP growth averages close to 5% p.a. over the Outlook, around half the average pace of growth since 2000.
- The slowing also reflects continuing sharp declines in energy intensity as economic activity within China gradually shifts away from energy-intensive industrial output towards more energy-light consumer and services activity, and policies drive further improvements in energy efficiency.
- China's energy intensity declines by 3% p.a. over the Outlook - significantly quicker than the projected global average - converging on US levels by 2035.

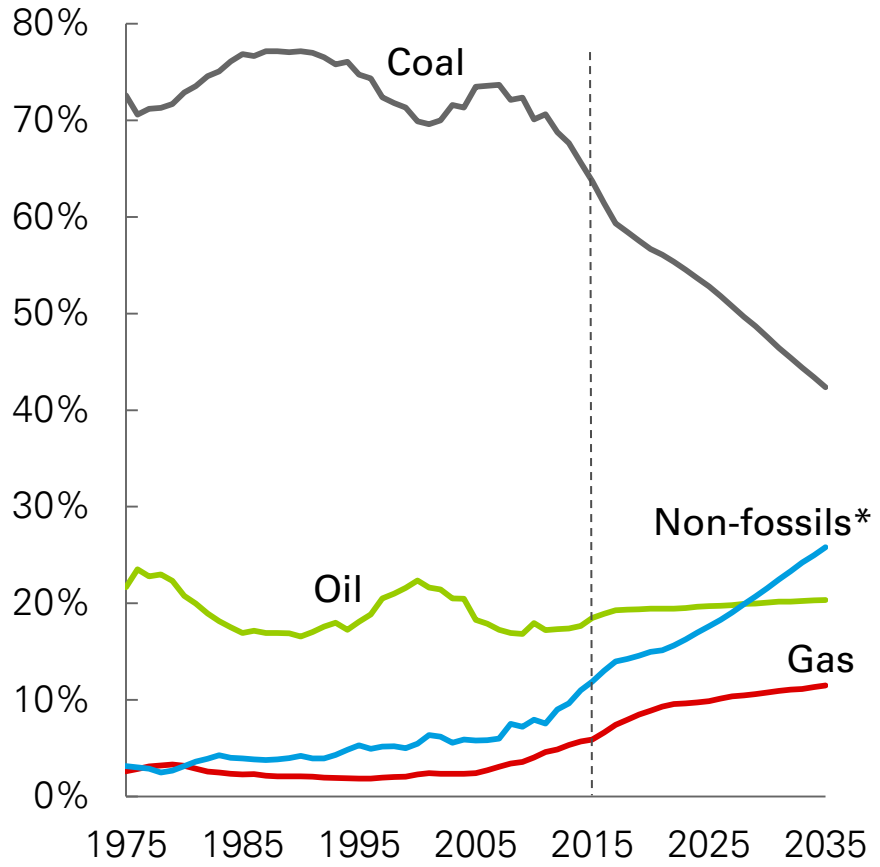
China is also shifting towards a lower-carbon energy mix...

Primary energy demand growth by fuel



*Including biofuels

Shares of primary energy

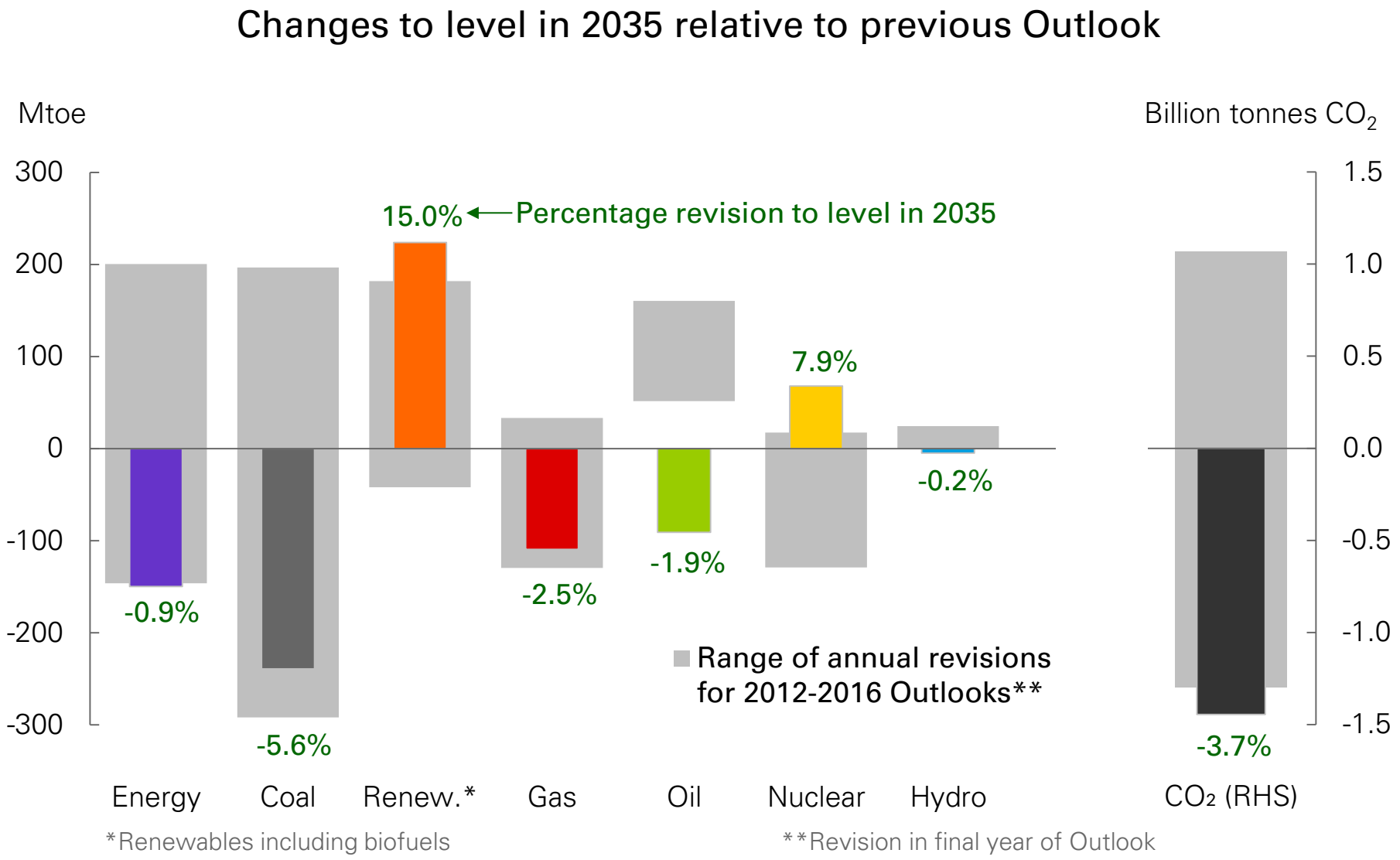


...with coal being displaced by lower carbon alternatives

- China's energy mix is also likely to change significantly over the next 20 years, driven by its changing economic structure and a policy commitment to move to cleaner, lower-carbon fuels.
- In particular, after providing almost two-thirds of China's increasing energy needs over the past 40 years, China's coal consumption is projected to broadly plateau over the Outlook.
- As a result, the share of coal in China's energy demand falls from around two-thirds in 2015 to less than 45% by 2035.
- Much of this reduced share is replaced by renewables, nuclear and hydroelectric power, which supply more than half of China's increasing energy demands over the Outlook. The combined share of these fuels in China's energy mix rises from 12% in 2015 to over 25% by 2035.
- China's consumption of natural gas also increases sharply, with its share almost doubling over the Outlook to 11% in 2035.

Main revisions

Energy demand in 2035 has been revised down…

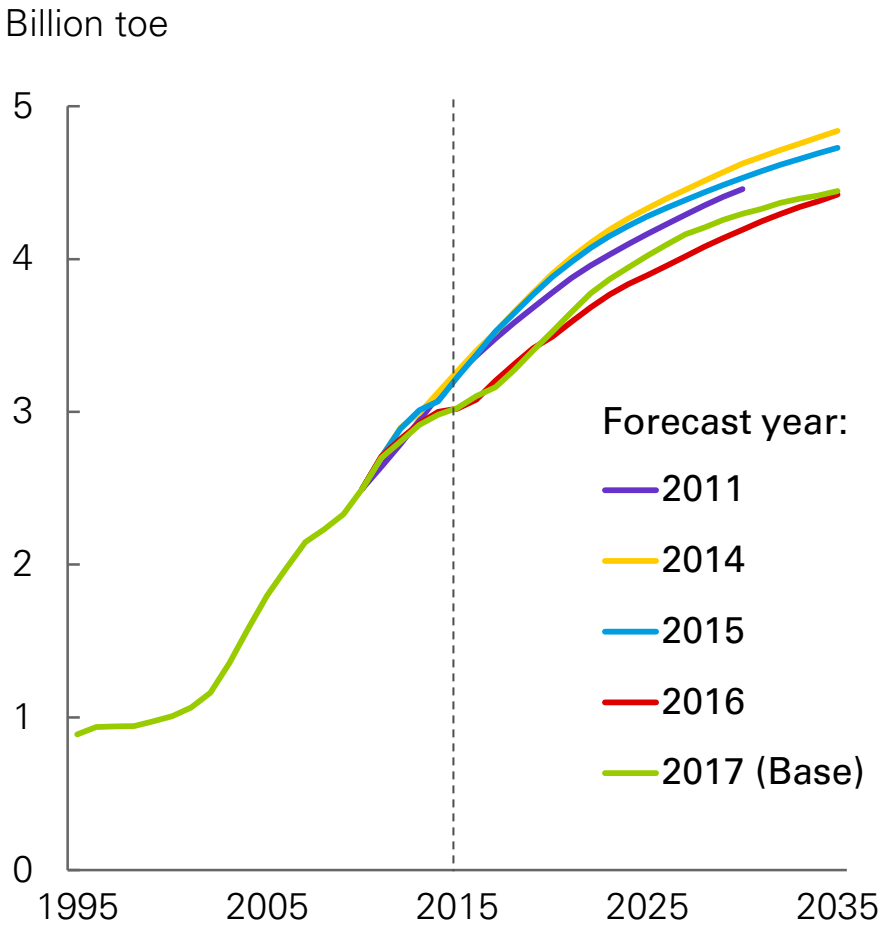


…with a further shift in the fuel mix towards renewables

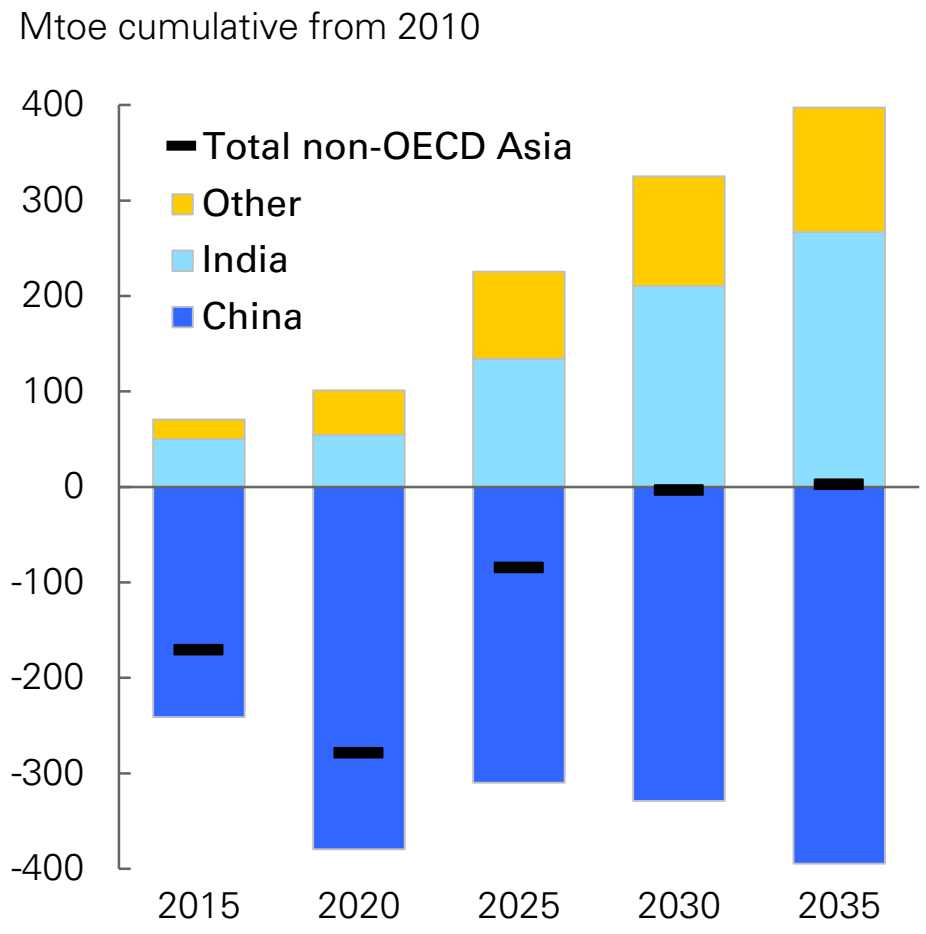
- Energy demand in 2035 has been revised down by almost 1% (-150 Mtoe) relative to the 2016 Outlook. This is a similar-sized revision to last year, but large relative to historical revisions. The downward adjustment reflects weaker economic prospects, with GDP in 2035 expected to be 2% lower than a year ago.
- The largest downward revision is to coal (-6%, -240 Mtoe), where there is increasing evidence that a rebalancing of economic growth within China together with tightening climate and environmental policies are likely to lead to a plateauing in China's coal consumption over the Outlook.
- Renewables have been revised up 15% (220 Mtoe) - the largest revision in percentage terms - as the prospective path for costs continues to surprise on the downside. As a result, the use of both coal and gas in the power sector has been revised down, with gas consumption in total down 2.5% (-110 Mtoe) by 2035.
- The upward revision in the share of non-fossil fuels relative to fossil fuels has led to an improvement in the expected carbon intensity of the fuel mix, contributing to a sizeable downward revision in the level of carbon emissions by 2035 (-3.7%, -1.4 billion tonnes of CO_2 on a like-for-like basis).

Chinese energy demand has been revised down…

China primary energy forecasts



Primary energy in non-OECD Asia: revisions vs 2014 Outlook

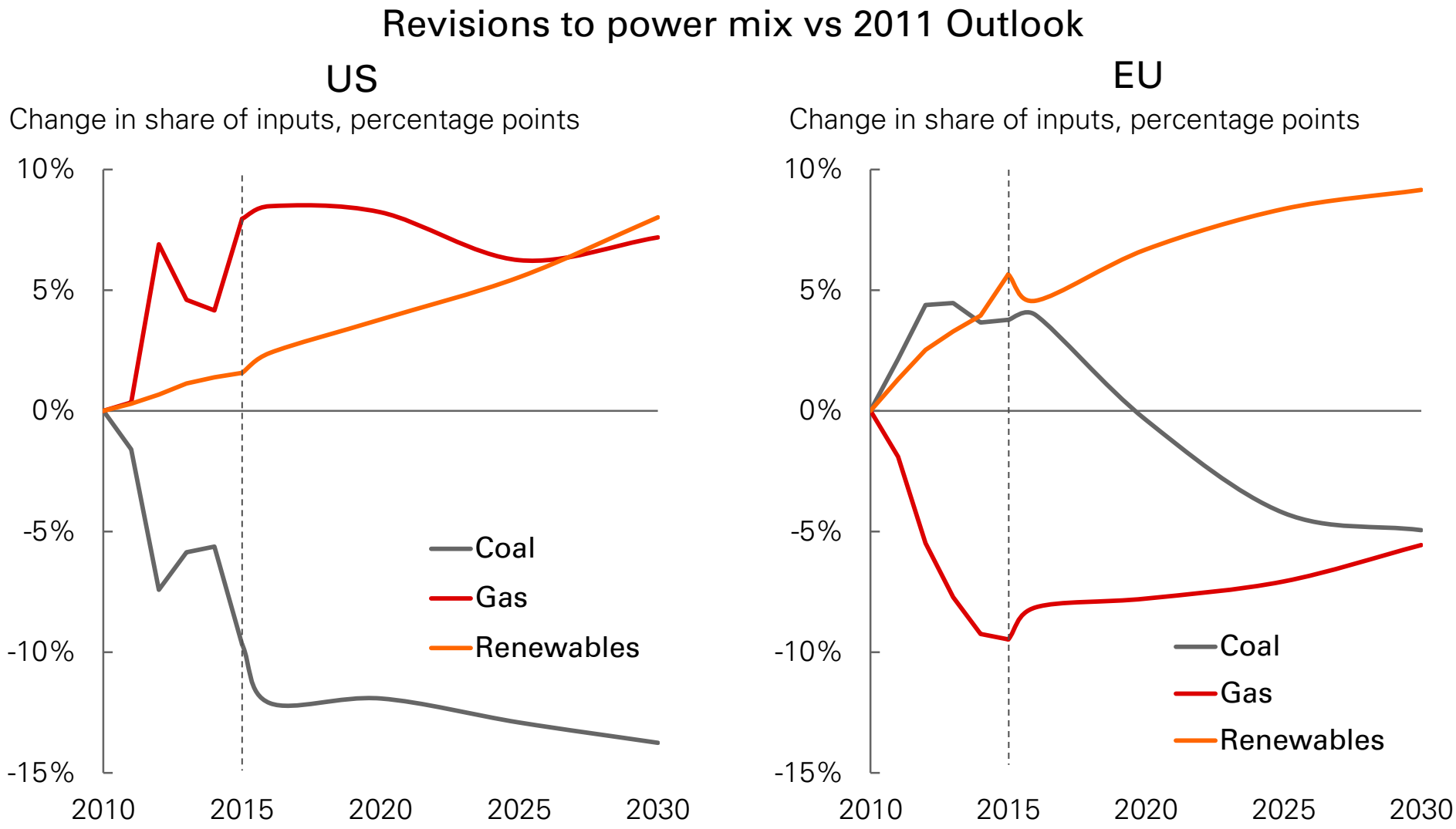


Note: Projected growth from each outlook applied to latest 2010 data

…offset by stronger growth in other parts of emerging Asia

- The outlook for Chinese energy demand has been revised down significantly over the past three years: the current outlook for China's energy consumption in 2035 is 8% (400 Mtoe) below our view in 2014.
- Around half of that difference reflects lower-than-expected outturns for energy consumption in recent years, as economic growth has slowed more quickly than expected and energy intensity has fallen more sharply. The remainder reflects weaker prospects for economic growth, particularly in the second half of the Outlook.
- Despite this large downgrade to Chinese consumption, the expected level of energy demand in emerging Asia as a whole in 2035 is broadly unchanged: upward revisions to energy consumption in India and other emerging Asia economies offset the reductions to Chinese demand.
- These upward revisions to Asian energy demand outside of China reflect a more upbeat view of economic growth, partly reflecting the expectation that as China's economy matures and rebalances, some industries will migrate to cheaper, lower-income Asian economies, such as India, Indonesia or Vietnam.

Renewables in US and EU power mix have been revised up…



…but offsetting revisions to gas and coal differ markedly

- The expected share of renewables in both the US and EU power sectors has been revised up significantly since 2011: up 8 percentage points (pp) in the US and 9 pp in the EU by 2030. But the associated revisions to the shares of coal and gas in the two power sectors differ quite markedly.
- In the US, the unexpected strength of the shale gas revolution since 2011 has also led to a significant upward revision to the expected share of natural gas (7 pp). The main casualty is coal, crowded out by the greater-than-expected competitiveness of both renewables and gas, such that its share has been revised down 14 pp.
- In contrast, the upward revision to the share of renewables in the EU power sector has been offset by broadly similar downward revisions to the shares of natural gas (-6 pp) and coal (-5 pp).
- Absent a significant increase in the availability of gas in the EU, to achieve a similar pattern of revisions to the US would require stronger-than-expected policy support for gas relative to coal.

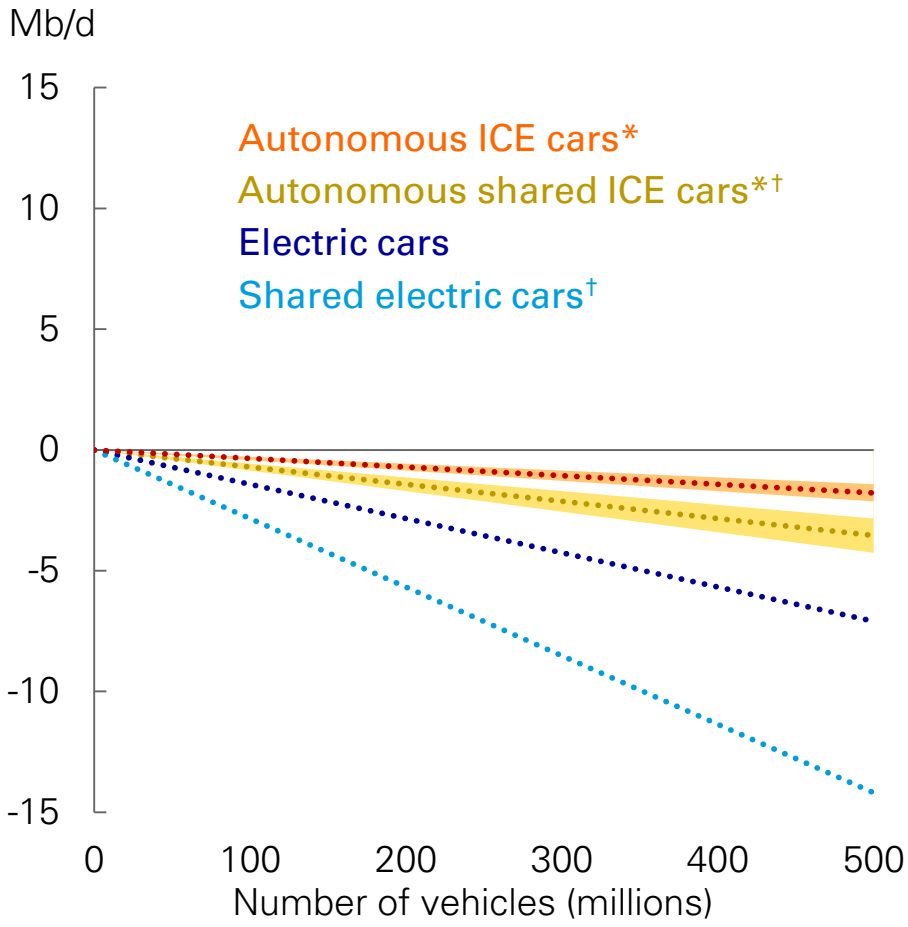
Key uncertainties

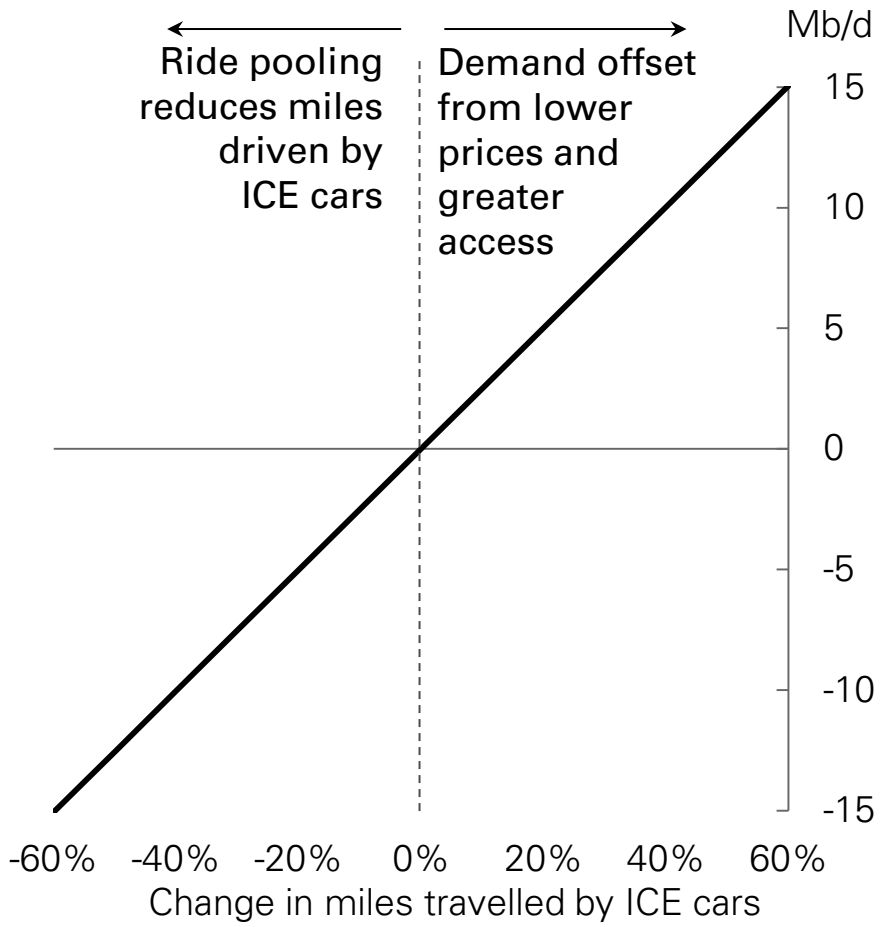
- A faster mobility revolution
- Alternative pathways to a lower carbon world
- Risks to gas demand

- The base case in the Outlook presents the single 'most likely' path for energy demand and the evolution of the fuel mix over the next 20 years. As such, it helps to highlight the main trends and forces that are likely to shape global energy markets over the next two decades.
- But there are many risks and uncertainties surrounding the base case. It is possible to explore some of those uncertainties by varying a few of the key assumptions and judgements underpinning the base case and assessing their impact.
- We explore three key uncertainties that are central to the form the energy transition will take over the next two decades. These uncertainties, which are described in more detail in the following pages, are not exhaustive but provide some insight into how varying some of the key assumptions might affect the projected trends.
- For a discussion of some of the key uncertainties beyond 2035 see pages 86 to 93.

A faster mobility revolution could disrupt oil demand…

Impact on oil demand in 2035





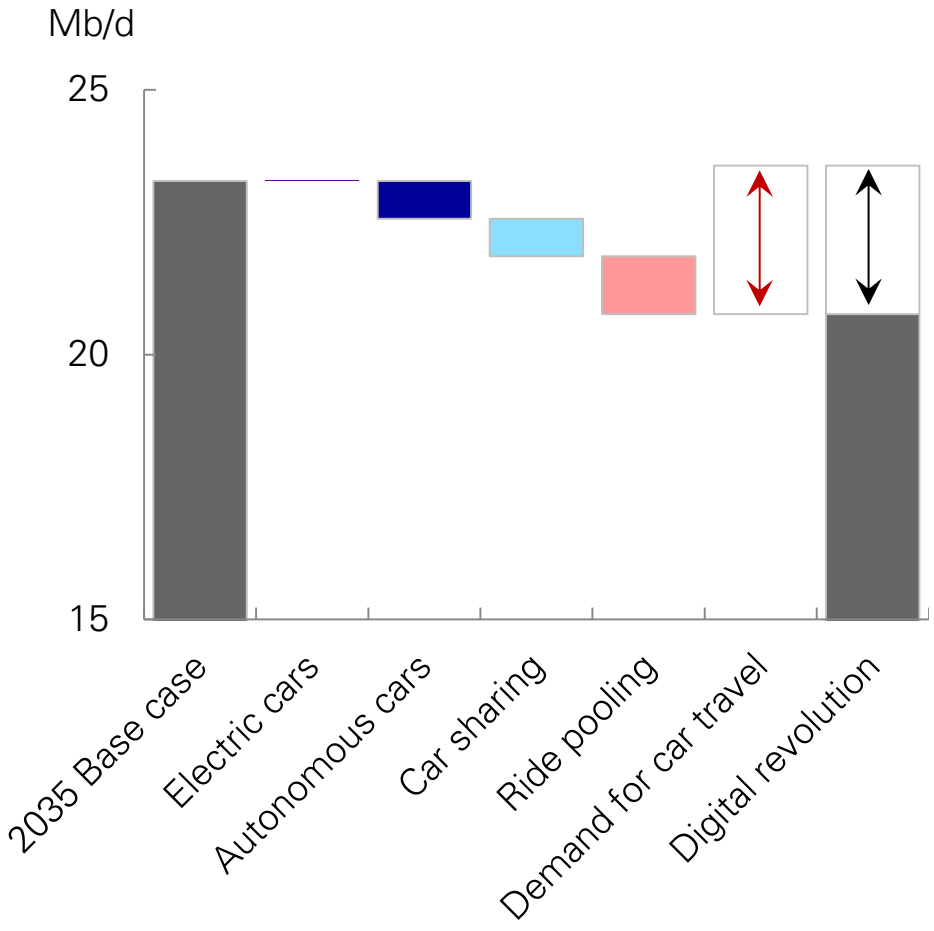
*Ranges depend on relative efficiency of human versus autonomous drivers
†Car sharing assumes each car is driven twice as many miles as a 'normal' car

…but the size and direction depends on its form

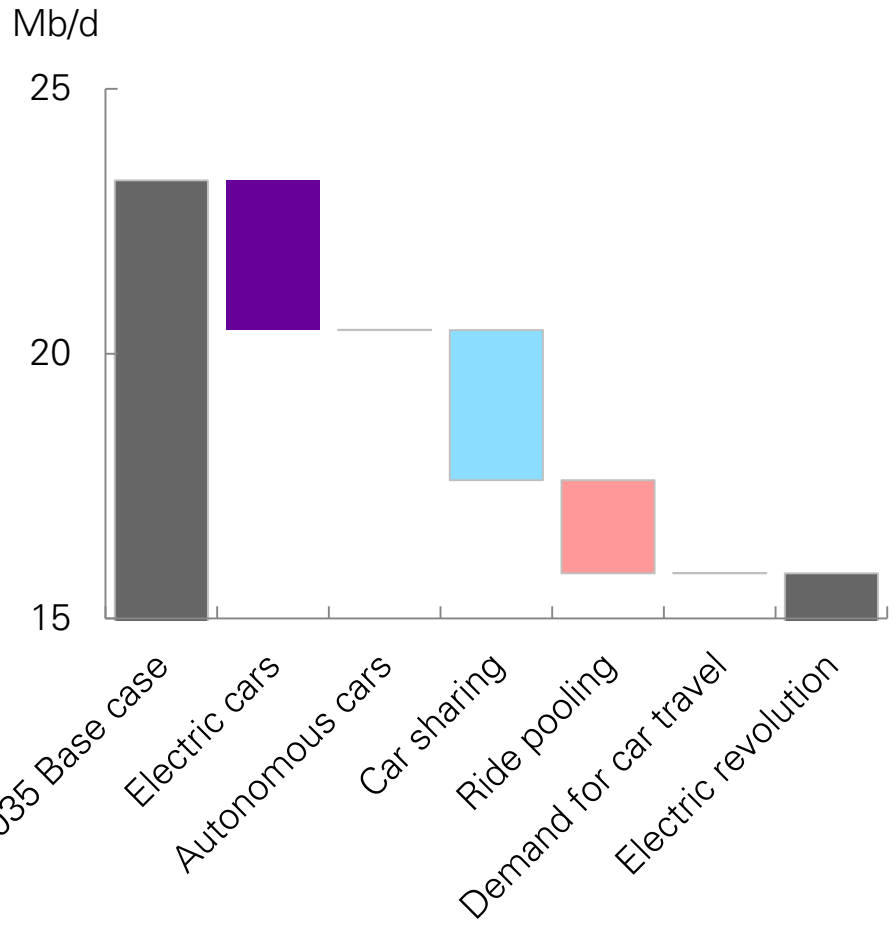
- Electric vehicles are part of a broader mobility revolution that is taking place over the Outlook, including autonomous vehicles, car sharing and ride pooling. What impact could a faster-than-expected revolution have on oil demand?
  - Electric vehicles (EV): reduce the number of internal combustion engine (ICE) cars. An extra 100m battery electric vehicles could lower oil demand by around 1.4 Mb/d.
  - Autonomous vehicles (AV): increase efficiency and so reduce energy demand. If AVs are 25% more fuel efficient, 100m autonomous ICE cars could lower oil demand by 0.4 Mb/d (autonomous EVs reduce demand for electricity but not oil).
  - Car sharing: on its own doesn't affect energy demand, it simply increases the intensity with which vehicles are used. But if combined with a new technology, such as an EV or AV, it can act to amplify the effect of this technology since more miles are travelled using this technology and less using conventional cars.
  - Ride pooling: reduces the number of vehicle miles driven by raising the number of occupants per vehicle. A 10% fall in vehicle miles lowers oil demand by 2.5 Mb/d.
- But the mobility revolution could also provide an offsetting boost to the demand for car travel by lowering costs and enabling wider access to cars.

Two illustrative scenarios highlight how oil demand…

Digital revolution: Impact on oil demand in cars in 2035



Electric revolution: Impact on oil demand in cars in 2035

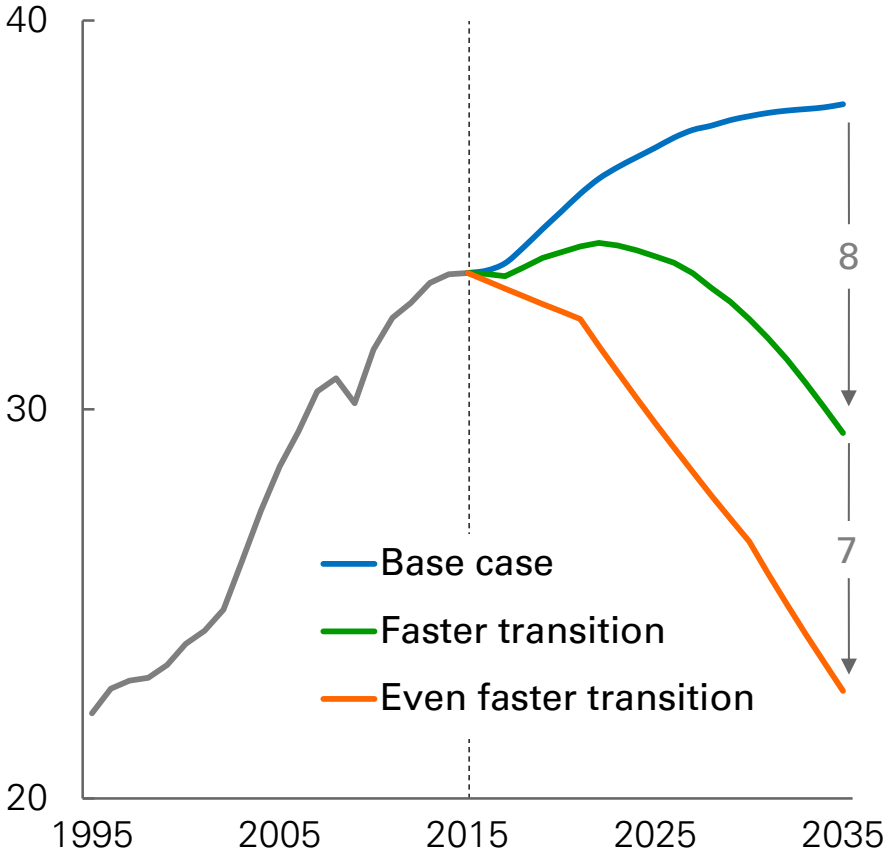


...might vary depending on the nature of the revolution

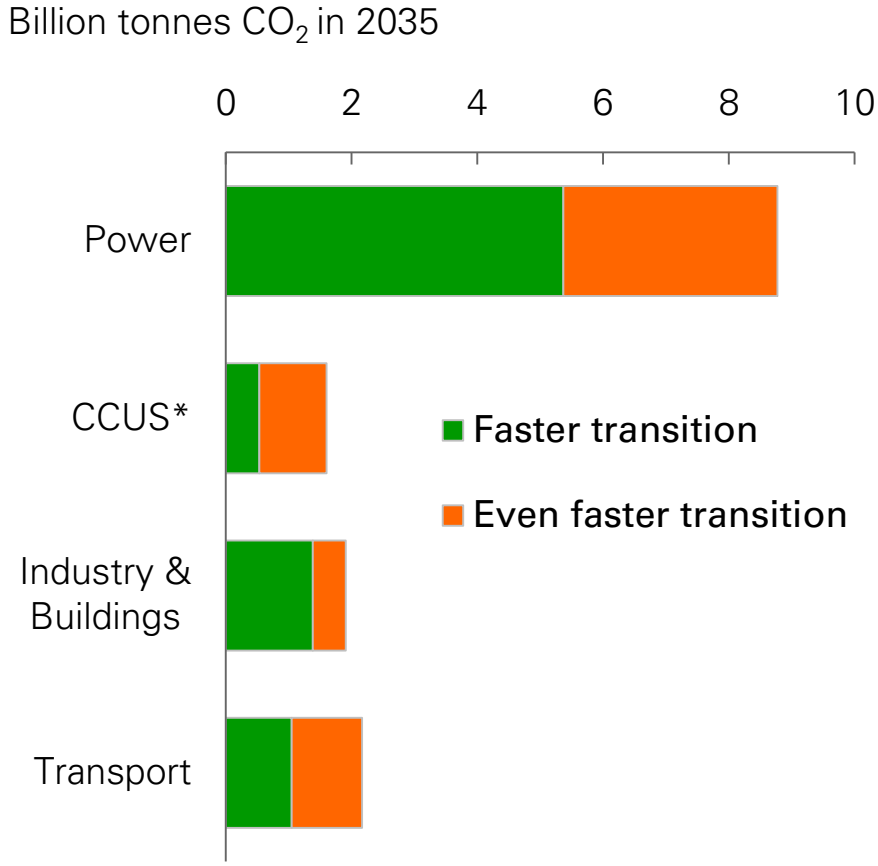
- The impact of a faster mobility revolution on oil demand depends on its form. Two scenarios are used to explore the potential effects: these scenarios are purely illustrative and can be scaled up or down (the Annex describes the calibrations used).
- Digital revolution - this scenario assumes the technologies underpinning AVs, car sharing and ride pooling progress more rapidly than assumed in the base case, but reductions in battery costs and penetration of EVs are broadly in line. The greater number of oil-based AVs improves vehicle efficiency and so reduces oil demand. This impact is amplified by AVs being used for car sharing. Ride pooling further reduces oil demand. But these technological advances reduce the cost of car travel and enable greater access causing demand for car travel (and hence oil) to increase. The net effect for oil demand depends on the size of this demand offset.
- Electric revolution - this scenario builds on the *Digital revolution* but assumes a more rapid penetration of electric cars, and that AVs, car sharing and ride pooling are all implemented only with EVs. In this case, the greater efficiency associated with AVs has no implications for oil demand (since it effects only EVs), but car sharing of EVs amplifies the intensity with which they are used and hence their impact on oil demand. Since these technological advances reduce the cost of travelling by electric cars, the extra miles that result boost demand for electricity rather than oil.

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

Carbon emissions



Reductions in emissions versus base case



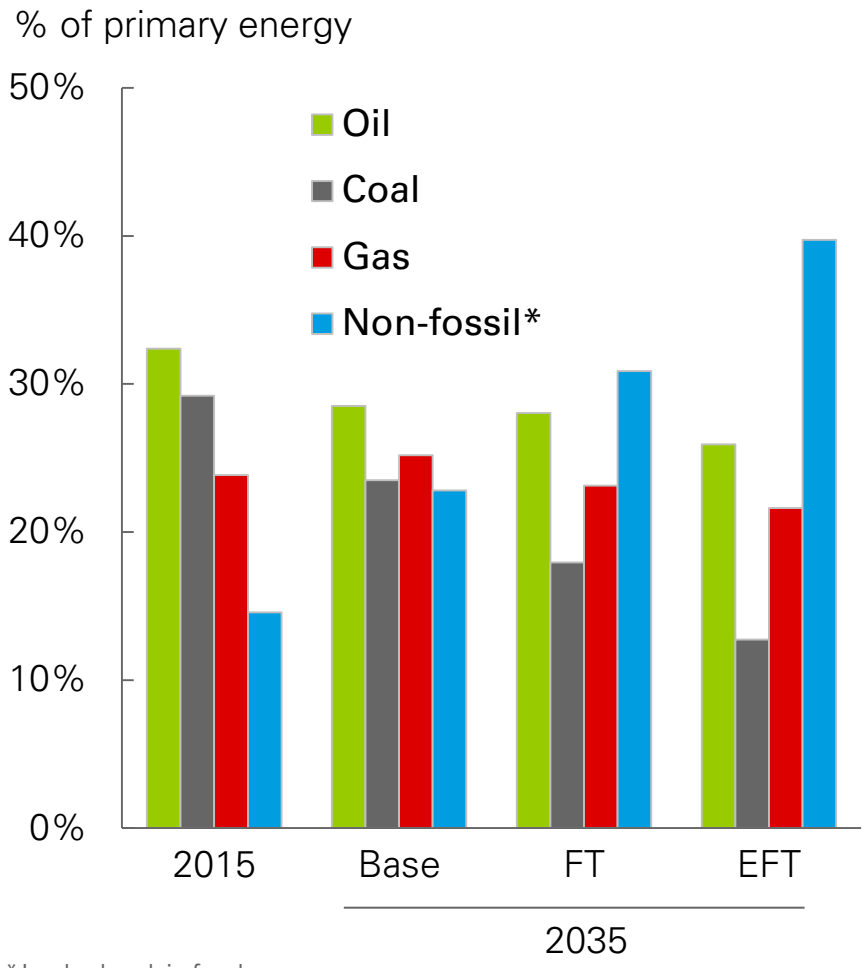
*Carbon capture, use and storage (predominantly in power sector)

…is a major uncertainty in the outlook for energy

- The pace of growth of carbon emissions in the base case is assumed to slow sharply relative to the past, but still falls well short of the significant falls in carbon emissions likely to be required to meet the goals set out at the COP21 meeting in Paris.
- The 'faster transition' case (FT) assumes that a range of existing policy mechanisms are tightened by far more than envisaged in the base case. Carbon prices in leading economies rise to $100/tonne in real terms by 2035 and a range of other policy interventions encourage more rapid energy efficiency gains and fuel switching.
- As a result, emissions peak in the early 2020s and by 2035 are 12% below 2015; global energy intensity and carbon intensity improve at unprecedented rates. Most of the abatement relative to the base case comes from decarbonizing the power sector.
- That still leaves a significant gap: the 'even faster transition' case (EFT) illustrates a possible configuration that delivers an emissions trajectory that matches the path of the IEA 450 scenario. Emissions in this case are 32% below 2015 levels by 2035. Most of the incremental abatement comes from the power sector: by 2035 power is almost entirely decarbonized, with global emissions from power generation less than a quarter of their 2015 level.

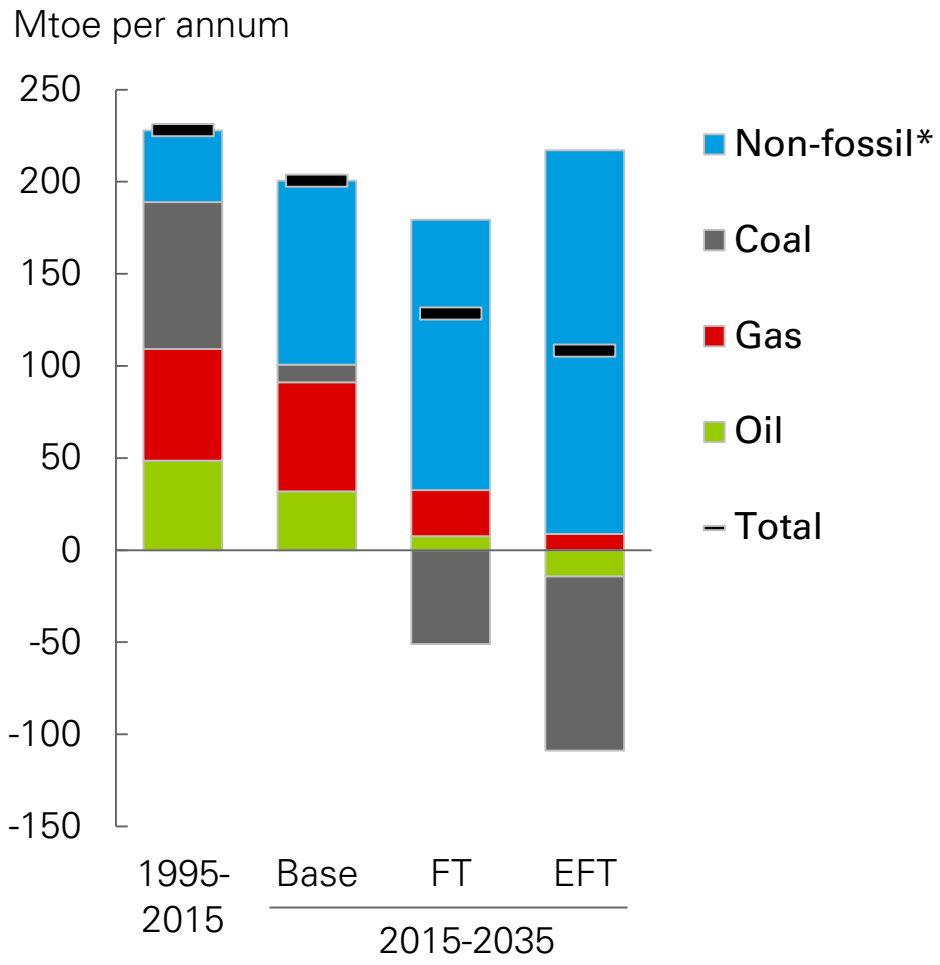
The speed of transition has a significant impact…

The changing fuel mix



*Includes biofuels

Annual demand growth by fuel



…on the growth of energy and its composition

- Energy demand continues to grow in both the alternative cases, but at reduced rates (0.9% p.a. for 'faster transition, and 0.8% p.a. for 'even faster').
- Speeding up the transition has a marked impact on fuel shares. In the 'faster transition' case renewables, with nuclear and hydroelectric power, overtake oil by 2035; and in the 'even faster' case exceed oil and coal combined. That said, in both cases, oil and gas still provide around half of the world's energy in 2035.
- The most radical shifts are seen in the power sector. By 2035, non-fossil fuels supply nearly 80% of global power in the 'even faster' case; and more than a third of the carbon emissions from the remaining coal and gas power generation are captured and stored.
- Non-fossil fuels provide all the net growth in energy in both cases, pushing coal into decline. Renewables are the main driver, with their share of energy by 2035 rising to 16% in the 'faster transition' case and 23% in the 'even faster' case, compared with 10% in the base case.
- Oil demand is declining by 2035 in both cases, although in the 'faster transition' case oil still grows slightly over the Outlook. Gas maintains some modest growth in 'faster transition', but plateaus in the 'even faster' case squeezed out by non-fossil fuels.

Comparison with other low carbon scenarios…

	Faster transition	Even faster transition	IEA 450	MIT 2° Base	IHS Markit 'Solar Efficiency'	Greenpeace 'Revolution'
CAGR (%)* 2015-2035						
Carbon emissions	-0.7%	-2.0%	-2.0%	-2.0%	-2.8%	-3.2%
Total energy	0.9%	0.8%	0.4%	0.5%	-0.7%	-0.1%
Energy intensity	-2.4%	-2.5%	-3.0%	-2.9%	-4.0%	-3.5%
Carbon intensity	-1.5%	-2.7%	-2.3%	-2.5%	-2.1%	-3.5%
Share of total energy, 2035						
Oil & gas	51%	48%	48%	46%	51%	39%
Renewables†	16%	23%	17%	29%	19%	38%
Share of abatement vs. 2015						
Power sector	>100%	89%	77%	74%	58%	35%

* Compound annual growth rate † includes biofuels

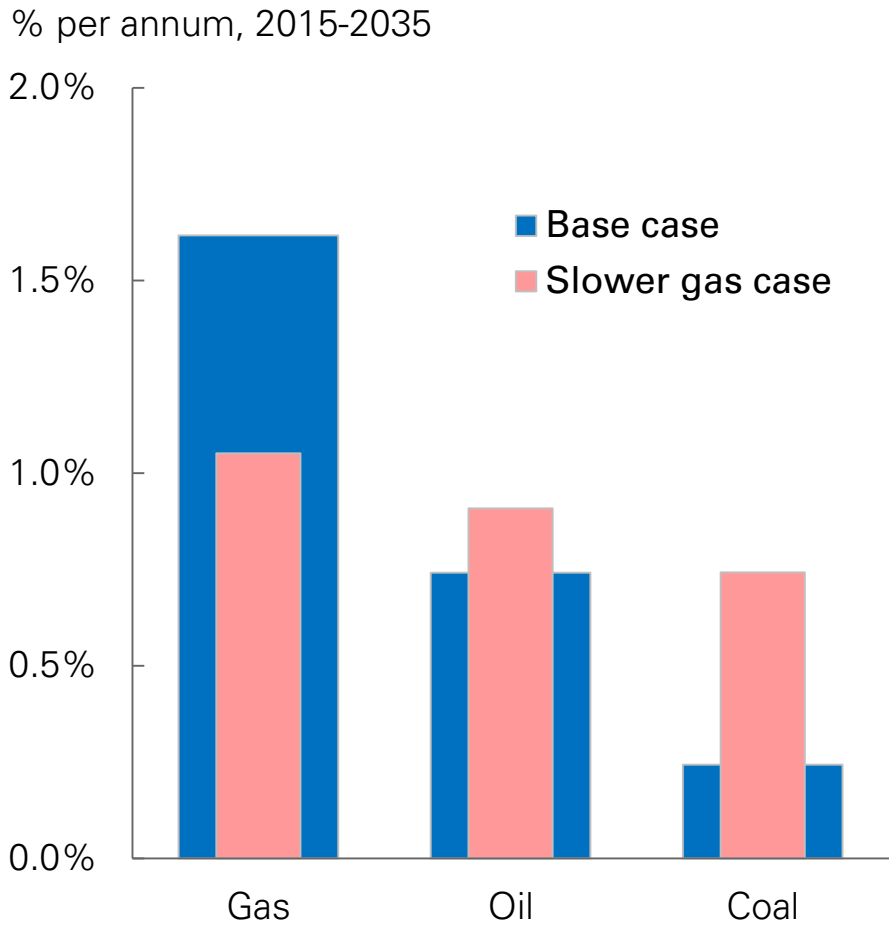
See page 101 for a technical note on comparison methodology and page 102 for details of sources

...reveals similarities and differences

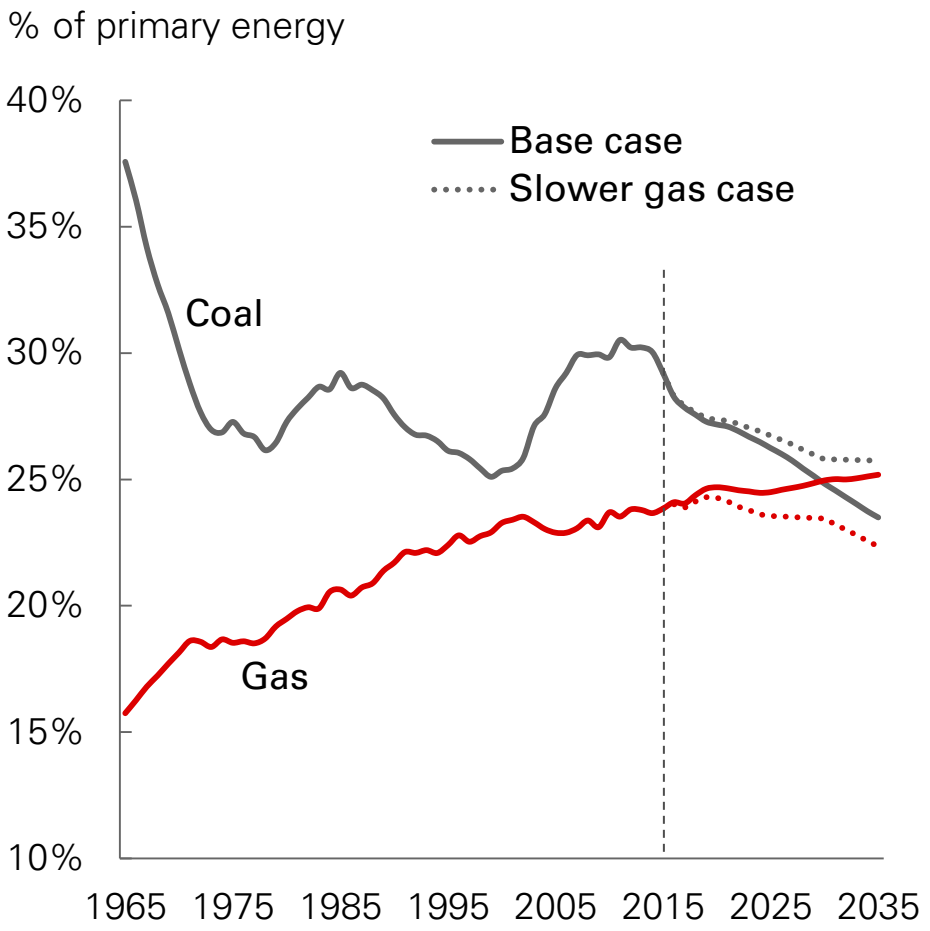
- By design, the 'even faster' case matches the carbon emission decline of the IEA 450 Scenario, but it achieves that decline with a different mix of efficiency gains and fuel switching. A selection of other scenarios that show similar declines in carbon emissions illustrates the wide range of plausible paths towards a lower-carbon future.
- These scenarios have some common features. All project declines in both energy intensity and carbon intensity (carbon emissions per unit of energy) at historically unprecedented rates. And almost all show the power sector providing the largest reduction in emissions.
- The differences among the scenarios largely reflect differences in assumptions about the relative costs of technologies, and about non-cost factors that influence the pace of technology deployment. The uncertainty around these factors makes it difficult to pick any particular path as the best way forward. This underpins the role of carbon pricing since it provides incentives for businesses, markets and consumers alike to follow the most efficient path as technologies and behaviours evolve.
- In most of these scenarios, oil and gas together still provide almost half of the world's energy in 2035. The main exception is the Greenpeace scenario, which sees the greatest scope for both energy savings and growth in renewables.

Gas demand growth could be slower…

Consumption growth by fuel



Shares of global primary energy

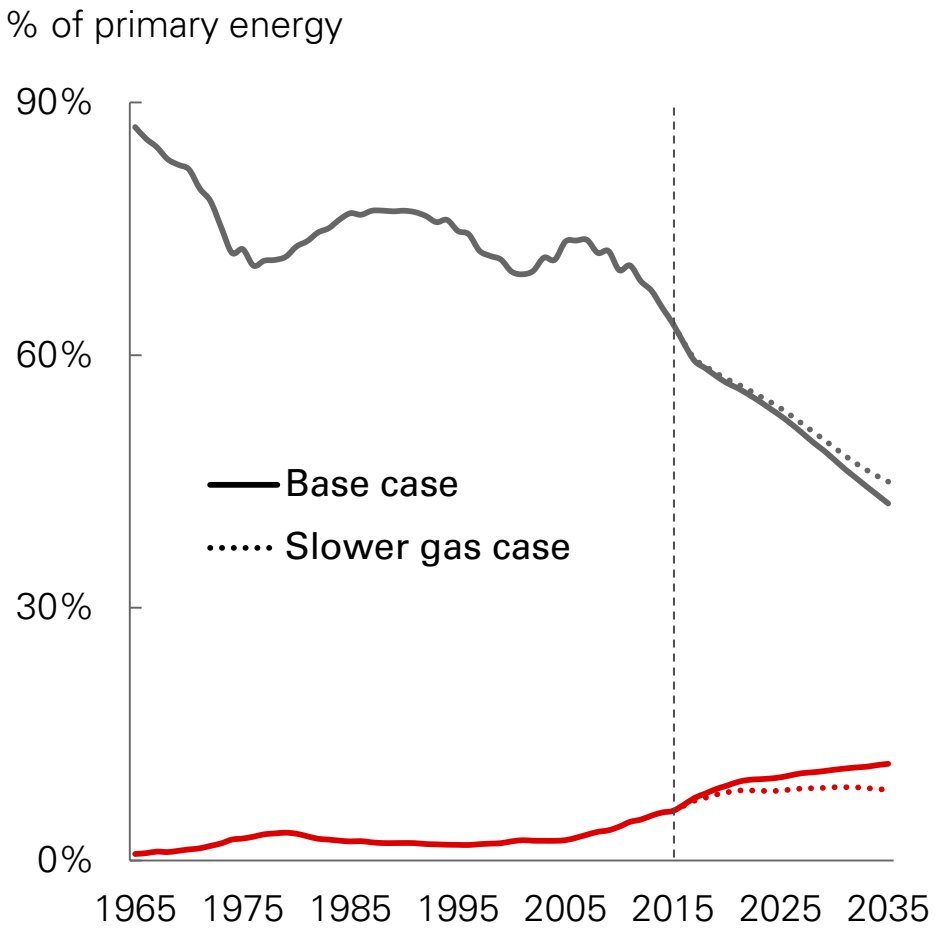


…if less priority is attached to moving away from coal

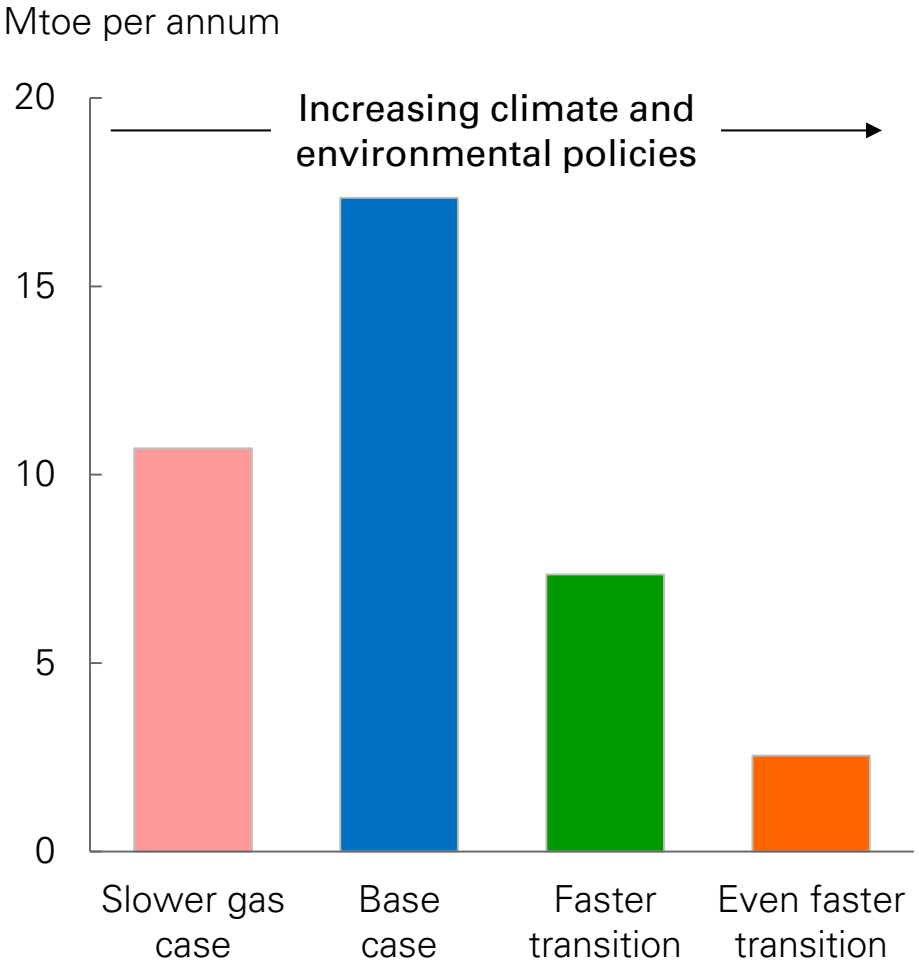
- Natural gas is projected to grow at more than twice the rate of either oil or coal, with its share within primary energy increasing throughout the Outlook.
- The strength of natural gas demand partly reflects gas gaining share from coal helped by government policies encouraging a shift away from coal and supporting growth in gas.
- The 'faster transition' cases (pages 76 to 81) illustrate how tighter climate policies may cause the growth of gas to be slower than anticipated. It is also possible that the growth of natural gas may be threatened if there is less government support encouraging a switch from coal into gas.
- To explore this possibility, we created an alternative 'slower gas' case where the demand for coal is more resilient than in the base case, with slower growth in gas consumption.
- The growth of natural gas is a third slower (1.1% p.a. versus 1.6% p.a.), such that the share of gas within primary energy falls over the Outlook. The share of coal continues to fall in this alternative case, but less rapidly than in the base case.

The strength of natural gas demand could be challenged…

China primary energy shares



Global gas growth 2015-2035



...from both stronger and weaker environmental policies

- This alternative case assumes that climate and environmental polices tighten by less than expected in the base case. In particular, the set of regulatory policies aimed at promoting a shift away from coal and towards natural gas are considerably weaker and there is effectively no support from carbon pricing. This is equivalent to assuming an increase in the price of gas relative to coal of around 50% compared to the base case.
- In China (which accounts for one-third of the global reduction in gas demand relative to the base case) the share of coal within total energy still declines, but at a slightly slower rate. The impact on Chinese gas consumption is more marked, with the share of gas in China's energy mix increasing only slightly, rather than almost doubling as in the base case.
- The 'slower gas' case, together with the faster transition cases, demonstrates that the strength of natural gas demand envisaged in the base case could be challenged by alternative assumptions about the strength of future climate and environmental policies, with both stronger and weaker policy assumptions posing potential threats.

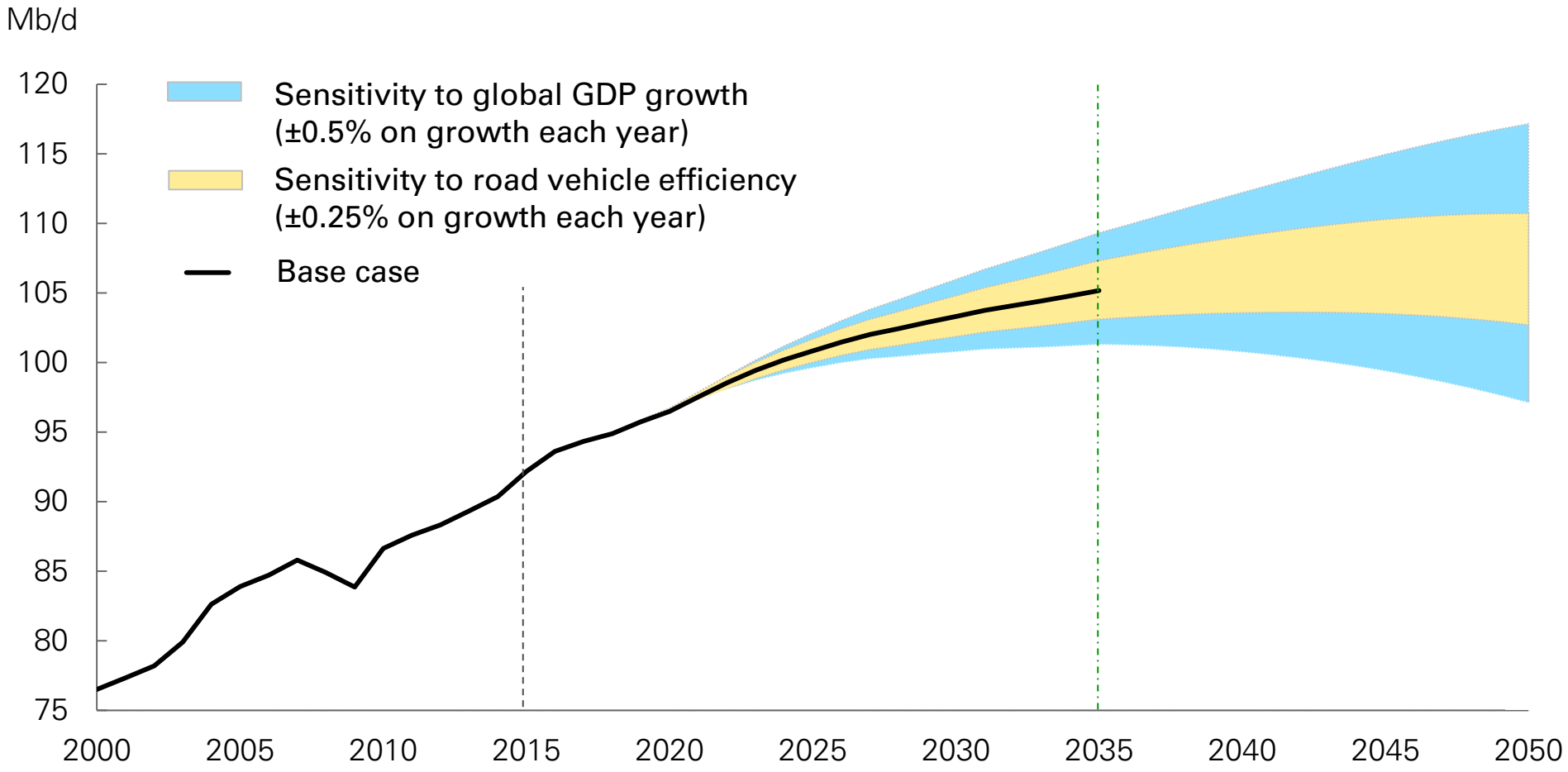
Beyond 2035

- When will global oil demand peak?
- What role will Africa play in driving energy demand?
- Will power dominate global energy demand growth?

- The Energy Outlook considers global energy trends over the next 20 years.
- The uncertainty about future energy trends increases substantially as we look beyond the Outlook's 20 year horizon since there is increasing scope for the existing stock of machines and buildings to be replaced and for new technologies to alter fundamentally the way in which the world uses energy.
- But there are some important issues and questions relating to the energy transition that occur beyond 2035.
- We explore three such issues in the following pages. Given the considerable uncertainty, rather than attempt to construct a single 'most likely' case, we consider a range of possible outcomes and the key factors likely to affect the outcome.

The point at which global oil demand will peak…

Illustrative paths for oil demand under different assumptions

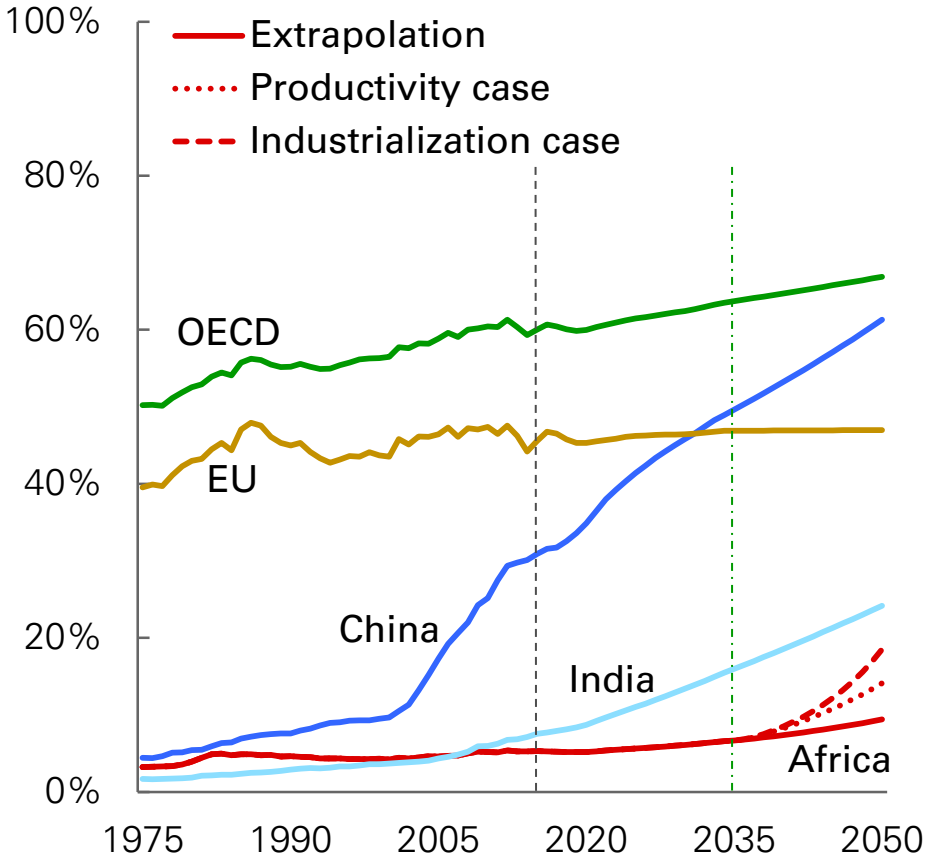


...depends on GDP growth, efficiency trends and climate policy

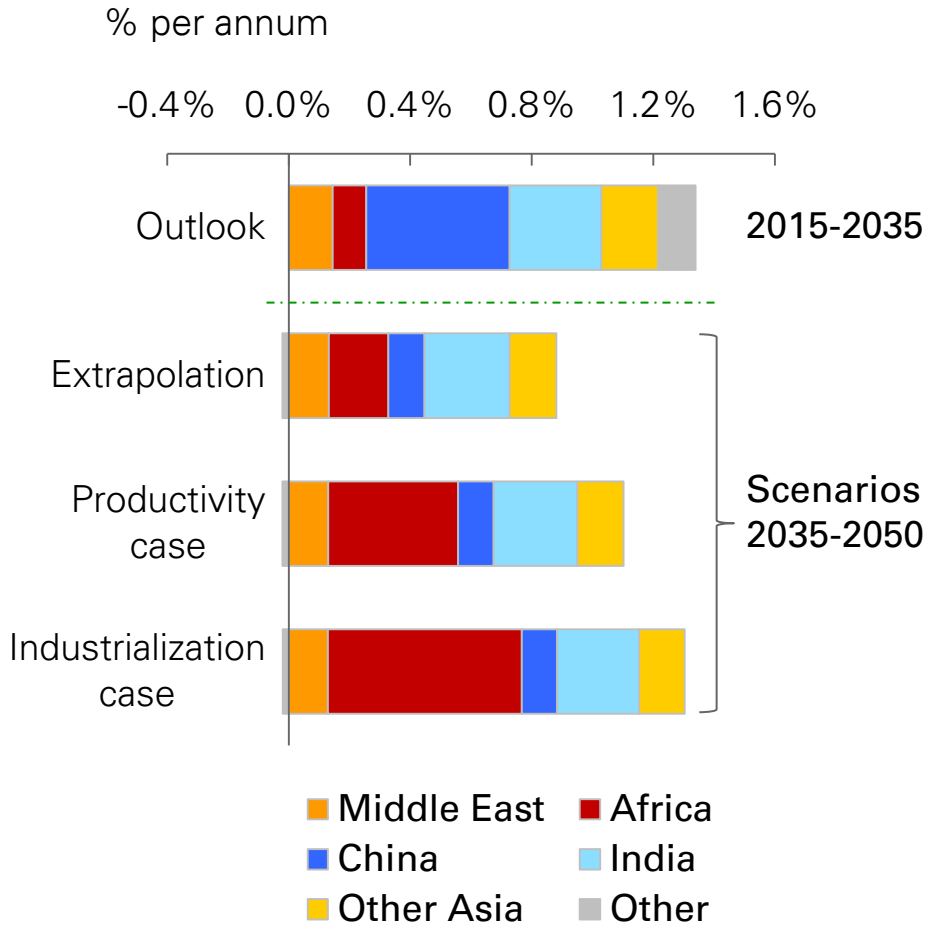
- In the base case, oil demand grows throughout the Outlook driven by increasing prosperity in emerging economies. But the pace of growth gradually slows, as transport efficiency improves and the degree of fuel switching builds.
- A simple extrapolation of these trends would suggest that oil demand may start to decline during the mid-2040s. But it might peak much sooner or later.
- If, for example, global GDP growth turns out stronger than a simple extrapolation would imply, or road vehicle efficiency improves less quickly, plausible scenarios suggest oil demand may not begin to fall until the second half of the century.
- By contrast, if GDP growth is slower than implied by past trends, fuel efficiency improves more quickly, uptake of alternative fuel vehicles is faster, or climate policies are more stringent, oil demand may start to fall much earlier. Oil demand is declining by 2035 in both the 'faster transition' and 'even faster transition' cases.
- Although the eventual peak in oil demand will be symbolic of a world transitioning away from oil, it would mark only the first point of decline. Oil is likely to remain a significant source of global energy consumption for many decades.

The role Africa will play in driving global energy demand…

Energy per person as proportion of the US



Primary energy growth by region

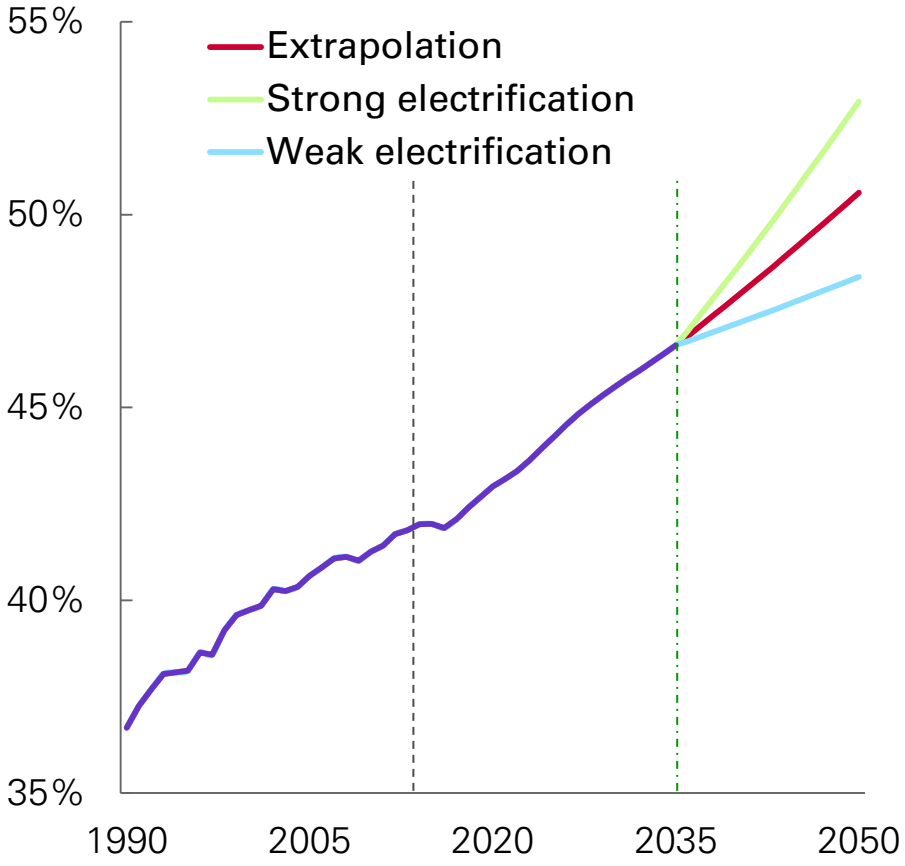


...depends on productivity growth and industrial structure

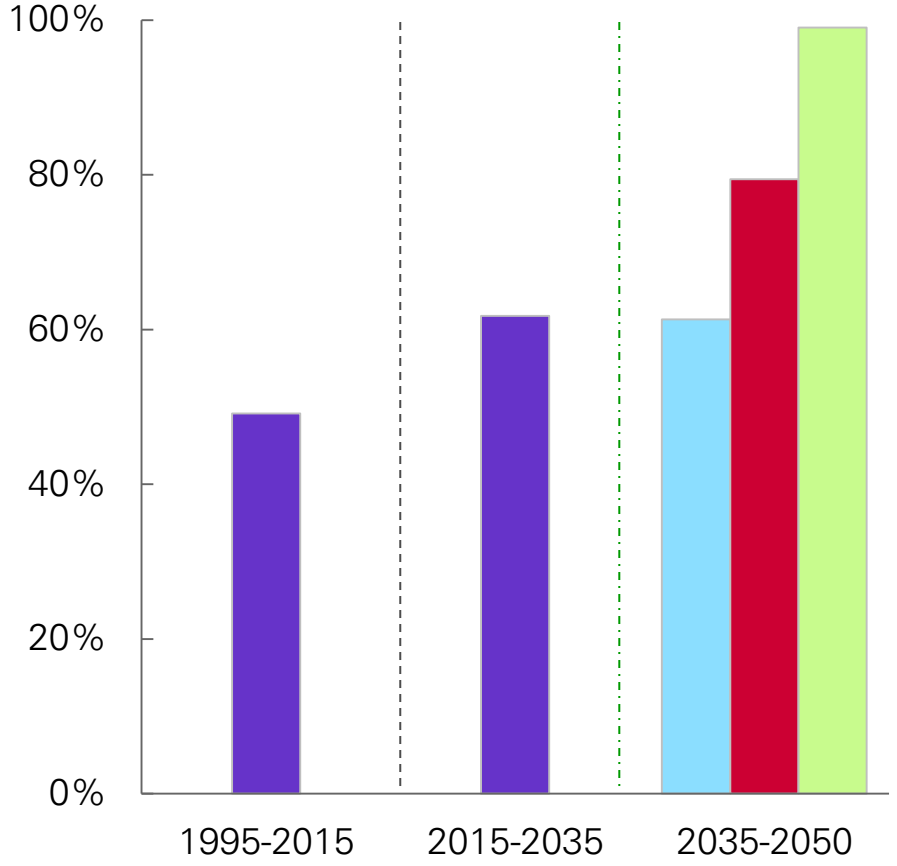
- The extent and nature of Africa's economic development is likely to play a key role in determining the growth of global energy beyond 2035.
- Growth in energy demand is projected to slow towards the end of the Outlook as the stimulus from China and India fades. A simple extrapolation implies that growth in global energy demand could slow to around 0.9% p.a. in 2035-2050, compared with 1.3% over the Outlook and 2.3% in 2000-2015.
- But such an extrapolation implicitly assumes continued relatively slow growth in Africa, with little convergence in productivity relative to best practice. Despite a quarter of the world's population living in Africa by 2050, it would account for less than 10% of global GDP and energy demand. What happens if Africa's economy and energy demand grows more rapidly?
- If African productivity increased in line with India's over the past decade ('Productivity' case) this could lead to stronger growth in African, and hence global, energy demand. And if these productivity gains were accompanied by increased industrialization, and hence rises in energy intensity similar to that seen by China at the turn of this century ('Industrialization' case), energy growth beyond 2035 may not slow relative to the rate expected over the Outlook.

The power sector consumes a growing share of energy…

Share of power in primary energy consumption



Power's contribution to primary energy demand growth



...and by 2050 could account for all growth in primary energy

- The power sector consumes almost two-thirds of the increase in primary energy over the Outlook. How important could power be as a source of energy demand growth beyond 2035?
- In the Outlook, the relationship between growth in GDP and power demand declines relative to the recent past. Assuming that this weaker relationship persists beyond 2035, a simple extrapolation would imply that power demand consumes 80% of the increase in primary energy between 2035-2050.
- Strong electrification case: if the pace of electrification is quicker than expected, such that the relationship between economic growth and power demand is close to its recent historical average, then increases in power demand could account for the entire increase in primary energy between 2035-2050.
- Weak electrification case: if a combination of abundant supplies of oil and gas, together with faster industrialization in emerging markets, dampens the pace of electrification - similar to that seen over the past 10 years - the contribution of power to primary energy growth beyond 2035 may be similar to that over the Outlook.

Annex

Key figures: Energy

	Consumption (Mtoe)		Shares (%)		Change (Mtoe)		Change (%)		Annual growth (%)	
	2015	2035	2015	2035	1995-2015	2015-2035	1995-2015	2015-2035	1995-2015	2015-2035
Primary energy	13147	17157	100%	100%	4559	4010	53%	31%	2.2%	1.3%
By fuel:										
Oil	4257	4892	32%	29%	971	635	30%	15%	1.3%	0.7%
Gas	3135	4319	24%	25%	1211	1183	63%	38%	2.5%	1.6%
Coal	3840	4032	29%	24%	1595	193	71%	5%	2.7%	0.2%
Nuclear	583	927	4%	5%	57	344	11%	59%	0.5%	2.3%
Hydro	893	1272	7%	7%	330	379	59%	42%	2.3%	1.8%
Renewables*	439	1715	3%	10%	394	1276	870%	291%	12.0%	7.1%
By sector:										
Transport	2471	3027	19%	18%	898	556	57%	23%	2.3%	1.0%
Industry	3117	3610	24%	21%	1060	493	52%	16%	2.1%	0.7%
Non-combusted	817	1227	6%	7%	300	410	58%	50%	2.3%	2.1%
Buildings	1222	1296	9%	8%	61	74	5%	6%	0.3%	0.3%
Power	5519	7997	42%	47%	2241	2478	68%	45%	2.6%	1.9%

*Renewables includes wind, solar, geothermal, biomass, and biofuels

Key figures: Macro, energy intensity and CO_2 emissions

	Level		Change (absolute)		Change (%)		Annual growth (%)	
	2015	2035	1995-2015	2015-2035	1995-2015	2015-2035	1995-2015	2015-2035
GDP* (trillion US$)	105	204	53	100	104%	95%	3.6%	3.4%
Population (billions)	7.3	8.8	1.6	1.5	28%	20%	1.2%	0.9%
GDP per capita* (thousand US$)	14	23	5.4	9.0	60%	62%	2.4%	2.5%
Energy intensity (toe per US$m)	126	84	-42	-42	-25%	-33%	-1.4%	-2.0%
Net CO_2 emissions† (billion t CO_2)	33.5	37.7	11.3	4.2	51%	13%	2.1%	0.6%

*GDP and GDP per capita figures are shown in $2010 prices converted to US dollars at Purchasing Power Parity
† CO_2 emissions are shown net of carbon capture, use and storage

Digital revolution mobility scenario: assumptions

Assumptions are illustrative only and can be scaled up or down to consider alternative calibrations.

Assumptions in 2035:	Impact on oil demand (Mb/d)
Electric vehicles (EVs): No additional EVs relative to the base case.	0
Autonomous vehicles (AVs): 200 million AVs. Each AV is 25% more fuel efficient than a conventional car.	-0.7
Car sharing: Occurs via AVs. On average each AV is driven twice as many miles per year as a conventional car - doubling the disruptive impact of AVs.	-0.7
Ride pooling: 40% of urban car journeys are pooled and 25% of all car miles are urban, so 10% of all miles are affected by pooling. Each pooled ride has twice as many occupants per vehicle, which reduces total mileage by 5%. Pooling occurs via all car types (EVs and ICEs) so the effects are distributed proportionately.	-1.1
Demand for car travel: The range reflects uncertainty about the magnitude of the cost reduction, the sensitivity of demand to any fall in costs, and any additional impact of new technology on demand. The upper bound assumes the cost of digital car travel falls by up to 33% and a price elasticity of demand for travel of up to -1. This boosts miles travelled by digital cars by up to 33%, which translates to an increase in total miles travelled of up to 7.5%. In addition, digital technologies create new sources of demand from new user groups (the old, young, and empty cars driven autonomously), which boost miles travelled by up to a further 7.5%.	0 to +2.8

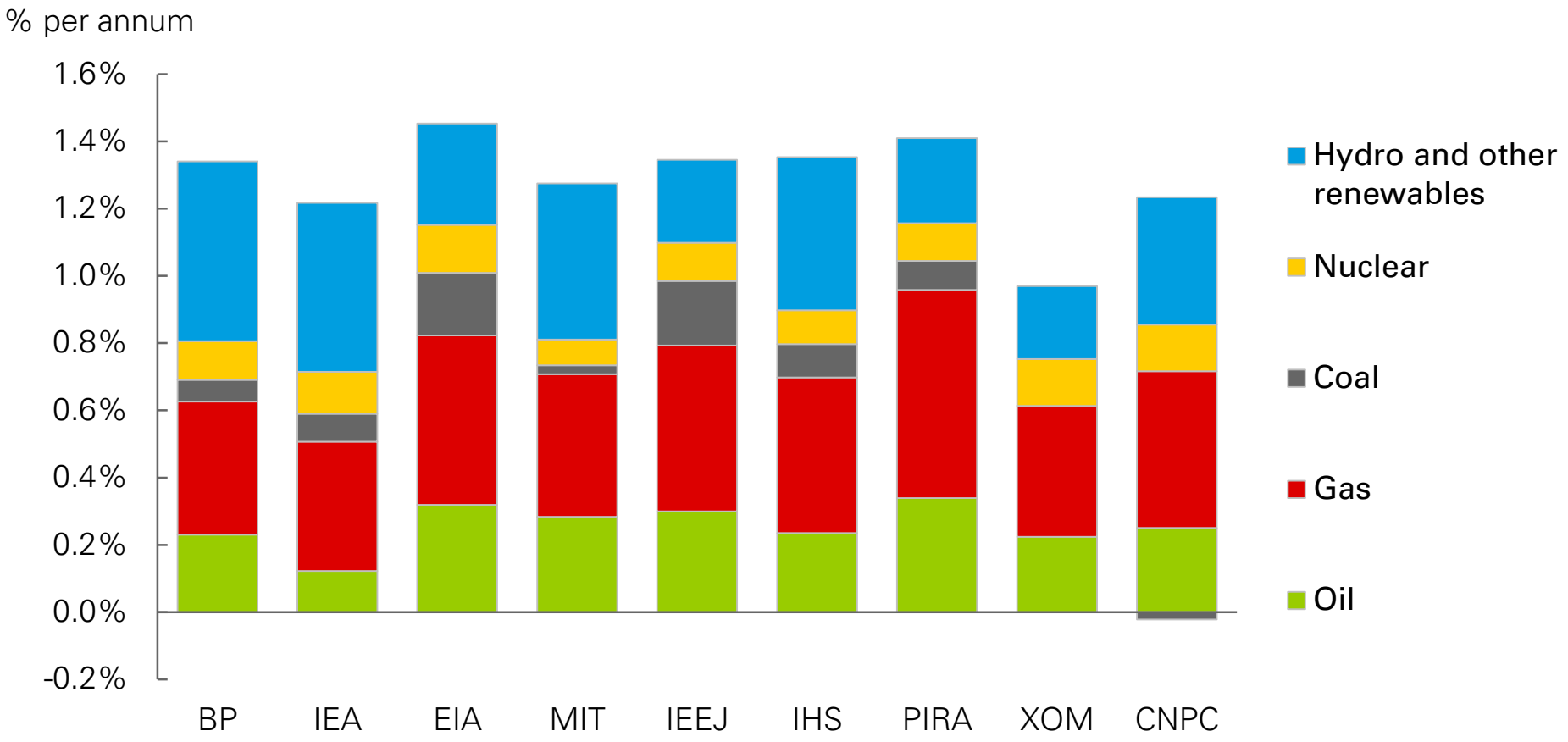
Electric revolution mobility scenario: assumptions

Assumptions are illustrative only and can be scaled up or down to consider alternative calibrations.

Assumptions in 2035:	Impact on oil demand (Mb/d)
Electric vehicles (EVs): An extra 200 million EVs relative to the base case, all battery-electric vehicles.	-2.8
Autonomous vehicles (AVs): 200 million AVs, all of which are electric. Each AV is 25% more fuel efficient than a conventional car, but since AVs are electric these efficiency gains only affect electricity demand, not oil demand.	0
Car sharing: Occurs via EVs. 200m EVs are driven twice as many miles per year as a conventional car - doubling the disruptive impact of the extra EVs.	-2.8
Ride pooling: 40% of urban car journeys are pooled and 25% of all car miles are urban, so 10% of all miles are affected by pooling. Each pooled ride has twice as many occupants per vehicle, which reduces total mileage by 5%. Ride pooling occurs via EVs so all of the reduction in miles falls on ICEs (ICE miles fall 10%).	-1.8
Demand for car travel: As with the digital revolution, new technologies reduce the cost of travel via electric cars and enable greater access to previously under-served user groups. But since all of the new technologies are implemented via electric vehicles, the additional miles travelled are powered by electricity not oil, so oil demand is unaffected.	0

Comparison with other energy outlooks

Contributions to growth of energy consumption, 2015-2035



For a key to the outlooks and details of sources see page 102

Notes on comparisons

- Long-run energy projections are available from many organizations. The list here is not exhaustive, but illustrates the range of views within a sample of projections. Some of the organizations represented here produce more than one projection; where possible we have tried to select a 'central' or 'reference' case.
- All the outlooks show continuing modest growth in oil, with gas growing more rapidly than oil and coal. 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; and 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 2015, taken from the BP Statistical Review of World Energy. The IEA case shown is the New Policies Scenario, for IHS it is the Rivalry Scenario. The EIA, MIT and IEEJ cases are each publication's reference case.

Comparison and other key data sources

Comparison data sources:

IEA: International Energy Agency, World Energy Outlook 2016 , Paris, France, November 2016

EIA: US Energy Information Administration, International Energy Outlook 2016, Washington, D.C., United States, May 2016

MIT: MIT Joint Program on the Science and Policy of Global Change, 2016 Food, Water, Energy and Climate Outlook, Cambridge, MA, United States, 2016

IEEJ: Institute of Energy Economics Japan, Asia/World Energy Outlook 2016, Tokyo, Japan, October 2016

IHS: IHS Energy, Rivalry: the IHS Planning Scenario, July 2016

PIRA: PIRA Energy Group, Scenario Planning Guidebook, Appendix, February 2016

XOM: ExxonMobil, 2017 Outlook for Energy: A View to 2040, December 2016

CNPC: CNPC Economics & Technology Research Institute, Energy Outlook 2050, 2016

Greenpeace, Energy Revolution, September 2015

Other key data sources:

BP p.l.c., BP Statistical Review of World Energy, London, United Kingdom, June 2016

International Energy Agency, Energy Balances of Non-OECD Countries, Paris, France, 2016

International Energy Agency, Energy Balances of OECD Countries, Paris, France, 2016

UN Population Division, World Population Prospects: The 2015 Revision, New York, United States, 2016

Disclaimer

This presentation contains forward-looking statements, particularly those regarding changes to the fuel mix, global economic growth, population and productivity growth, energy consumption, energy efficiency, mobility developments, policy support for renewable energies, sources of energy supply and growth of carbon emissions. 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; demographic changes; 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 (nor their respective officers, employees and agents) 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.

Unless noted otherwise, data definitions are based on the BP Statistical Review of World Energy, and historical energy data up to 2015 are consistent with the 2016 edition of the Review. Gross Domestic Product (GDP) is expressed in terms of real Purchasing Power Parity (PPP) at 2010 prices.