BP Energy Outlook 2035

Focus on North America, March 2015

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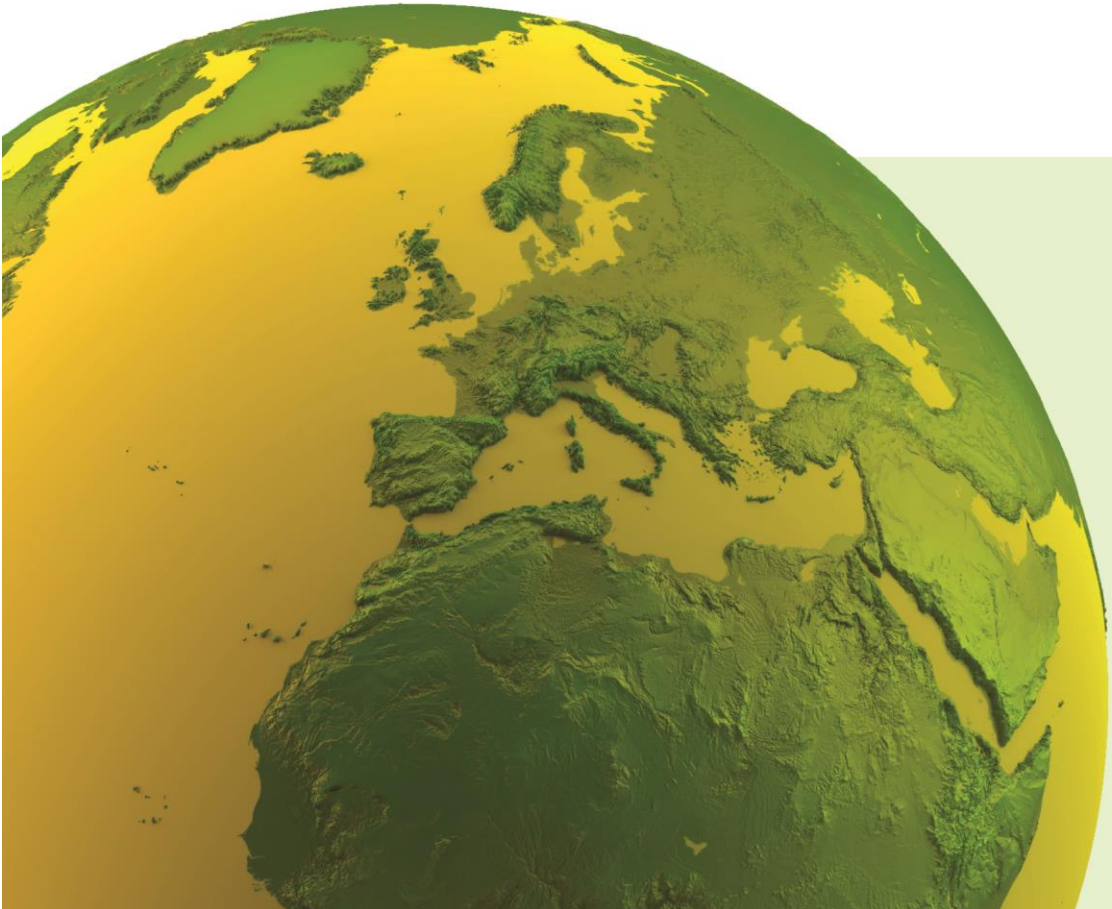

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Notes on method and assumptions

- 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.

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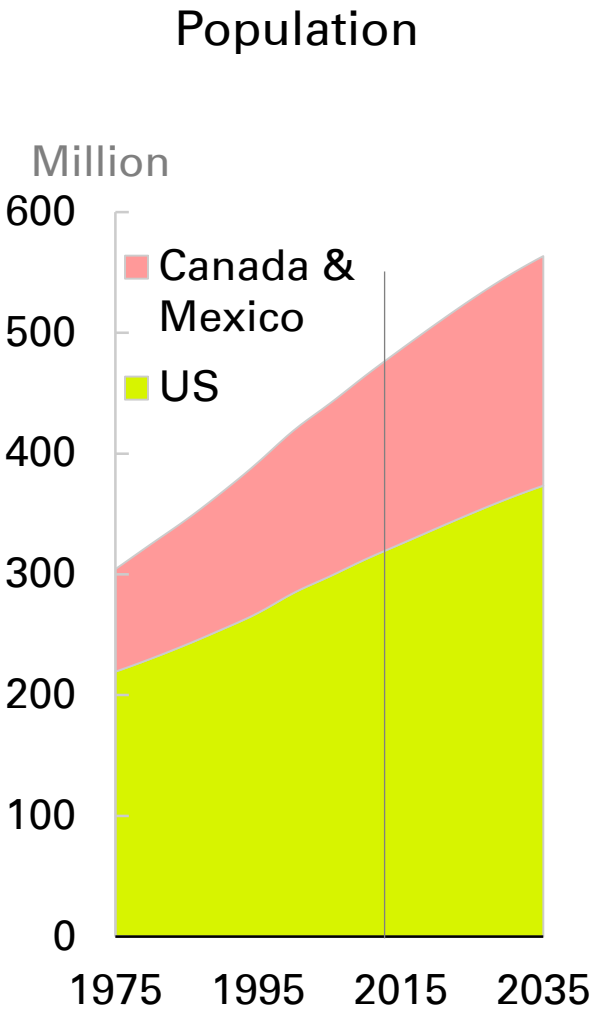
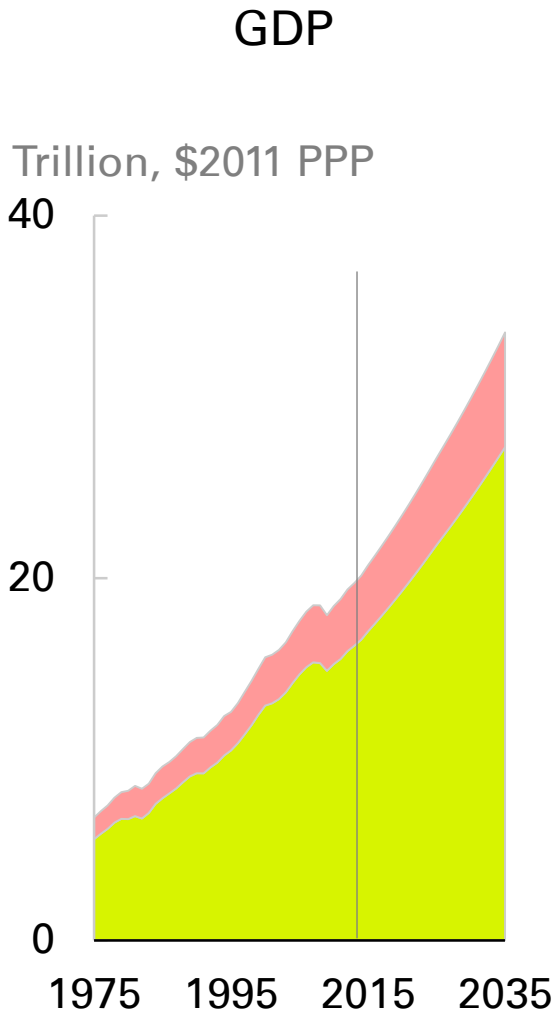
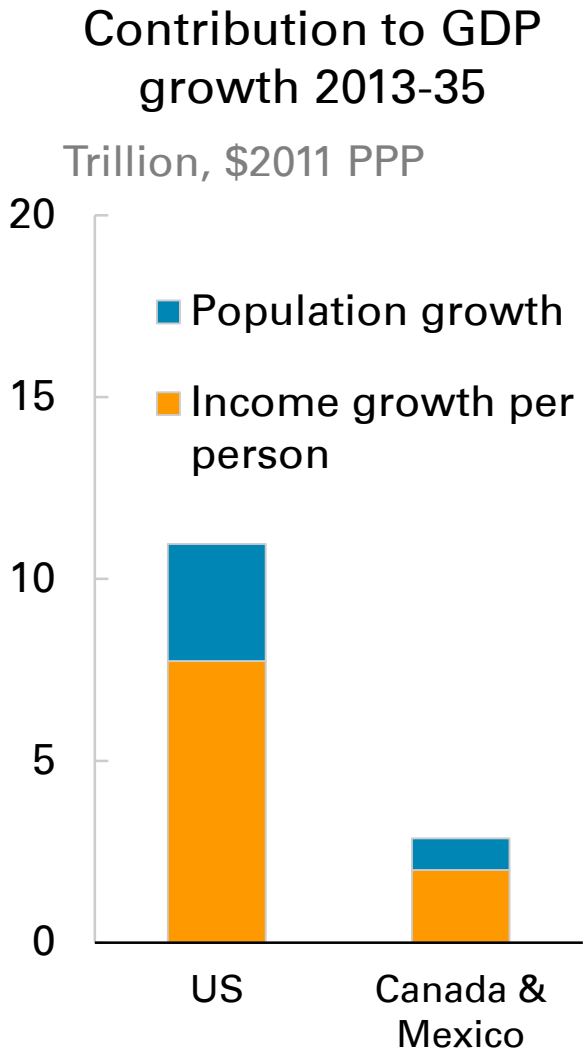
North American population and GDP…







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…grow over the Outlook

- Population growth and increases in income per person are drivers behind growth in energy demand.
- North America's population grows by 18% over the Outlook to reach 560 million by 2035, slightly slower growth than total world population which increases by 22% over the Outlook. US population grows by 17% over the Outlook, while Canada & Mexico's population grows by 21%.
- North American GDP is expected to increase by 70% by 2035, with growth of 67% in the US and 83% in Canada & Mexico.
- China surpassed the US as the world's largest economy in 2014 (expressed in terms of real Purchasing Power Parity at 2011 prices) and the US remains the world's 2nd-largest economy through 2035.
- North American GDP per person is expected to be 44% higher by 2035.

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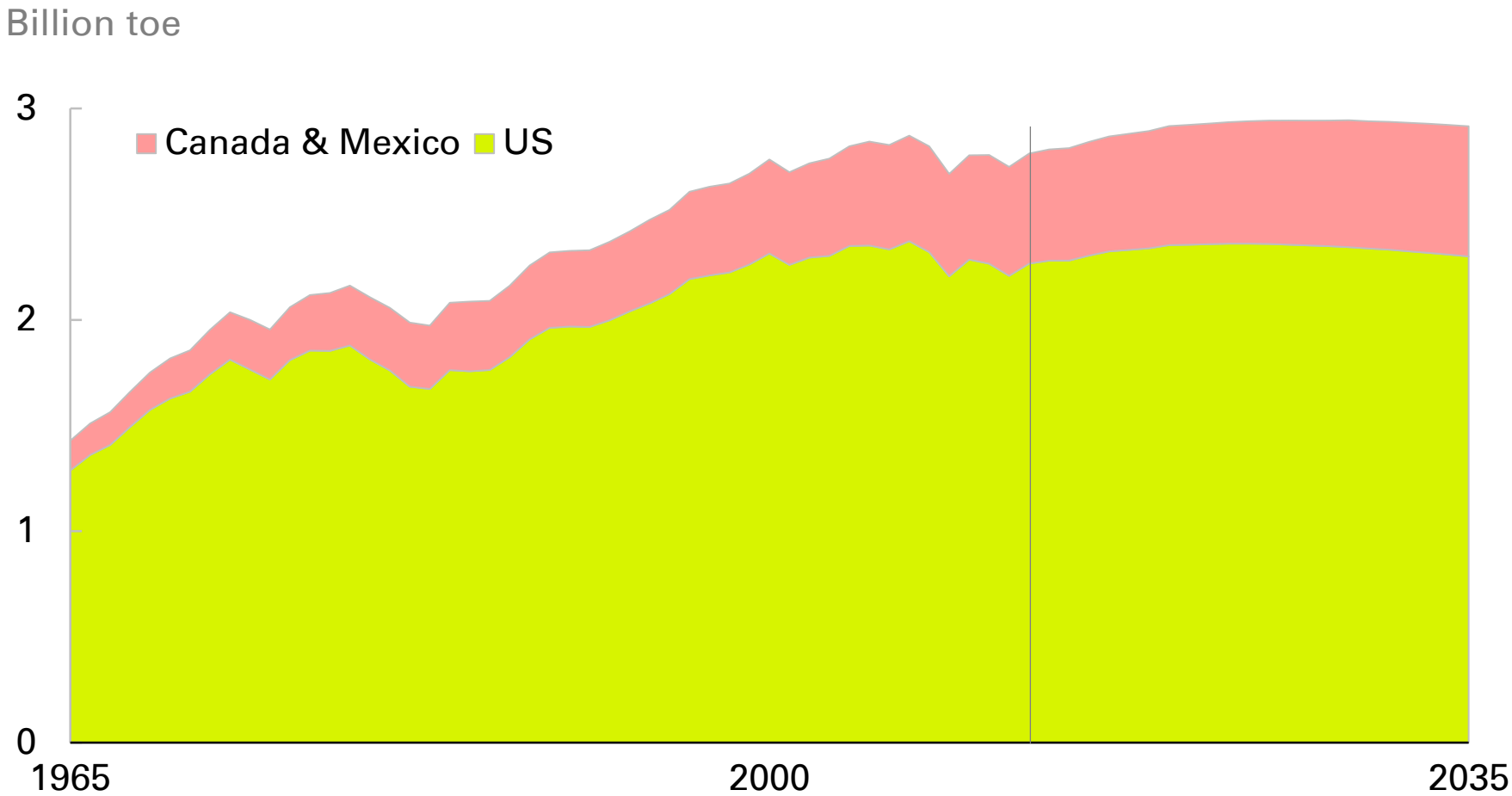
Primary energy consumption growth slows...



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…lowering North America's share of global demand

- Primary energy consumption increases by just 5% between 2013 and 2035, with growth averaging 0.2% p.a..
- This compares to global growth of 37% by 2035 and a global average of 1.4% p.a. from 2013 to 2035. As a result, North America's share of global demand declines from 22% today to 17% by 2035.
- Regional demand growth is concentrated in Canada & Mexico, where growth expands by 18% or 0.8% p.a.. In the US, growth expands by just 1% or 0.1% p.a. from 2013 to 2035. US demand begins to decline in 2025 and continues to fall there after.
- As a result, regional demand declines after 2030. The US never returns to its 2007 energy demand peak.

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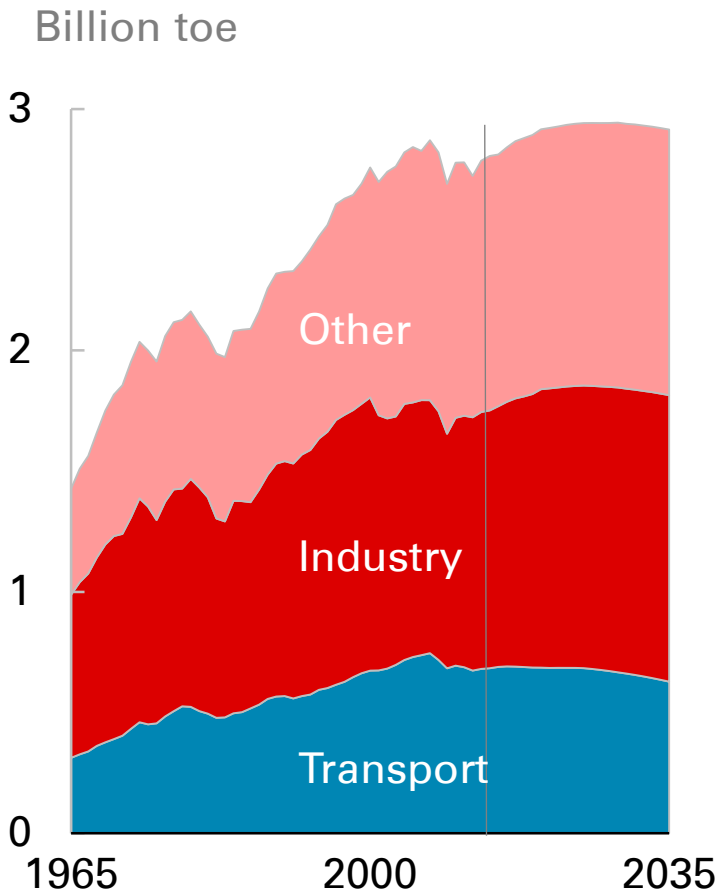
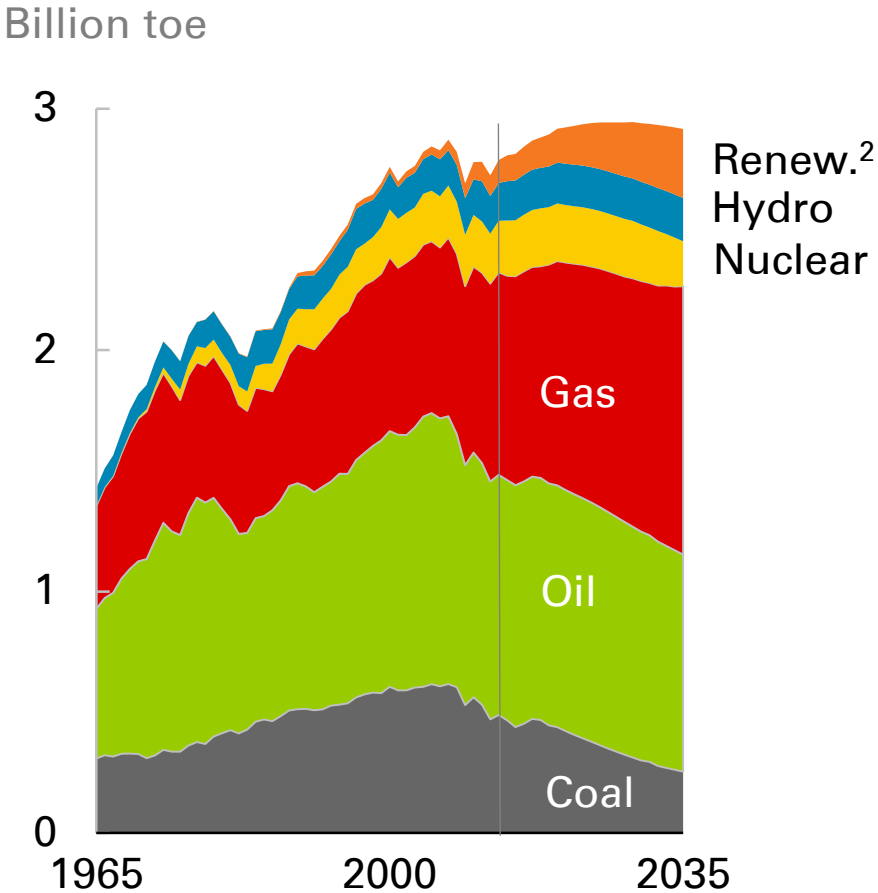
Slowing in the transport sector leads to declining oil demand...





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

[2]Includes biofuels

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…while coal loses share in power to renewables and gas

- Energy use in the transport sector declines 9% from 2013 to 2035, to its lowest level since 1996. The "other" sector (residential/commercial, services, and agriculture) compensates for the fall in transport demand with a 12% increase from 2013 to 2035, while the industrial sector grows by 6%.
- Oil consumption declines 0.5% p.a. over the Outlook as a result of falling demand in the transport sector. In the US, transport demand declines by 13% and by the end of the Outlook is at its lowest level since 1991 and 22% below its peak (2007).
- Coal declines by 2.9% p.a., driven by more aggressive environmental policies and competitively priced natural gas. Nuclear (-0.6% p.a.) demand also declines over the Outlook.
- Natural gas is the only fossil fuel to grow over the Outlook (1.3% p.a.), as demand grows in industry, power and "other". Renewables are the fastest growing group of fuels, increasing by 5.1% p.a.. Hydro-electric power increases 0.6% p.a., faster than total energy demand.

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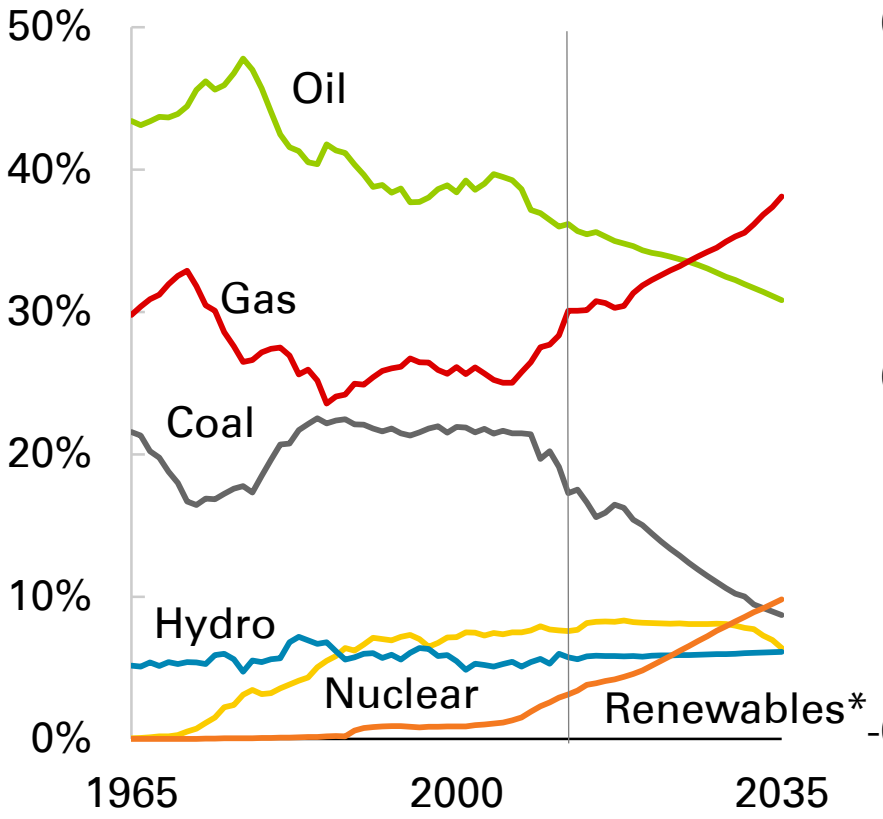
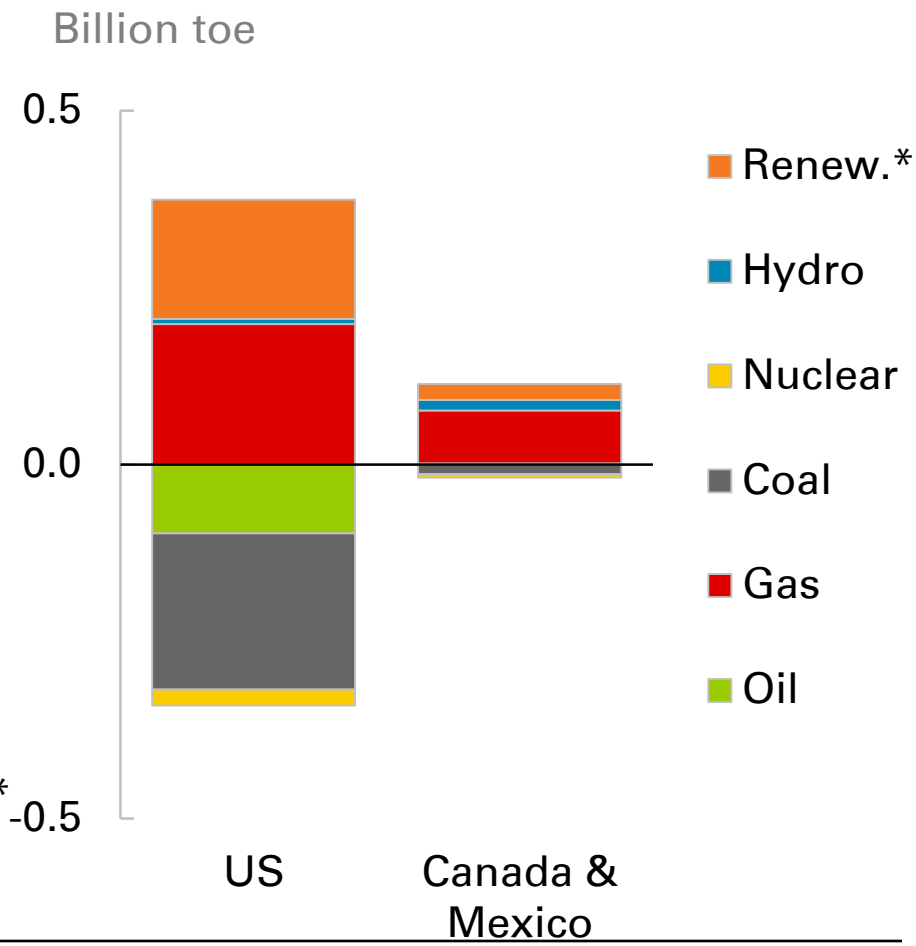
Natural gas overtakes oil as the dominant fuel…

Shares of primary energy



*Includes biofuels

2013-35 increments by fuel



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…while renewables also gain market share

- Shares of fossil fuels in the energy mix decline from 83% today to 78% by 2035. Shares of renewables (including biofuels) increase from 3% in 2013 to 10% in 2035, while hydro remains stable throughout the Outlook at 6% and nuclear remains near 8% until losing market share in the last few years of the Outlook.
- Shares of natural gas grow from 30% in 2013 to 37% in 2035, overtaking oil as the leading fuel around 2025. More than half of the increase in energy demand from 2013-2035 is met by natural gas.
- Oil's market share declines throughout the Outlook, reaching just 31% by 2035, the lowest share on record and down from a high of 48% in 1977. Coal's share drops to just 9%, also the lowest on record. Renewables overtake coal as the third largest fuel by market share by the end of the Outlook.
- In the US, declines in coal, oil and nuclear are offset by growth in gas and renewables. In Canada & Mexico, natural gas accounts for the largest share of energy consumption growth.

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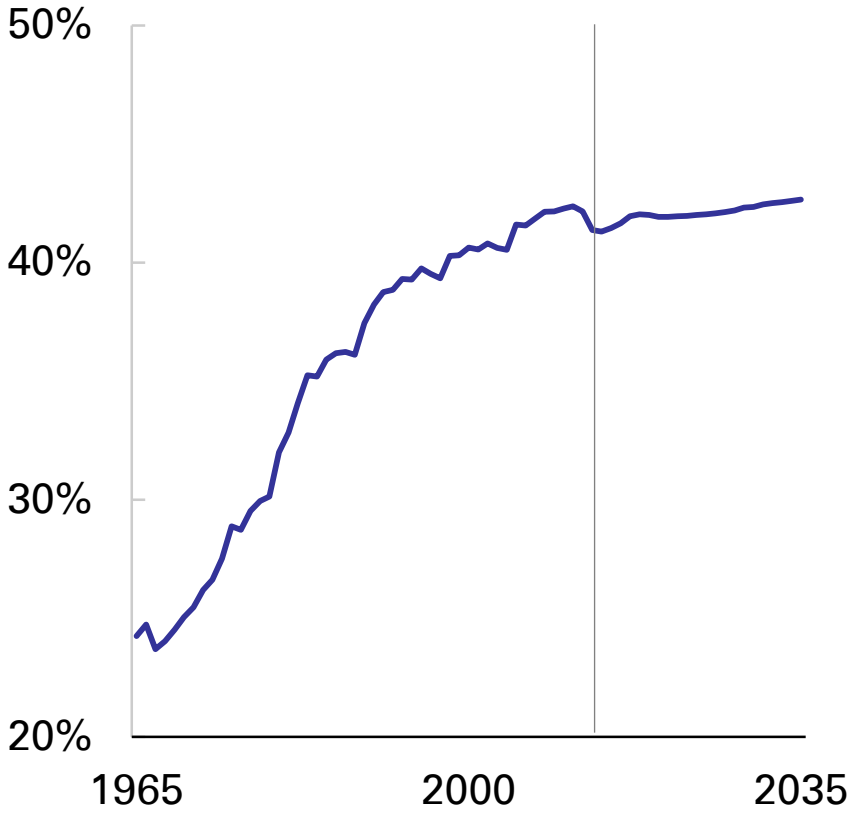
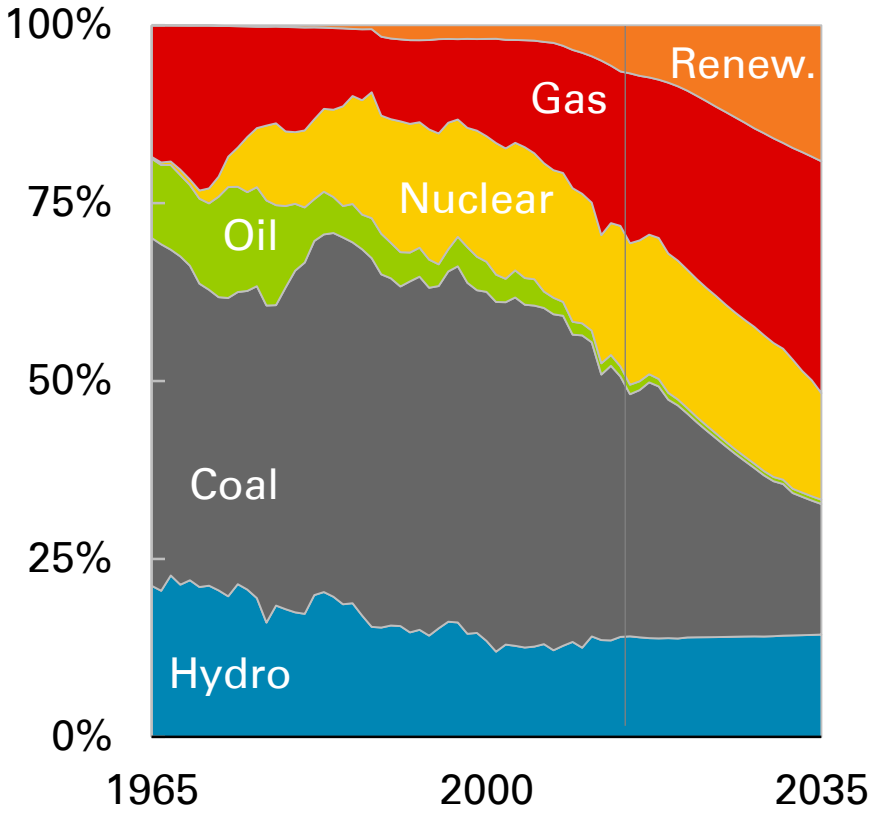
Growth in the power sector remains relatively stable…

Inputs to power as a share of total primary energy



Primary inputs to power



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…but the fuel mix in power generation evolves

- The share of primary energy devoted to power generation in North America is expected to increase just slightly over the Outlook rising from 41% today to 43% by 2035, below the OECD average of 47%. Power generation accounts for 70% of net energy demand growth.
- Power generation is the one sector where all fuels compete and so will play a major role in how the North American fuel mix evolves.
- In 2013 coal was the largest contributor to power generation with a 39% market share. But coal's market share declines steadily to reach 18% by 2035, the lowest share on record. Natural gas overtakes coal in 2025, and becomes the largest input to power generation, rising from a 22% share in 2013 to 33% in 2035. Renewables also contribute to the displacement of coal, reaching a market share of 19% by 2035.
- Carbon-free sources (renewables, hydro and nuclear) increase their combined share of power generation from 38% in 2013 to 48% by 2035. The outcome by 2035 is a more balanced and diversified portfolio of fuels for power generation.

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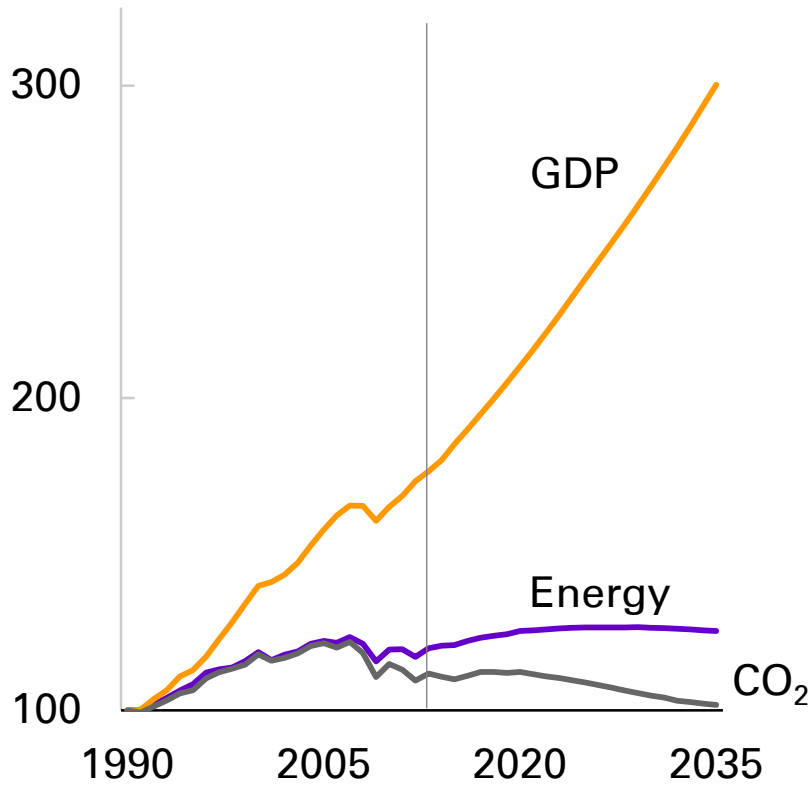
Energy efficiency restrains North American emissions…

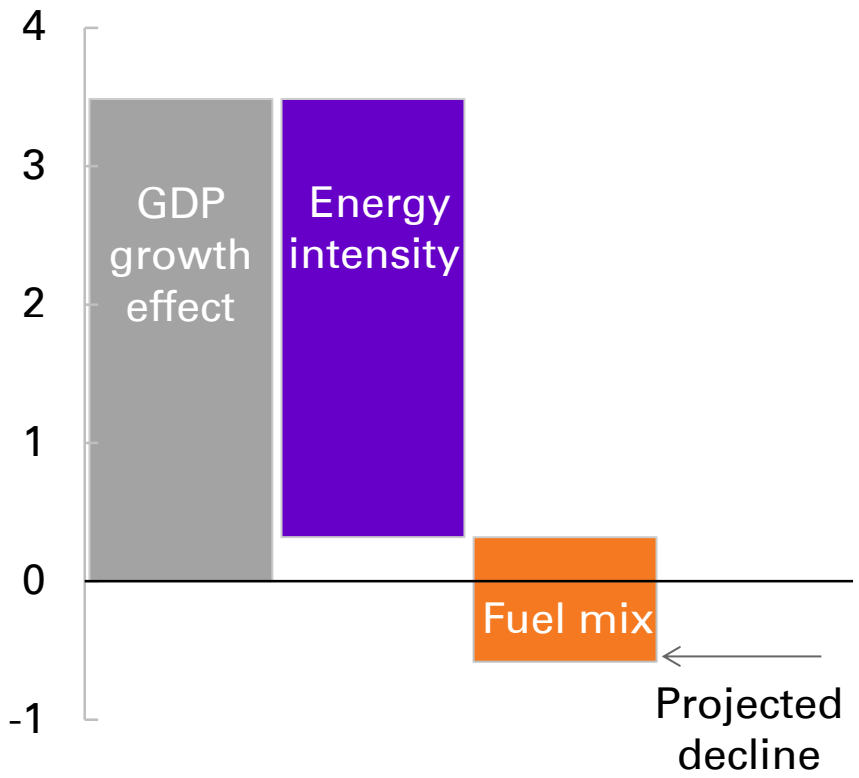
GDP, energy and emissions

Index: 1990 = 100



Emissions growth 2013 to 2035

Billion tonnes CO_2



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…but the changing fuel mix has only a modest impact

- Continuing declines in energy intensity – the broadest indicator of improving energy efficiency across the economy – leads to a marked widening in the gap between GDP and energy consumption. Energy intensity declines by 39% by 2035 (-2.2% p.a.).
- The gap between energy and CO_2 emissions reflects changes in carbon intensity, which is brought about by changes in the fuel mix. With renewables and gas gaining market share from coal and oil, the carbon intensity of the energy mix also improves.
- Total carbon emissions from energy consumption decrease by 9% between 2013 and 2035 (-0.4% p.a.), with the rate of decline speeding up in the last half of the outlook, (-0.7% p.a. from 2025 to 2035).
- Emissions by 2035 are the lowest since 1992.

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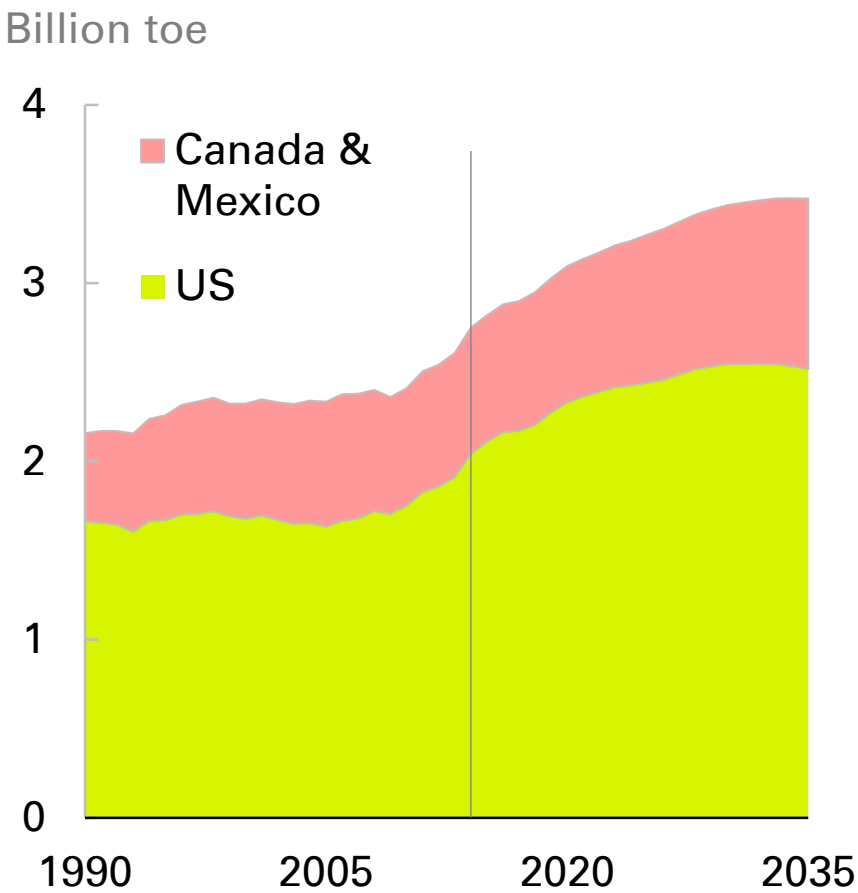
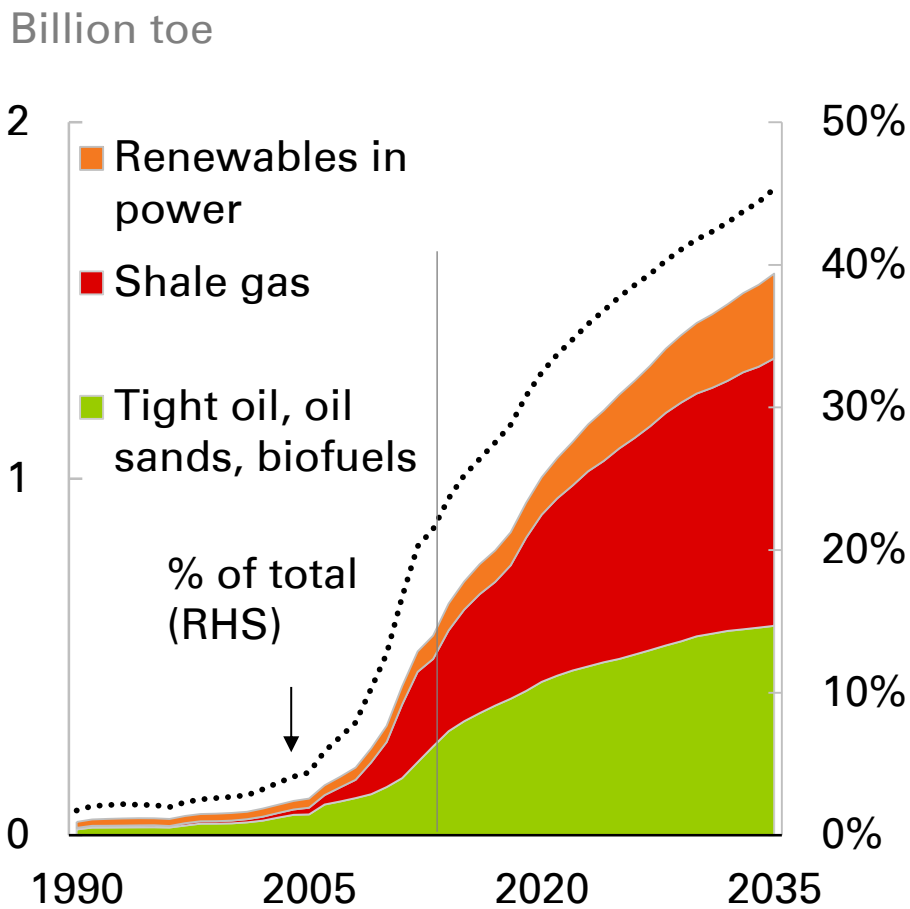
North American energy supply growth is driven by…

Primary energy production



New energy forms



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…unconventional oil and gas as well as renewables

- North American primary energy production grows at 1.3% p.a. between 2013 and 2035, slightly below the global average of 1.4% p.a.. Growth in primary energy production is far stronger than growth in consumption (0.2% p.a.).
- By 2035 the US accounts for 72% of regional production vs. 73% of output in 2013, as US output expands by 32%. This expansion over the Outlook is in stark contrast to growth of just 5% between 1990 and 2010.
- New sources of energy, aided by improved technology and productivity, account for all the net growth in North American supply. Renewables, shale gas, tight oil and oil sands in aggregate grow at 5% p.a. and reach a 45% market share by 2035, compared to 21% today and just 4% a decade ago.
- The growth of new energy forms has been enabled by the development of technology and underpinned by large-scale investments and supportive policy, and these conditions are assumed to continue over the Outlook.

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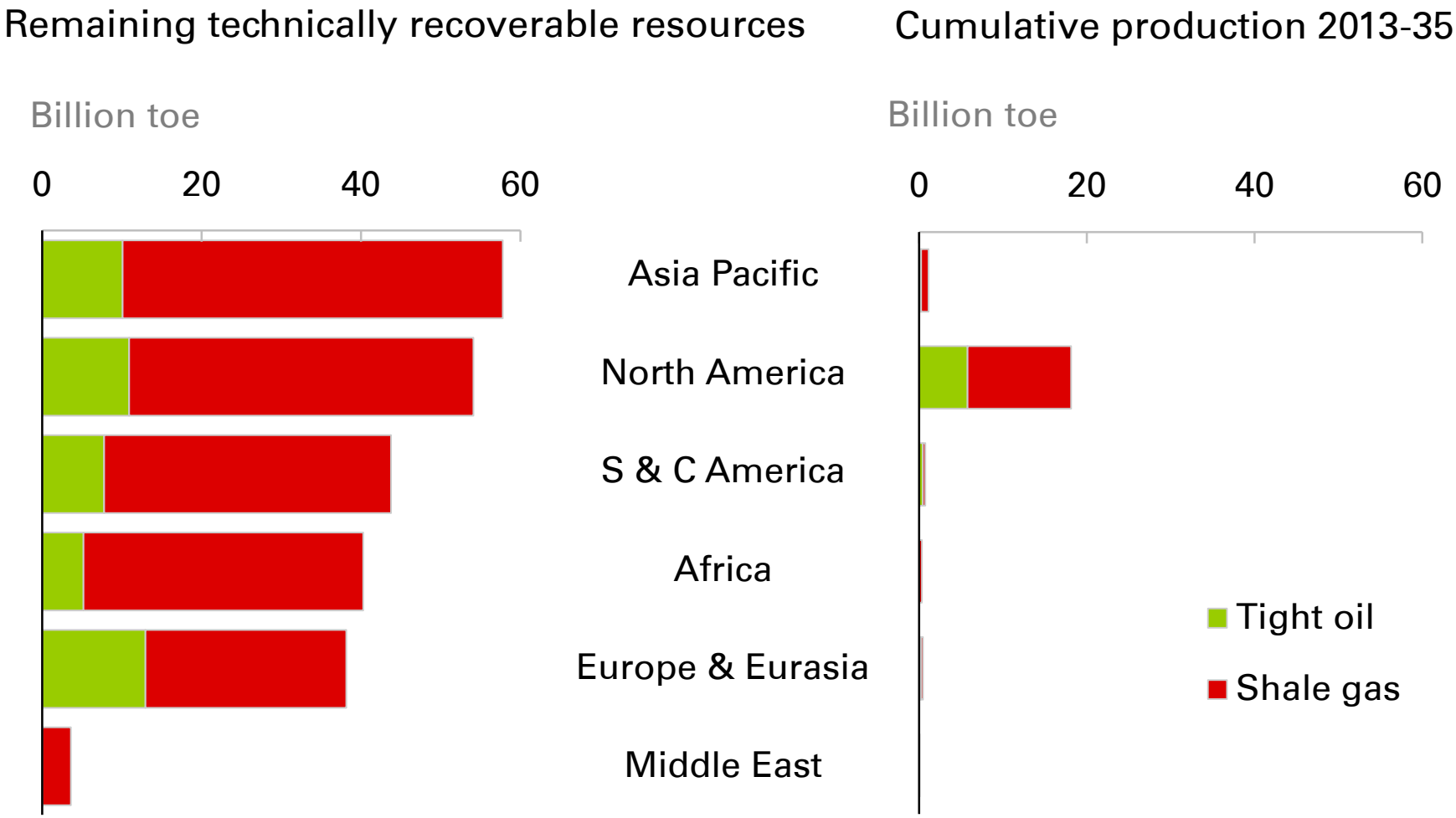
Shale gas and tight oil resources are thought to be abundant…



Source: Resources data © OECD/IEA 2014

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…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.

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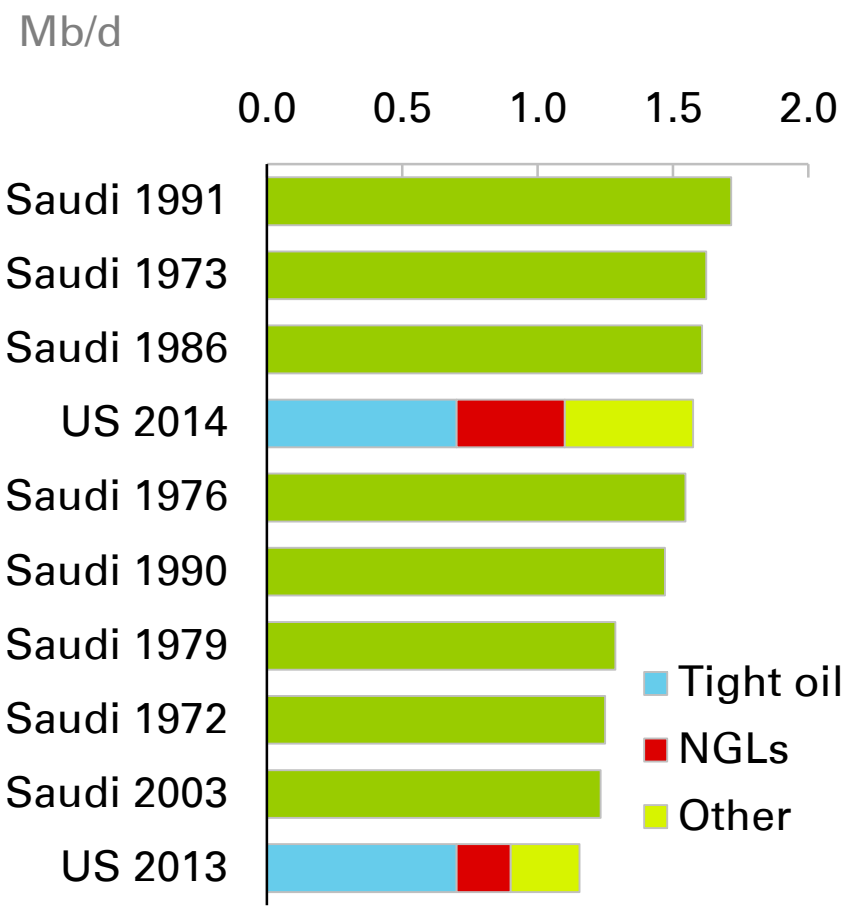
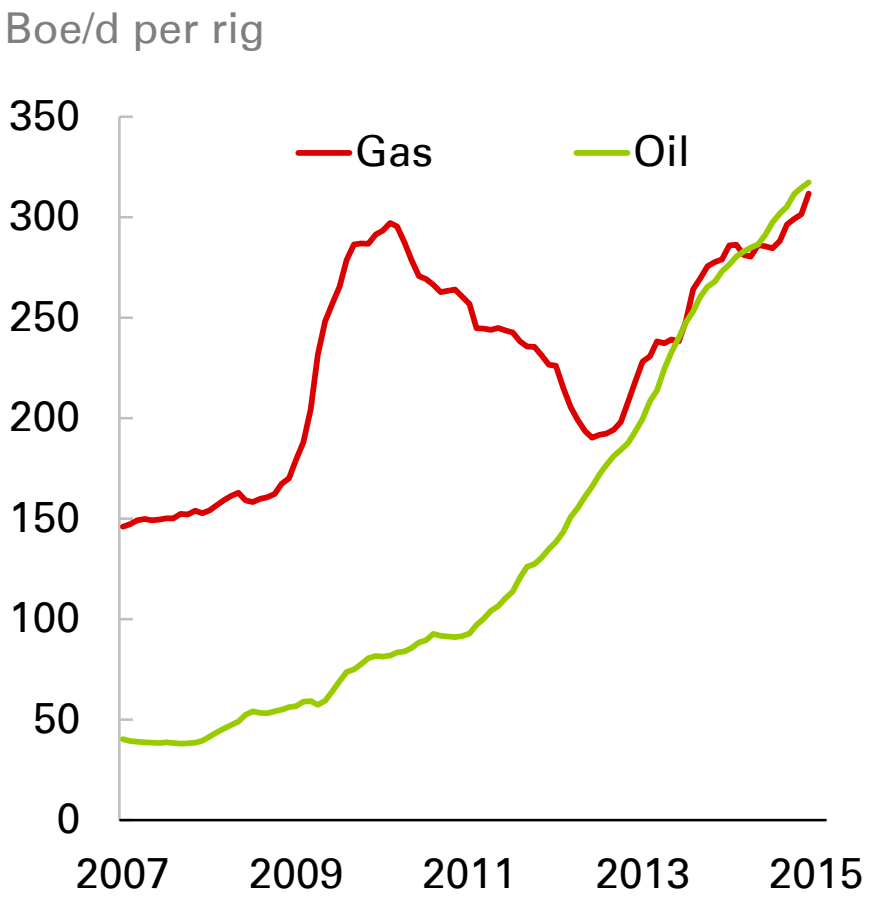
Drivers of tight oil and shale gas supply in the US…

Largest oil production increases



US new-well production per rig



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…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.

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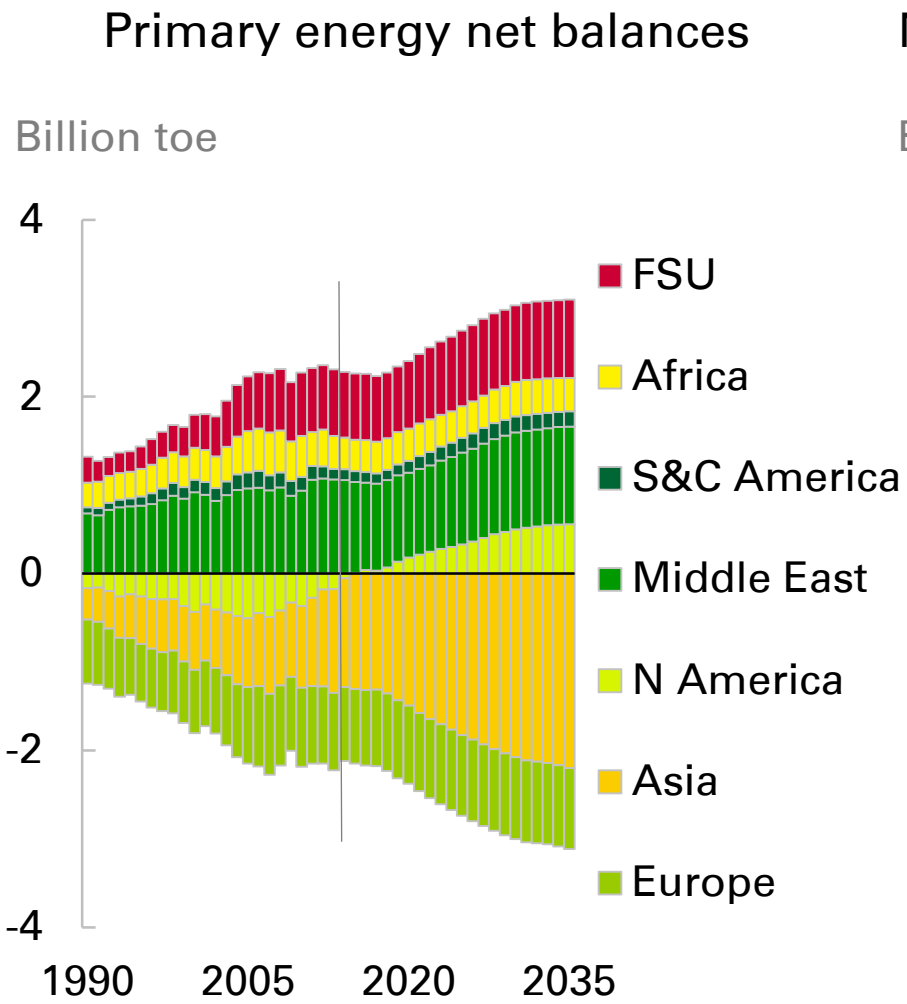
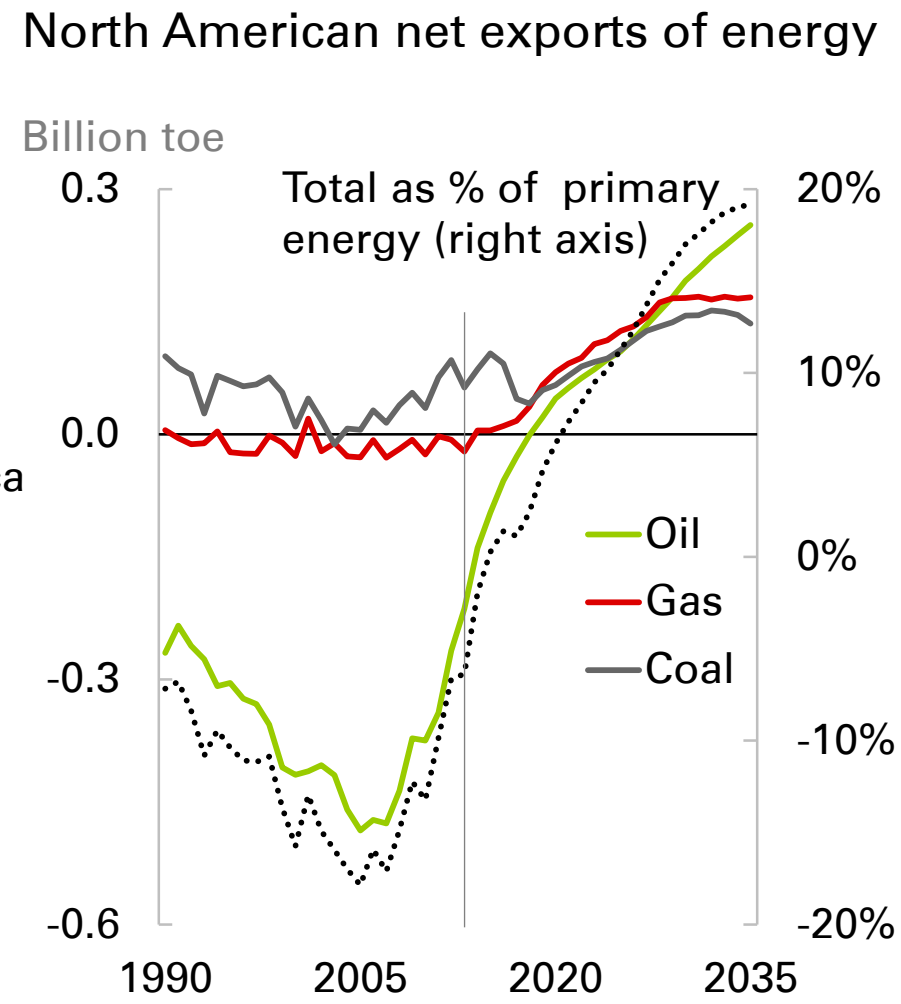
North America switches to a net exporting region in 2015…





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…with significant implications for global 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 becomes a net exporter this year (2015), and accounts for 66% of net global export growth 2015-35. Asia's imports 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. North America's share grows to 18% by 2035 while Russia remains the world's largest energy exporting country.
- North America switches from importing 6% of its energy in 2013 to exporting 19% by 2035. Oil accounts for over 60% of that reversal; the region becomes a net oil exporter in 2018. Regional net oil imports peaked in 2005 above 10 Mb/d; by 2035 net exports exceed 6.5 Mb/d.
- The region also becomes a net natural gas exporter and significantly increases coal exports.

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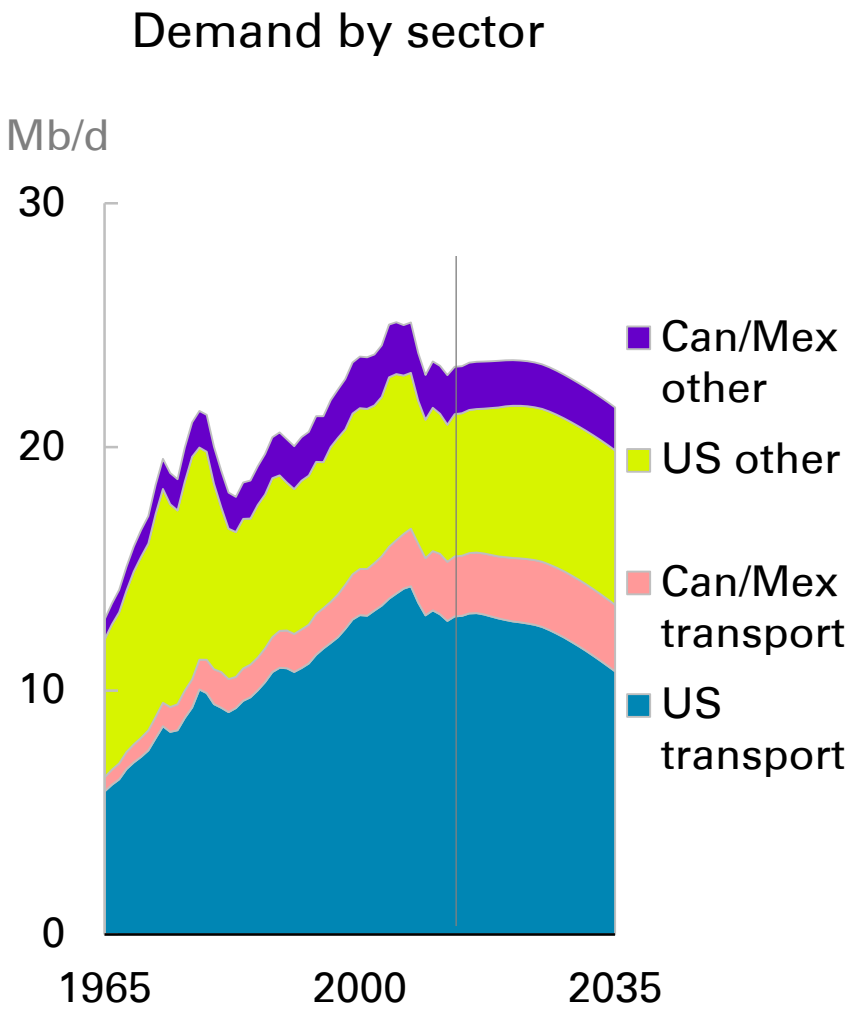
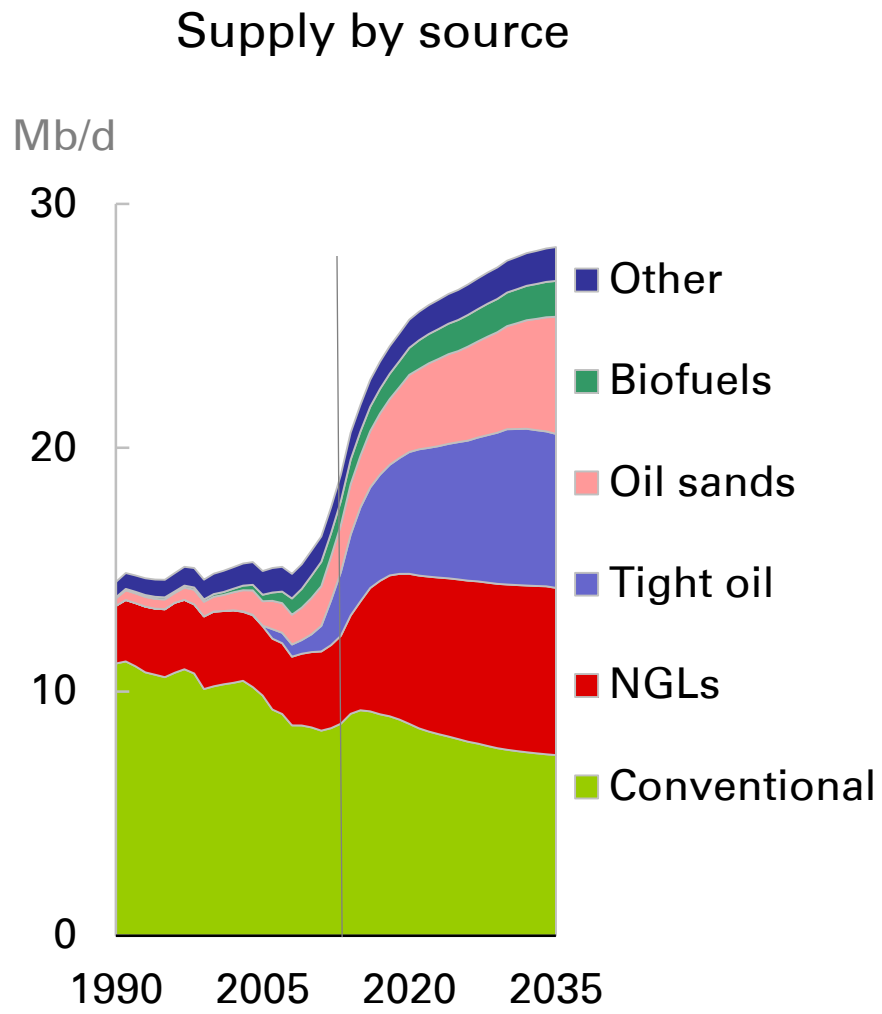
Falling US transport demand and rising unconventionals…





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…are shifting the North American oil balance

- Liquids consumption is likely to decline by around 2 Mb/d by 2035 to 22 Mb/d, the lowest level since 1995. Declines in US transport account for nearly 70% of the decline in demand.
- By sector, transport accounts for 63% of total North American liquids demand in 2035, down from 67% in 2013. Consumption in the transport sector slowly declines over the Outlook due to efficiency improvements and a modest displacement by natural gas and biofuels. Industry has the fastest growth rate (0.5% p.a.) driven by petrochemicals (see pages 31-32).
- 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 (4 Mb/d), NGLs (3 Mb/d), and oil sands (3 Mb/d). The US (6 Mb/d) and Canada (3 Mb/d) drive non-OPEC production growth. Overall, North American liquids supply increases by 49% by 2035.

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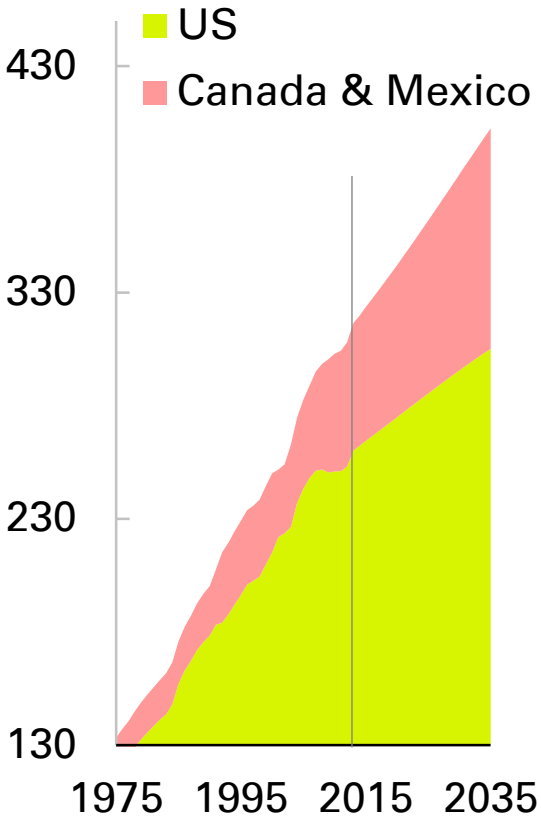
Vehicle numbers are likely to continue growing…

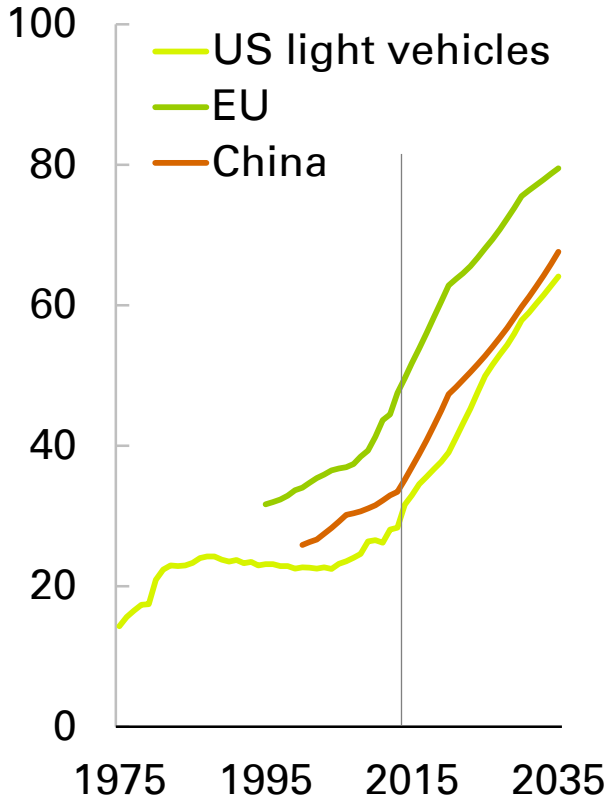
Vehicle fleet

Millions of vehicles



Fuel economy of new cars

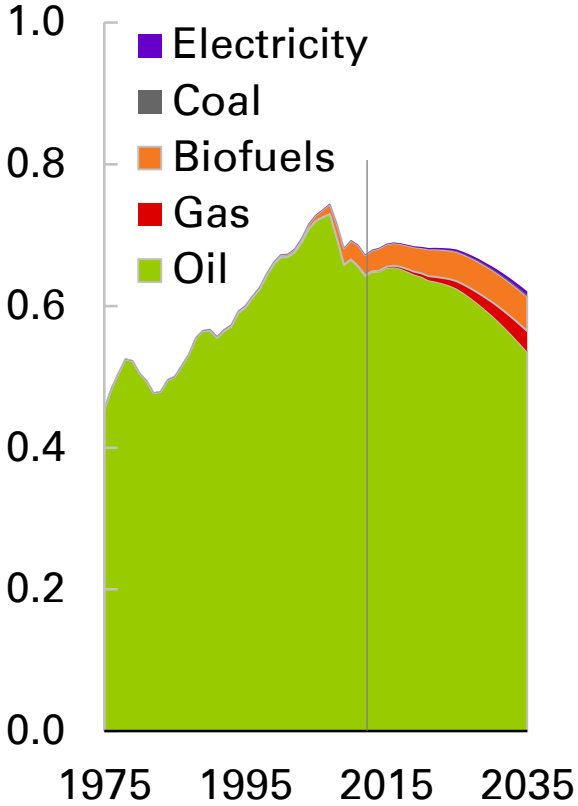
Miles per gallon*



*New European Driving Cycle

Transport demand

Billion toe



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…but efficiency improvements lead to falling transport demand

- The North American vehicle fleet (commercial vehicles and passenger cars) grows by 27% by 2035 to over 400 million, 17% of the global vehicle fleet.
- Fuel economy has improved in recent years, driven by consumer choice, tightening policy (e.g. CAFE standards in the US and CO_2 emissions limits in Europe), and improved technology. Efficiency gains are likely to accelerate over the Outlook, with US light vehicle fuel economy forecast to improve by 3.8% p.a. between 2013 and 2035, having improved by about 2.3% p.a. over the past decade.
- These efficiency gains reduce transport fuel demand, which falls by 9% despite a growing North American vehicle fleet.
- Transport fuel demand continues to be dominated by oil (87% in 2035), but the share of non-oil alternatives increases from 5% in 2013 to 13% in 2035, with natural gas the fastest growing transport fuel (16.4% p.a.). Biofuels remain the 2nd-largest fuel in transport, gaining market share from 4% today to 8% in 2035, growing 2.3% p.a..

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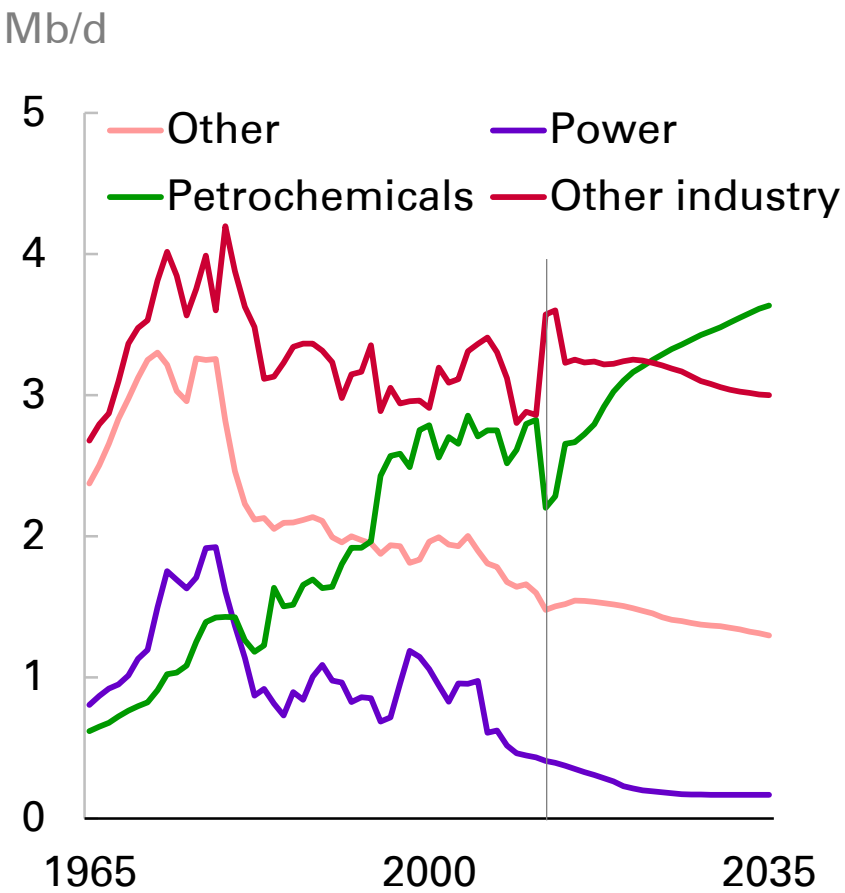
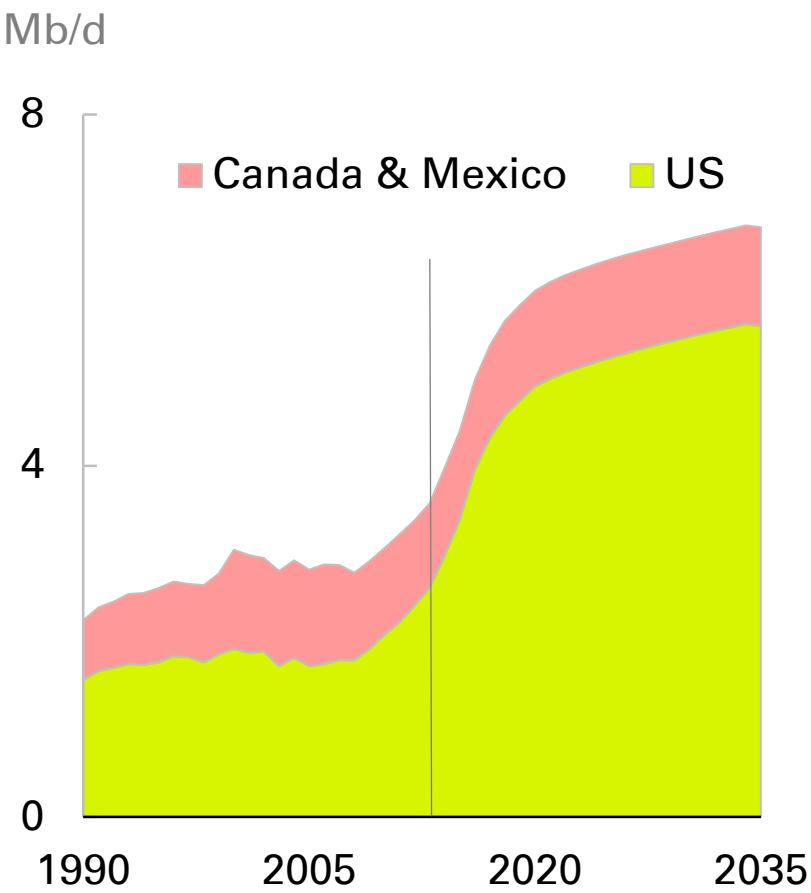
Petrochemicals are the other key driver of oil demand…

Oil demand outside of transport



NGLs production by region



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... aided by strong growth in US NGL supplies

- Since the oil price shocks of the 1970s, the use of oil outside of transport has been concentrated in petrochemicals, where there is limited scope for substitution by cheaper fuels.
- North American oil demand in petrochemicals increases by 2.1% p.a. (1.4 Mb/d) between 2013 and 2035 because there are limited alternatives and little scope for efficiency gains. This is reinforced by strong growth in domestic 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); US growth is strongest in the next decade, prompting robust growth in petrochemicals demand in the US.
- Petrochemicals is the only sector where demand for oil is expected to increase over the Outlook.

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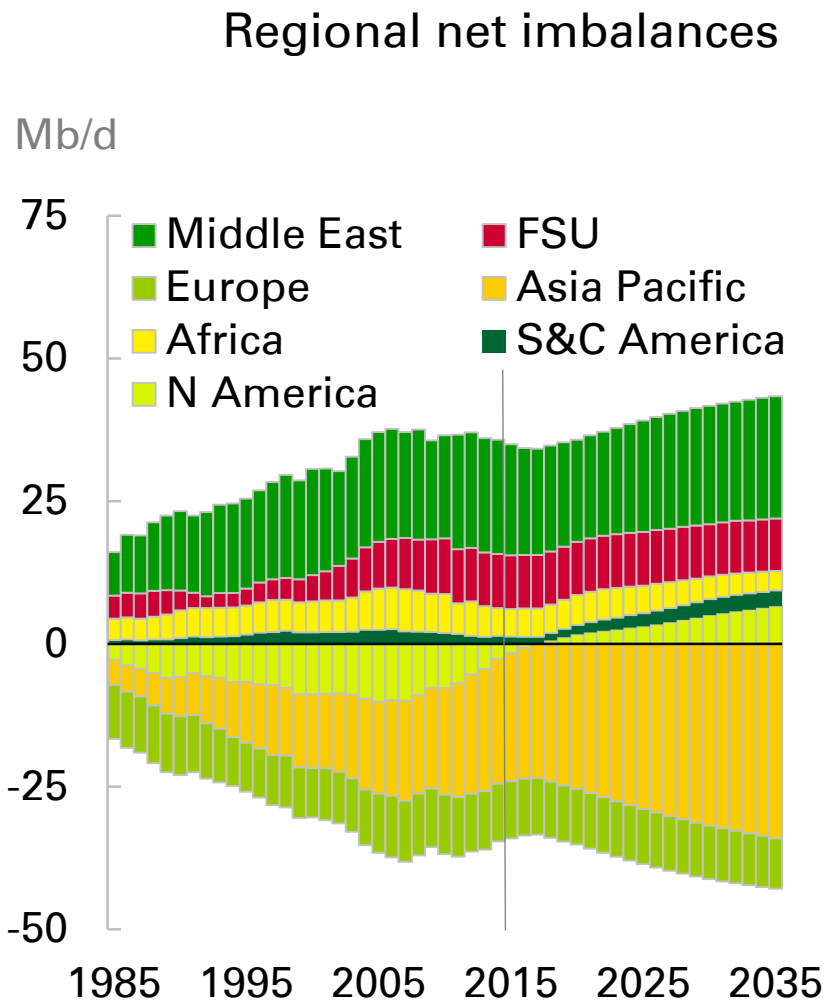
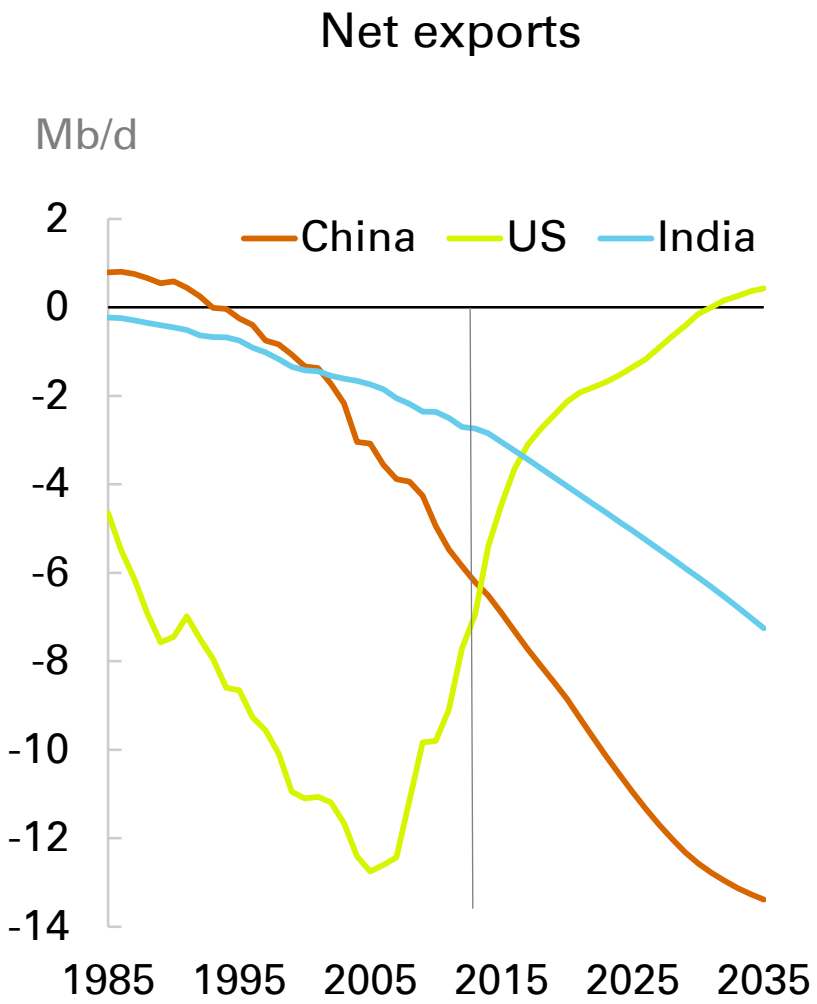
Oil trade patterns change as Asia's imports grow…





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…and the US becomes self-sufficient by the end of the Outlook

- Regional trade imbalances increase and become more concentrated. In particular, Asia accounts 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.

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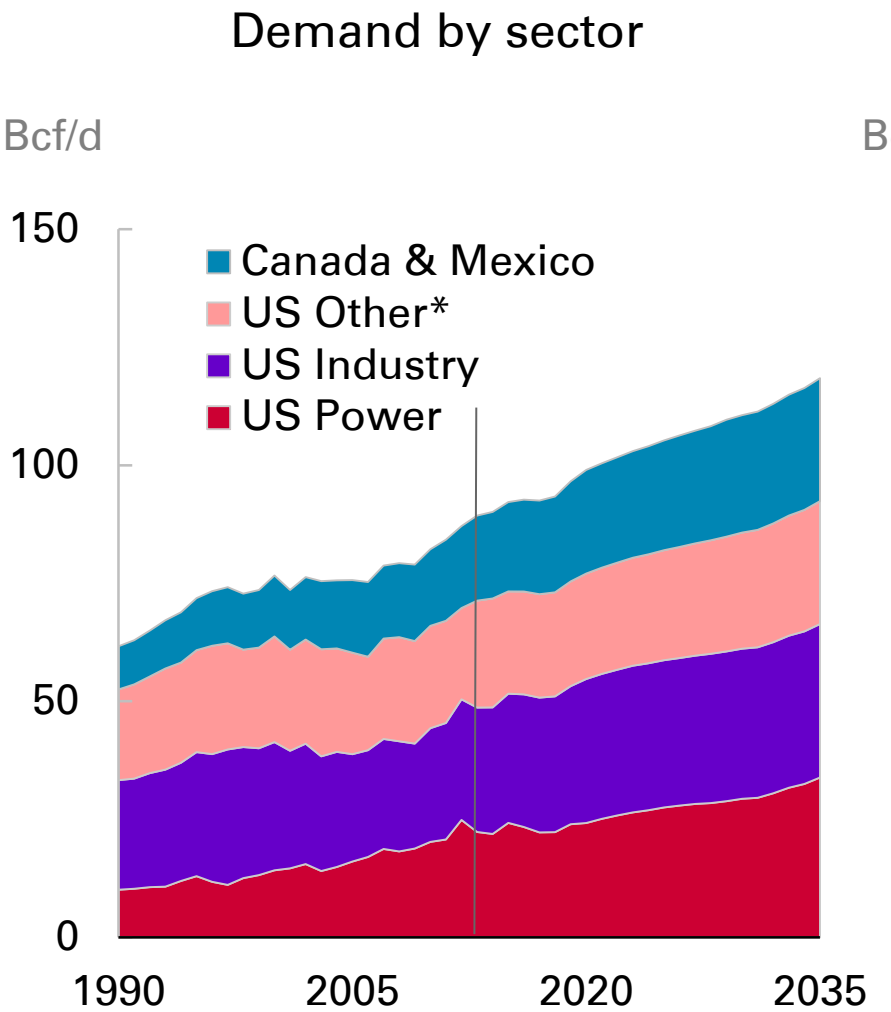
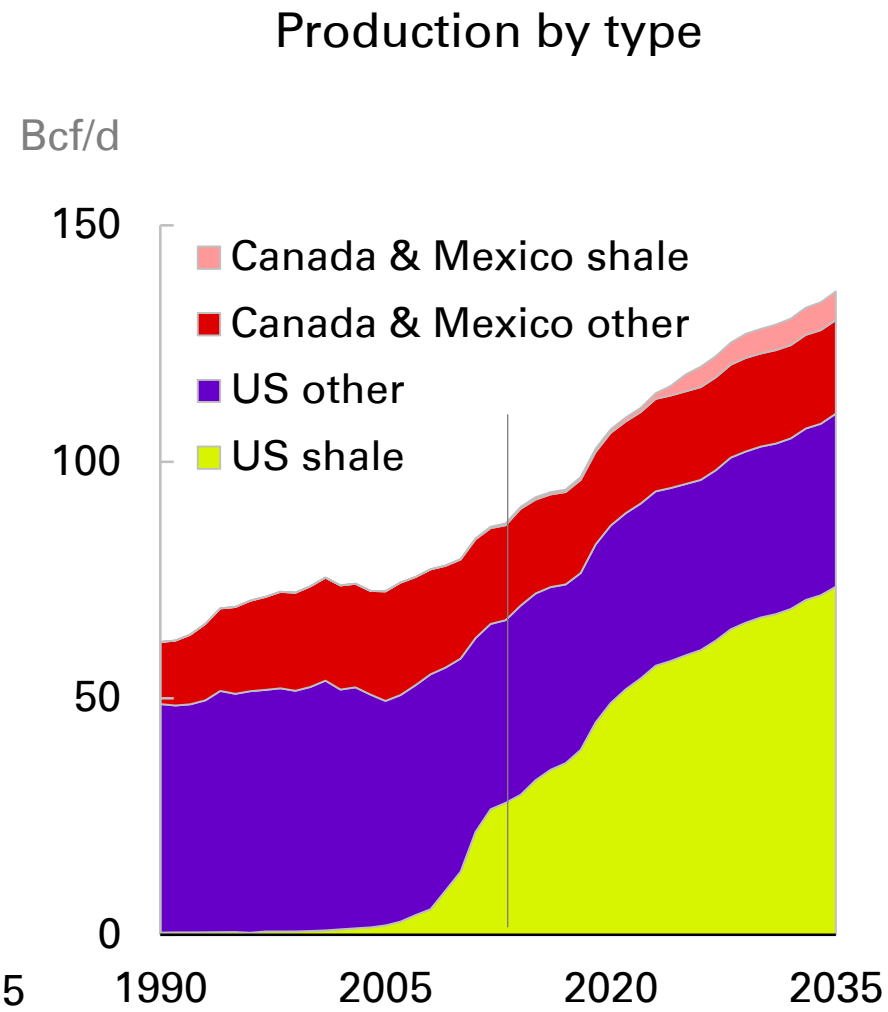
Natural gas demand expands across North America…





*Includes transport

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…while shale gas, especially in the US, drives supply growth

- North American natural gas demand is expected to grow by 1.3% p.a. over the Outlook, reaching 118 Bcf/d by 2035. US growth is expected in all sectors: power generation (12 Bcf/d), industry (6 Bcf/d), transport (3 Bcf/d), and "other" (0.5 Bcf/d). Demand in Canada & Mexico increases by 8 Bcf/d, driven mostly by power generation and industry.
- In North America, natural gas (and renewables) displace coal in power generation. Gas use in power generation expands by 59% and reaches a 33% market share by 2035, compared to 22% today. Gas in industry expands by 26% and by 2035 has a 46% market share in that sector. Gas in transport reaches a 5% market share in 2035.
- Shale gas production continues to grow strongly in the US (48 Bcf/d); later in the Outlook shale gas production grows in Canada & Mexico (6 Bcf/d). Growth in shale gas offsets declines in regional conventional supplies (-5 Bcf/d). The US remains the largest producer of natural gas in the world, accounting for 23% of production in 2035. Shale gas supplies account for nearly 60% of regional output by 2035.

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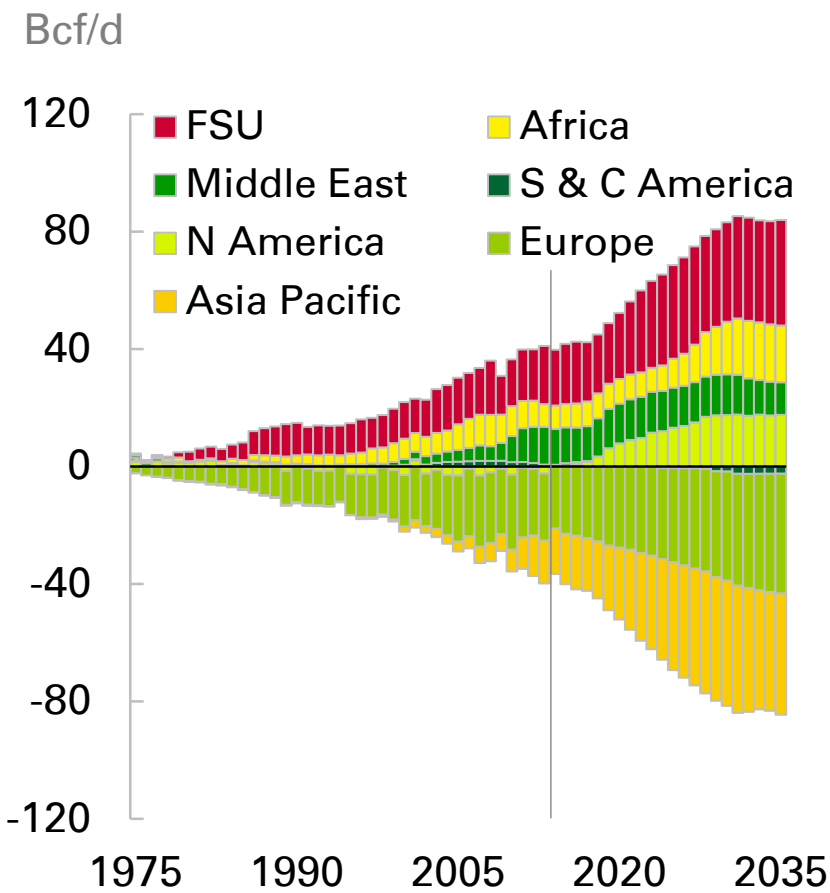
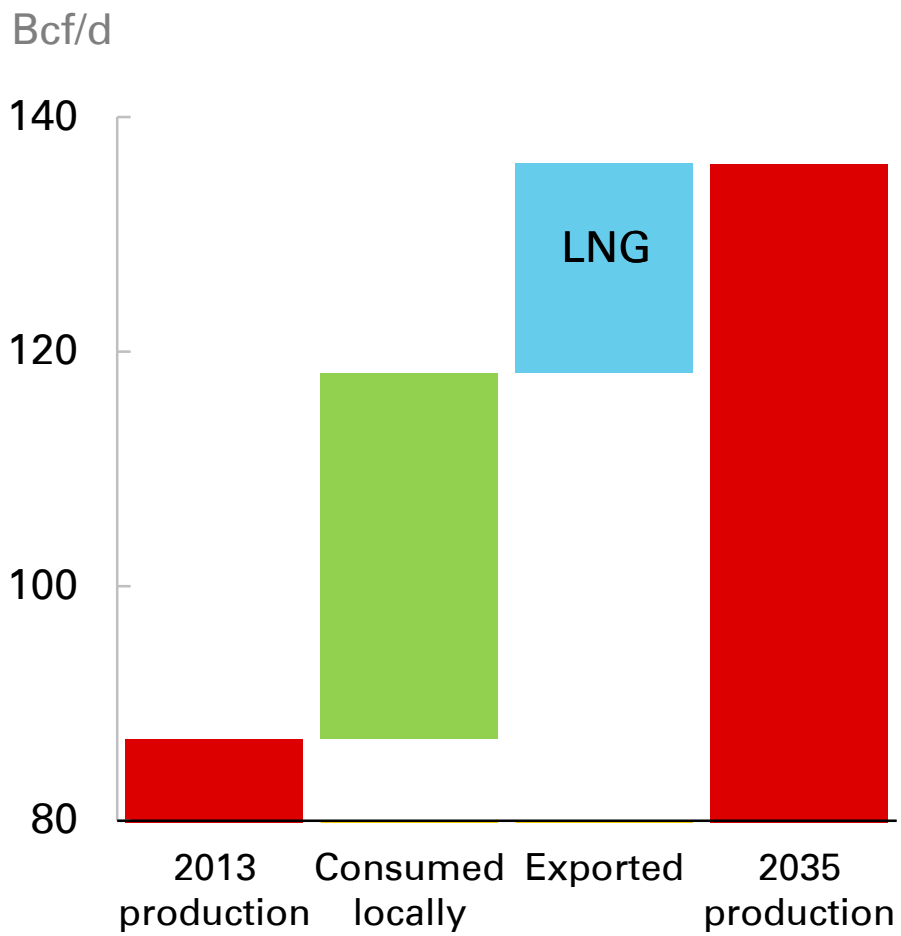
North America to become a key exporter…

Regional net imbalances



Production and trade growth



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…with expansion of LNG

- Global 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.
- North America switches to being a net exporter in 2019 and net exports reach 16 Bcf/d by 2035. In particular, the US, supported by 164% growth in shale gas production becomes a net natural gas exporter in 2017 and exports nearly 18 Bcf/d by 2035.
- The US becomes a net LNG exporter in 2016 and exports reach 14 Bcf/d by 2035. The US also becomes a net pipeline exporter in 2019 with net exports of about 4 Bcf/d.
- The expansion of global trade is driven by Asia Pacific imports, which 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.

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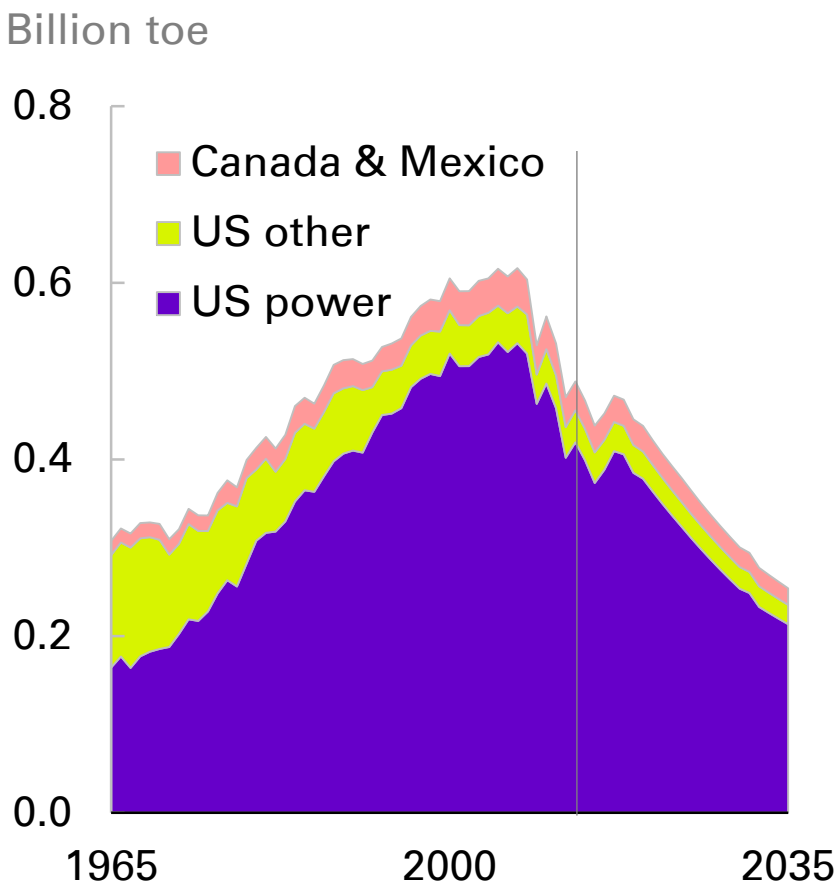
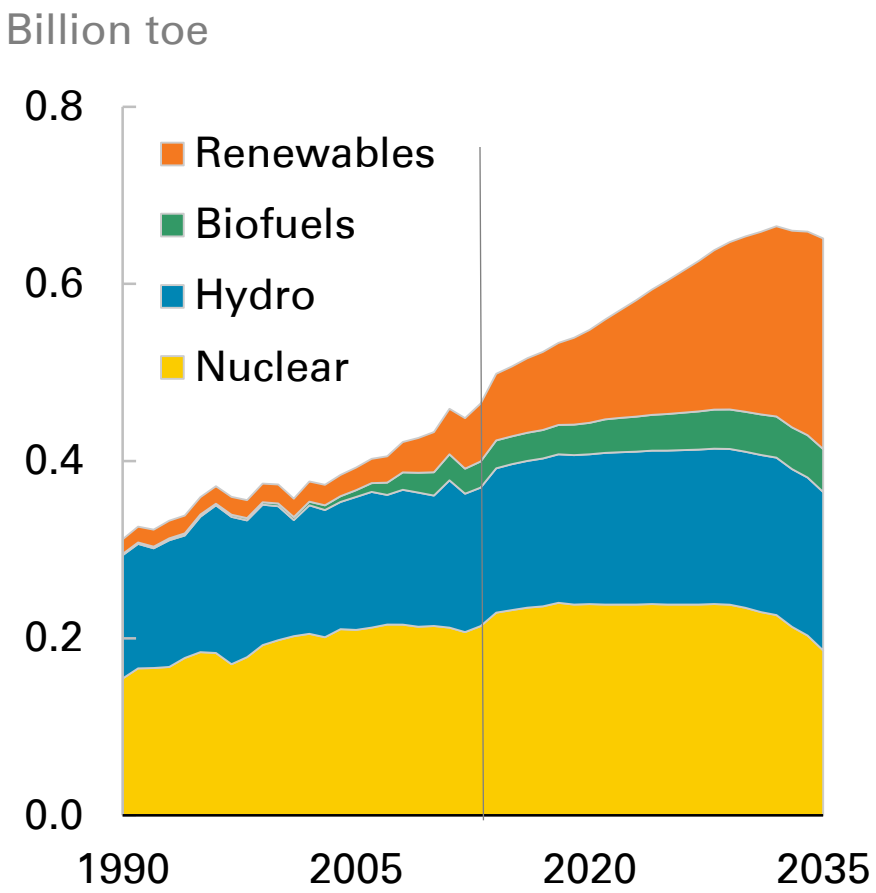
Coal consumption continues to decline in North America…

Consumption by sector



Non-fossil fuel demand



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…as does nuclear, while renewables and hydro expand

- North American coal consumption declines by 2.9% p.a. between 2013 and 2035, reaching its lowest level in our dataset. Coal demand is 48% lower in 2035 than it is today, despite an 8% increase in overall power demand (as natural gas and renewables gain market share).
- In the US, competitively-priced natural gas, rapidly growing renewables, and regulatory pressures on coal-fired power plants all limit coal's use. By 2026 natural gas overtakes coal as the dominant fuel in power generation and coal's market share declines from 39% today to 18% by 2035.
- Renewables (including biofuels) grow by 5.1% p.a. from 2013 to 2035 at the regional level, and by 5% and 6.3% in the US and Canada & Mexico, respectively. Renewables in power generation reach a 19% market share by 2035, while biofuels reach an 8% share in transport.
- Nuclear generation declines by 13% by 2035 (-12% in the US) due to plant retirements at the end of the Outlook, while hydro increases by 14% by 2035.

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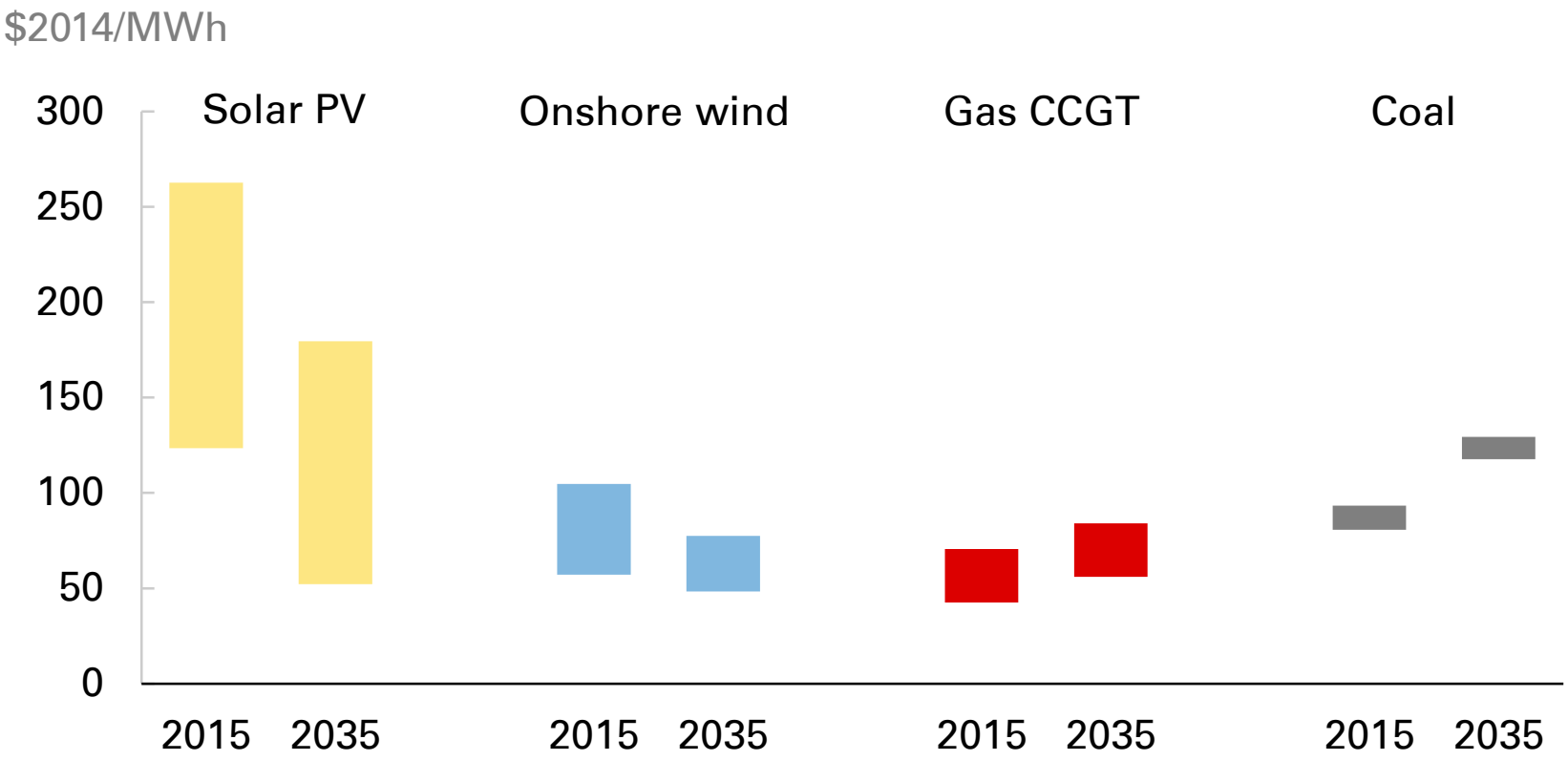
The falling cost of renewables…

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



* Levelized cost per MWh of building and operating a plant over its 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/metric ton.

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…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.

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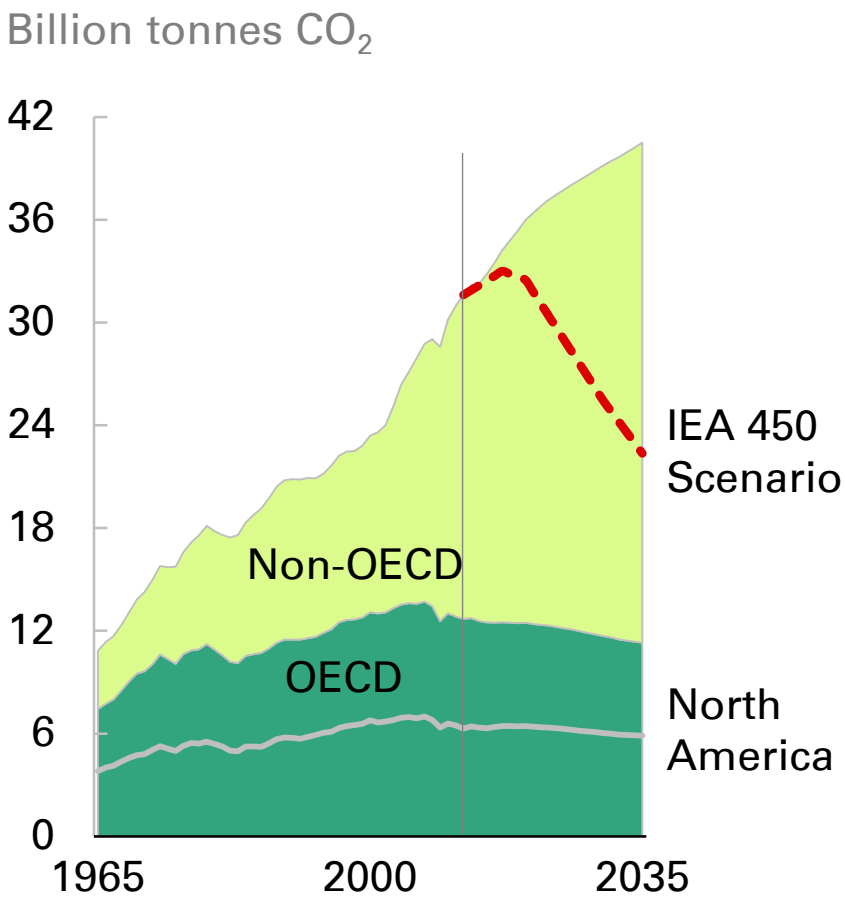
Global carbon emissions are rising too fast for comfort…

Emissions by region



Global 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.

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...which could trigger additional abatement policies

- Global CO_2 emissions from energy use grow by 25% (1% p.a.) over the Outlook. North American emissions decline by 9% (-0.4% p.a.) over the Outlook. Global emissions remain well above the path recommended by scientists, illustrated by the IEA's "450 Scenario". In 2035, global 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 global 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 and should not be interpreted as a set of recommendations. The options include those that: limit emissions from coal in the power sector; increase non-fossil fuel use; and improve energy efficiency.

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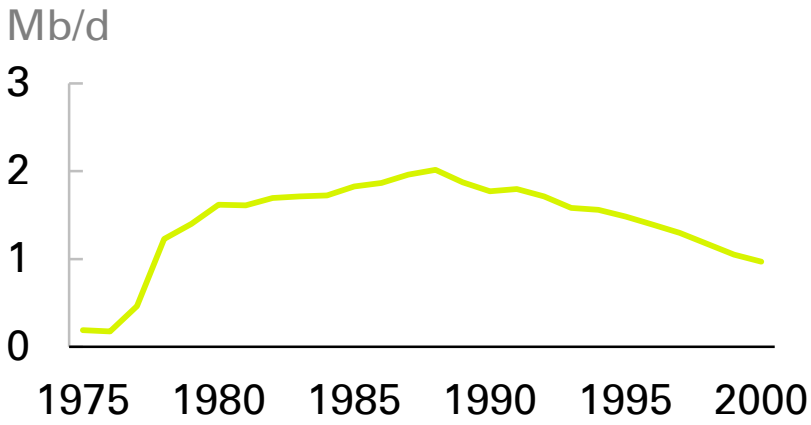
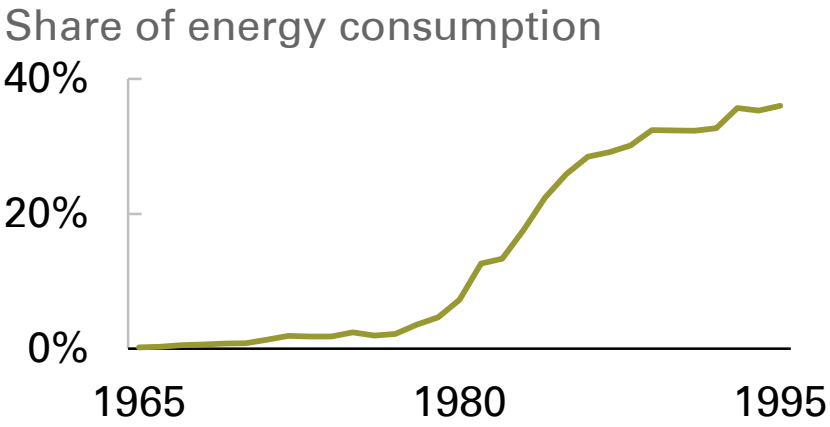
Heightened risk perceptions can have important implications…

Geopolitical risk

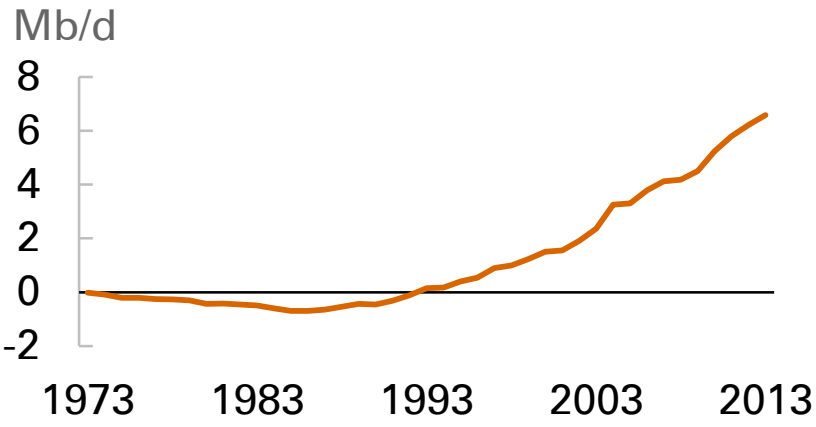
Alaska - oil production



France - nuclear power



China - oil imports



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…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.
- 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 approval of the Trans-Alaska pipeline in the US and the French decision to increase its dependence on nuclear energy (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.

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Conclusion

Continuous change is the norm for energy markets

- Changing energy mix
  - gas is the only fossil fuel to grow over the Outlook
  - continued rapid growth in renewables

- Changing energy trade patterns
  - North America becomes a net energy exporter
- Changing the carbon emissions path?
  - North American emissions fall, but...
  - ...global emissions grow
  - no silver bullet, let market pick the winners

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