

BP Energy Outlook 2035

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This presentation contains forward-looking statements, particularly those regarding global economic growth, population growth, energy consumption, policy support for renewable energies and sources of energy supply. Forward-looking statements involve risks and uncertainties because they relate to events, and depend on circumstances, that will or may occur in the future. Actual outcomes may differ depending on a variety of factors, including product supply, demand and pricing; political stability; general economic conditions; legal and regulatory developments; availability of new technologies; natural disasters and adverse weather conditions; wars and acts of terrorism or sabotage; and other factors discussed elsewhere in this presentation.



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Welcome to the 2014 edition of *BP's Energy Outlook*.



Published for the 4th time, the annual Energy Outlook reflects our best effort to describe a “most likely” trajectory of the global energy system, based on our views of likely economic and population growth, as well as developments in policy and technology. The *Outlook*, like its sister publication, the *Statistical Review of World Energy*, is the result of intensive analysis by our Economics Team; both documents have deservedly become standard references for those with an interest in energy.

Of course the future is uncertain: the numbers that make up this *Outlook* are less important than the long-term trends, the possible forks in the road ahead, and the choices they pose for decision makers in government and business.

This edition of the *Outlook* raises three big questions: Will the world have sufficient energy to fuel continued economic growth? Will that energy be secure? And will it be sustainable?

On the first question, our answer is a resounding “Yes!” We project that global energy consumption will rise by 41% by 2035, with 95% of that growth coming from rapidly-growing emerging economies. That growth rate is slower than what we have seen in previous decades, largely as a result of increasing energy efficiency. Trends in global technology, investment and policy leave us confident that production will be able to keep pace. New energy forms such as shale gas, tight oil, and renewables will account for a significant share of the growth in global supply. Energy efficiency promises to improve unabatedly, driven by globalization and competition.

On the question of security, our *Outlook* offers a mixed, though broadly positive, view. Among today's energy importers, the United States is on a path to achieve energy self-sufficiency, while import dependence in Europe, China and India will increase. Asia will become the dominant energy importing region. Russia will remain the leading energy exporter, and Africa will become an increasingly important supplier. While it will remain a key energy player, the Middle East is likely to see relatively static exports.

And on the question of sustainability, we project that global carbon dioxide emissions will rise by 29%, with all of the growth coming from the emerging economies. There are some positive developments: emissions growth will slow as natural gas and renewables gain market share from coal and oil. And emissions are expected to decline in Europe and the US. But we could do better.

This year, we extend the outlook to 2035 – far enough to see some key turning points: India is likely to surpass China as the largest source of energy demand growth; renewable energy will no longer be a minor player, surpassing nuclear energy; and OECD countries will have started to “crack the code” of sustaining economic growth while reducing energy demand.

Once again, the *Outlook* highlights the power of competition and market forces in unlocking technology and innovation to meet the world's energy needs. These factors make us optimistic for the world's energy future, and they suggest a way forward in mastering challenges such as security and sustainability.

I hope you find the *BP Energy Outlook* a useful addition to the global energy discussion.

Bob Dudley
Group Chief Executive



Note on method and assumptions

- This edition updates our view of the likely path of global energy markets and extends it to 2035. The underlying methodology remains unchanged – we make assumptions on changes in policy, technology and the economy, based on extensive internal and external consultations, using a range of analytical tools to build a single “most likely” view.
- We focus on these “most likely” numbers, to provide a basis for discussion. Of course the future is uncertain, and in the process of building the Outlook we explore the impact of alternative assumptions. While we do touch on some of the key uncertainties, the treatment of energy market risks here is by no means exhaustive.
- Unless noted otherwise, data definitions are based on the *BP Statistical Review of World Energy*, and historical energy data through 2012 is consistent with the 2013 edition of the *Review*. Gross Domestic Product (GDP) is expressed in real Purchasing Power Parity (PPP) terms and rescaled from 2005 to 2012 prices using a simple across-the-board increase for exposition purposes. All data sources are listed on page 96.

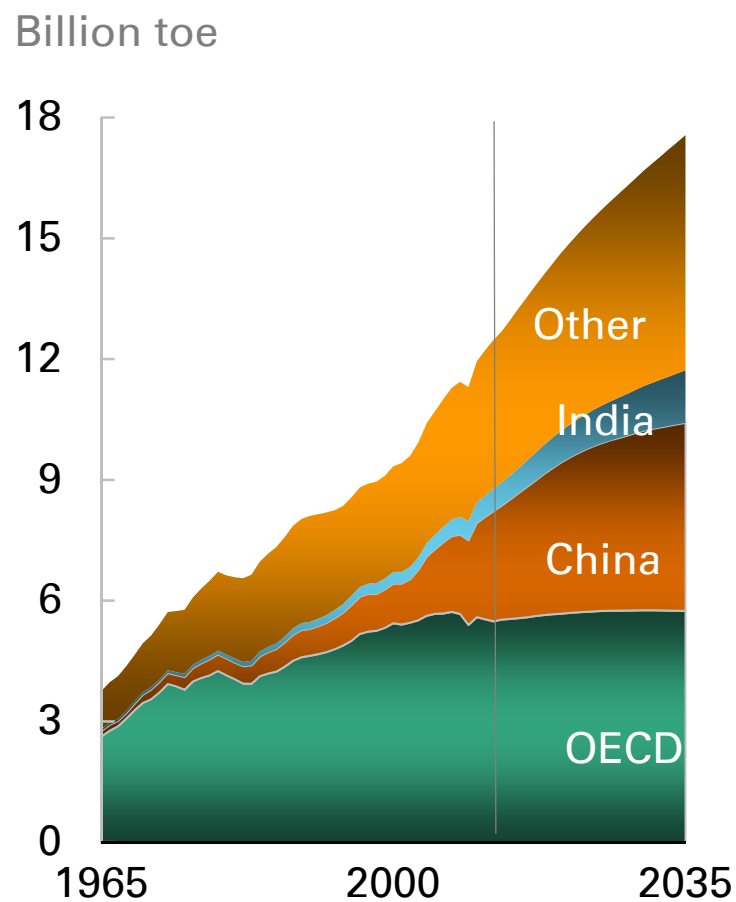


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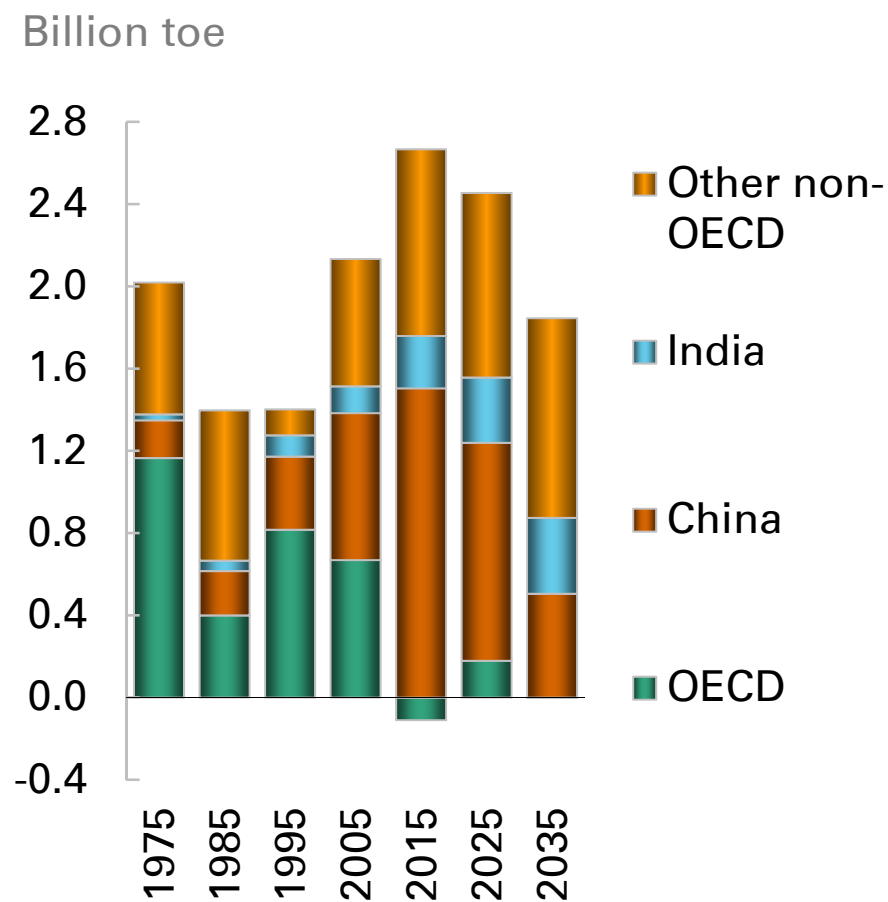


Primary energy consumption growth slows...

Consumption by region



Ten year increments by region





...and the growth is almost all in the non-OECD

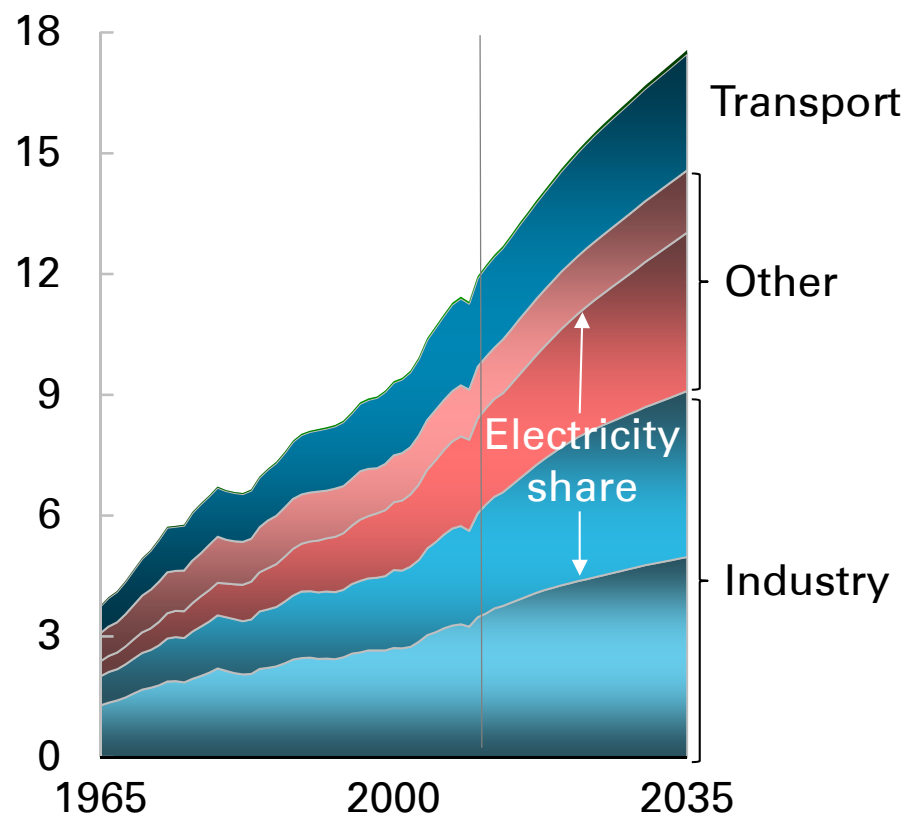
- Primary energy demand increases by 41% between 2012 and 2035, with growth averaging 1.5% per annum (p.a.). Growth slows, from 2.2% p.a. for 2005-15, to 1.7% p.a. 2015-25 and just 1.1% p.a. in the final decade.
 - We are leaving a phase of very high energy consumption growth, driven by the industrialization and electrification of non-OECD economies, notably China. The 2002-2012 decade recorded the largest ever growth of energy consumption in volume terms over any ten year period, and this is unlikely to be surpassed in our timeframe.
 - There is a clear long-run shift in energy growth from the OECD to the non-OECD. Virtually all (95%) of the projected growth is in the non-OECD, with energy consumption growing at 2.3% p.a. 2012-35. OECD energy consumption, by contrast, grows at just 0.2% p.a. over the whole period and is actually falling from 2030 onwards.
 - China has emerged as the key growth contributor, but by the end of the forecast China's contribution is starting to fade. India's contribution grows, almost matching that of China in the final decade of the forecast.
-



The strong impetus from industrialization...

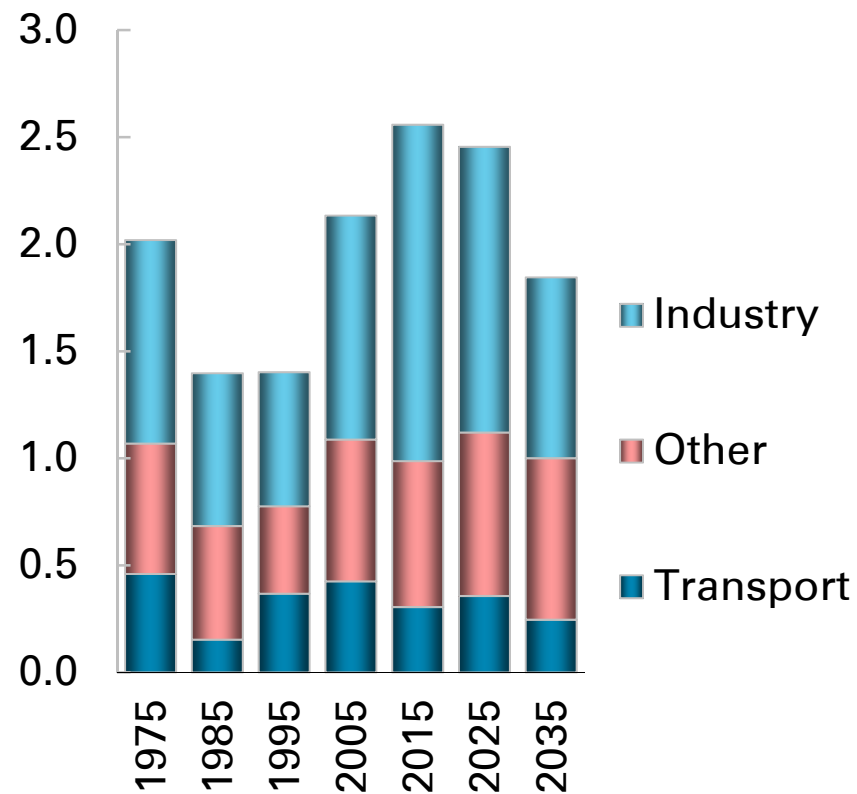
Consumption by sector

Billion toe



Ten year increments by sector

Billion toe





...starts to fade toward the end of the forecast

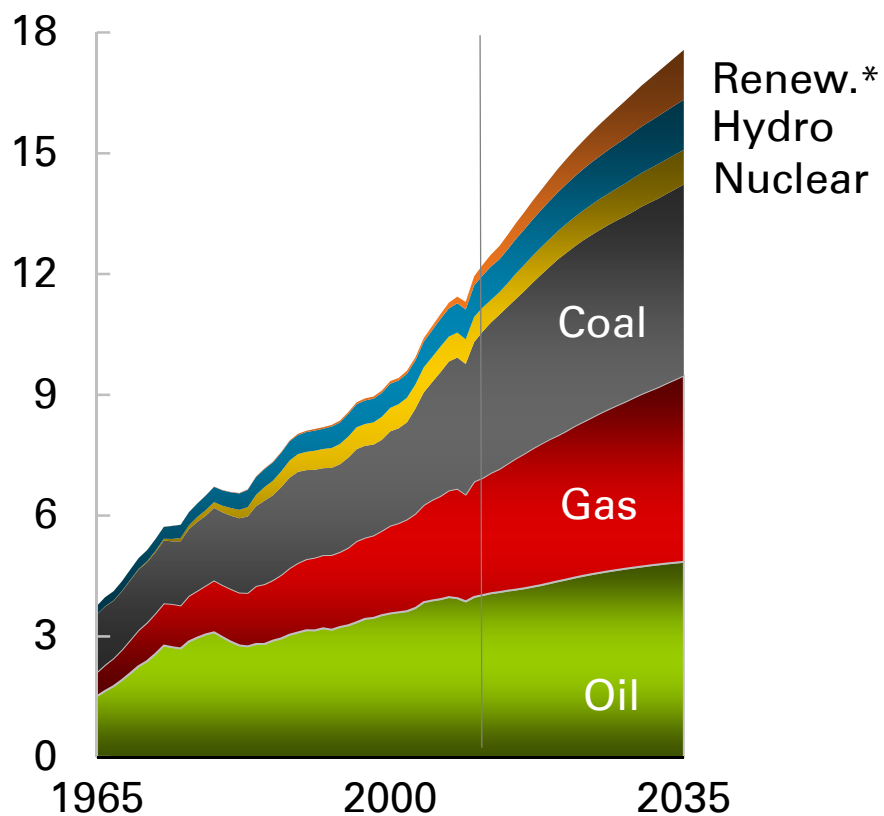
- By sector, industry remains the dominant source of growth for primary energy consumption, both directly and indirectly (in the form of electricity). Industry accounts for more than half of the growth of energy consumption 2012-35. This reflects the unprecedented pace and scale of industrialization in Asia. Energy for industry grows at 2.6% p.a. over the decade 2005-15, but this slows to just 1.0% p.a. in the final decade of the forecast as China's rapid industrialization comes to an end.
- The next major component of growth is energy used in the 'other' sector (residential, services and agriculture), predominantly in the form of electricity. By the final decade, growth in other sector energy use almost matches industry in volume terms.
- The transport sector continues to play a relatively small role in primary energy growth throughout the forecast, growing steadily but accounting for just 13% of total growth during 2012-35.



The slowdown in China and industry...

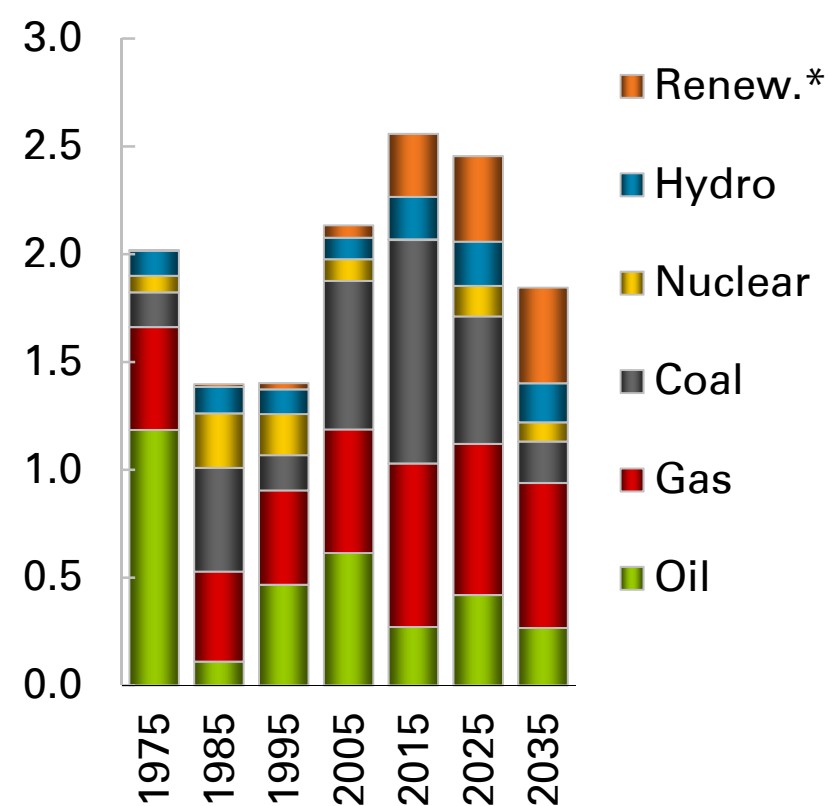
Consumption by fuel

Billion toe



Ten year increments by fuel

Billion toe



*Includes biofuels



...is reflected in a marked slowdown in coal growth

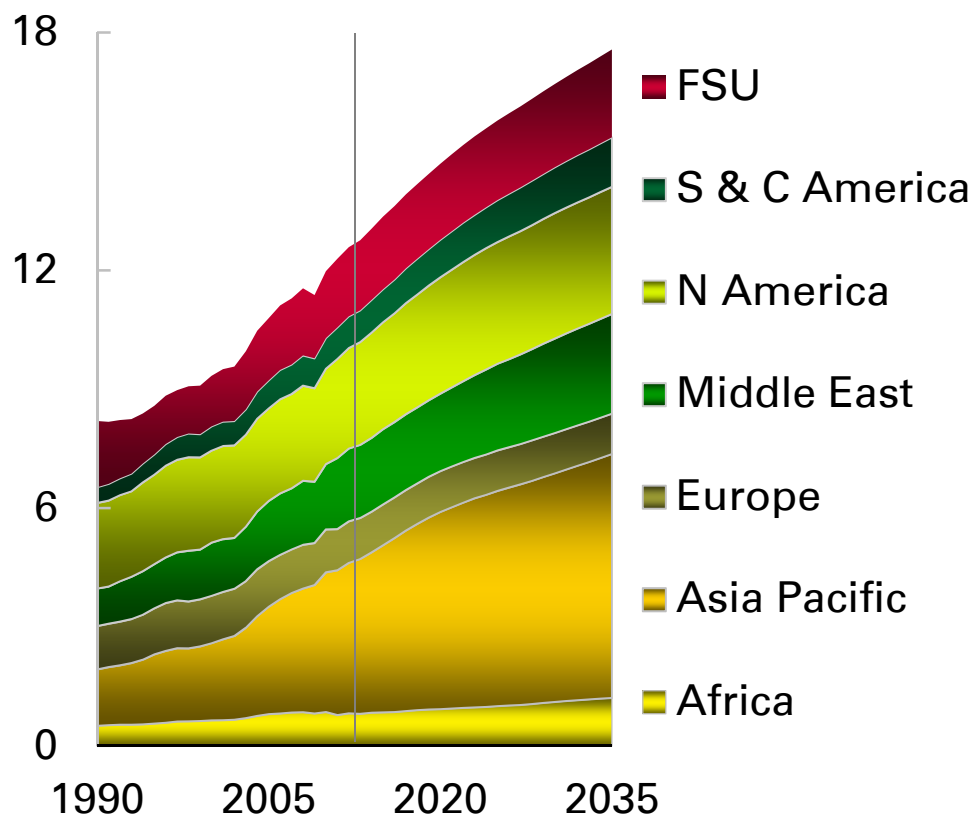
- All fuels show growth over the forecast period, with the fastest growth seen in renewables (6.4% p.a.). Nuclear (1.9% p.a.) and hydro-electric power (1.8% p.a.) both grow more rapidly than total energy.
- Among fossil fuels, gas is the fastest growing (1.9% p.a.) and the only one to grow more rapidly than total energy. Oil (0.8% p.a.) shows the slowest growth, with coal (1.1% p.a.) only slightly ahead.
- Coal's contribution to growth diminishes rapidly. It is currently the largest source of volume growth, but by the final decade coal adds less volume than oil and is only just ahead of hydro. Again, this reflects the shift away from coal-intensive industrialization in China.
- In that final decade, gas is the largest single contributor to growth; but non-fossil fuels in aggregate contribute even more than gas, accounting for 39% of the growth in energy in that period.



New sources help to supply sufficient energy...

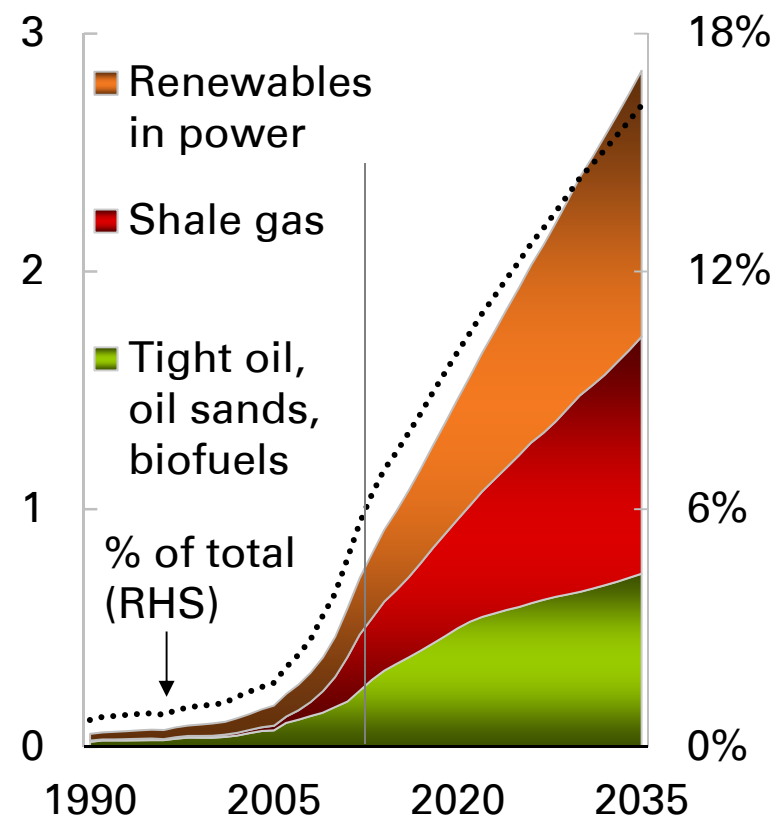
Primary energy production

Billion toe



New energy forms

Billion toe





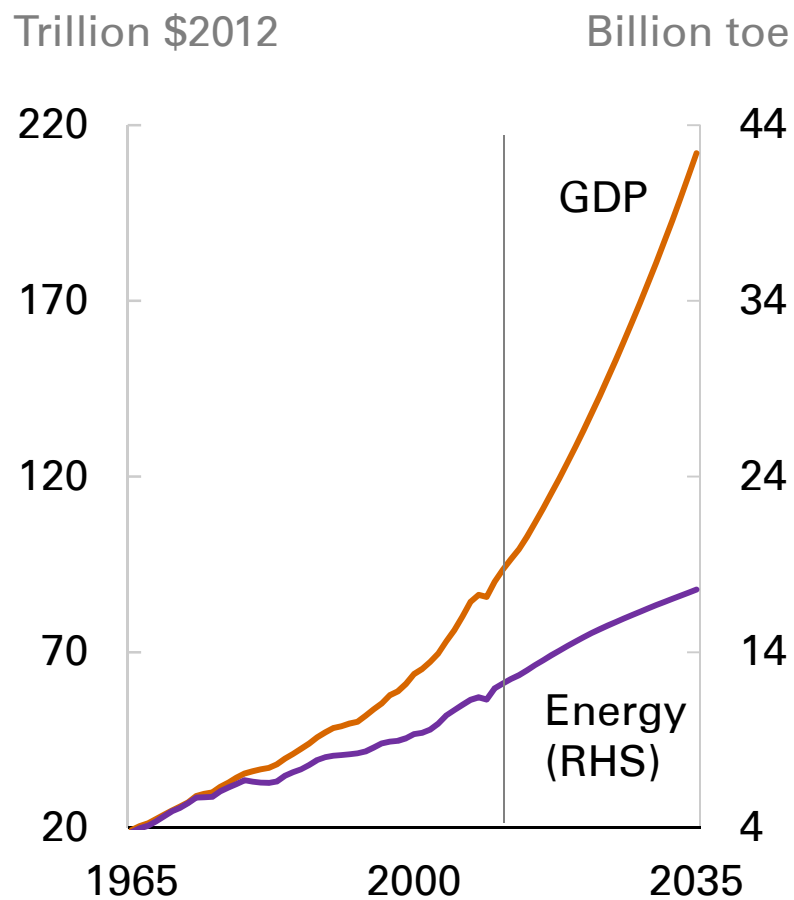
...to meet demand growth

- World primary energy production grows at 1.5% p.a. from 2012 to 2035, matching consumption growth. Growth is concentrated in the non-OECD, which accounts for almost 80% of the volume increment.
 - There is growth in all regions except Europe. Asia Pacific shows both the fastest rate of growth (2.1% p.a.) and the largest increment, providing 47% of the increase in global energy production. The Middle East and North America are the next largest sources of growth, and North America remains the second largest regional energy producer.
 - There is expansion across all types of energy, with new energy forms playing an increasingly significant role. Renewables, shale gas, tight oil and other new fuel sources in aggregate grow at 6.2% p.a. and contribute 43% of the increment in energy production to 2035.
 - The growth of new energy forms is enabled by the development of technology and underpinned by large-scale investments. Our Outlook assumes that the right competitive and policy conditions are in place to support that investment and technical progress.
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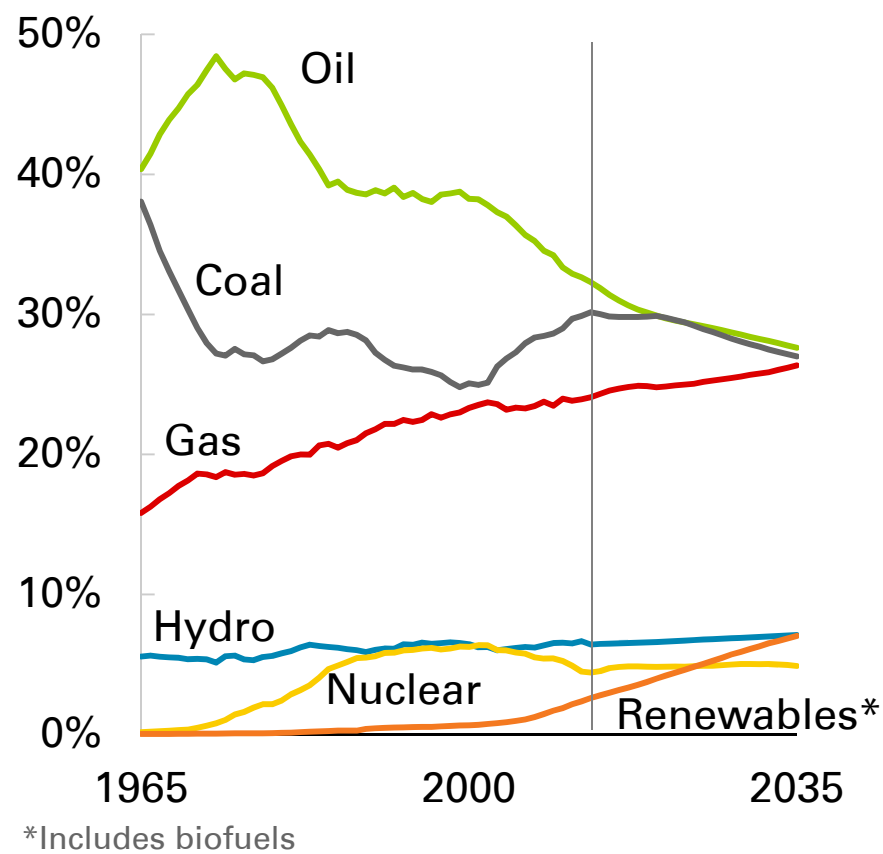


Energy is gradually decoupling from economic growth...

GDP and energy



Shares of primary energy





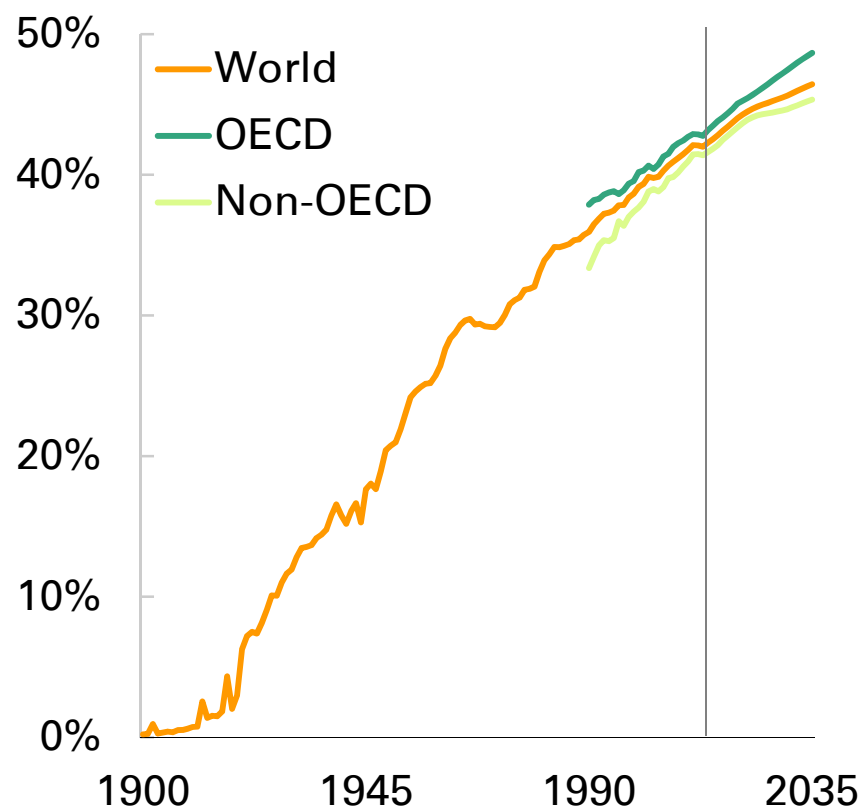
...and the fuel mix is slowly shifting away from fossil fuels

- Energy consumption grows less rapidly than the global economy, with GDP growth averaging 3.5% p.a. 2012-35. As a result energy intensity, the amount of energy required per unit of GDP, declines by 36% (1.9% p.a.) between 2012 and 2035. The decline in energy intensity accelerates; the expected rate of decline post 2020 is more than double the decline rate achieved 2000-2010.
- Fuel shares evolve slowly. Oil's share continues to decline, its position as the leading fuel briefly challenged by coal. Gas gains share steadily. By 2035 all the fossil fuel shares are clustering around 27%, and for the first time since the Industrial Revolution there is no single dominant fuel. Taken together, fossil fuels lose share but they are still the dominant form of energy in 2035 with a share of 81%, compared to 86% in 2012.
- Among non-fossil fuels, renewables (including biofuels) gain share rapidly, from around 2% today to 7% by 2035, while hydro and nuclear remain fairly flat. Renewables overtake nuclear in 2025, and by 2035 they match hydro.

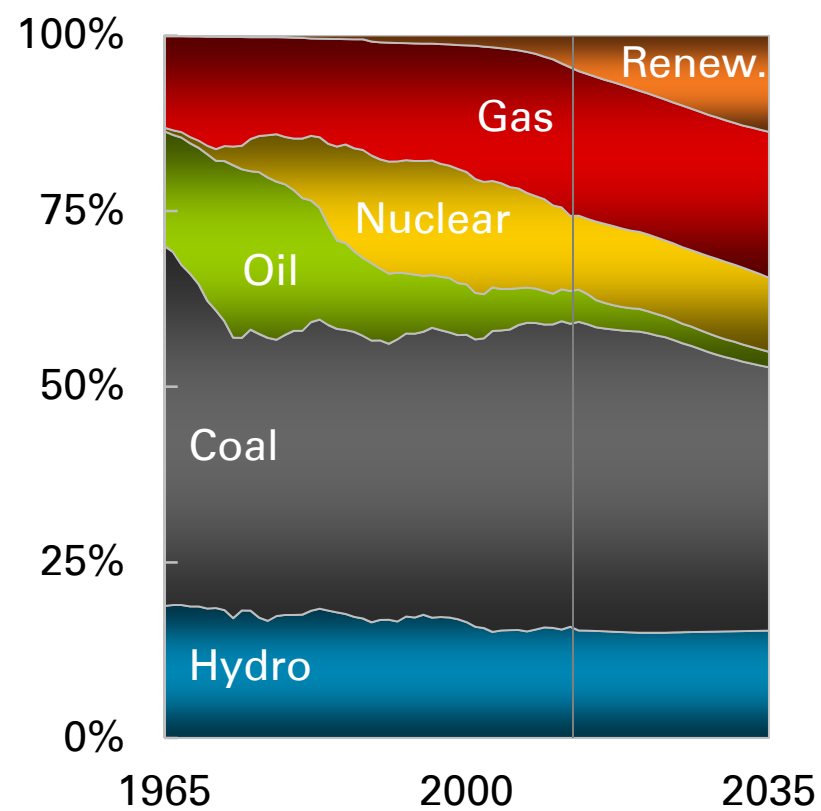


The power sector takes an increasing share of energy...

Inputs to power as a share of total primary energy



Primary inputs to power





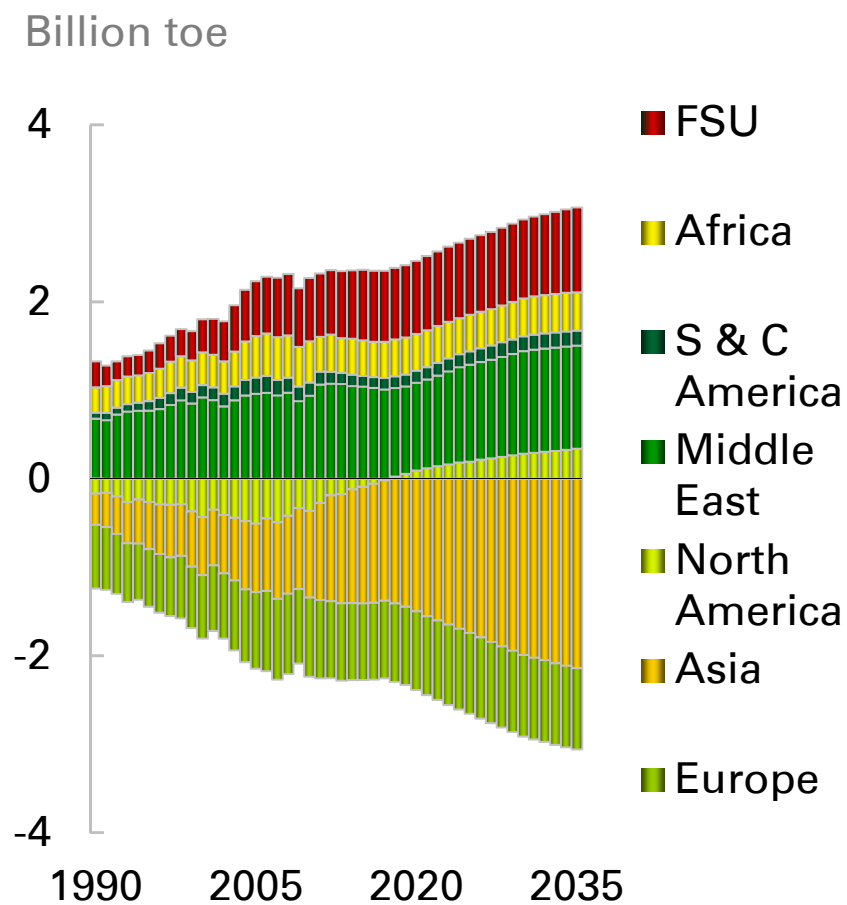
...and plays a key role in shaping the fuel mix

- One of the longest established trends in energy is the increasing role of the power sector. The share of primary energy devoted to power generation rises in industrializing as well as in mature economies, where growth is dominated by the service sector.
- In 2012, 42% of primary energy was converted into electricity in the power sector, up from 30% in 1965. By 2035 that share will rise to 46%. Fuels for power generation account for 57% of the growth in primary energy consumption 2012-35. And the power sector is the one place where all the fuels compete.
- At the global level coal remains the largest source of power through 2035, although in the OECD coal is overtaken by gas. Carbon-free sources (renewables, hydro and nuclear) increase their combined share of power generation from 32% in 2012 to 37% by 2035. Renewables overtake nuclear as a source of power generation in 2028, increasing their share of power generation from 5% today to 13% in 2035, and showing little sign of approaching any limit to their market share.

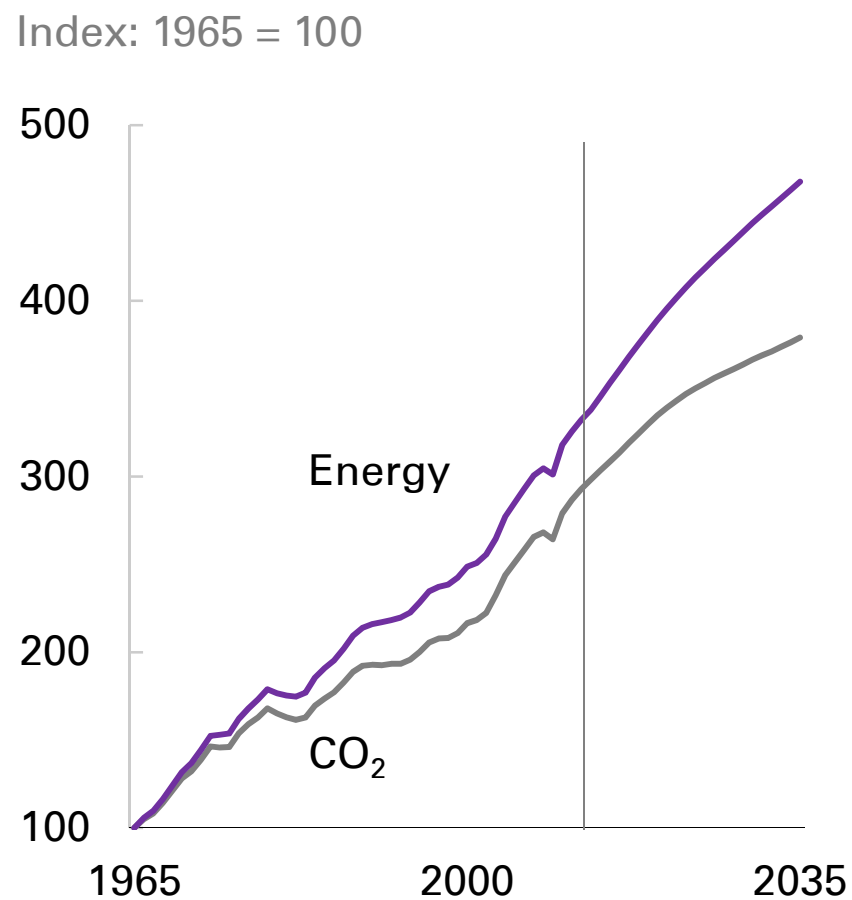


The security and sustainability of energy supply...

Primary energy net balances



Energy and CO₂ emissions





...continue to pose significant challenges

- Regional energy imbalances – production minus consumption for each region – suggest that trading relationships will change significantly by 2035. North America switches from being a net importer of energy to a net exporter around 2018. Meanwhile, Asia’s need for imported energy continues to expand; by 2035 Asia accounts for 70% of inter-regional net imports – and nearly all of the growth in trade.
- Among exporting regions, the Middle East remains the largest net regional energy exporter, but its share falls from 46% in 2012 to 38% in 2035. Russia remains the world’s largest energy exporting country. Energy security is a theme that will run through the fuel-by-fuel projections described later in this Outlook.
- The biggest challenge in terms of sustainability remains the level of carbon emissions, which continue to grow (1.1% p.a.) – slightly slower than energy consumption, but faster than recommended by the scientific community. We will also address this challenge in more detail later.

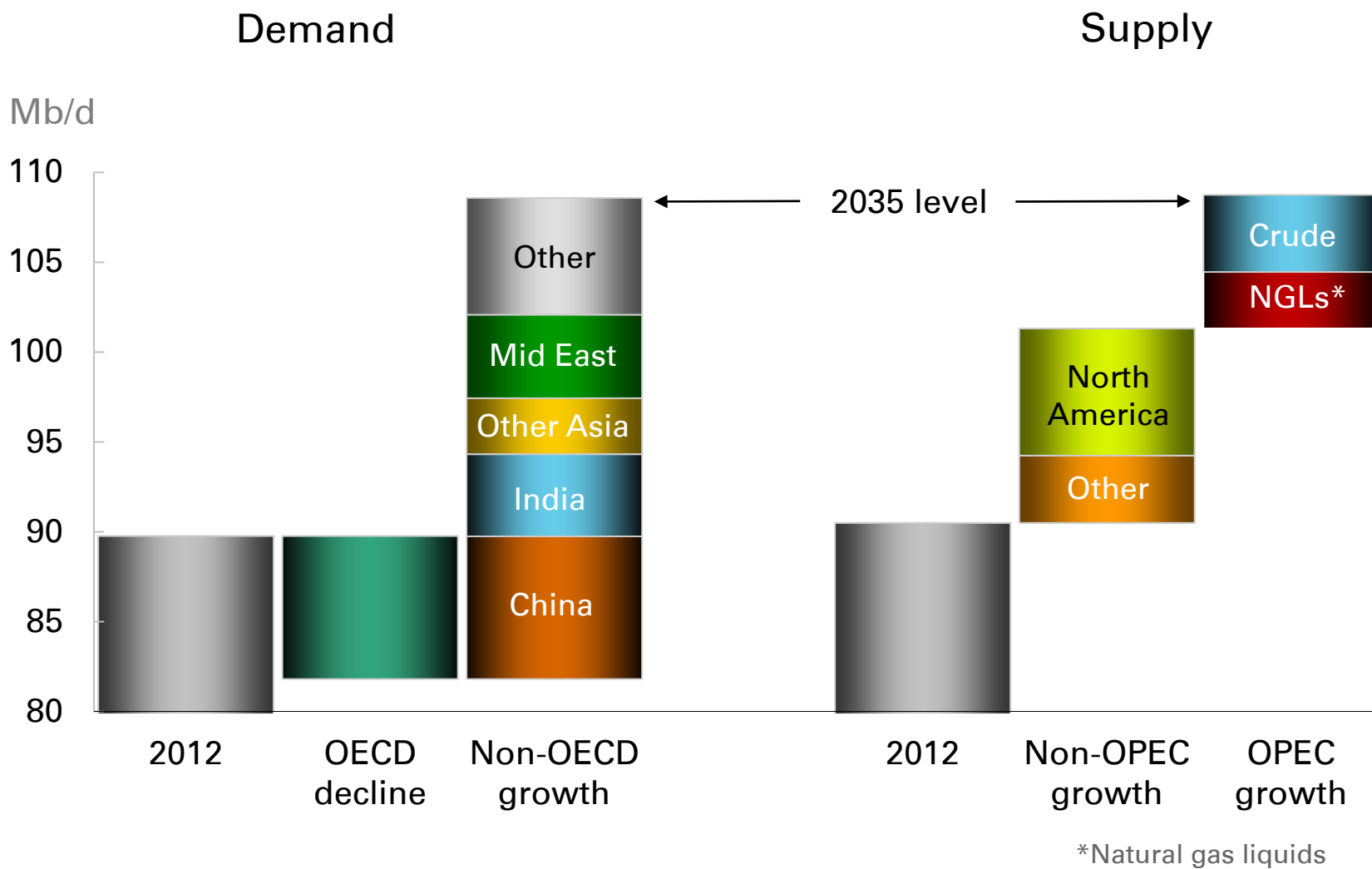




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The global liquids balance reflects shifts...





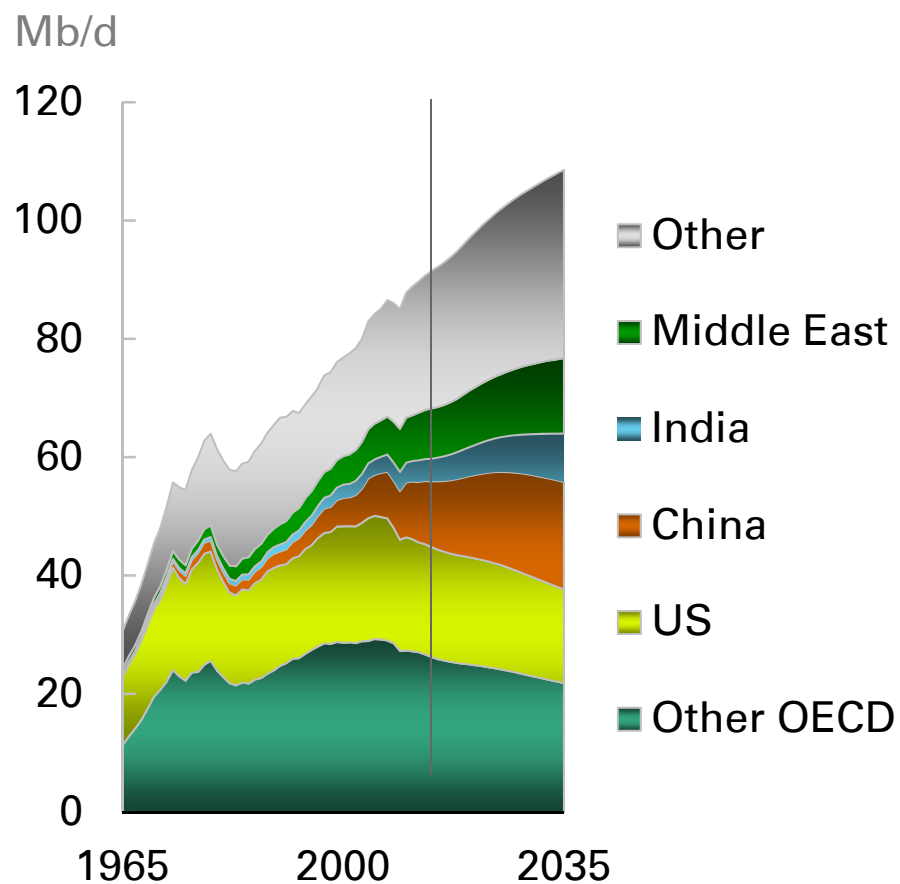
...in non-OECD demand and non-OPEC supply growth

- Oil is expected to be the slowest growing fuel over the outlook period. Global liquids demand (oil, biofuels, and other liquids) nonetheless is likely to rise by around 19 Mb/d, to reach 109 Mb/d by 2035.
- Demand growth comes exclusively from rapidly growing non-OECD economies. China, India and the Middle East account for nearly all of the net global increase. OECD demand has peaked and consumption is expected to decline by 8 Mb/d.
- Rising supply to meet demand growth will come primarily from non-OPEC unconventional sources and, later in the outlook, from OPEC. By 2035, non-OPEC supply is expected to have increased by 10.8 Mb/d while OPEC production will have expanded by 7.4 Mb/d.
- The largest increments of non-OPEC supply will come from the US (3.6 Mb/d), Canada (3.4 Mb/d), and Brazil (2.4 Mb/d), which offset declines in mature provinces such as the North Sea. OPEC supply growth will come primarily from NGLs (3.1 Mb/d) and crude oil in Iraq (2.6 Mb/d).

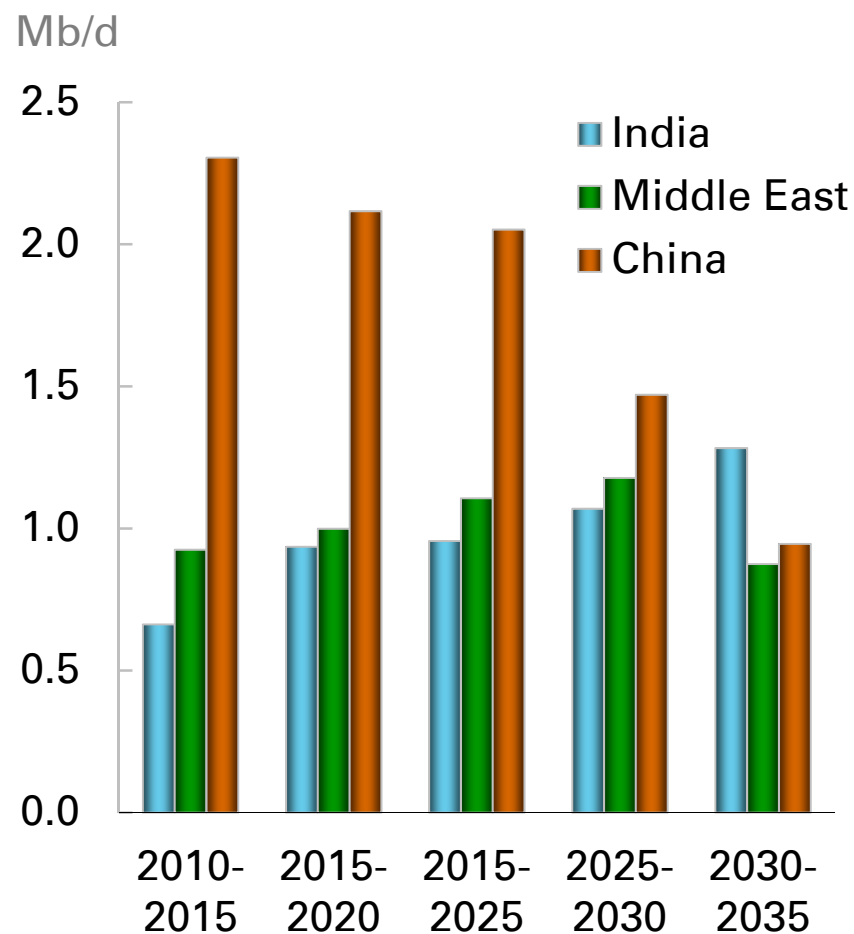


Asia and the Middle East drive liquids demand growth...

Demand by region



Five year increments





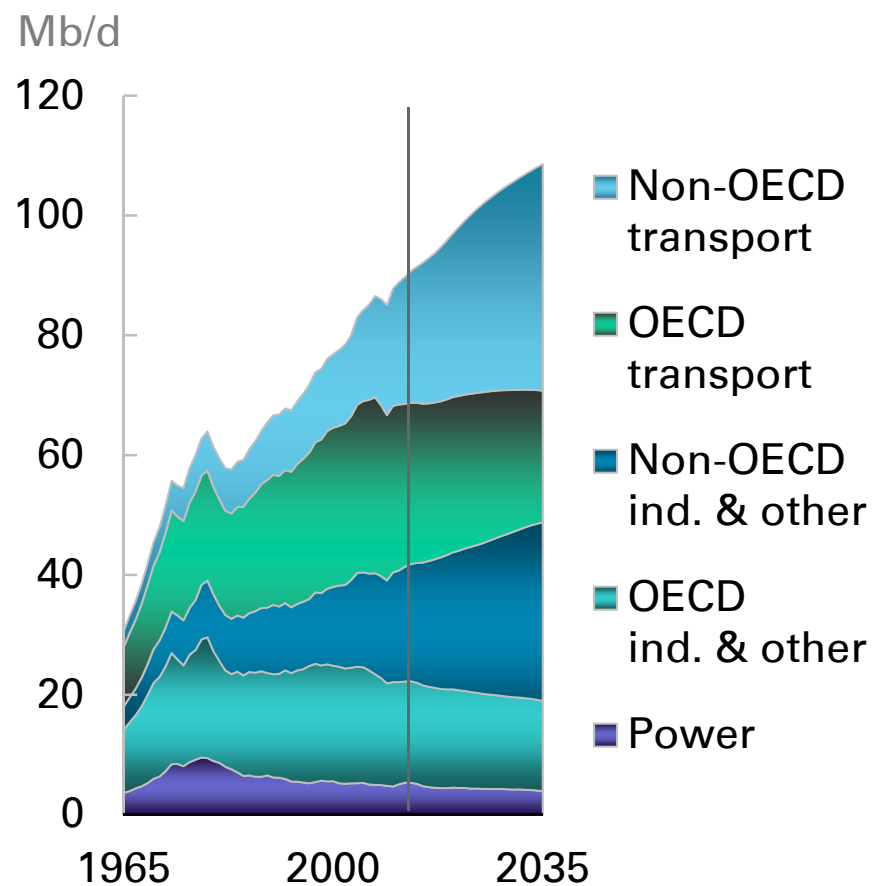
...with growth in India overtaking China by 2035

- Global liquids consumption is projected to reach 109 Mb/d by 2035 but growth continues to slow (from 1.3% p.a. in 2000-12 to 0.6% for 2025-35). OECD consumption is projected to fall by 8 Mb/d to 37.6 Mb/d in 2035, the lowest since 1985. Non-OECD consumption will reach 71 Mb/d by 2035 – 60% higher than in 2012.
- Demand in China grows by 8 Mb/d to 18 Mb/d in 2035, surpassing the US in 2029 (US demand falls 2.7 Mb/d to 15.8 Mb/d over the outlook period). India and the Middle East are the next largest contributors, both growing by 4.6 Mb/d while other non-OECD Asia sees growth of 3.1 Mb/d.
- Although China provides the largest increment to liquids demand over the outlook period, its growth volumes slow relative to those observed over the last 10 years. During 2030-35 Chinese demand rises by only 0.9 Mb/d (versus 2.3 Mb/d for 2005-10) making India the largest contributor to demand growth (1.3 Mb/d for 2030-35). The Middle East also sees growth of 0.9 Mb/d during this period, and overtakes the US to become the largest per capita consumer of oil in 2033.

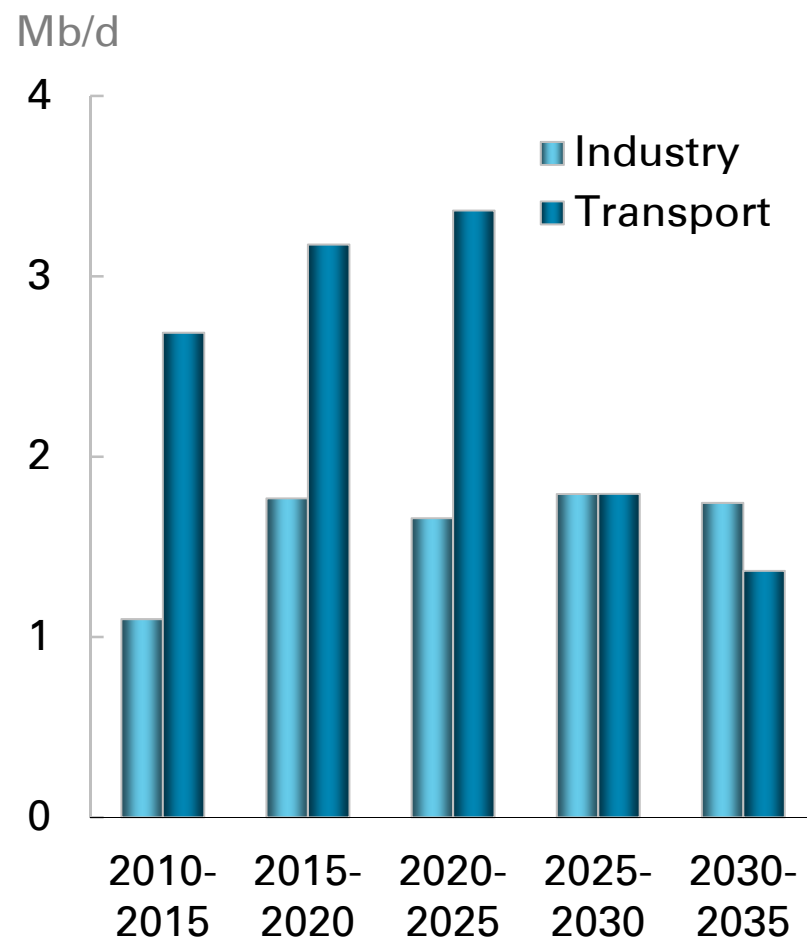


Liquids demand growth is largest in non-OECD transport...

Demand by sector



Five year increments





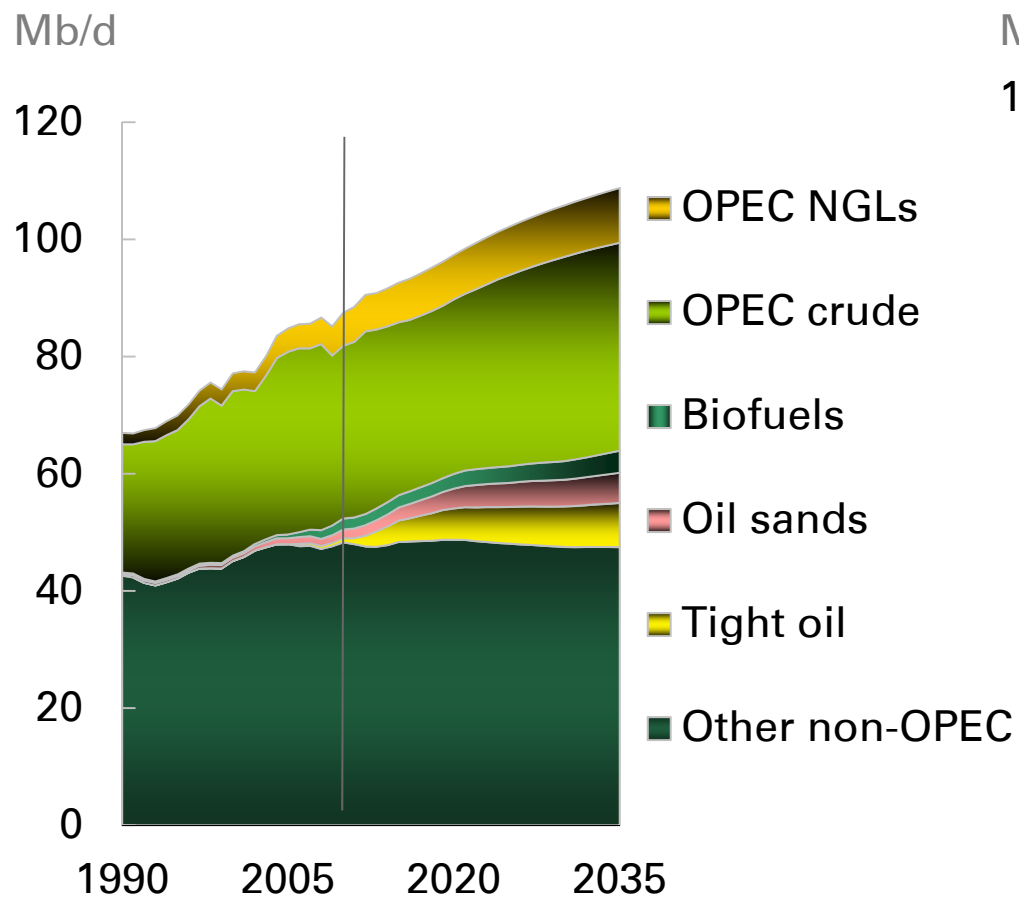
...but growth in industry becomes increasingly important

- By sector, liquids demand growth to 2035 comes primarily from non-OECD transport (16.6 Mb/d) – due to a rapid increase in vehicle ownership – and from non-OECD industry (8.7 Mb/d, largely for petrochemicals).
- OECD demand declines across all sectors. Outside of transport there are two main drivers: the continued displacement of oil by cheaper alternative fuels, and the closure of uneconomic industrial plants (in refining and petrochemicals) in favour of newer plants in the non-OECD. In transport, declines are first driven by vehicle efficiency improvements (despite slow growth in the OECD vehicle fleet) and then by increasing penetration of non-liquid alternative fuels, such as natural gas.
- At the global level, transport demand growth for liquid fuels slows post 2025, as efficiency gains and displacement by gas ramp up, falling below growth in industry between 2030 and 2035. Industrial growth remains steady since the production of petrochemicals is already an efficient process and as yet there are no large scale alternatives to oil available.

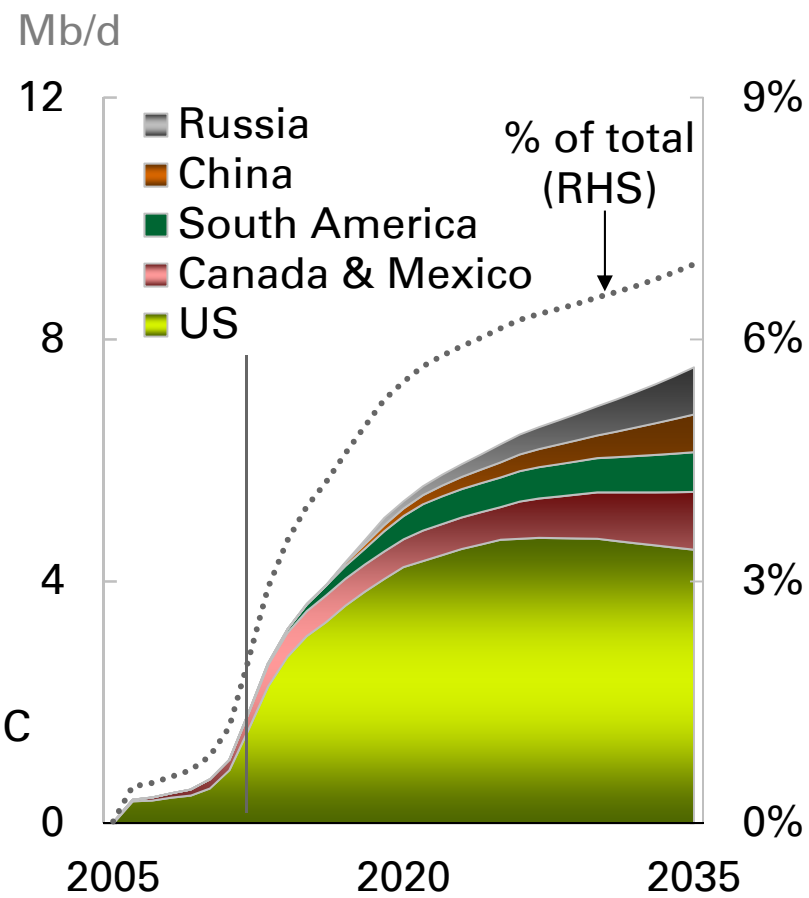


Supply growth is supported initially by unconventional...

Liquids supply by type



Tight oil supply





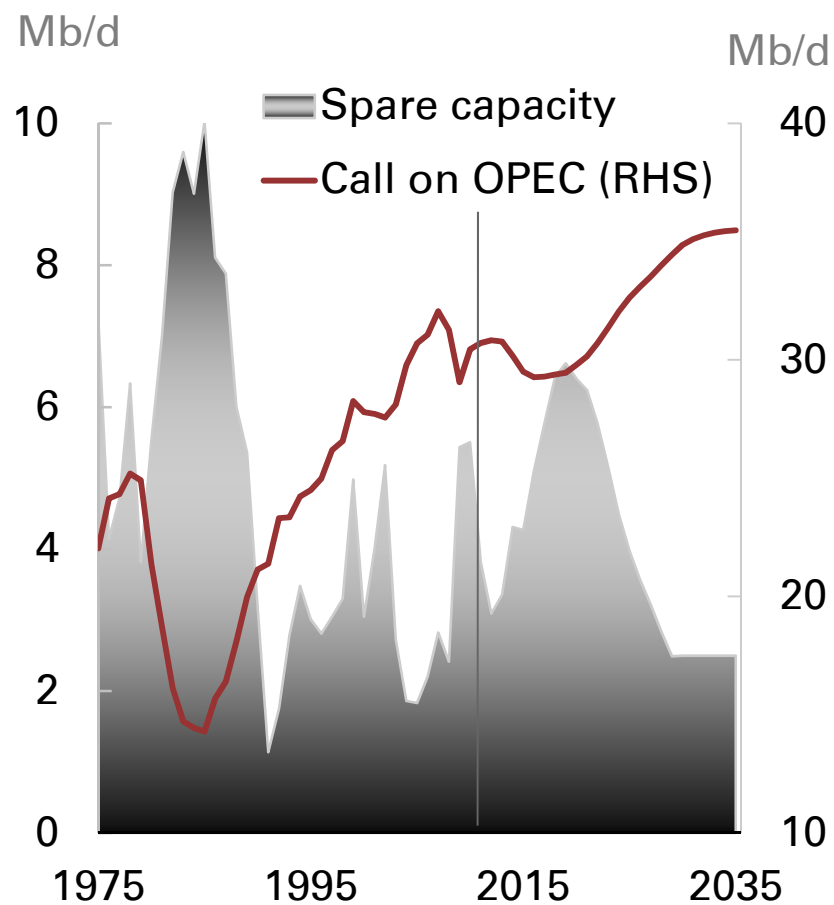
...pushing the need for OPEC growth to later in the outlook

- Liquids supply will expand by over 18 Mb/d with non-OPEC production contributing nearly 11 Mb/d of growth and OPEC crude and NGLs accounting for the rest. Unconventionals will drive non-OPEC growth and delay the need for higher OPEC supplies.
- By 2035, growth of tight oil (5.7 Mb/d), biofuels (1.9 Mb/d), and oil sands (3.3 Mb/d) alone will have accounted for 60% of global growth and all of the net increase in non-OPEC production.
- Tight oil will account for 7% of global supplies in 2035 while biofuels and oil sands obtain market shares of 3% and 5%, respectively. North America will dominate the expansion in unconventionals with 65% of global tight oil and with Canada responsible for all the world's oil sands production.
- OPEC crude production will not expand significantly until 2025, but by the end of the forecast period will be up over 4 Mb/d. OPEC NGLs will continue to expand on increasing natural gas production in the Middle East and contribute over 3 Mb/d to growth.

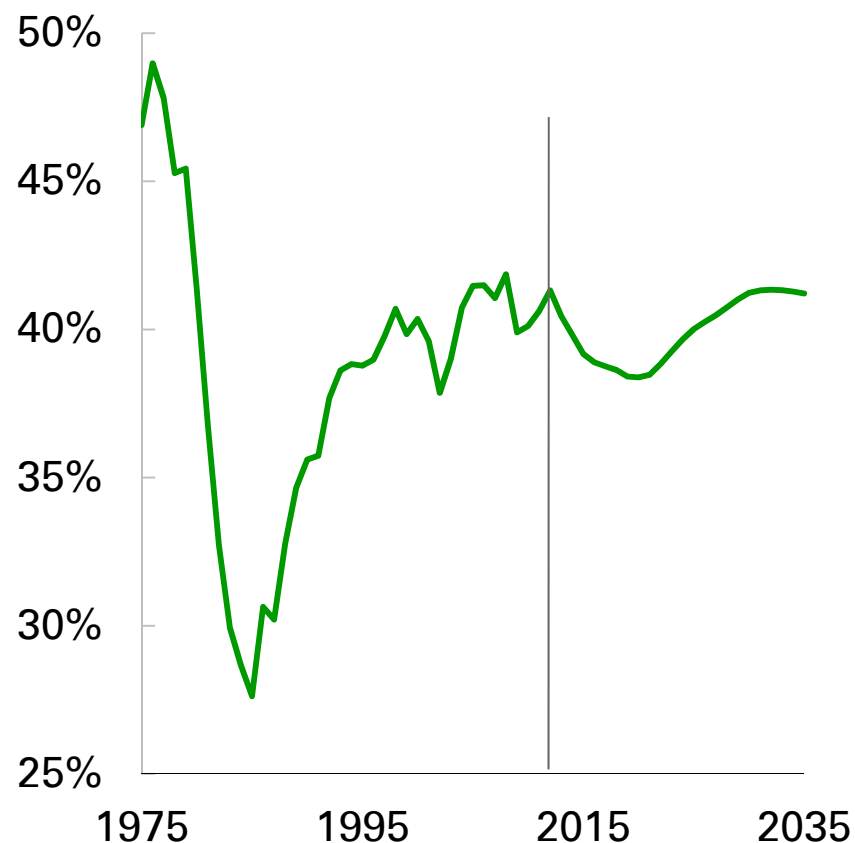


Oil balances suggest OPEC will be challenged...

OPEC spare capacity



OPEC share of global supply





...but the experience of the 1980s is unlikely to be repeated

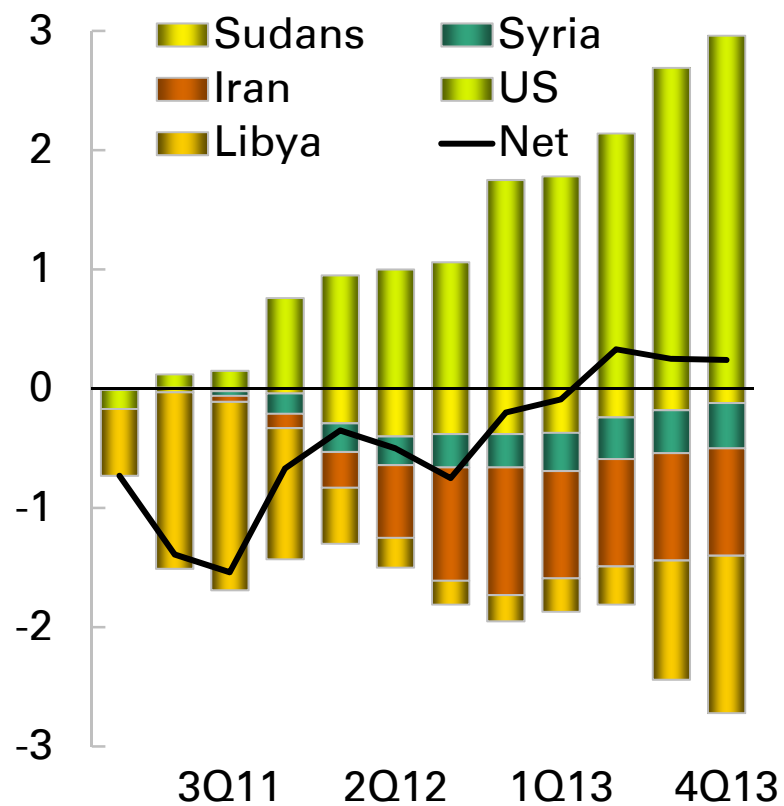
- In our outlook, demand growth slows and non-OPEC supplies rise – both as a result of high prices. We assume that OPEC members cut production over the current decade. As a result, spare capacity will exceed 6 Mb/d by 2018, the highest since the late 1980s.
- The market requirement for OPEC crude is not expected to reach today's levels for another decade before rebounding. While we believe that OPEC members will be able to maintain discipline despite high levels of spare capacity, cohesion of the group is a key oil market uncertainty.
- The challenging decade ahead for OPEC, however, is unlikely to be a repeat of the 1980s. At that time, spare capacity peaked at over 10 Mb/d and the group's share of global supply dropped well below 30%.
- The key difference is the response of demand, which collapsed after the price shock of the 1970s, due to the combination of fuel substitution and efficiency improvements. Furthermore, spare capacity as a share of crude production will peak at 7%, compared to 17% in 1985.



Supply disruptions reduce the immediate impact on OPEC...

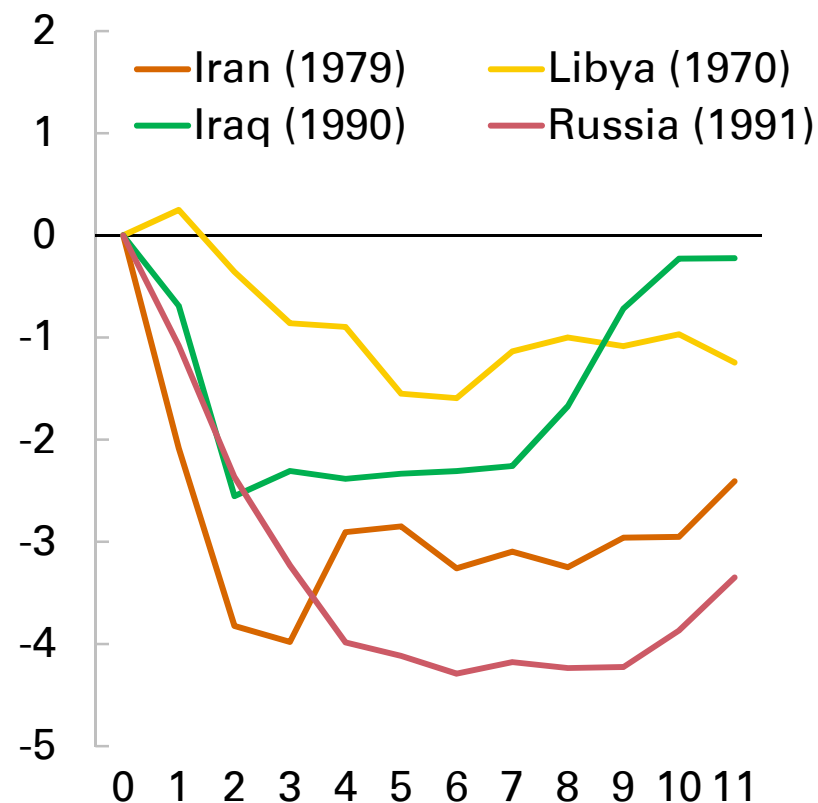
Recent disruptions

Change since 4Q10, Mb/d



Historical disruptions

Change from pre-disruption level*, Mb/d



*Event occurs in year 1

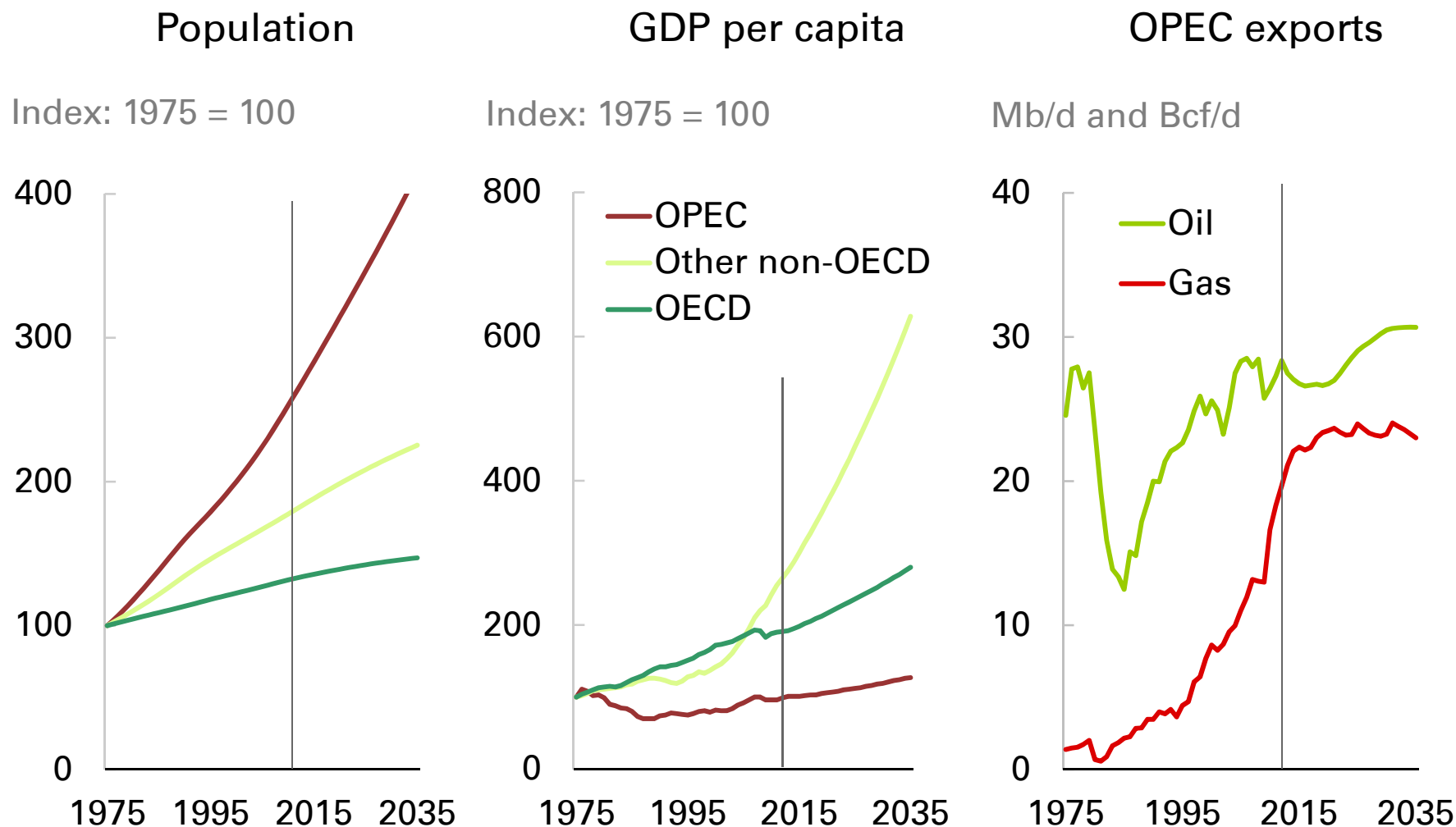


...and history suggests recovery will take time

- Since the advent of the Arab Spring in 2011, supply disruptions have become a key feature of today's oil market. Libyan production suffered a complete shutdown in early 2011, followed by disruptions in Syria due to civil war, Sudan as the country split, and Iran due to international sanctions.
- By the end of 2013, disruptions in those countries had removed over 2 Mb/d from global markets. Meanwhile, US output surged due to tight oil, nearly matching disruptions barrel for barrel. Absent those disruptions, prices would likely have come under pressure without OPEC action.
- While non-OPEC supply growth – led by unconventional – may place pressure on OPEC in the medium term, historical precedent suggests that supply disruptions take years to fully recover, which could provide some cushion for OPEC. Revolutions in Libya and Iran, war and sanctions in Iraq, and the collapse of the Soviet Union all resulted in production declines that persisted for at least a decade following the disruptive event.



OPEC countries face pressure from rising populations...



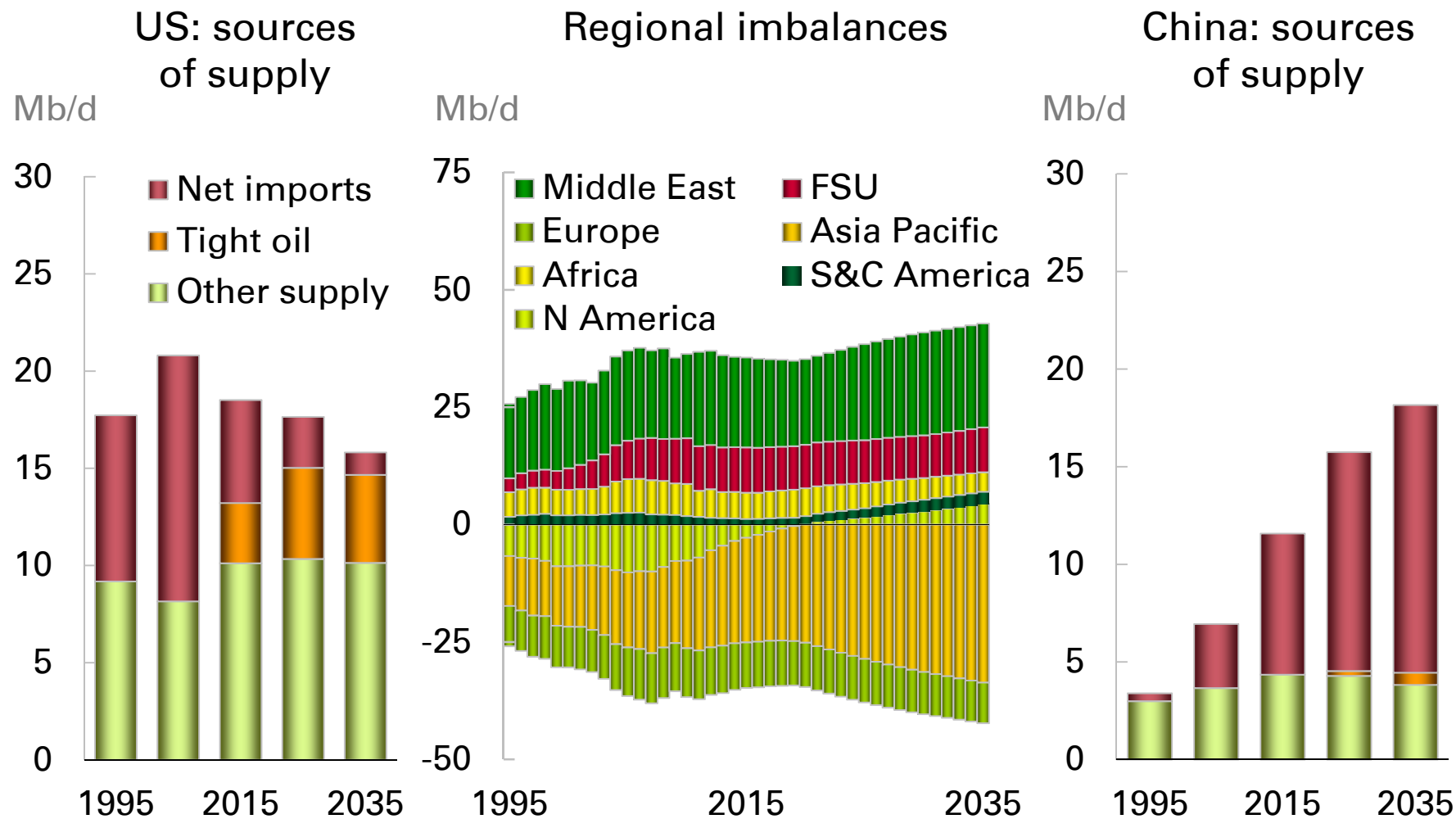


...booming energy demand and limited economic growth

- High population growth, limited economic opportunities, and the burden of high energy demand (largely due to subsidies) create pressures on OPEC (and other oil-producing) countries.
- Population growth in OPEC countries has outpaced the rest of the non-OECD for the past 40 years and the growth rate over the next 20 years will be more than double that of the rest of the emerging markets.
- OPEC GDP per capita has been stagnant since 1975, compared to a 200% increase in the rest of the non-OECD. GDP per capita is set to expand by just 30% to 2035, compared to 130% in the other emerging markets.
- The level and growth rates of energy use per capita are also well ahead of other non-OECD countries. Today, OPEC countries consume nearly 75% more energy per capita than the non-OECD average. This will limit the growth of both oil and natural gas exports.
- These factors have contributed to recent oil supply disruptions and could pose risks to future capacity and production prospects.



Oil trade continues to shift from West to East...





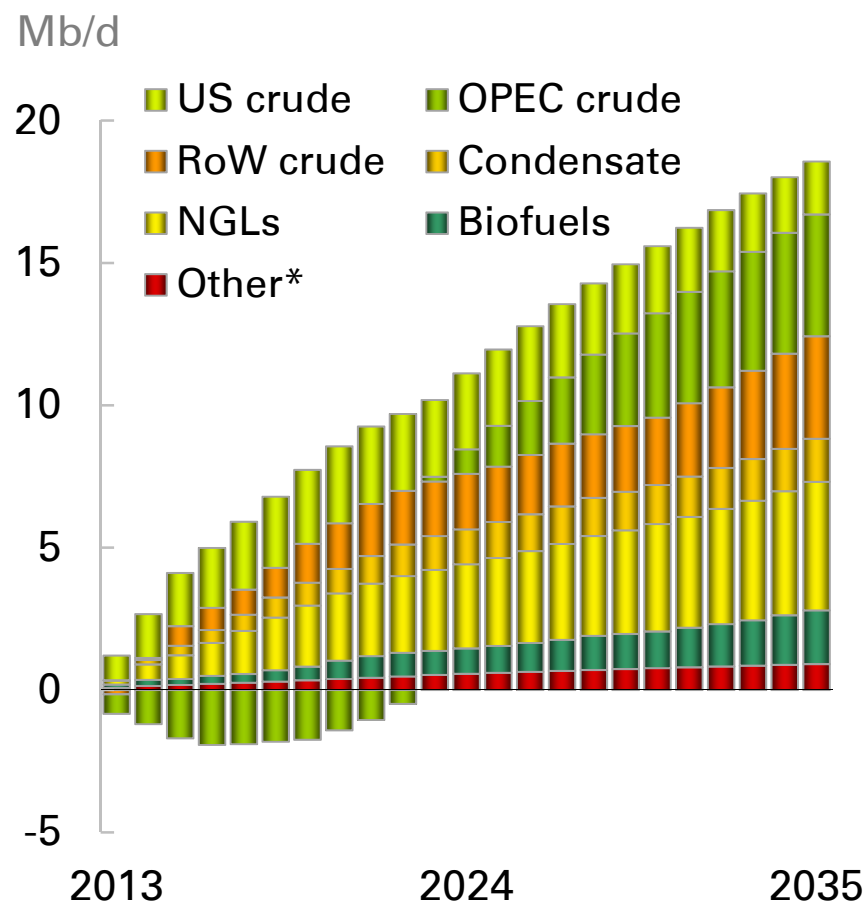
...but Asia's import needs go beyond the Middle East

- In the US, the increase in tight oil production coupled with declining demand will continue the dramatic shift in import dependence. Imports are set to decline from a peak of well over 12 Mb/d, or 60% of demand, in 2005 to just 1 Mb/d, or less than 10% of demand in 2035.
 - China's import requirement, on the other hand, is projected to more than double from today's levels to almost 14 Mb/d, or 75% of demand, a level and share of demand higher than the US at its peak. China will likely surpass the US as the world's largest importer next year and largest consumer by 2029.
 - On a regional basis, led by China's growing import requirement, Asia's imports will account for nearly 80% of inter-regional net imports by 2035, up from 57% today.
 - Meanwhile, the Middle East's share of inter-regional net exports will dip from 54% in 2012 to 52% by 2035, suggesting that Asia will not only require Middle Eastern oil, but will also pull oil from other surplus regions such as the Americas, Africa, and the FSU.
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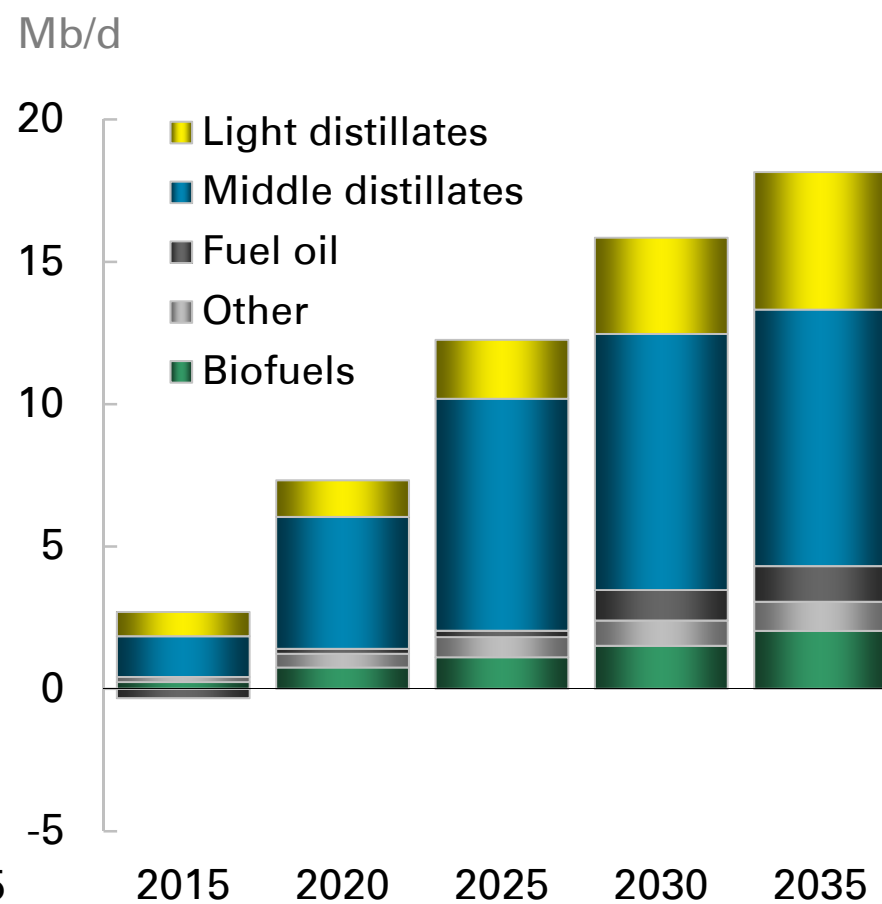


The growth of alternatives will challenge refiners...

Cumulative liquids supply growth



Cumulative liquids demand growth



*Includes gas-to-liquids, coal-to-liquids and refinery volume gain

...as will demand growth trends and crude market dynamics

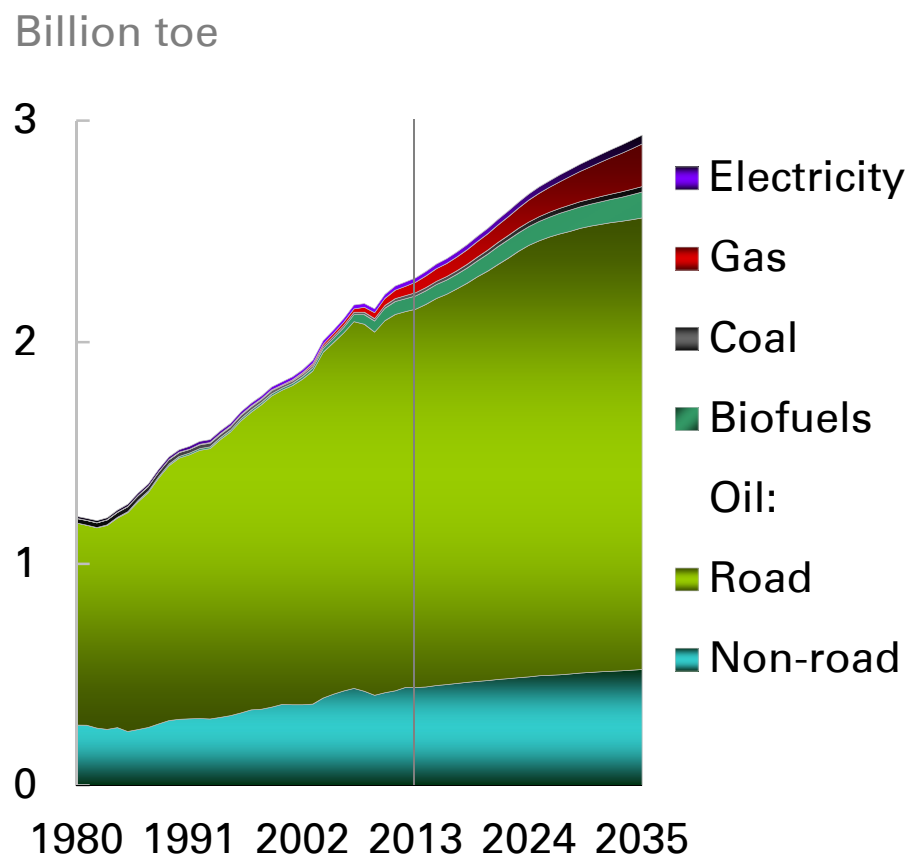


- Liquids supply growth comprises a variety of sources; of total liquids supply growth to 2035 of around 19 Mb/d, about 7 Mb/d comes from NGLs, biofuels and other liquids that do not require refining.
- In the medium term, OPEC oil production cuts are offset mainly by US output growth that may not be fully exportable. The scope for non-US refiners to grow throughputs *in aggregate* could therefore be impacted.
- There will also be uneven regional impacts as new East of Suez refining capacity takes a disproportionate share of crude run growth, keeping the pressure on crude run levels in weaker refining centres, such as Europe.
- Liquids demand growth is heavily biased towards middle distillates, especially jet-fuel and diesel, while light distillate demand growth will be partly met by new supplies of NGLs and condensates.
- This will require refiners to adjust product yields. Gasoline cracks are already more volatile than diesel, reflecting an increasing tendency for a supply overhang to develop outside of the driving season.

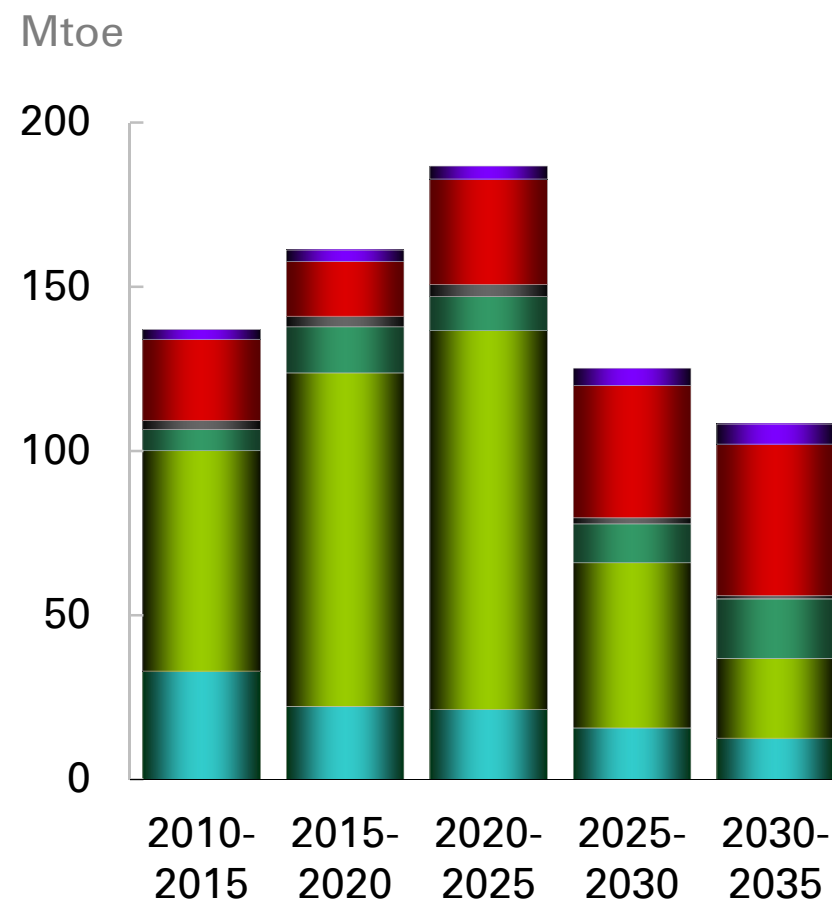


Global transport demand growth slows...

Transport demand by fuel



Five year increments by fuel





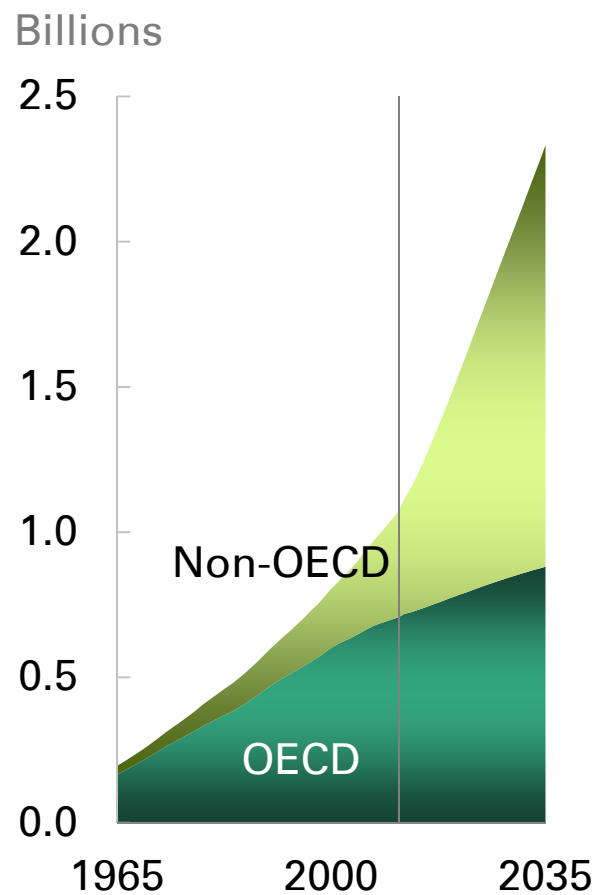
...as prices and policy boost vehicle fuel economy

- Energy consumption growth in transport slows to 1.1% p.a. between 2012 and 2035 (from 1.9% p.a. 1990-2012) primarily due to accelerating gains in fuel economy. Other factors include the impact of high oil prices on driving behaviour (reduced average miles driven), vehicle saturation in the OECD, and non-OECD fuel subsidy reduction.
 - Transport demand will remain dominated by oil (still 87% in 2035, mostly for road use), since alternatives are likely to remain uneconomic in many market segments without policy support. Natural gas (including gas-to-liquids) is the fastest growing alternative (6.8% p.a.) – particularly LNG for heavy duty vehicles and shipping – and is expected to overtake biofuels in 2022 before reaching almost 7% of transport by 2035. On an energy basis, the biofuels share grows from 2.5% currently to 4% by 2035 while the electricity share grows to just 1.5%.
 - By the end of the outlook period, natural gas is starting to make significant inroads into the transport sector – between 2030 and 2035 gas contributes more to transport demand growth than oil (46 versus 37 Mtoe), restricting oil's growth rate to only 0.3% p.a. during this period.
-

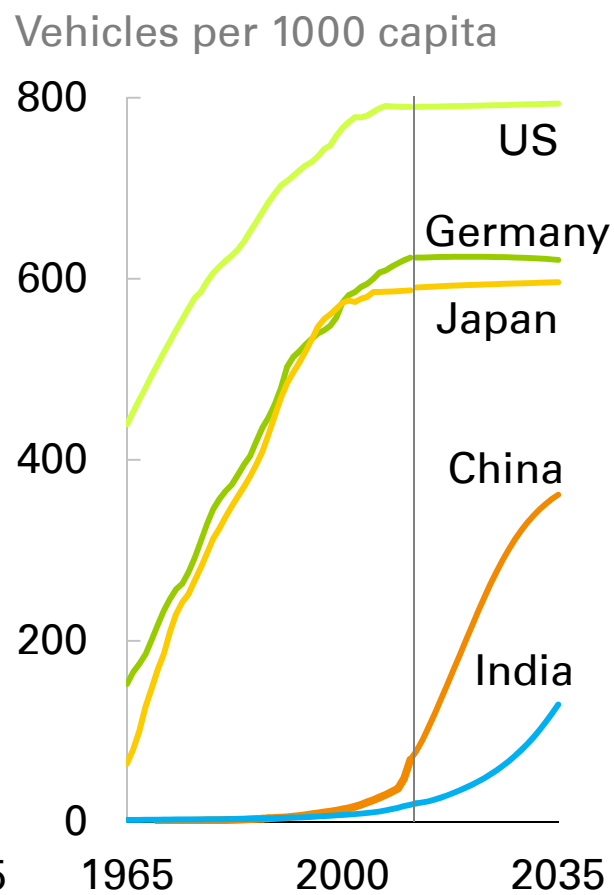


Vehicle numbers are set to grow rapidly in the non-OECD...

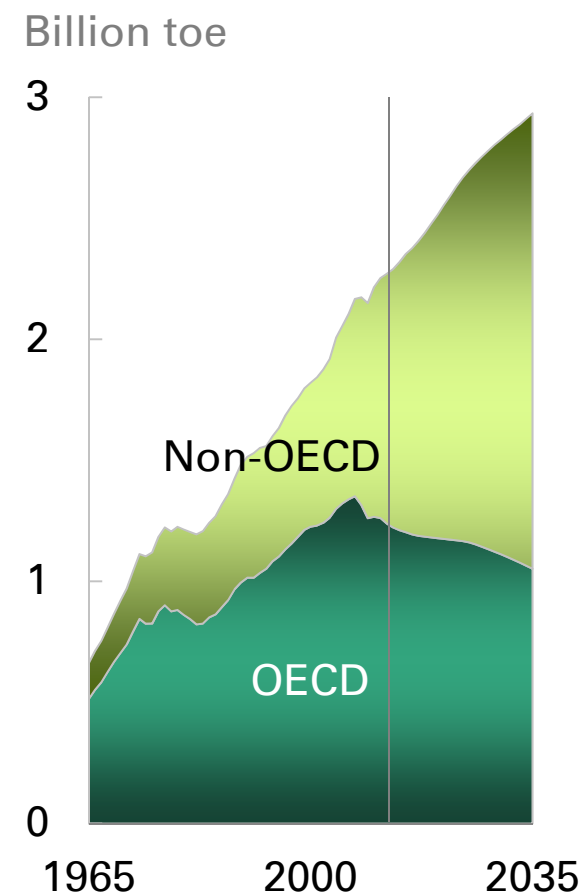
Vehicle fleet



Vehicle ownership



Transport demand





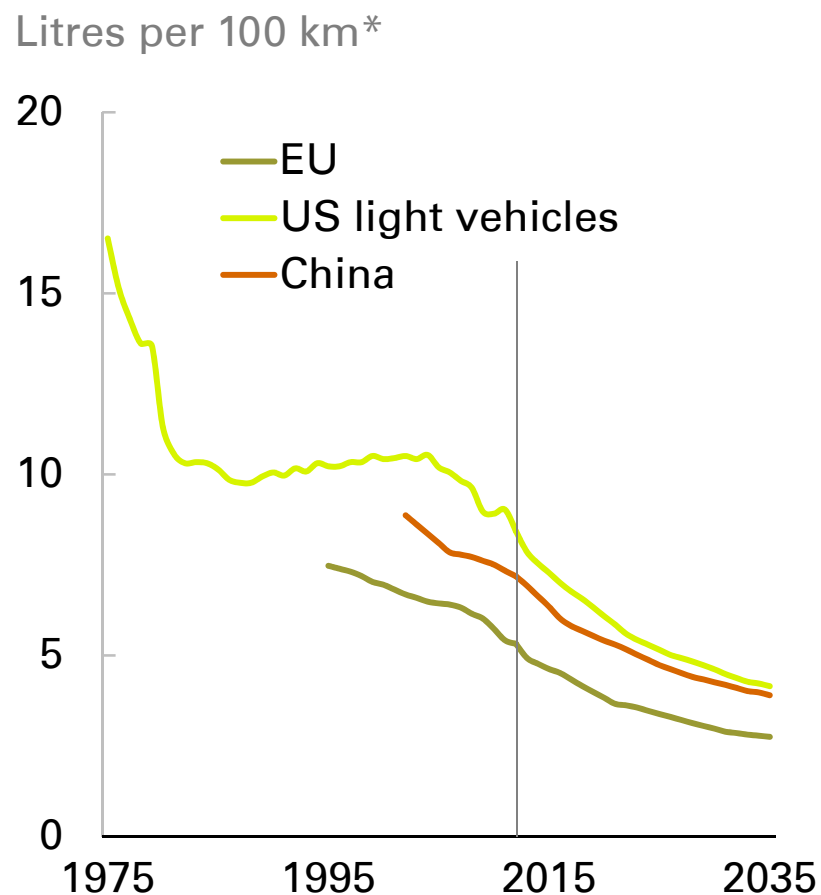
...while OECD growth slows due to saturation

- The global vehicle fleet (commercial vehicles and passenger cars) grows rapidly – more than doubling from around 1.1 billion today to 2.3 billion by 2035. Most of the growth is in the developing world (86%) with some mature markets at saturation levels.
 - The non-OECD's vehicle population more than triples from 0.4 to 1.5 billion over the outlook period and overtakes the OECD fleet in 2022.
 - Between 2012 and 2035, vehicle density per 1000 population grows from 20 to 130 in India (8.4% p.a.) and from 80 to 360 in China (6.9% p.a.). China is likely to follow a slower path to vehicle ownership than seen historically in other countries due to higher recent oil prices and policies to limit oil import dependency and congestion, including rising fuel and road taxation and widespread mass transportation.
 - Efficiency improvements limit growth in transport demand relative to vehicles. Non-OECD transport demand rises by 'only' 82% despite the tripling of vehicles. In the OECD, transport demand falls (by 15%) since efficiency gains outweigh slow growth of the vehicle fleet (22%).
-



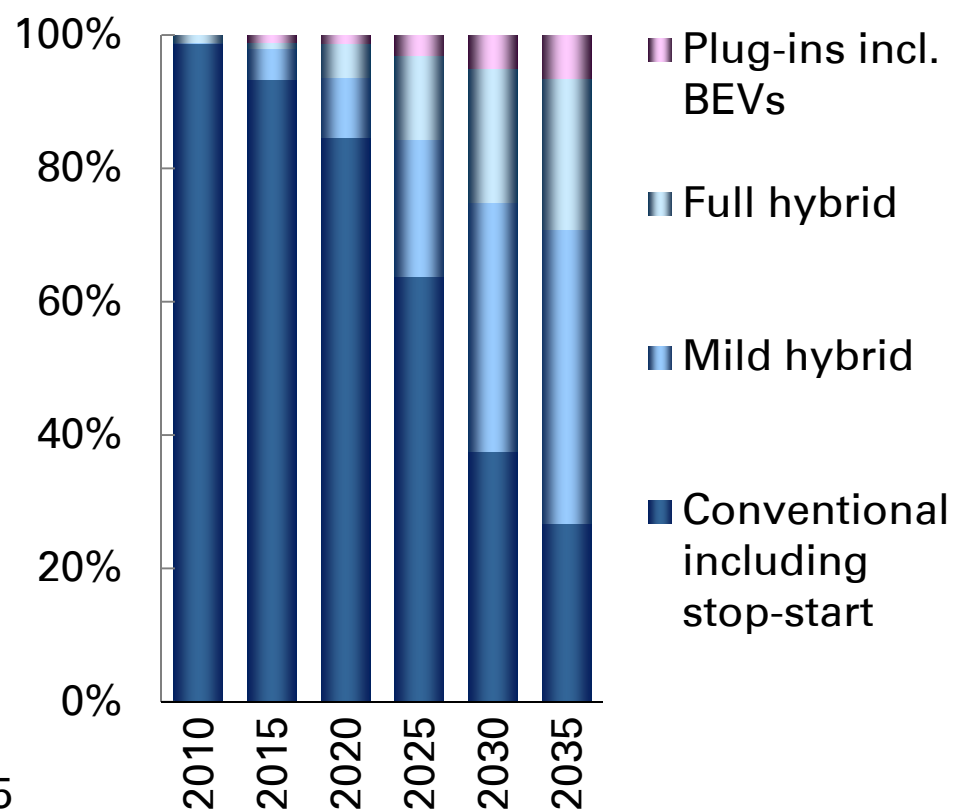
Policy and technology enable efficiency improvements...

Fuel economy of new cars



*New European Driving Cycle

Vehicle sales by type



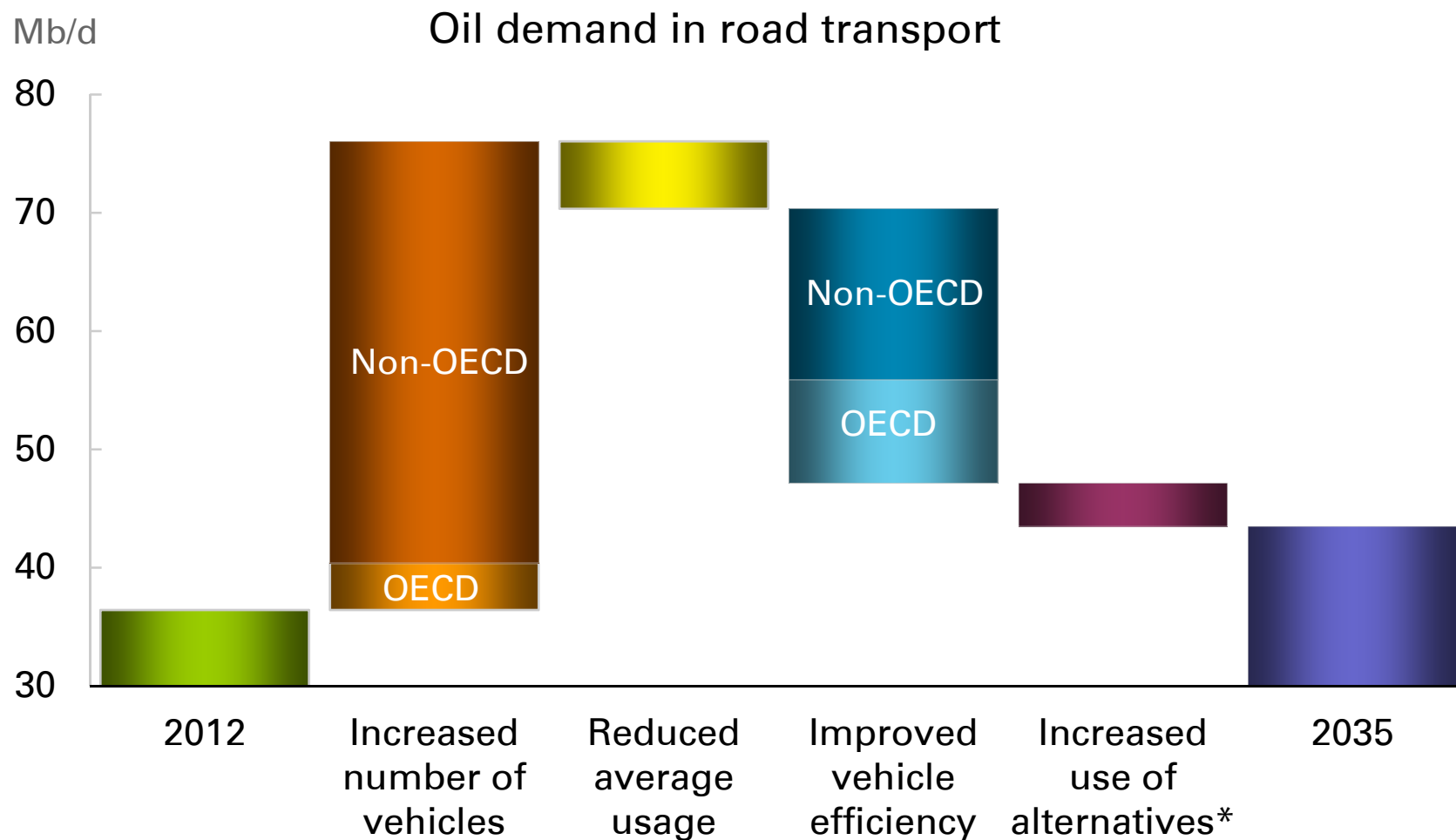


...as the vehicle fleet gradually shifts to hybrids

- Fuel economy has been improving in recent years at rates not seen since the period after the first oil price shock in 1973. Recent gains have been driven by consumer reaction to rising prices and tightening policy (e.g. CO₂ emissions limits in Europe and CAFE standards in the US) and have been made possible by technology improvements.
 - Efficiency gains are likely to be sustained, with new car fuel economy in the US, EU and China improving by 2.5%-3% p.a. over the outlook period. The gains come initially from powertrain enhancements (direct injection, stop-start, engine downsizing, boosting) and other measures such as light-weighting, followed by the gradual penetration of hybrid powertrains into the vehicle fleet.
 - By 2035, sales of conventional vehicles fall to a quarter of total sales, while hybrids dominate (full hybrids 23%, mild hybrids 44%). Plug-in vehicles, including full battery electric vehicles (BEVs), are forecast to make up 7% of sales in 2035. Plug-ins have the capability to switch to oil for longer distances and are likely to be preferred to BEVs, based on current economics and consumer attitudes towards range limitations.
-



Efficiency has the biggest impact on oil in road transport...



* Includes biofuels, GTL, CTL, CNG, LNG and electricity



...but alternative fuels play a greater role post 2030

- Assuming no changes to vehicle usage, efficiency and the use of alternatives, oil demand in road transport would increase by a massive 40 Mb/d over the forecast, more than double our projected oil demand growth (19 Mb/d), due mostly to more vehicles in the non-OECD. Instead we project oil demand growth for road transport to be 7 Mb/d.
- Vehicle fleet fuel economy is forecast to improve by 2% p.a., saving 23 Mb/d by 2035 – more than half of the incremental oil demand that would be required under the above “no change” case.
- Average miles driven per vehicle is expected to fall (saving 6 Mb/d) due to high fuel prices (partly due to rising taxes or reduced subsidies), congestion and mass transit. In addition, increased private ownership in the non-OECD from low levels is likely to lead to lower vehicle utilization.
- Alternative fuels play a smaller role in limiting oil’s growth due to barriers delaying scale-up; e.g. blend limitations for biofuels, CNG/LNG logistics and battery costs for electric vehicles. Post 2030, however, the absolute growth in alternatives outpaces growth for oil.



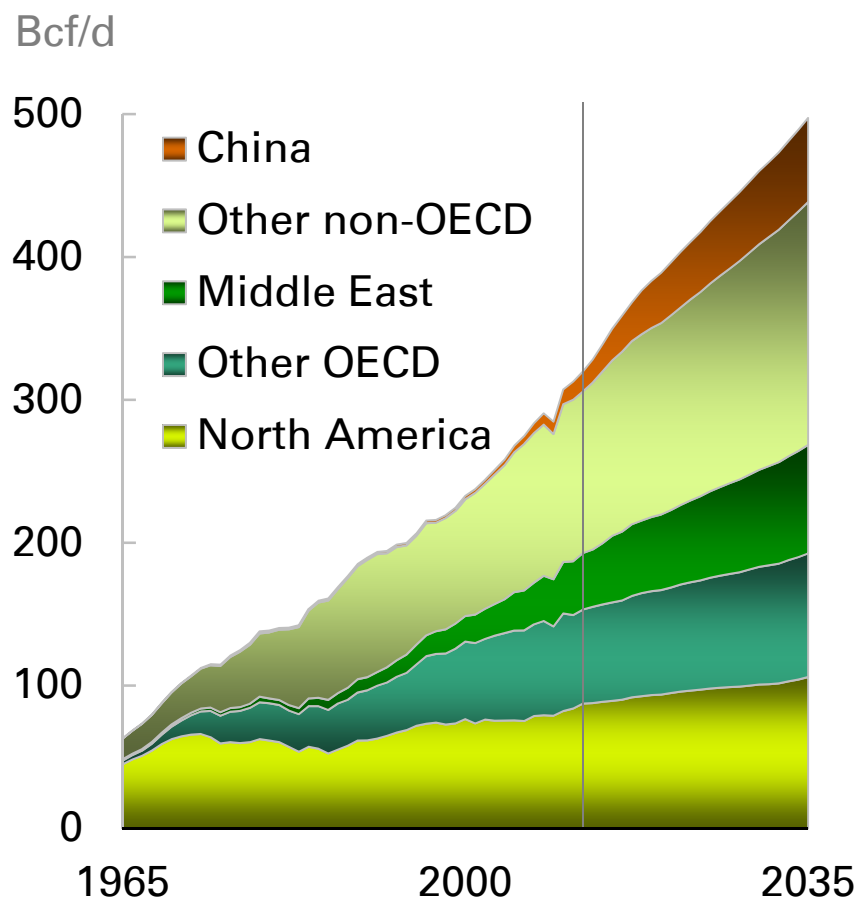


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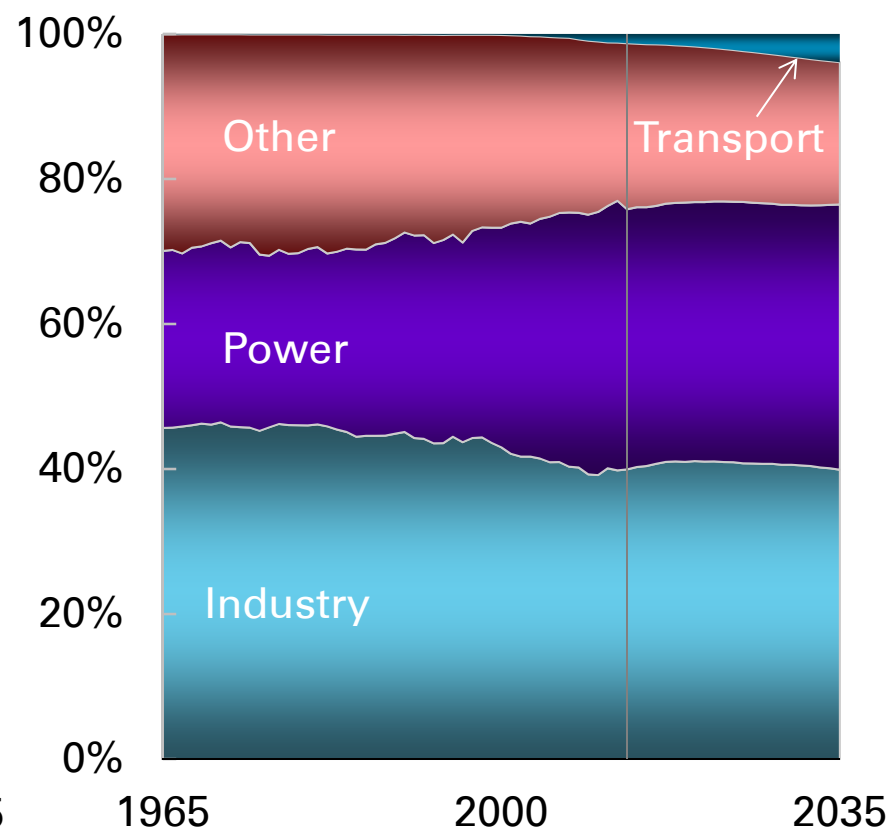


Natural gas demand continues its steady growth...

Demand by region



Demand by sector





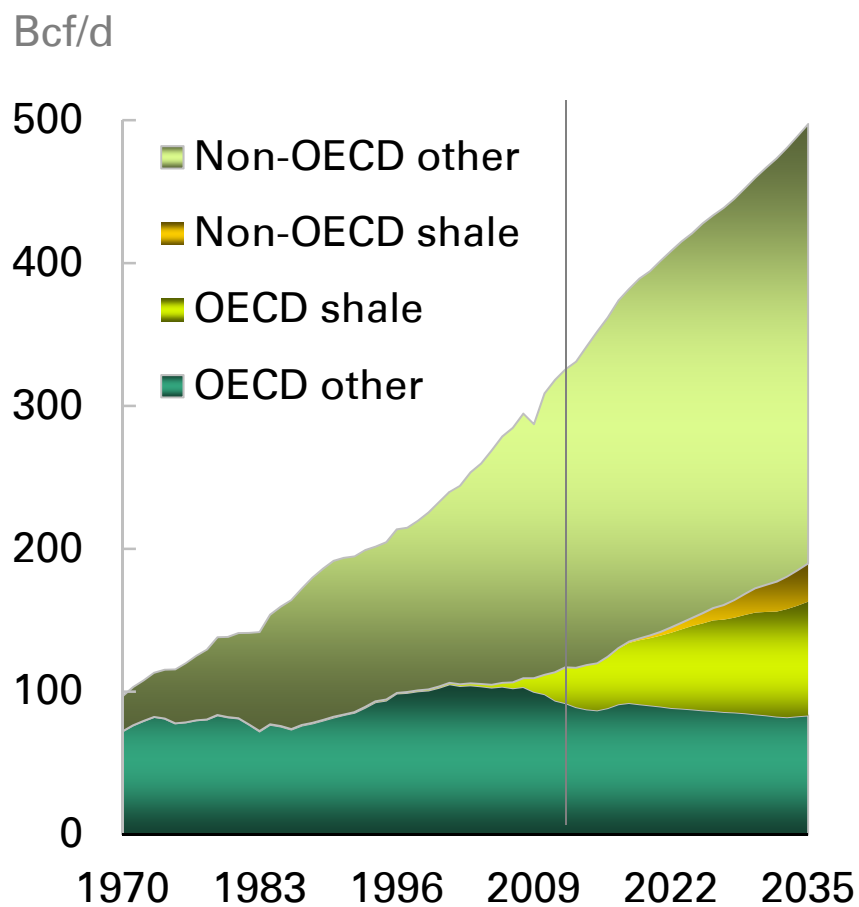
...in all regions and all sectors

- Global demand for natural gas will grow by 1.9% p.a. over the outlook period, reaching 497 Bcf/d by 2035, with non-OECD growth (2.7% p.a.) outpacing the OECD (1% p.a.).
- In the OECD, gas will overtake oil as the dominant fuel by 2031, reaching a share of 31% in primary energy by 2035. But in the non-OECD, gas remains in third place, behind coal and oil, with a 24% share of primary energy by 2035.
- The fastest growing sector is transport (7.3% p.a.), but this is from a small base. In volume terms the largest growth comes from industry (71 Bcf/d, 1.9% p.a.) and power (63 Bcf/d, 1.9% p.a.).
- The pattern of growth by sector differs between the OECD and non-OECD. OECD volume growth comes primarily from the power sector (17 Bcf/d, 1.2% p.a.) followed by industry (10 Bcf/d, 0.8% p.a.), while industry remains the largest source of non-OECD growth (61 Bcf/d, 2.6% p.a.).

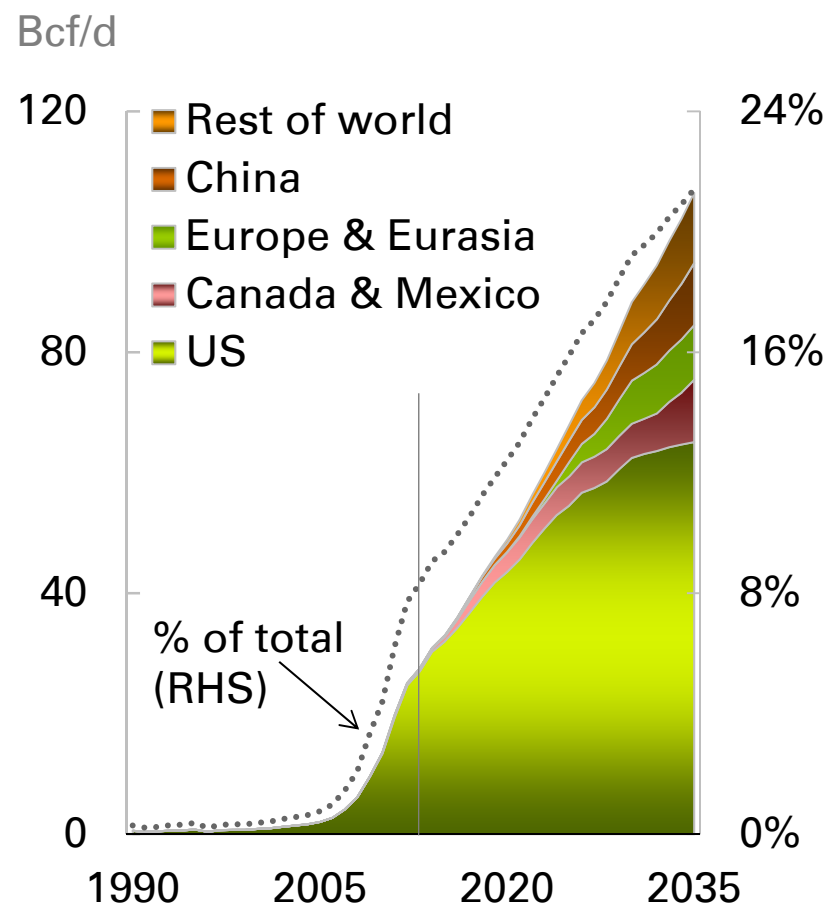


Shale gas shows the fastest production growth...

Gas production by type and region



Shale gas production





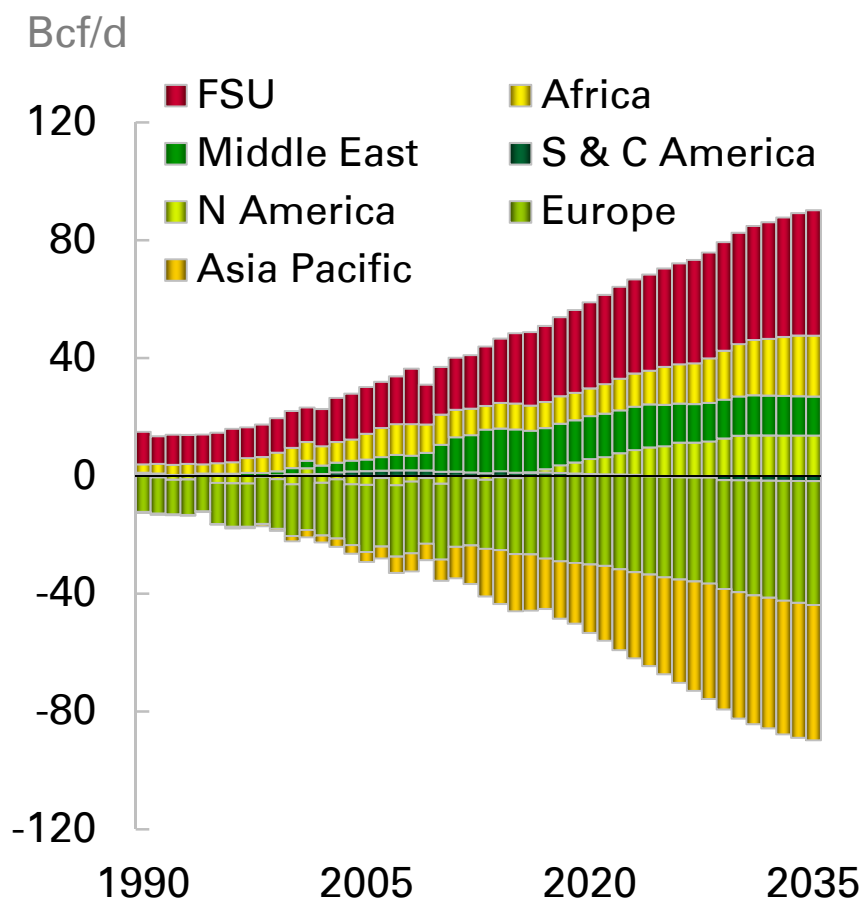
...but conventional sources provide the largest increment

- Global gas supply is expected to grow by 1.9% p.a. or 172 Bcf/d over the outlook period, reaching a total of 497 Bcf/d by 2035. Shale gas is the fastest growing source of supply (6.5% p.a.), providing nearly half of the growth in global gas.
- Gas supply growth is concentrated in the non-OECD (126 Bcf/d or 2.1% p.a.) accounting for 73% of global growth. Almost 80% of non-OECD growth is from non-shale sources. OECD supply growth (1.5% p.a.) comes exclusively from shale gas (5.1% p.a.), which provides nearly half of OECD gas production by 2035.
- Shale gas supply is dominated by North America, which accounts for 99% of shale gas supply until 2016 and for 70% by 2035. However, shale gas growth outside North America accelerates and by 2027 will overtake North American growth. China is the most promising country for shale gas growth outside North America, accounting for 13% of world shale gas growth; together, China and North America will account for 81% of shale gas by 2035.

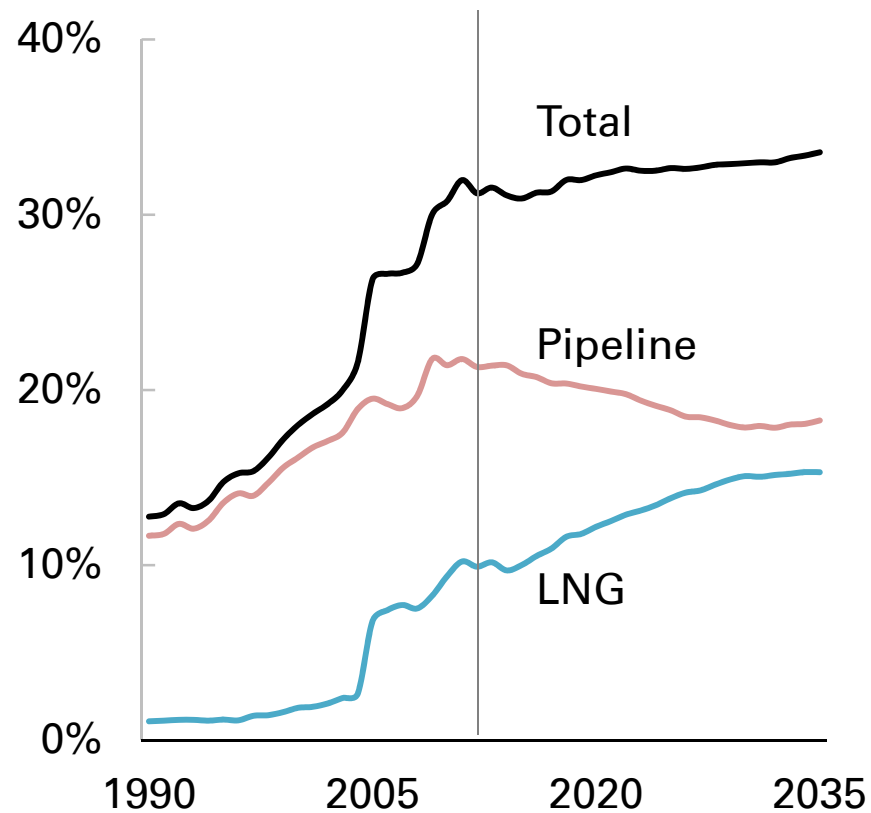


Gas trade continues to expand...

Regional net exports



Imports share of consumption





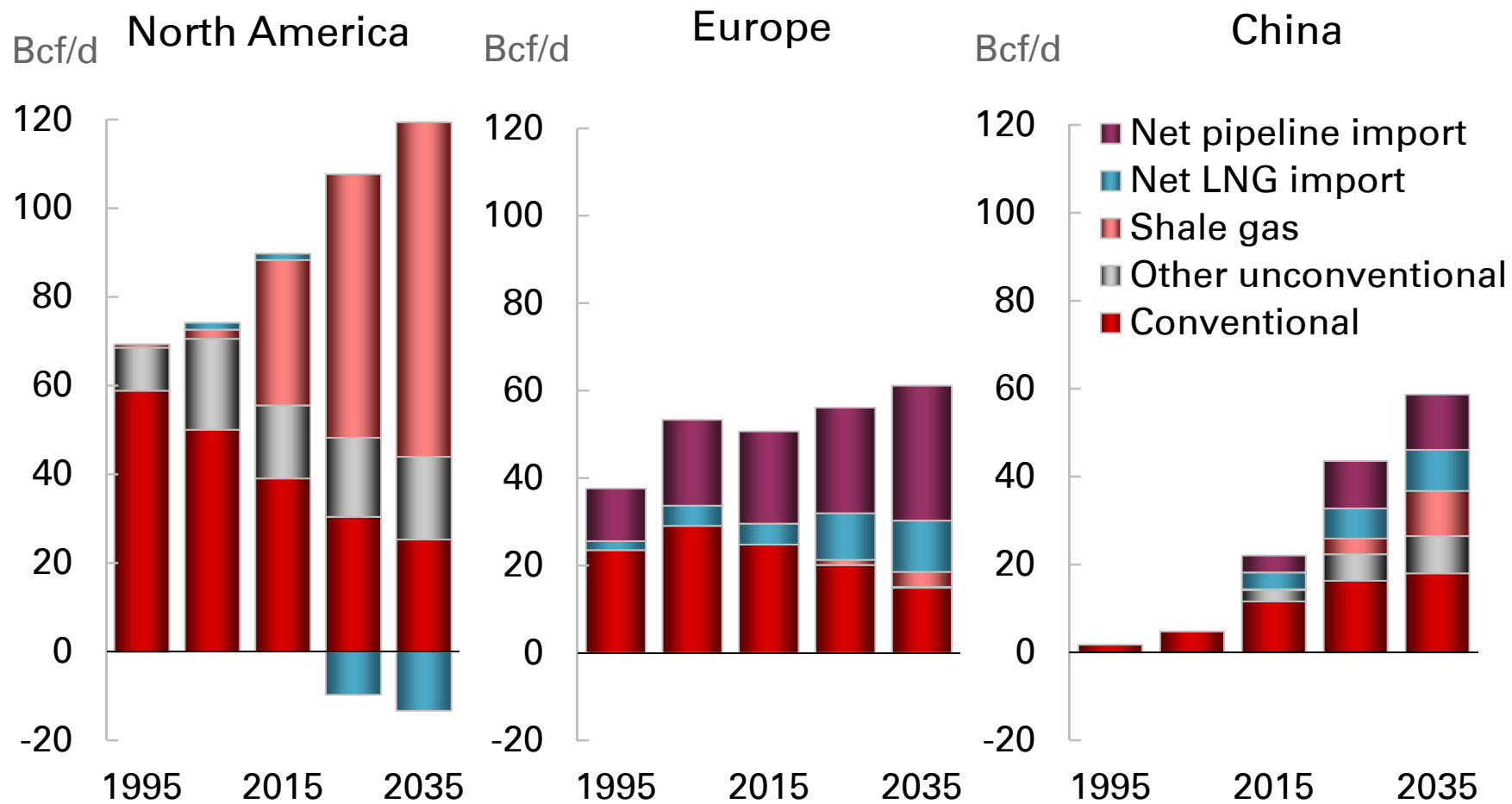
...with Asia overtaking Europe as the key importing region

- Net inter-regional imbalances are expected to more than double in our forecast, growing by 4% p.a. or 53 Bcf/d.
- The expansion of trade is driven by Asia Pacific where imports will more than triple and account for 51% of net inter-regional imports by 2035. Asia Pacific is expected to overtake Europe as the largest importing region by 2026. Meanwhile, the growth of shale gas turns North America from a net importer today into a net exporter in 2017.
- The share of total gas consumption that is imported grows steadily, from 31% in 2012 to 34% in 2035; but the projected rate of increase is markedly slower than recent history. Pipeline remains the primary method for gas trade, but it declines as a share of consumption, due to the reduced need for pipeline imports into the US and slow demand growth in Europe.
- Nonetheless, the flexibility and integration of the global gas market continues to increase due to rapidly growing LNG trade (3.9% p.a.); LNG's share of traded gas rises from 32% in 2012 to above 46% by 2035, while its share of consumption expands from 10% to 15%.



Differences in the prospects for unconventional gas...

Sources of gas supply by region





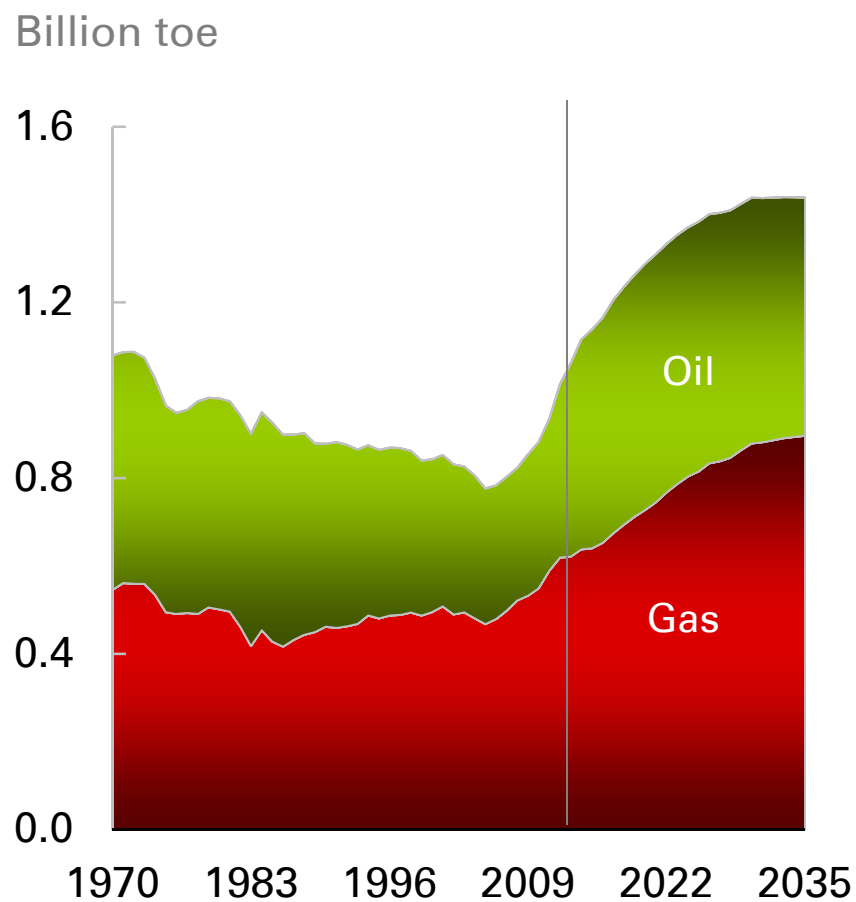
...shape regional supply patterns

- North American unconventional gas supplies will grow by 3.4% p.a. over the forecast period, more than offsetting the 2.3% p.a. decline in conventional production, and allowing domestic supply to grow by 1.4 % p.a.. The growth in unconventional gas stems almost exclusively from shale gas which expands by 50 Bcf/d (4.9% p.a.).
- Europe sees domestic production decline by 1.4% p.a. over the outlook, despite expanding unconventional supplies reaching 3.7 Bcf/d by 2035. Although European gas demand grows by just 1% p.a., Europe increasingly relies on imported gas, in particular on net imports via pipeline which meet 51% of demand by 2035, up from 37% today.
- China, by contrast, enjoys strong growth in domestic production (5.7% p.a.) across all types of supply. Shale gas makes the largest contribution to growth (10 Bcf/d, 42.7% p.a.), with most of it coming on line after 2020. Nonetheless, Chinese demand growth will still require a rapid expansion of imports (8.3% p.a.) both via pipeline and LNG. Pipeline imports from the FSU remain the dominant source of imports, expanding by 8.0% p.a..

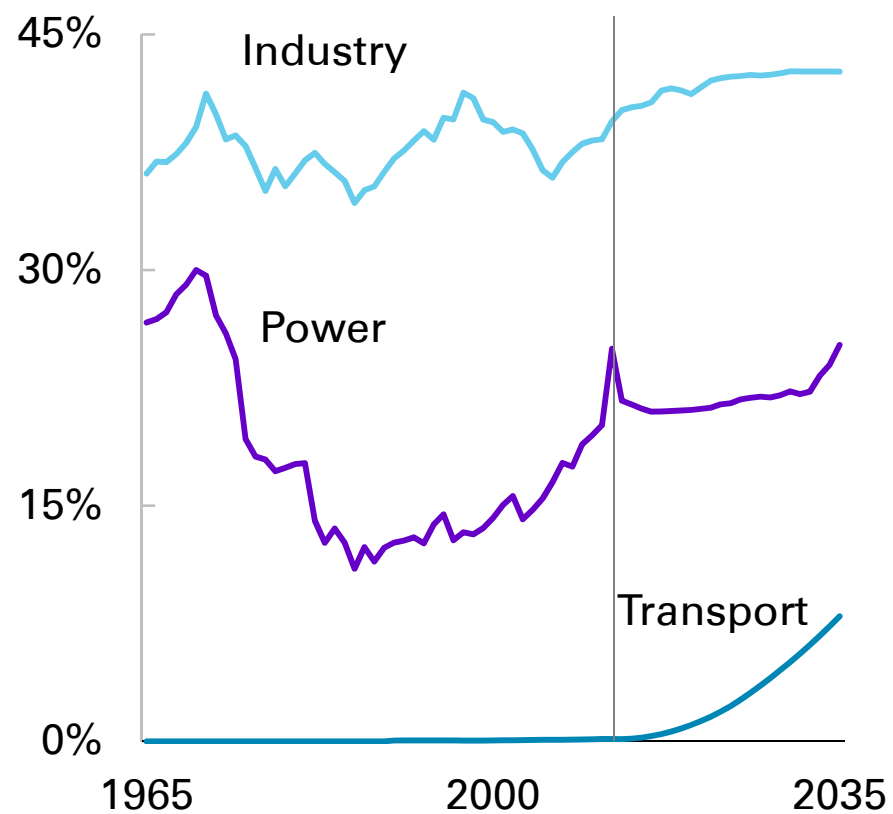


The shale revolution in the US provides an example...

US oil and gas supply



Gas share of US sector demand





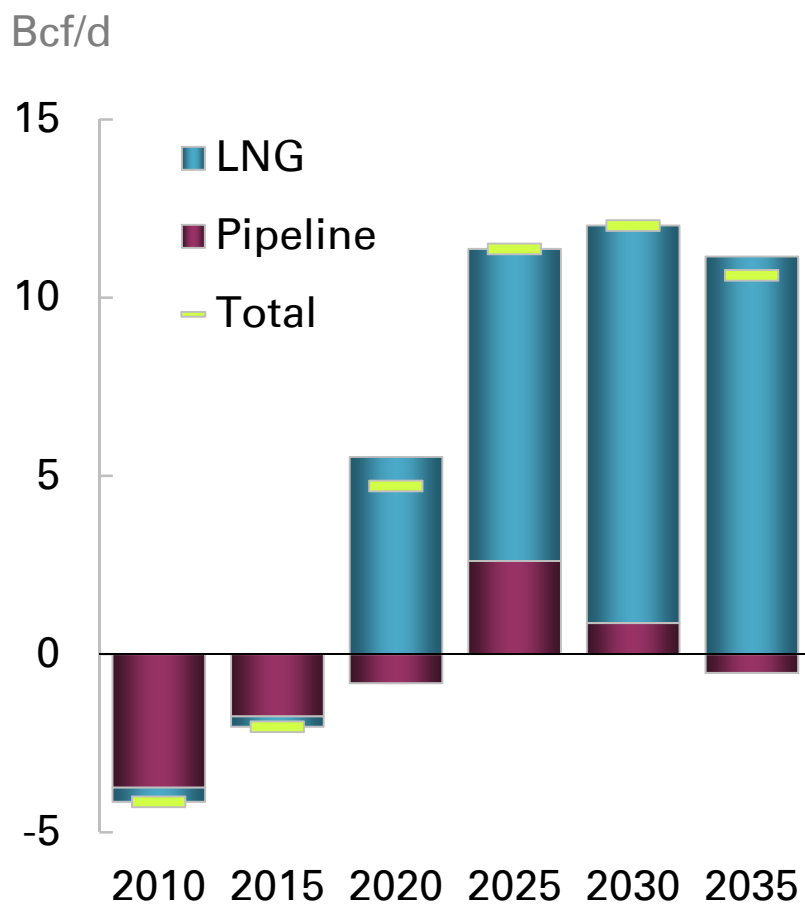
...of how energy markets adjust

- US shale gas output will grow by 4.3% p.a. between 2012 and 2035, enabling US gas production to rise by 45%. This is causing a series of adjustments in energy markets; some already evident, others developing over time.
 - One of the first responses has been on the supply side. A flexible rig fleet that can switch between oil and gas has responded to relatively low gas prices by focussing more on liquids growth.
 - On the demand side, shale gas gives US natural gas a competitive advantage relative to other fuels. This is already visible in the power sector, where gas is likely to continue to grow (0.5% p.a.) at the expense of coal, despite the rapid expansion of renewables.
 - Next, gas will gain market share in the industrial sector, from 39% in 2012 to 42% by 2035. And finally, gas will start to penetrate the transport sector. Gas is the fastest growing fuel (18% p.a.) in a sector where overall demand is falling (-0.9% p.a.). By 2035 gas will account for 8% of US transport sector fuels, almost matching biofuels.
-

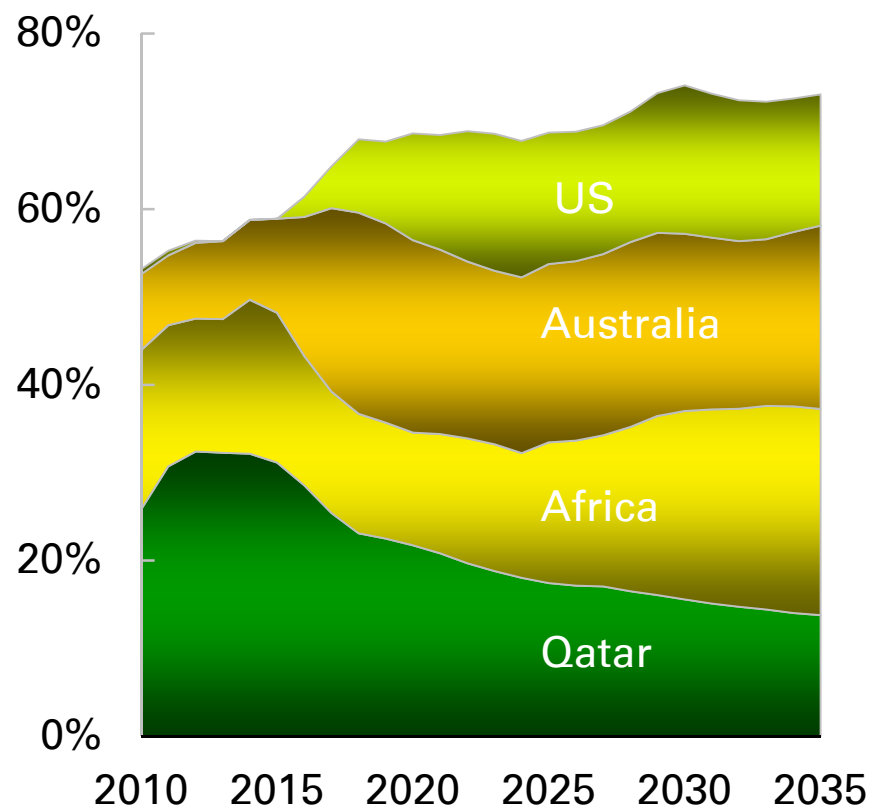


Shale gas will completely change the US gas trade picture...

US natural gas net exports



Share of global LNG trade



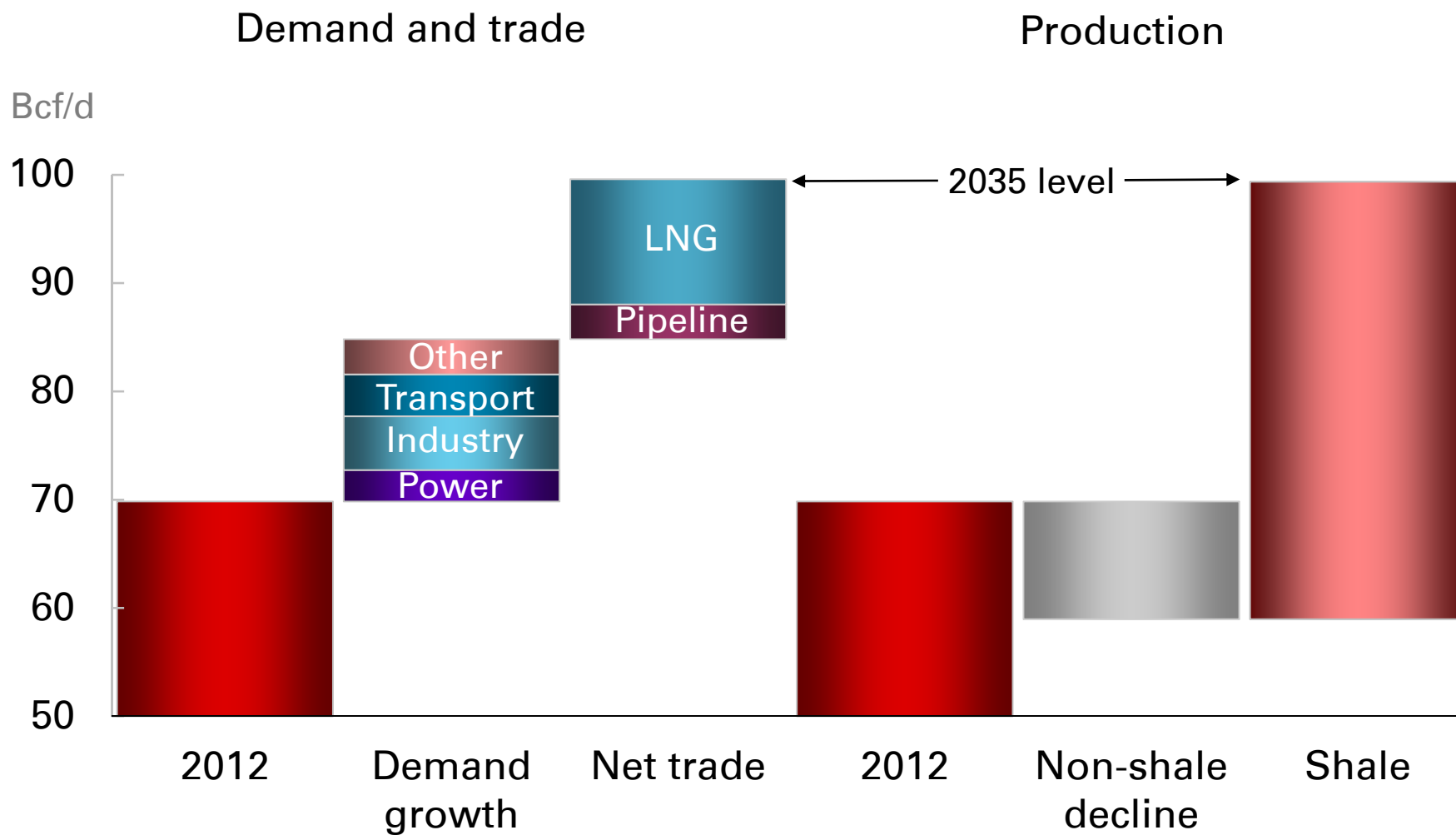


...with a profound impact on global LNG trade

- Perhaps the most dramatic adjustments to shale gas are seen in trade flows. The US is set to shift from a net importer of gas today to a net exporter in 2018, with net exports reaching 10.6 Bcf/d by 2035. It will become a net LNG exporter from 2016, reaching a total net LNG export volume of 11.2 Bcf/d by 2035.
- The arrival of US LNG exports at scale has a profound impact on global LNG markets, contributing to a shake-up in the structure of LNG supplies. Australia is set to overtake Qatar as the largest LNG exporting country by 2019, followed by the US overtaking Qatar in 2030. And Africa as a region is likely to overtake the Middle East.
- Increasing diversification of LNG supply sources supports the globalization of the gas market. Australia is expected to be the largest LNG exporter in 2035 with a share of 21% of global LNG trade; that compares to a share of 32% held by the dominant supplier today, Qatar.



US shale gas not only offsets declines in conventional supply...





...but also accommodates demand growth and shifts in trade

- US domestic gas production has been revitalized by the shale gas 'revolution'. US shale gas output by 2029 will exceed the highest level ever achieved by conventional gas production in the US. By 2035, shale gas production will be just short of US total gas output in 2012.
- How does the market accommodate this shale gas 'shock'? All the elements of the supply and demand balance adjust, responding to relative price movements. Conventional supply declines faster than it would have done in the absence of shale; gas gains share in the various segments of US energy markets, in competition with other fuels; and US gas gains share in the international market in competition with other suppliers.
- These responses emerge at different timescales, from the easiest and least constrained (e.g. coal to gas switching in power) to the more difficult and slowest (e.g. developing the infrastructure and technology to get gas into transport).



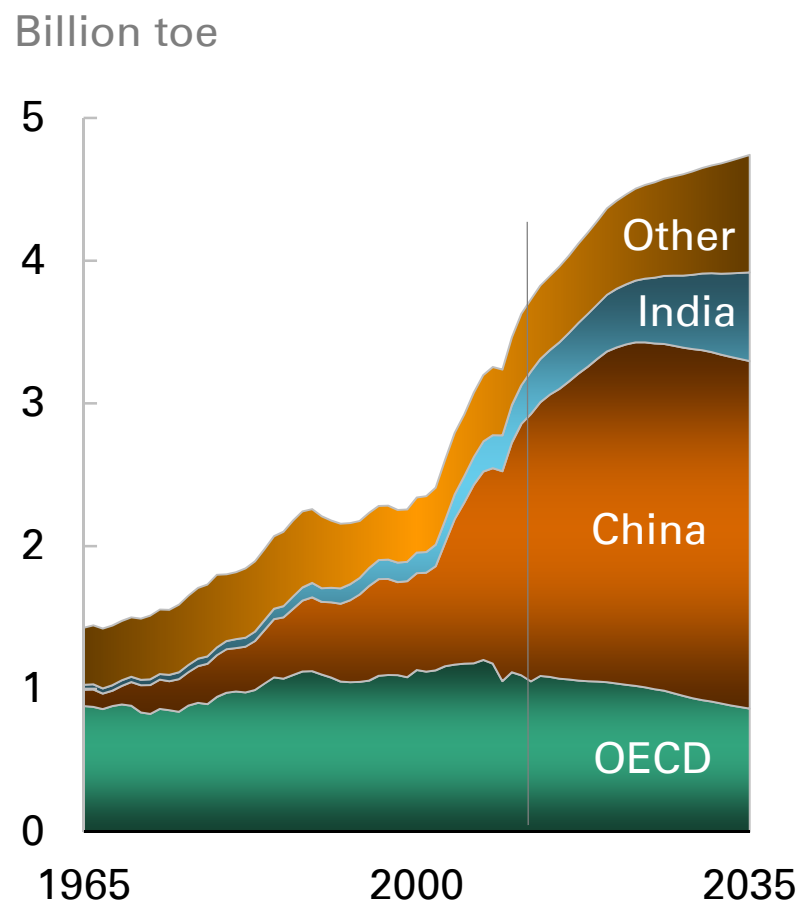


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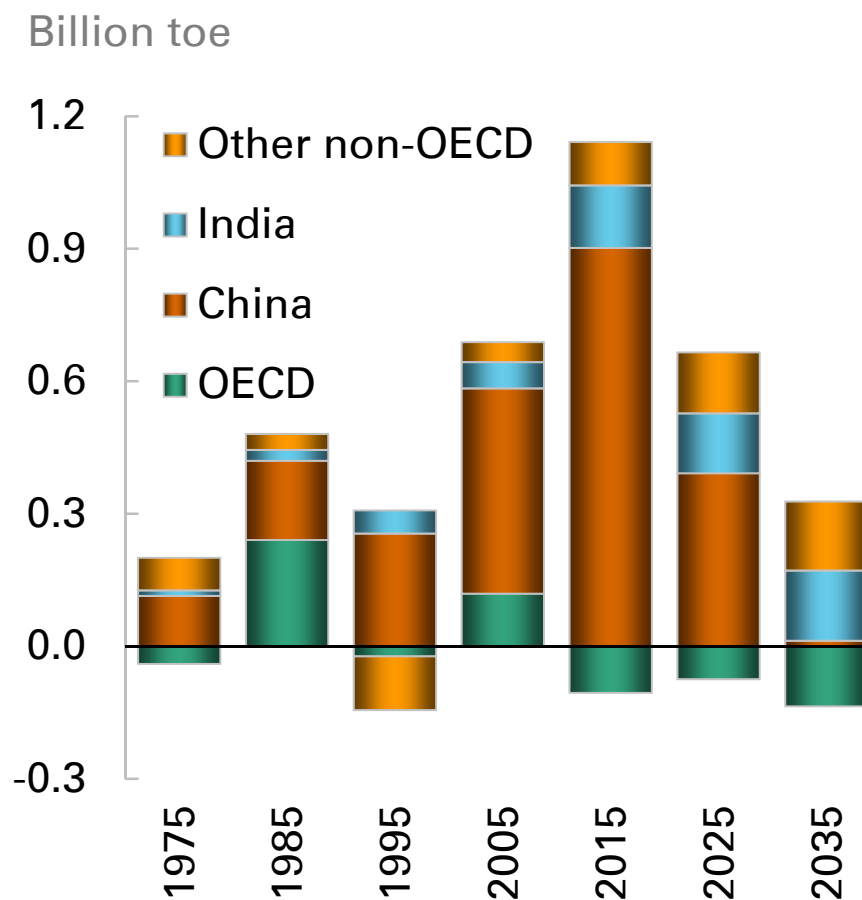


Coal consumption growth slows in the non-OECD...

Consumption by region



Ten year increments by region



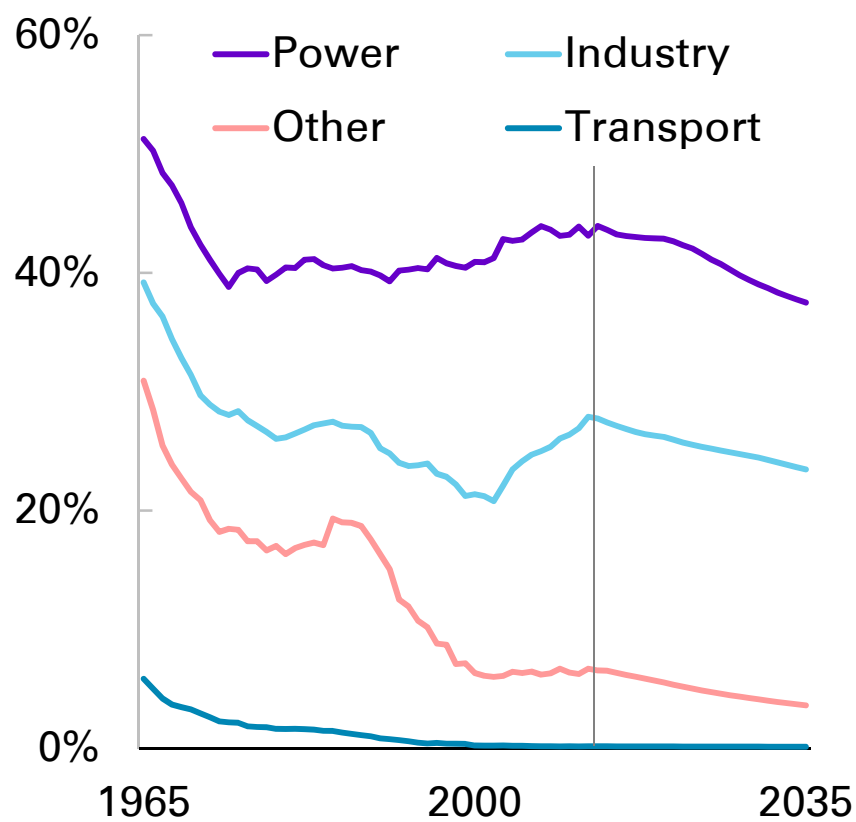


...while the OECD reduces its reliance on coal

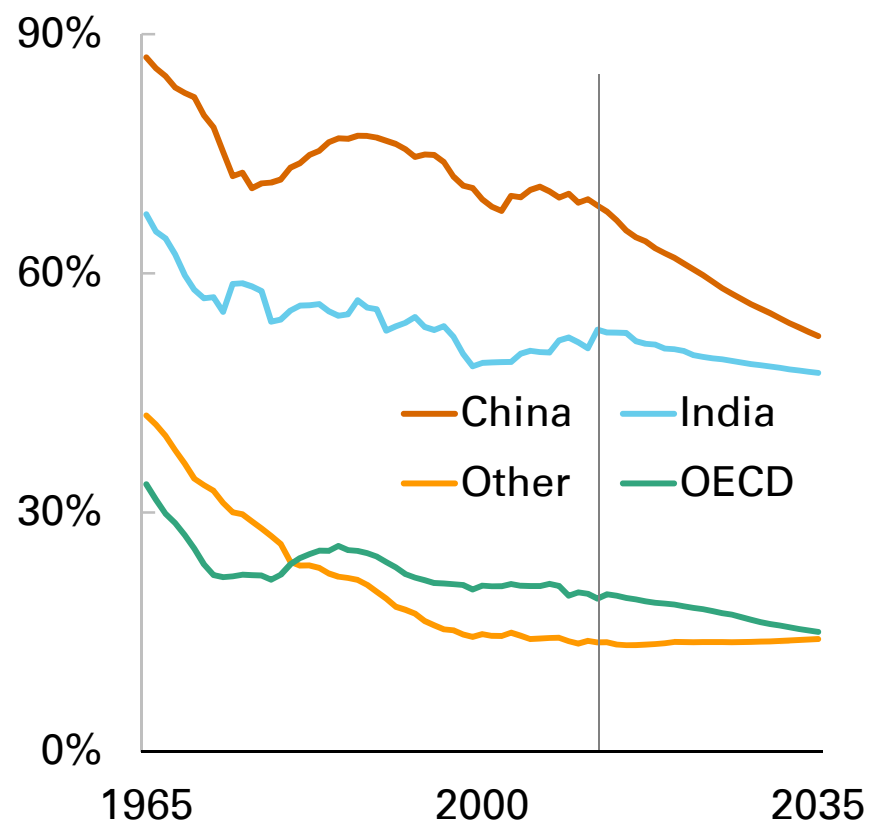
- Global coal consumption rises by 1.1% p.a. in 2012-35. Consumption continues to grow in the non-OECD (1.6% p.a.), offsetting the decline in the OECD (-0.9% p.a.). China and India combined will contribute 87% of global coal growth to 2035. With 51% of global consumption, China remains the largest coal consumer in 2035, while India (13%) will overtake the US to occupy second place in 2024. The OECD's share will drop from 28% in 2012 to 18% in 2035.
 - China's coal demand growth decelerates rapidly from 902 Mtoe (6.1% p.a.) in 2005-15 to just 13 Mtoe (0.1% p.a.) in 2025-35. After 2030, demand will likely decline (-0.1% p.a.), driven by the rebalancing of China's economy toward services and domestic consumption, and supported by efficiency improvements and more stringent environmental policy. China's profile explains the marked slowdown in global coal growth.
 - India's demand growth, in contrast, remains robust; rising from 142 Mtoe (5.9% p.a.) in 2005-15 to 159 Mtoe (3.0% p.a.) in 2025-35 as the country's industrialization continues. In the final decade India replaces China as the leading source of coal demand growth.
-

Coal loses market share...

Coal share in sector



Coal share in primary energy



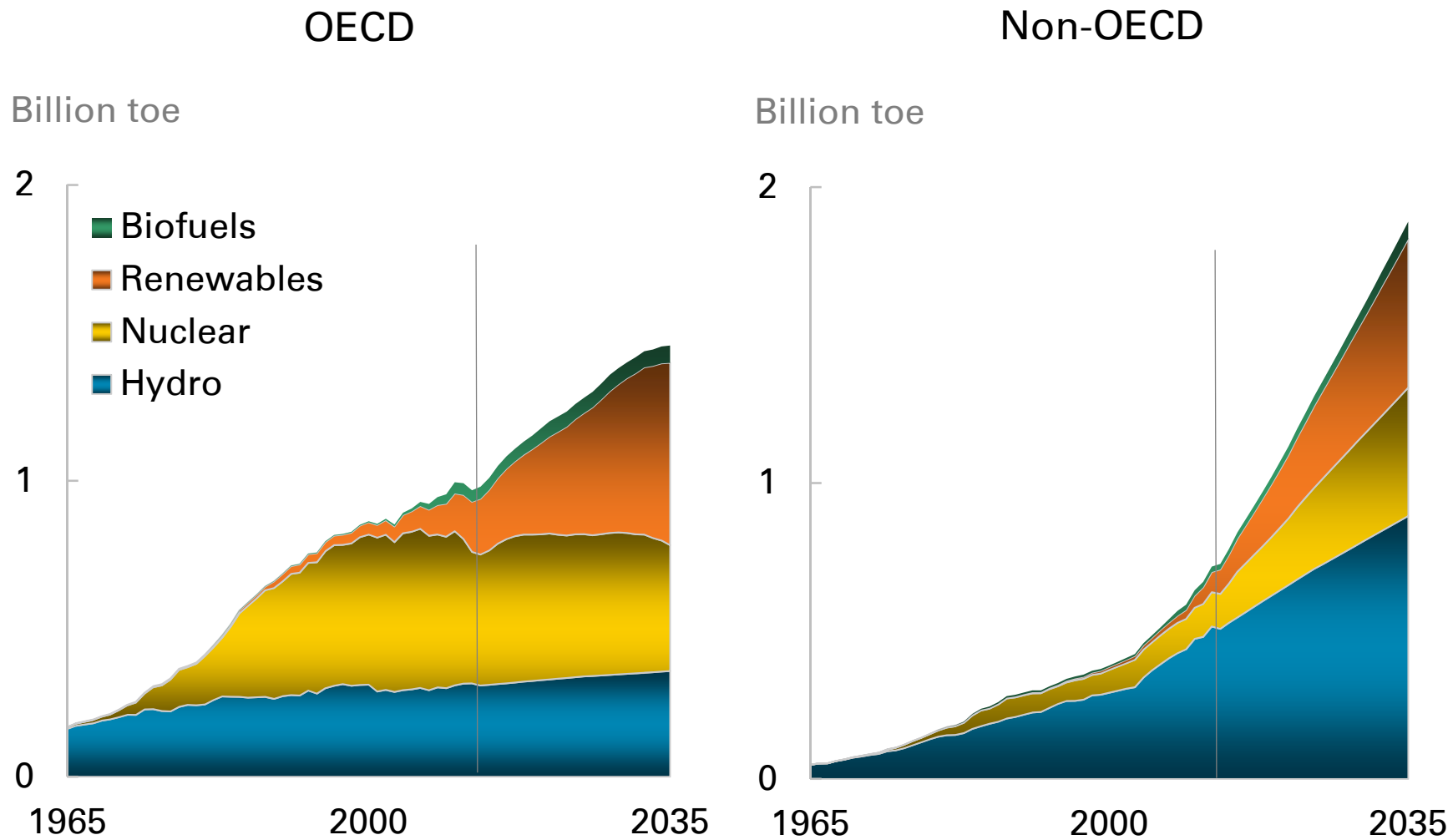


...as the global economy gradually switches to cleaner fuels

- Coal's share declines in all sectors. In power generation, the largest coal consuming sector, the share of coal will decline from 43% in 2012 to 37% by 2035, as renewables gain share.
- In industry, where coal has been gaining importance since 2002, it is beginning to lose market share (from 28% in 2012 to 23% in 2035) to electricity and gas.
- Following a long-term trend, coal's share in the other sector, where it is replaced by electricity, continues to fall (from 7% to 4%).
- Globally, coal's share in primary energy will decline from 30% in 2012 to 27% in 2035. It declines across all regions except non-OECD Asia outside China and India, where abundant coal and expensive gas cause coal's share to rise, offsetting the fall in share elsewhere in the non-OECD.
- By 2035, China is still the region with the highest coal share in primary energy (52%), despite recording the largest decline in that share (from 68% in 2012).



Renewables lead the growth of non-fossil fuels in the OECD...





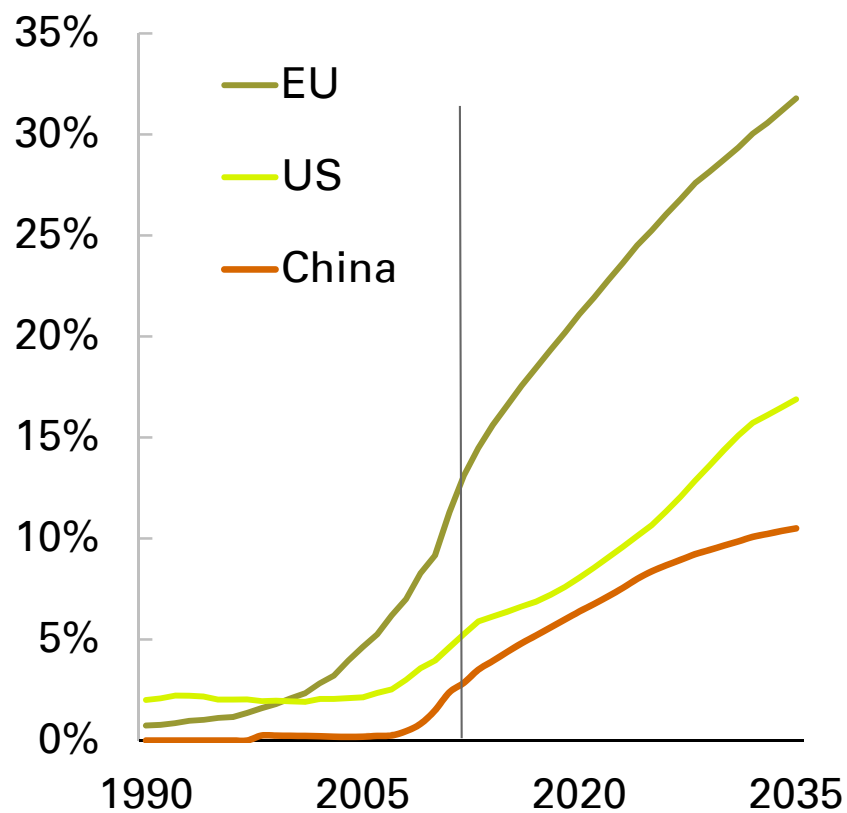
...while growth is more evenly spread in the non-OECD

- In aggregate, non-fossil fuels grow faster than total energy consumption in both the OECD (1.8% p.a.) and the non-OECD (4.3% p.a.): between 2012 and 2035 the non-fossil share of primary energy increases from 18% to 25% in the OECD, and from 10% to 16% in the non-OECD.
- In the OECD, the rapid growth of renewables in power (5.8% p.a.) more than offsets declining nuclear (-0.2% p.a.) and weak growth in hydro power (0.5% p.a.). Non-fossil fuels are the leading source of energy growth in the OECD, ahead of natural gas.
- By contrast, the non-OECD sees significant growth in all non-fossil sources, led by renewables (9.1% p.a.), then nuclear (5.9% p.a.) and hydro power (2.4% p.a.). Non-fossil fuels contribute 24% of the growth of primary energy in the non-OECD to 2035, almost matching the roughly equal contributions of oil, gas and coal.

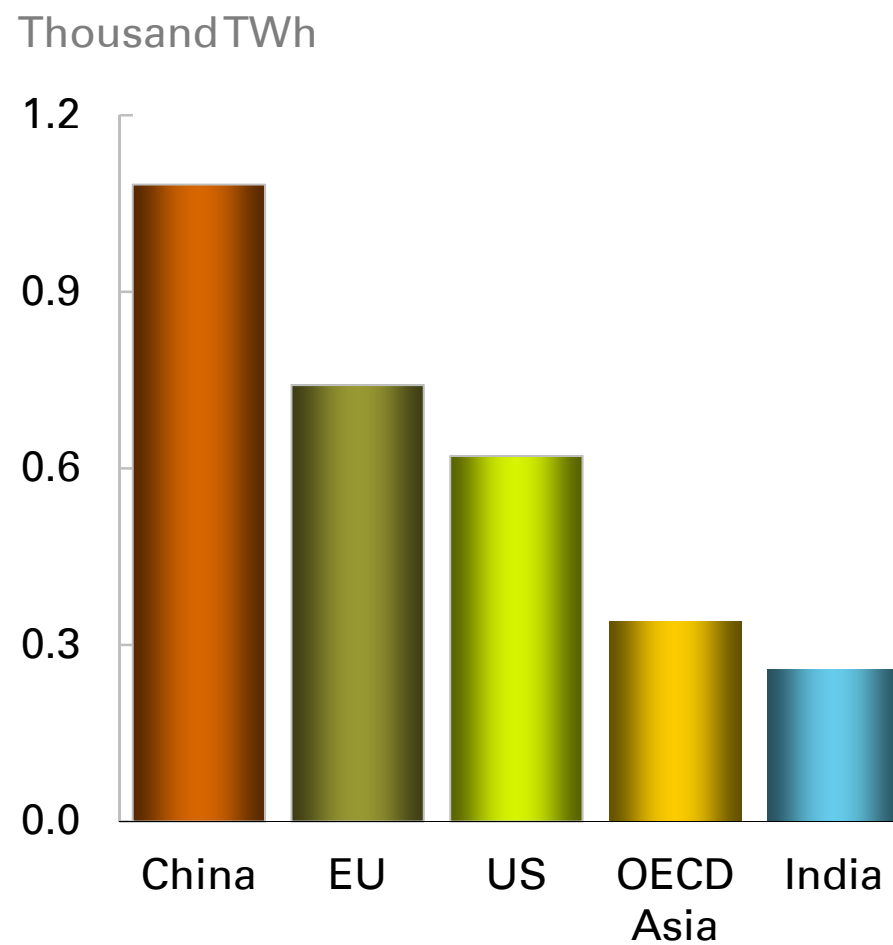


Renewables in power gain share most rapidly in Europe...

Renewables share of power



Renewables growth 2012 to 2035





...while China adds the most volume

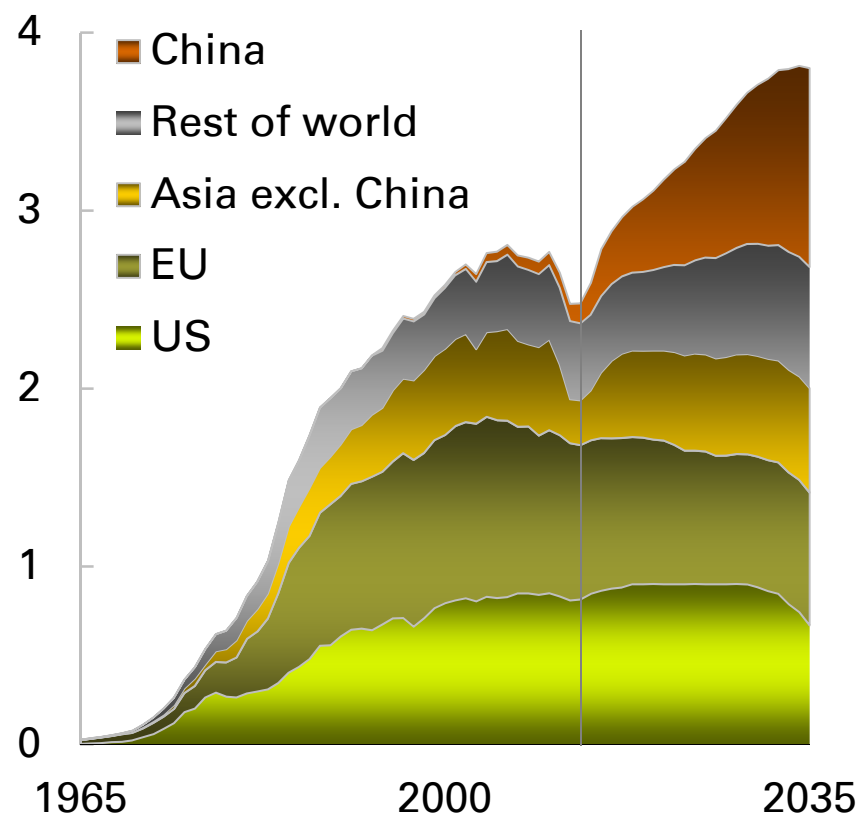
- The deployment of renewables for power has been led by Europe, with a strong policy push in the EU in particular; the EU will continue to have the highest penetration rates of renewables worldwide. The share of renewables in power generation in the EU increases from 13% in 2012 to 32% in 2035.
- Continued improvements in the cost and performance of renewables reduce the need for policy support. From around 2020 wind power is increasingly able to compete without subsidization – particularly in markets that have a significant carbon price. By 2030, wind will be a serious contender for any new-build power, especially in regions where carbon prices reach \$40/tonne or more.
- This enables the continued penetration of renewables in Europe, and the spread of renewables to other regions. In terms of renewables volume growth, the EU is surpassed by China, and almost matched by the US.



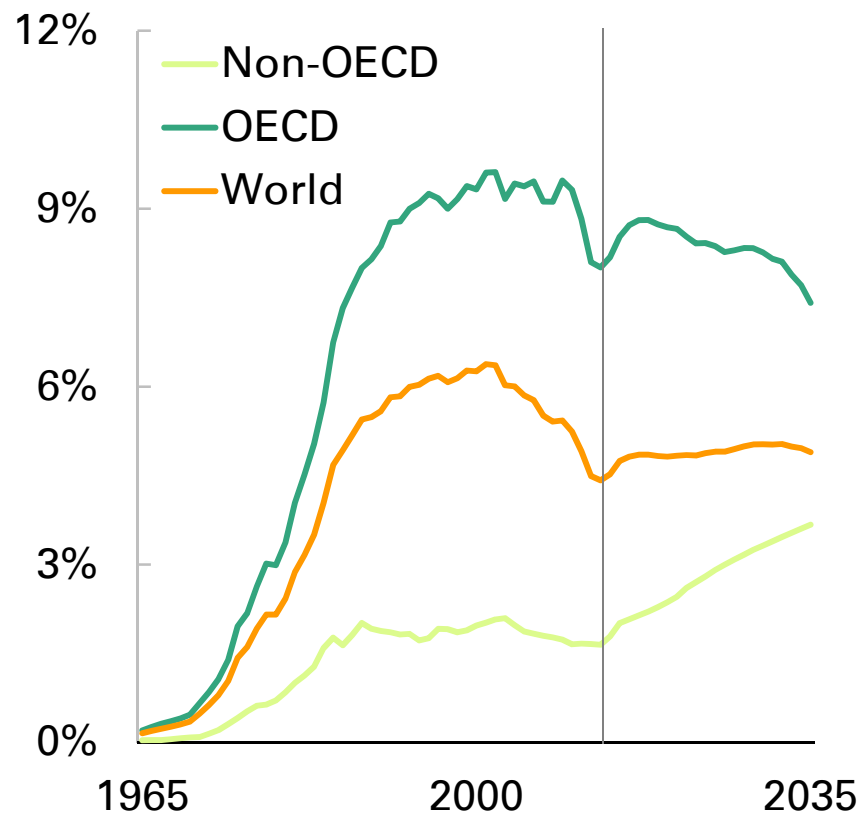
Global nuclear power production rises...

Nuclear generation by region

Thousand TWh



Share of nuclear in primary energy





...on the back of growth in China, Russia and India

- Global nuclear energy is projected to grow by 1.9% p.a. between 2012 and 2035. However, as a share of global primary energy demand, nuclear power peaked in 2001 and is not expected to return to past levels.
- In the OECD, nuclear generation is expected to decline (-0.2% p.a.) as aging plants are gradually decommissioned. The economics of nuclear energy, given stringent safety requirements remain difficult in competitive markets, and very few new plants are expected to be built.
- Global growth therefore is driven by the non-OECD (5.9% p.a.) and in particular by China, where new capacity additions will match the growth seen in the US and EU in the 1970s and 1980s.
- Looking beyond 2030 illuminates a potential turning point for nuclear energy. Many reactors among the first adopters of nuclear technology, such as the US and Europe, will approach technical retirement, while only a few countries plan to add new capacity. Even allowing for additional lifetime extensions, we may well see a peak in nuclear energy.





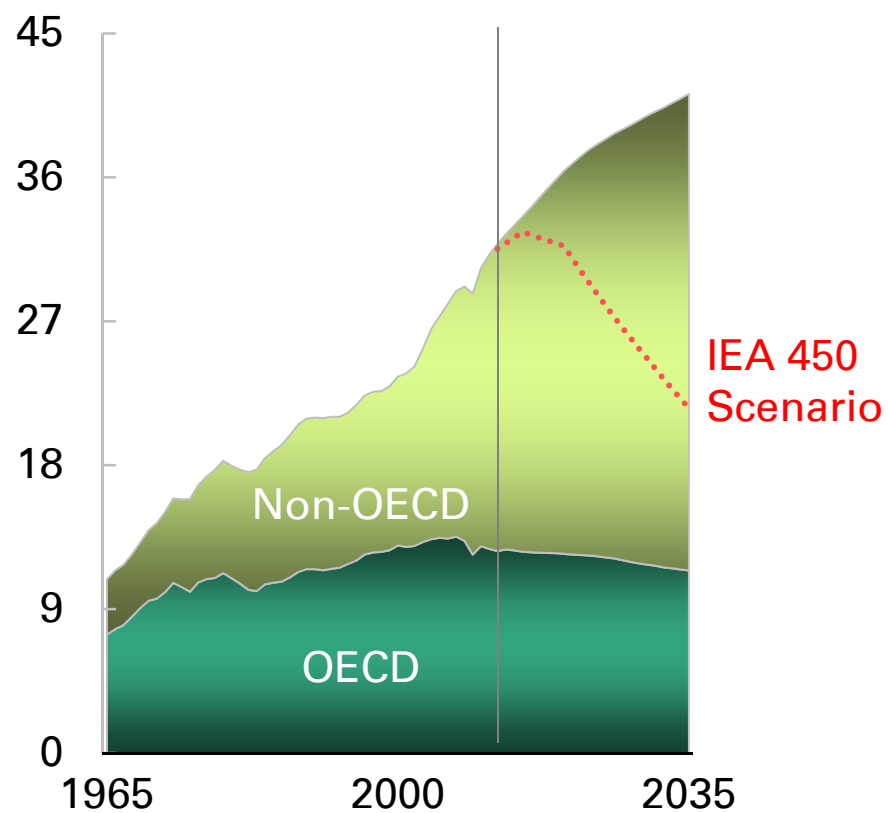
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CO₂ emissions from energy use continue to rise...

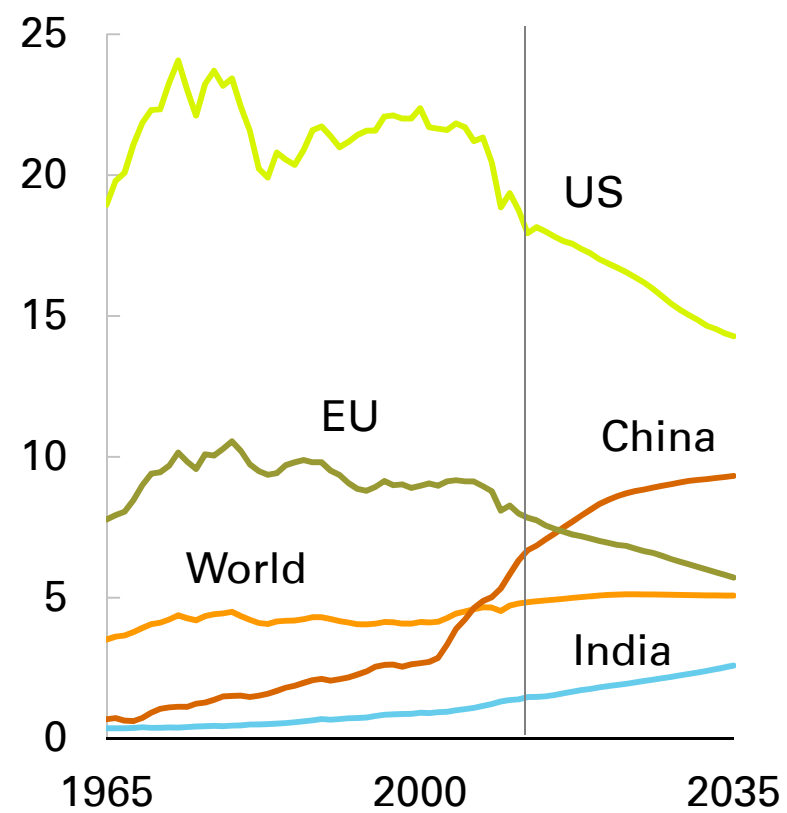
Emissions by region

Billion tonnes CO₂



Emissions per capita

Tonnes CO₂





...with per capita emissions declining in the OECD

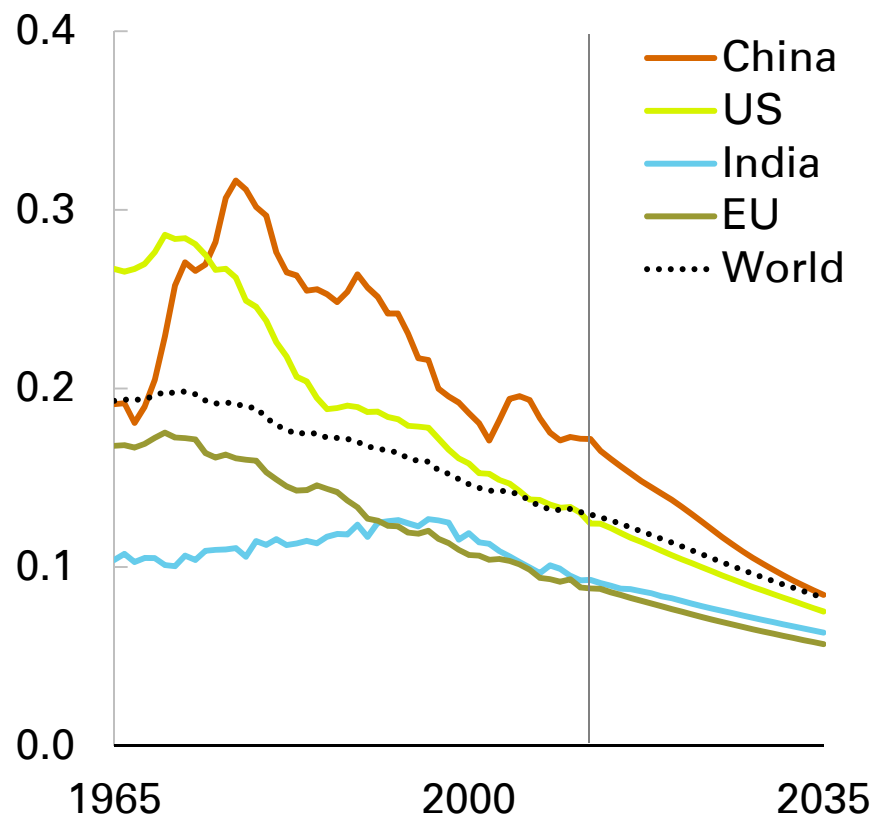
- Global CO₂ emissions from energy use grow by 29% or 1.1% p.a. over the forecasting period. Policies to curb emissions continue to tighten, and the rate of growth of emissions declines, but emissions remain well above the path recommended by scientists (illustrated by the IEA's "450 Scenario"). Global emissions in 2035 are nearly double the 1990 level.
- Emissions growth is due to non-OECD economies (1.9% p.a.) while OECD emissions continue to decline (-0.4% p.a.). The OECD falls back to 1990 levels; non-OECD emissions in 2035 are more than triple the 1990 level.
- Emissions grow more slowly than energy consumption, as the energy mix gradually decarbonises. By fuel, coal and gas each contribute 38% of the increase in emissions, with 24% coming from oil.
- In per capita terms, China overtakes the EU in 2017, and the OECD average in 2033, but remains well below the US level in 2035.



Energy intensity of GDP and carbon intensity of energy...

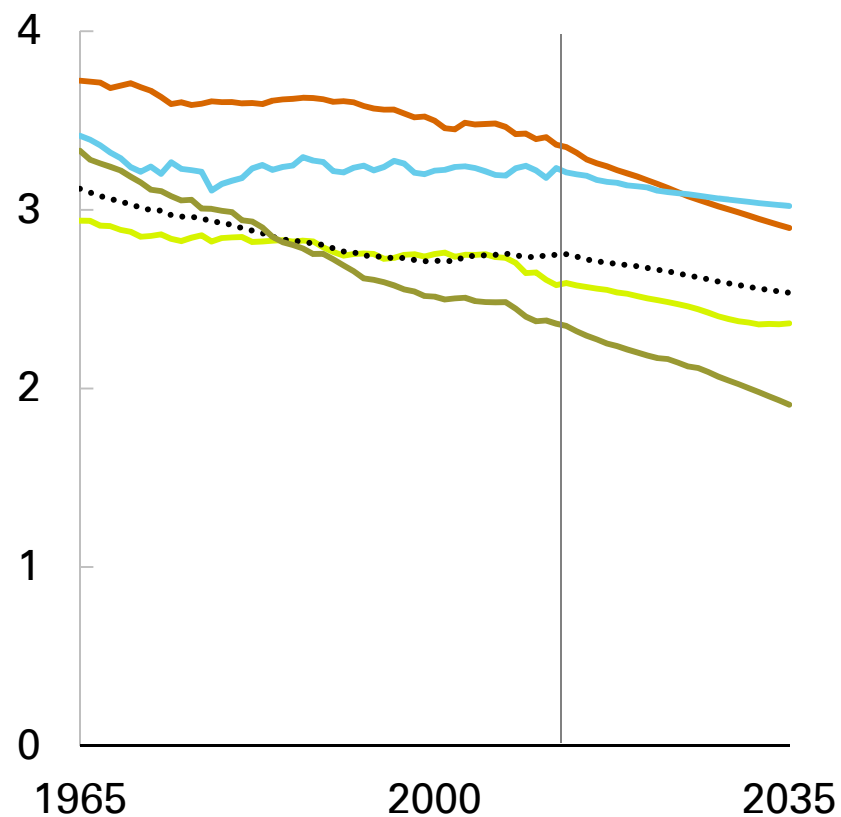
Energy intensity

Toe per thousand \$2012 GDP



Carbon intensity

Tonnes CO₂ per toe





...follow different patterns

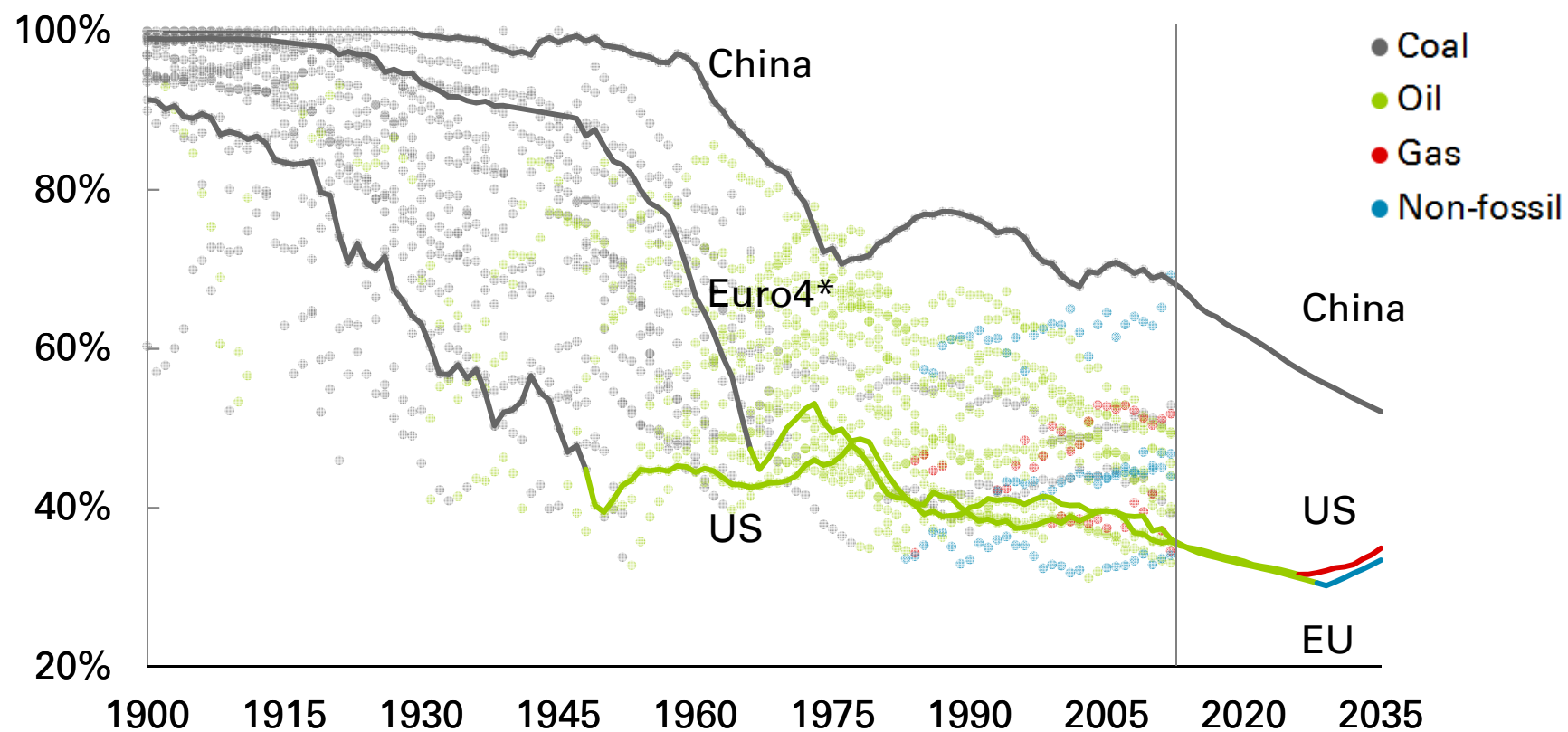
- Given economic growth, CO₂ emissions depend on energy intensity (the amount of energy used per unit of GDP) and carbon intensity or the carbon content of the energy mix (carbon per unit of energy).
 - Global energy intensity is improving rapidly, converging across countries at lower and lower levels. We project it to decline by a further 36% by 2035 (-1.9% p.a.), with differences across countries the smallest since the Industrial Revolution. Decline and convergence are both the outcome of market forces and global competition, promoting the most efficient use of energy everywhere.
 - Carbon intensity, in contrast, declines at a slower pace – by 8% between 2012 and 2035 (-0.3% p.a.). There is also no apparent convergence, with countries following different, albeit downward trends.
 - Changes in carbon intensity are a function of changes in the fuel mix. In the absence of a price for carbon, the fuel mix is shaped by other factors and the observed decline in carbon intensity, as well as the path followed by individual countries, becomes a by-product of those other factors.
-



The fuel mix diversifies over time...

Evolution of the fuel mix in 20 major countries

Share of dominant fuel



*France, Germany, Italy and United Kingdom pre-1965



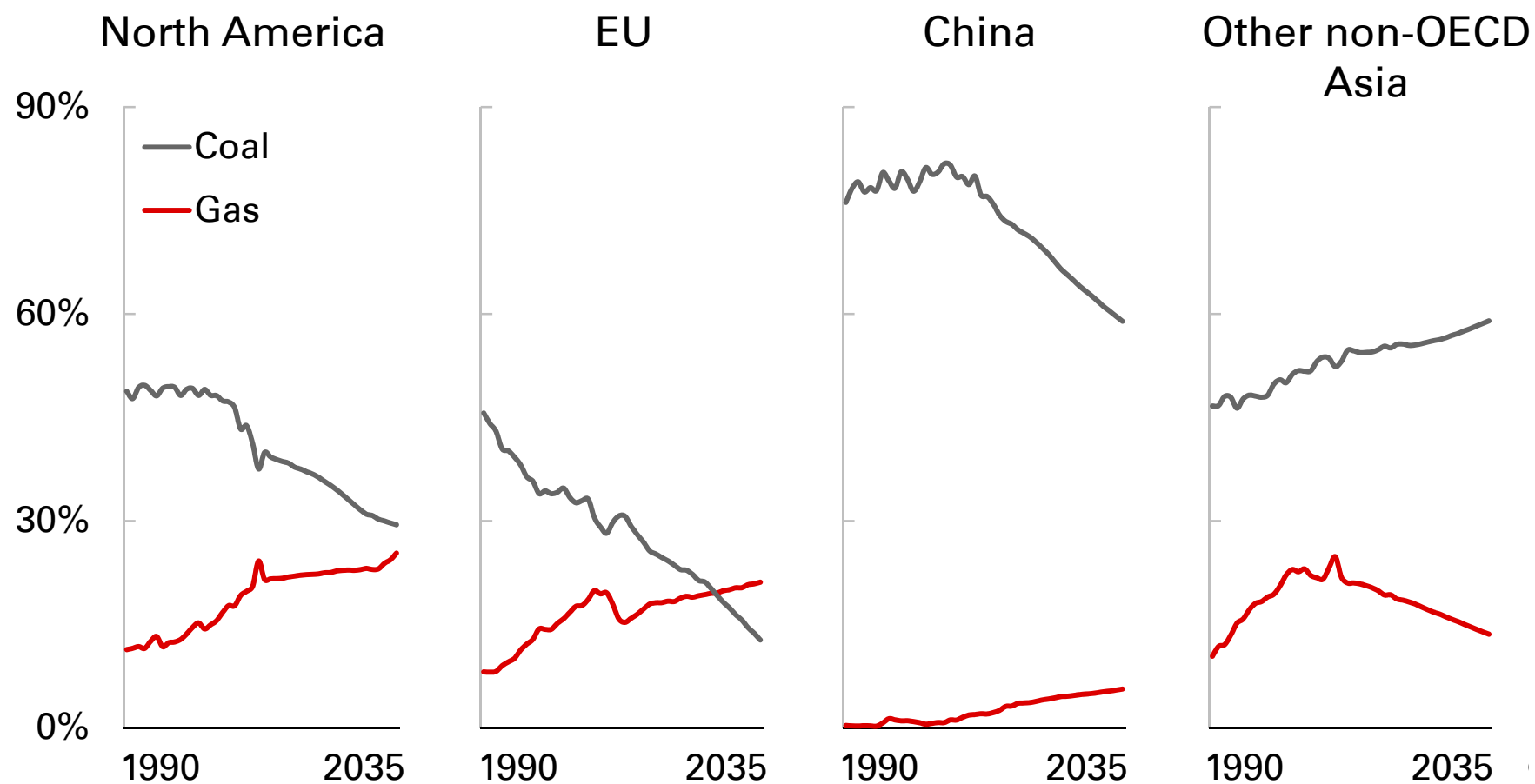
...and becomes less carbon intensive as a by-product

- Historically, as economies grew richer and more sophisticated, the fuel mix became more diversified. The scope for changes in the fuel mix depends on technology, resource endowments and tradability, and the underlying economic structure. As incomes rise we put a premium on cleaner and more convenient fuels. The actual substitution between fuels is typically guided by relative prices.
- Early industrialization was based almost entirely on coal. Cheap oil and the internal combustion engine helped oil to replace coal as the dominant fuel. Gradually, the energy mix diversified further with fuels specializing in various applications (oil in transport, coal in power). Overall, the fuel mix remains determined by availability and the local cost of fuels. Countries with lower energy intensity tend to have more scope to afford cleaner and more convenient fuels.
- The historical pattern of fuel diversification has tended to reduce carbon intensity, but until recently, this trend was largely the accidental outcome of changes in the availability and relative cost of various fuels.



The power sector is the main driver of fuel mix changes...

Share of power sector fuel consumption





...with different regional outcomes for coal-gas competition

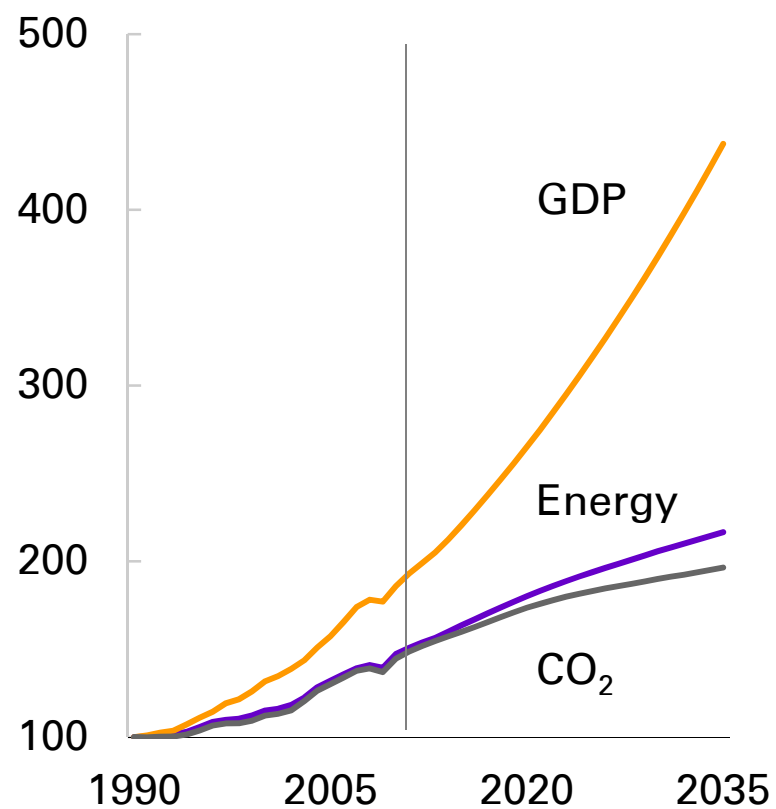
- The power sector, where all fuels compete, is the largest and most diversified driver of the global fuel mix. The global competition between coal and natural gas gives an example of the underlying forces at work.
 - Changes are relatively small on the global level. The share of coal in power generation falls from 43% to 37% between 2012-35, while the share of natural gas remains at 21%. But these aggregate changes mask much livelier regional patterns.
 - In North America, gas gains on the back of new technologies unlocking new, cheaper supplies. In the EU, a similar outcome but on the back of carbon price and climate change policy (but note the temporary replacement of gas with cheaper coal in recent years). China's economy is based on local coal; economic rebalancing and a preference for cleaner fuels will, with rising income, gradually change this situation. In the rest of developing Asia, coal simply remains the most economic option.
 - These massive changes partly offset each other. Except in the EU, they are driven by economics.
-



Energy efficiency is restraining emissions growth...

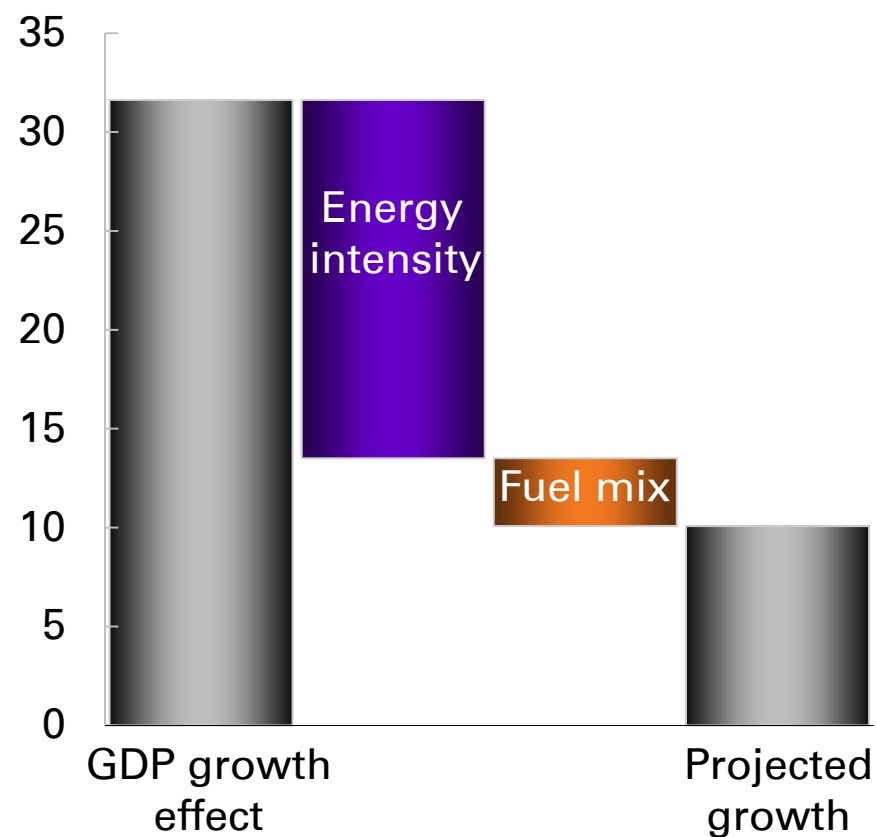
GDP, energy and emissions

Index: 1990 = 100



Emissions growth 2012 to 2035

Billion tonnes CO₂





...but fuel mix changes remain a missed opportunity

- The widening gap between GDP and energy consumption illustrates the impact of falling energy intensity; and the gap between energy and CO₂ emissions reflects changes in carbon intensity, brought about by changes in the fuel mix.
- Without the projected decline in energy intensity, CO₂ emissions in 2035 would be more than 40% higher than our forecast, given the projected economic growth. The effect of the expected change in the fuel mix is much smaller – about one fifth as large – though bigger than in the past.
- More than half of the fuel mix effect comes from the rising share of renewables; most of the remainder comes from changes in the fossil fuel mix, in particular, the substitution of coal with gas.
- Competition and innovation, guiding the global improvement in energy intensity, are not directing changes in the energy mix toward faster improvements of carbon intensity. The market does not do for carbon intensity what it does for energy intensity because energy is costly, and carbon is not.

Conclusion



Meeting the global energy challenge



- Sufficient and available?
 - Yes – new energy sources and efficiency improvements
- Secure and reliable?
 - Mixed – improving for some, a concern for others
- Sustainable?
 - Room for improvement

Image credit: NASA

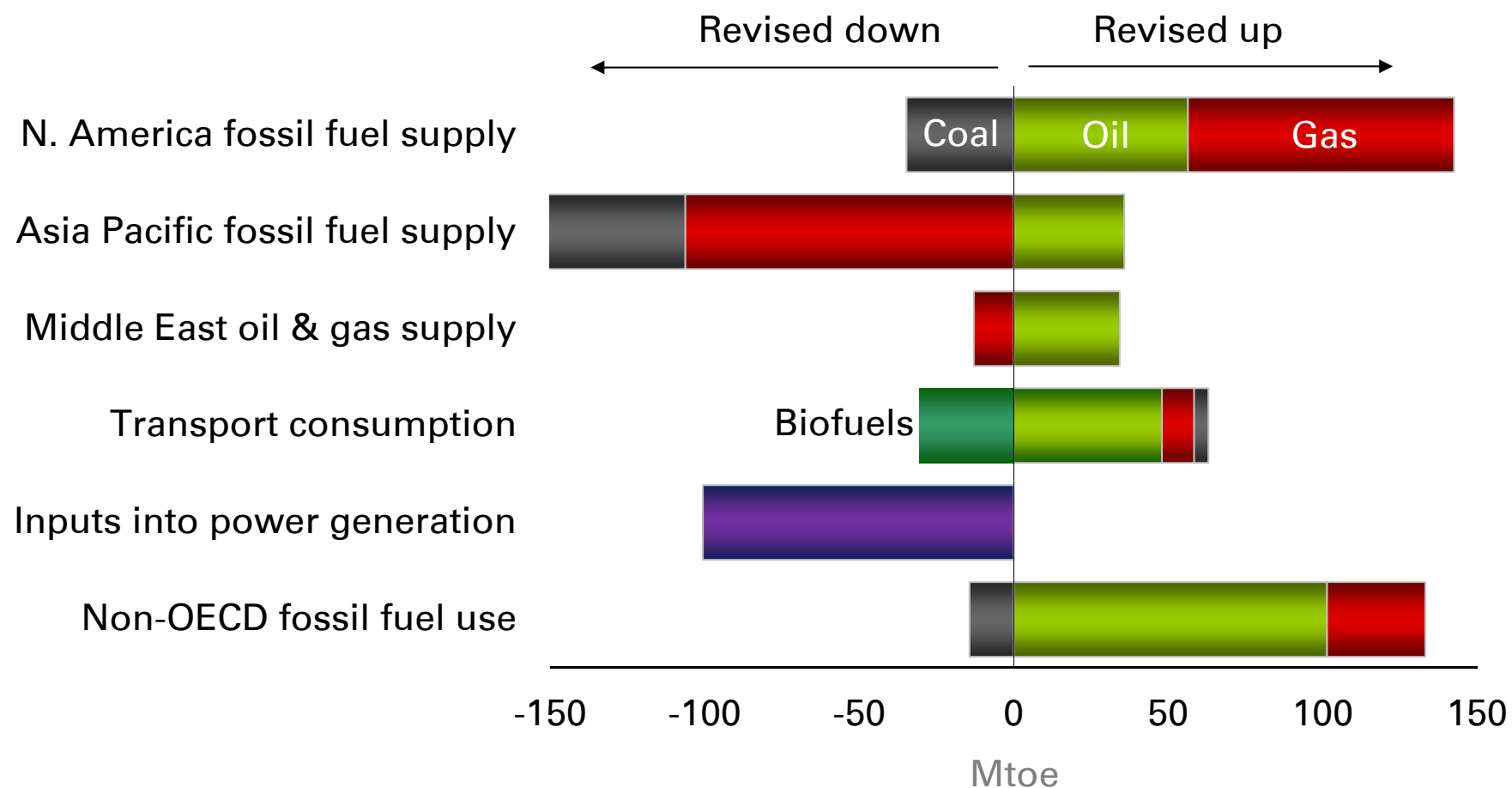


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Key changes versus last year's *Outlook*...

Changes in 2030 levels versus the January 2013 *Outlook*





...result in little net change in total energy

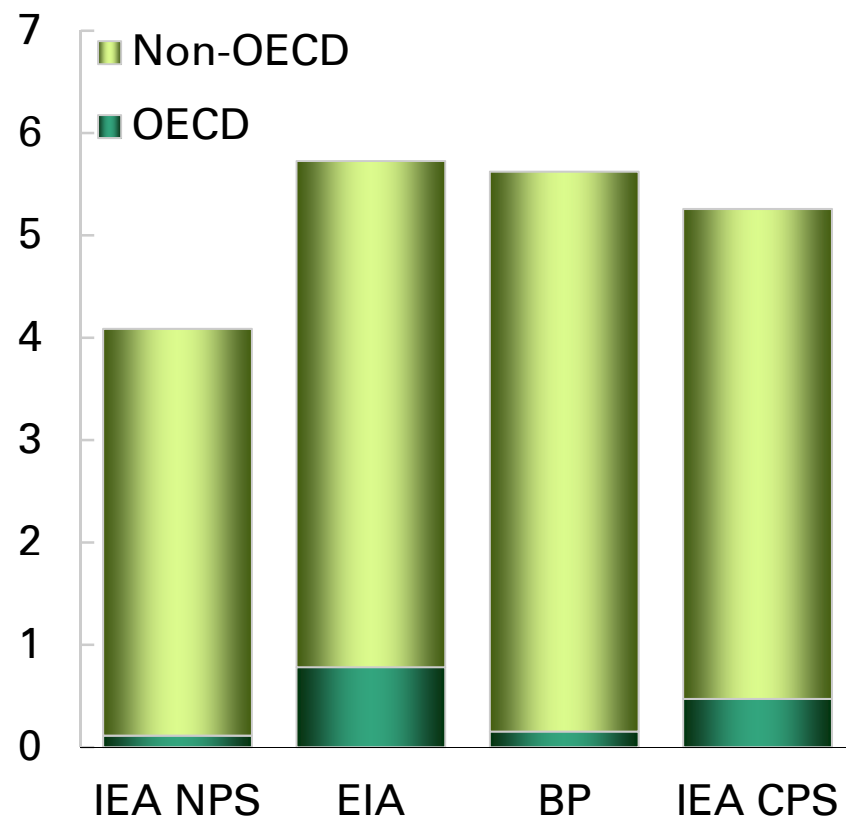
- Our aggregate projection for world energy demand and supply is little changed since our last Outlook – down by about 0.2% in 2030.
 - North America's oil and natural gas supply outlook has been revised higher (7%) due to evolving expectations for shale gas/tight oil plays.
 - Higher oil production in North America, Asia Pacific and the Middle East offsets reduced output in Europe and Africa and helps to meet incremental oil demand throughout the non-OECD.
 - Asia Pacific natural gas supply has been revised down as LNG expansion in the region is assumed to proceed at a more measured pace.
 - Oil and gas useage in the transport sector has been revised up, partly reflecting the need to offset a drop in biofuel supplies resulting from more modest expectations of the penetration of next generation fuels.
 - Inputs to power generation have been revised down, despite little change to electricity consumption, due to a more optimistic outlook for improvements in conversion efficiency.
-



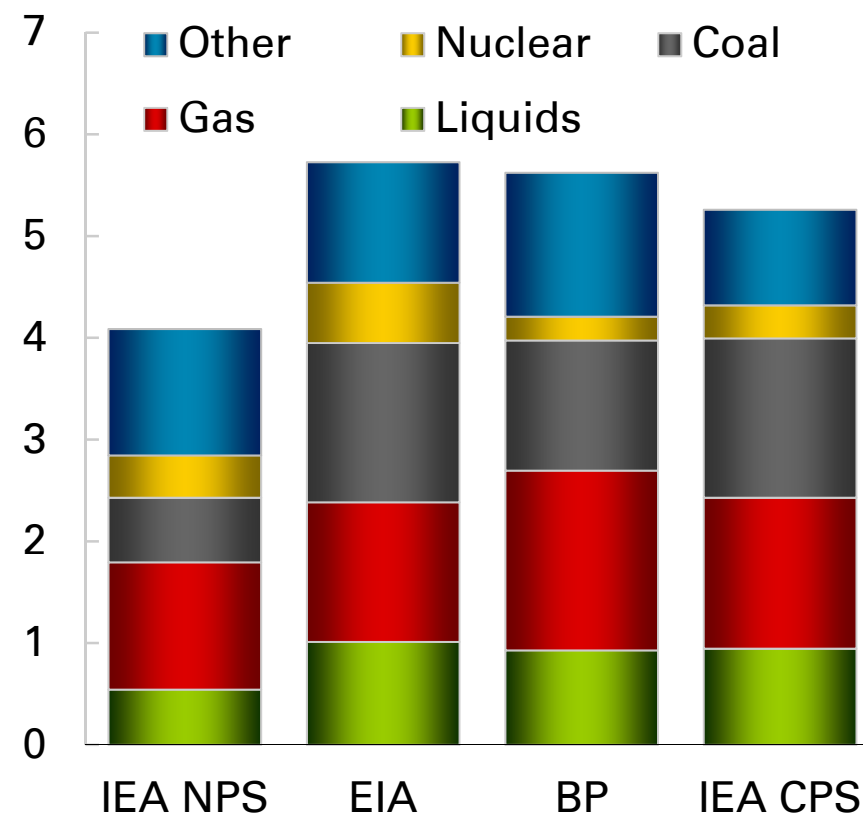
Comparison with other outlooks: the key difference...

Growth of energy consumption, 2010-2035

Billion toe



Billion toe





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

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



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