



Long-Term Energy Outlook

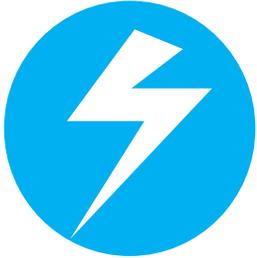
Trends, Challenges, and Opportunities in a Rapidly Evolving System

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Key Takeaways



The Global Energy System

No major near-term transformation likely owing to the momentum advantage of existing energy networks



Behavioral Economics

Uncertainty in consumer behavior is a key component of deployment in renewables and mobility developments



Cost Structure Uncertainties

Forecasts for renewable energy have been hampered by rapid improvements in technology and materials



The Climate Challenge

Emission reduction targets agreed at Paris are not sufficient to meet the 450ppm goal

Economic activity and population growth drive energy demand relative fuel cost, government policies, and behavior set mix



GDP and population growth drive energy

Global GDP rising 3.7% 2015-2030; population up 1.1 billion (90% in non-OECD)



Efficiency & consumer behavior

Improving efficiency & shifts in consumer behaviors reducing the energy intensity of the world economy



Electricity demand

Fastest-growing form of end-use energy consumption, rising 1.5% per year



Policy can shape fuel mix

Efforts to diversify fuel mix favor non-fossil penetration in most key markets

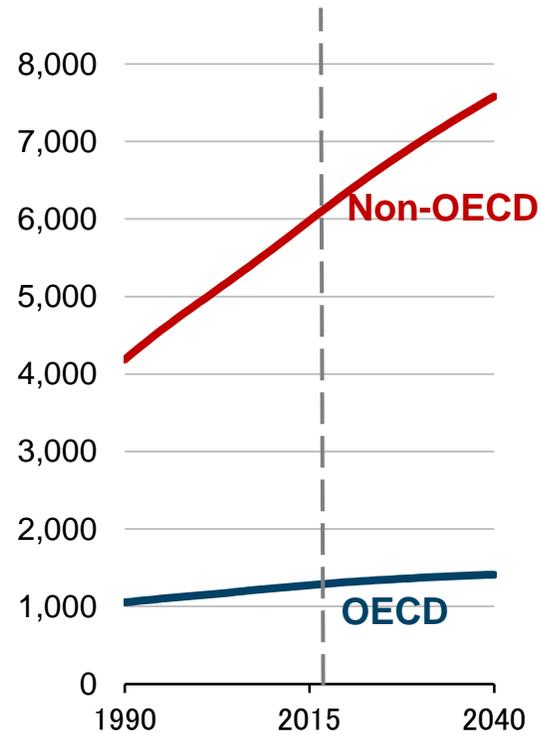


Disruptive technology could upset the consensus

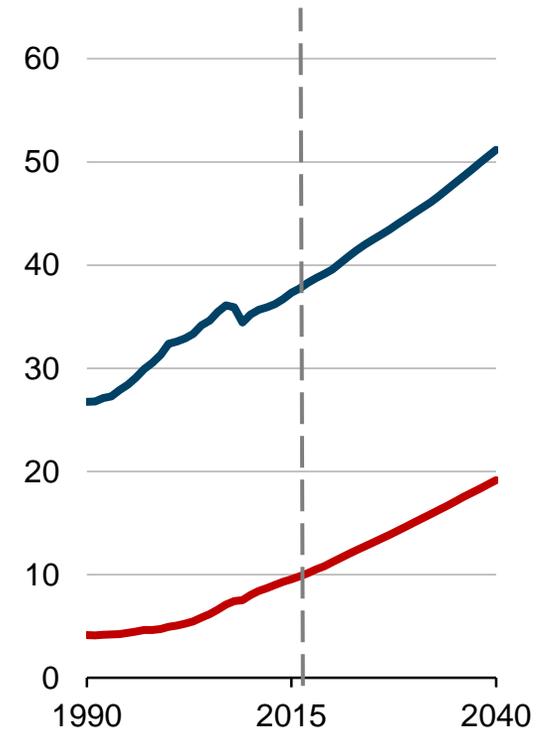
Reference case projections are not meant to be forecasts

Although population and per capita output continue to rise, energy and carbon intensity are projected to continue to fall in the EIA Reference Case

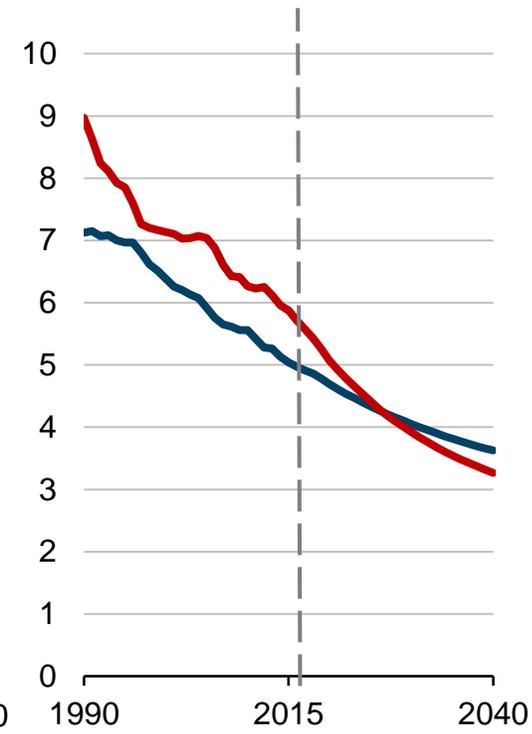
Population
Million people



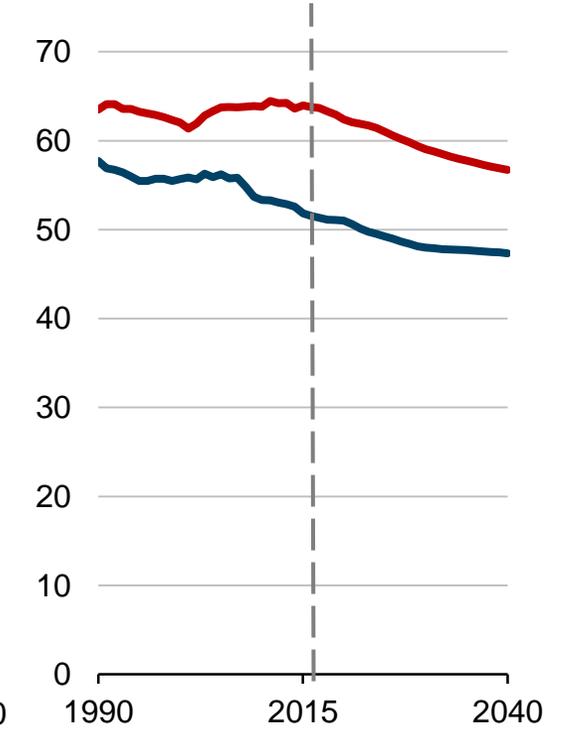
Per capita gross domestic product
Thousand dollars



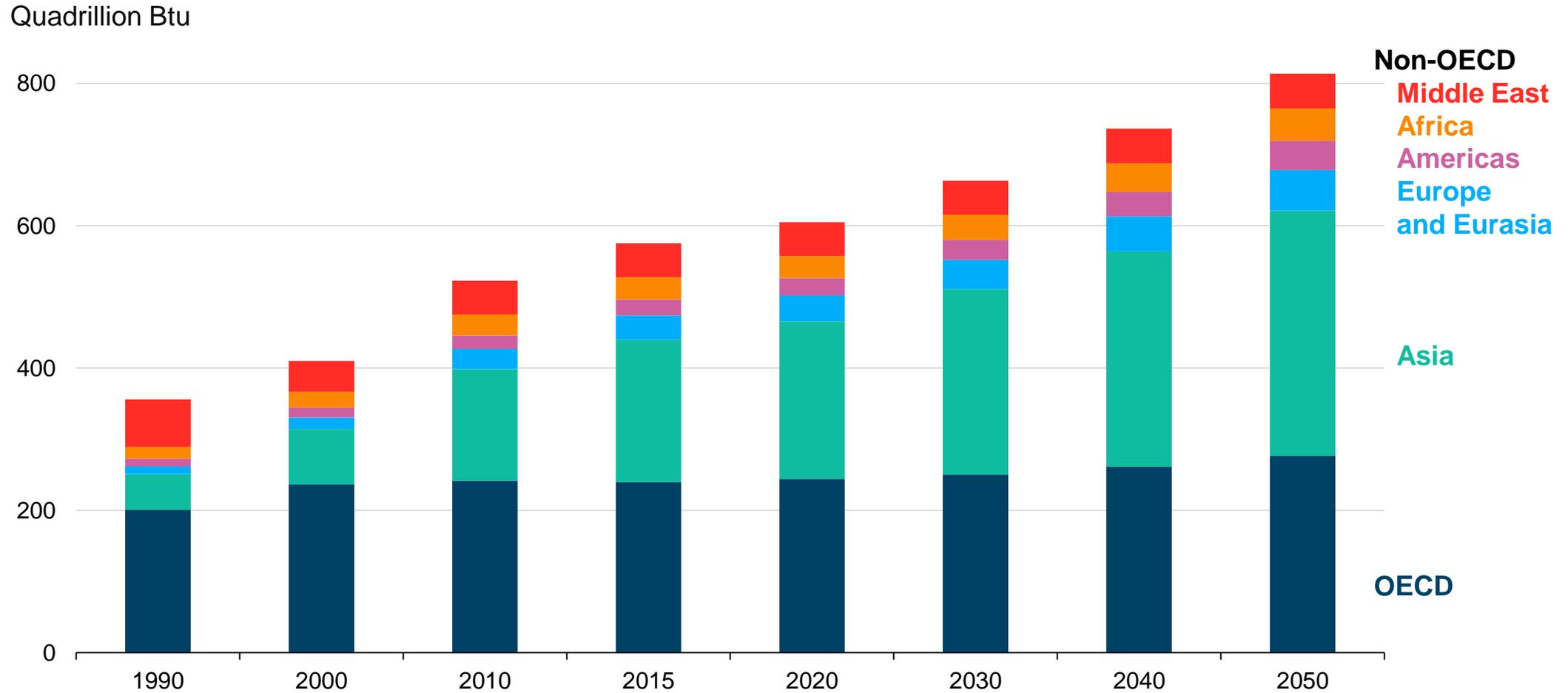
Energy intensity
Thousand Btu per dollar



Carbon intensity
Metric tons CO2 per billion Btu



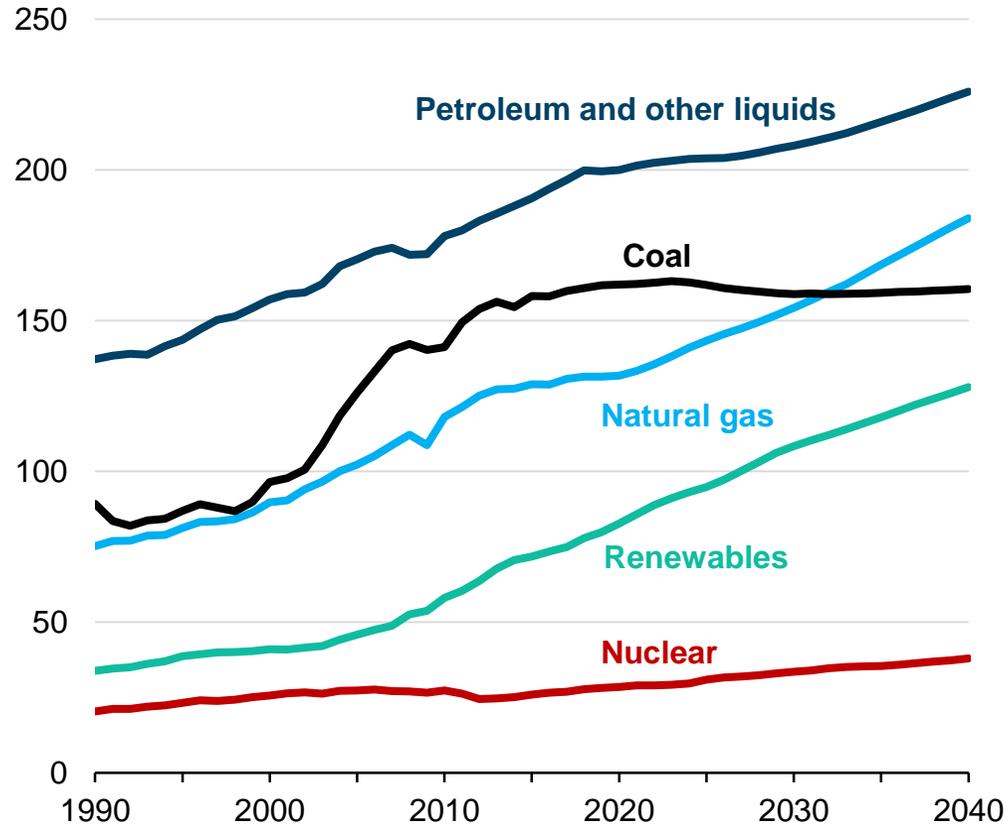
World primary energy consumption: non-OECD growth dominates



World energy consumption: Coal not growing and could fall faster; renewables growing the fastest; electricity is the largest energy user

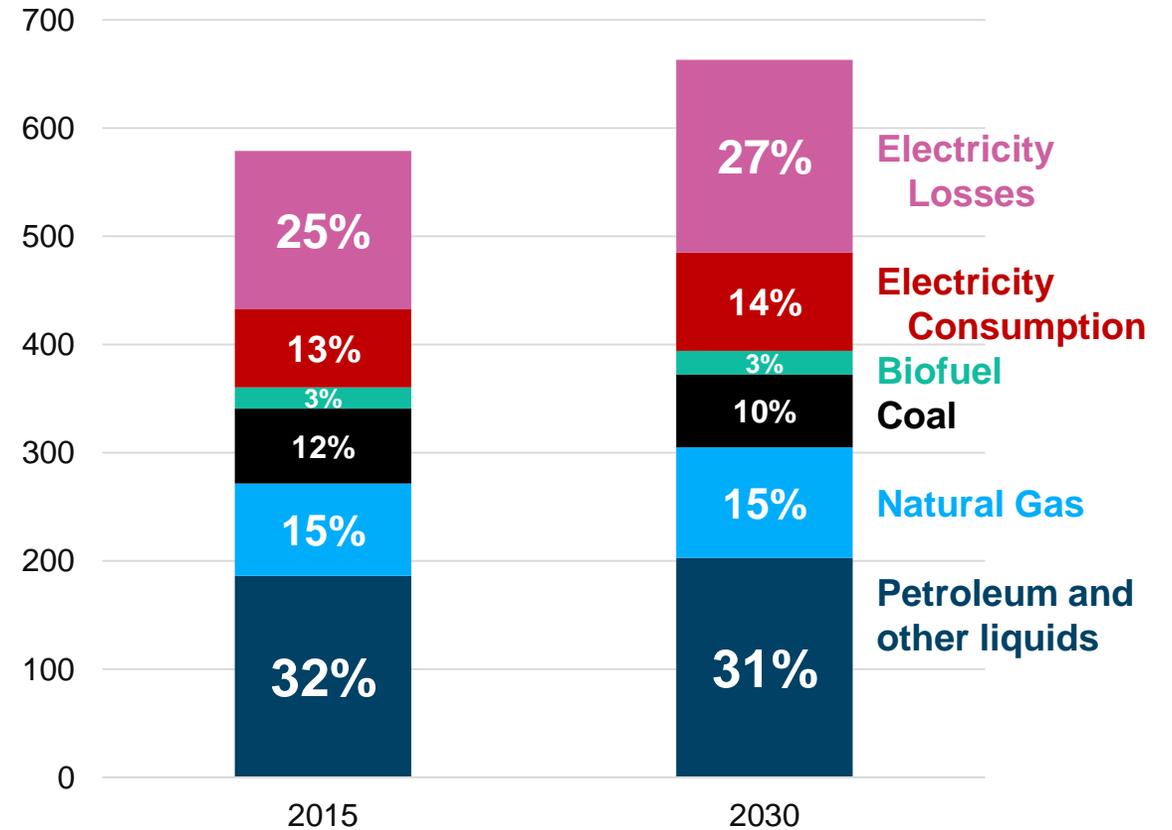
World energy consumption by fuel source

Quadrillion Btu



World energy consumption by fuel (with electricity separated)

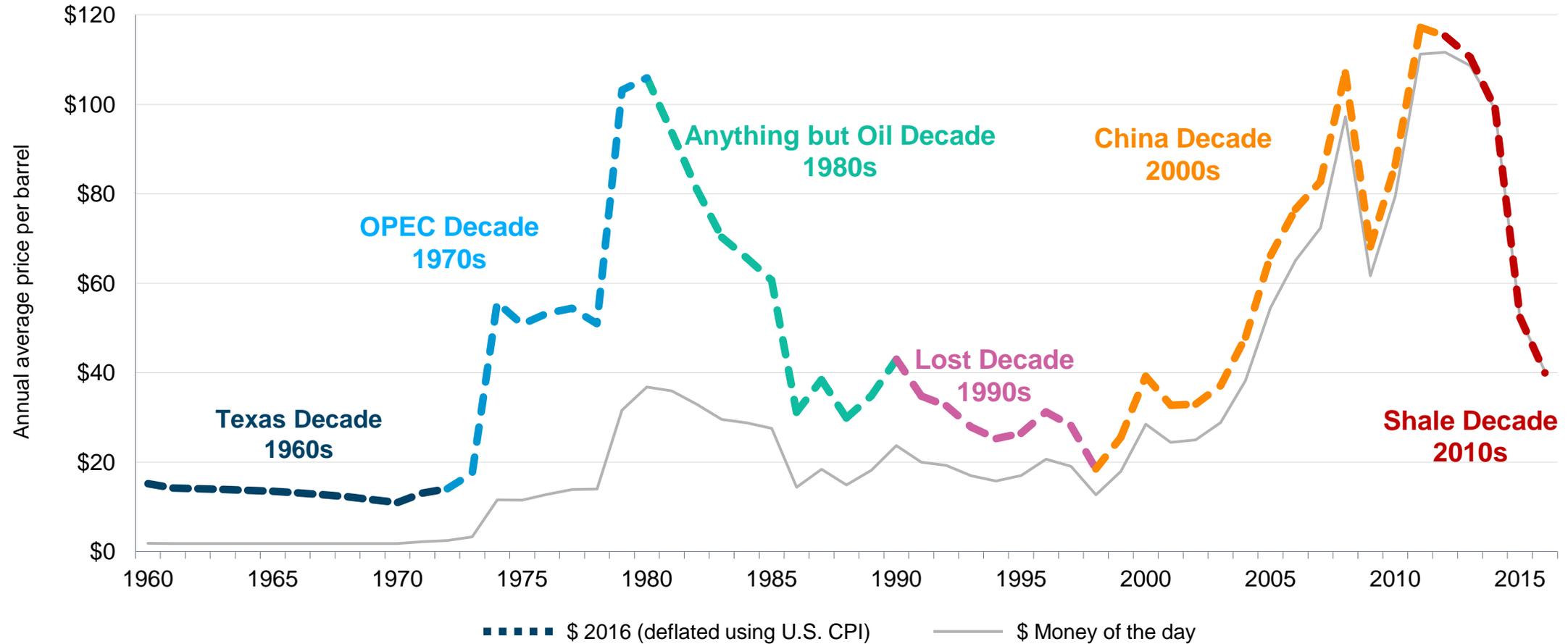
Quadrillion Btu



Oil Markets

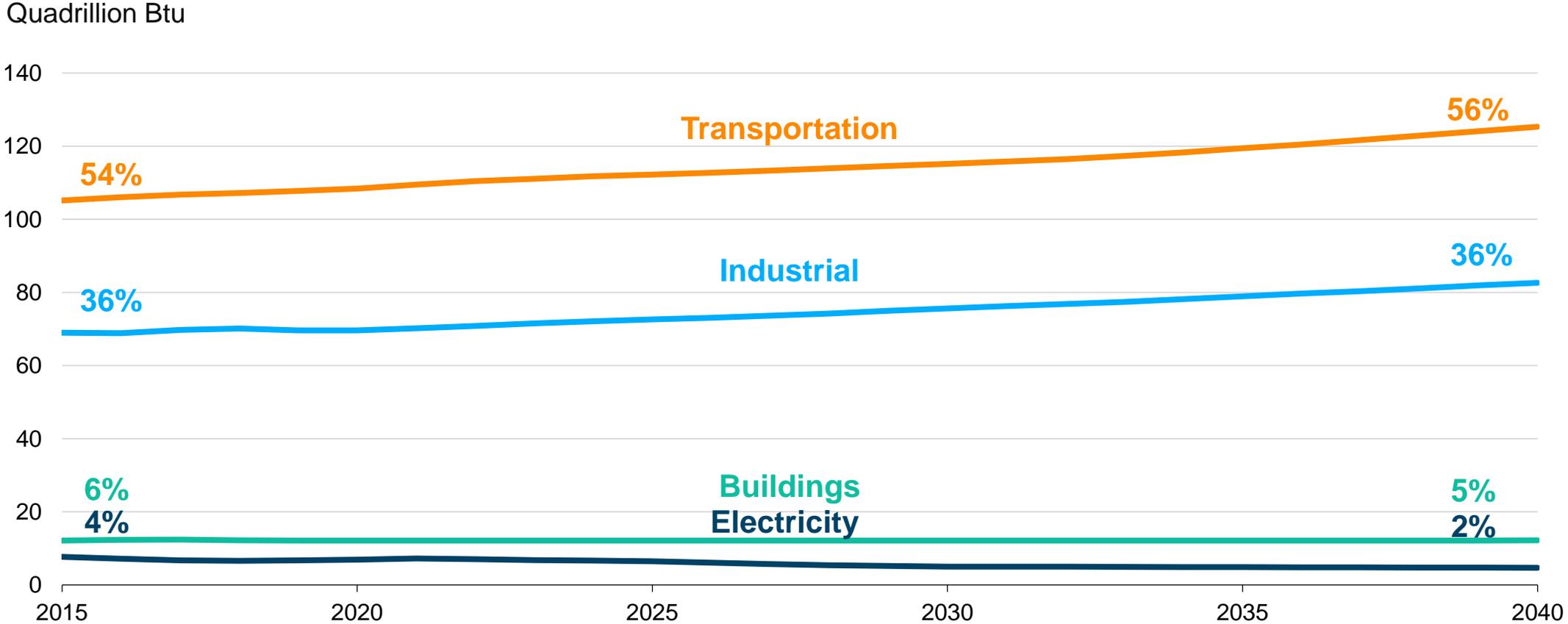
Current global oil price cycle not over yet: Lower prices to prevail for longer

Crude oil prices in real 2015 US dollars and nominal US dollars



*1960-83 prices – Arabian Light; 1984-2017 Dated Brent

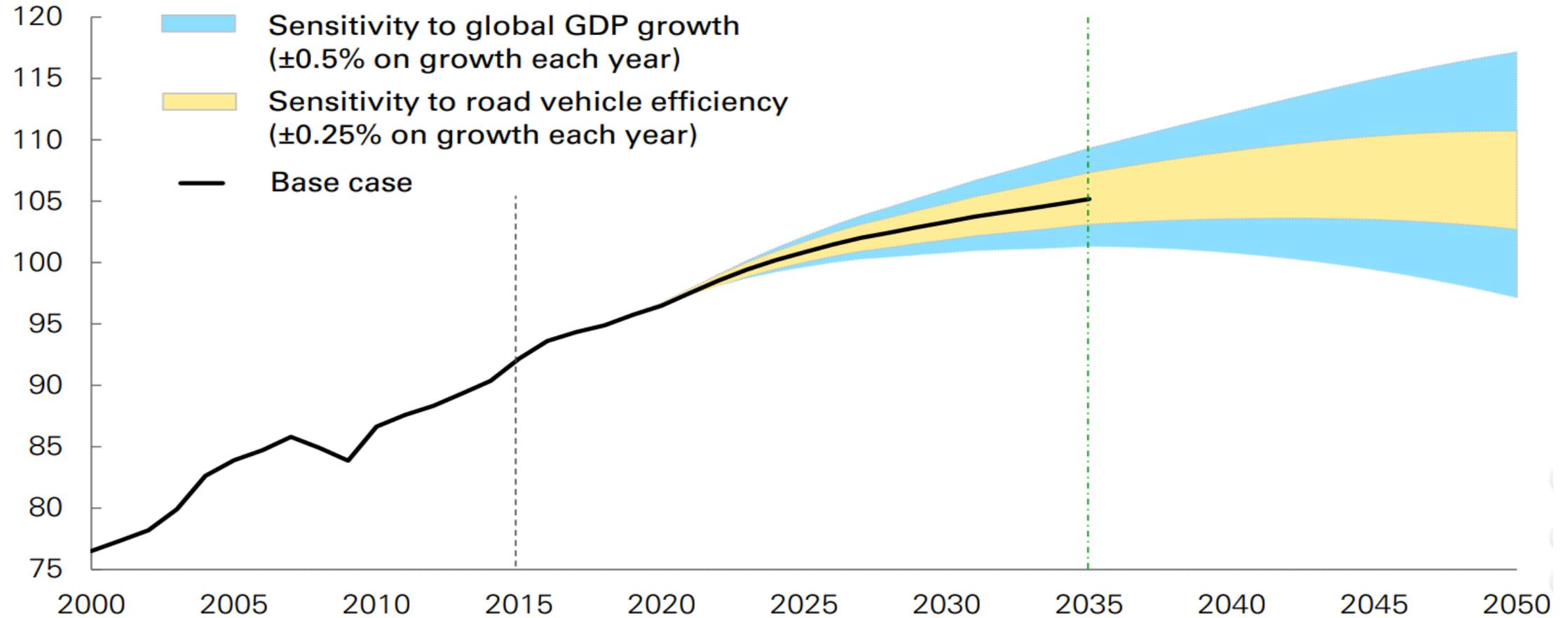
Sectoral shares of world liquids use hold relatively constant in the EIA Reference Case even as total consumption increases



Note: Percentages express a sector's liquids consumption compared to total use of these fuels across all end uses.

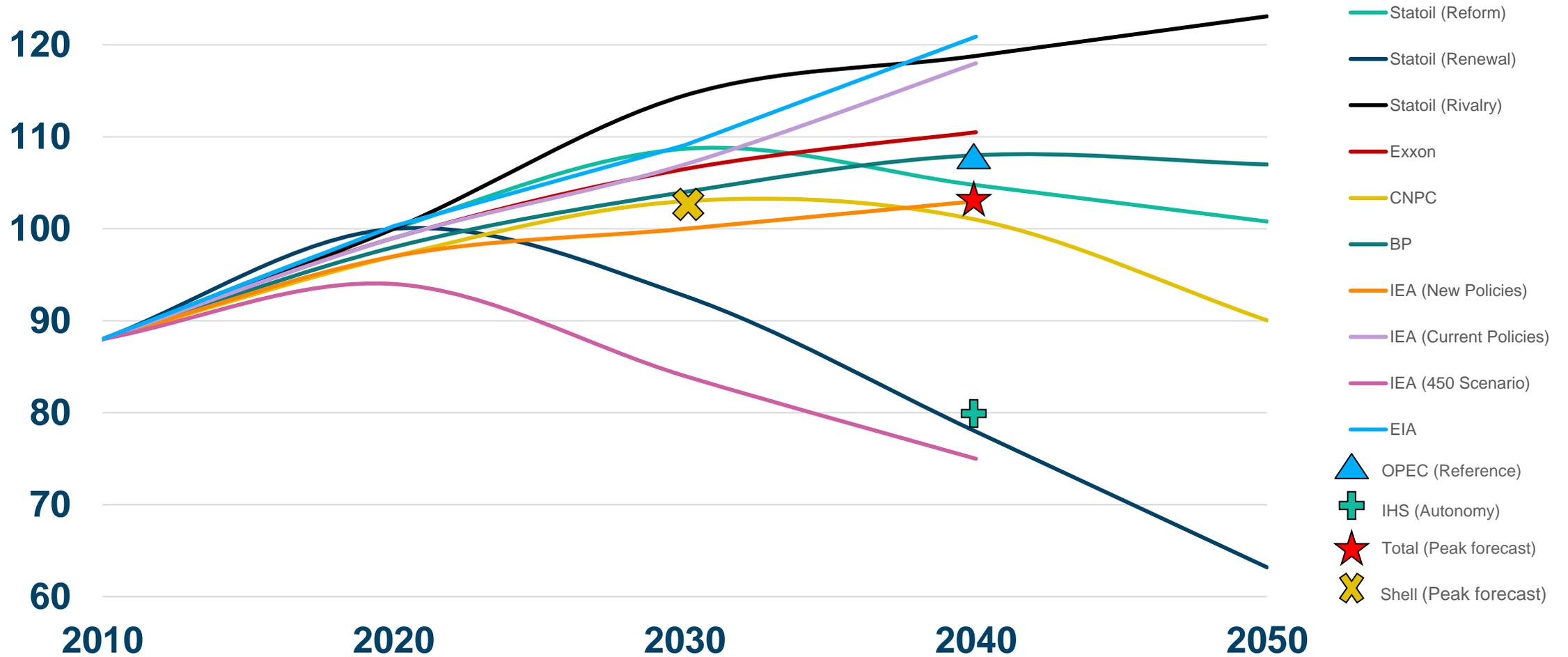
Peak demand depends on GDP growth, efficiency trends, climate policy and a host of other factors

Million barrels per day



Uncertainty for future oil demand

Million barrels per day

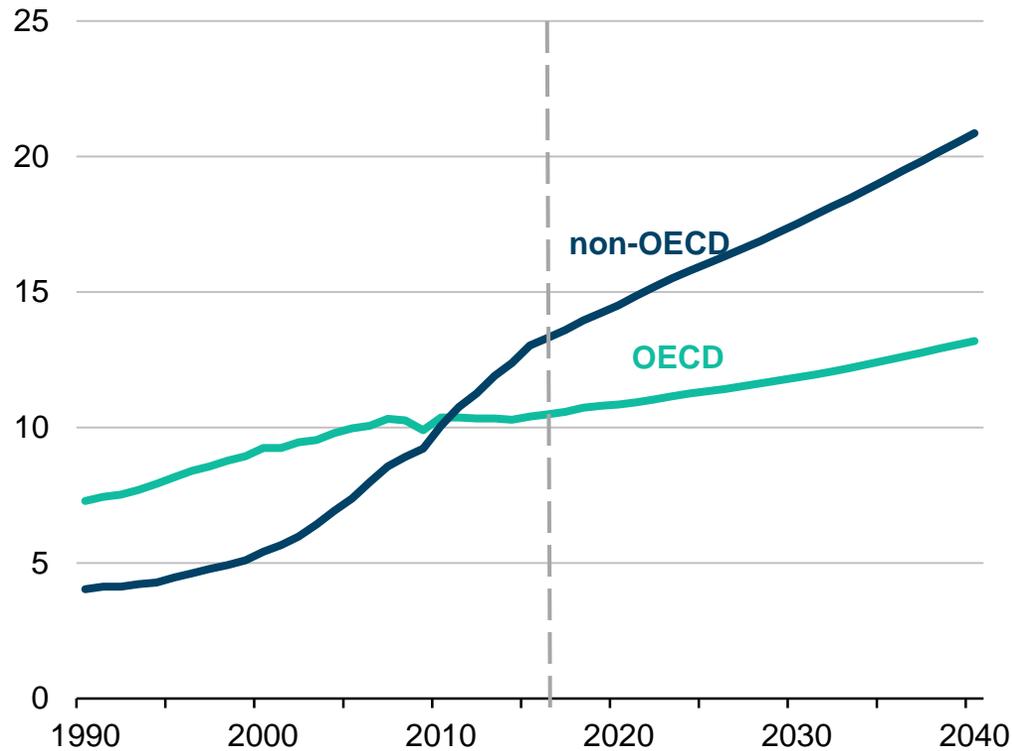


Electricity Markets and Renewable Energy

Net electricity generation in non-OECD countries increases twice as fast as in the OECD with building use being a major contributor to growth in the EIA Reference Case

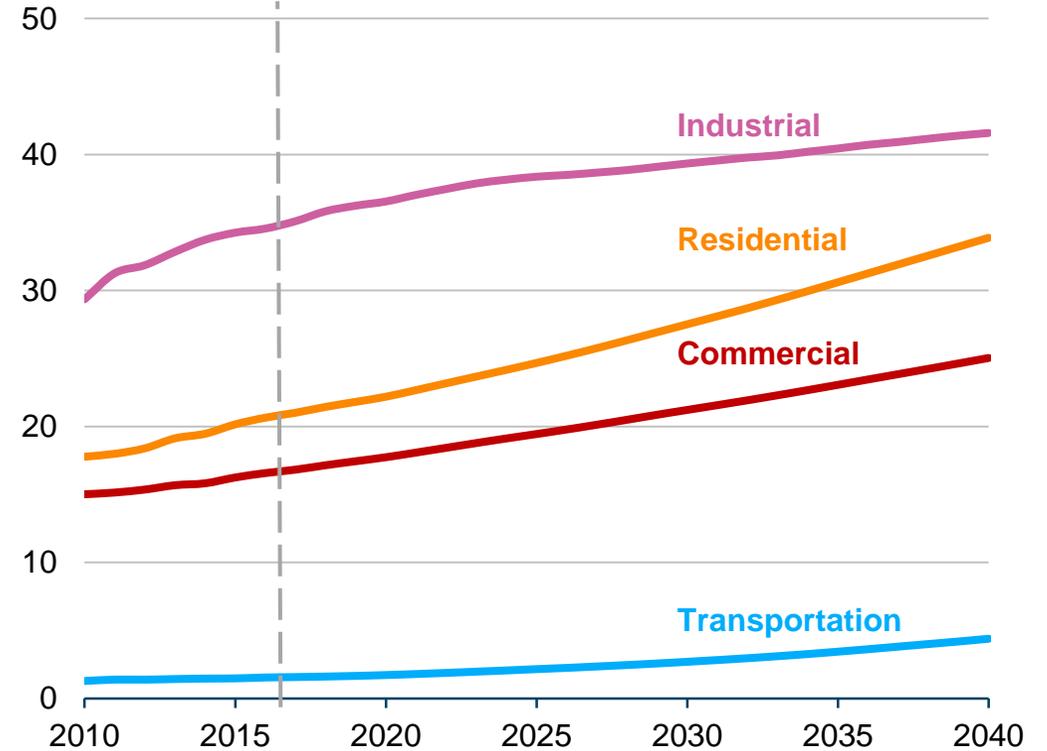
OECD and non-OECD net electricity generation

Trillion kilowatt-hours



World electricity use by sector

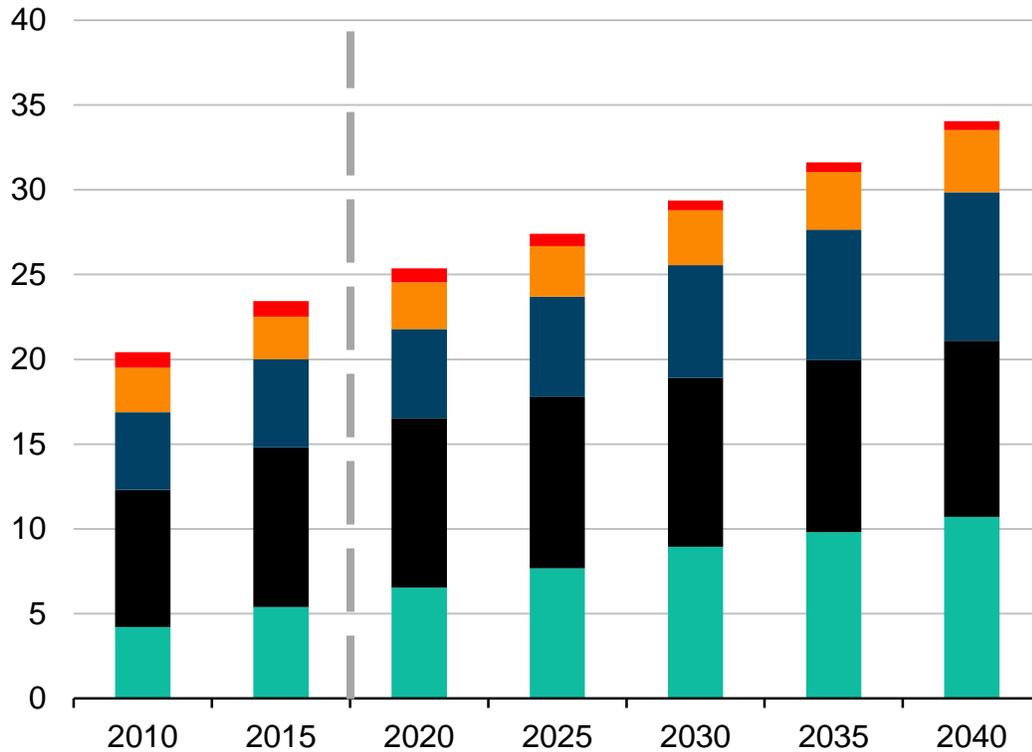
Quadrillion Btu



In the EIA Reference Case, renewables and natural gas provide much of the growth in electricity generation with their combined share of the total rising to 57% in 2040

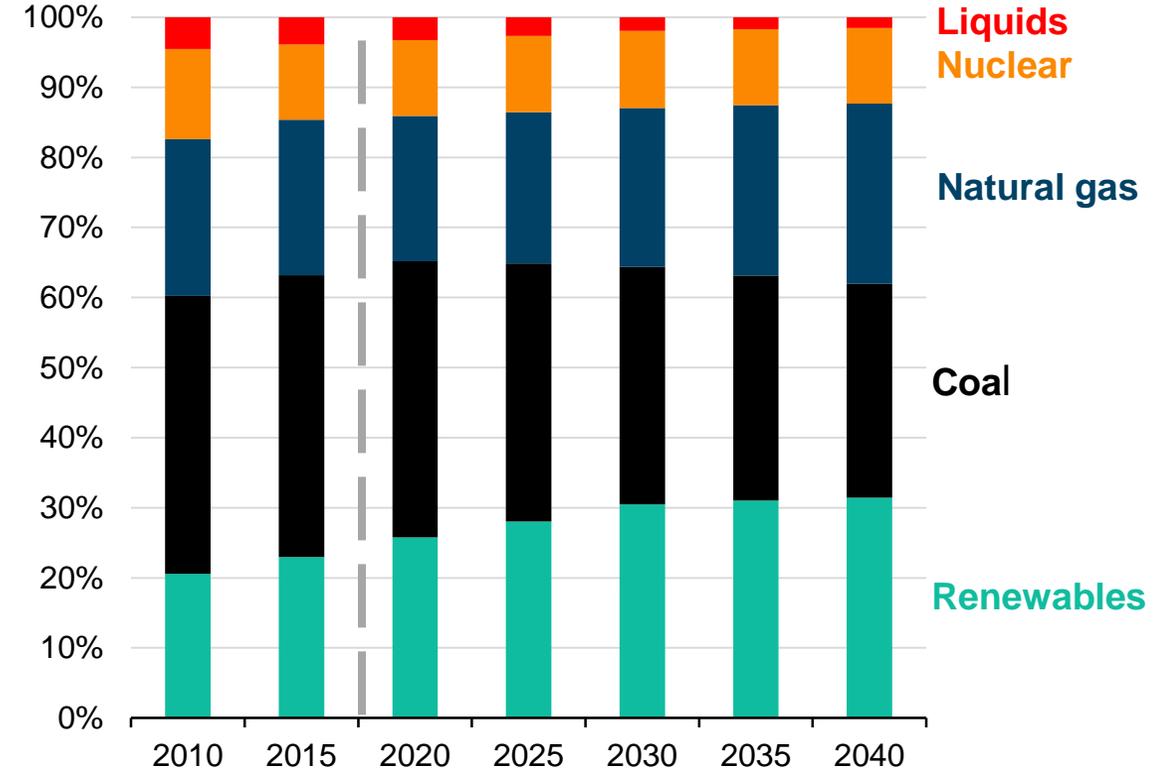
World electricity generation by fuel

Trillion kilowatt-hours



Share of net electricity generation

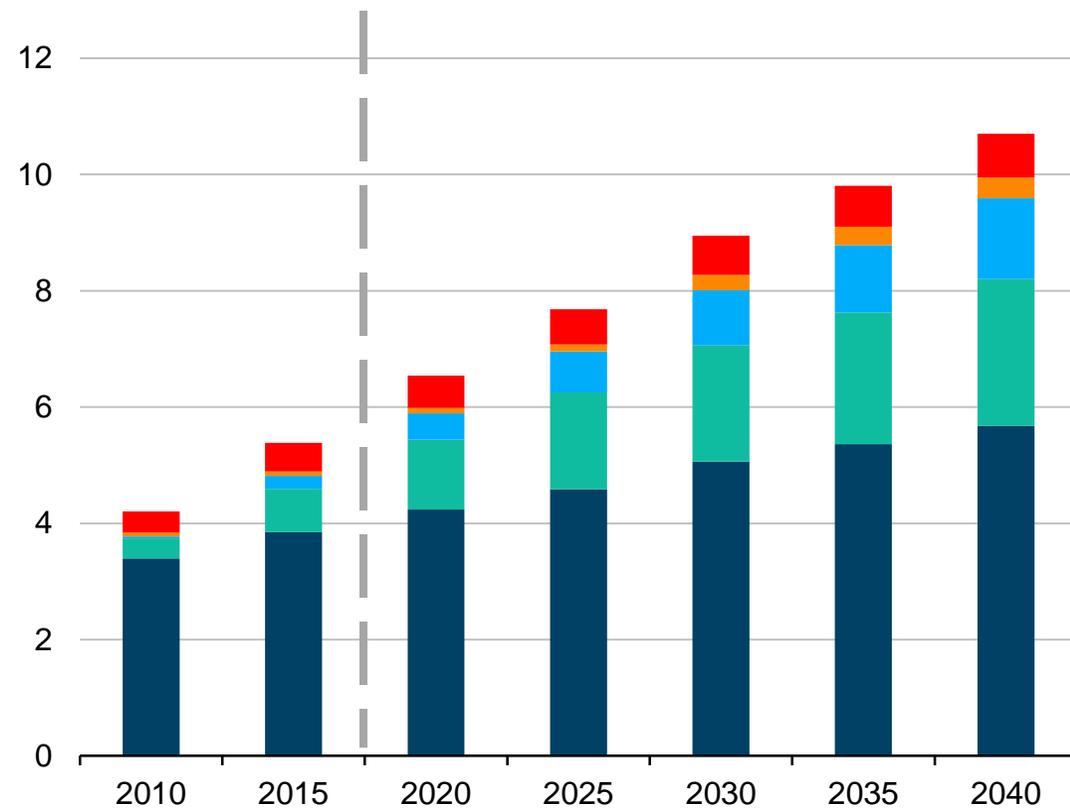
Percent



Wind and solar dominate growth in renewables and represent two-thirds of related capacity additions by 2040

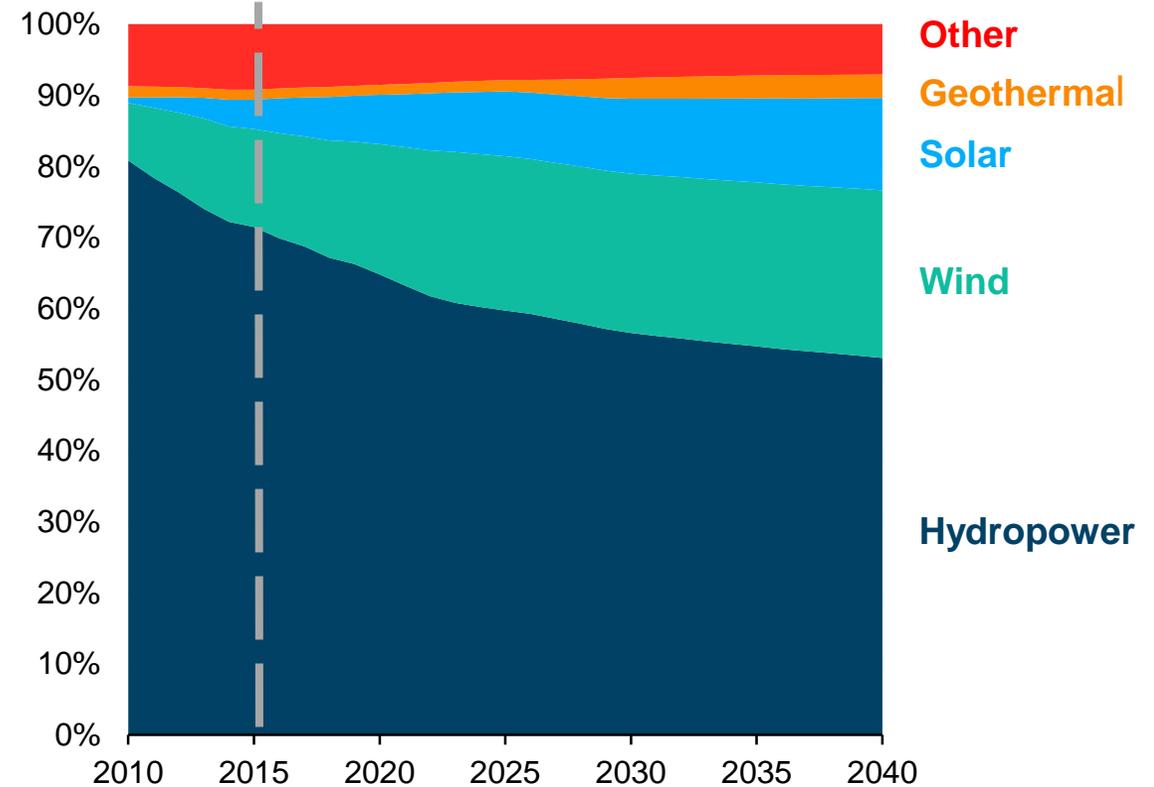
World net electricity generation from renewable power

Trillion kilowatt-hours



Share of renewable energy

Percent



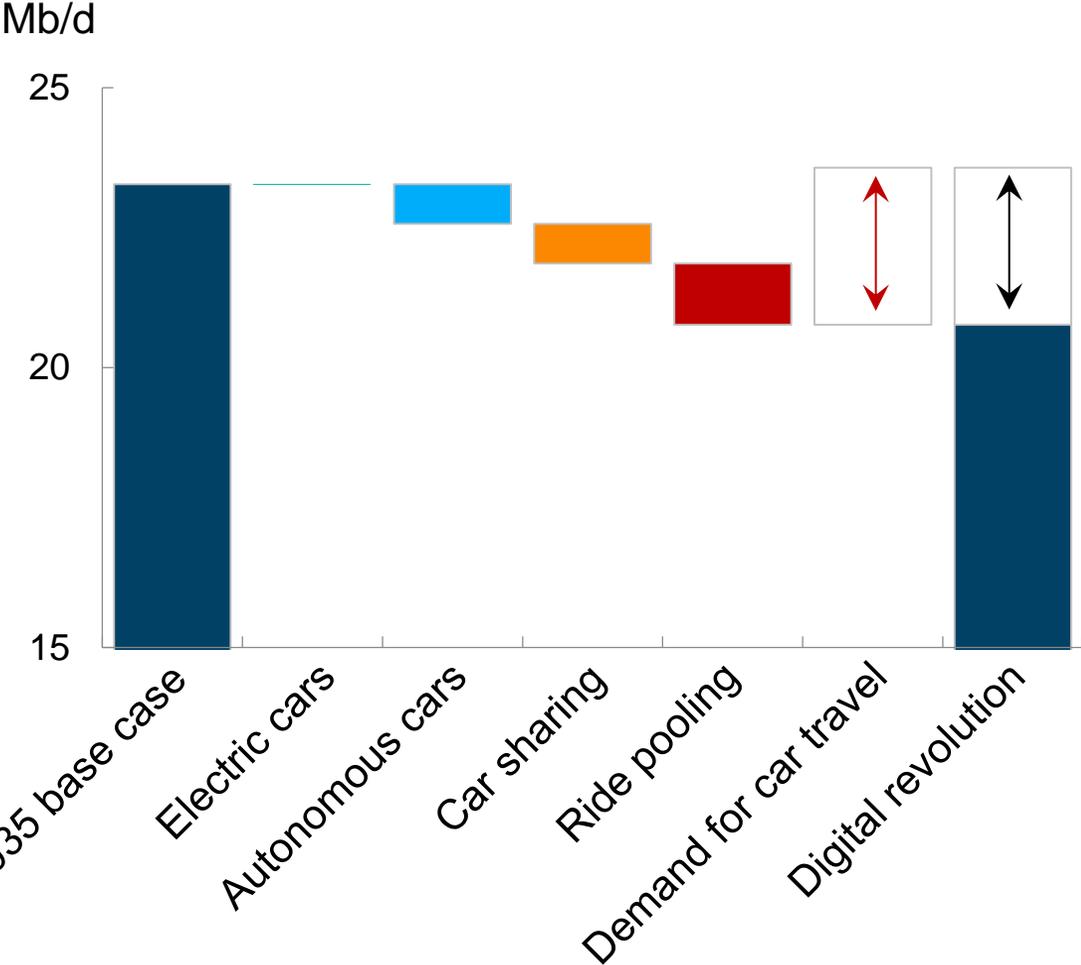
Disruptions

Key innovations/assumptions that could change the consensus energy outlook

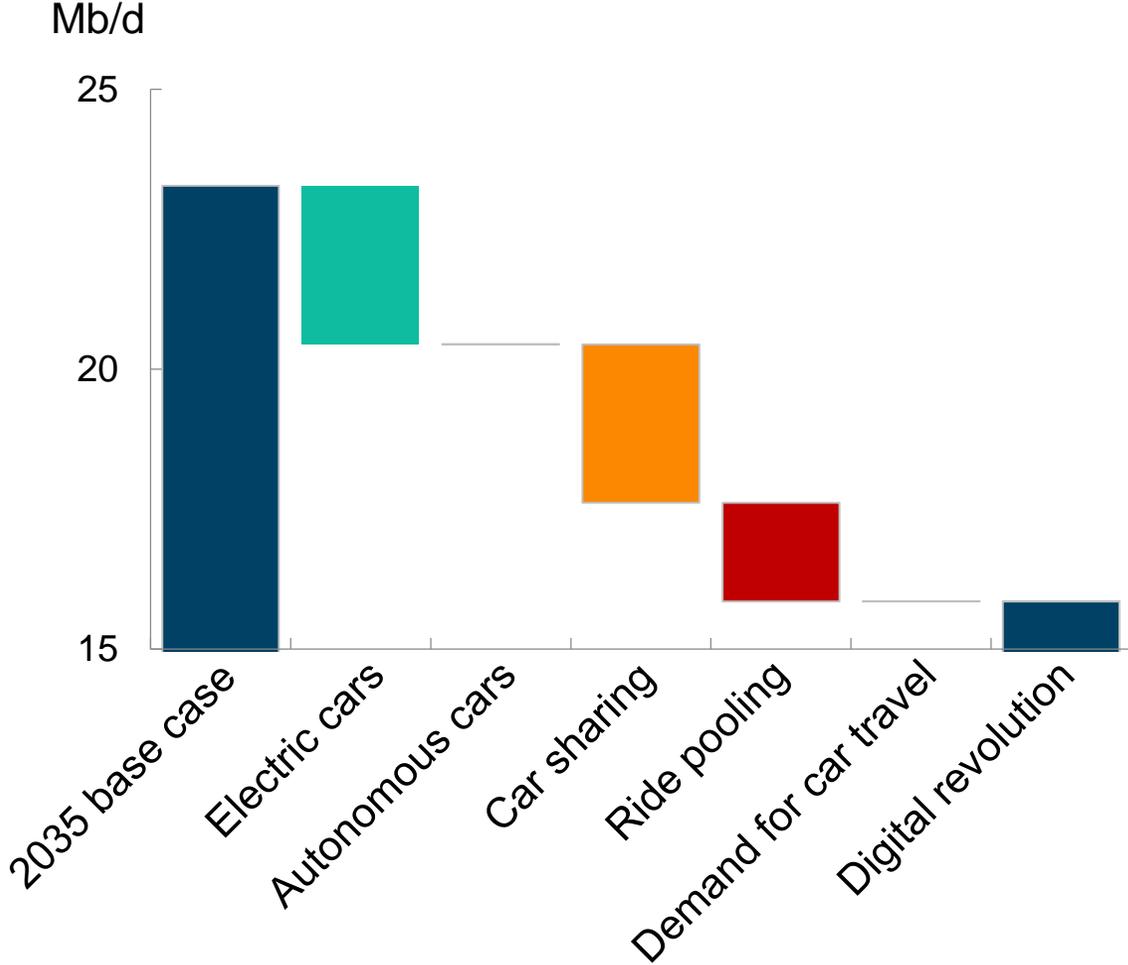
- Economic / population growth trends
- Innovations in Buildings / Industry / Transportation efficiency
- Electric vehicles / Autonomous vehicles
- Wind / Solar cost reductions
- Utility and grid-scale batteries / super-grids / distributed power
- Shale – enhanced recovery rates
- Automated drilling /smarter completions and tie-ins
- Carbon tax, fee / Carbon capture, use, and sequestration (CCUS)
- Nuclear: Small Modular Reactors (SMRs) / Fusion

Mobility revolution scenarios: Impact on oil demand in cars in 2035

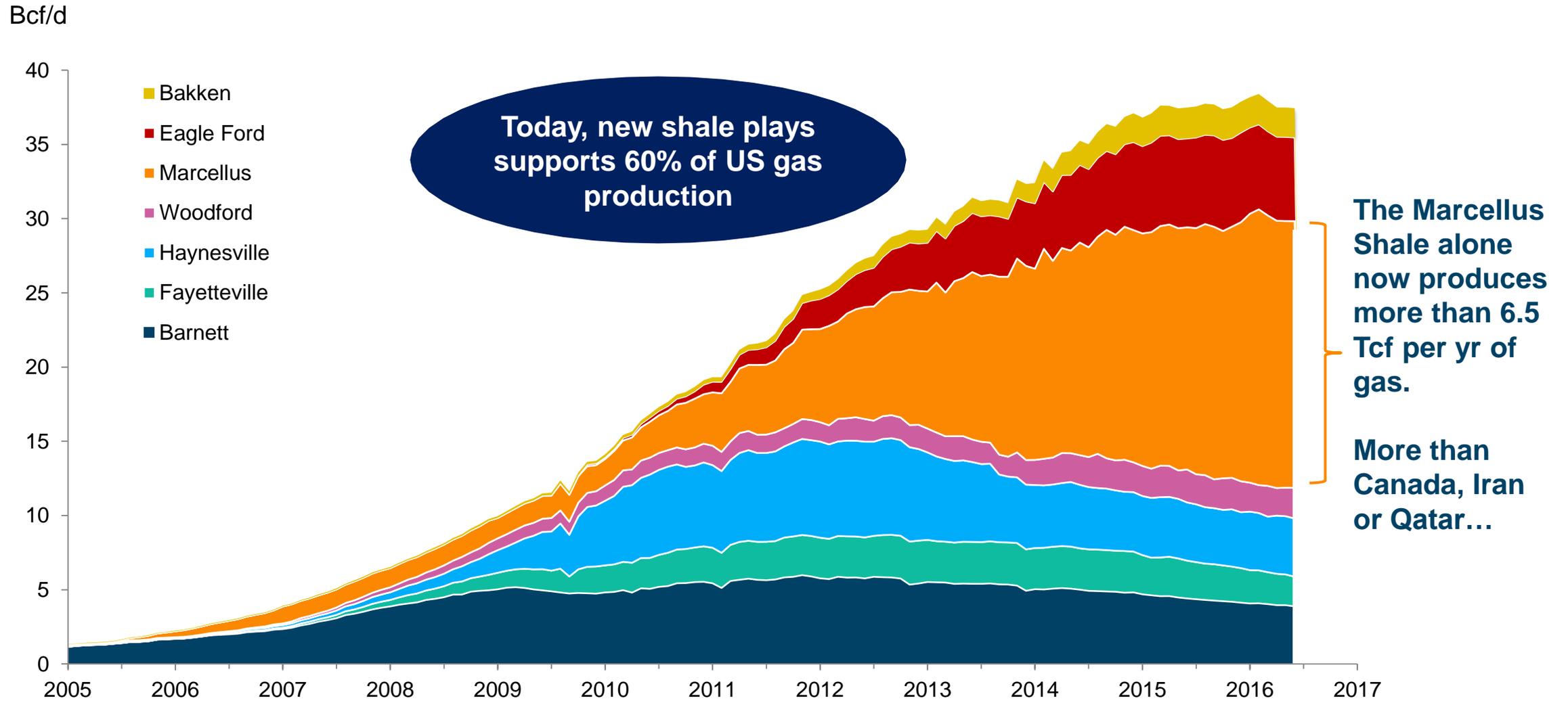
Digital revolution



Electric revolution



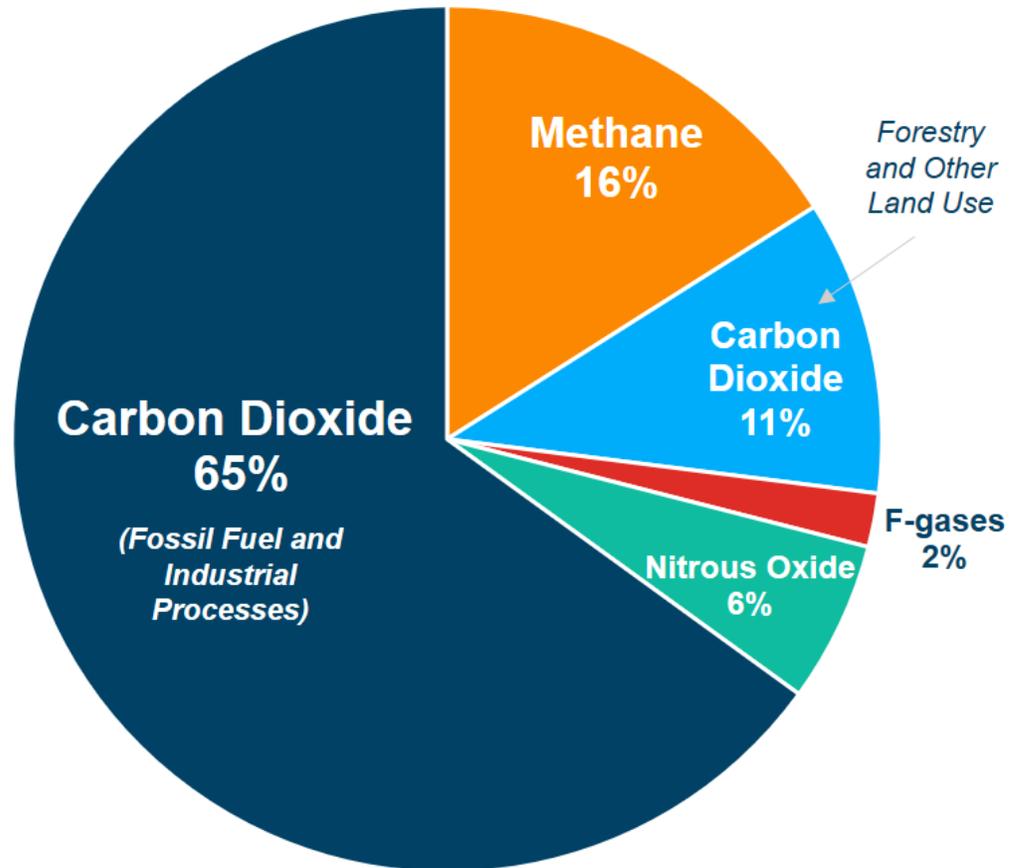
Shale revolution is not necessarily over – technology advancements continue



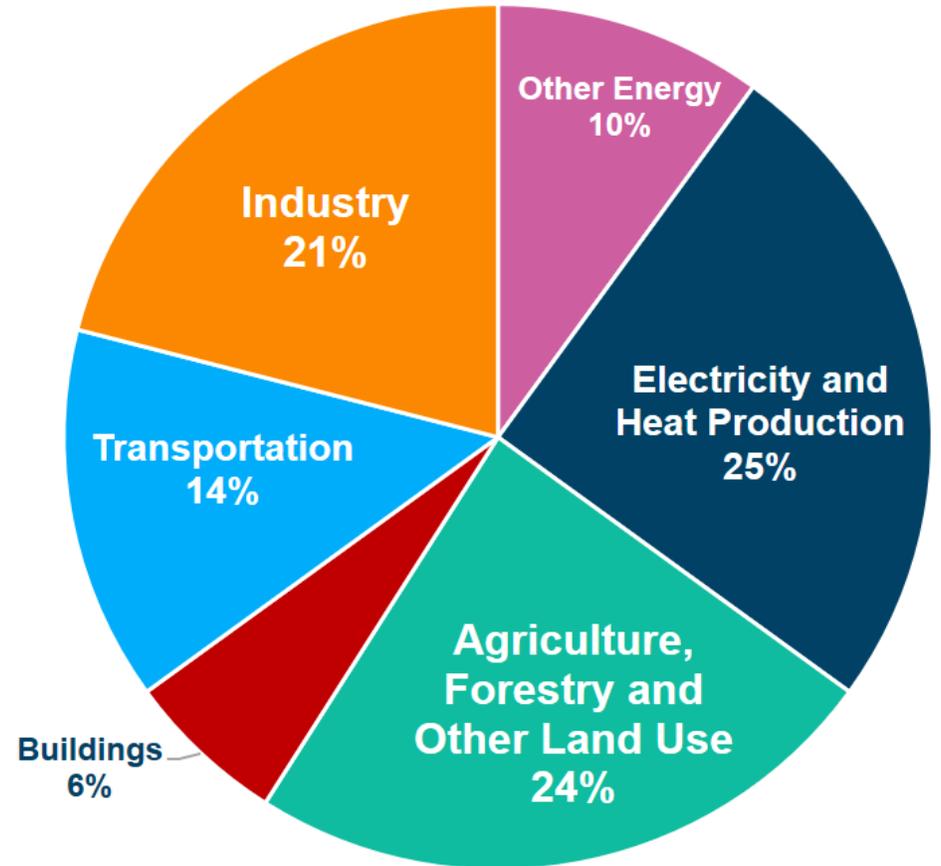
Paris & Policy

Global greenhouse gas emissions: not just fossil fuels

Emissions by Gas

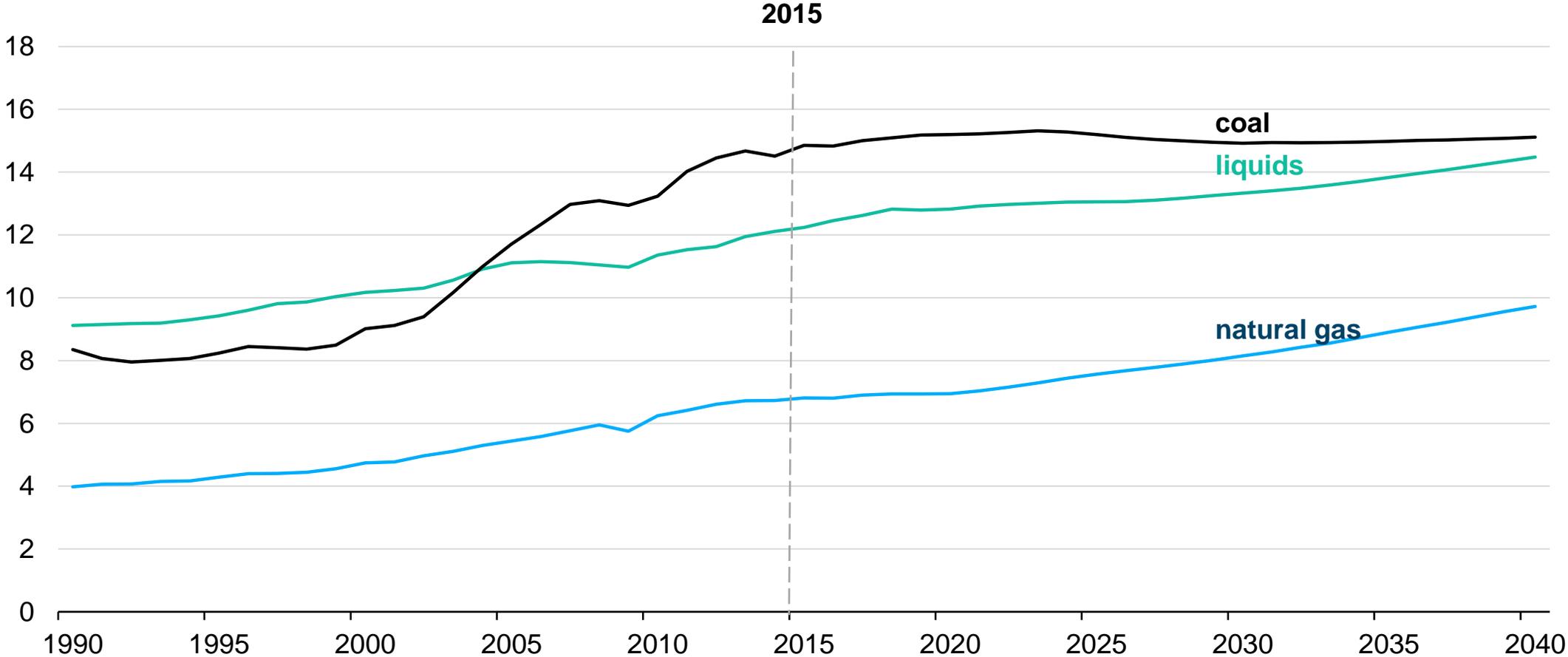


Emissions by Economic Sector



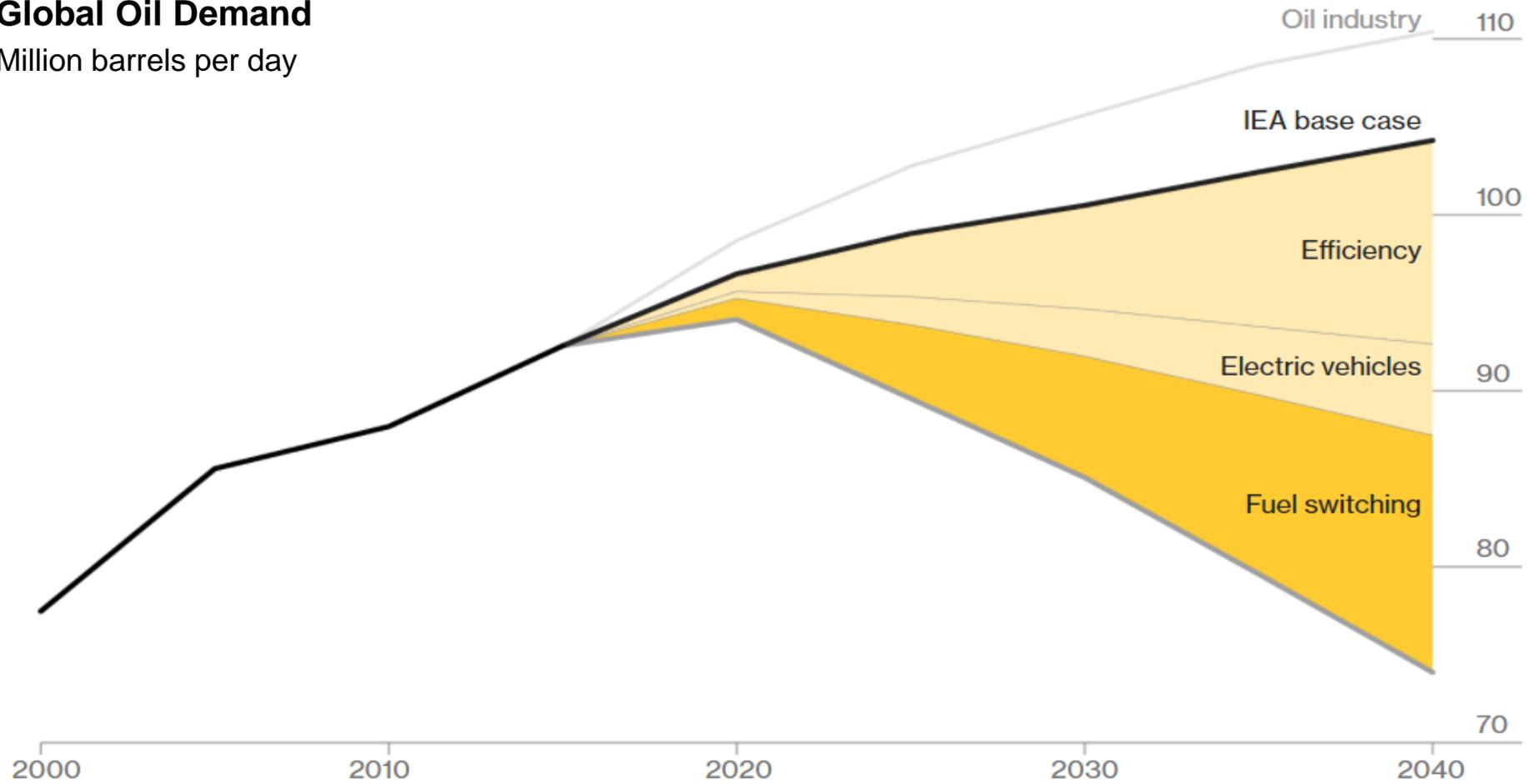
Energy-related carbon dioxide emissions by fuel

Billion metric tons



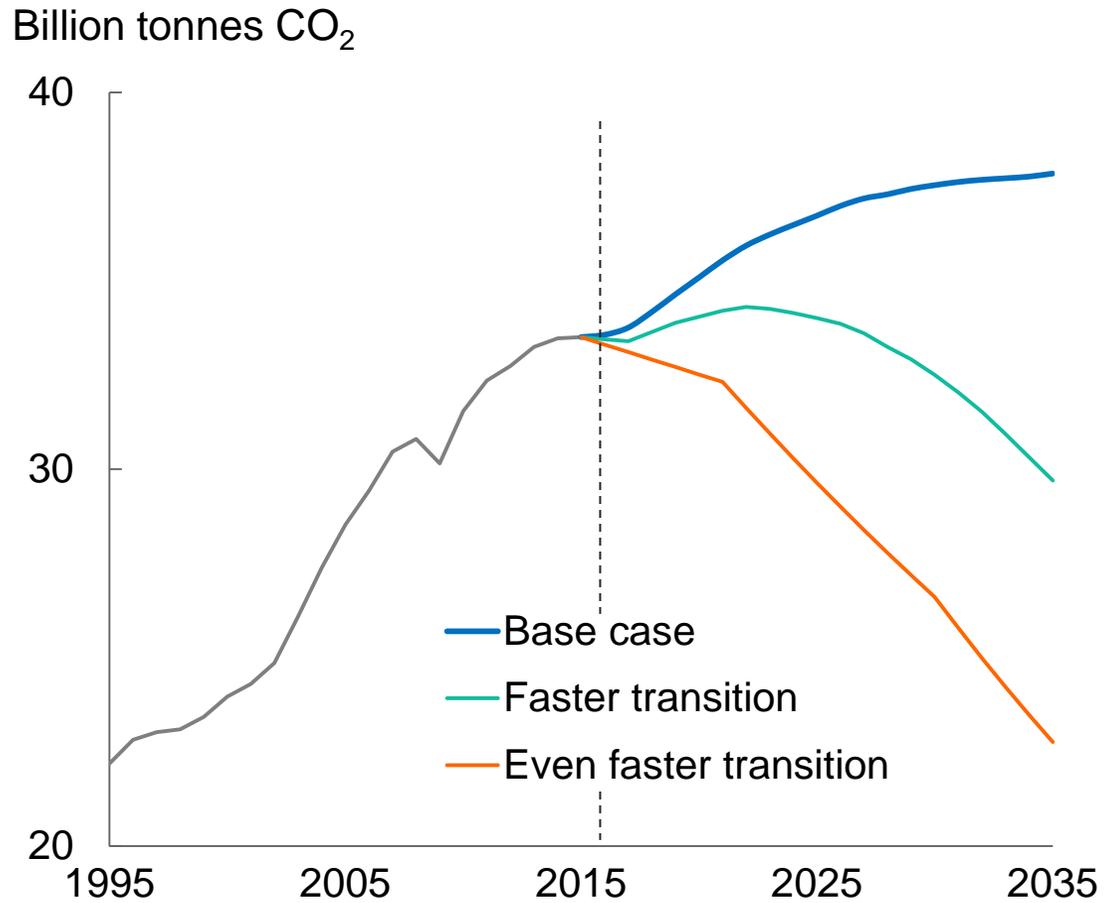
The 450 Scenario: How might that look?

Global Oil Demand
Million barrels per day



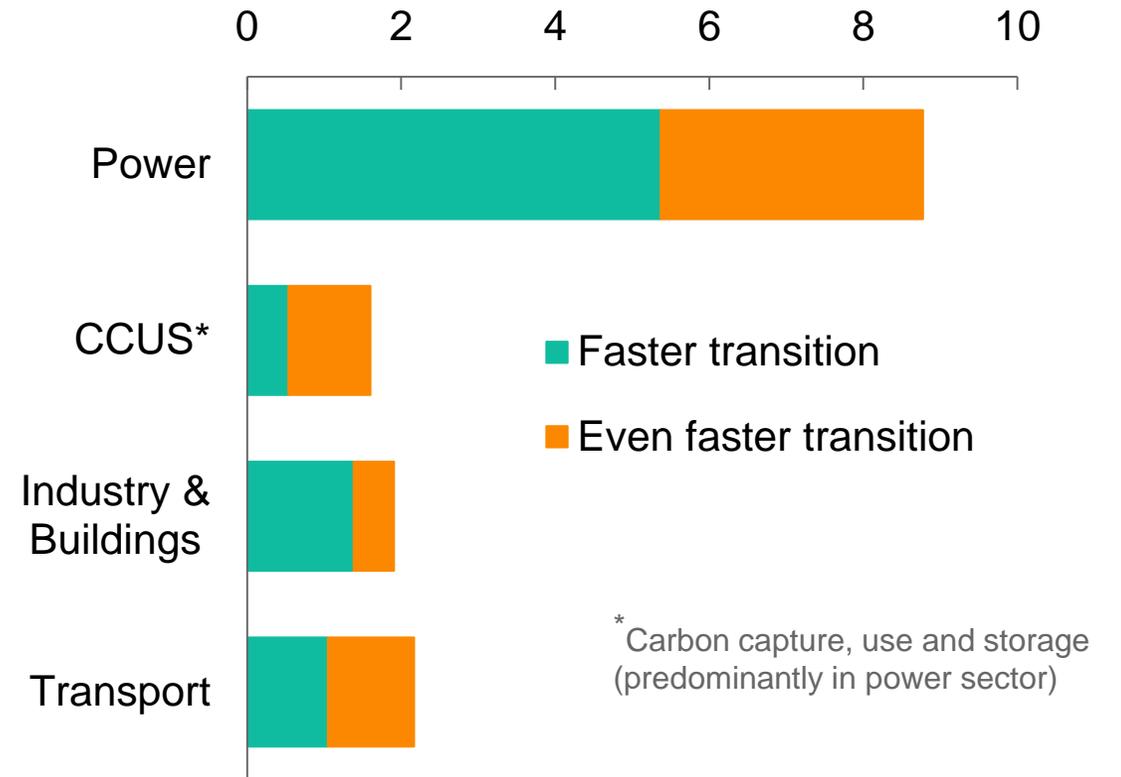
Faster transition pathways

Carbon emissions



Reductions in emissions versus base case

Billion tonnes CO₂ in 2035



Perversity, futility, and jeopardy: Why change is resisted

Perversity thesis

Any purposeful action to improve some feature of the political, social, or economic order will make it (or something else) worse

Futility thesis

Attempts at transformation will be futile - they will simply fail to "make a dent" in the problem

Jeopardy thesis

Argues that the cost of the proposed change or reform is too high as it endangers some existing order

Snapshot of key energy issues by region/country

	U.S.	EU	China	Japan
Environment	NIMBY Opposition to development	Paris Climate Agreement	Air and water pollution	Under control
Security	Using energy abundance as a geopolitical tool	Russia & The Middle East	Managing growing import dependence	Diversity and efficiency
Economy	Market driven	German model - Energiewende	Dominate manufacturing & exports of new energy technology	Affordability
Safety	Oil and gas operations	Nuclear concerns	Quality control	Nuclear accident

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- Collaborating with government, industry, academia and nonprofits leaders
- Assisting decision makers to craft smart energy policies that balance economic, environmental, and security priorities

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