THE OXFORD INSTITUTE FOR ENERGY STUDIES

A RECOGNIZED INDEPENDENT CENTRE OF THE UNIVERSITY OF OXFORD

UNIVERSITY OF OXFORD

Revenue Analysis

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The Economics of Energy Corporations (2)

A major offshore oil production facility

- Multi-billion dollar projects offshore require huge up-front spending
- Onshore projects can be more incremental with production

Shale oil development in Texas

- Each well in a shale development is an individual investment with its own economics
- The numbers are smaller, but equally important to investors

A giant gas field in West Siberia

- Even onshore fields require large infrastructure, and geography / weather play a key role in costs

Production Profile

A conventional oil or gas field production profile

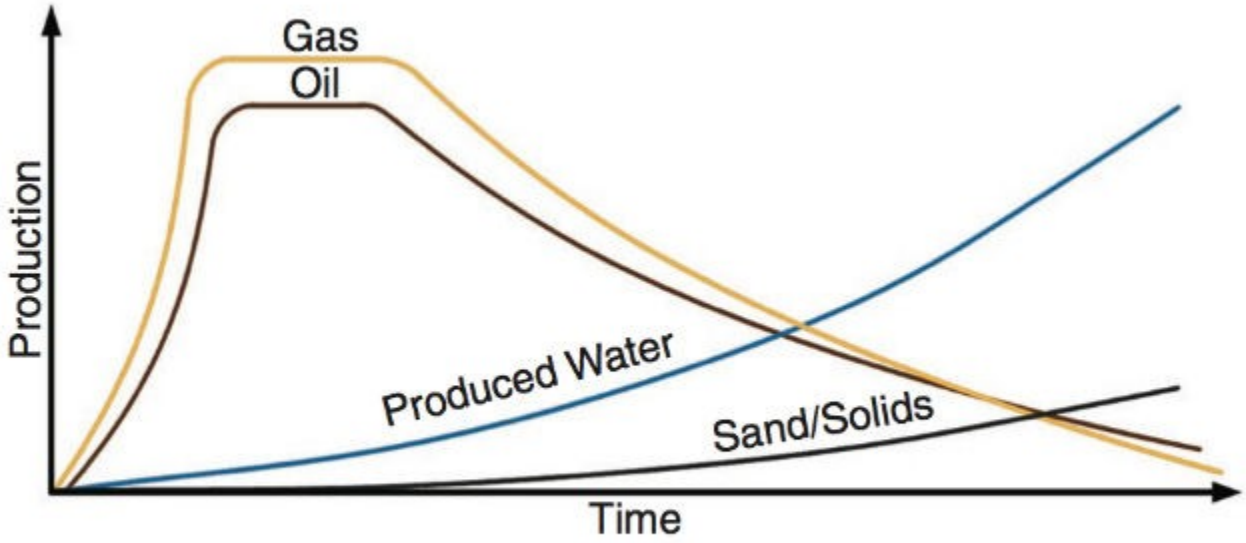
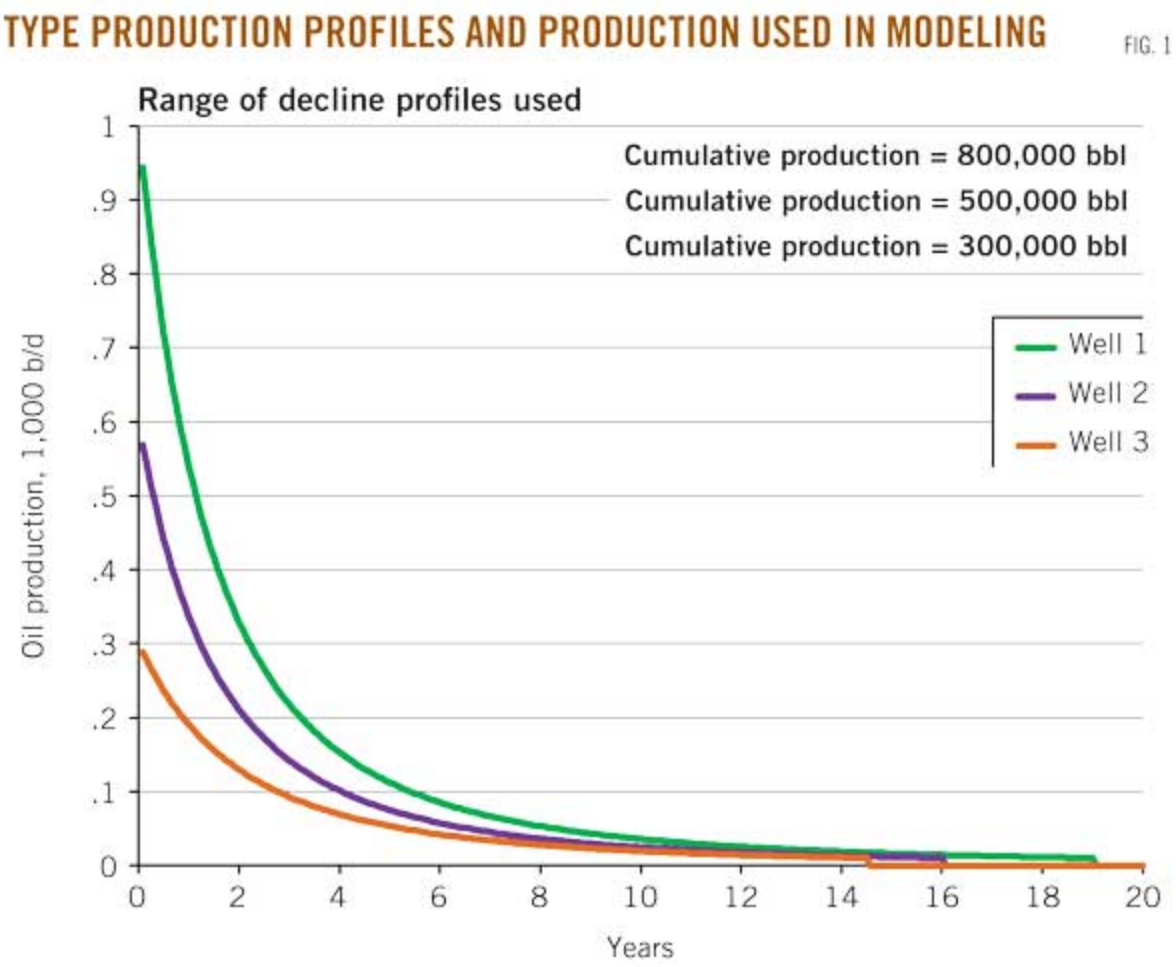


Fig. 1—A typical oilfield production profile.

1. Initial surge to peak production
2. Plateau at peak for a number of years
3. Gradual decline towards abandonment
4. Water and solids production increases, undermining performance

Shale Oil Production Profile

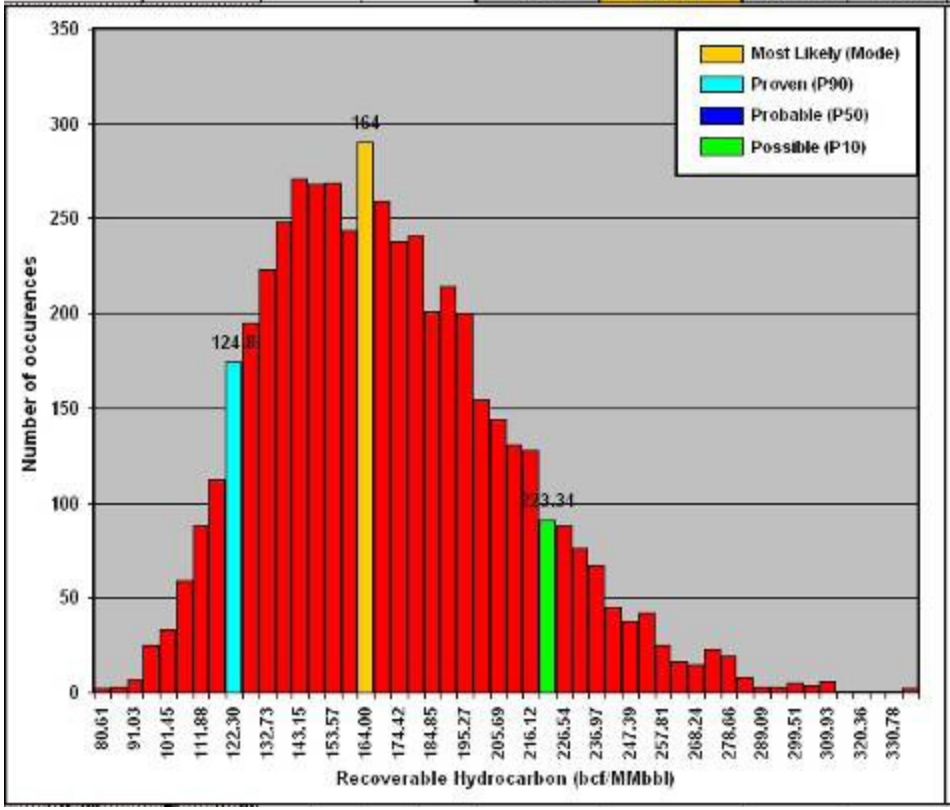


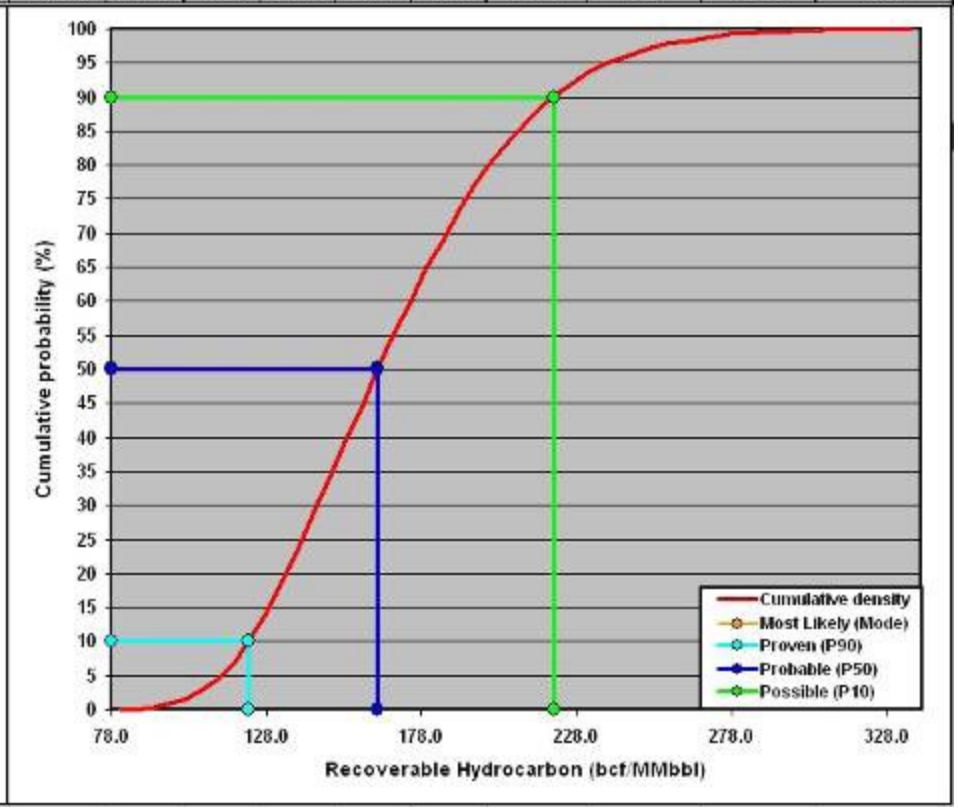
1. Immediate surge to peak production
2. Rapid decline over the first few years
3. Long plateau at low production rates

Create a theoretical cashflow based on assumptions known to date

Monte Carlo reserve simulation: results and input parameter summary

Prospect Name	Modelling and structural parameters			Statistics	Recoverable hydrocarbon (bcf/MMbbl)	Volumetric parameters				Petrophysical parameters				PVT parameters			Field development parameters
	Number of Iterations	Reservoir Type	Trap Type			OWC/GWC depth (m)	Reservoir thickness (m)	Reservoir area (km^2)	GRV (10^8 m^3)	Φ (%)	Sw (%)	S_{hc} (%)	Area N/G	Reservoir Pressure (MPa)	Reservoir Temperature (°C)	Expansion Factor (Sm^3/Rm^3)	Recovery factor
M11-1 Preliminary results	5000	GAS	Simple Layer	Minimum	78.13	2800.01	18.25	8.002	148.12	9.52	20.15	60.30	1.00	46.08	97.00	322.00	0.604
				Most Likely	164.00	2803.41	25.29	8.070	224.85	12.23	30.15	69.85	1.00	46.08	97.00	322.00	0.704
				Maximum	338.45	2849.96	39.77	11.171	412.92	14.09	39.70	79.85	1.00	46.08	97.00	322.00	0.849
				P90	124.80	2804.86	21.79	8.158	193.22	10.66	24.55	64.52	1.00	46.08	97.00	322.00	0.650
				P50	166.48	2824.61	27.01	8.947	245.14	12.02	29.97	70.03	1.00	46.08	97.00	322.00	0.714
				P10	223.34	2844.68	34.13	10.192	315.06	13.19	35.48	75.45	1.00	46.08	97.00	322.00	0.790





Oil Production Forecast

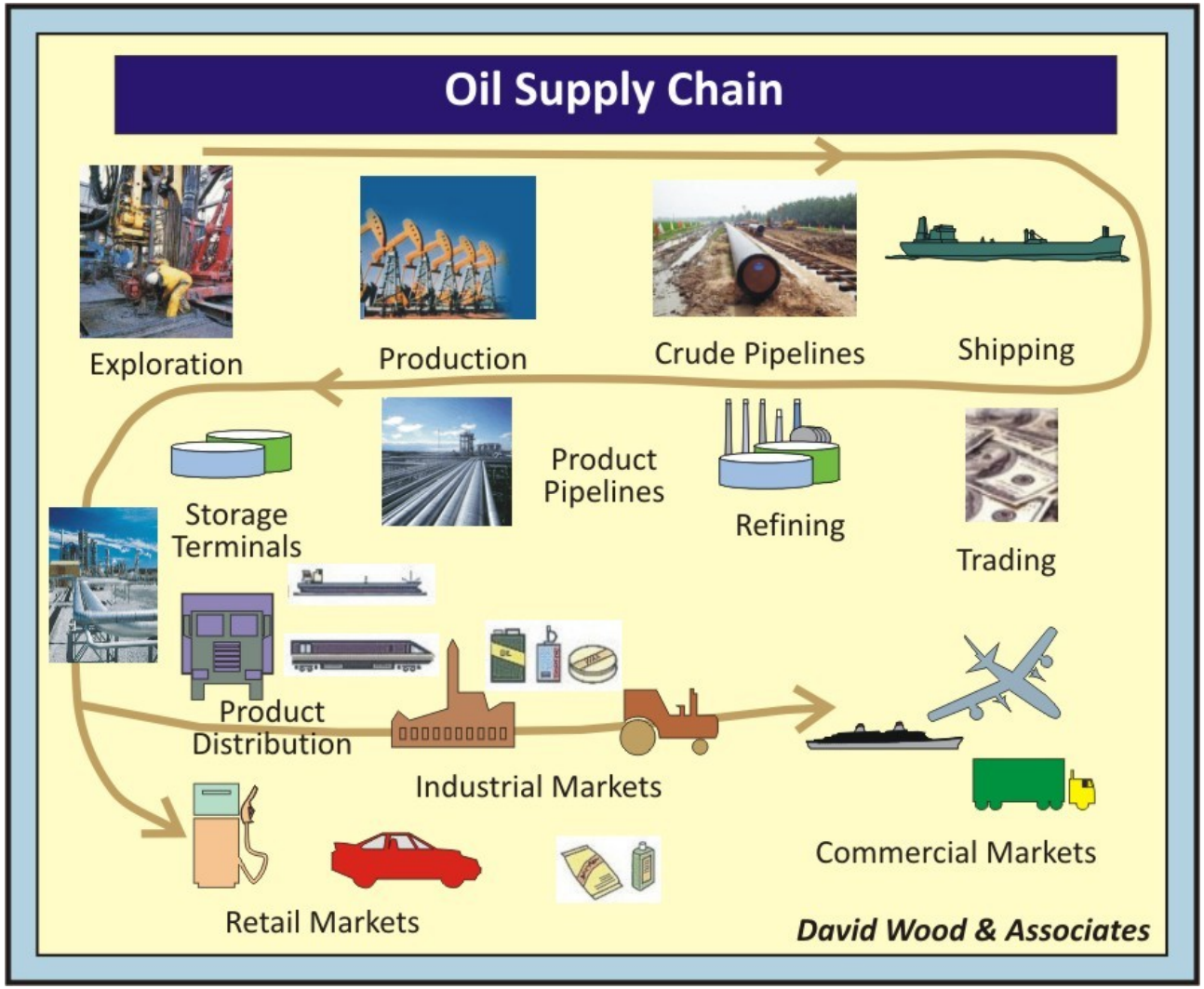
Key Elements

- Time from first investment to first oil
- Ramp up period
- Peak production
- Peak production period
- Decline rate

Let’s model a conventional production profile

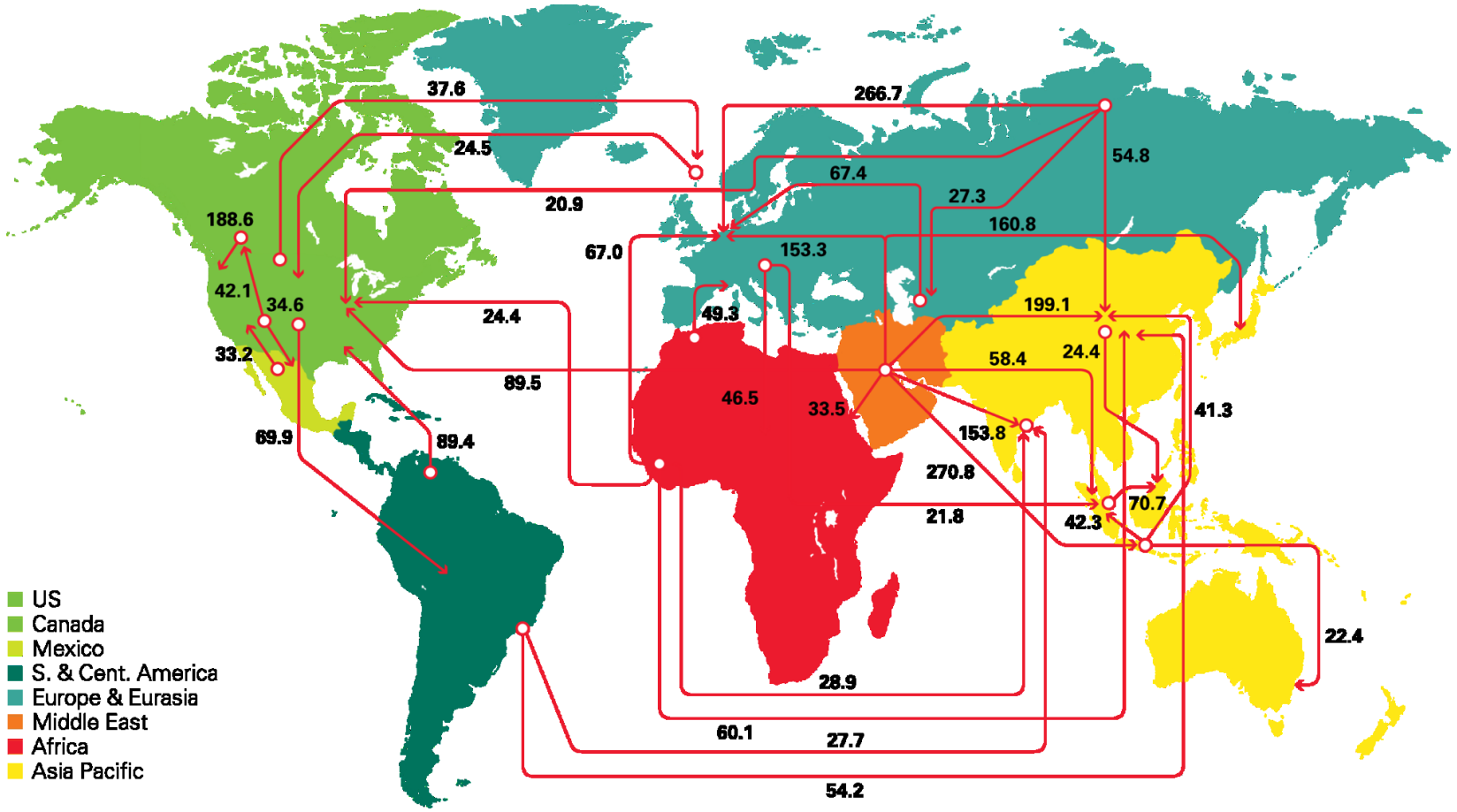
- Reserves – 1 billion barrels of oil plus 500Bcf of gas
- Start date – 5 years after first investment
- Peak production – 5% of reserves
- Time to peak – 4 years
- Length of peak – 7 years
- Decline rate – 5%

Domestic supply chain



- We are concerned about well to refinery gate in domestic market

Export supply routes

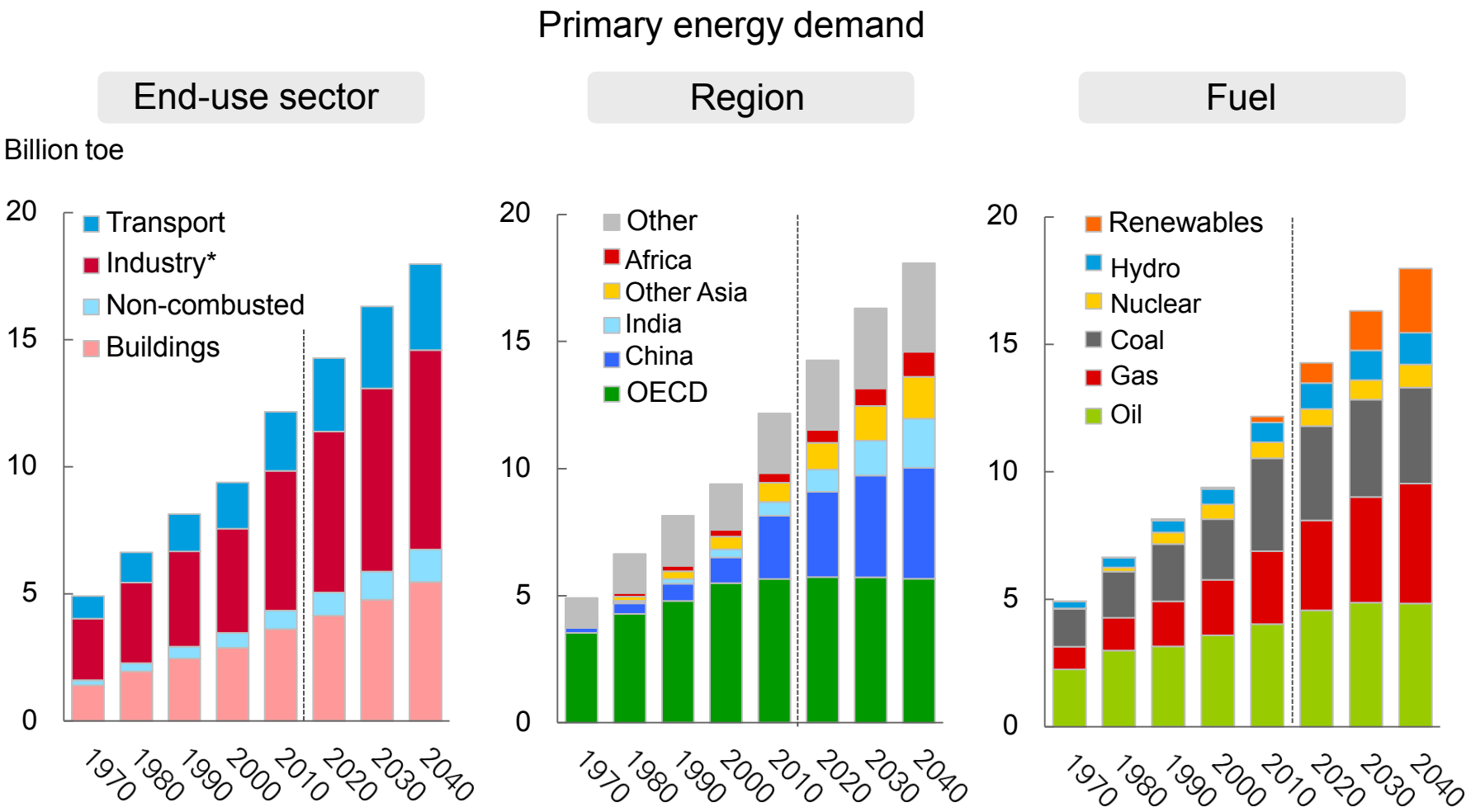


- Export price based on global markets
- Domestic price often lower due to subsidies / market constraints

Some Scenario Planning

- We need to have some opinions of fuel prices for our cashflow model
- Future of oil and gas prices is critical to revenues
- Impact of changing energy economy is increasingly evident and needs to be discussed
- Strategic planning departments create a base case and various alternative outcomes around it
- The ultimate conclusion needs to be some price forecasts

Energy transition is underway

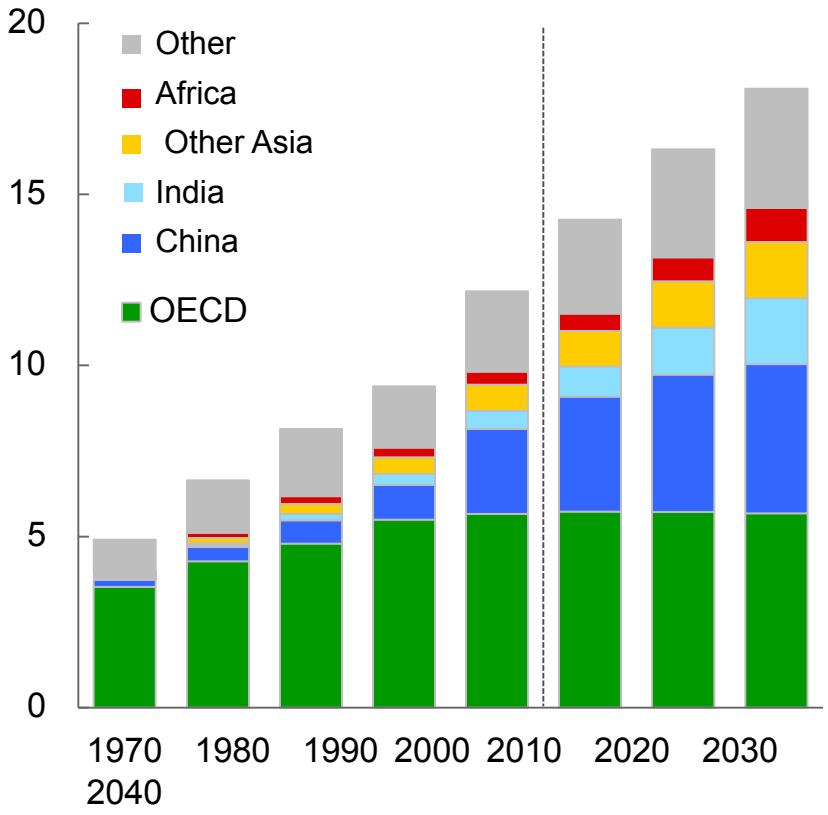


*Industry excludes non-combusted use of fuels

Growth in energy demand is driven by increasing prosperity

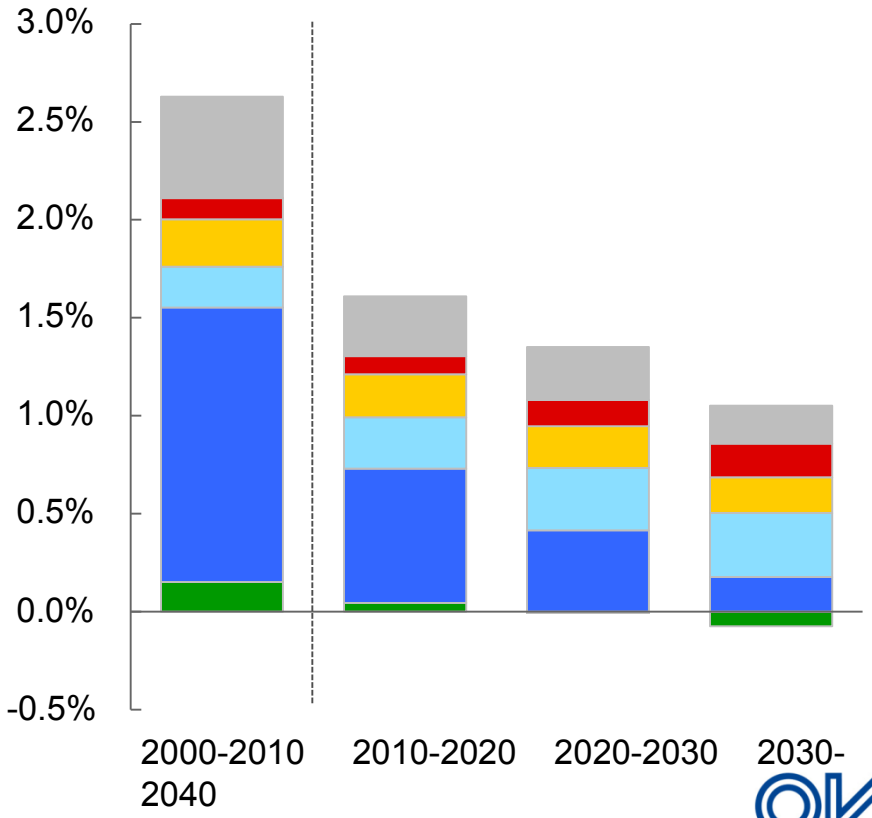
Primary energy consumption by region

Billion toe



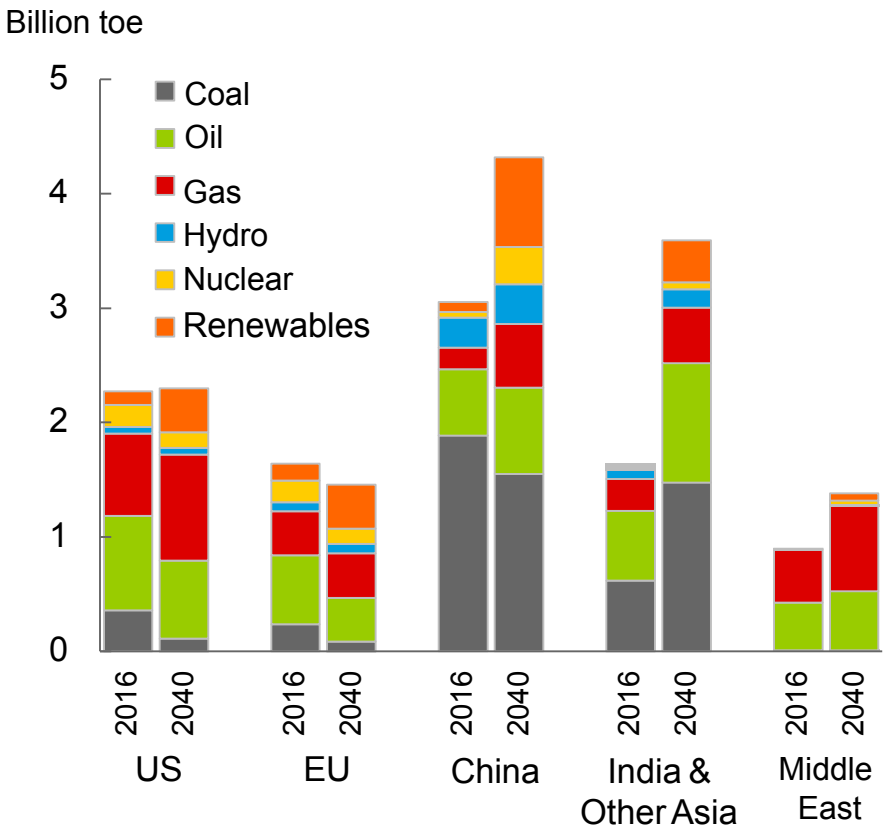
Primary energy growth and regional contributions

% per annum

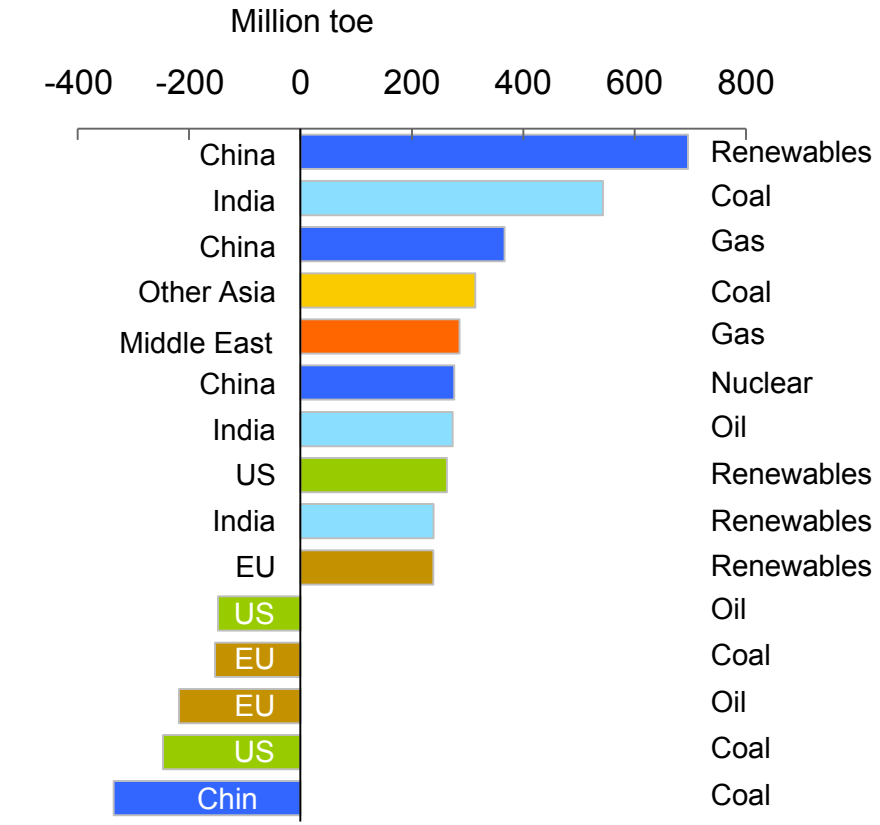


Differences in the fuel mix across regions

Primary energy demand by fuel and region



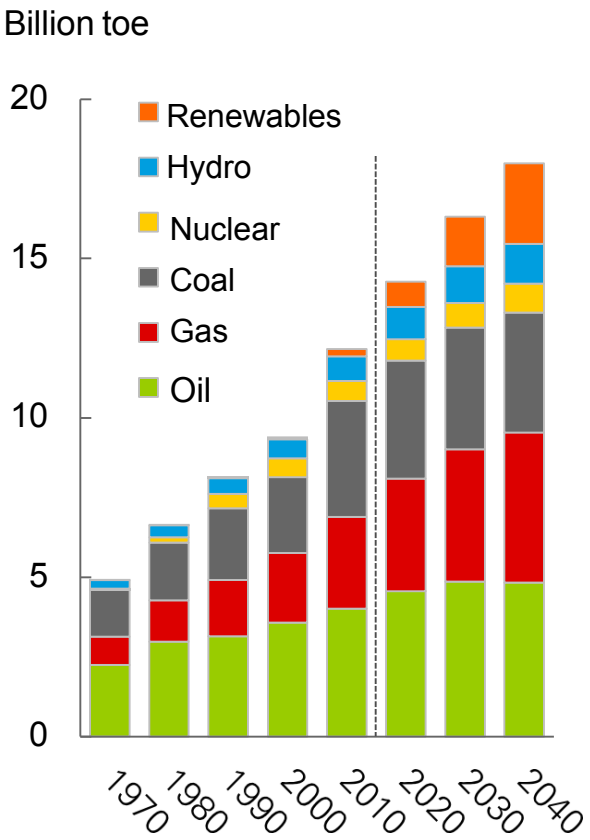
Changes 2016-2040† by fuel and region



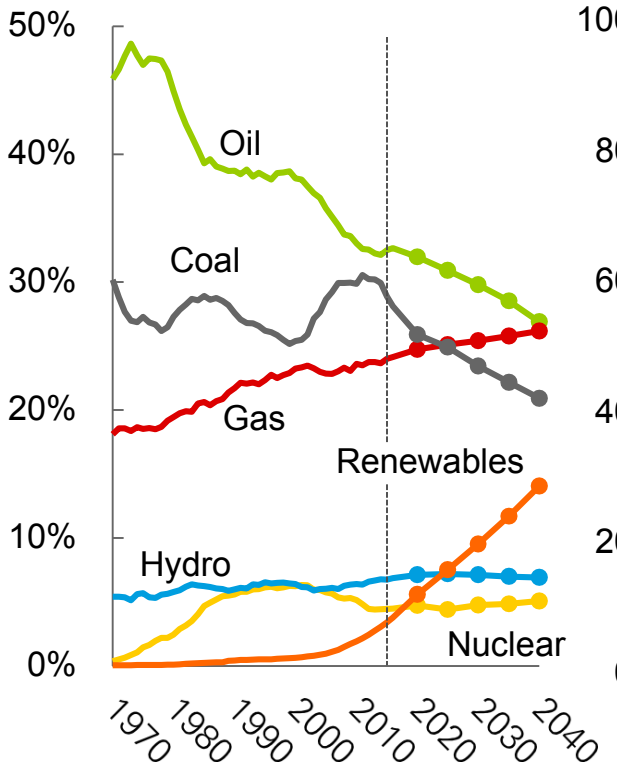
†Ten largest increases and five largest declines

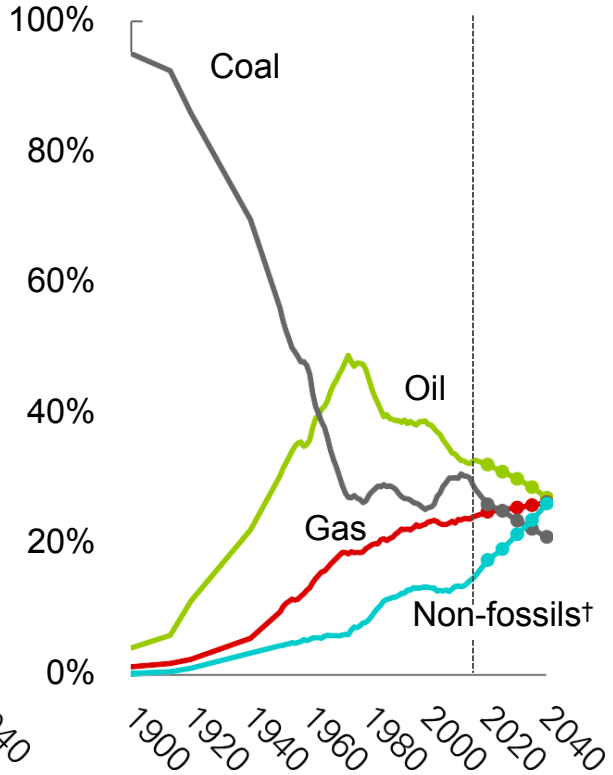
The transition to a lower carbon fuel mix continues…

Primary energy consumption by fuel



Shares of primary energy

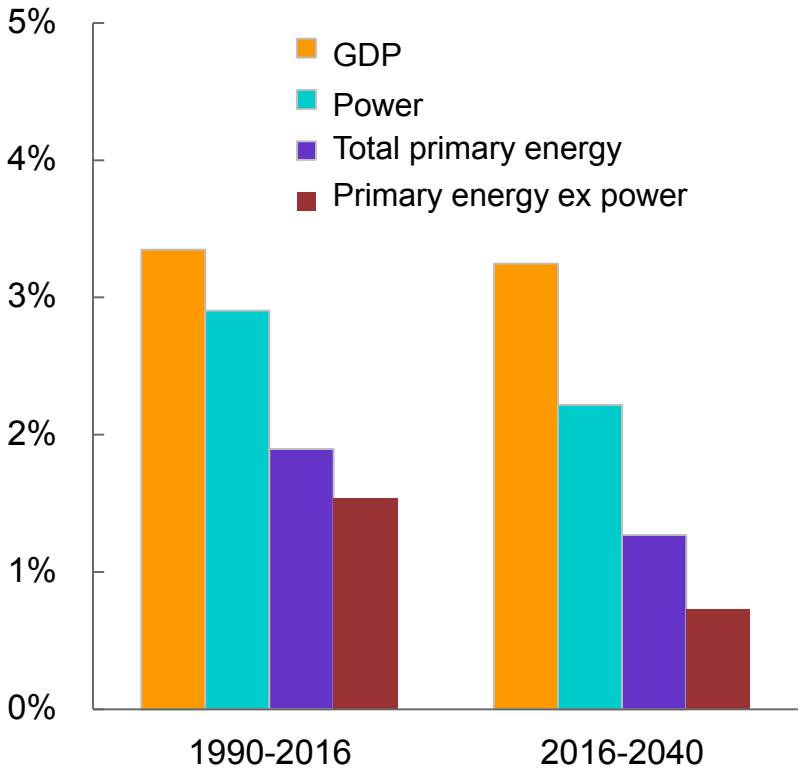




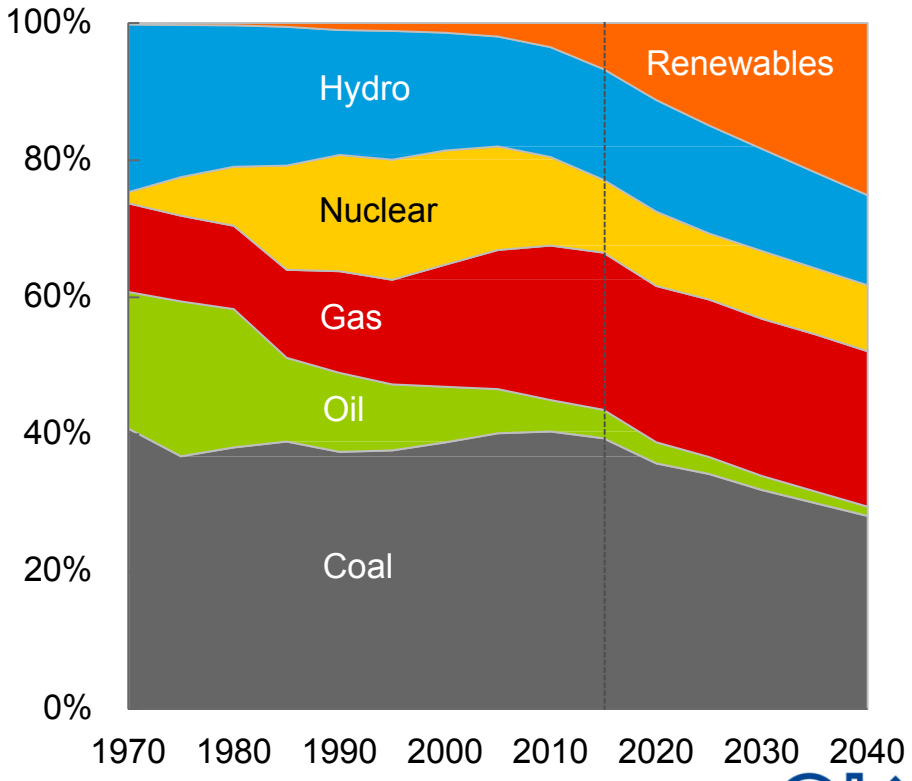
† Non-fossils includes renewables, nuclear and hydro

The world continues to electrify…

Growth of GDP, power and primary energy
% per annum

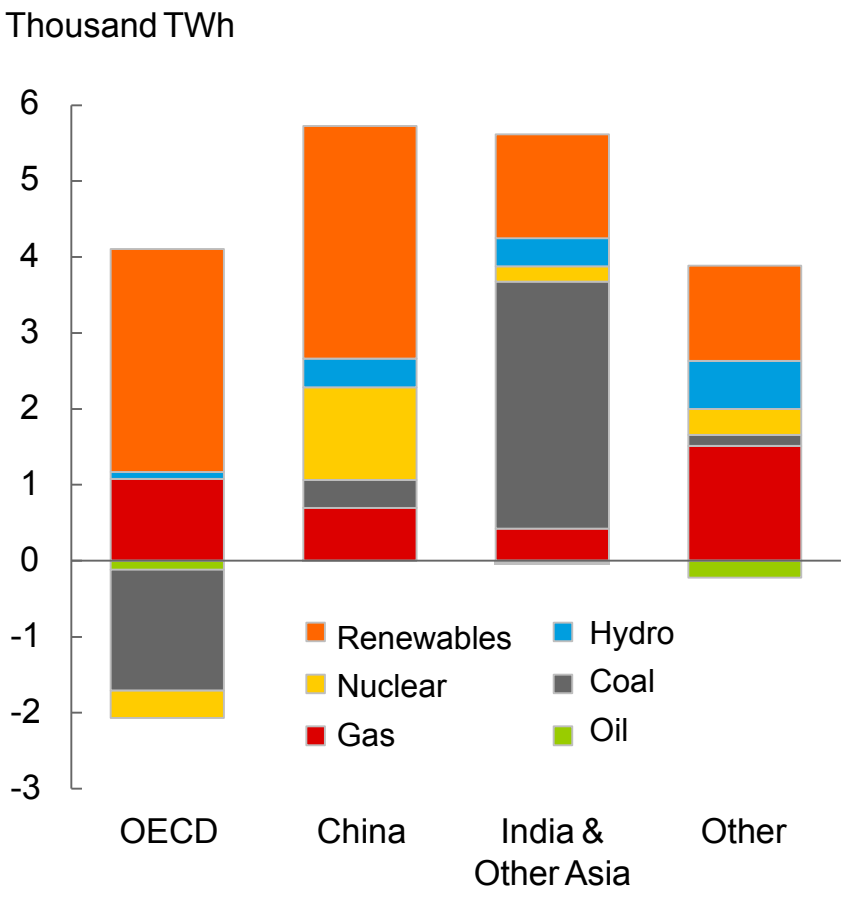


Shares of total power generation

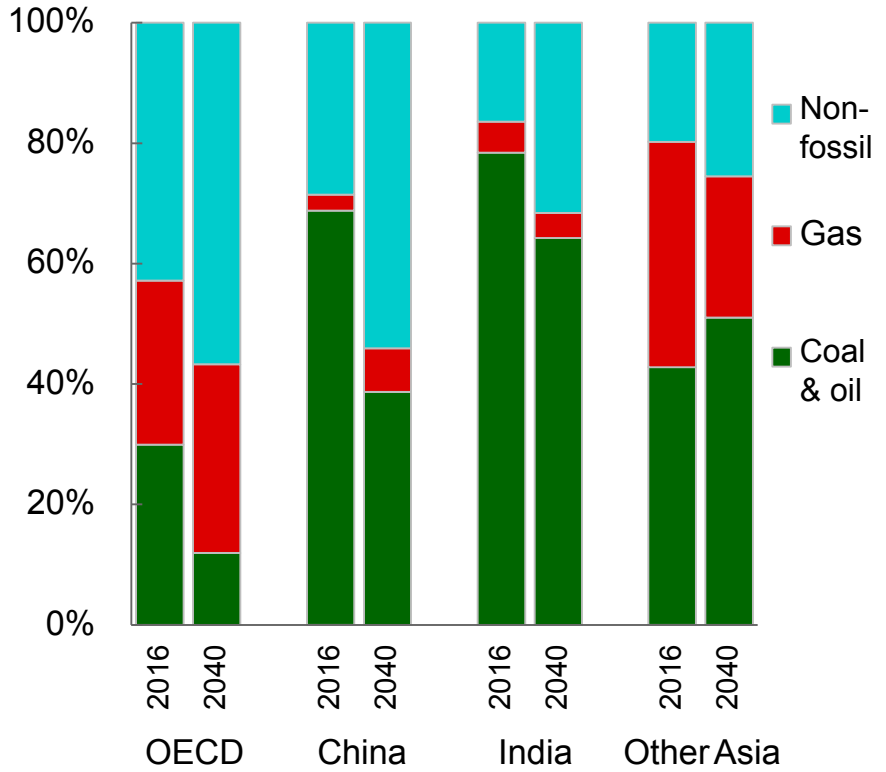


The increasing share of renewables is led by China and OECD

Growth of power generation, 2016-2040

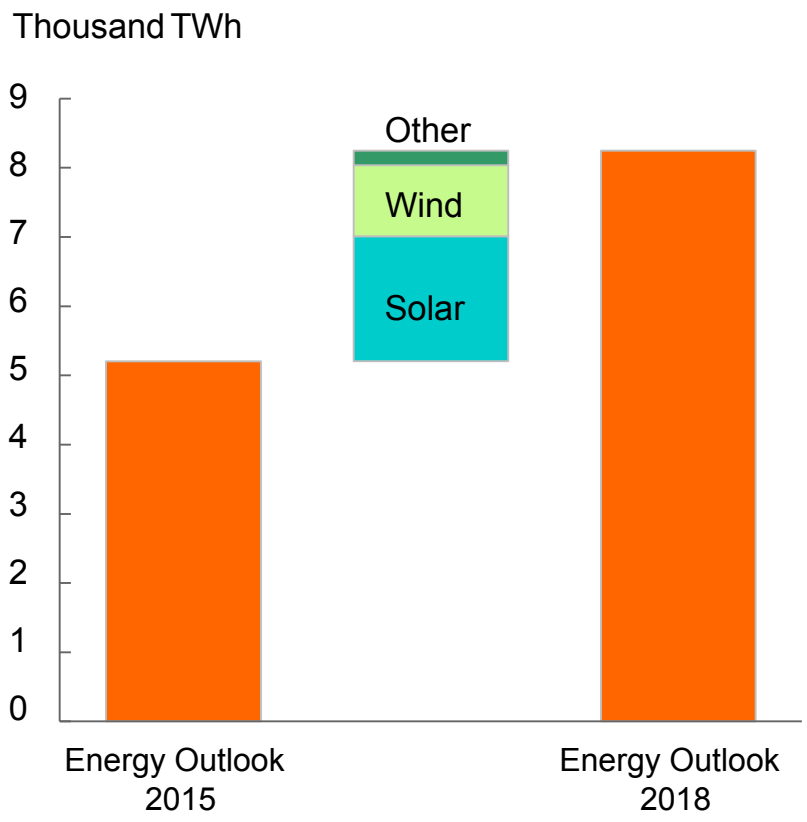


Shares of power generation, 2016 and 2040

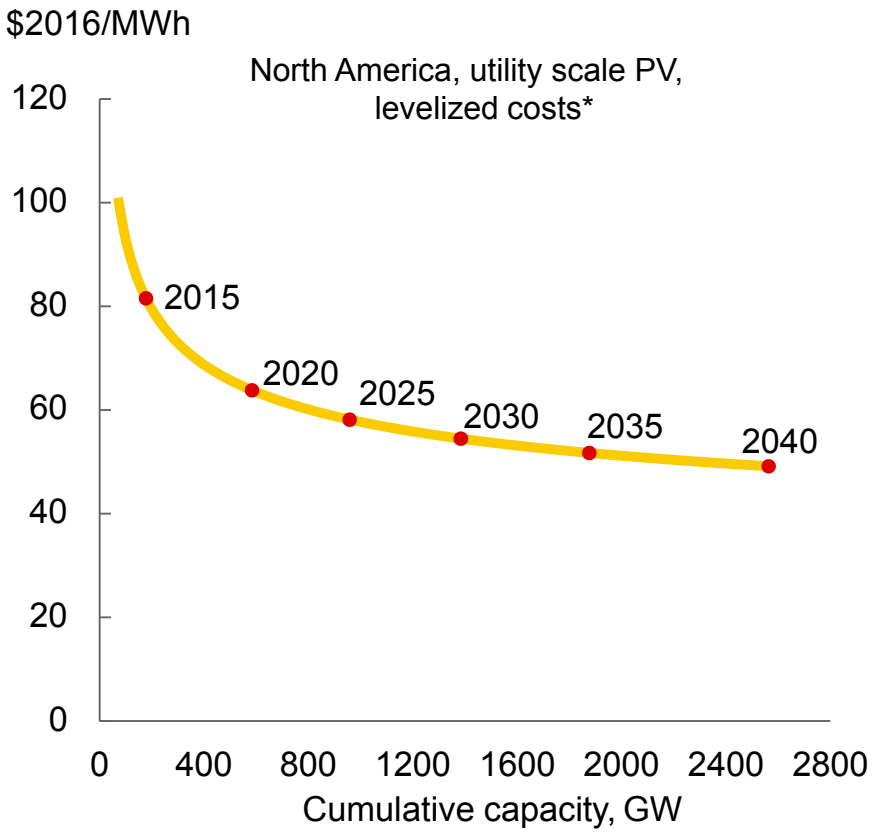


The outlook for renewables has increased significantly

Change to the projected level of renewable power in 2035



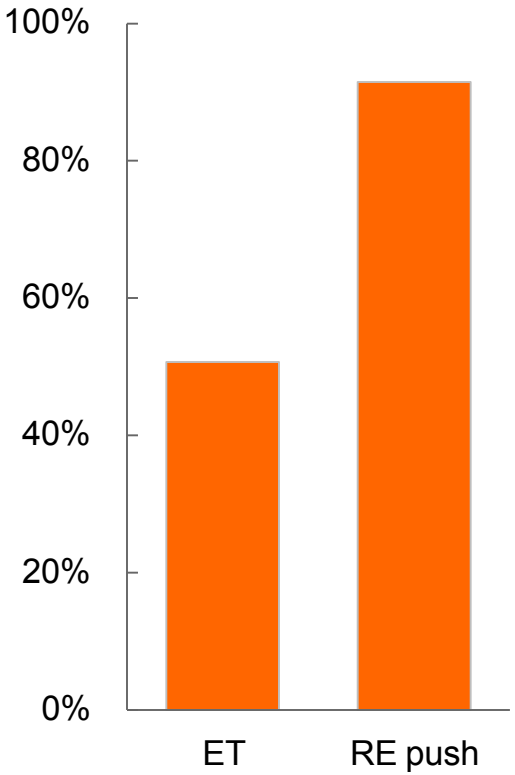
Solar PV learning curve



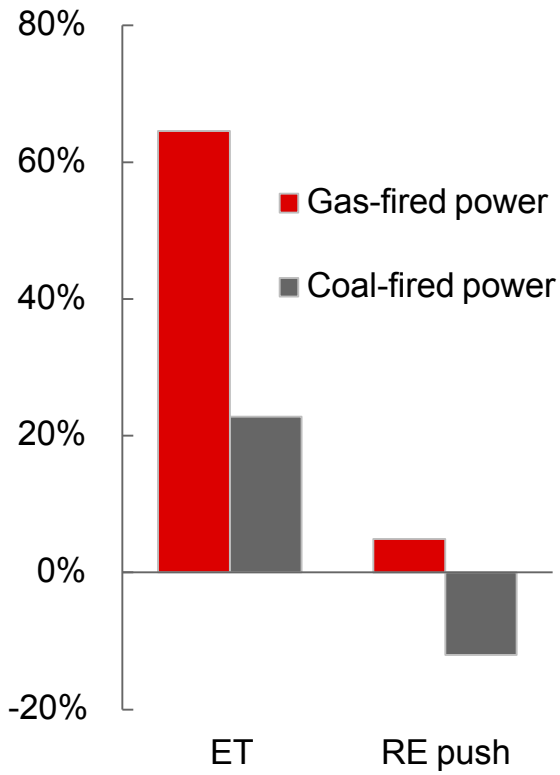
*Cost per MWh of building and operating a plant over its lifetime. Excludes subsidies, tariffs and the cost of grid integration.

Alternative scenario: more sustained support for renewables

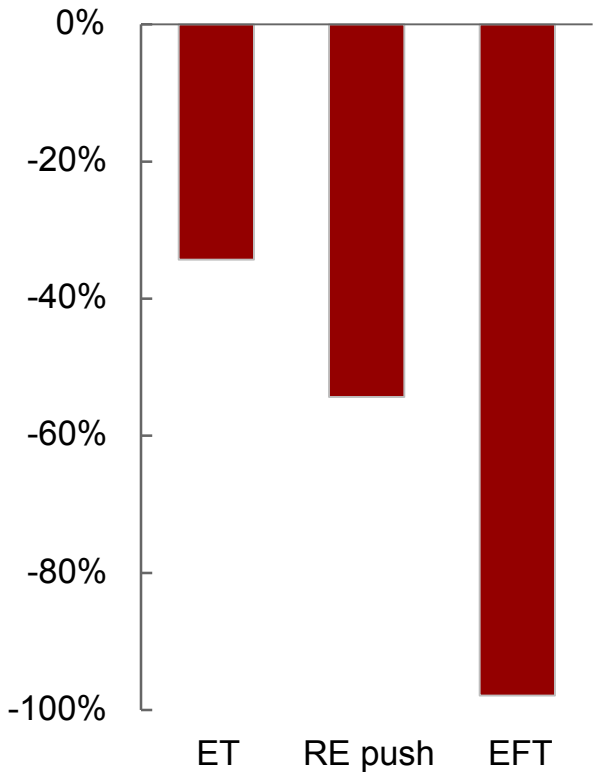
Renewables share of power growth, 2016-2040



Change in gas and coal power output, 2016-2040

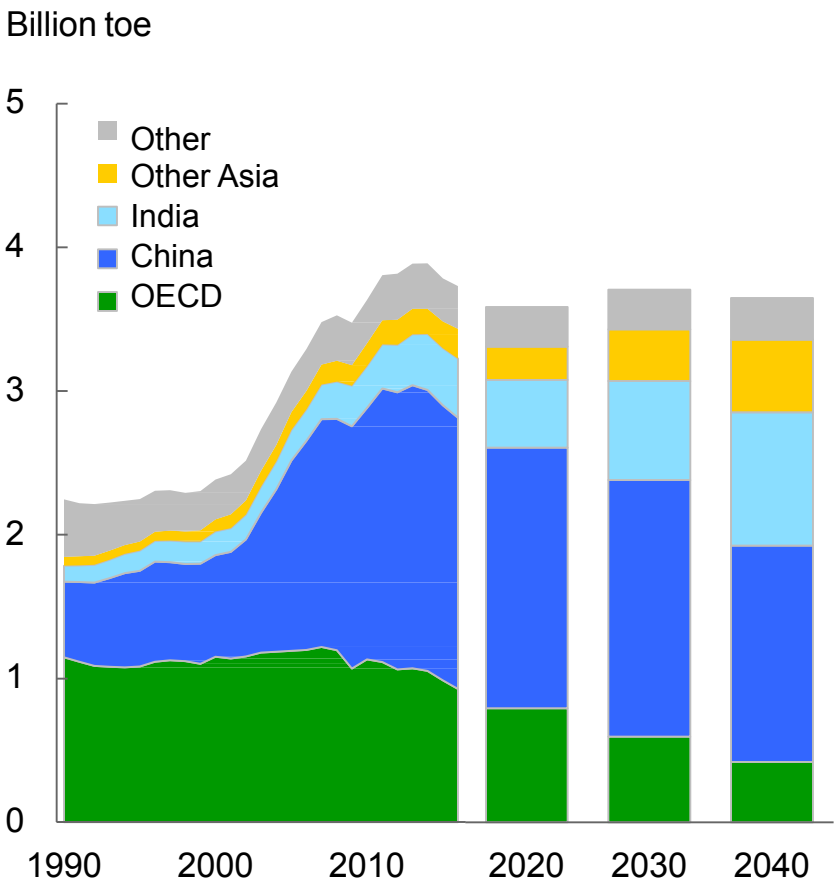


Change in carbon intensity of power, 2016-2040

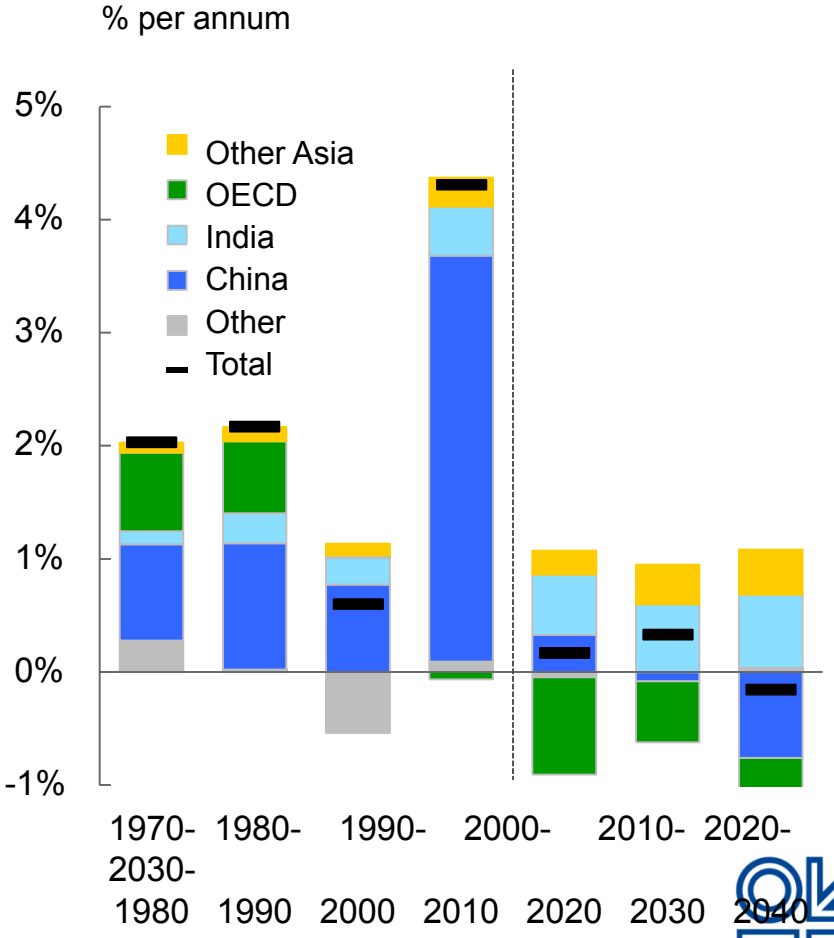


Global coal demand flatlines, with falls in China and OECD

Coal consumption by region

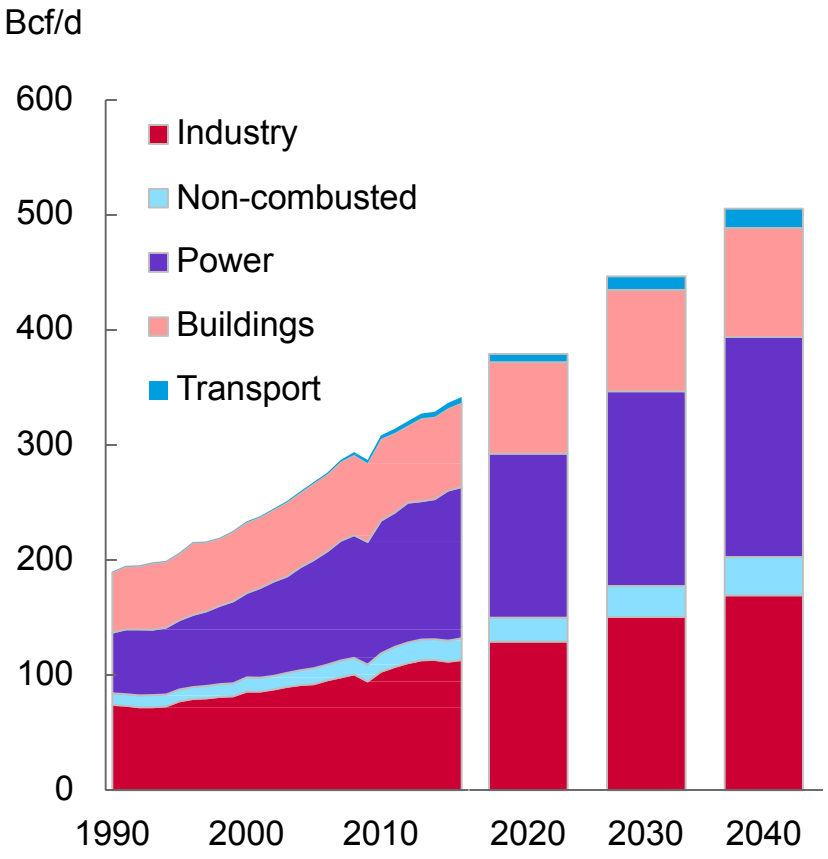


Coal consumption growth and regional contributions

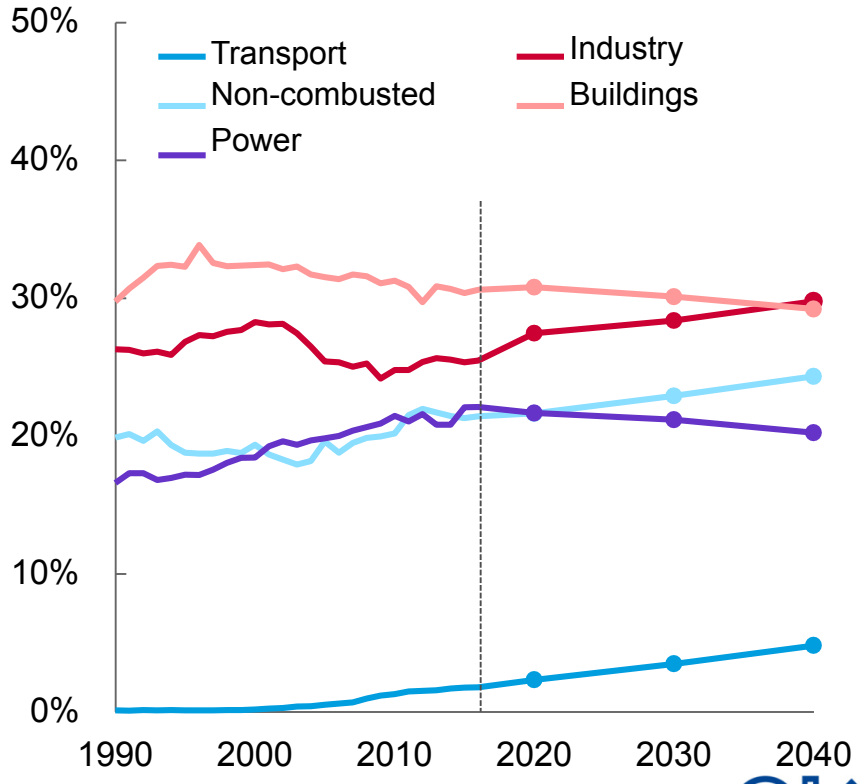


Growth in natural gas demand…

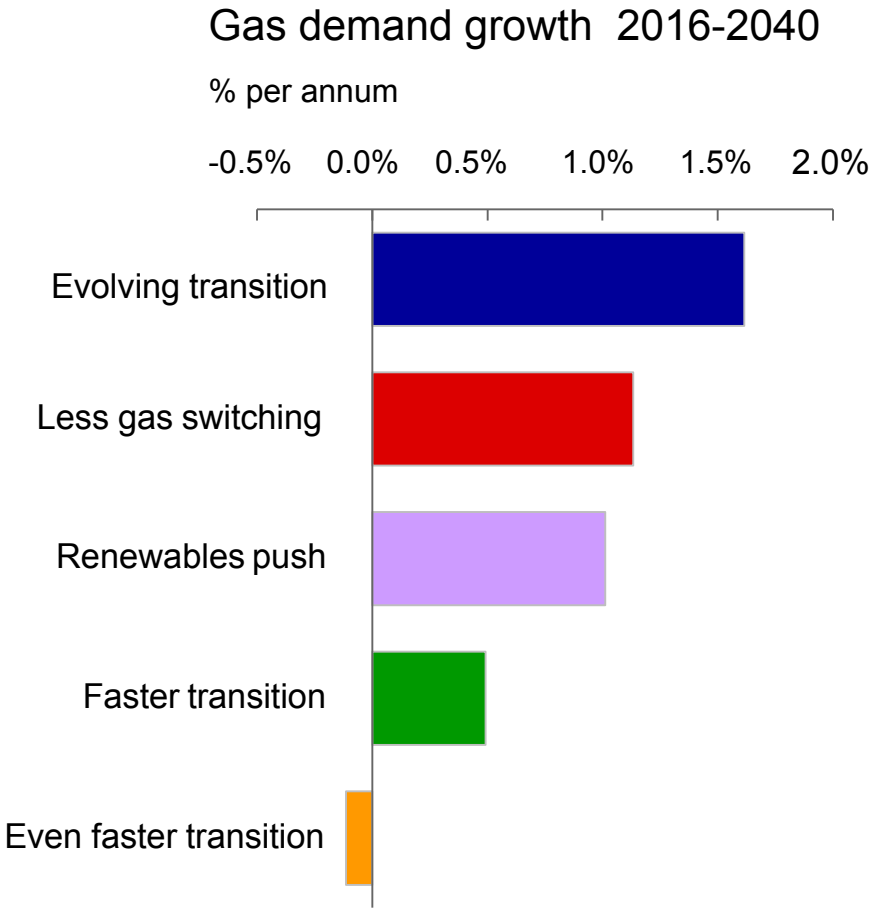
Gas consumption by sector

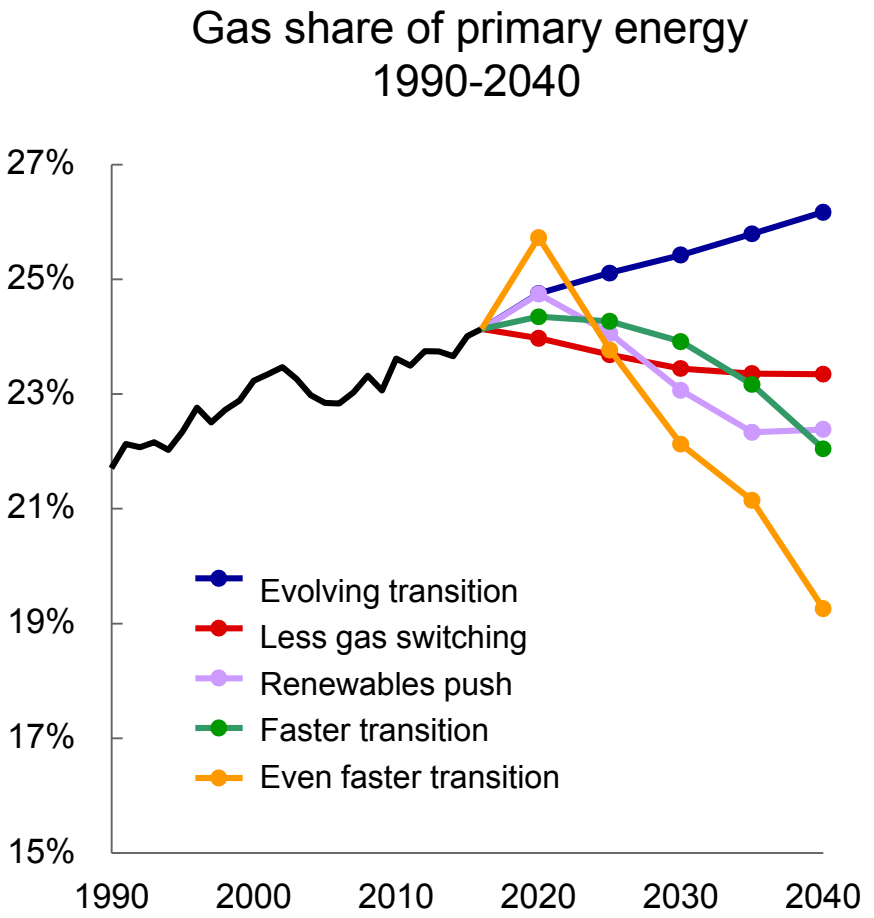


Gas share by sector

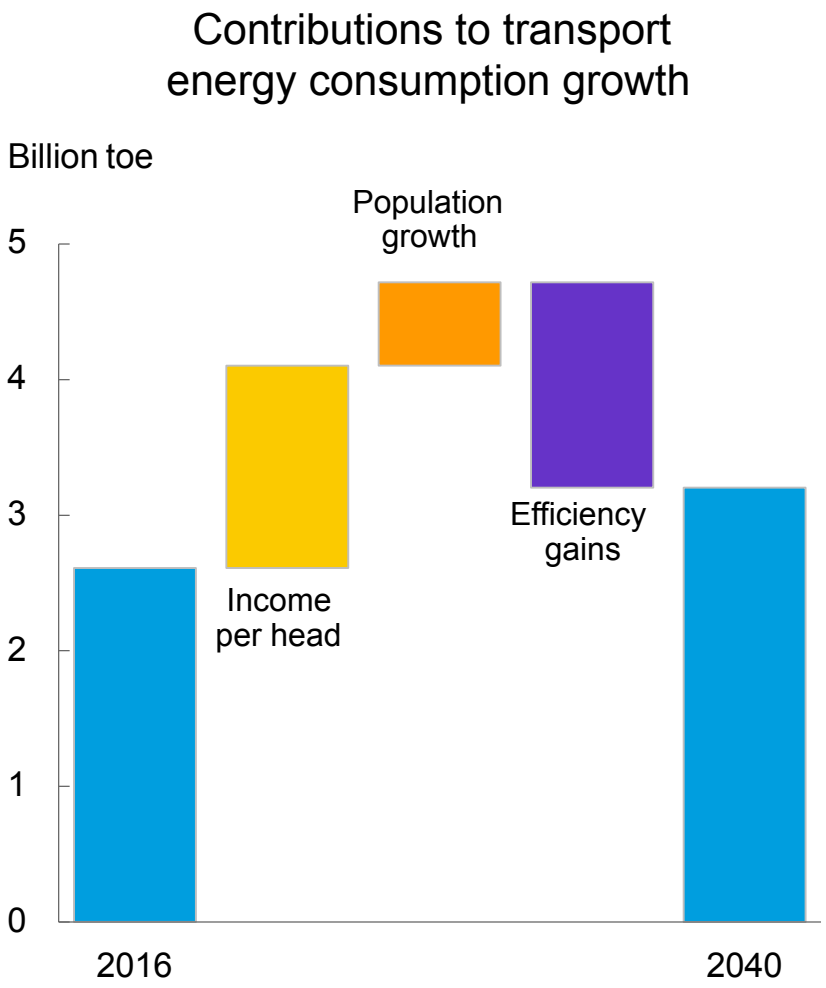


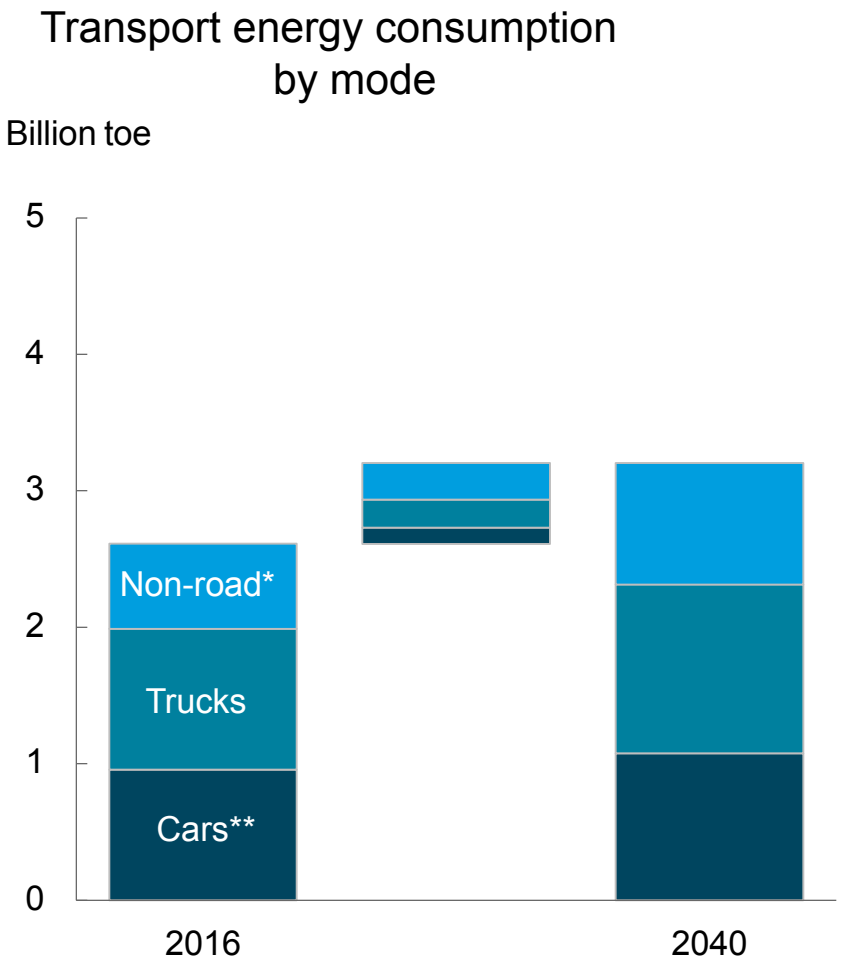
Prospects for gas demand could be dampened





Growth of fuels used in transport slows…

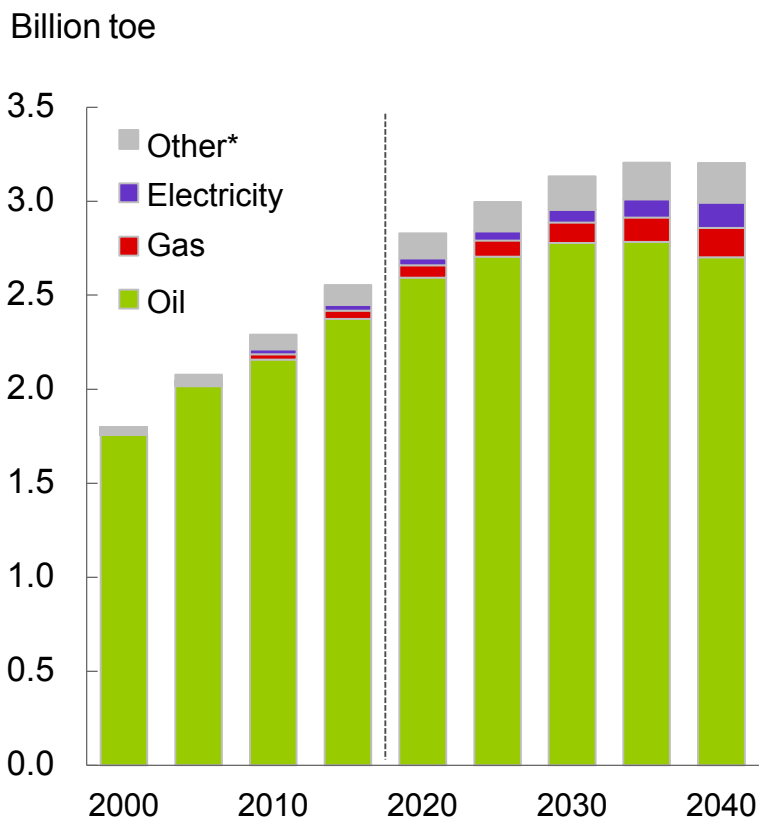




*Aviation, Marine and Rail
**Includes 2- and 3- wheelers

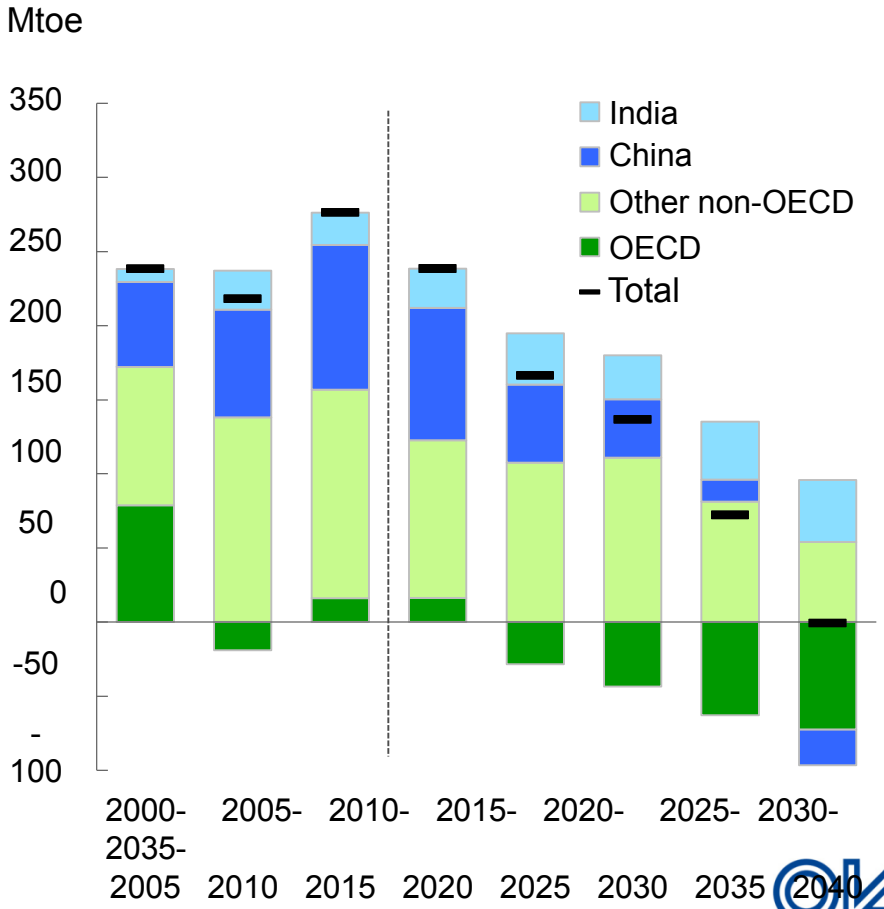
Transport demand continues to be dominated by oil…

Transport energy consumption by fuel type



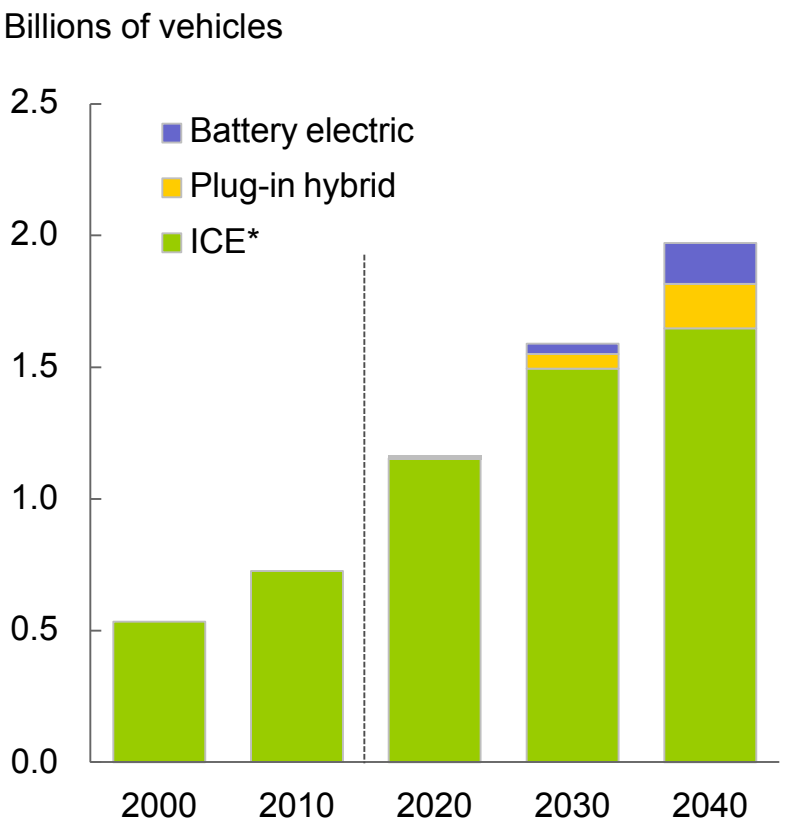
*Other includes biofuels, gas-to-liquids, coal-to-liquids, hydrogen

Transport energy consumption growth by region

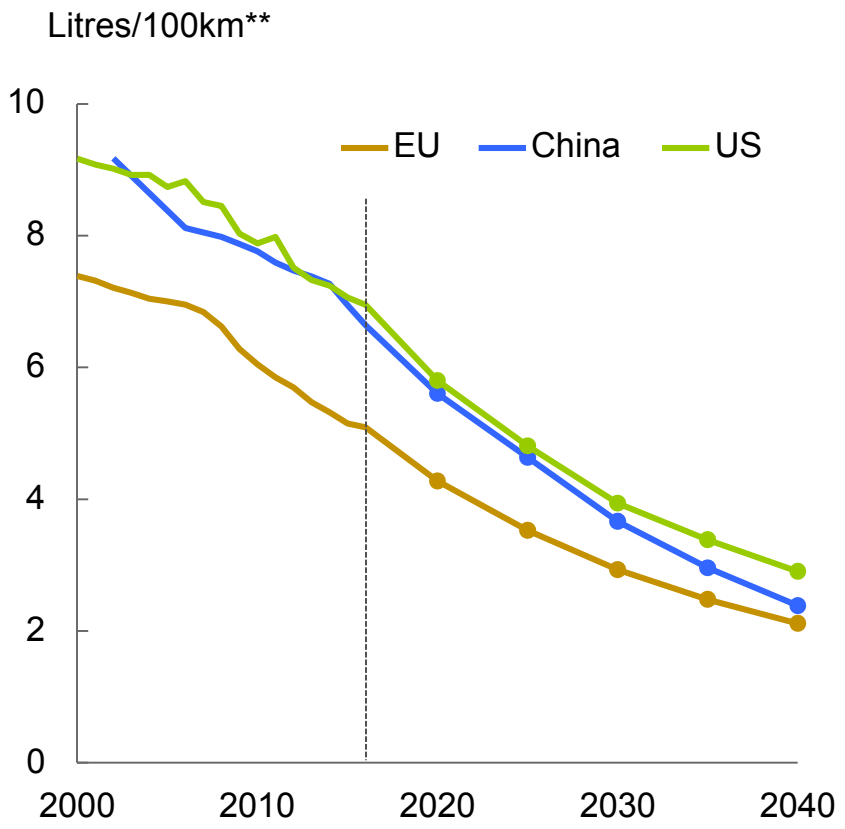


The passenger car parc grows substantially...

Passenger car parc by type



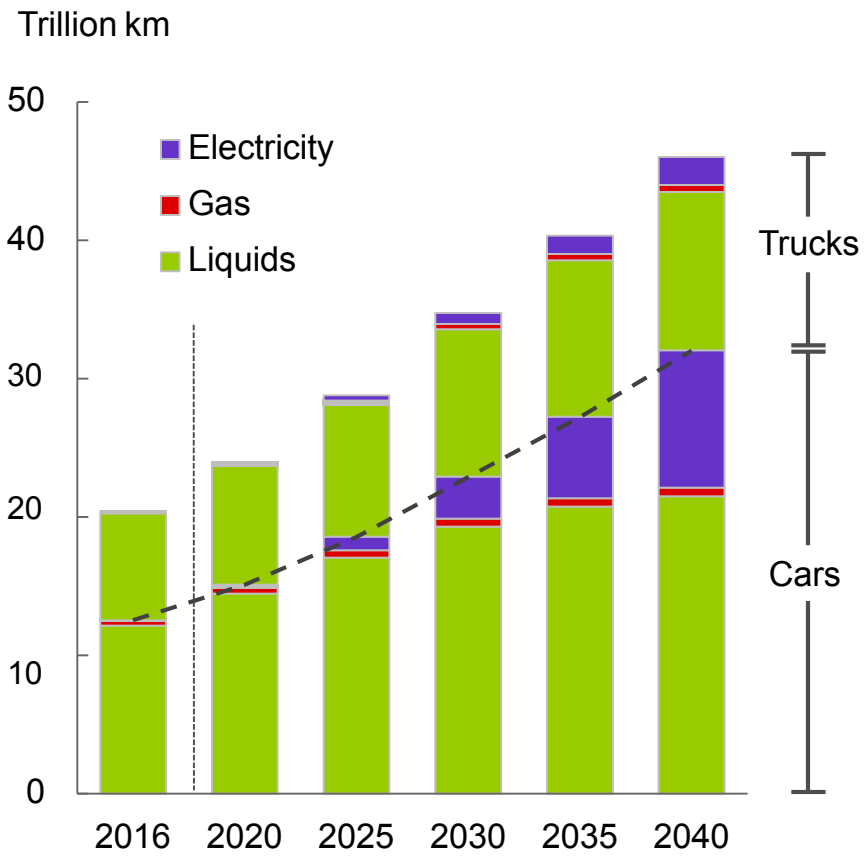
Fuel economy of new cars



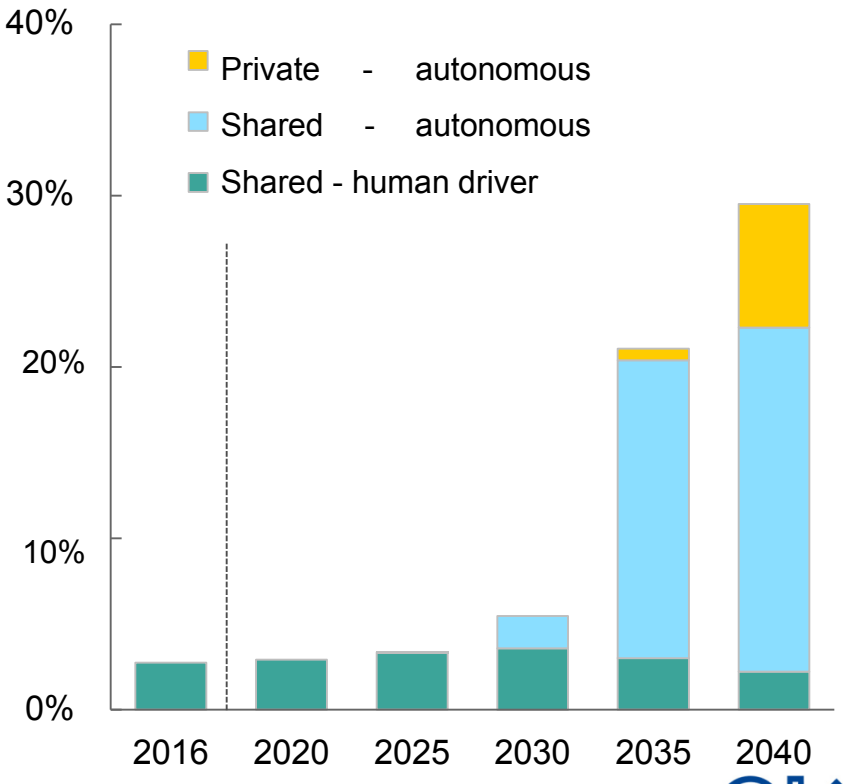
*ICE vehicles includes hybrid vehicles which do not plug into the powergrid
**Based on the NEDC (New European Drive Cycle), gasoline fuel

Road transport will be affected by the mobility revolution…

Vehicle kilometres (Vkm) by fuel type

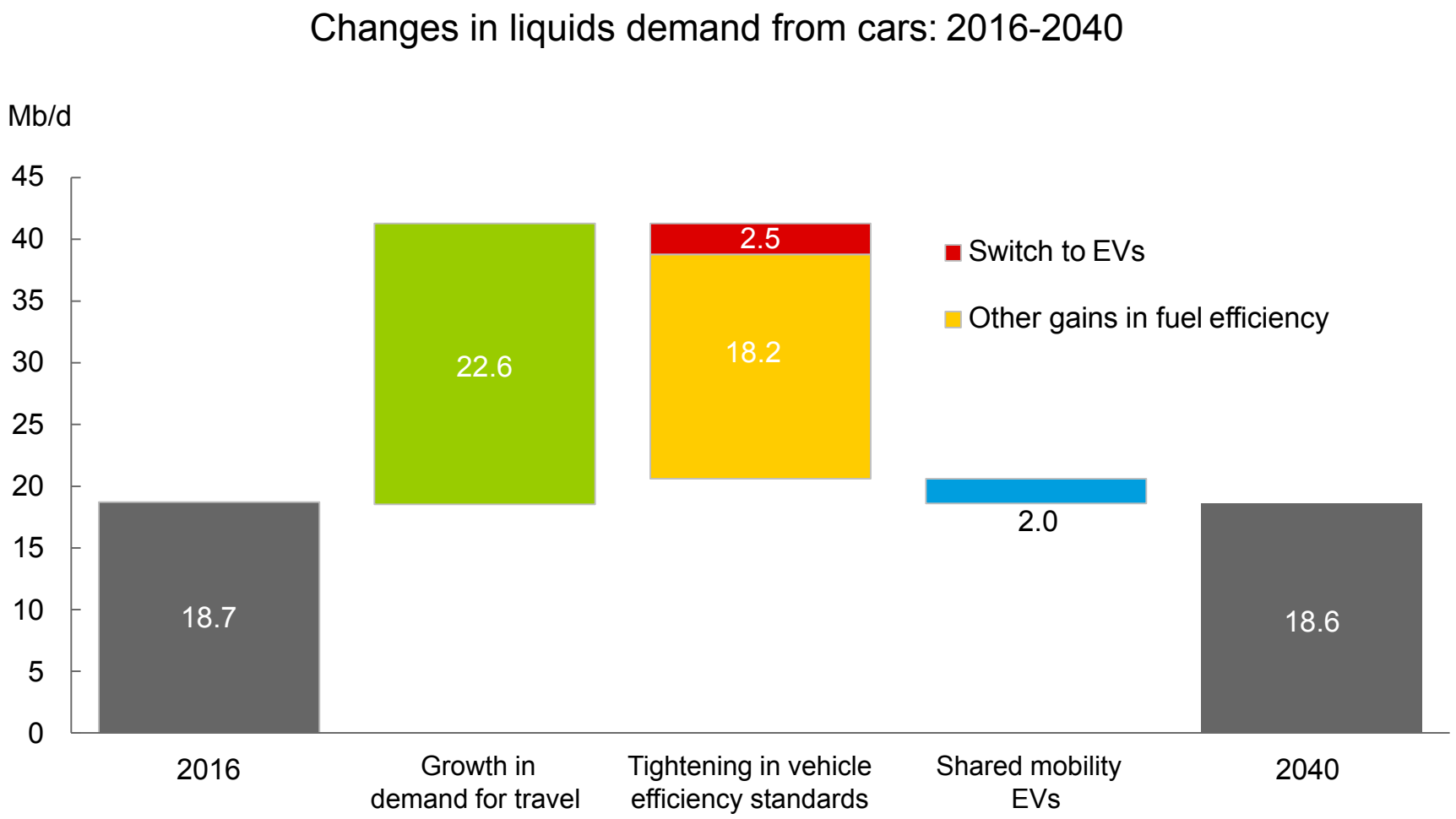


New mobility share of total Vkm

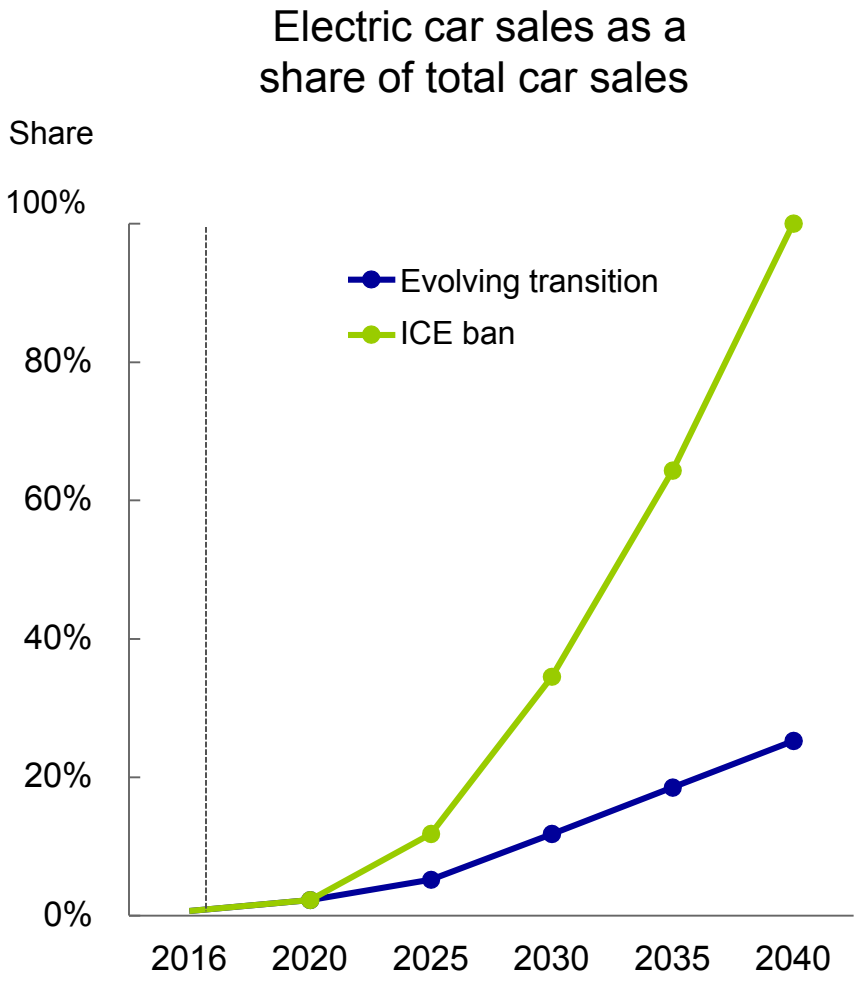


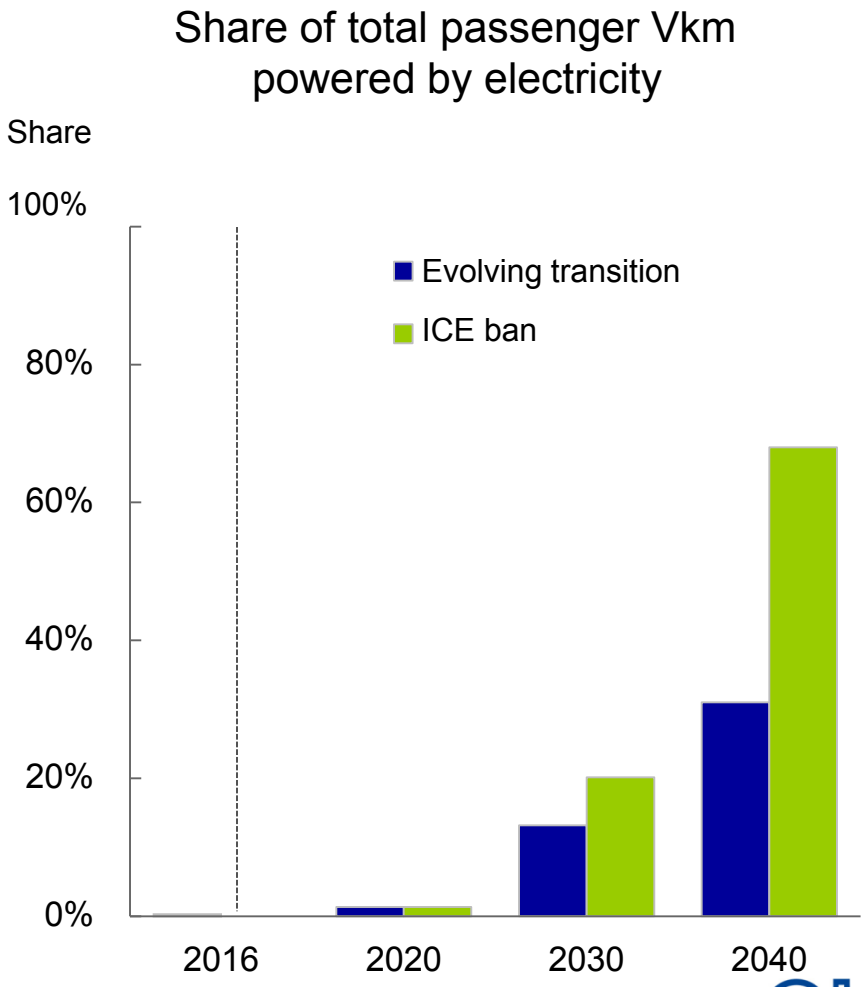
Cars excludes 2- and 3- wheelers

Liquid fuel use in cars is broadly flat…



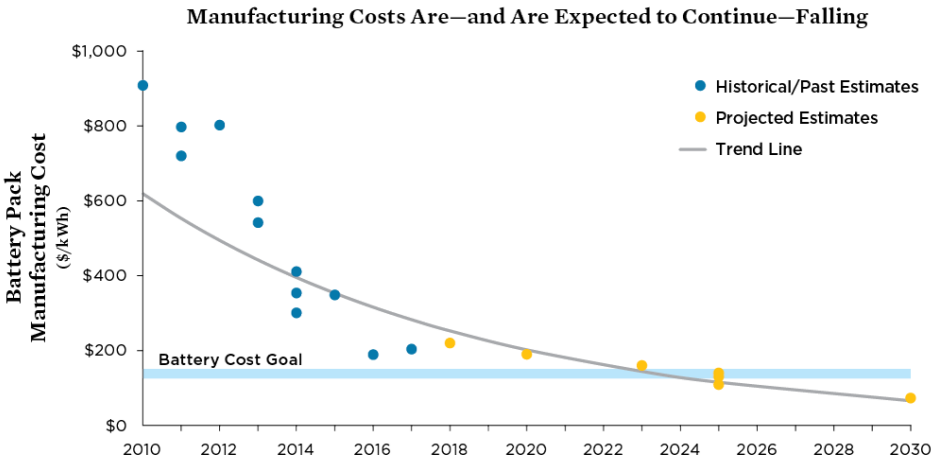
Alternative scenario: impact of faster growth in electric cars…



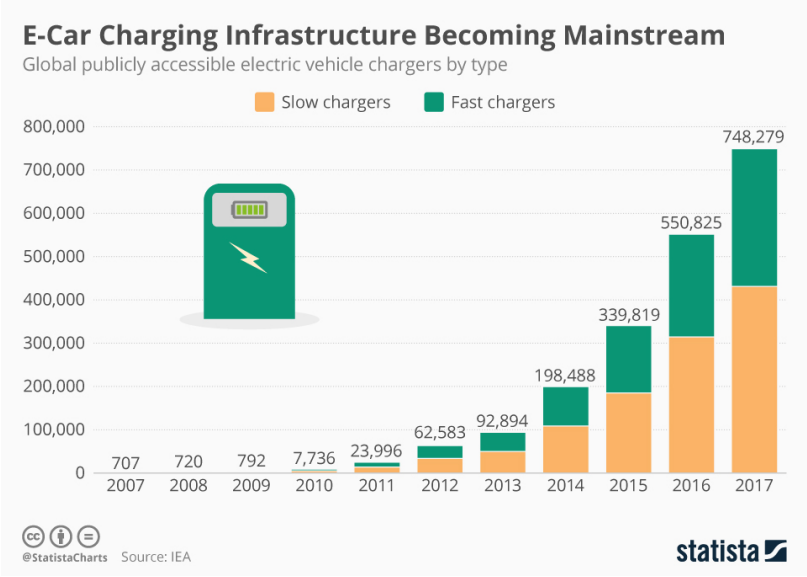


Some infrastructure and technology issues

Battery prices ($/kwh)



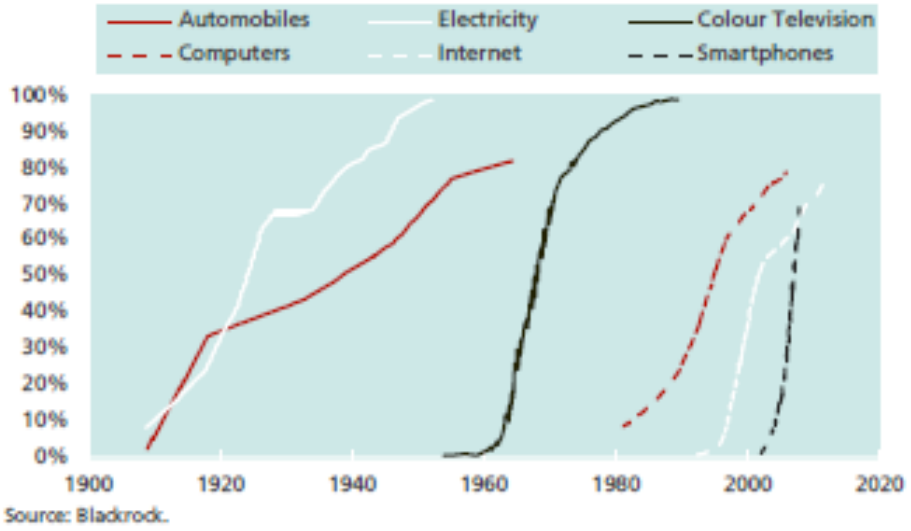
Charging stations worldwide



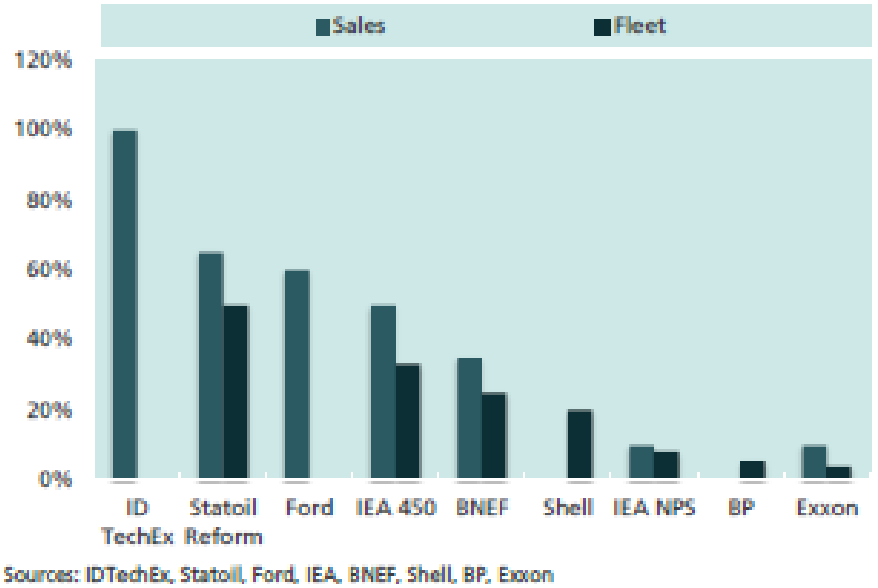
- Battery prices have been falling at 21% p.a. since 2008
- They could reach $100/kwh by 2025, at which point a car battery would cost around $6,000
- Charging infrastructure has also expanded rapidly, with a CAGR of 95%
- Policy plays a key role – China has plans to build 5 million charging points by 2020

Behavioural economics could suggest rapid growth

US household penetration of new technologies



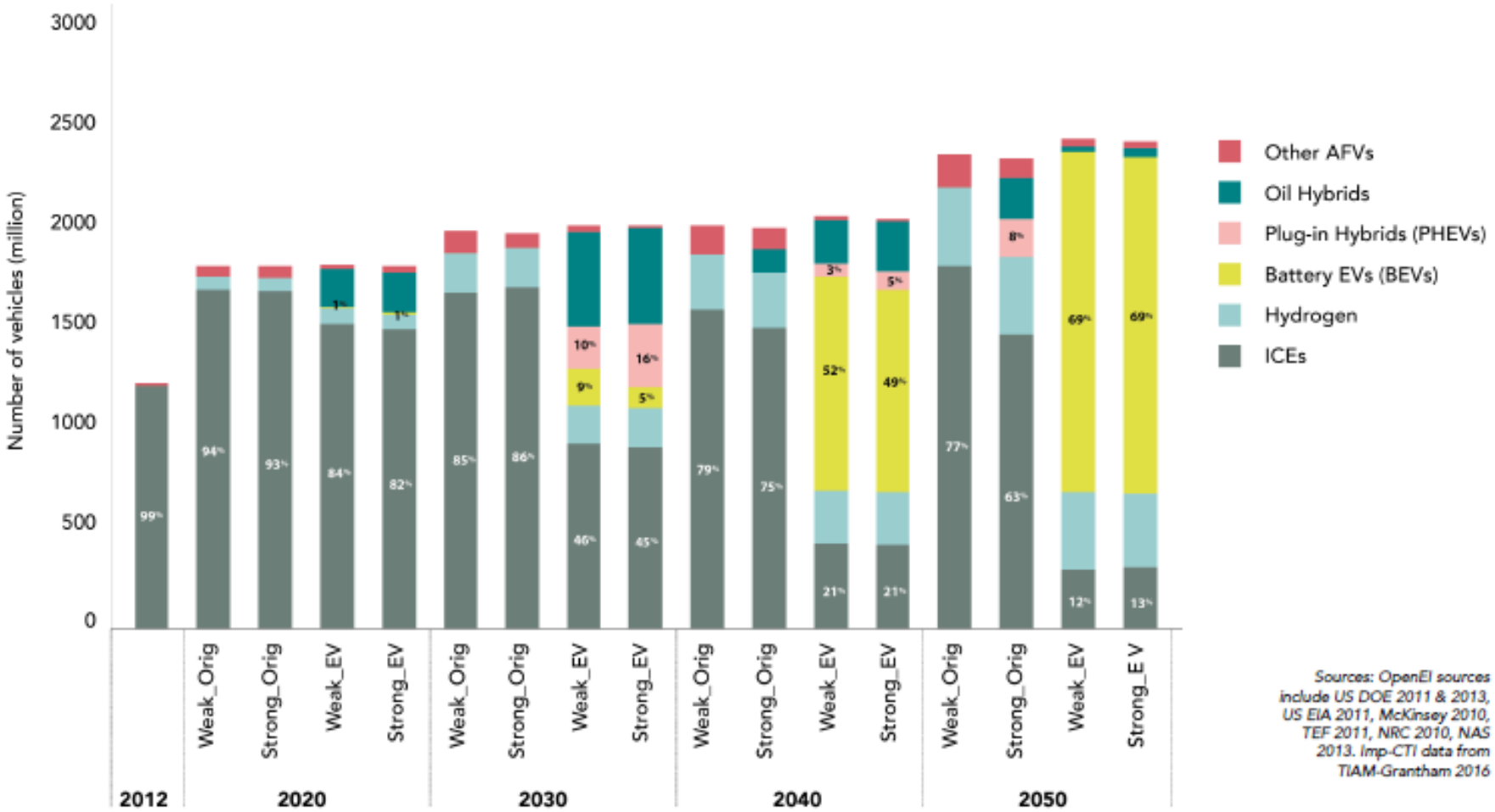
EV share of sales and fleet, end of period



- Consumer adoption will be vital to the success of electric vehicles
- If consumers start to think of EVs as an attractive and superior technology, then historical analogies suggest a rapid growth trajectory
- A key element in the decision will be cost, and the debate therefore centres on battery technology

Optimistic longer term scenarios see dominance by EVs although the variations in outcome are wide

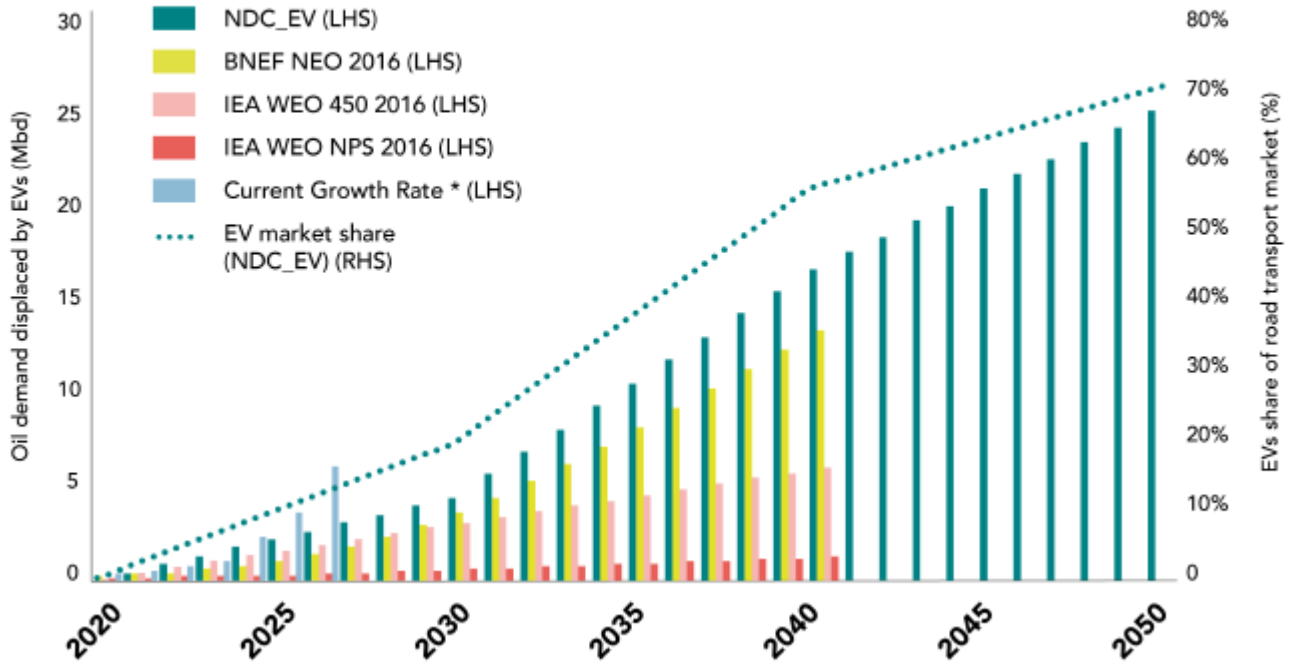
Figure 9: The share of road transport met by different vehicle technologies under original and lower EV costs, and varying climate policy effort[4]



Sources: OpenEI sources include US DOE 2011 & 2013, US EIA 2011, McKinsey 2010, TEF 2011, NRC 2010, NAS 2013. Imp-CTI data from TIAM-Grantham 2016

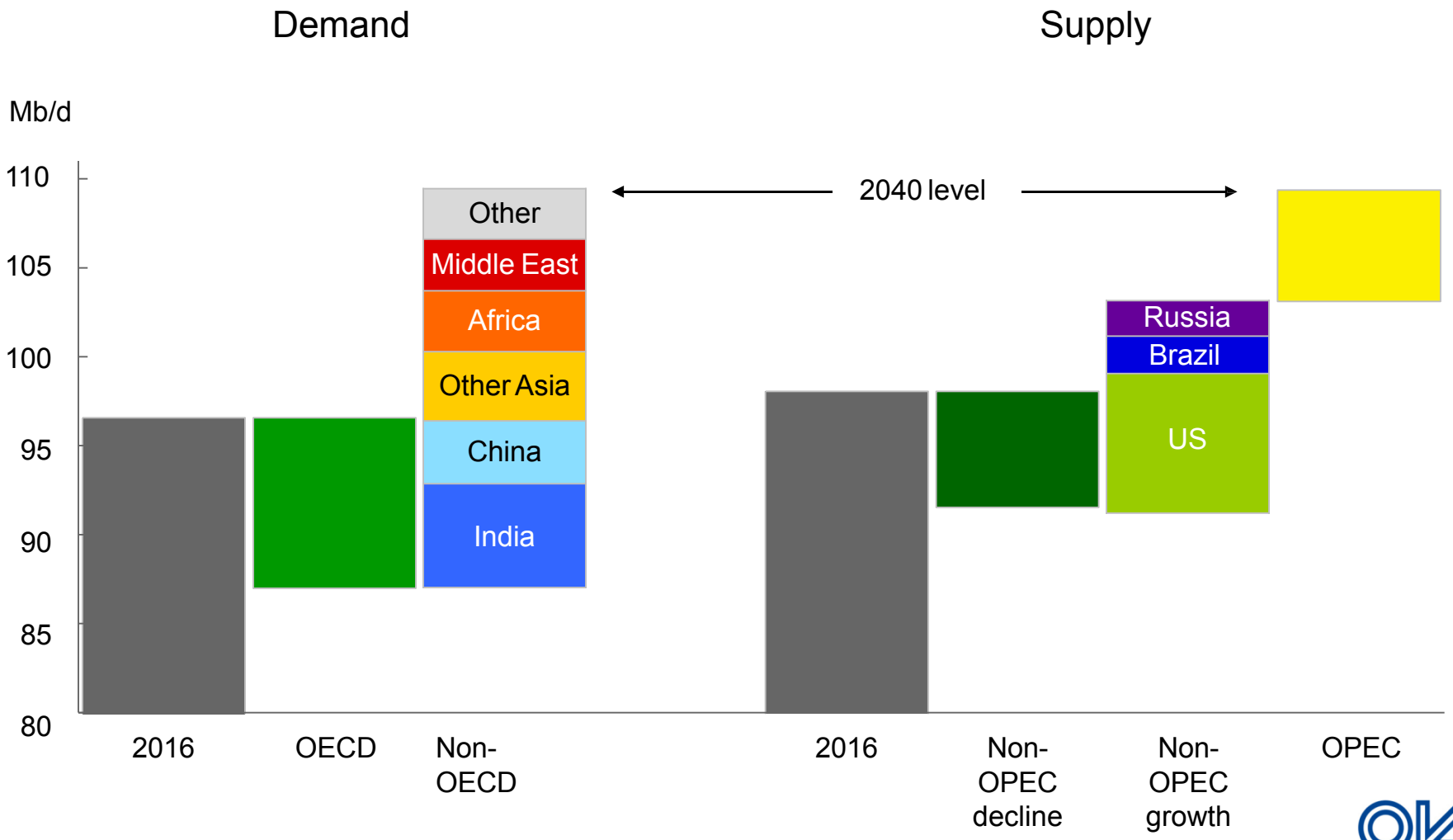
The impact on oil demand could be very significant

Figure 10: Comparing levels of oil demand displaced by EVs across institutional projections[4]



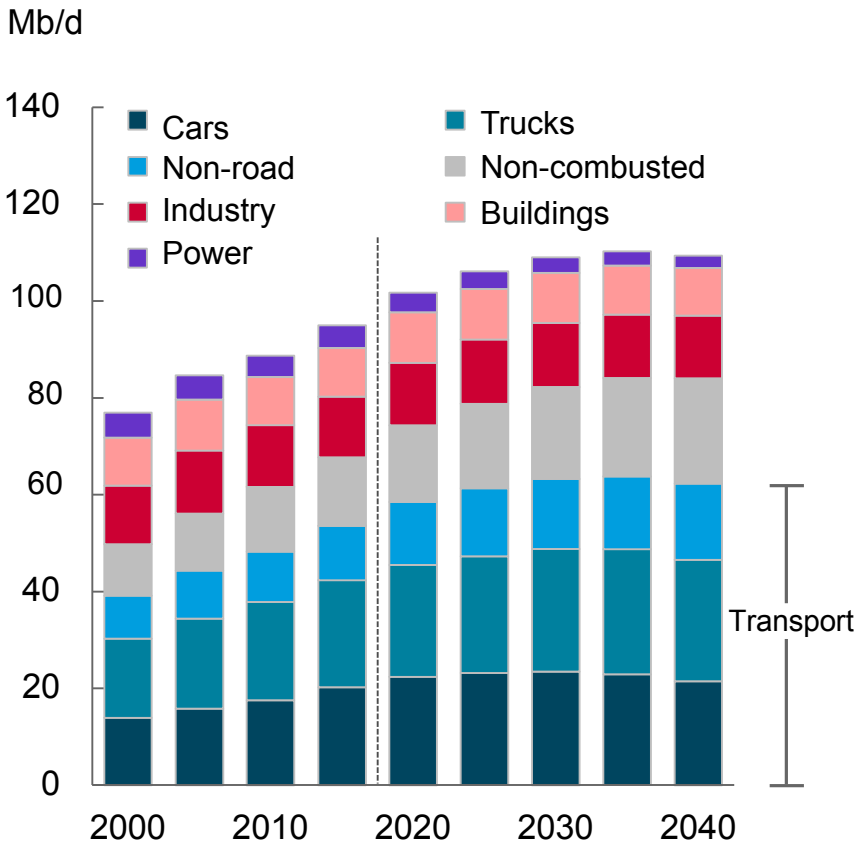
- A loss of even 5 million bpd would be huge, given that oil demand has historically grown by around 1mmpd per annum
- However, would a price collapse slow the switch away from oil?

Growing demand for liquid fuels in emerging economies

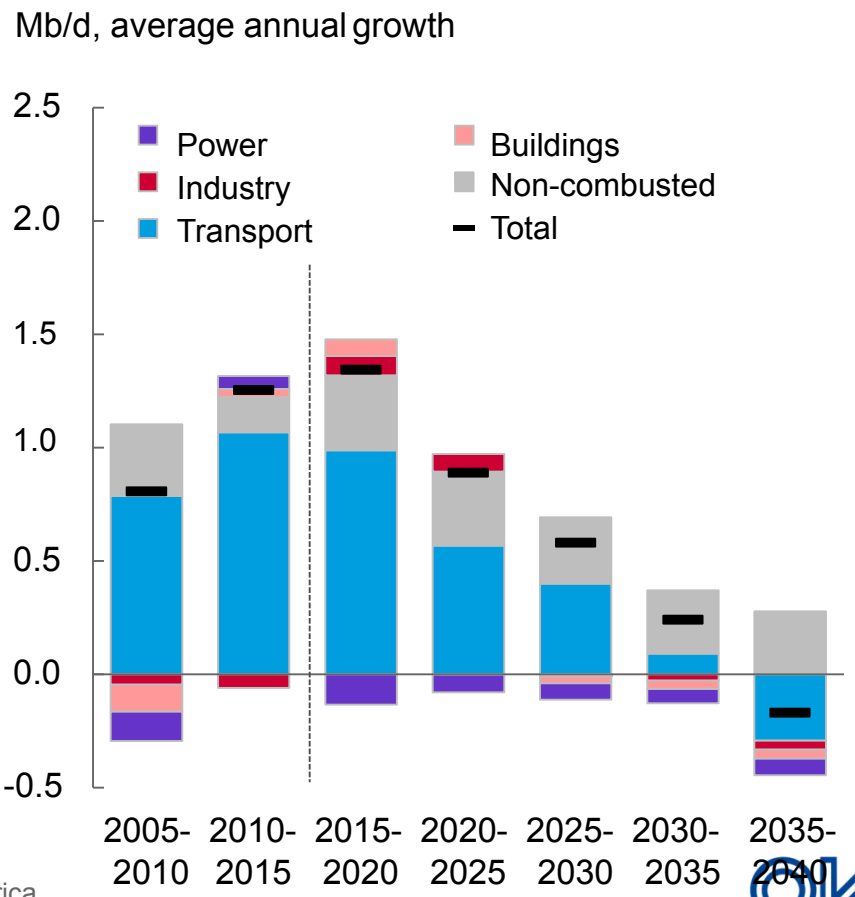


Liquids demand grows materially over the period to 2040

Liquids demand



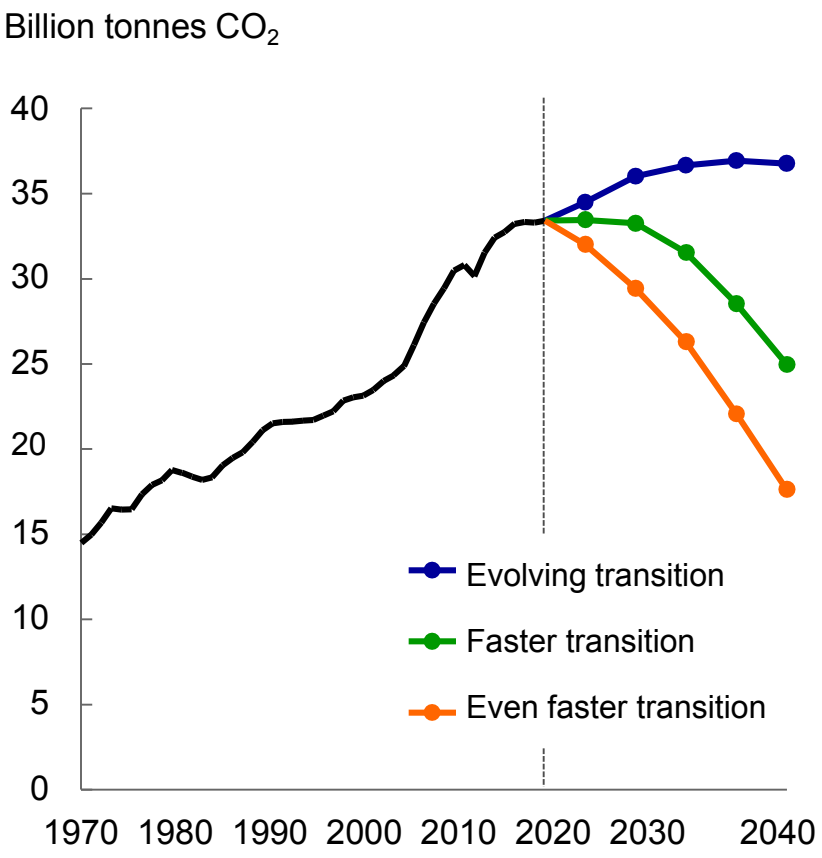
Liquids demand growth



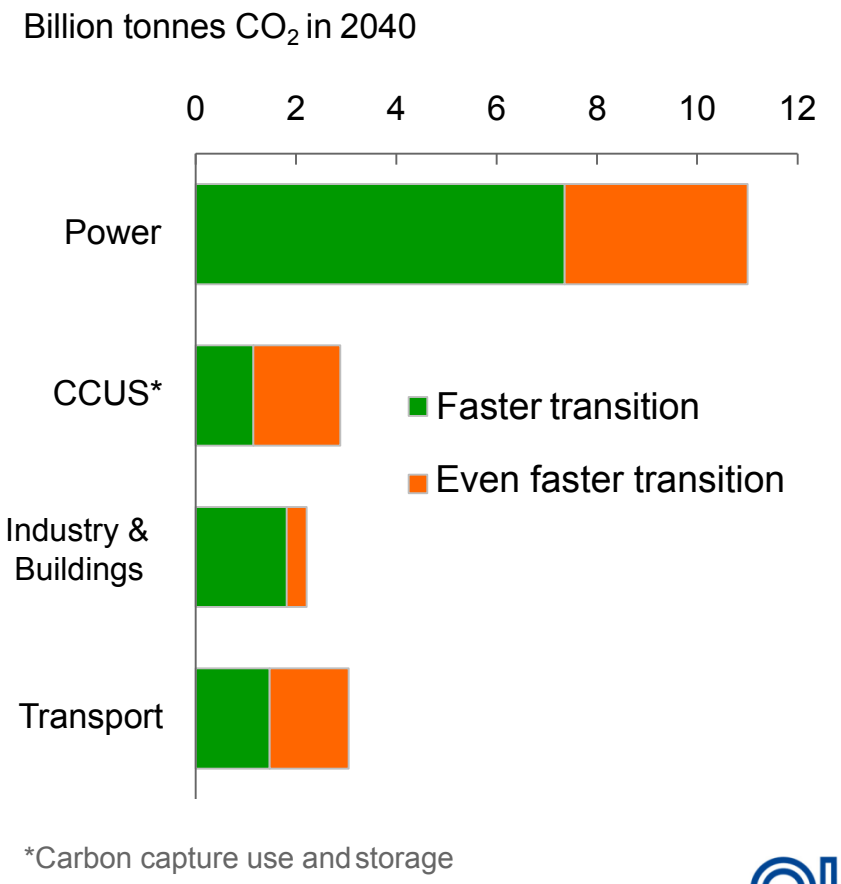
Cars include 2- and 3- wheelers. Trucks include most SUVs in North America. Non-road includes aviation, marine and rail

Carbon emissions continue to grow in the ET scenario

Carbon emissions



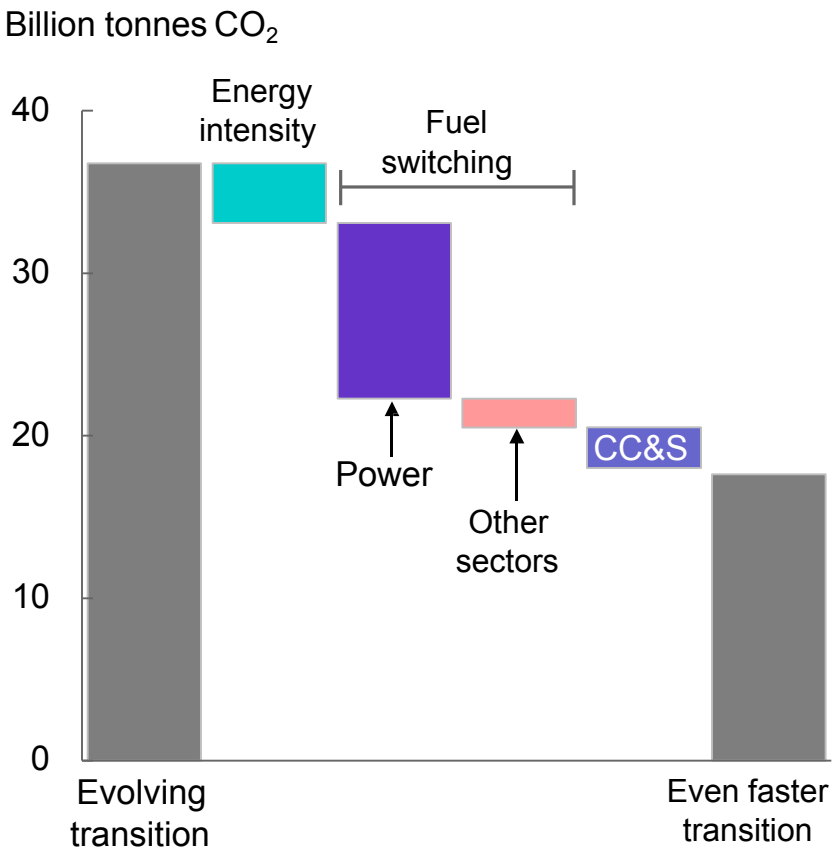
Reductions versus ET scenario



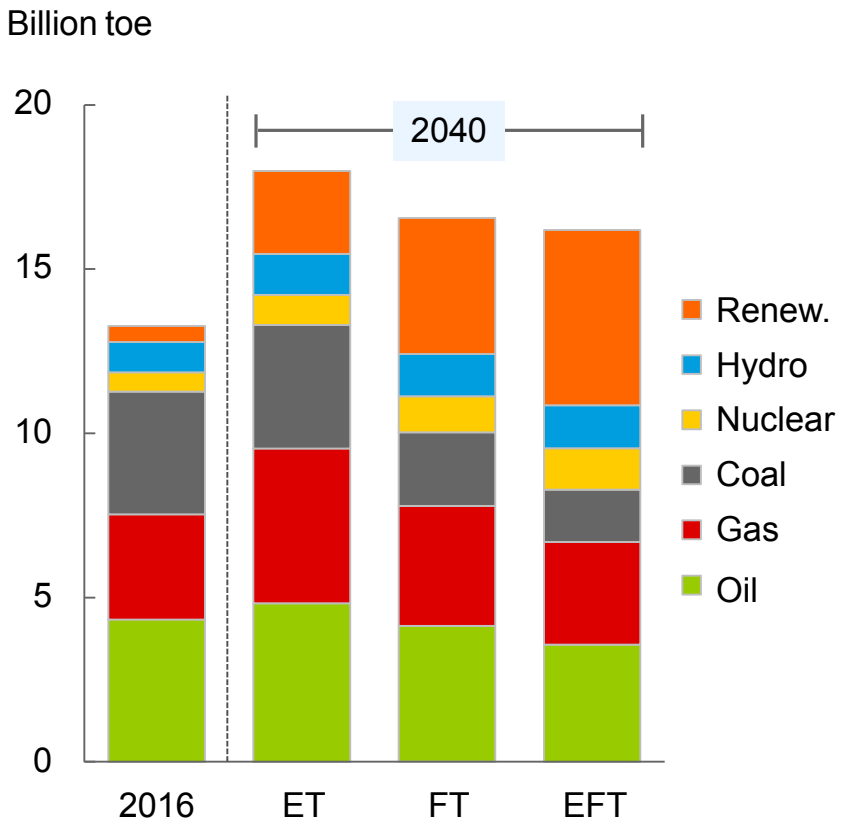
*Carbon capture use and storage

Alternative scenario: impact on global energy system

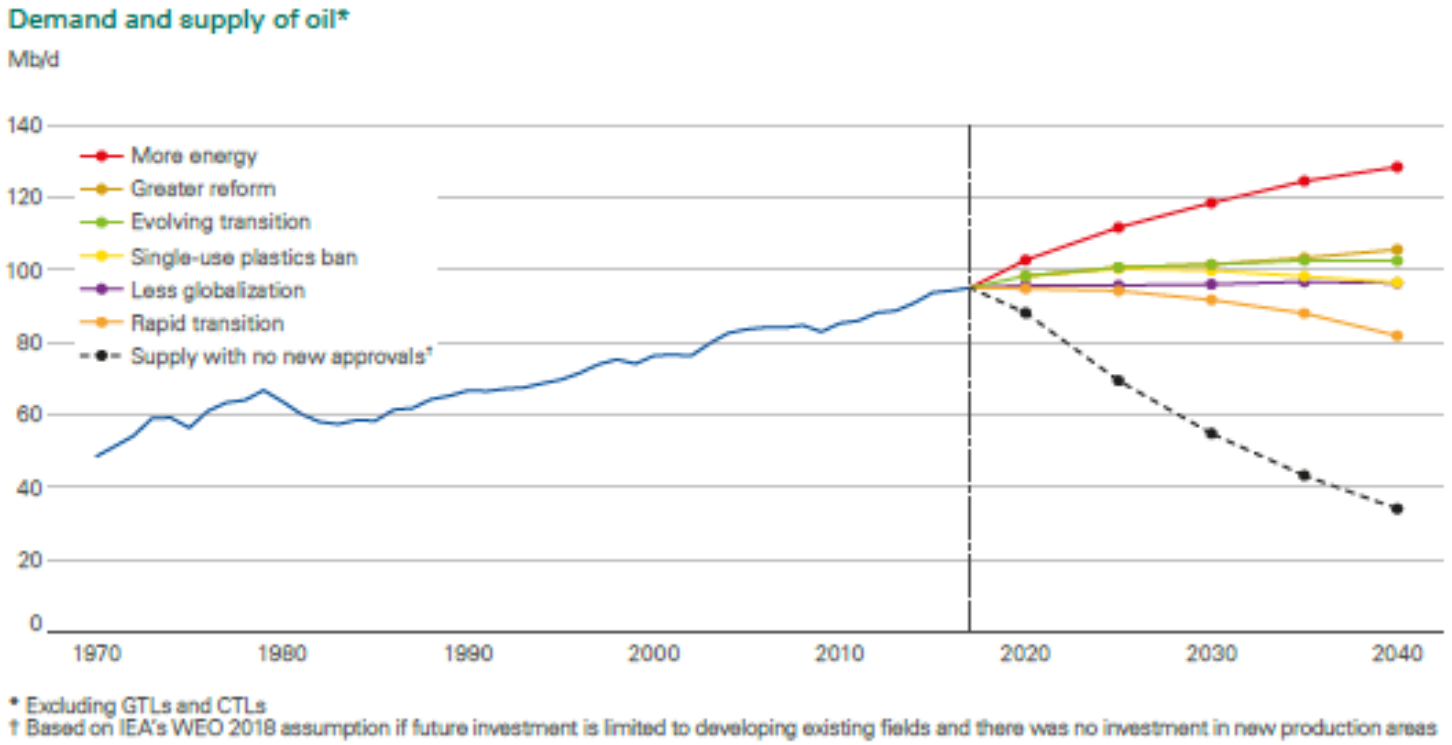
Carbon emissions in 2040: EFT versus ET scenario



Primary energy consumption by fuel



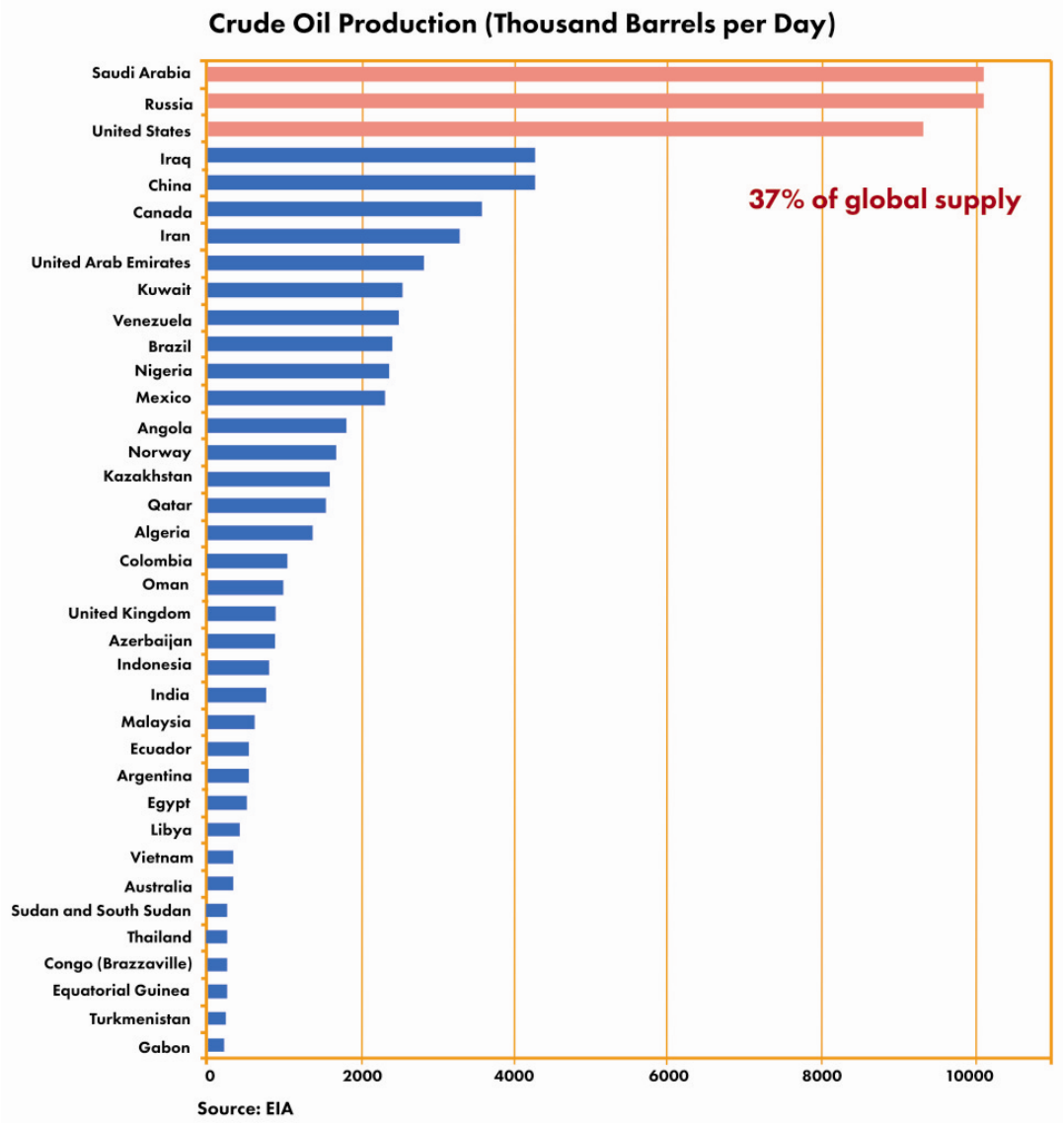
Alternative Scenarios for Oil Demand



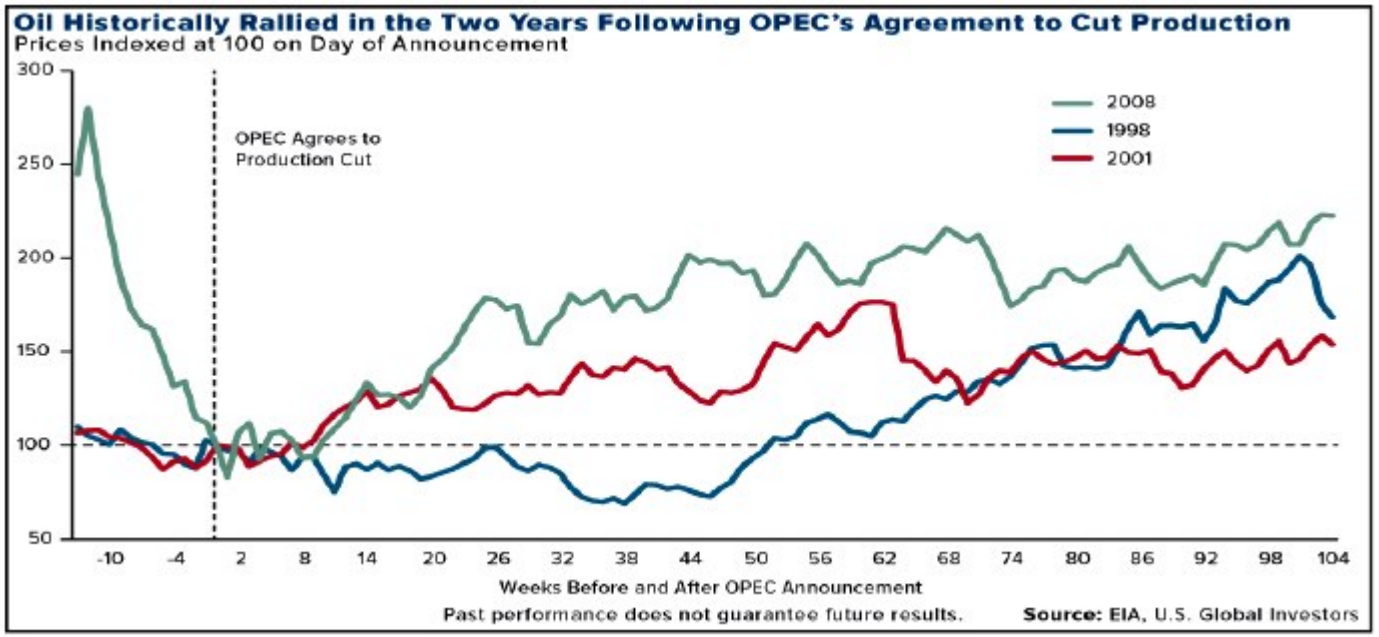
- Broad range of scenarios based on development of energy economy
- Spread between high and low demand is over 40mmbpd
- New supply will be needed though; existing fields will inevitably decline

Oil production is dominated by three countries

- Saudi Arabia, Russia and the US account for more than one third of global oil output
- The Middle East is the dominant region, accounting for around 35% of output
- OPEC countries generate 42% of the world's oil, giving the cartel a strong lever over prices
- Many traditional non-OPEC countries are now in decline, other than the US

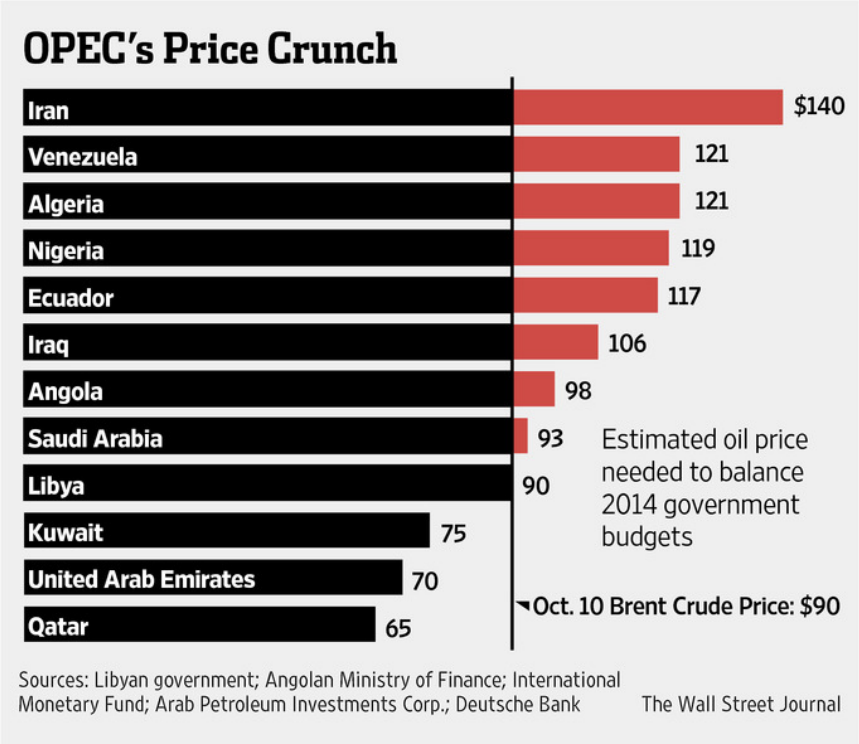


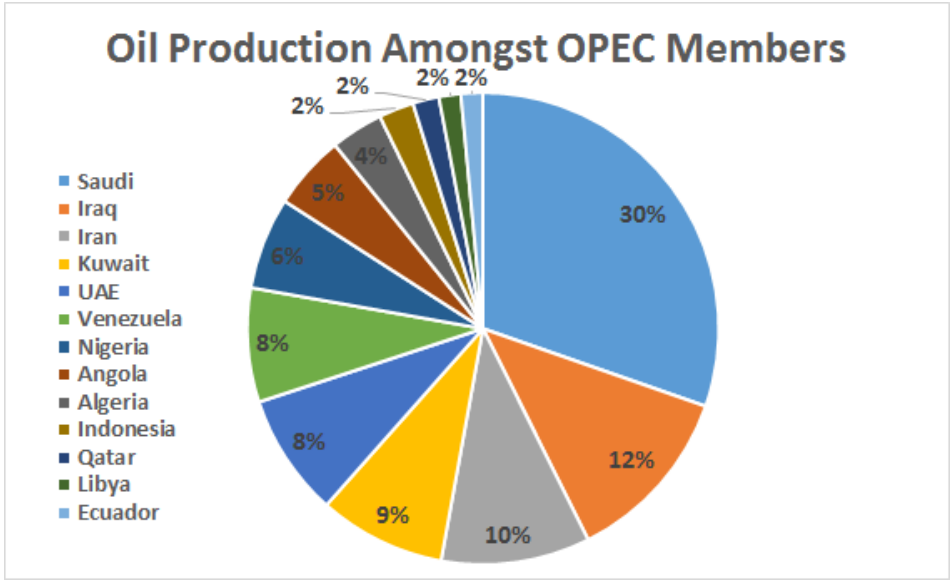
Impact of OPEC



- OPEC accounts for around 40% of global oil production
- It tries to act as a cartel to control the oil price within an "acceptable" range
- Most recent cut was in November 2016 – price has risen from $45 per barrel to $70

OPEC is a volatile organisation



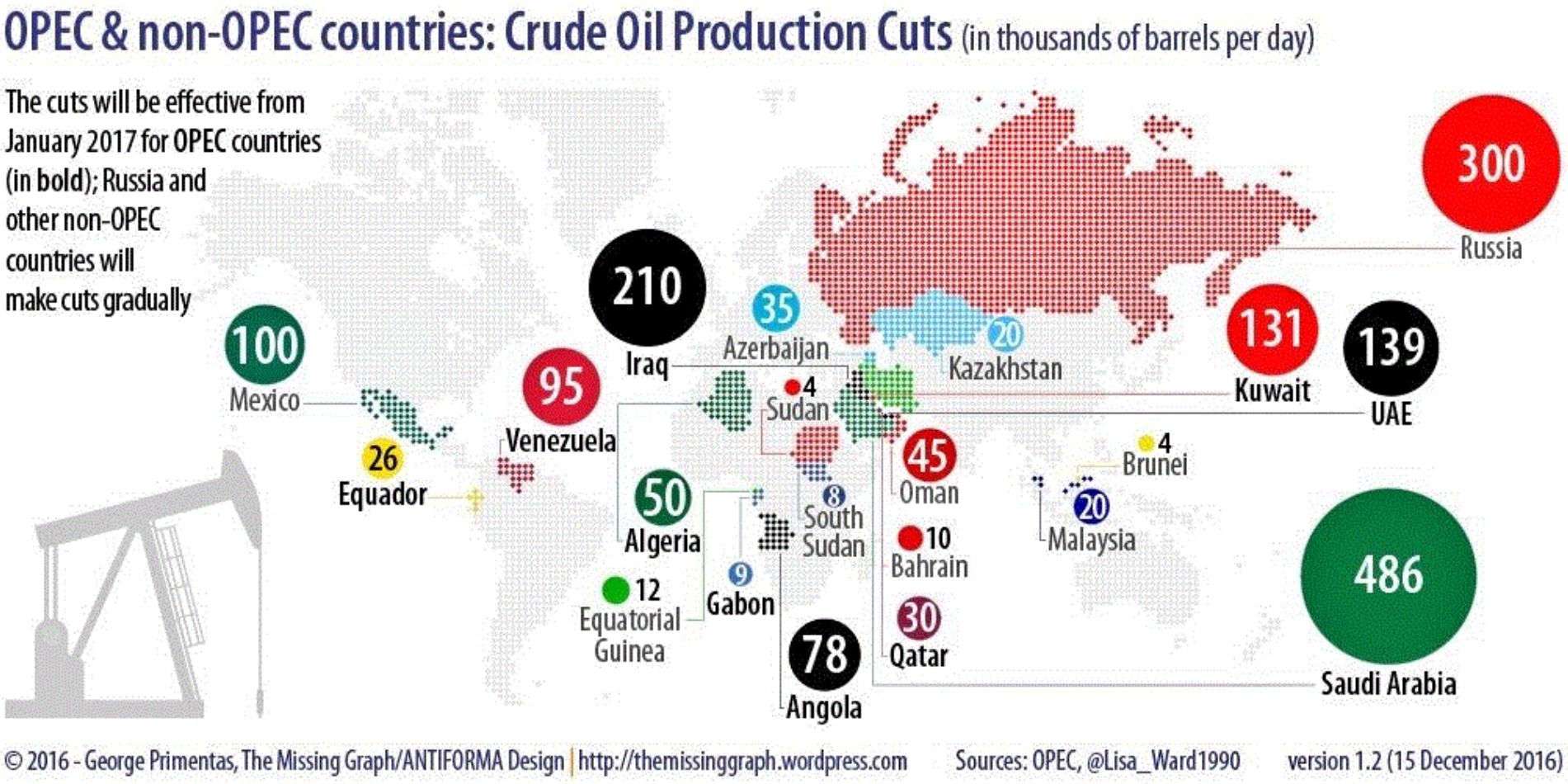


- The budgets of OPEC countries need high oil prices
- The politics of the Middle East provides a clear risk to oil production

OPEC decisions about future oil production and oil prices are critical for new projects

- Need to maximise oil revenues
- Historic strategy to preserve oil for future generations
- Now the question is whether there is a long-term future for oil?
- Largest reserve holders risk failing to monetise resources
- Low cost producers do not want to allow higher cost producers to take market share
- How to find the optimal balance?

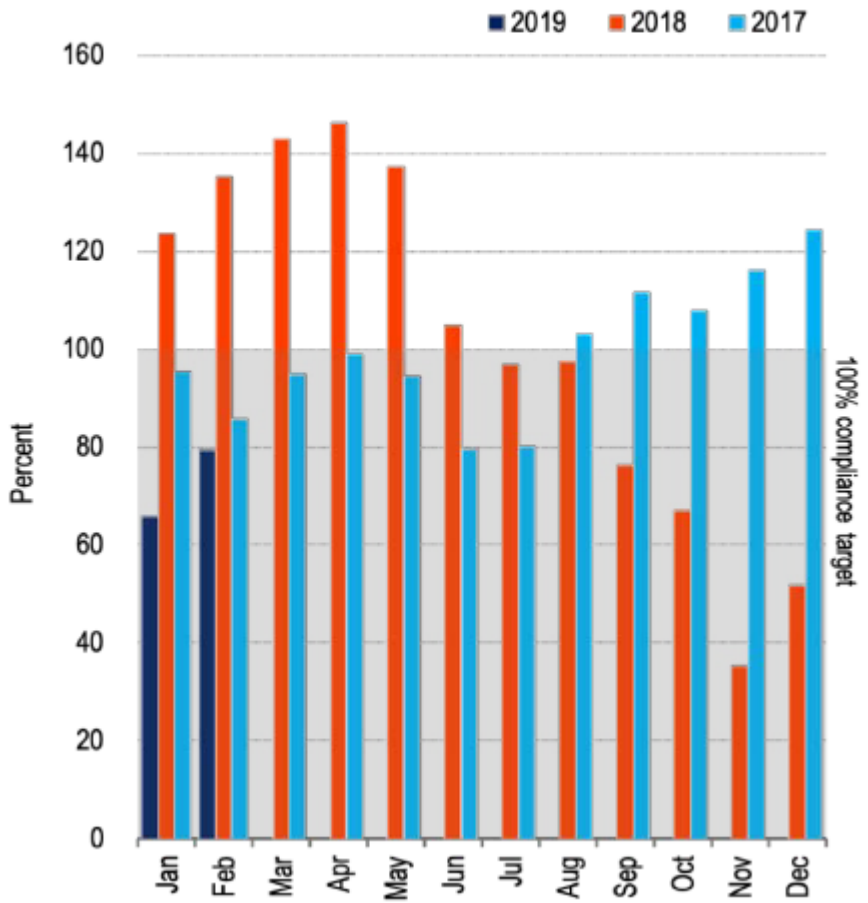
Current strategy – avoid very low oil prices by cutting production



- What happens next? An oil glut from US shale or an oil shortage due to lack of investment and growing demand?

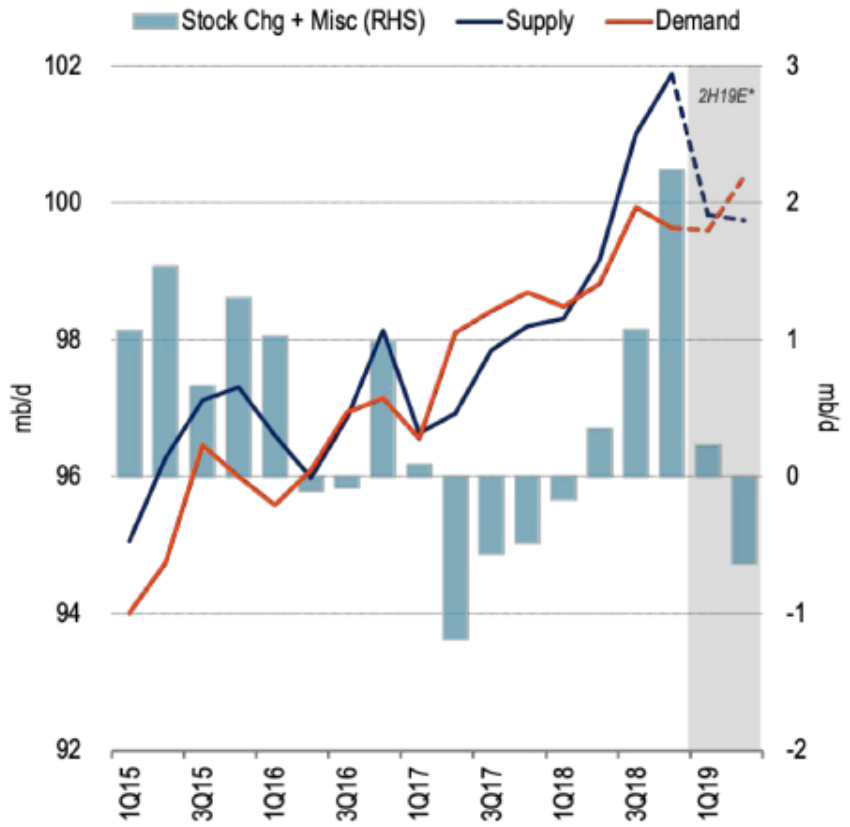
OPEC and Russian compliance with 2016 agreement has been patchy

OPEC+ compliance, Jan 17 – Feb 19



Monitoring stock levels is key in the short-term

Supply/Demand balance, 1Q15 – 2Q19

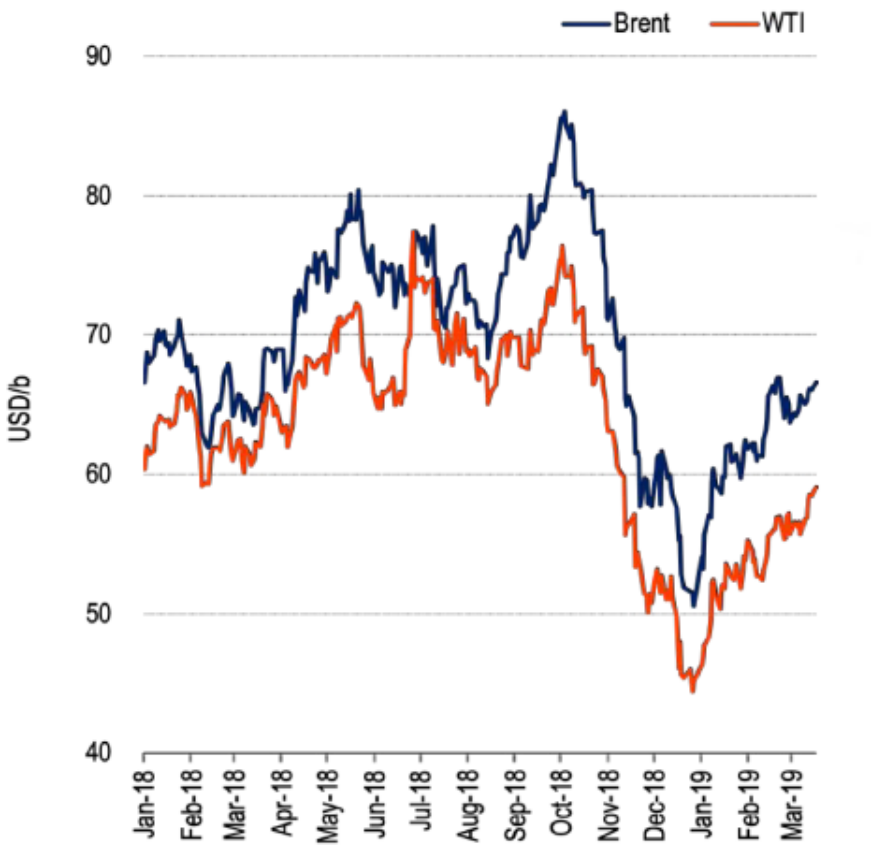


* Assumes 100% OPEC compliance and further declines from Venezuela and Iran.

High or rising stock levels mean oversupply of oil, generally leading to lower prices

The oil price has been volatile

Daily Brent and WTI price, Jan 18 – Mar 19

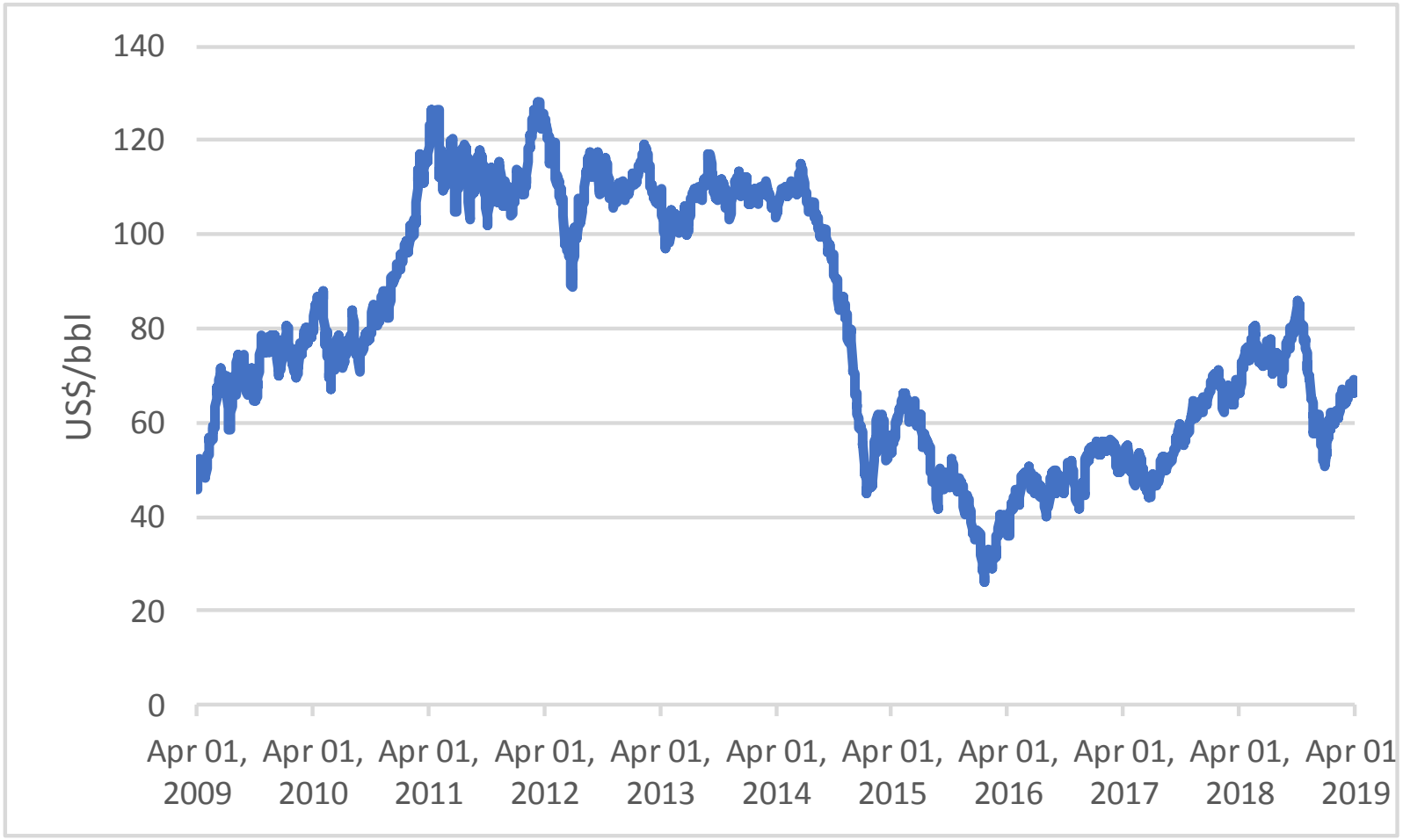


- Politics and economics have played a role
  - OPEC and Non-OPEC compliance with production cuts
  - US imposition of sanctions on Iran, but then granting exemptions

President Trump and his tweets have triggered responses

Daily Brent price and information signals, Jan – Dec 18

The Oil Price – A Volatile History



- Range over the past decade has been $140 to $25 per barrel
- Price has more than doubled in the past two years
- 10 year average is $79 per barrel, 5 year average is $68

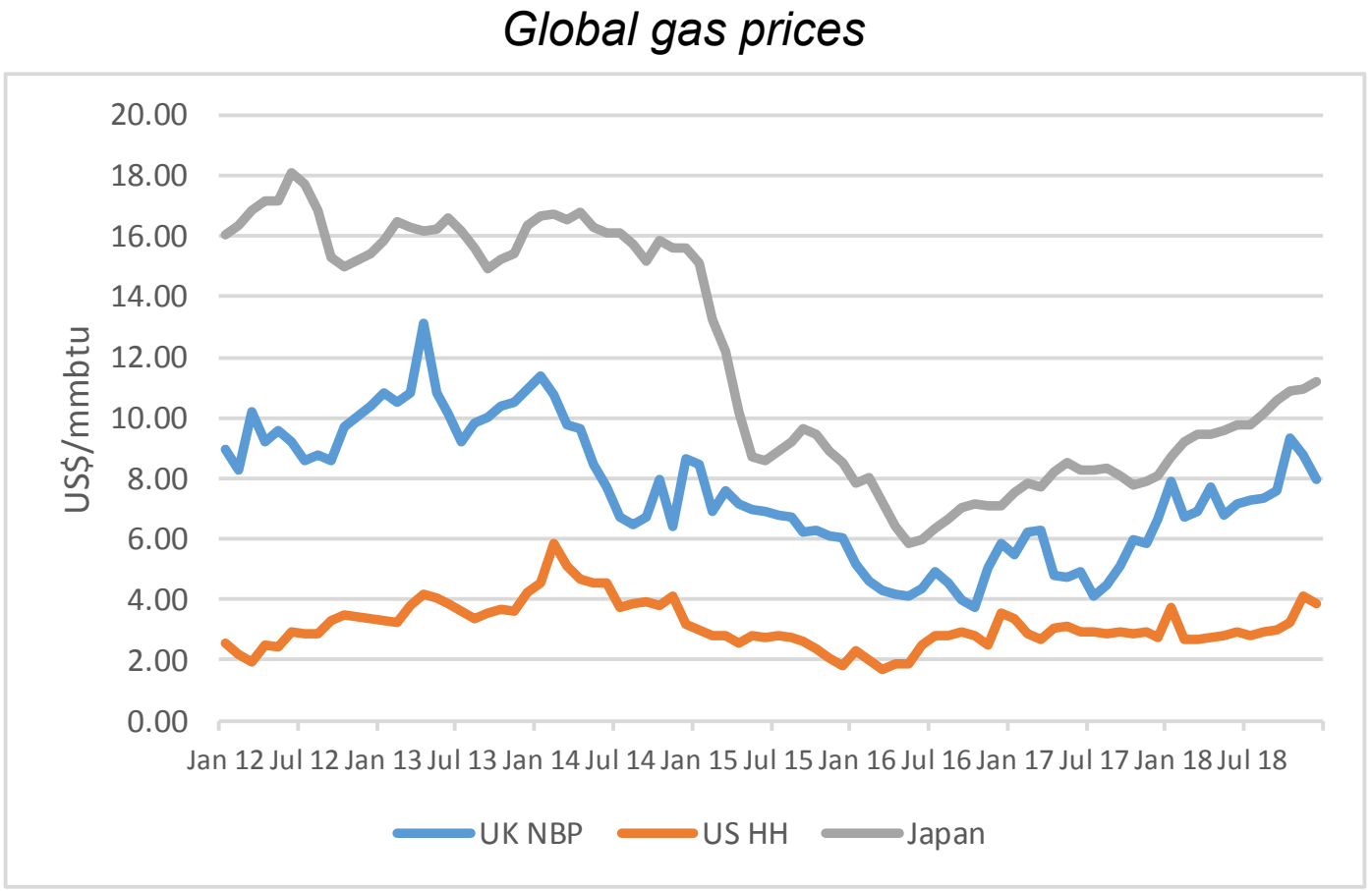
Let’s make an oil price forecast!

- Base case
- Upside case
- Downside case
- Disaster (worst) case
- Does the investment need to work in all of these scenarios?

Gas Price

- Gas price has tended to be at a discount to oil on a heat equivalent basis
- 1 barrel of oil equals 6 million cubic feet (mcf) of gas
  - 1 million barrels = 1 billion cubic feet (Bcf)
- Oil price to gas price calculation:
  - » (Oil price / 6) x gas discount
  - » 60 / 6 x 90% = $9/mcf
- Gas industry analysts also talk about the relationship between gas and oil prices as a slope
- The slope is just the gas price divided by the oil price in percent
  - 9 / 60 = 15% slope
  - Slope on a heat equivalent basis is 16.67%
  - Normal slope is between 11% to 15% to allow for gas price discount

Gas market has been developing, especially in Europe



Gas increasingly priced relative to competing gas supply, not relative to oil

text

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