

# Lecture 1: An Introduction to the Global Energy Economy

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# Introduction to the Course

1. Global energy situation and current trends
2. Value chain and prices
3. Companies and governments
4. The impact of new energy
5. Decision-making at energy corporations
6. The Russian oil sector and its impact
7. The Russian gas sector and its impact
8. Russian energy and geo-politics



# The Question

- What are the economic and related political issues that will most affect short and long-term decision-making at one of the following:
  - ExxonMobil?
  - Rosneft?
  - CNPC?
  - Saudi Aramco?
  - Gazprom?
  - A Japanese energy utility?



# World Energy Consumption – A Long-Term View

## GLOBAL ENERGY CONSUMPTION AND MIX 1800 - 2013

BASED UPON DATA FROM BP STATISTICAL REVIEW 2014 (1965 - 2013), PRE 1965 AND BIOMASS FROM SMIL

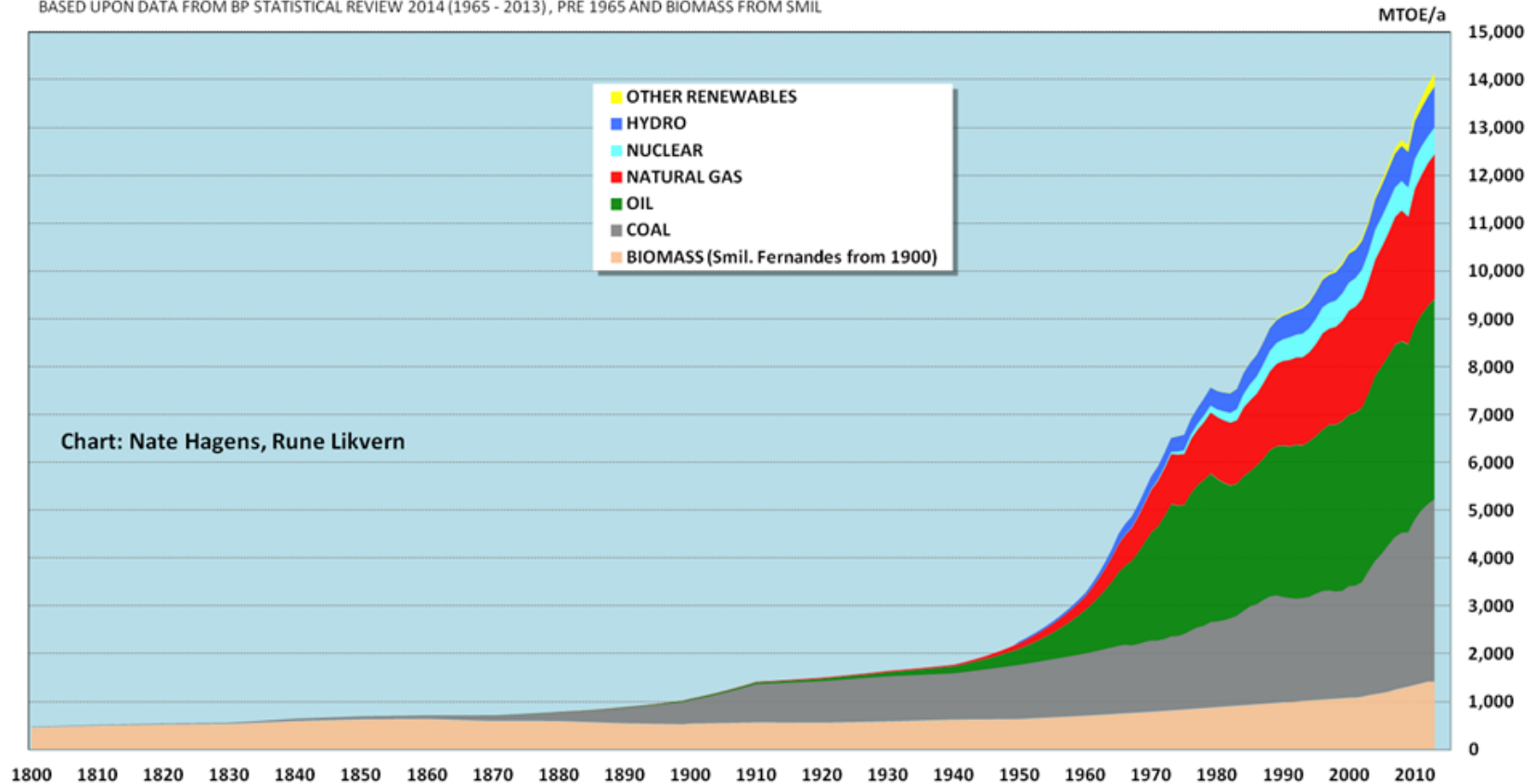
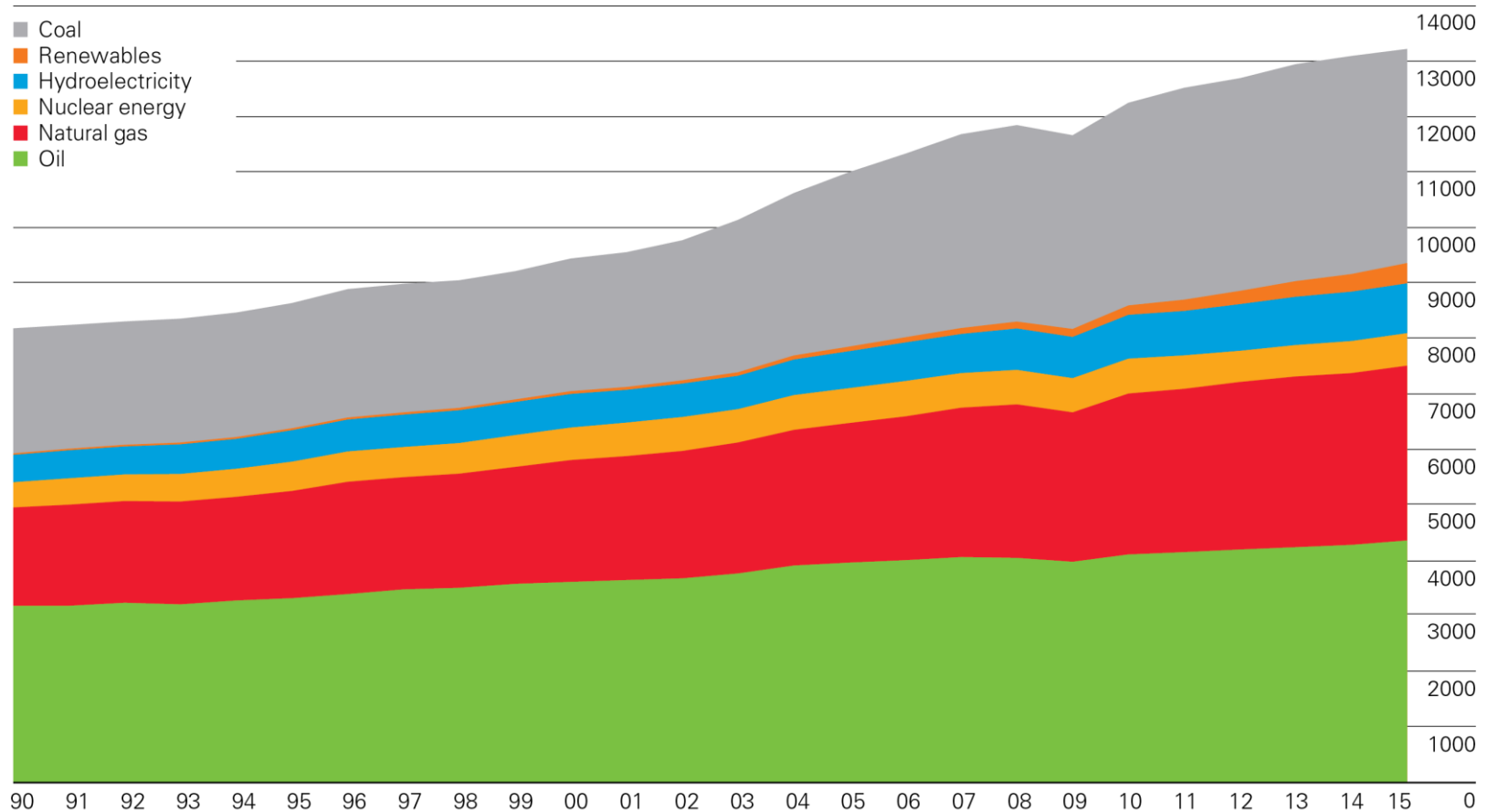


Chart: Nate Hagens, Rune Likvern

- World energy consumption has grown dramatically in the past century, driven by and catalysing economic growth
- Energy availability supports modern living standards and human development



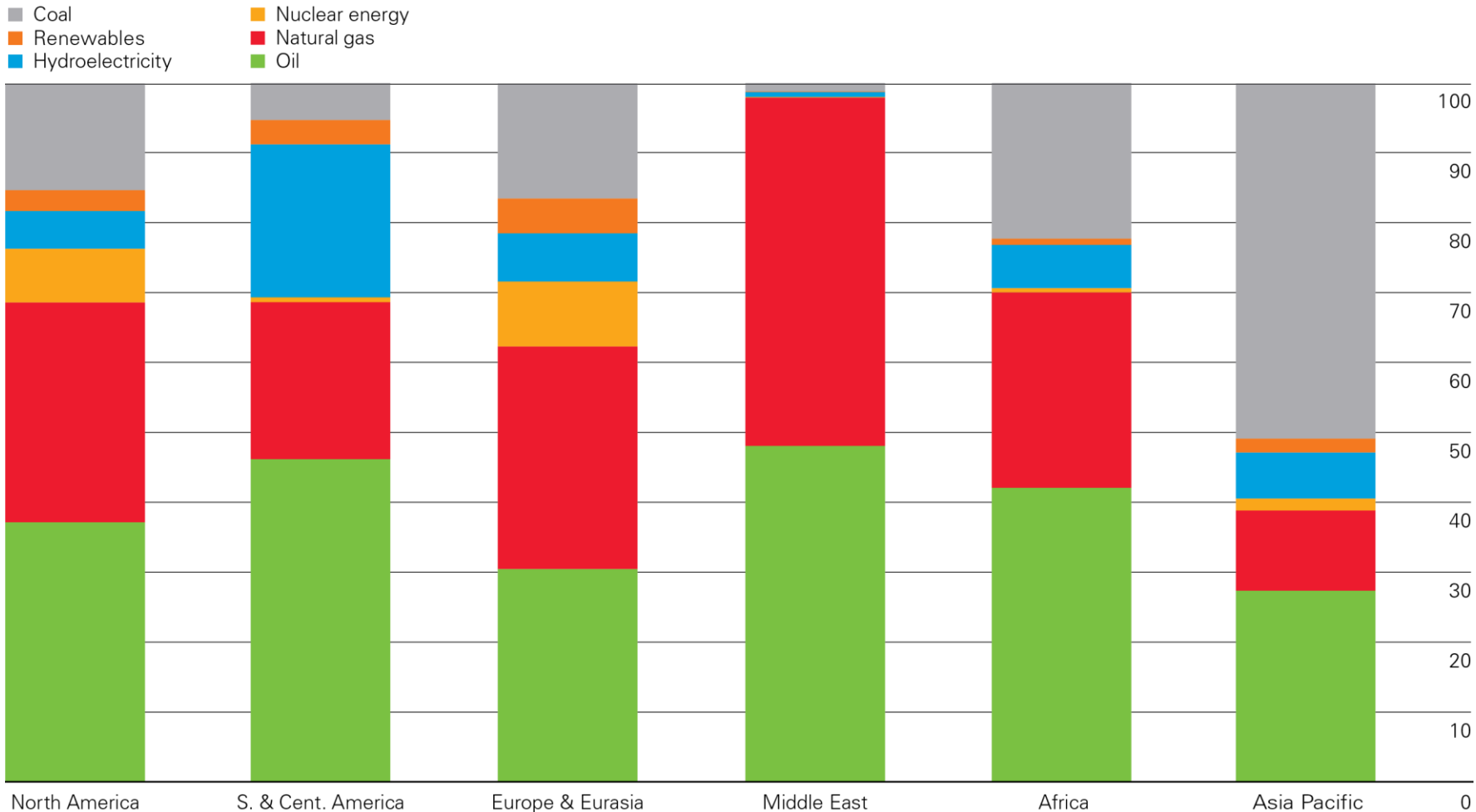
# Primary energy consumption since 1990 (mmtoe)



- Overall energy demand has been growing by around 1% per annum
- The key primary fuels have been hydrocarbons, which account for 80%+ of total energy consumption
- Renewables are growing fast but from a very low base



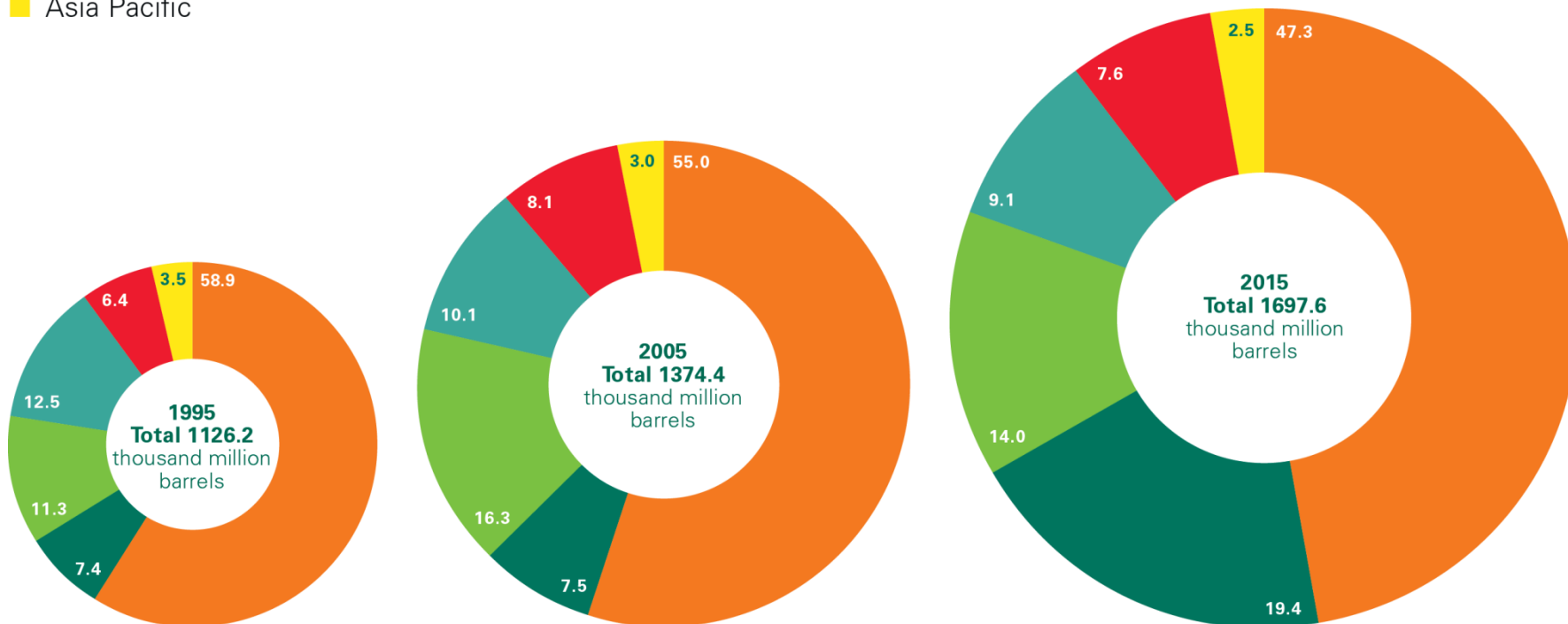
# Primary energy regional consumption by fuel (2015, %)



- Fuel split is very different by region, and is generally driven by indigenous supply
- Countries are reluctant to be over-committed to imports



# The growth in oil reserves and the regional split

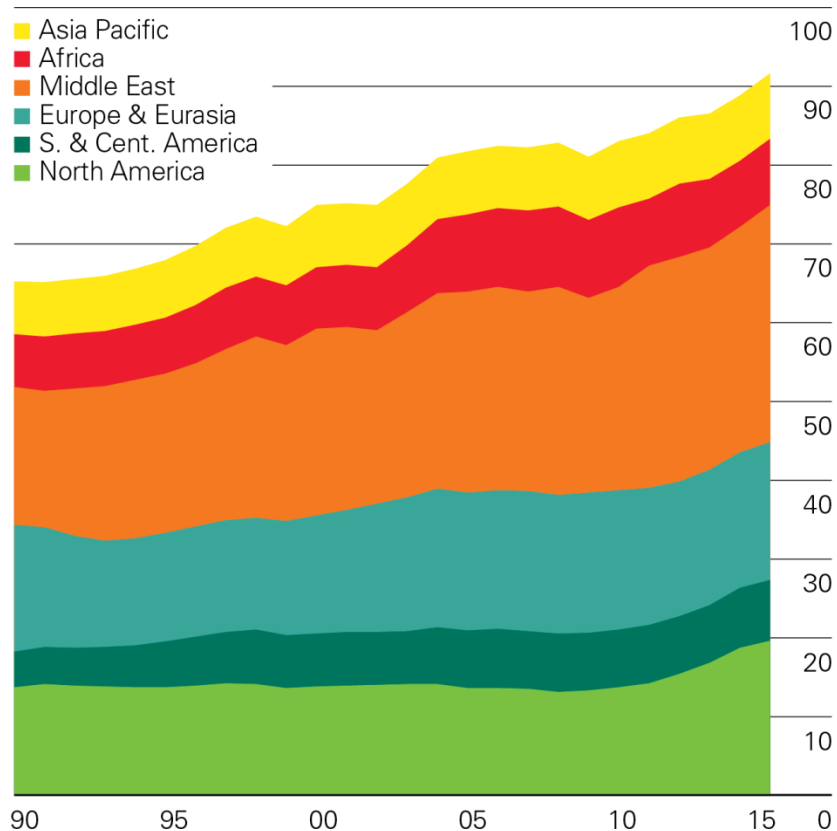


- Oil is not running out – proved reserves are up by 50% since 1995
- Middle East continues to dominate, but other regions are growing – the Americas in particular

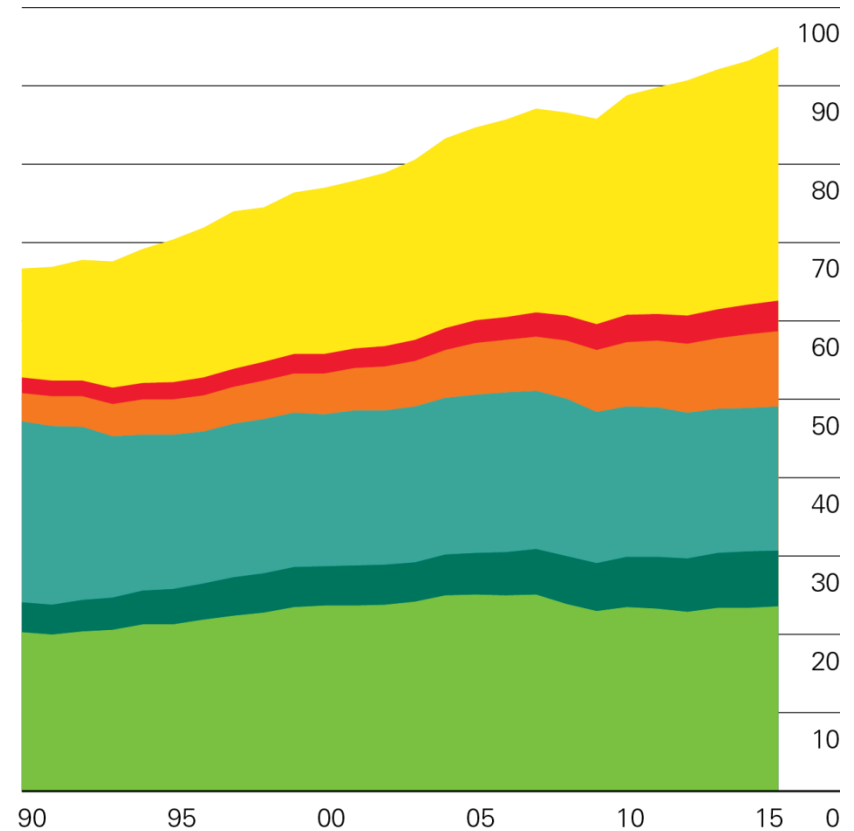


# Oil production and consumption by region (mmbpd)

## Production



## Consumption



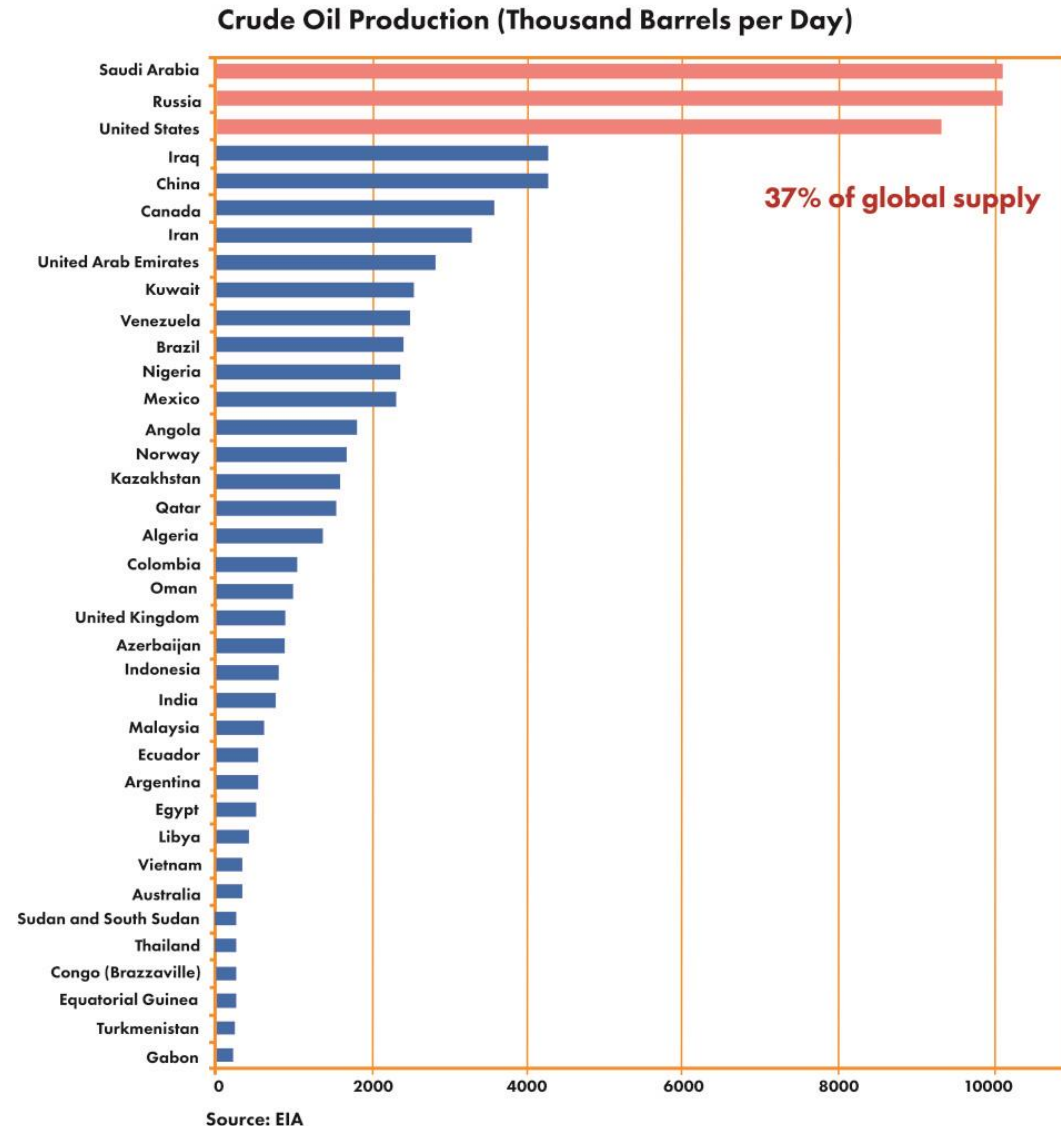
- North American production is up sharply, thanks to shale oil
- Middle East production account for around one third of the total
- Europe and Eurasia is only flat thanks to growth in Russia
- Demand growth is almost entirely driven by Asia



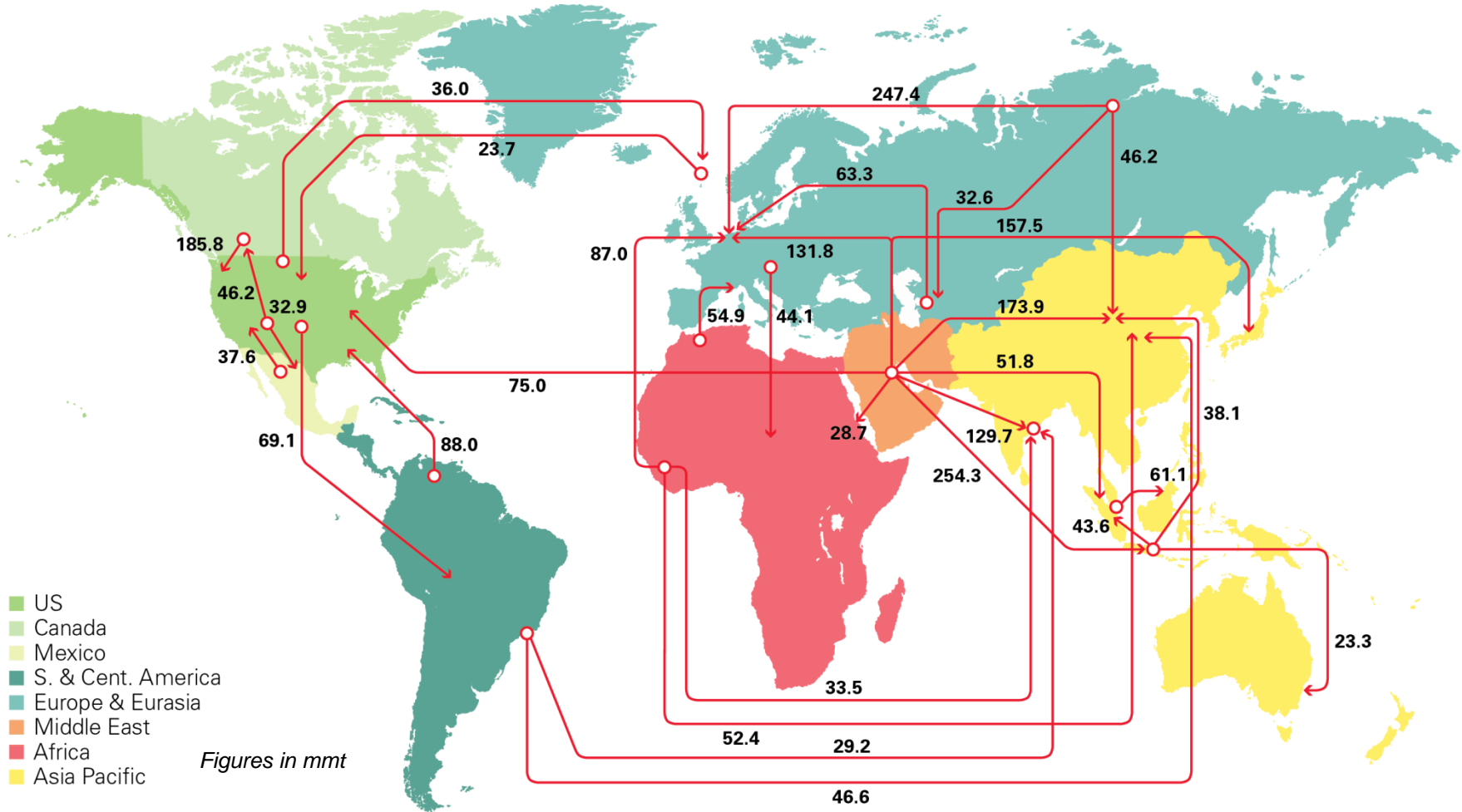


# Oil production is dominated by three countries

- 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



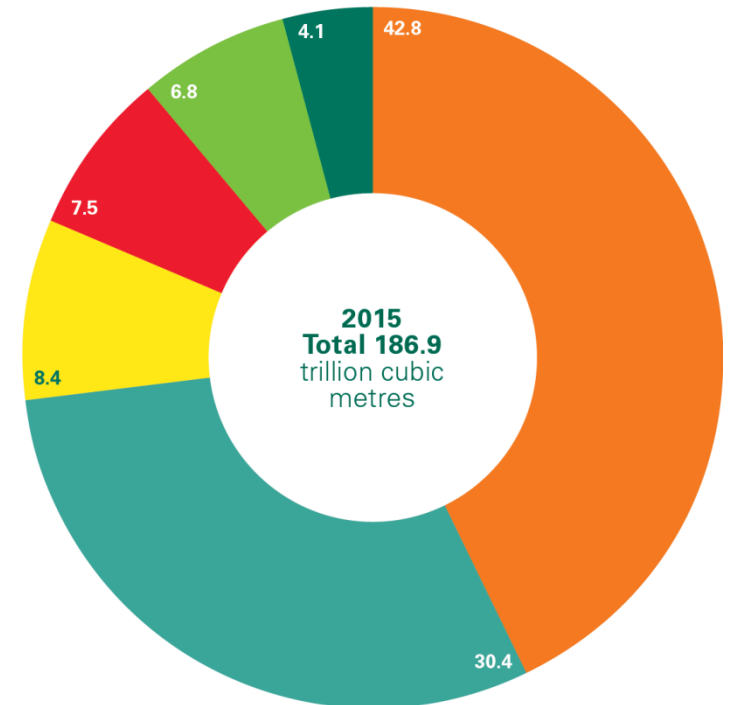
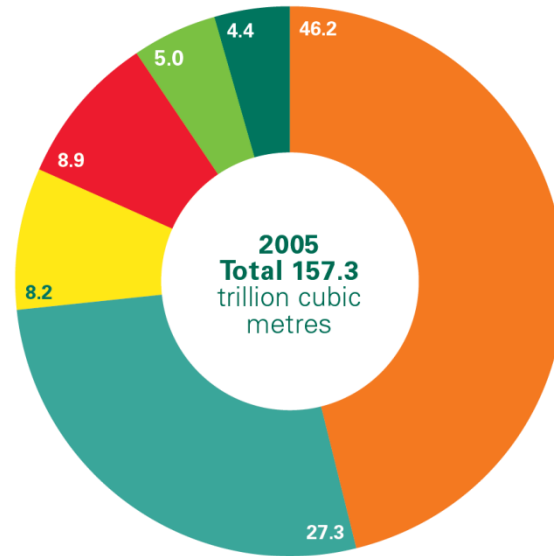
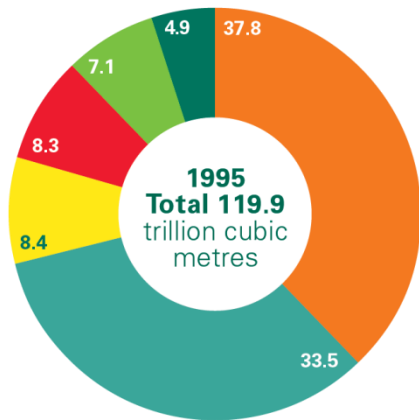
# Oil is a global commodity



- Oil is traded in multiple directions across the globe
- Much of the trade originates from the Middle East and flows West and East
- Prices are set relative to a set of global benchmarks



# Gas reserves by region (1995, 2005, 2015)

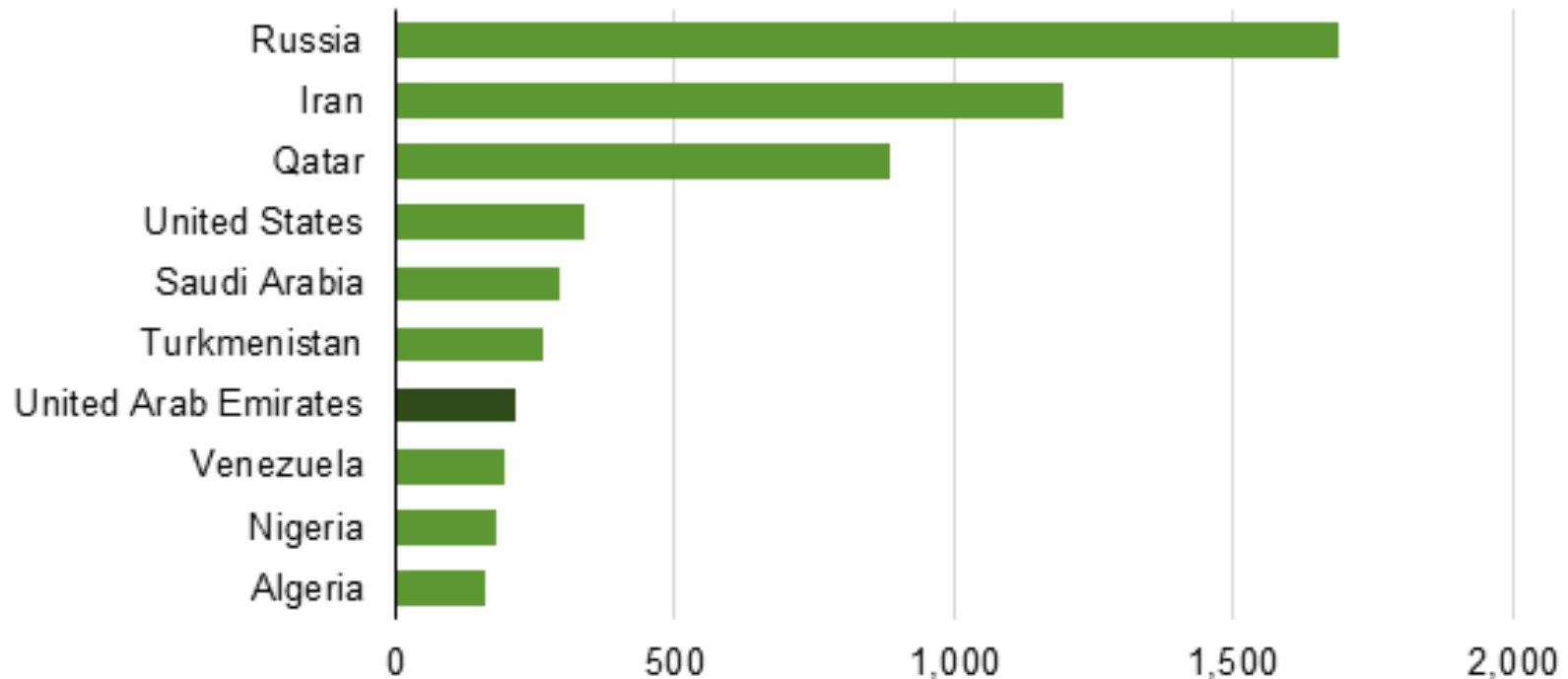


- The Middle East also contains huge amounts of gas, although Russia is the main exporting country
- Gas reserves have grown dramatically as it has increasingly become an important fuel for power generation



# Familiar faces control the world's largest gas reserves

Top 10 natural gas proved reserves holders  
trillion cubic feet

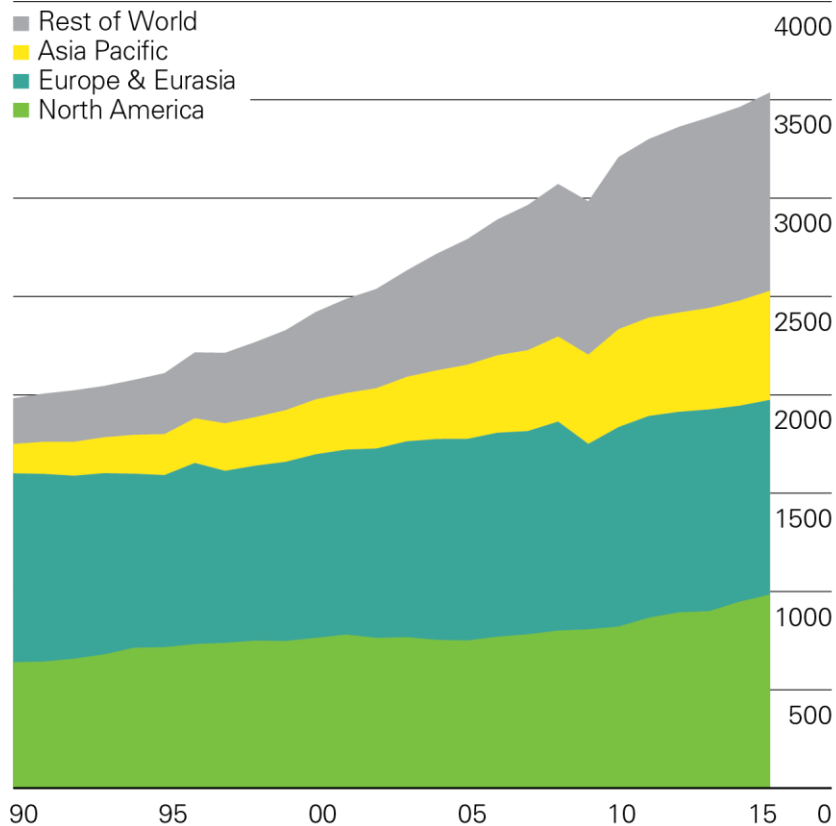


- Oil and gas are often found together, so it is no surprise that the US, Saudi Arabia and Russia are towards the top of the reserves list
- Gas has traditionally been a much more regional fuel, due to the difficulties and cost of transporting it

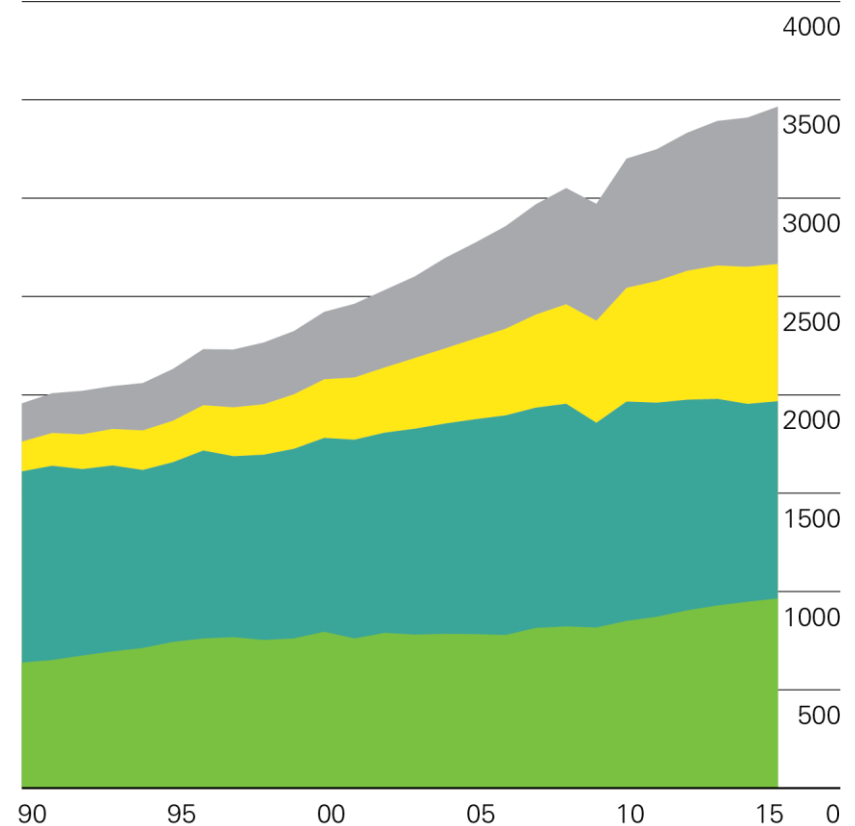


# Gas production and consumption by region (bcm)

## Production



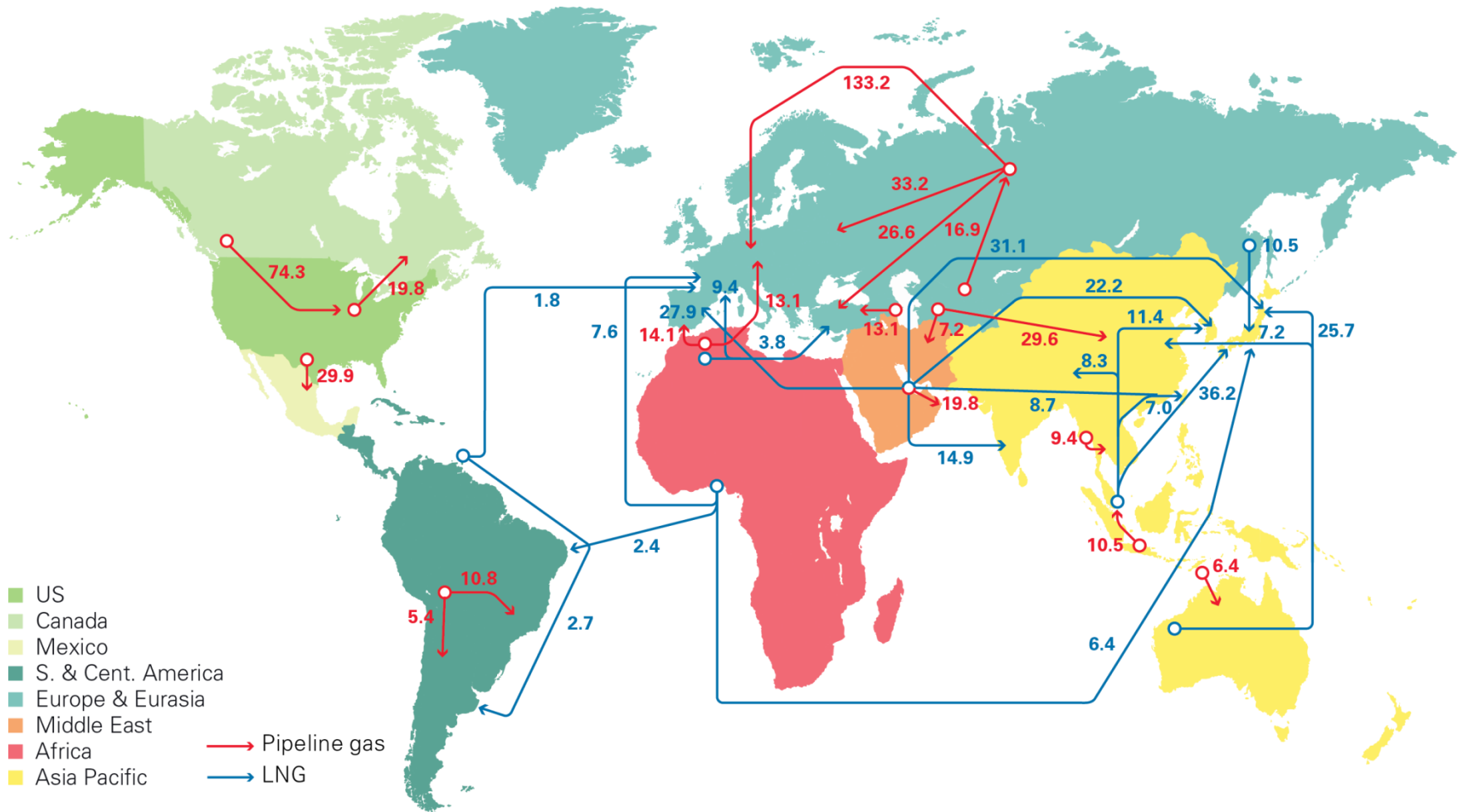
## Consumption



- Europe and North America have traditionally been the largest consumers of gas
- Major infrastructure in both regions facilitates indigenous production and imports
- Asia, the Middle East and Latin America are growing fast, however



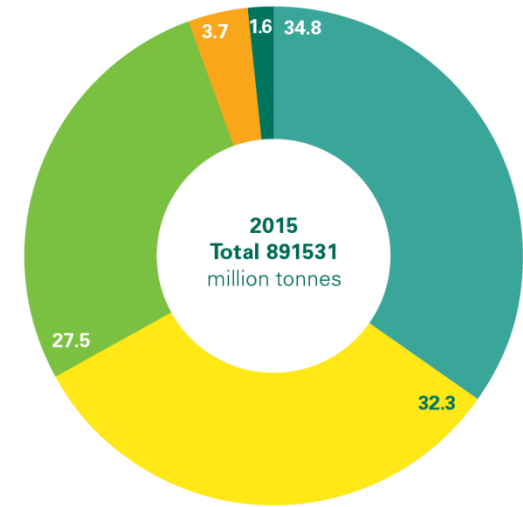
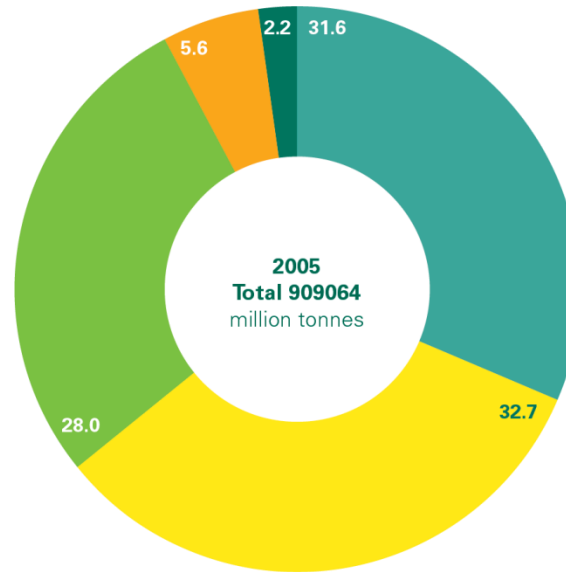
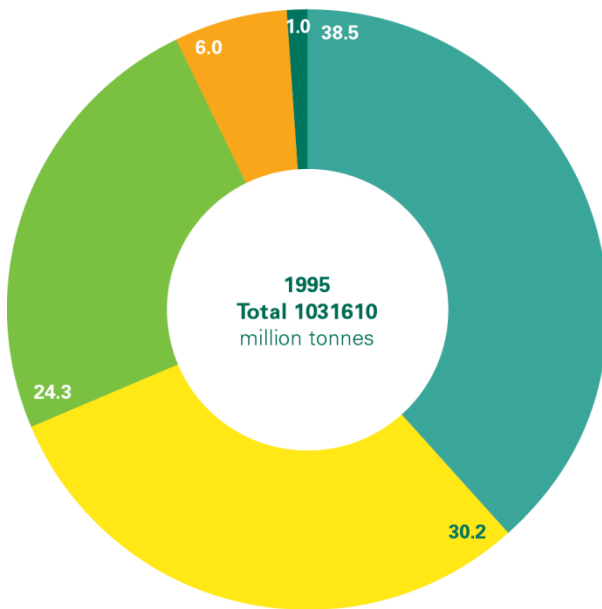
# Gas trade flows (bcm)



- Gas trade flows via two transport methods – pipeline and LNG
- Historically pipeline flows have dominated, leading to regionalisation
- LNG is now turning gas into a more global commodity



# Coal reserves by region (1995, 2005, 2015)

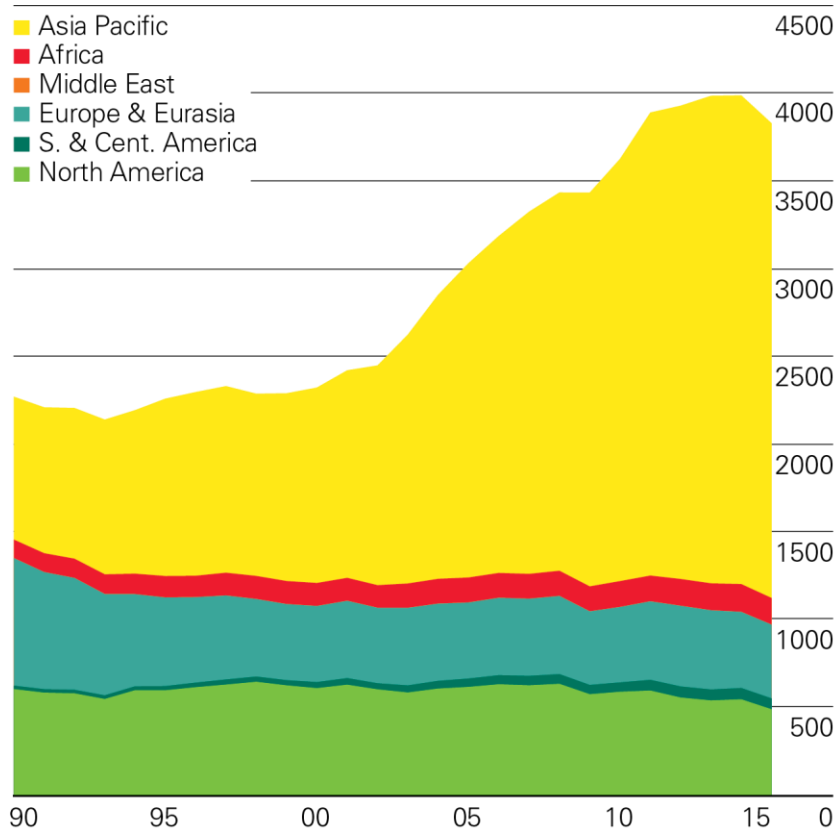


- Coal reserves are in decline – the uncertain future of the fuel in a decarbonising world is creating a disincentive to invest
- Europe has the largest reserve base, with Asia close behind, but individual countries are key to understanding coal's position in global energy economy

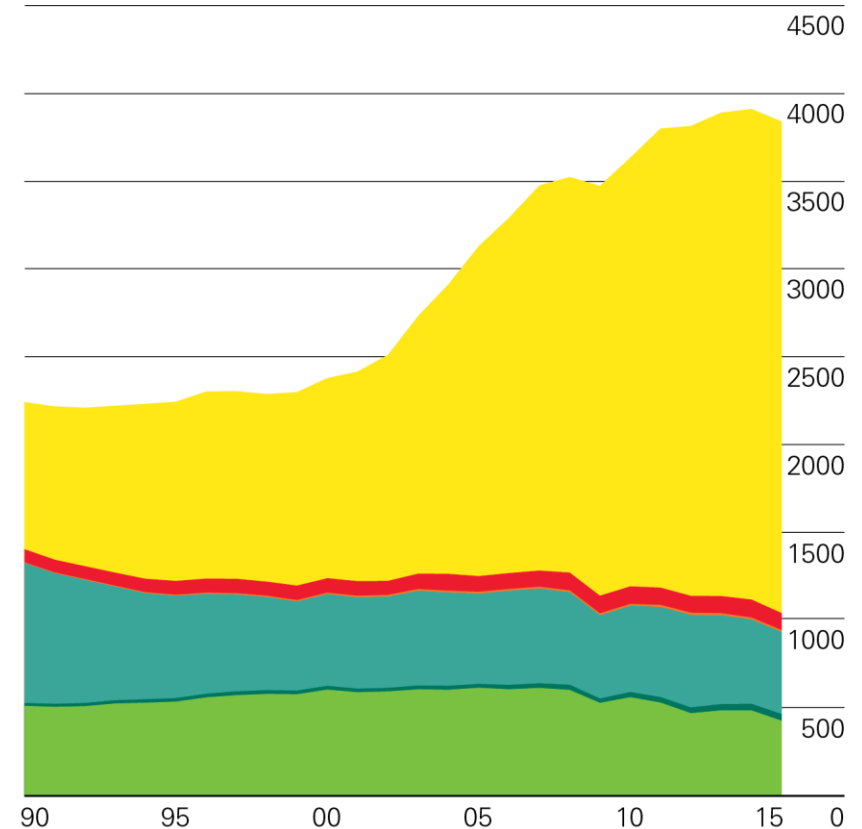


# Coal production and consumption by region (mt)

## *Production*



## *Consumption*



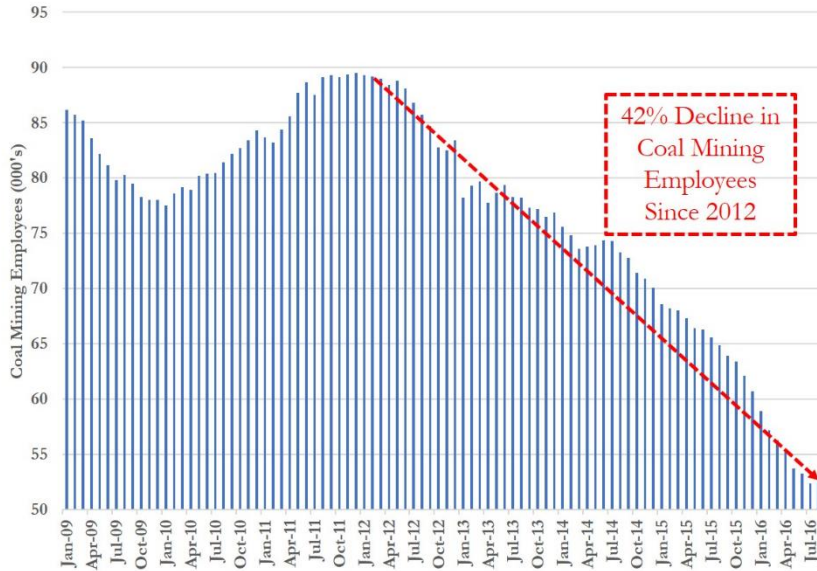
- The majority of production and consumption is in Asia, and has grown rapidly
- China and India are the key players, as coal is both countries' major indigenous energy resource
- Decline in North America driven by the arrival of shale gas





# Decline in US coal industry

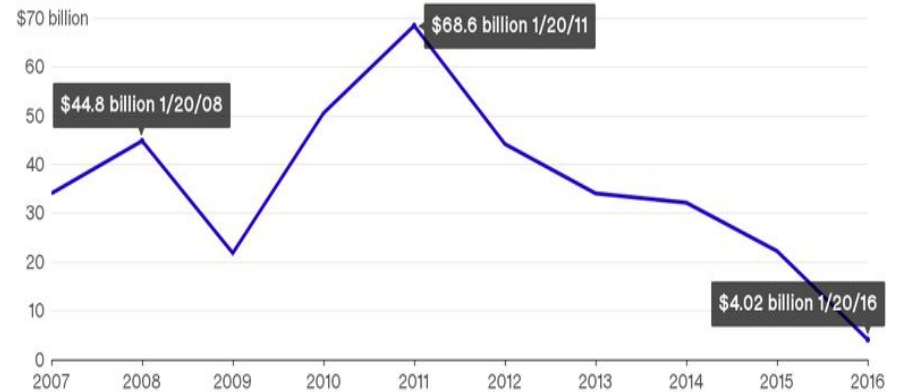
## Employment in US coal industry



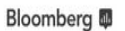
## Market value of US coal companies

### Plunging Coal

The combined market cap of publicly traded U.S. coal miners has cratered since 2011.



Source: Data compiled by Bloomberg

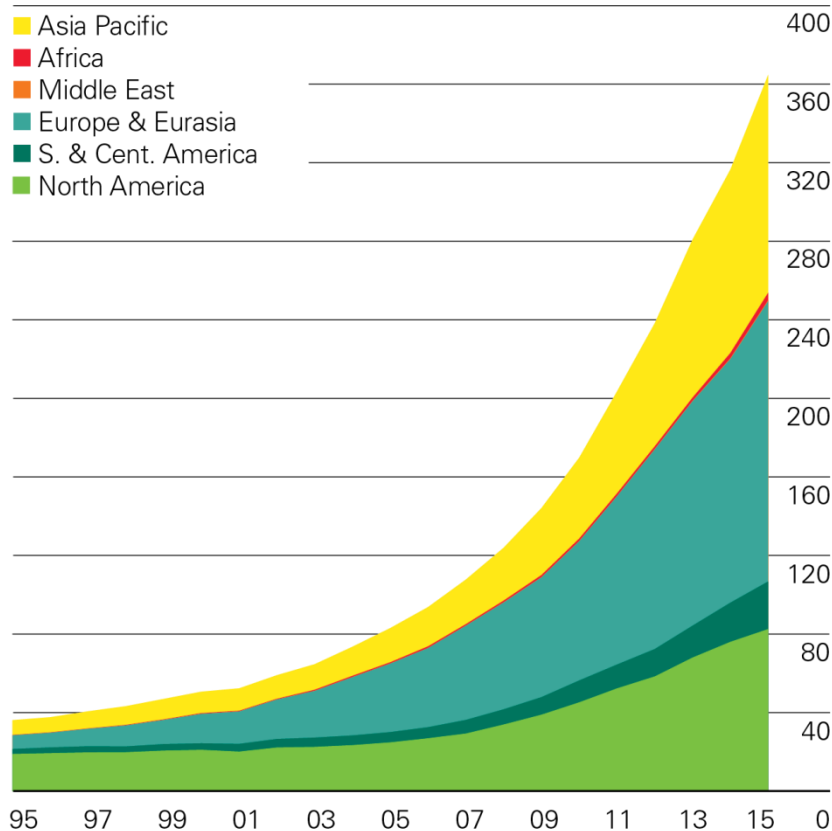


- The US coal industry has collapsed over the past five years
- Although the environment has been a background cause, in fact it has been all about economics – cheap gas prices
- Ironically, US coal has been exported to regions where gas is more expensive – Europe being a prime example

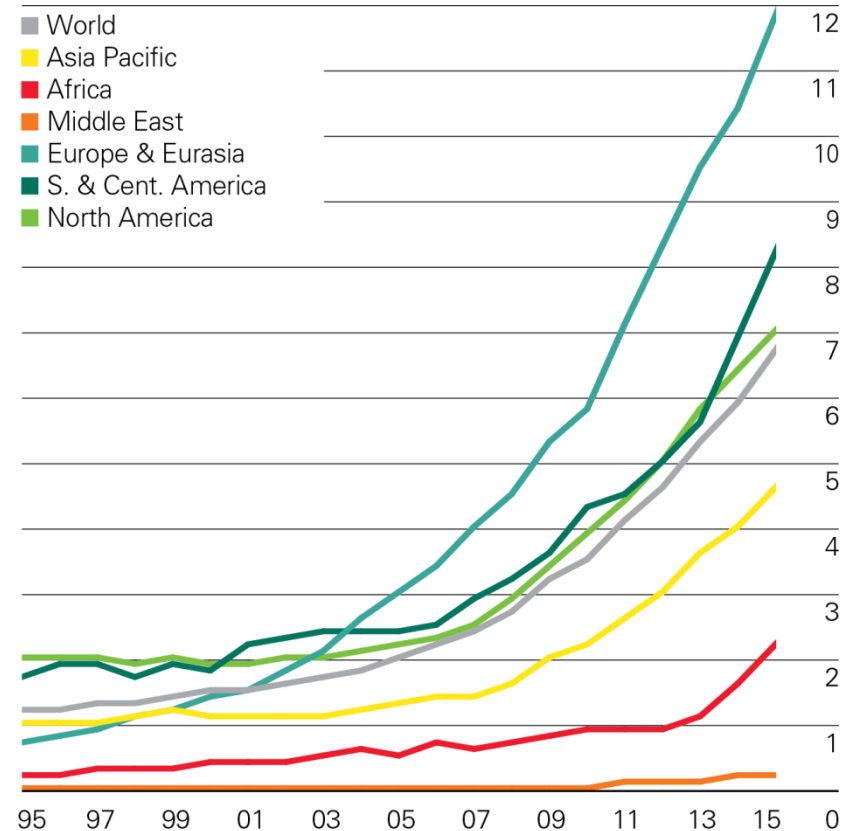


# Renewable energy consumption / share of power by region

## Consumption (MMTOE)



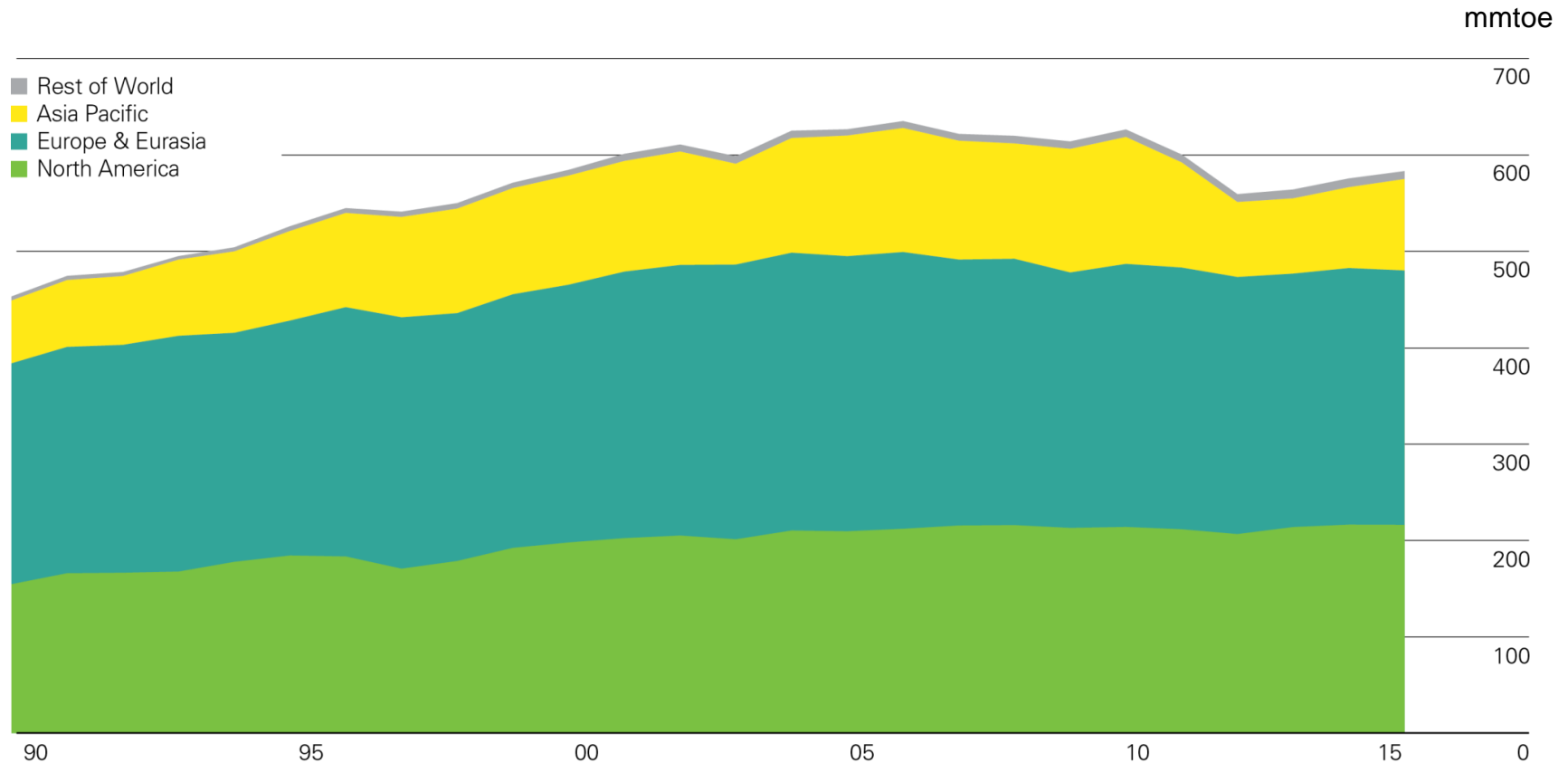
## Share of power generation (%)



- Growth in renewable energy has been dramatic – it now accounts for around 7% of the global input to electricity
- Europe has been leading the way, catalysed by policy initiatives in Germany
- Growth in Asia accelerating, as search for indigenous energy continues



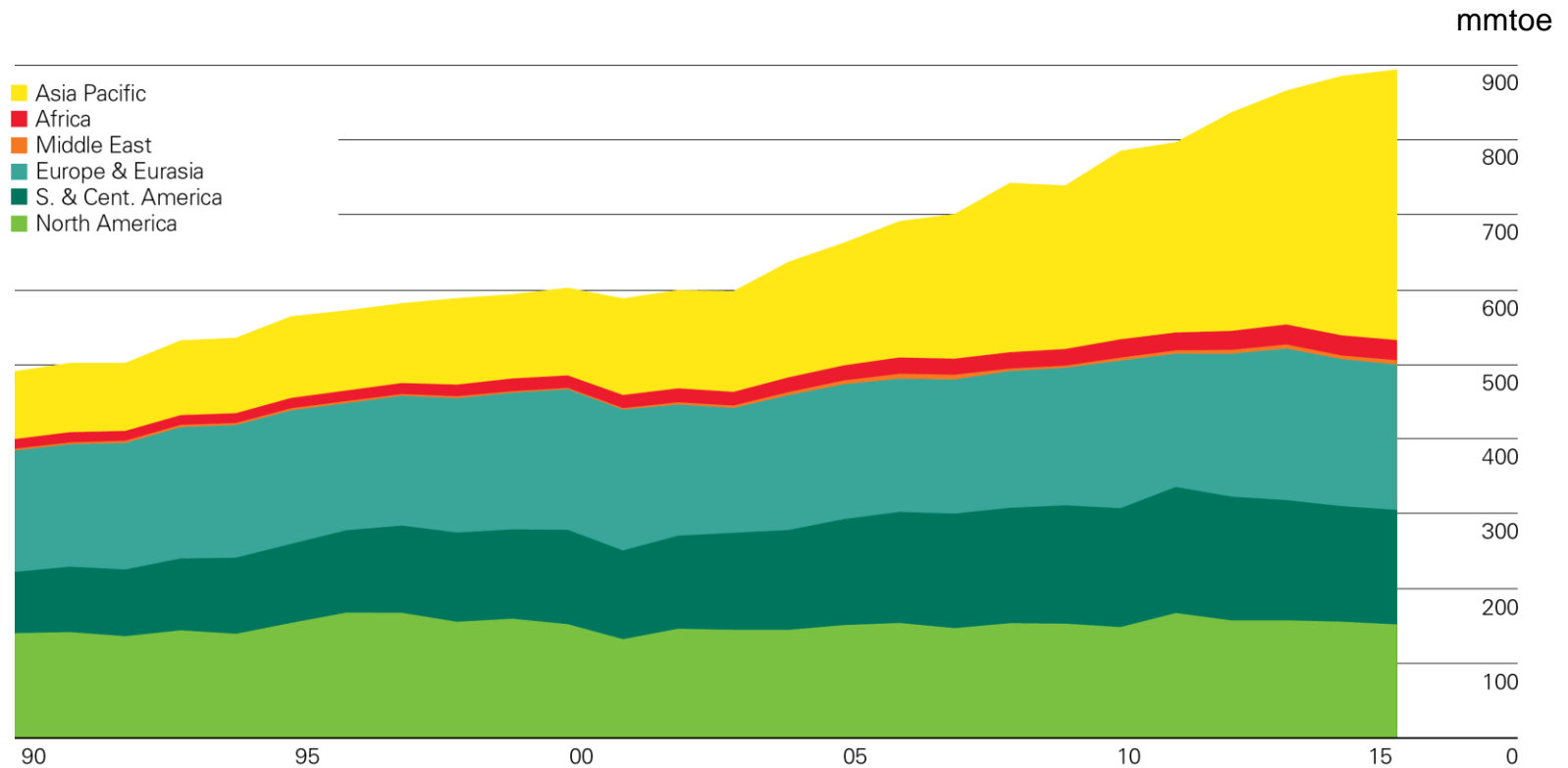
# Nuclear Energy – A Relatively Stagnant Story



- 1.3% growth in 2015, but long-term trend is flat
- Trend is away from traditional regions of Europe and US towards Asia
- China is at the forefront of new nuclear growth, in the search for indigenous energy production



# Hydro-electric – reaching its limits?



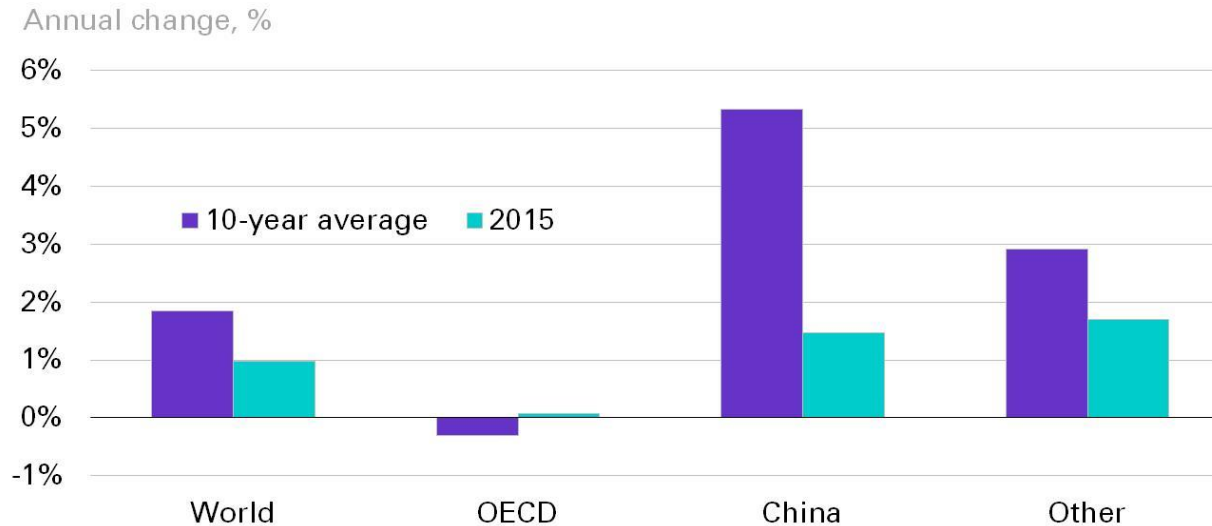
- A similar story for hydro, with more growth
- 1% growth overall in 2015, held back by drought in South America and some parts of Central Europe
- Upside potential limited from here, other than in Asia



# Energy demand growth is moving away from OECD countries



## Primary energy growth



BP Statistical Review of World Energy

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- Growth in energy demand is moving towards the developing world
- 2015 was a difficult year, but China remained the fastest growing energy consumer in the world
- Africa, the Middle East and SE Asia are also growing from low bases



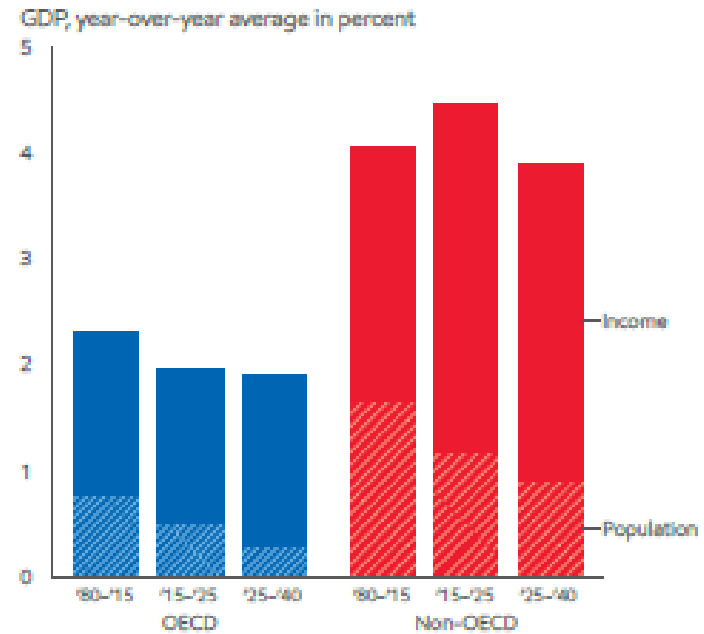
# Key drivers of energy consumption

## World demographics continue to shift



Source: World Bank, EcoinMobil estimates

## Non-OECD leads economic expansion

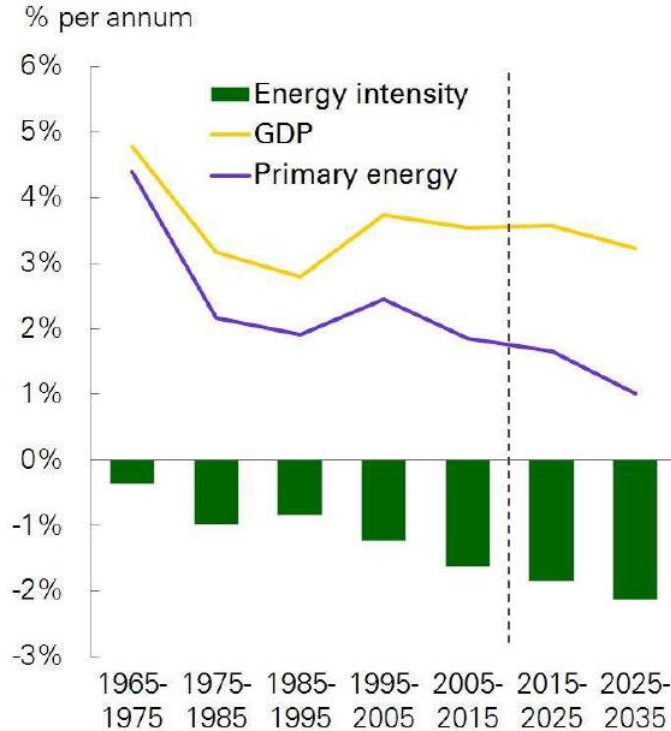


- Global population currently 7.3 billion, expected to reach 9.1 billion by 2040
- Population mainly in non-OECD countries, in many of which the alleviation of energy poverty is a huge issue
- Economic growth is another key driver, leading to increased personal wealth and greater use of energy intensive products
- Again non-OECD countries dominate growth, with their share of global GDP set to rise from 35% to 50% by 2040

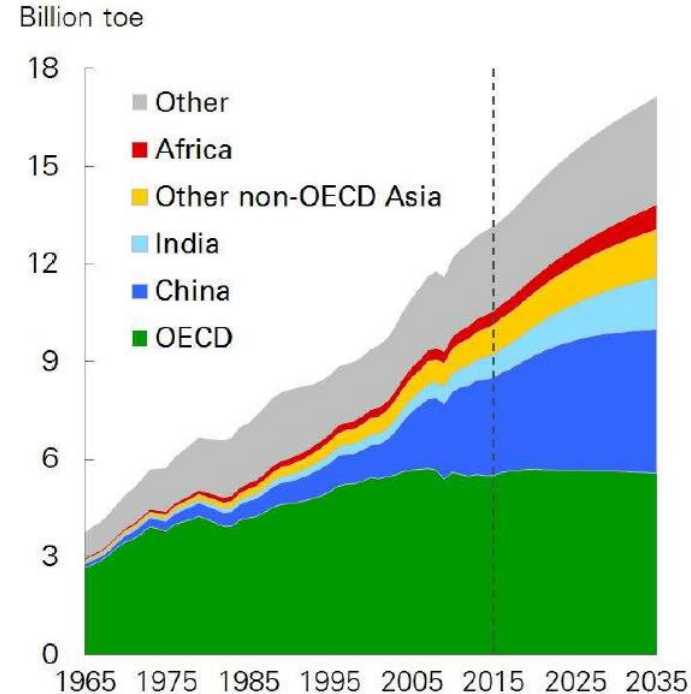


# Energy intensity is improving but demand will still grow

## Growth in GDP and primary energy



## Energy consumption by region

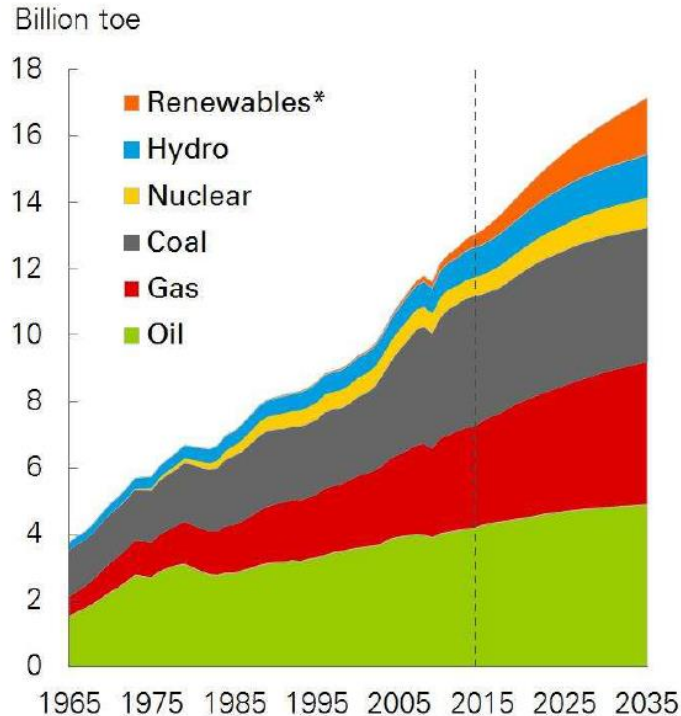


- Technology is helping the world use energy more efficiently, by reducing the amount of energy used to generate each unit of economic output
- Since 1970 global energy intensity has fallen by around 1% per annum
- In 2016, for example, global GDP grew by 3% versus a 1% growth in energy demand



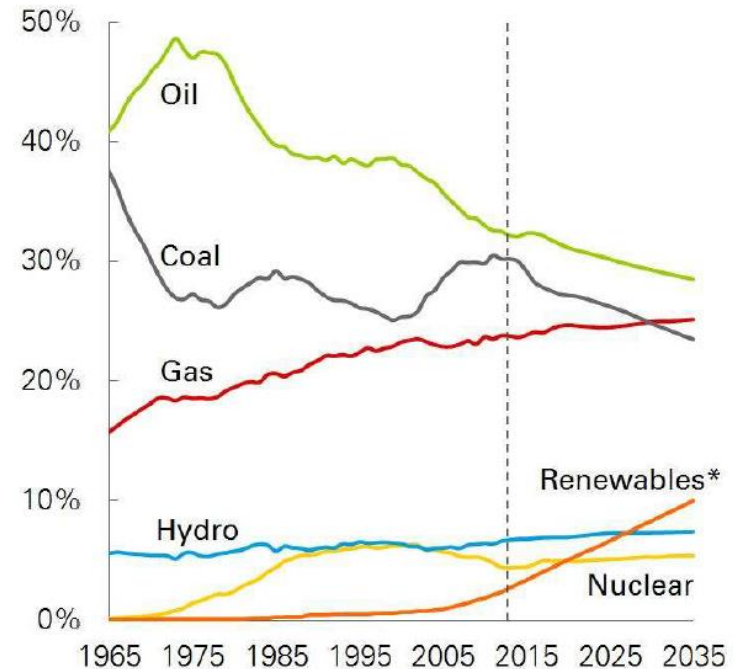
# The shifting global energy economy

Primary energy consumption by fuel



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

Shares of primary energy

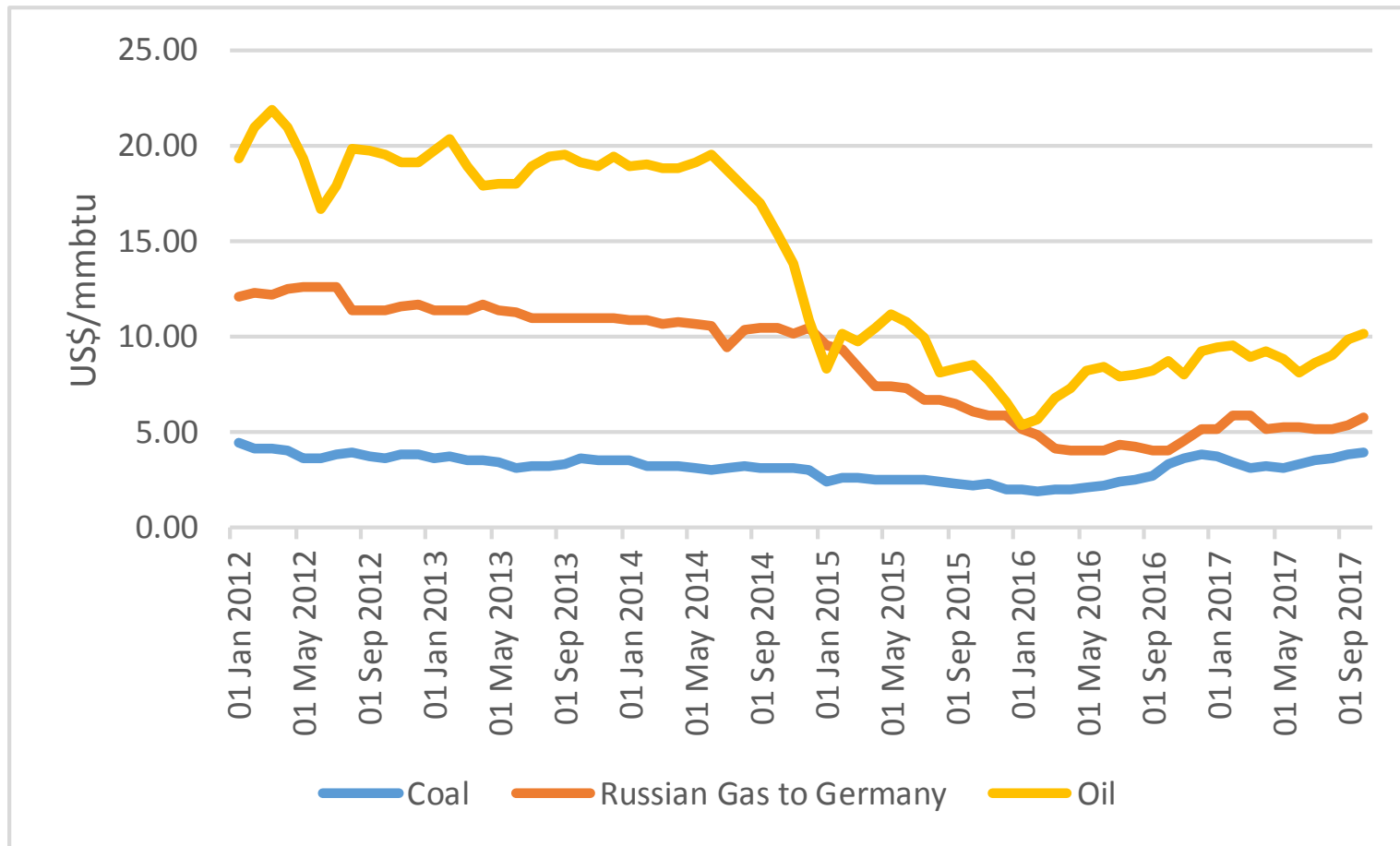


- Rise of renewables now having a noticeable impact on hydrocarbons
- Incremental demand growth is increasingly being accounted for by non-fossil fuels, leading to oversupply and lower prices
- Are we seeing a new paradigm for oil, gas and coal pricing, with significant commercial and political consequences?





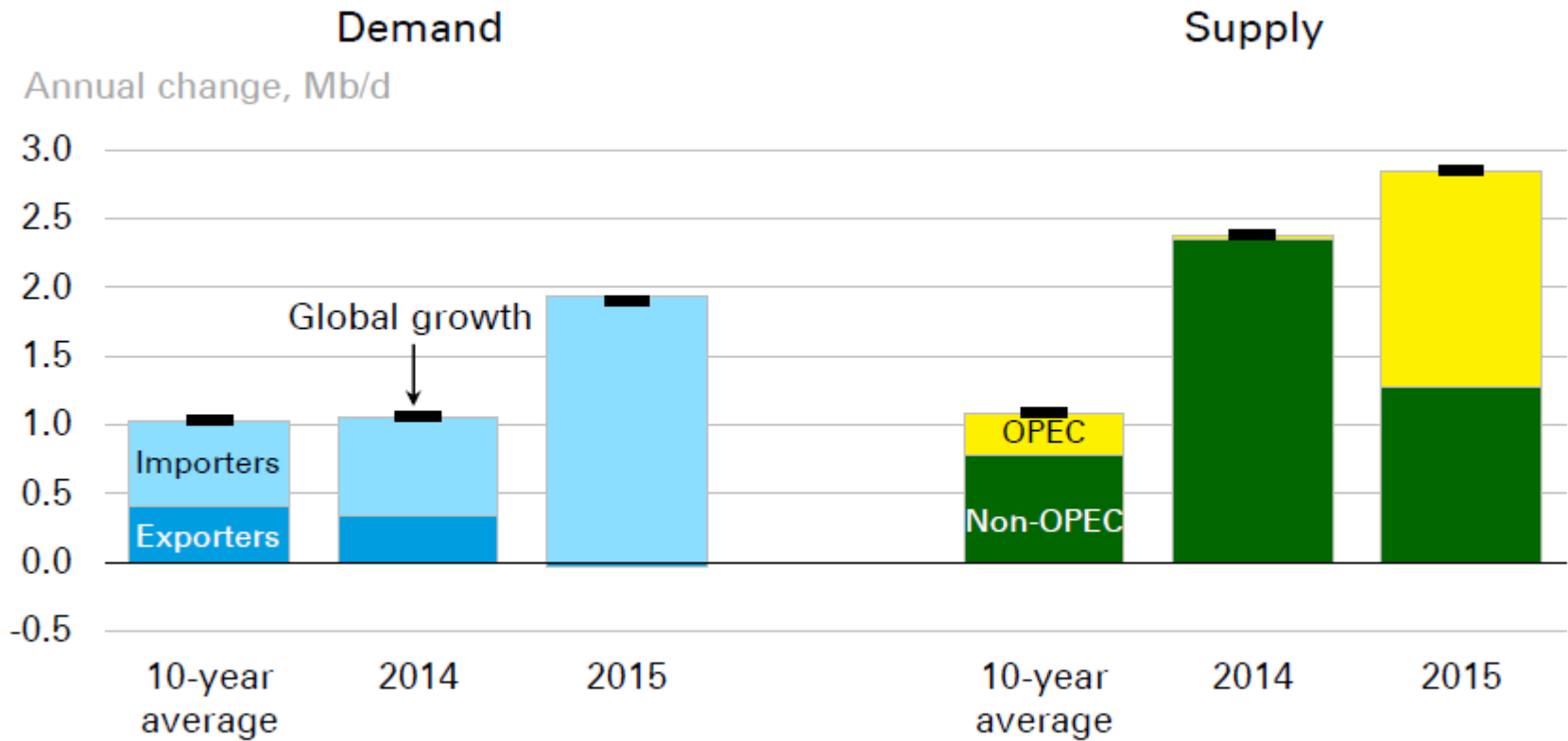
# Global energy prices – short and long-term trends



- Are we in a new era of lower commodity prices, or will there be rebound as supply and demand re-balance?



# In 2014-2016 the oil market was significantly oversupplied

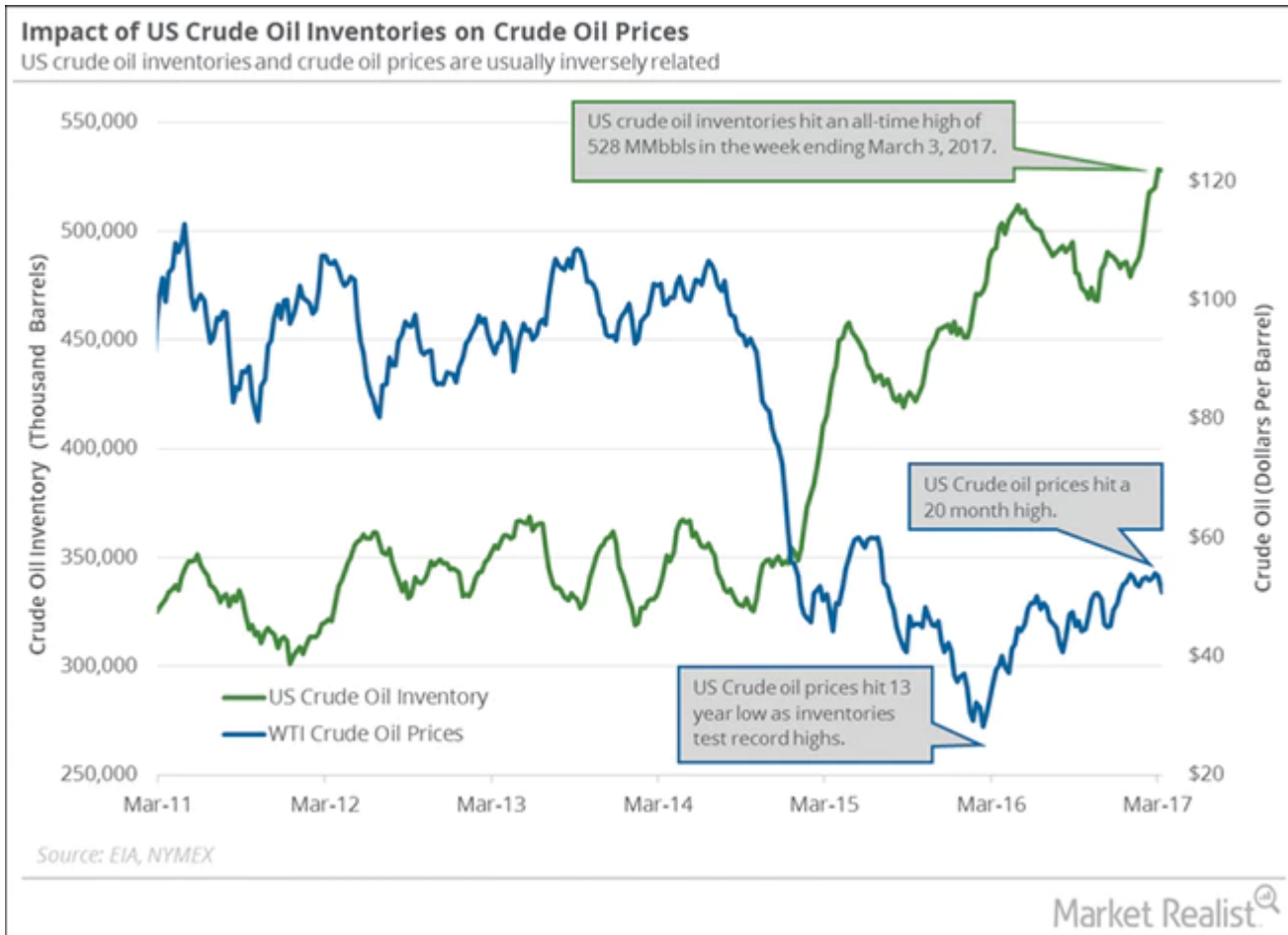


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- Oil demand growth has been fairly consistent at 1-2mmbpd per annum
- 2015 was a strong year as the market responded to lower prices
- Saudi Arabia (and OPEC) were competing for market share with Russia and the US, in particular US shale oil



# Oil market has been oversupplied



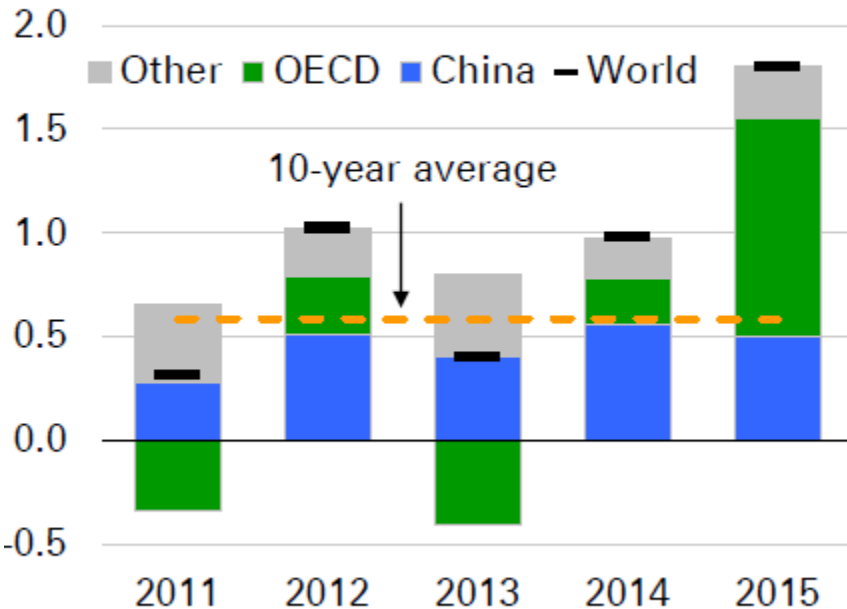
- Inventories have been very high relative to historical norms
- The oil price has moved in an equal and opposite direction
- OPEC has been attempting to resolve this situation while also contending with the new problem of US shale oil production



# Downstream margins have benefitted from lower oil price

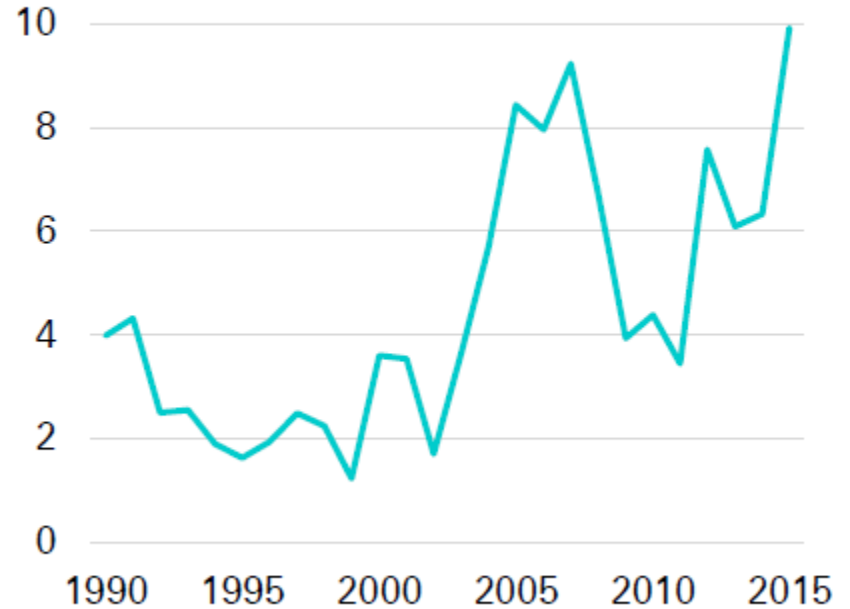
## Refinery throughput

Annual change, Mb/d



## Global refining margins\*

\$/bbl



\* Average of regional margins, as defined in the Statistical Review.

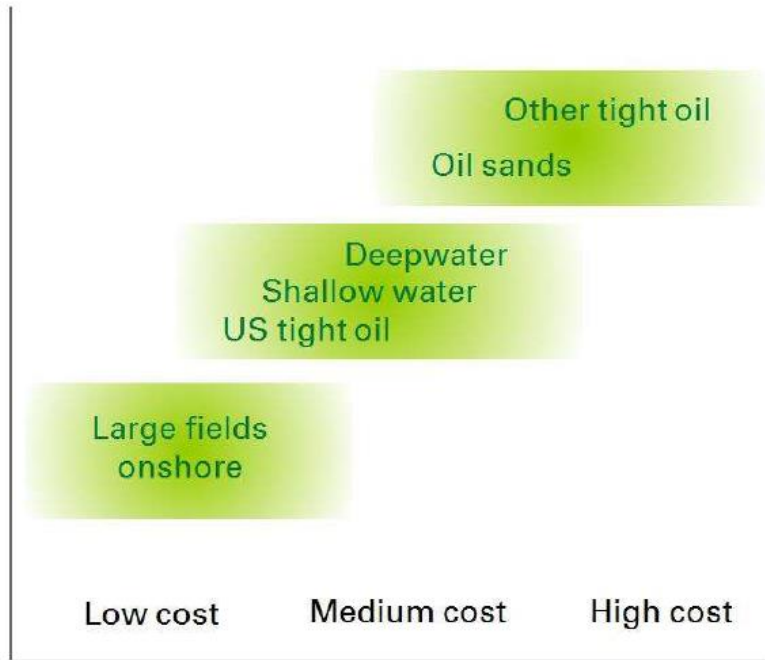
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- Global refinery throughput jumped by almost 2mmbpd, and margins reached record highs of \$10/barrel
- Refining capacity utilisation increased to 82%, allowing downstream players to make good profits
- Essentially, consumer demand for products increased as prices fell

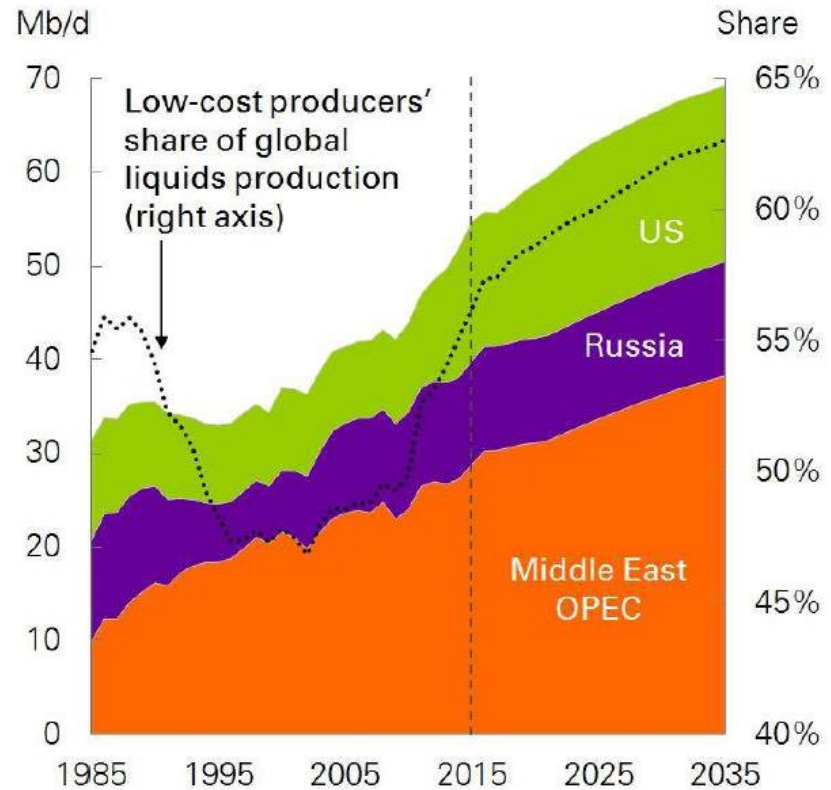


# Abundance of oil resources can lead to change in behaviour

Cost of supply (pre-tax)



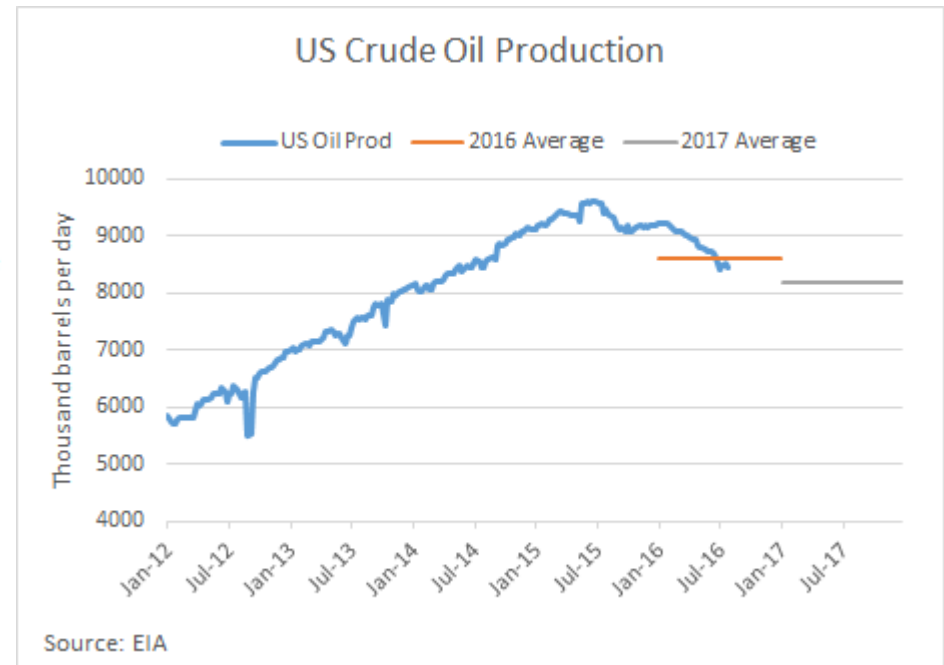
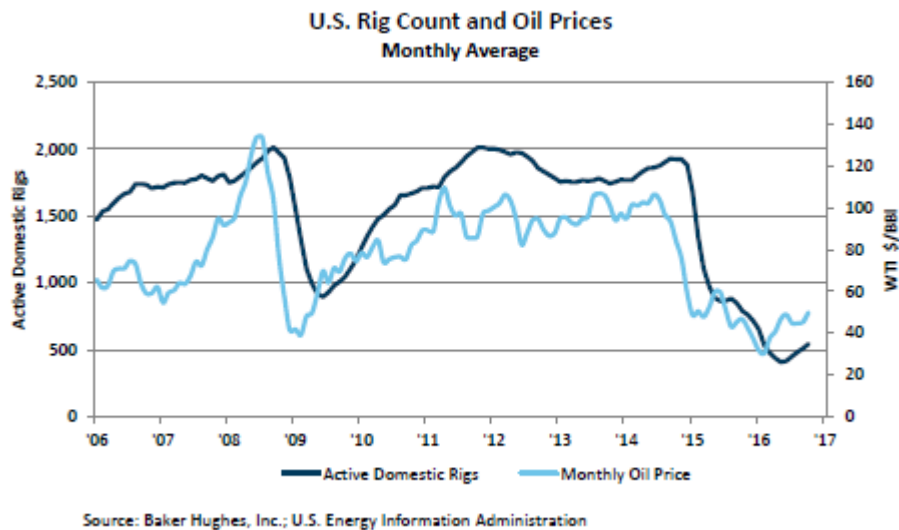
Oil supply of lower-cost producers



- Low cost producers may decide they need to get oil out of the ground sooner rather than later
- Middle East versus Russia versus US a key future battle



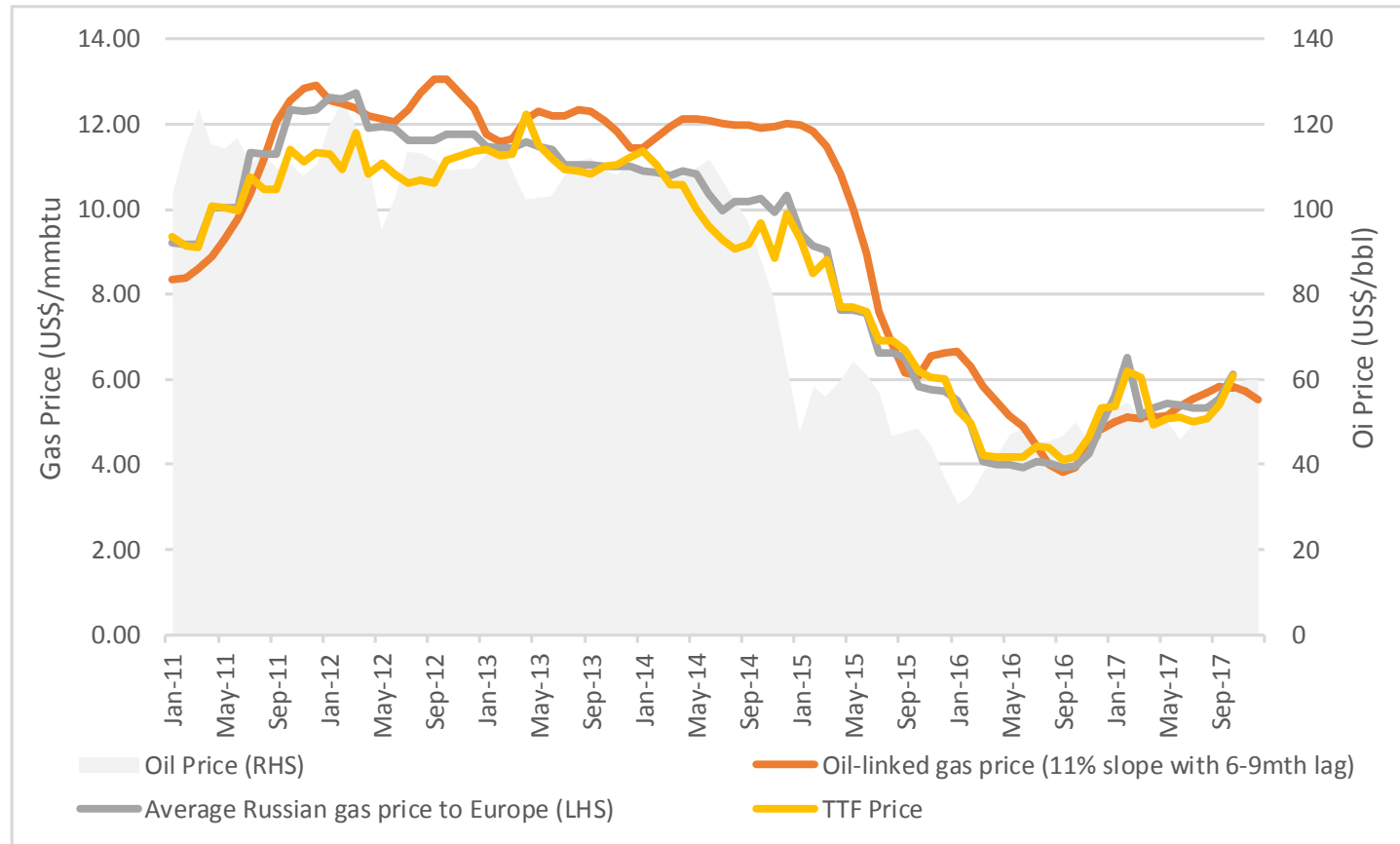
# US oil production reacted very fast to lower oil price



- Lower oil prices led to a reduction in US drilling and a decline in production
- Nevertheless, OPEC was forced to constrain its own output at the beginning of 2017
- The balancing of corporate, government and consumer needs, as well as the longer term outlook for oil demand, has led to a complex bargaining game



# Gas prices continue to have a strong link to oil prices

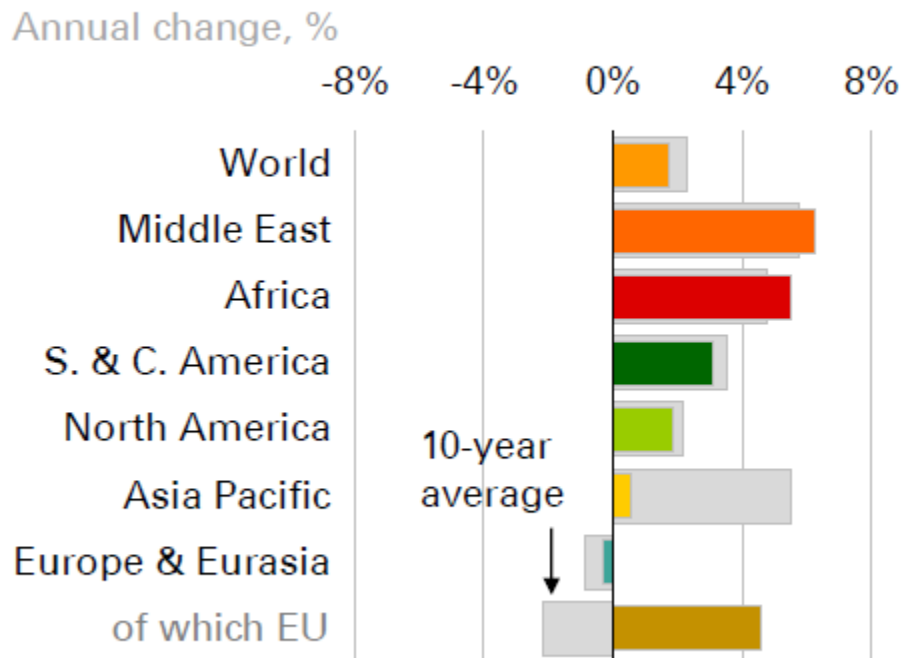


- Gas prices fell sharply in 2016, led by oil prices
- The average decline in Asia was 46%, in Europe 21% and the US 40%
- Market forces tend to set the price in the US, while in Europe and Asia there is still a strong correlation with the oil price
- The differential between Asia and Europe fell sharply in 2016, and Russian gas became very competitive in Europe

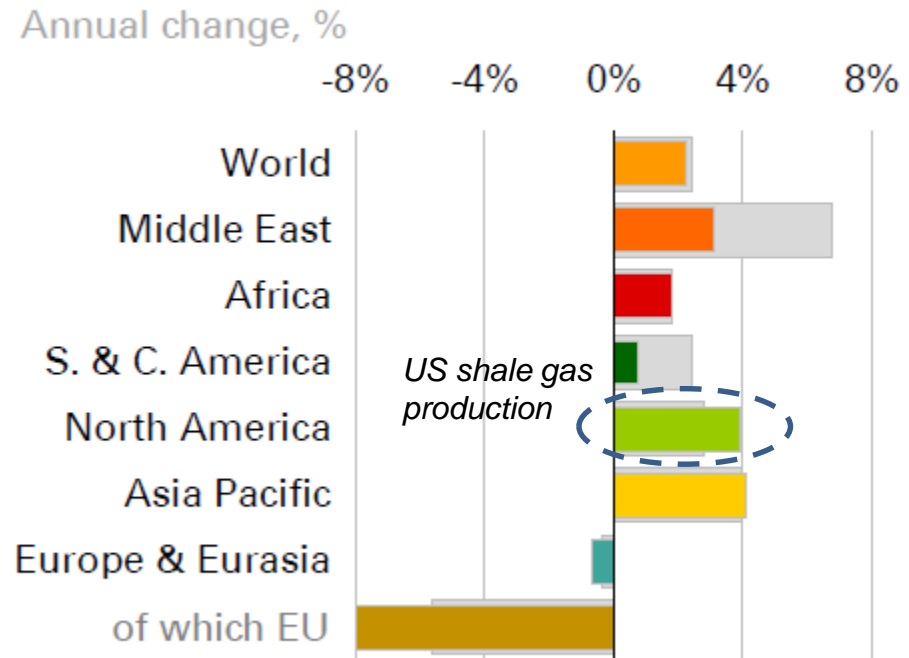


# Gas demand growth has remained strong

## Regional demand growth



## Regional supply growth



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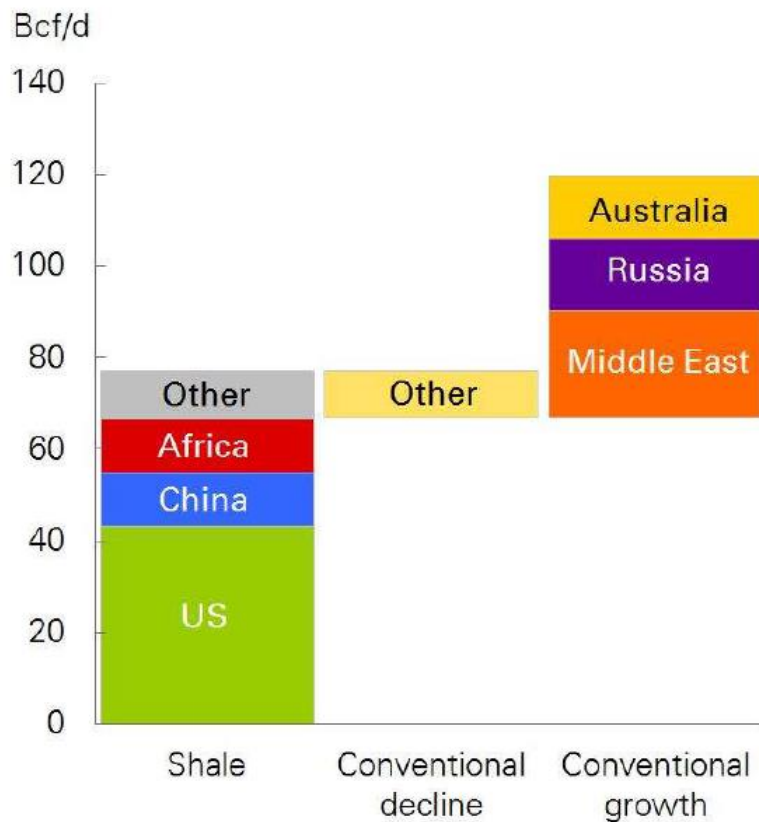
- Gas consumption grew by 1.7% in 2015, although the regional and sectoral results were mixed
- Gas gained market share in the power sector, displacing coal which had been significantly cheaper for a number of years
- However, Asian growth was a concern, as it was much lower than the 10-yr average, while the residential and industrial sectors were sluggish globally



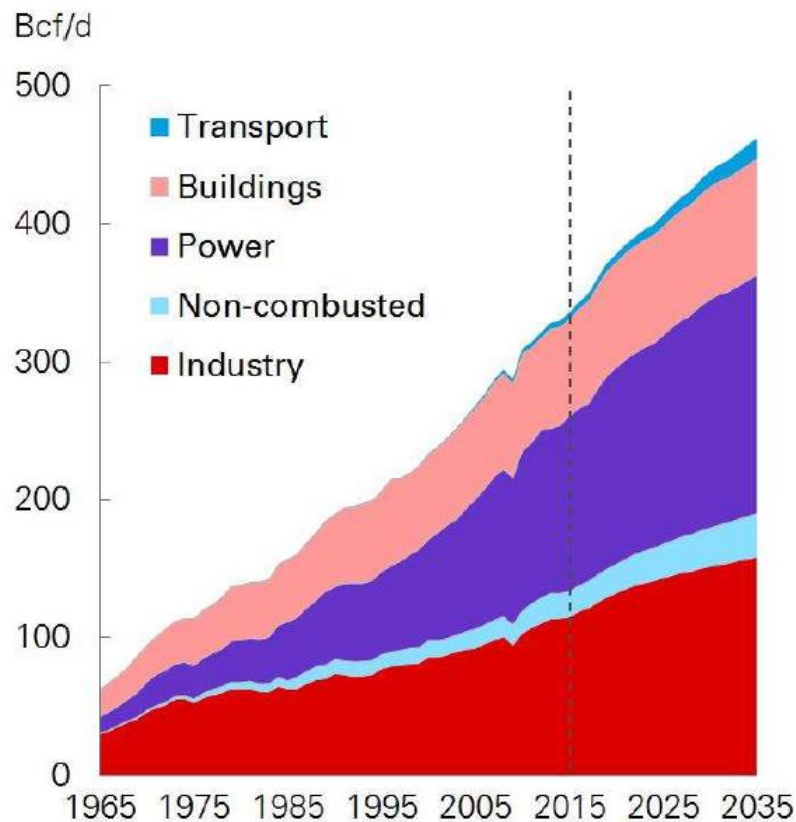


# Gas consumption to grow

## Gas supply growth 2015-2035



## Gas consumption by sector

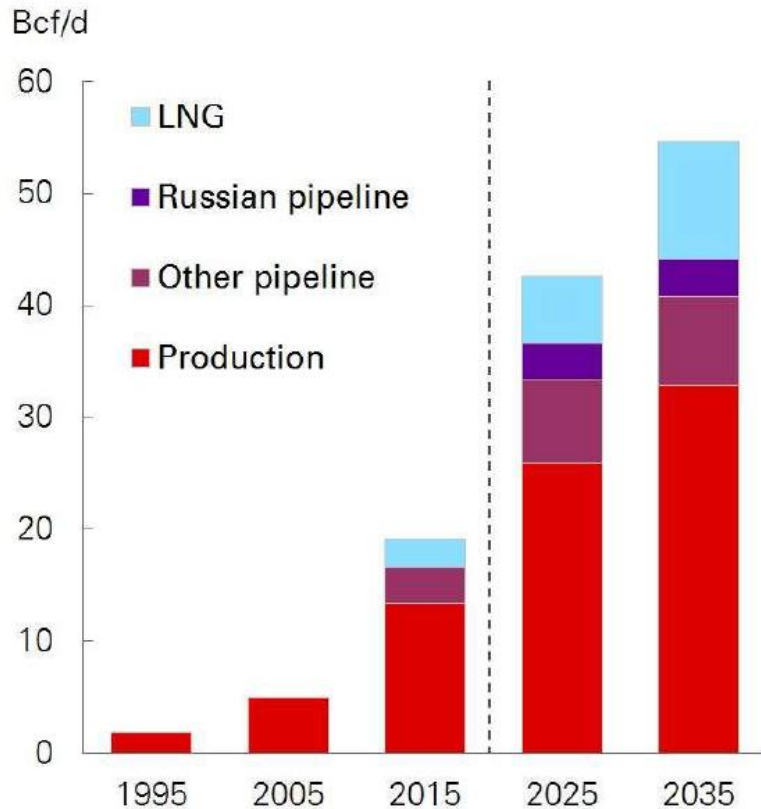


- Gas consumption growth driven by power and industry
- Shale production to play a major role in meeting demand

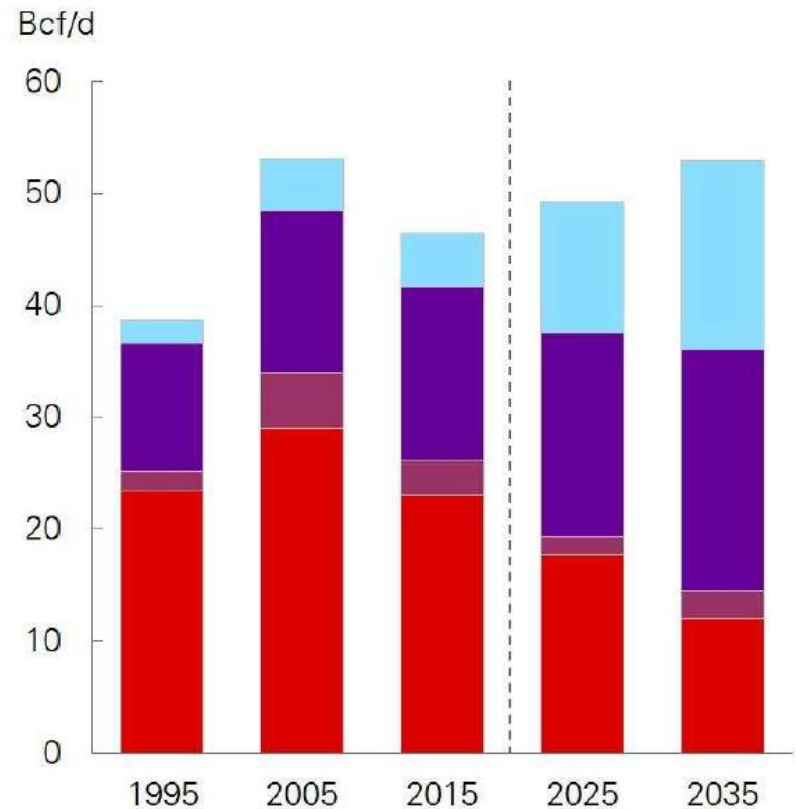


# LNG and pipeline exports to offer diversified supply sources

## Gas supply to China



## Gas supply to Europe

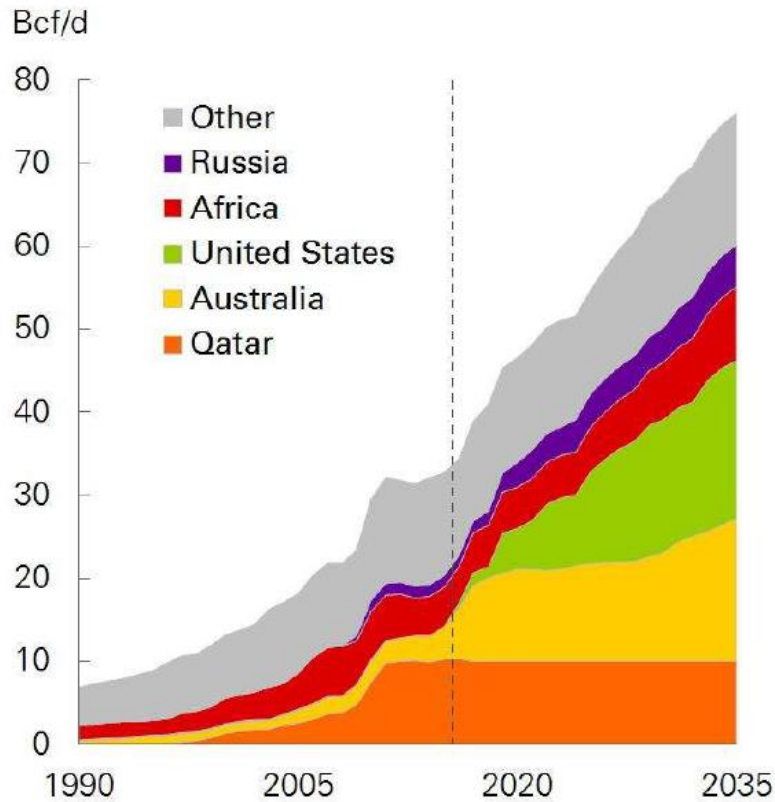


- Major importers seek to find as many different sources of supply as possible
- LNG to play a major role in globalising the world gas market

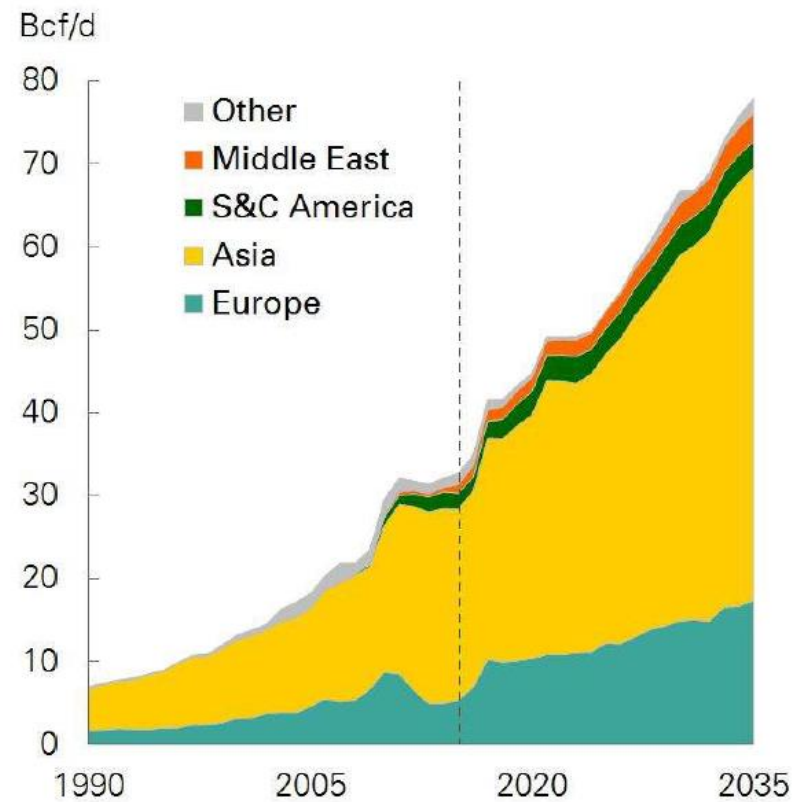


# Growing LNG demand adds liquidity to global gas market

## LNG supply



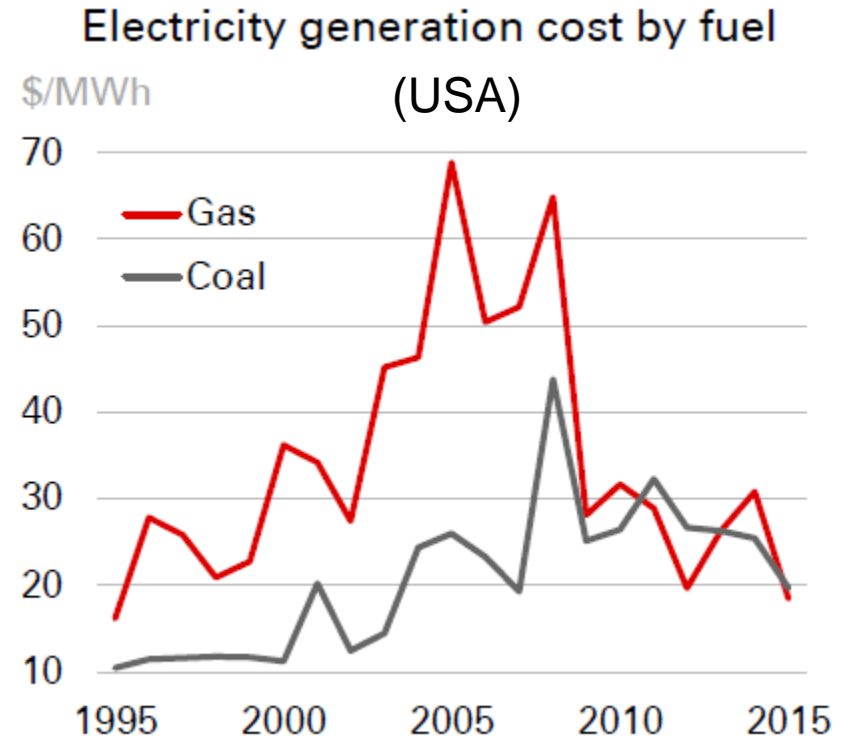
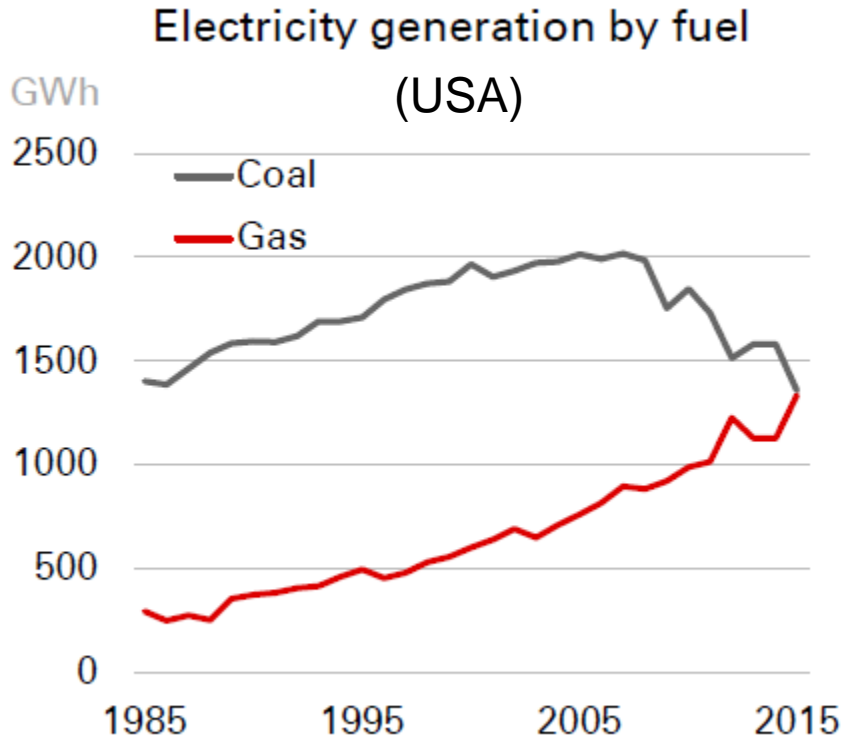
## LNG demand



- US, Australia and Middle East to dominate growth of LNG supply
- Asia will be the major customer
- The importance of eastern markets is unavoidable



# Ultimately, economics trumps environment



Source: includes data from EIA

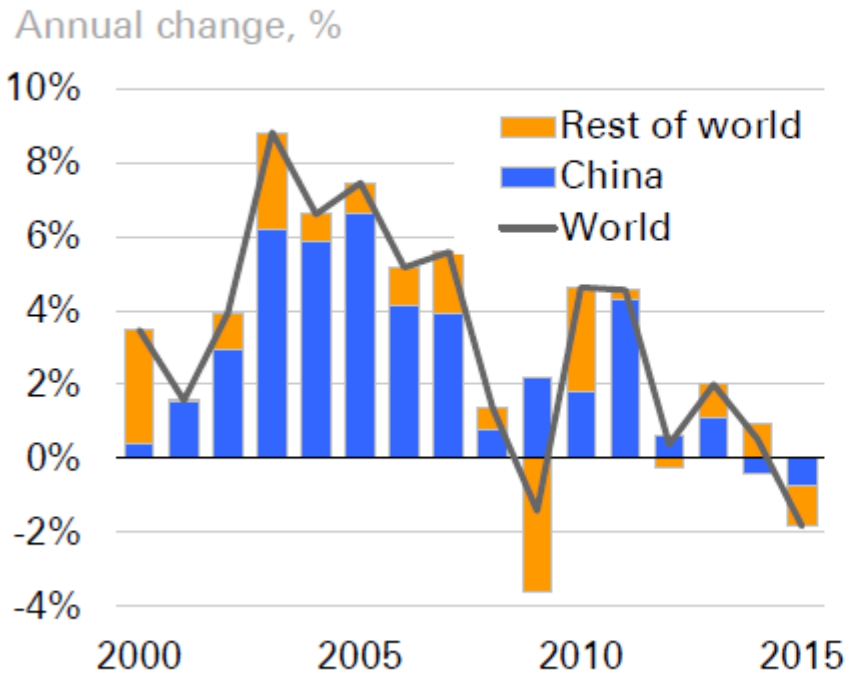
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- While coal was cheaper than gas for power generation in the US, its share of the market grew
- As soon as shale gas arrived, and gas prices fell, gas grew more rapidly and coal demand declined
- Ironically, excess coal was exported, reducing the price in Europe and displacing gas in the power sector

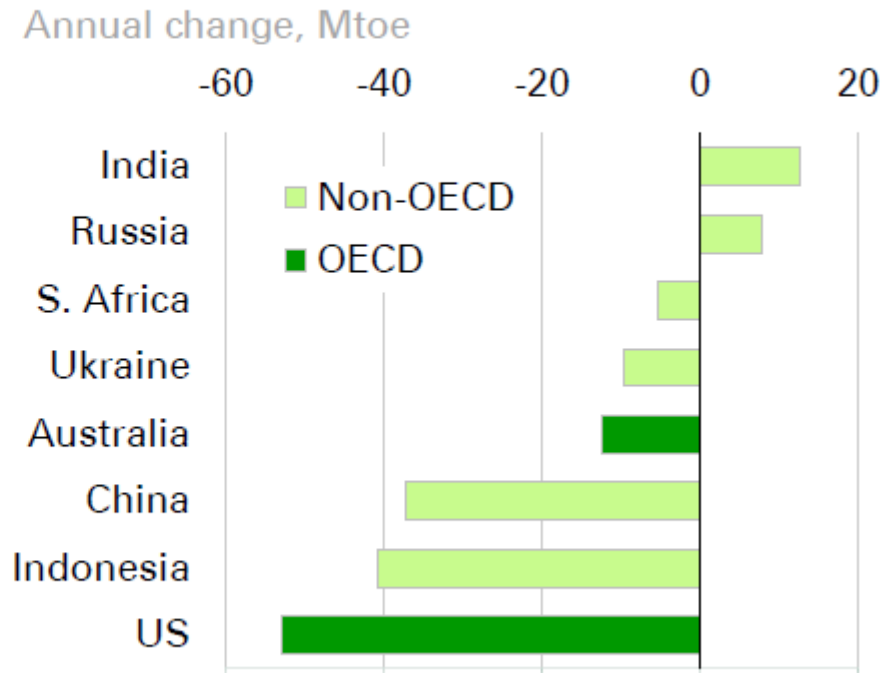


# Coal increasingly under pressure

## Global coal demand growth



## Largest changes in coal supply



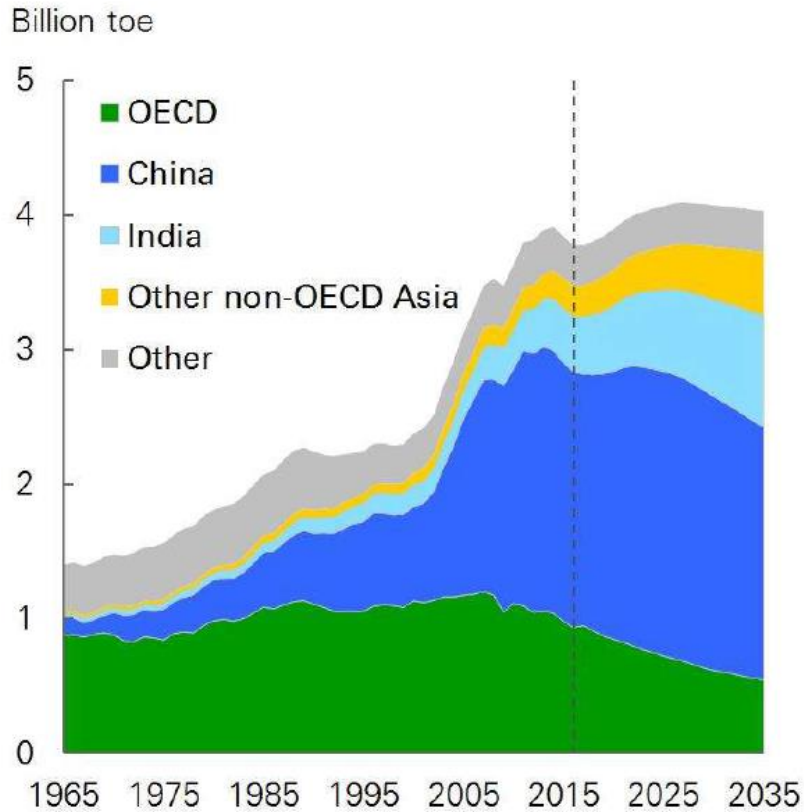
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- Coal is under pressure due to environmental concerns
- Demand is naturally in decline, but falling prices are creating an economic dilemma for many countries
- Interesting that production has started to decline in China, but also that it continues to rise in India
- Differing political and economic drivers in each country

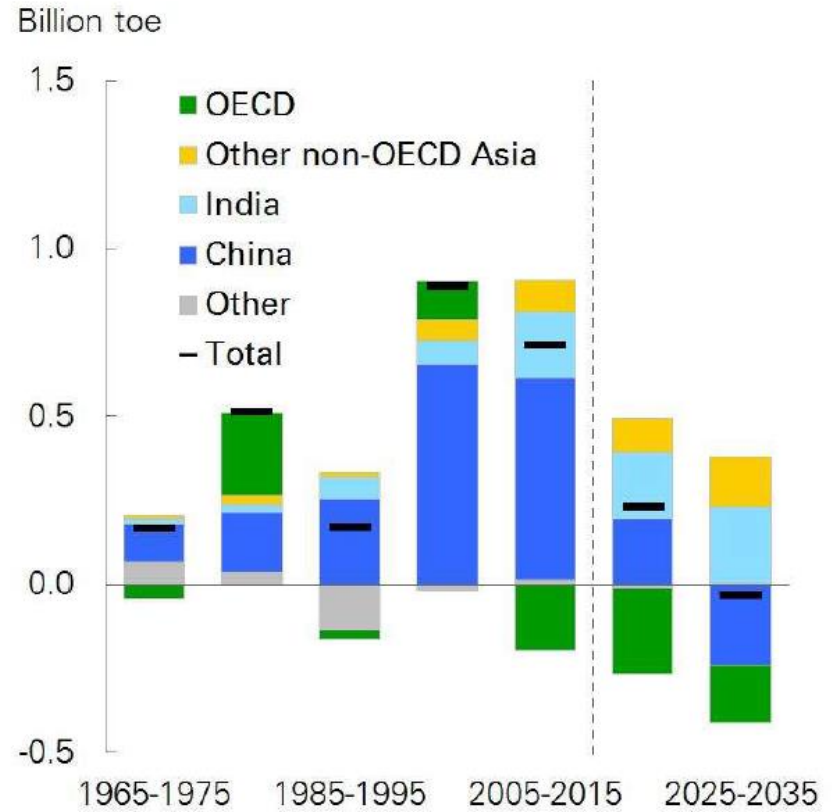


# Coal consumption to plateau/decline

## Coal consumption by region



## Ten-year increments by region



- OECD to lead shift away from coal
- Indigenous producers may find it more difficult to justify diversification

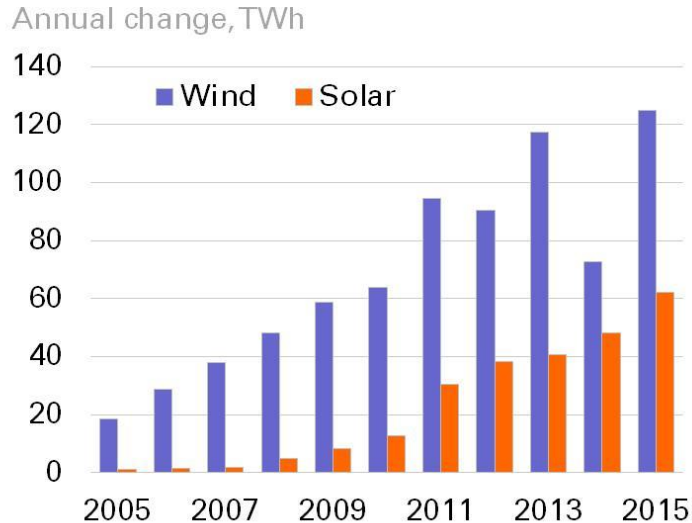


# Wind power leads the way for renewables

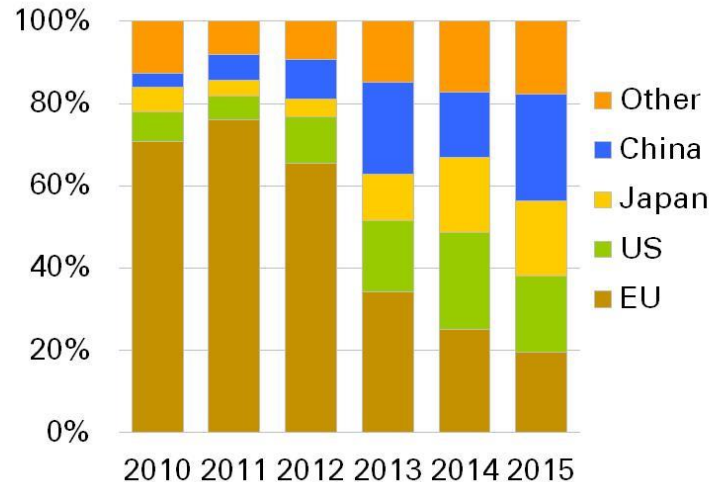


## Renewables growth

Wind and solar growth



Shares of solar growth



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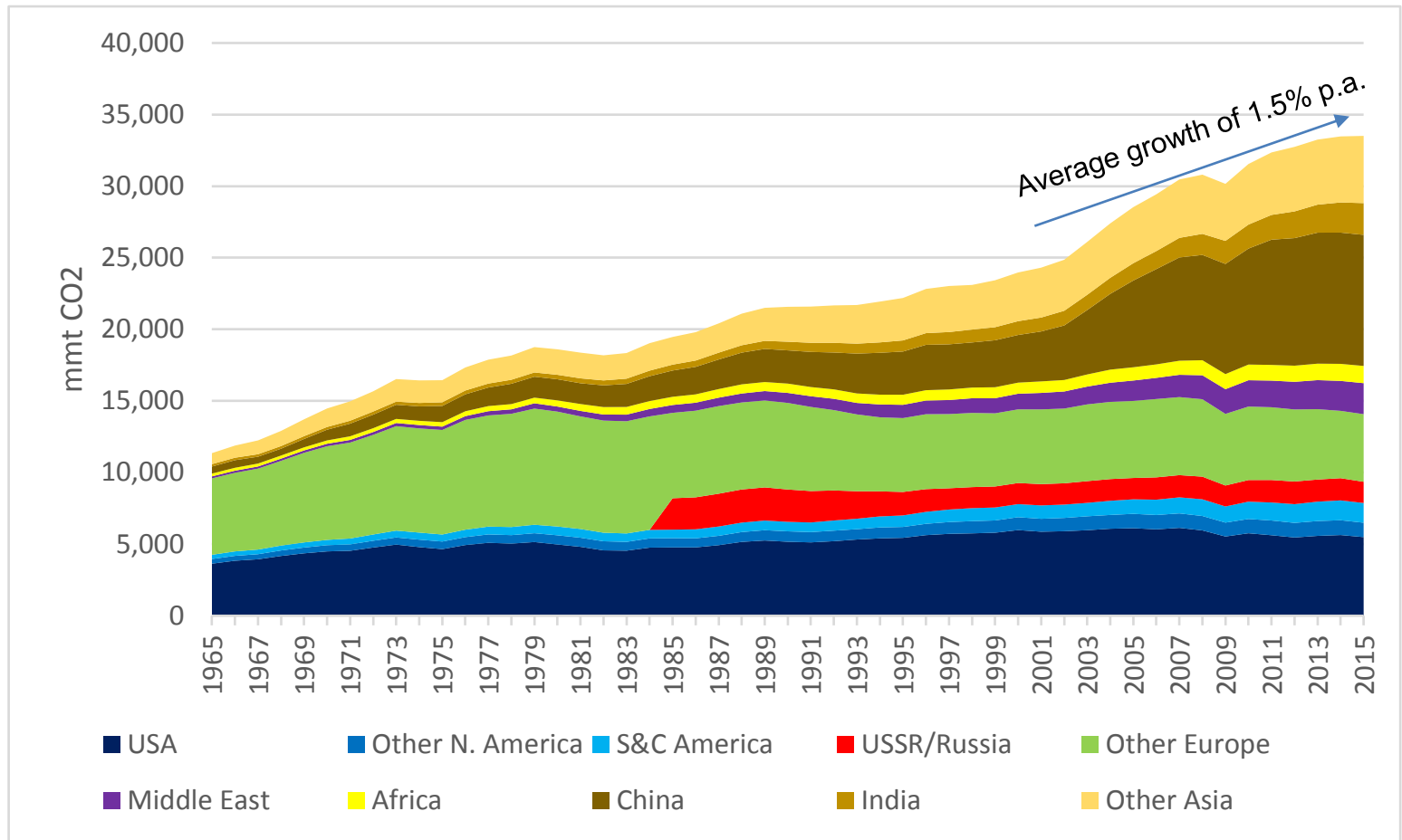
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- Although renewable energy only accounts for 3% of total energy, it grew by 15% in 2015
- It accounted for all the increase in global power generation and nearly 40% of total energy growth
- Solar is growing very fast (33% in 2015) but wind power still leads the way in terms of absolute growth





# History of CO2 Emissions



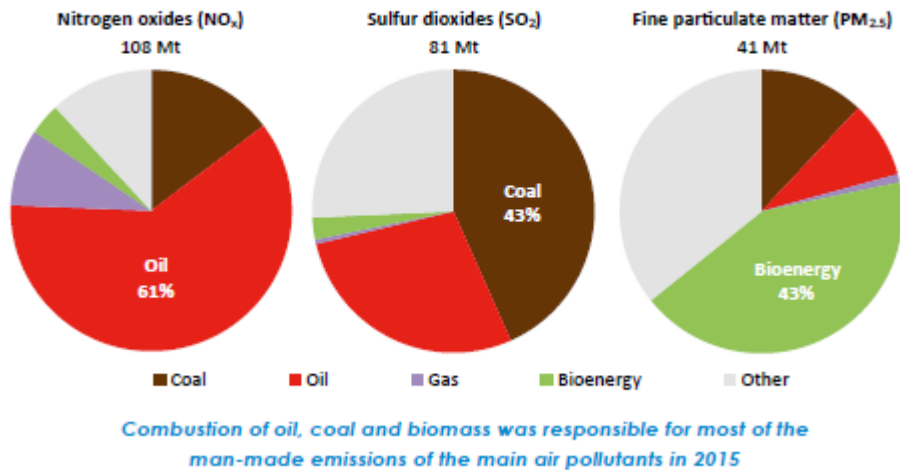
- Carbon emissions have grown consistently to 2014, but were then almost flat in 2015 and 2016 due to sluggish economic growth and greater energy efficiency
- Key question is whether we have reached a peak, or is this just a cyclical downturn?



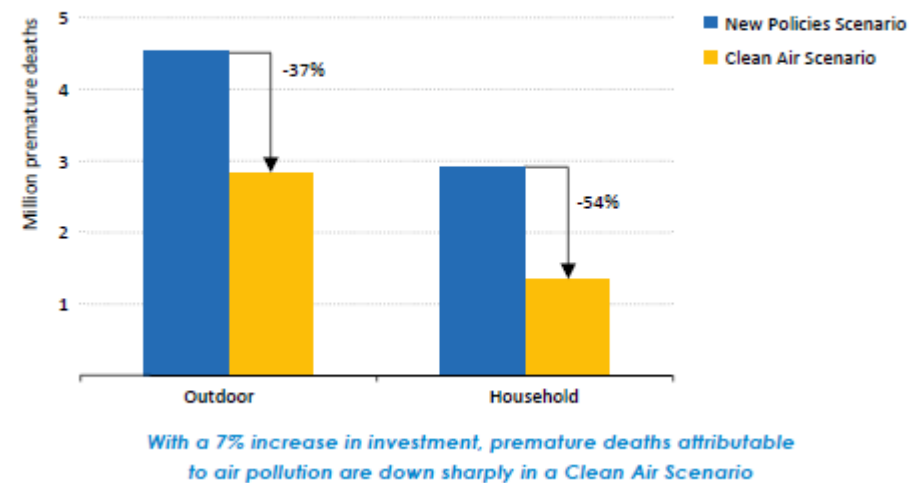


# Air pollution is becoming an almost more important short-term issue

**Figure 2.10** ▶ Estimated anthropogenic emissions of the main air pollutants by source, 2015



**Figure 2.12** ▶ Premature deaths attributable to global air pollution in the New Policies and Clean Air Scenarios, 2040



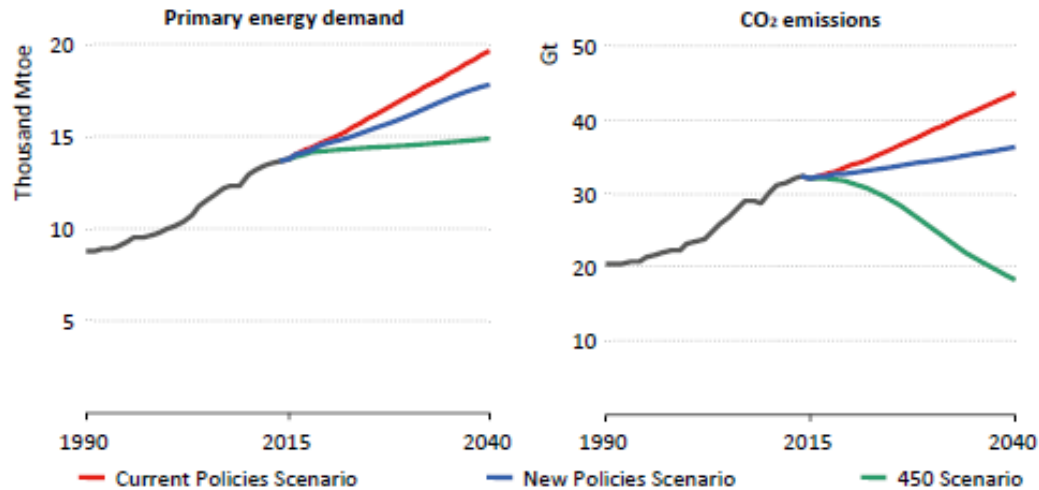
- Air pollution is a more immediate social and political issue than carbon emissions
- China is well known for its poor air quality in many cities, but even in Europe a number of regions are well below acceptable levels
- Governments are aware that a failure to react on a key health issue could lead to a violent backlash
- Air pollution could therefore be a key driver towards a cleaner energy economy



Having said that, in the longer term global warming is the key issue, and things clearly need to change if we are to meet 2 degree target

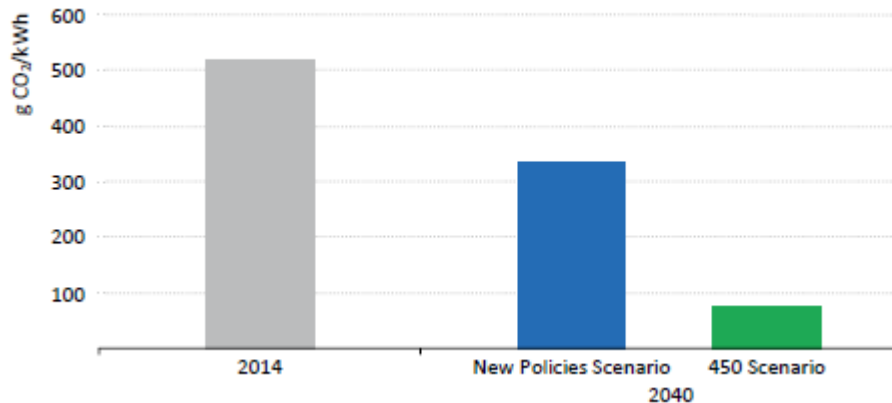
### *Energy demand and CO2 emissions in different IEA scenarios*

Demand must not grow...



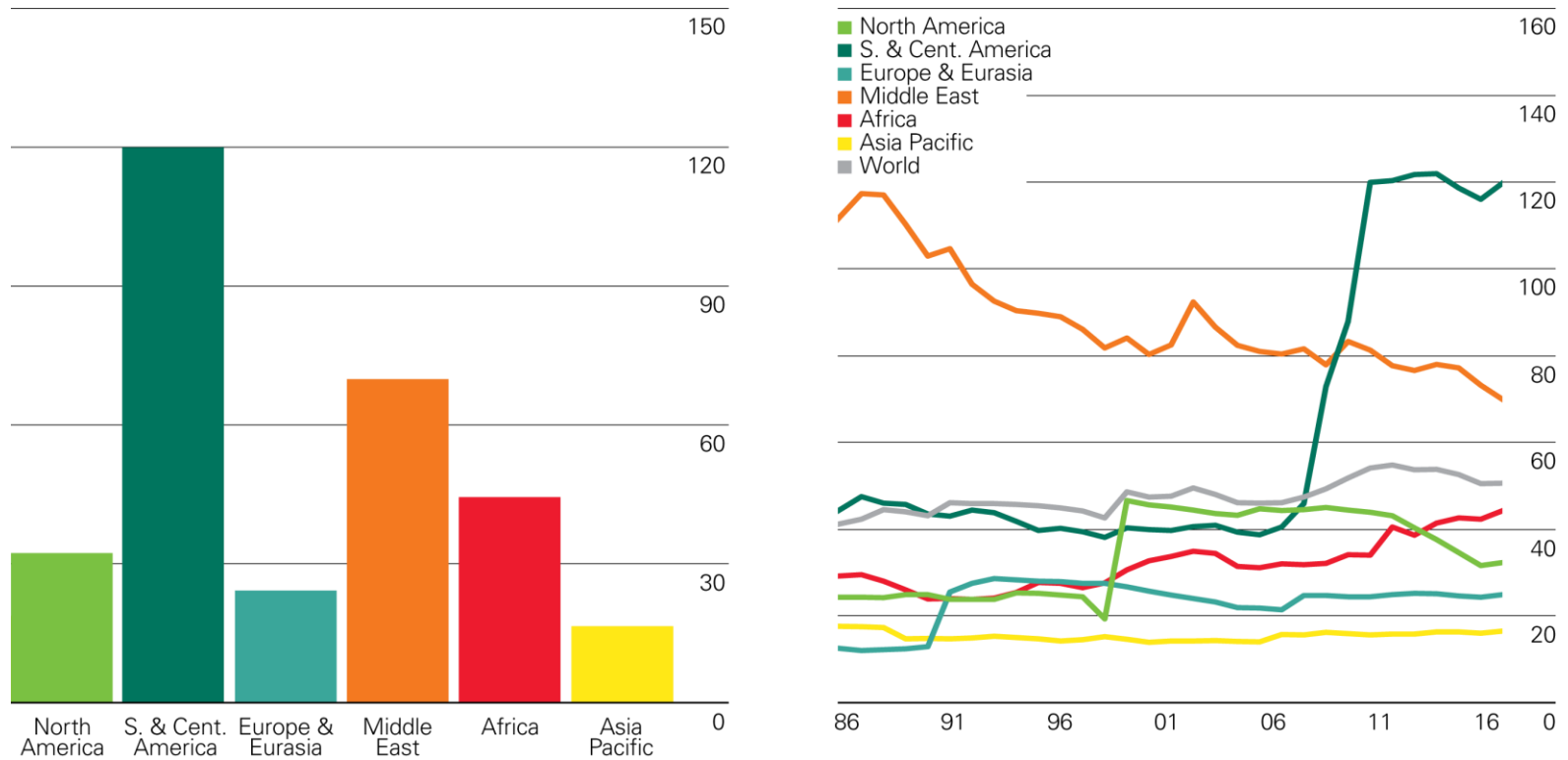
### *Emissions intensity from power sector*

...and renewable output must



# This leaves a vital question for companies / regions with large fossil fuel reserves

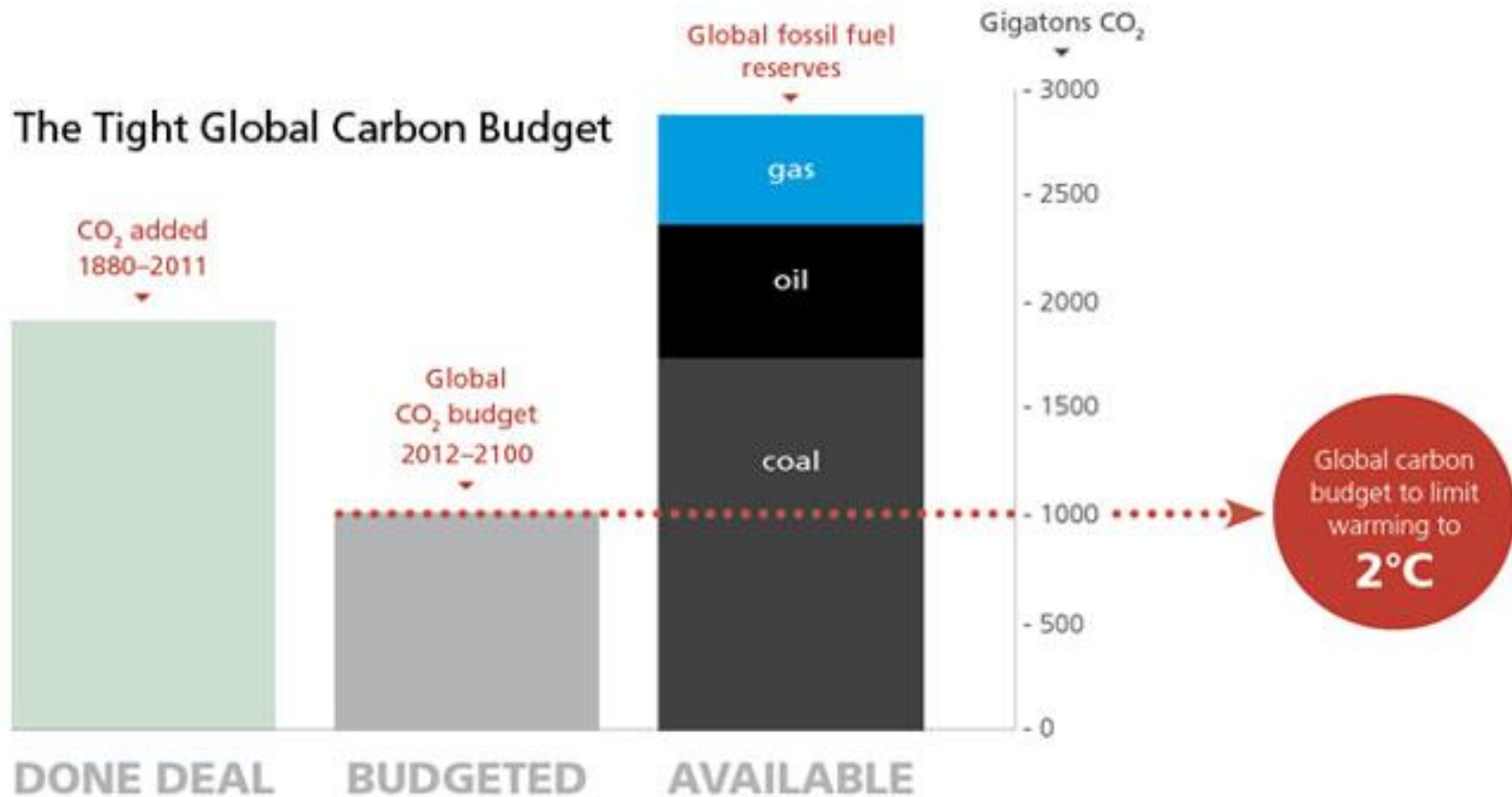
## Fossil fuels reserves to production ratios (years)



- Coal reserves would last well over 100 years in most regions, while oil and gas reserves have a 50 year reserves life on average
- This assumes that no further exploration is ever carried out
- Will these reserves ever be produced, and perhaps more importantly who can get theirs out of the ground first?



# Looking at the global carbon budget, the race is on to produce fossil fuels while you can



- This has vast political and commercial consequences, as countries and companies have to react to a fast changing energy economy
- The futures of Russia and the Middle East are closely bound up to the issue of whether this carbon budget will or can be enforced



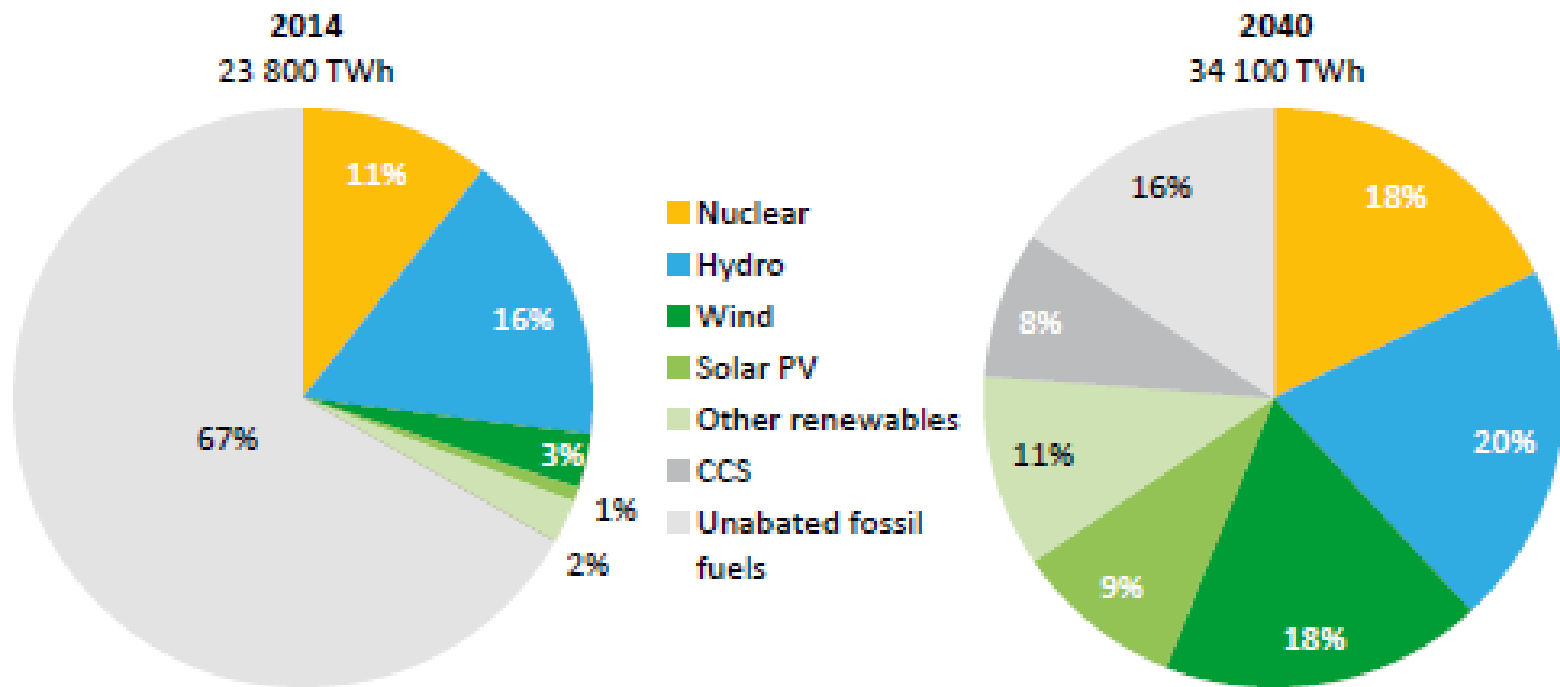
# World Energy Demand by Fuel and Scenario

	2000	2014	New Policies		Current Policies		450 Scenario	
			2025	2040	2025	2040	2025	2040
Coal	2 316	3 926	3 955	4 140	4 361	5 327	3 175	2 000
Oil	3 669	4 266	4 577	4 775	4 751	5 402	4 169	3 326
Gas	2 071	2 893	3 390	4 313	3 508	4 718	3 292	3 301
Nuclear	676	662	888	1 181	865	1 032	960	1 590
Hydro	225	335	420	536	414	515	429	593
Bioenergy*	1 026	1 421	1 633	1 883	1 619	1 834	1 733	2 310
Other renewables	60	181	478	1 037	420	809	596	1 759
<b>Total</b>	<b>10 042</b>	<b>13 684</b>	<b>15 340</b>	<b>17 866</b>	<b>15 937</b>	<b>19 636</b>	<b>14 355</b>	<b>14 878</b>
<i>Fossil-fuel share</i>	<i>80%</i>	<i>81%</i>	<i>78%</i>	<i>74%</i>	<i>79%</i>	<i>79%</i>	<i>74%</i>	<i>58%</i>
<b>CO<sub>2</sub> emissions (Gt)</b>	<b>23.0</b>	<b>32.2</b>	<b>33.6</b>	<b>36.3</b>	<b>36.0</b>	<b>43.7</b>	<b>28.9</b>	<b>18.4</b>

- The outcomes for hydrocarbons are very different in scenarios that look at current likely outcomes versus outcomes needed to meet climate targets
- In a world where we meet the 2 degree target, coal demand would halve from current levels and oil demand would fall by 25%
- However, fossil fuel share would still be 58% in 450 Scenario



## Power sector mix in 450 scenario

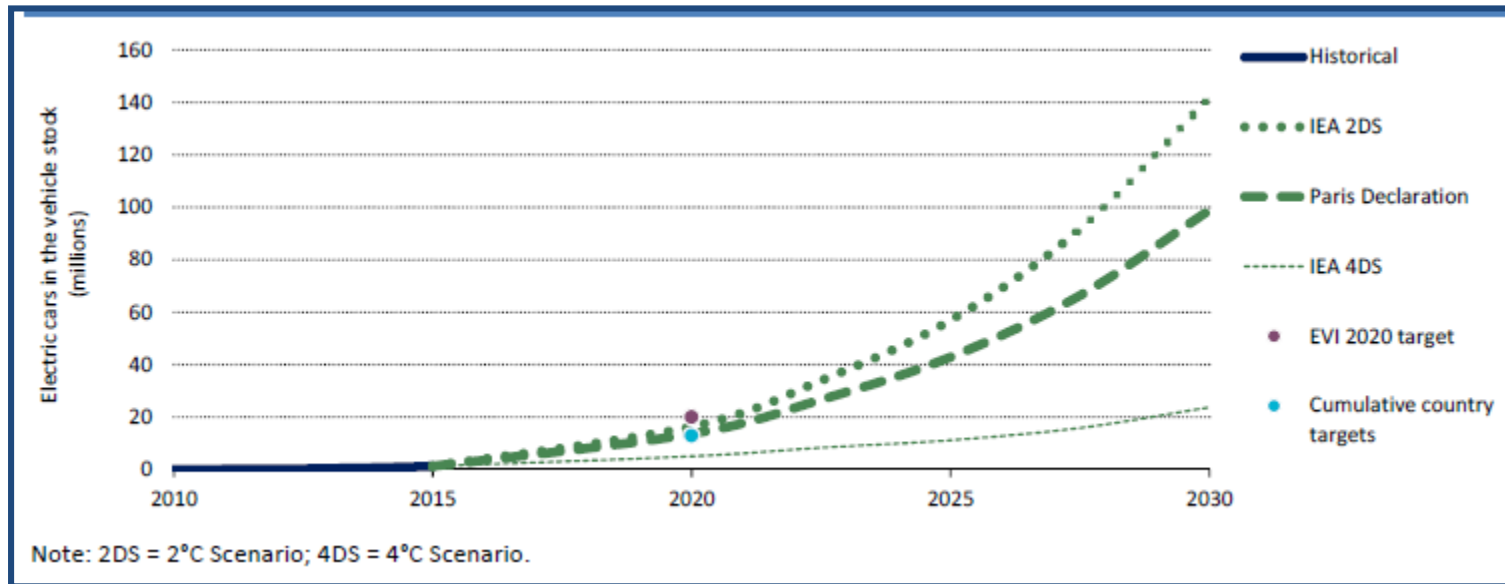


- Radical change is reflected most in the power sector
- Non-fossil fuels would account for 76% of the mix in 2040 in the 450 scenario
- Renewables share would rise from 6% to 37%, with huge implications for the power system and the role of fossil fuels
- Much will depend on how intermittency is managed, with battery technology development a key factor



# Change in Transport Sector could also be significant

## *Electric vehicle scenarios to 2030*



- Electric cars currently account for 0.9% of global vehicle fleet (including hybrids)
- Various targets have been set for growth over the next 15 years
  - EVI 20 wants 20 million by 2020
  - Paris agreement on electric mobility see 100 million by 2030
  - IEA 2 degree scenario sees requirement for 140 million
  - Current trajectory implies a 4 degree outcome
- At what point can electric cars account for all incremental growth in transport fleet?



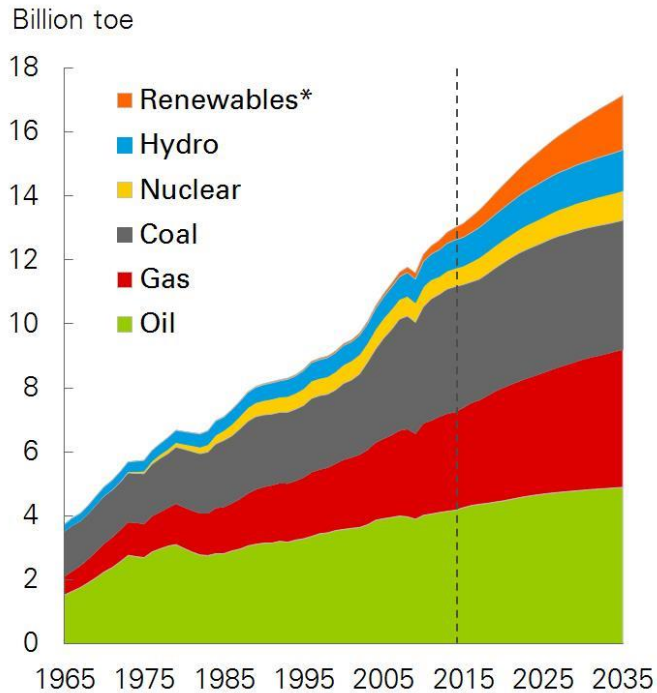
# The BP View

Base case: Primary energy



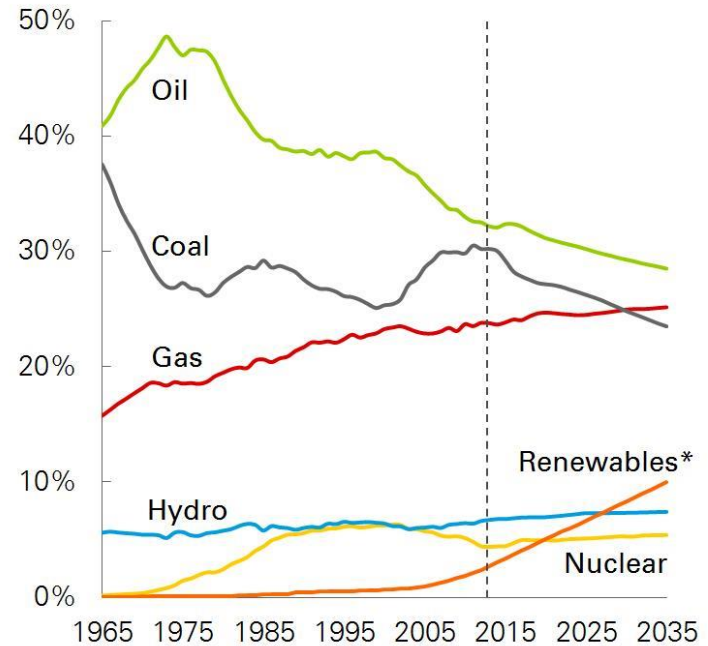
The gradual transition in the fuel mix continues...

Primary energy consumption by fuel



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

Shares of primary energy



- Oil and gas companies show a more balanced outlook, based on the view that policy will not achieve environmental goals





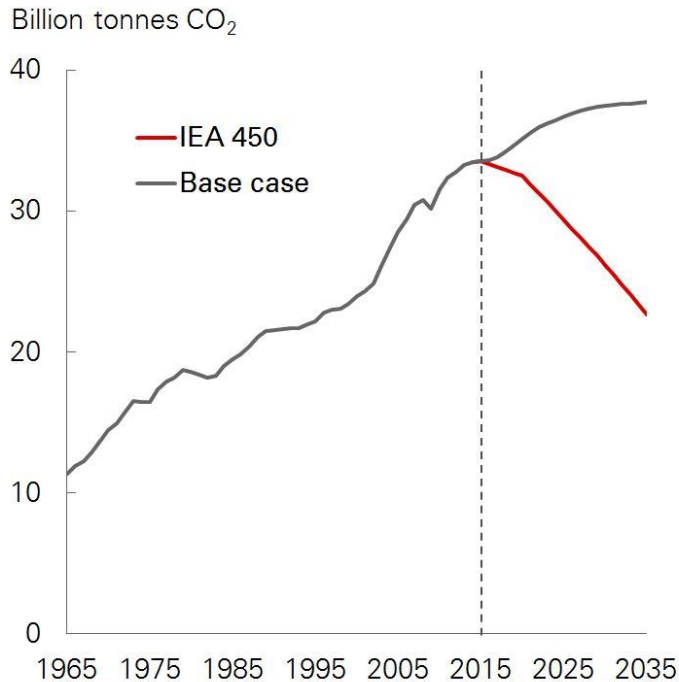
# With bad climate consequences

Base case: Carbon emissions

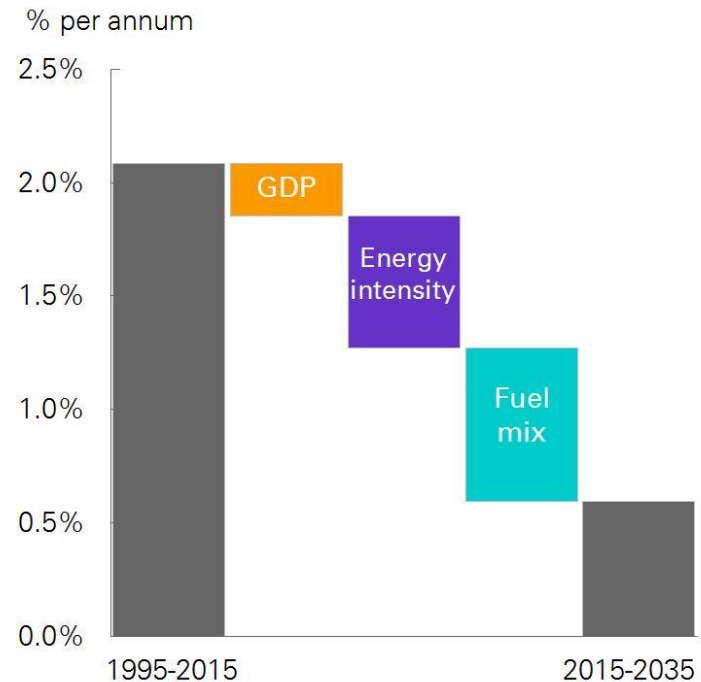


Carbon emissions look set to continue to rise...

### Carbon emissions



### Contributions to slower growth of carbon emissions



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

2017 Energy Outlook

20

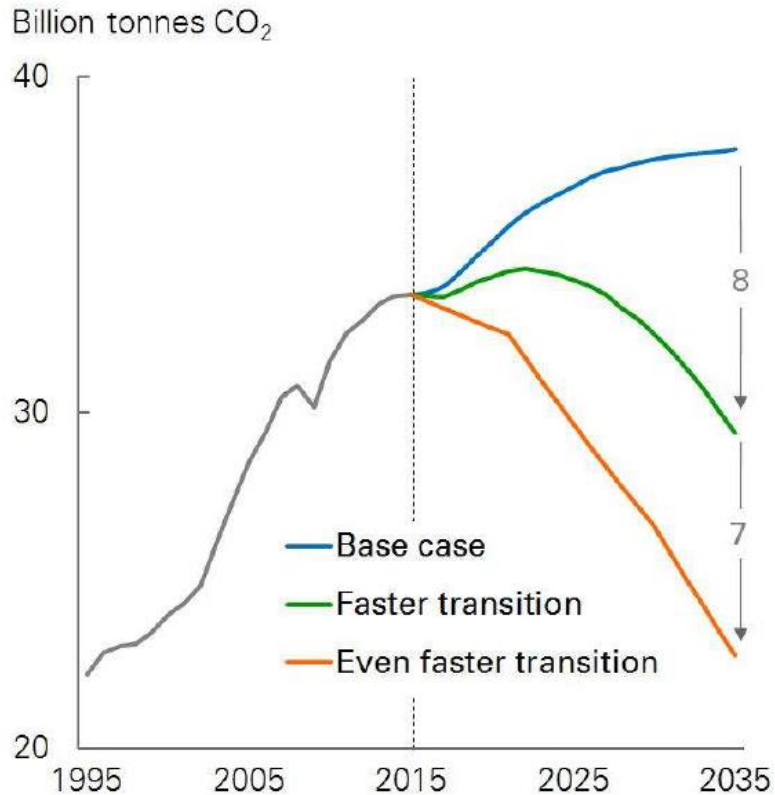
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- They clearly believe that governments will succumb to commercial pressure and will not have the will to force through change which could have uncomfortable social, political and economic consequences

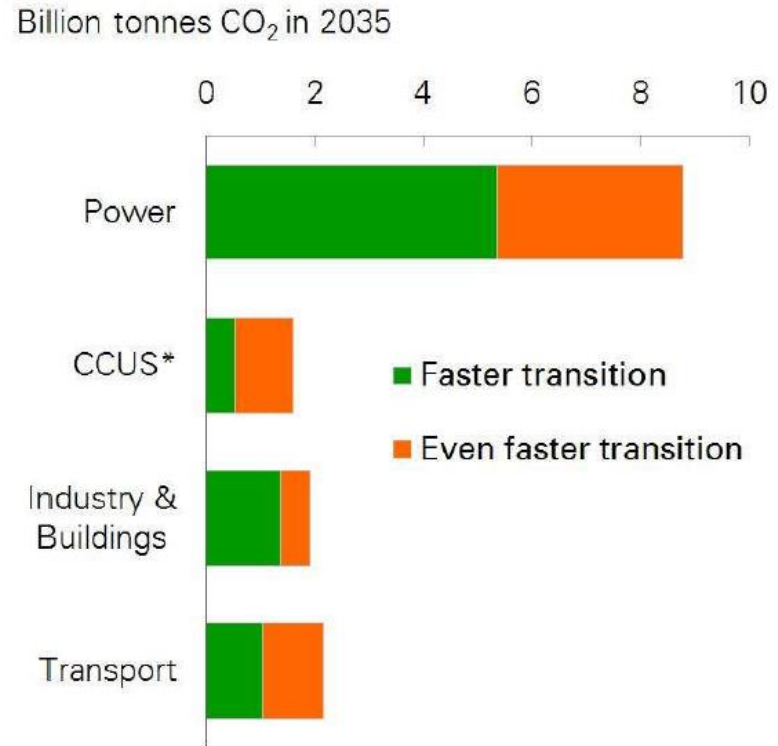


# How aggressive are we going to be on climate change?

## Carbon emissions



## Reductions in emissions versus base case



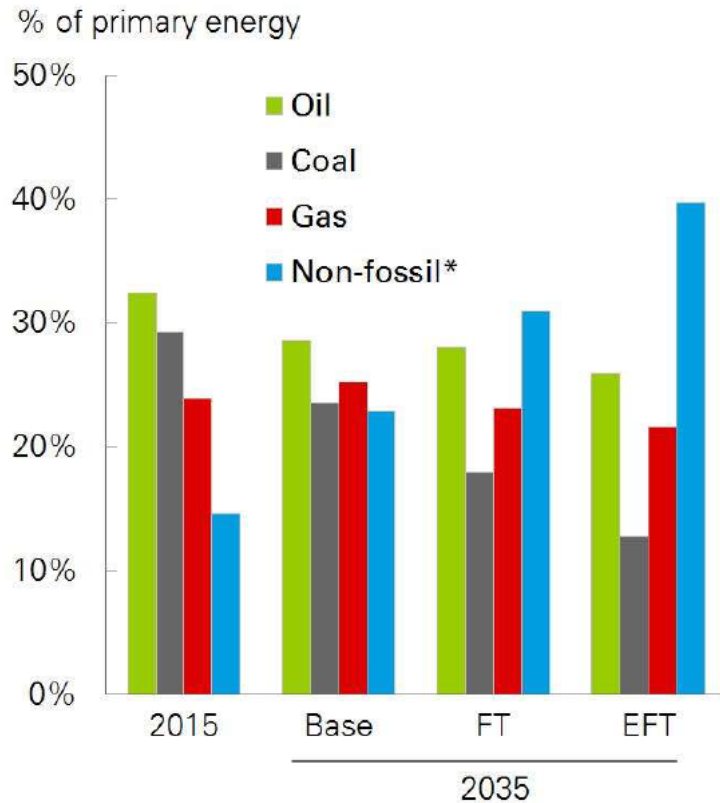
\*Carbon capture, use and storage (predominantly in power sector)

- Most estimates of future energy usage do not meet 2 degree target
- If the world is to avoid excessive warming then measures will need to be taken across all sectors of the economy

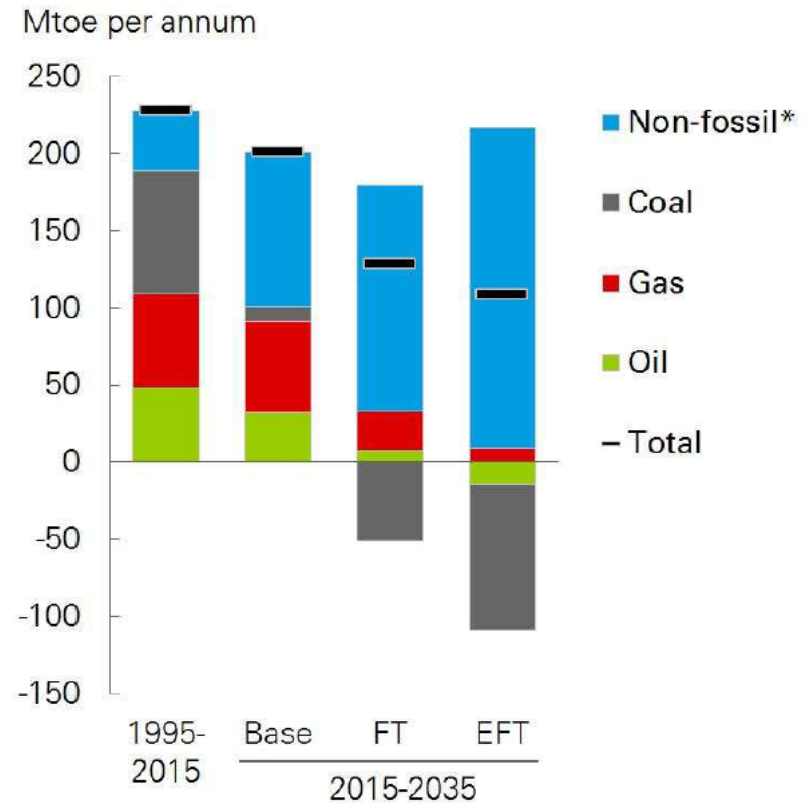


# Impact of fuel mix of various scenarios

## The changing fuel mix



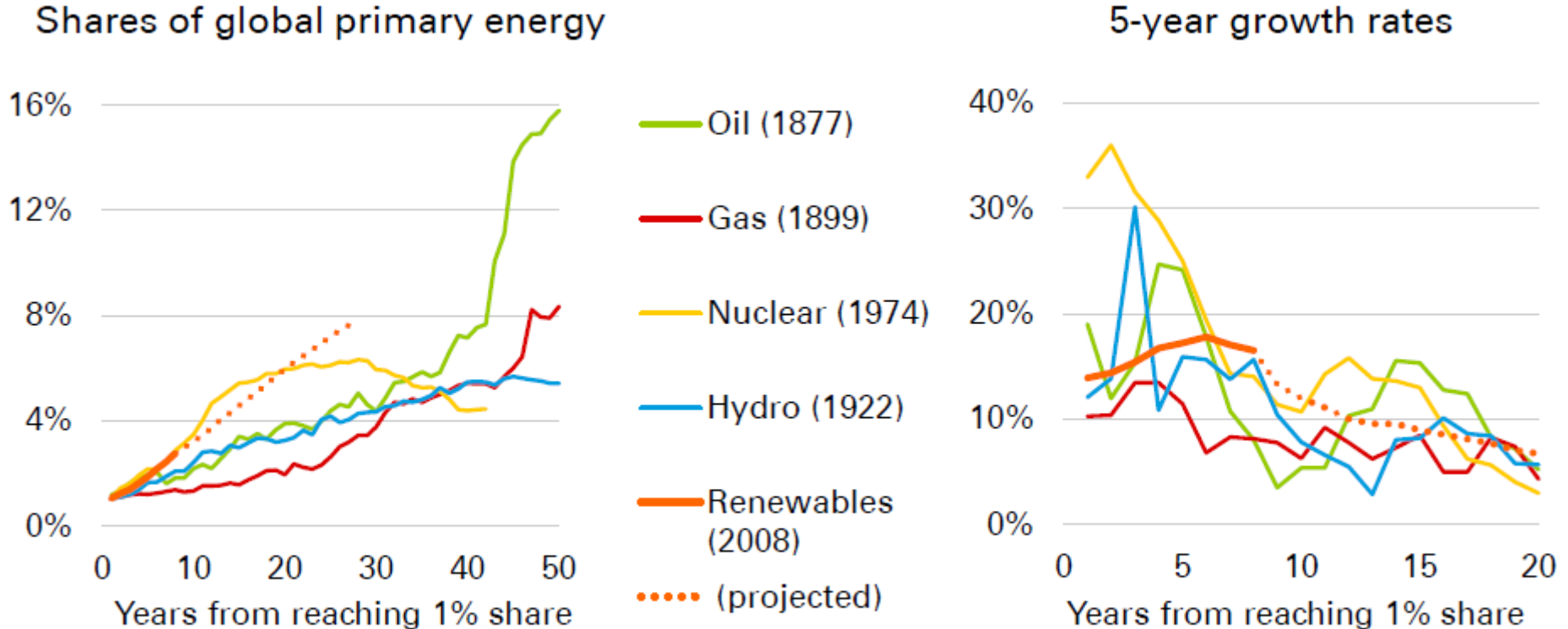
## Annual demand growth by fuel



- The future of coal looks bleak if climate targets are to be met
- However, in the long-term oil and gas also face very challenging futures



# Key question concerns the pace of change – can it be sustained?



Note: - For sources of data pre-1965 see "Economic development and the demand for energy" by Ruehl et al, Energy Policy, 2012.

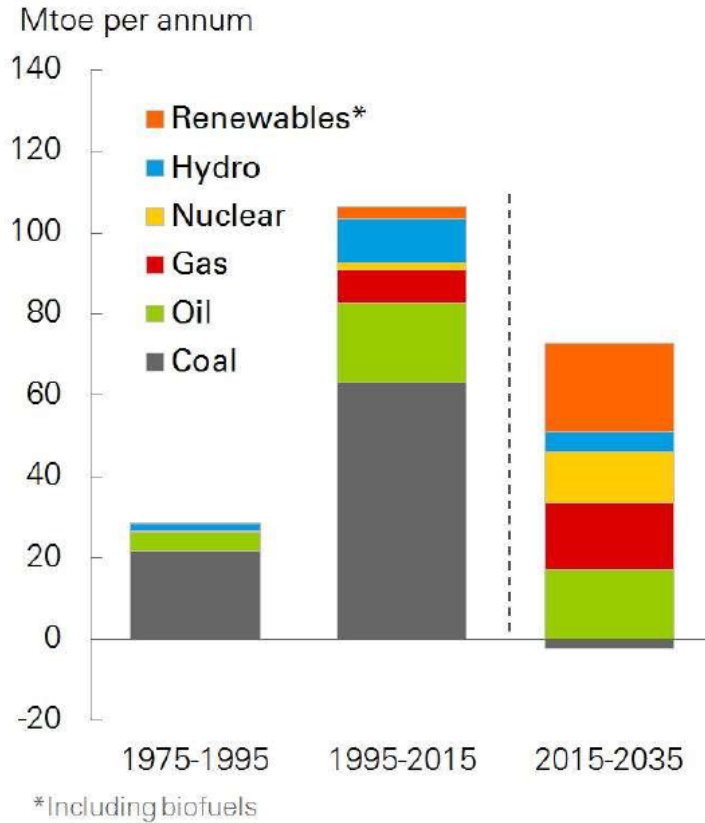
BP Statistical Review of World Energy

- A key question is whether transition to a greener energy economy can continue at the rapid initial pace
- History would suggest a slowing in the growth of renewable energy, but the rapid growth of other technologies creates an alternative argument
- Energy companies are currently operating in a world of high uncertainty

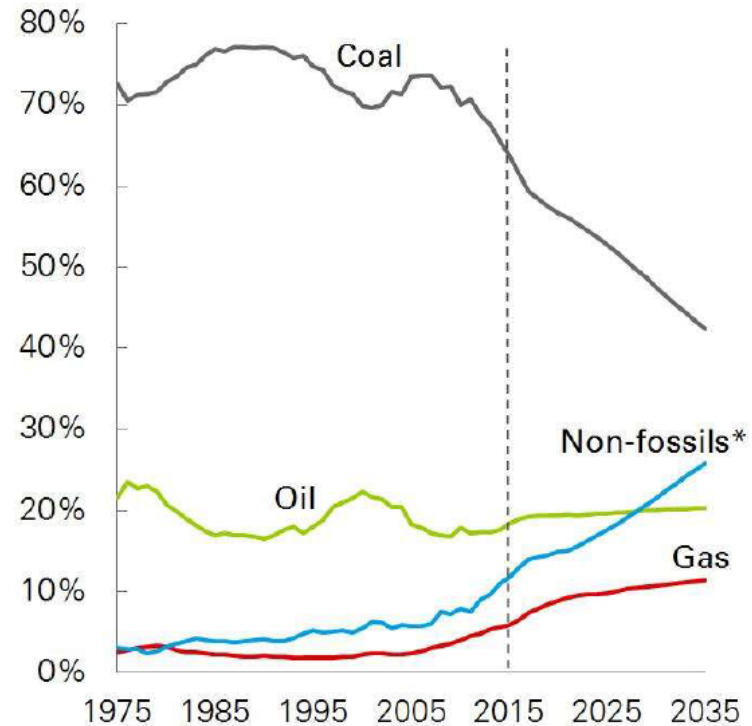


# The future of Chinese energy demand is key

## Primary energy demand growth by fuel



## Shares of primary energy



- Chinese attitudes to energy can shape to world energy landscape
- The speed of shift to non-fossil fuels will be crucial, as will the attitude to energy import security



# Capital Spending in the Energy Sector

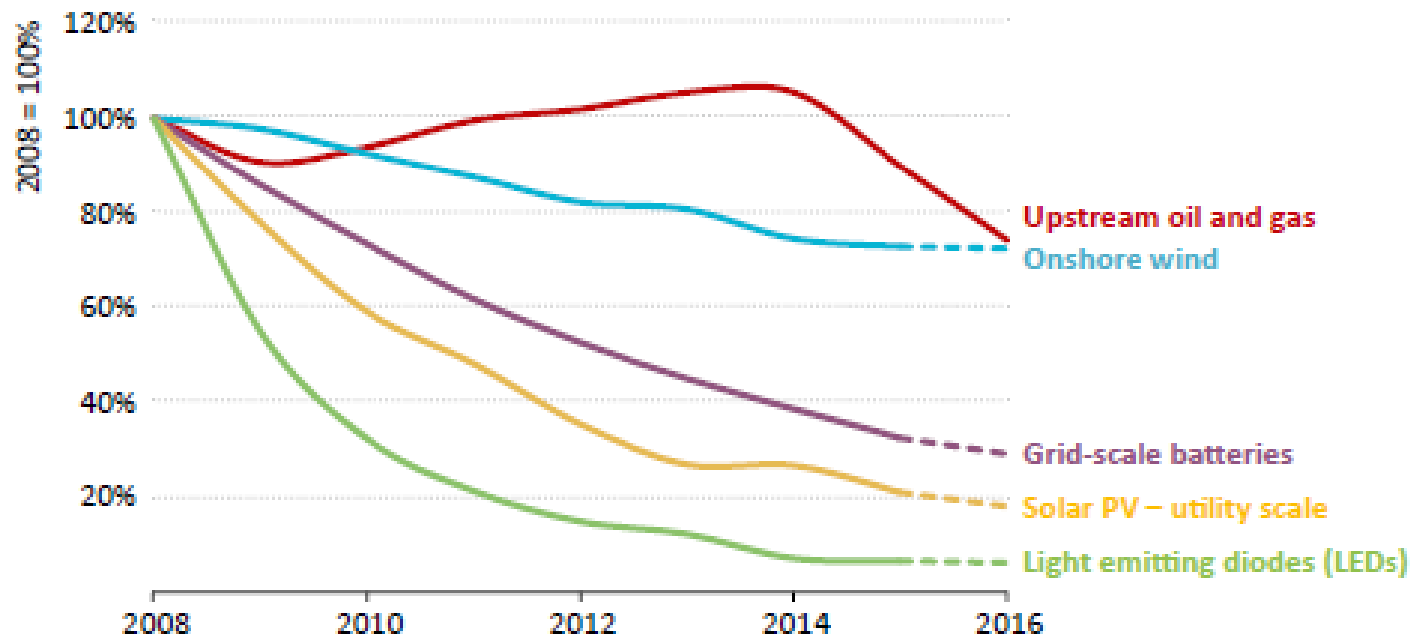
	2010-15*	New Policies		Current Policies		450 Scenario	
	Per year	Cumulative	Per year	Cumulative	Per year	Cumulative	Per year
Fossil fuels	1 112	26 626	1 065	32 849	1 314	17 263	691
Renewables	283	7 478	299	6 130	245	12 582	503
Electricity networks	229	8 059	322	8 860	354	7 204	288
Other low-carbon**	13	1 446	58	1 259	50	2 842	114
<b>Total supply</b>	<b>1 637</b>	<b>43 609</b>	<b>1 744</b>	<b>49 098</b>	<b>1 964</b>	<b>39 891</b>	<b>1 596</b>
Energy efficiency	221	22 980	919	15 437	617	35 042	1 402

\* The methodology for energy efficiency investment derives from a baseline of efficiency levels in different end-use sectors in 2014, the annual figure for energy efficiency in this column is the figure only for 2015. \*\* Includes nuclear and CCS.

- Uncertainty creates a reluctance to invest, but huge amounts of capital will be required to provide energy for a growing population
- Two interesting questions emerge:
  - Will sufficient capital be found to maintain growth in renewables, especially if subsidies start to be removed?
  - Will there be sufficient incentive to invest in the hydrocarbons that will still be needed, if competition drives prices down?
- How much should be left to markets and how might governments intervene?



# Cost trends are positive, supporting commercial returns



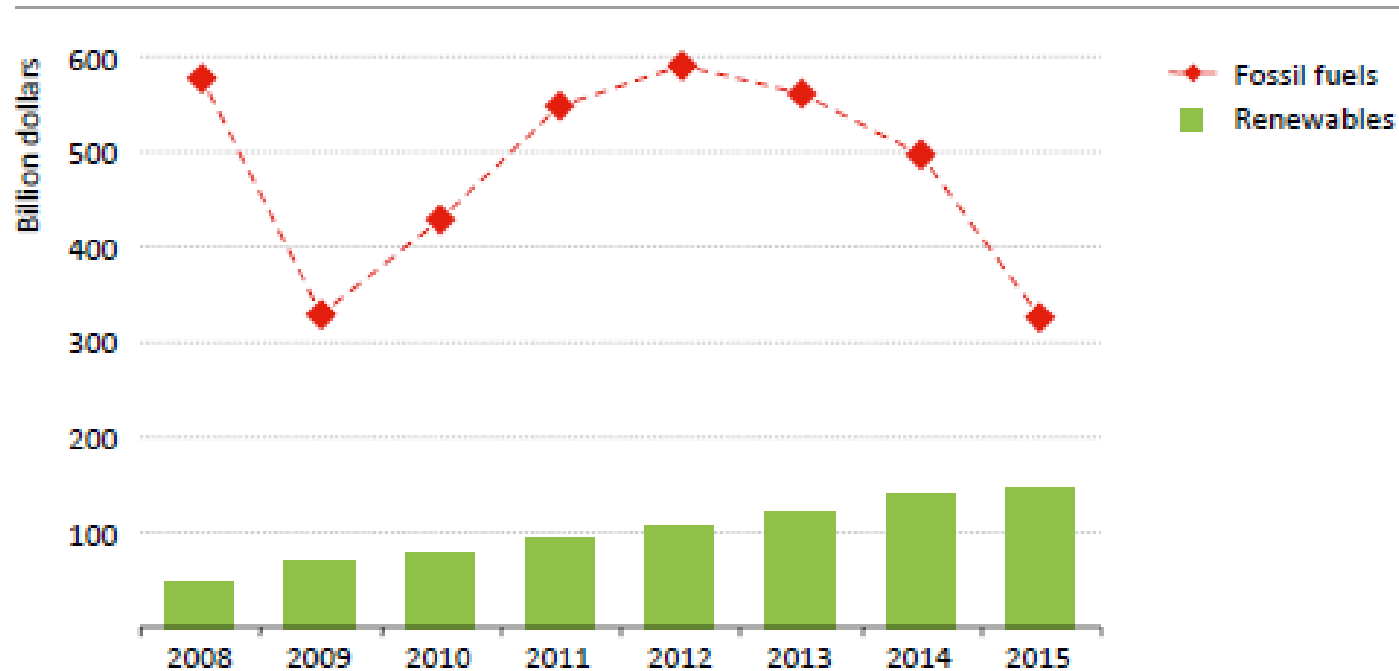
Cost deflation has affected diverse technologies across the energy spectrum

Source: IEA World Energy Investment 2016 (IEA, 2016c).

- Lower oil prices have driven oil and gas costs down
- Innovation and new technologies are reducing renewable costs lower, and battery costs have also fallen fast
- Can these trends be sustained and will full competition in an open market between energy sources ever be the preferred outcome?



# Governments have subsidised all forms of energy



*The drop in fossil-fuel prices and in the value of subsidies has raised prospects for reform; the fall in technology costs has boosted the effectiveness of subsidies for renewables*

- Hydrocarbons have been priced at very low levels in many producing countries, and in developing countries with high levels of poverty
- Renewables have been subsidised via government support, often funded by energy levies
- What government support may/should be required in future?





# 10 key questions for the Global Energy Economy

1. Has the world broken the link between GDP growth, energy demand and CO2 emissions?
2. Which fuels and technologies are posed to do well in a post COP21 world?
3. Are there limits to the growth of renewable energy?
4. What is needed to meet the 2 degree temperature target?
5. What can the energy sector do to reduce air pollution?
6. Is energy investment capital heading where it is needed?
7. How might the main energy security risks evolve?
8. Are we on a path to universal access to energy?
9. Are global energy subsidies shifting from fossil fuels to renewables?
10. How will commercial, political and policy priorities be balanced as the world energy economy develops?

