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The Impact of New Energy

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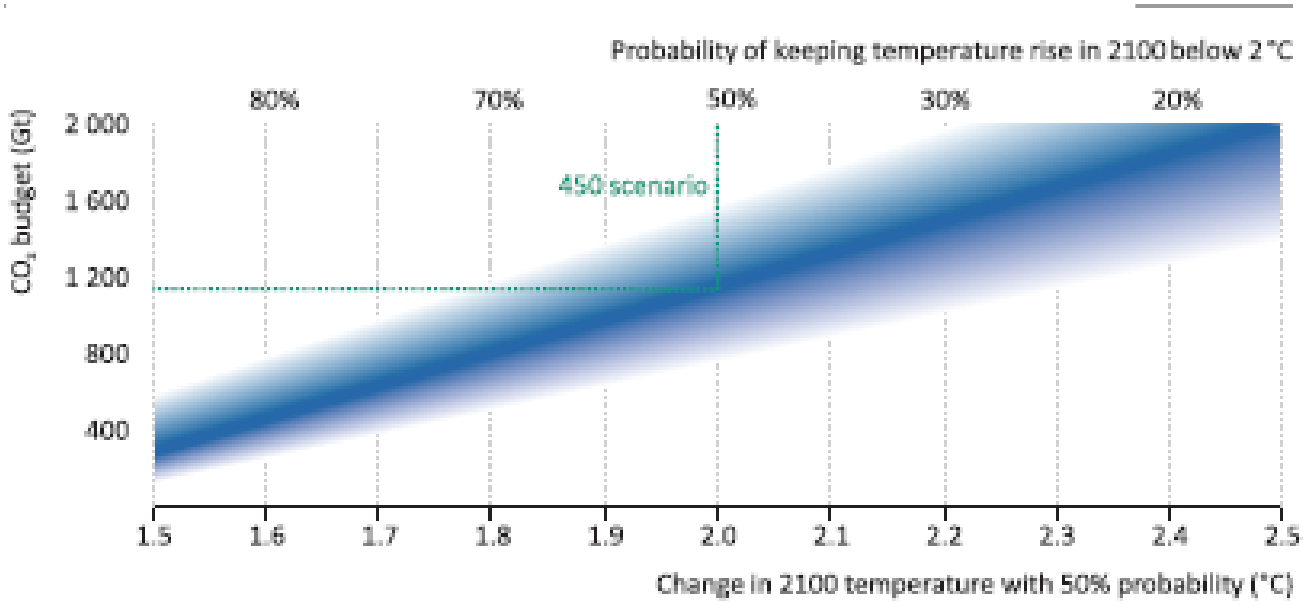
November 2018

Temperature targets and the Carbon Budget

Probability of temperature change versus carbon budget



Remaining CO_2 budgets are very sensitive to small changes in target temperature thresholds and probabilities

Note: Shaded area represents the band of uncertainty relating CO_2 budgets to the temperature rise in 2100.

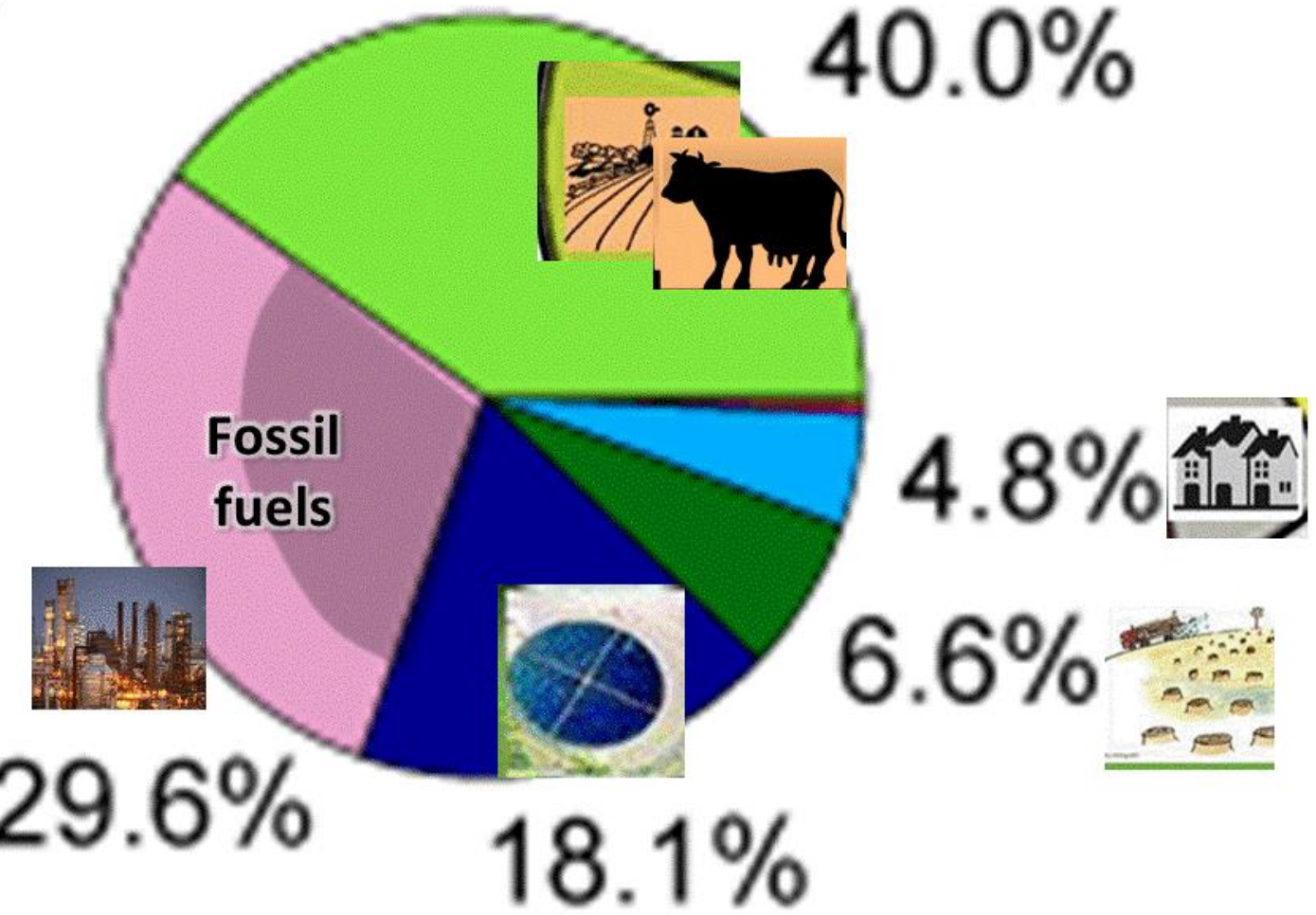
Sources: IPCC (2014); IEA analysis using MAGICC.

- Generally assumed that the 2 degree target will only be met by restricting the overall carbon budget to 1000Gt
- However, the range of estimates is quite wide, adding to uncertainty and possible lack of commitment

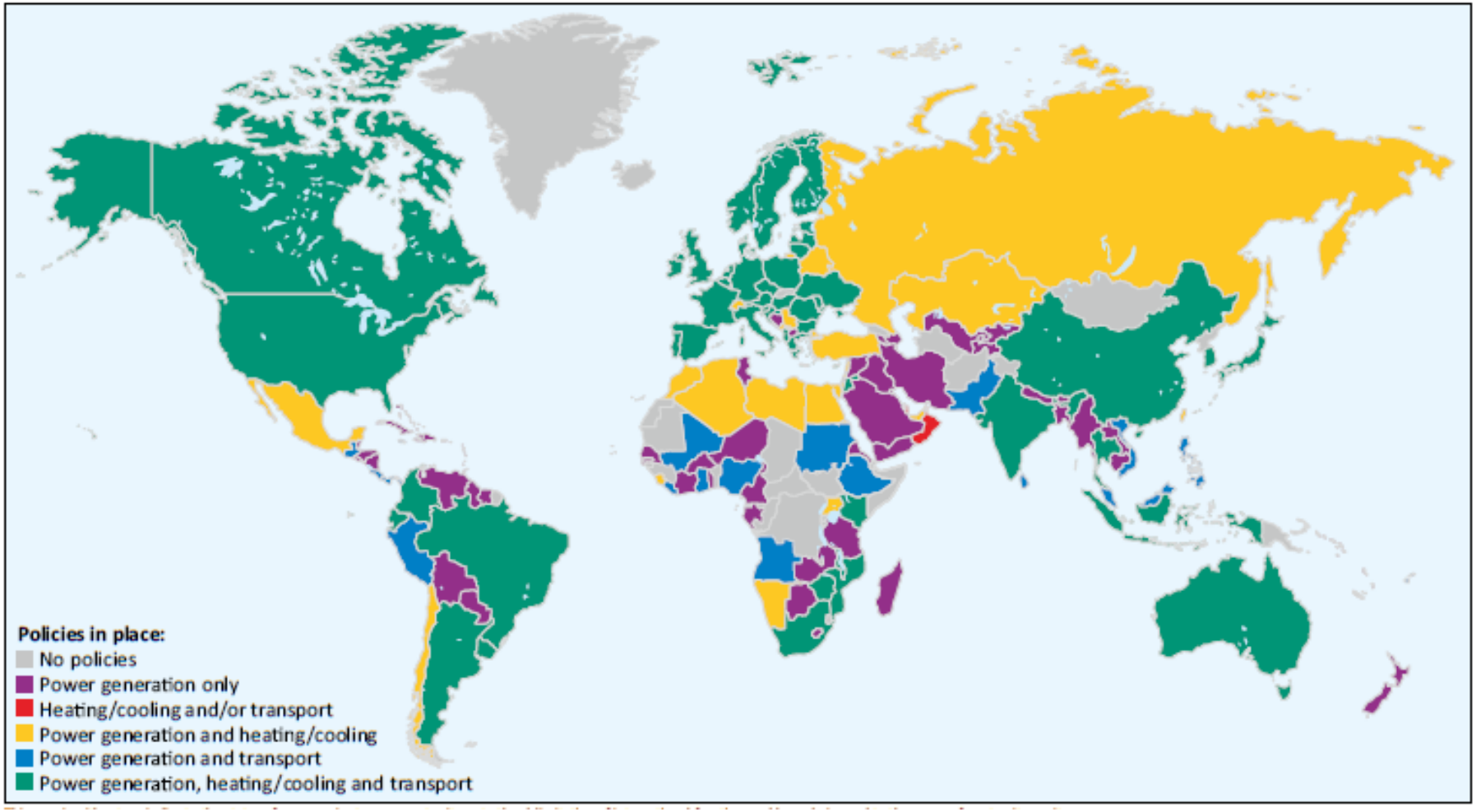
Methane Emissions – The Main Causes

Global methane emissions 18% of total

IPCC 2007

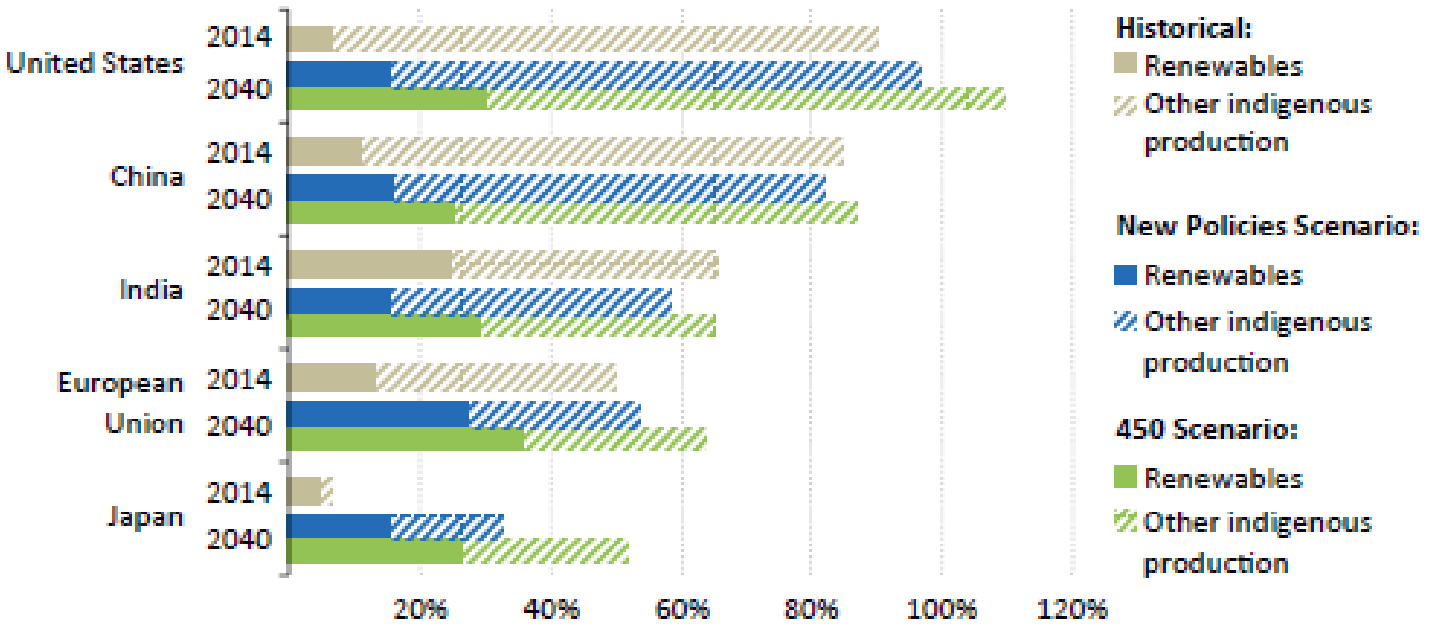


Global policy coverage



- Global policy cover on environmental regulation is extensive, but implementation is the key issue
- COP21 provided no binding targets – companies are struggling to plan in an uncertain environment

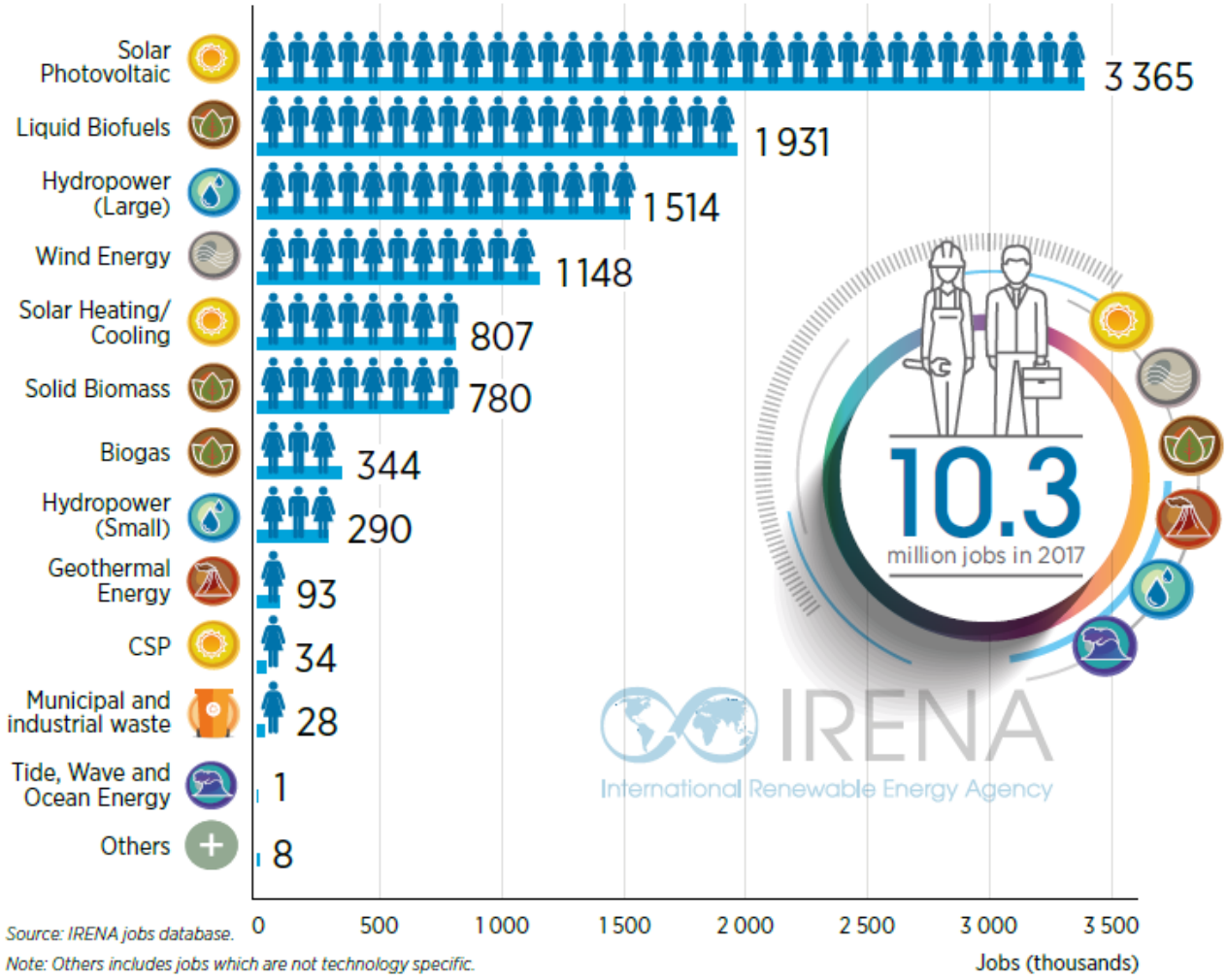
Security of Supply argument for Renewables



The increased deployment of renewables in the 450 Scenario helps to reduce relative reliance on energy imports in many regions

- Many countries are keen to reduce reliance on imports of fossil fuels
- Renewables can provide a growing source of indigenous energy
- They bring their own security of supply risk (intermittency) and arguably make the long-term supply of other fuels more risky

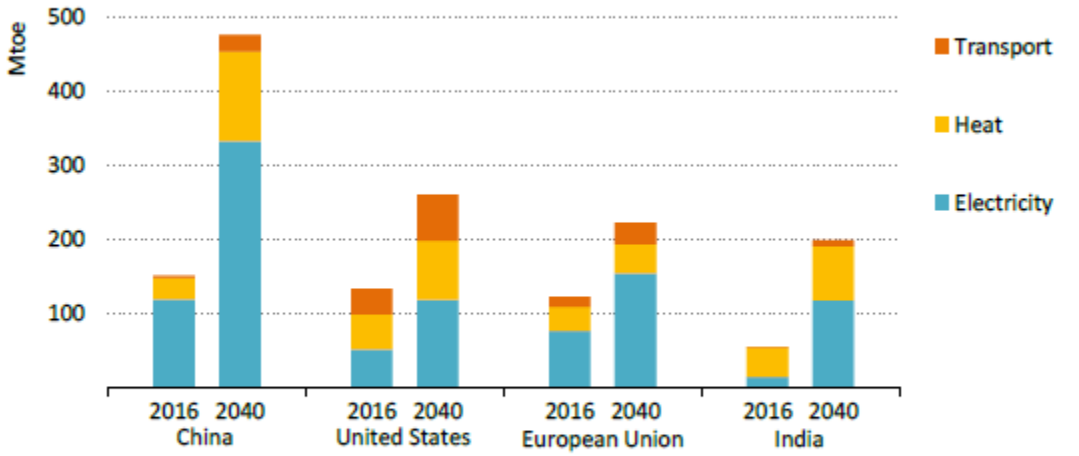
Domestic economies can benefit from jobs in a new sector



- Number of jobs in renewable energy is rising rapidly – 6.5 million in 2013, 7.7 million in 2014 and over 10 million in 2017
- Meanwhile employment in oil and gas fell by 18%

Decarbonisation trends are key to energy economy outlook

Figure 7.8 ▷ Renewable energy use by sector from a consumer perspective and by region in the New Policies Scenario

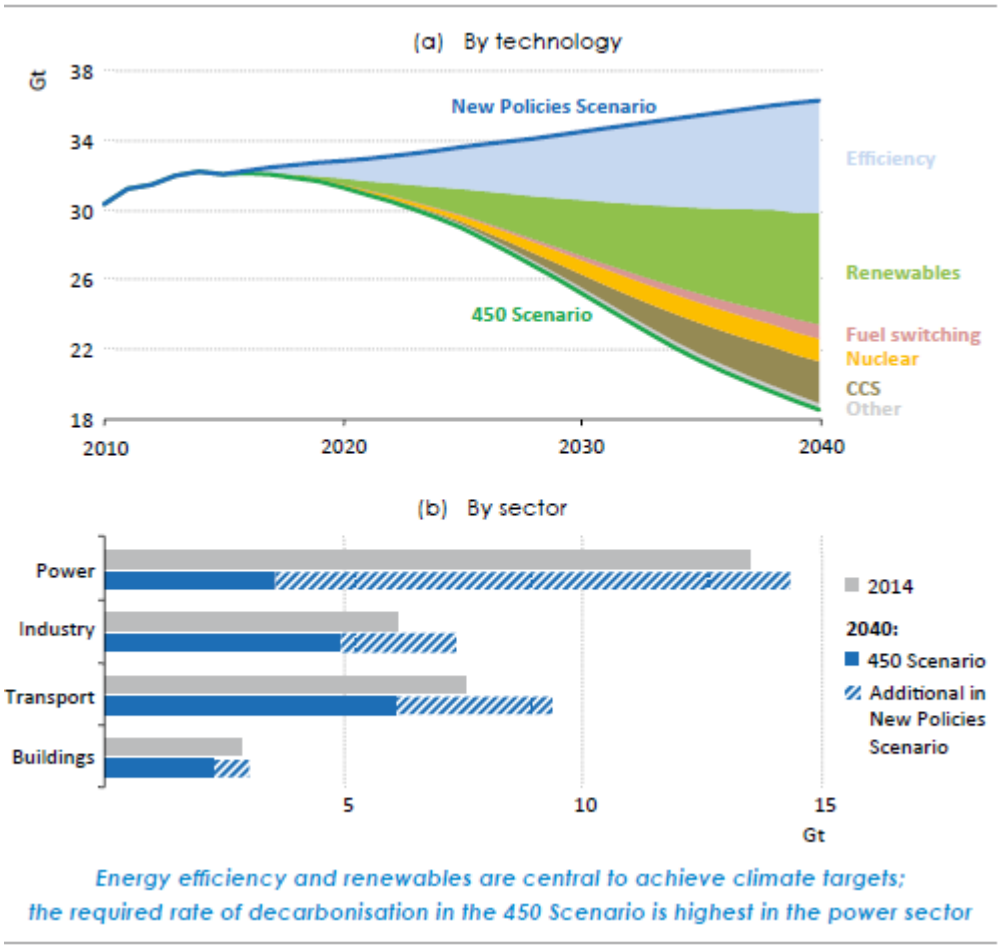


Renewables-based electricity leads the expansion in renewable energy use

Note: All sectors are considered from a consumer perspective, i.e. electricity shown represents the share of electricity demand provided by renewables, including electricity used for transport and heat.

- The global strategy for decarbonisation is the most important factor in the future of the energy economy
- Changes in the power sector, transport and final energy demand will shape the future of energy companies for decades
- The rise of renewable energy, and the increase in non-fossil fuel demand by end-consumers, will force energy companies to adopt new strategies and corporate structures

Global CO2 emissions reductions to reach 450 scenario

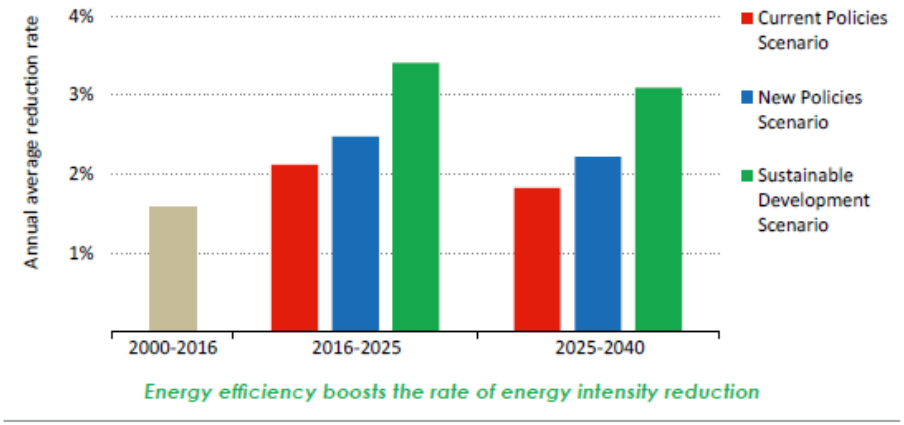


Energy efficiency and renewables are central to achieve climate targets; the required rate of decarbonisation in the 450 Scenario is highest in the power sector

- Energy efficiency will be a vital component in reaching temperature goals, essentially reducing energy demand
- The growth in renewables will be equally important, with other technologies making minor contributions

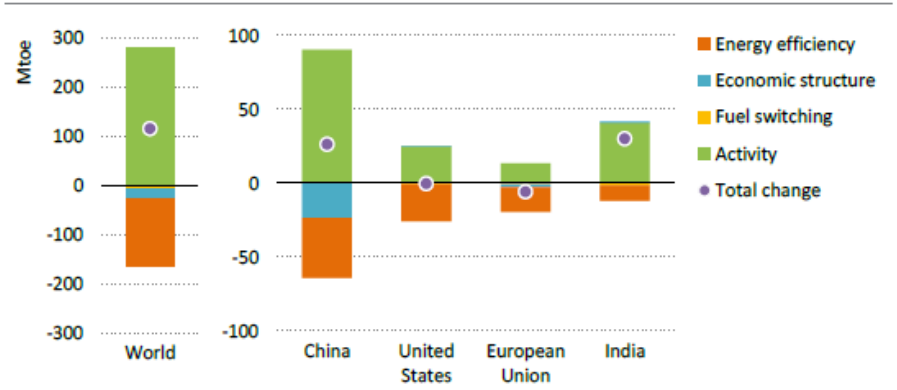
Share of global energy consumption covered by energy efficiency regulation

Figure 7.2 ▷ **Global energy intensity reduction by scenario**



Energy efficiency boosts the rate of energy intensity reduction

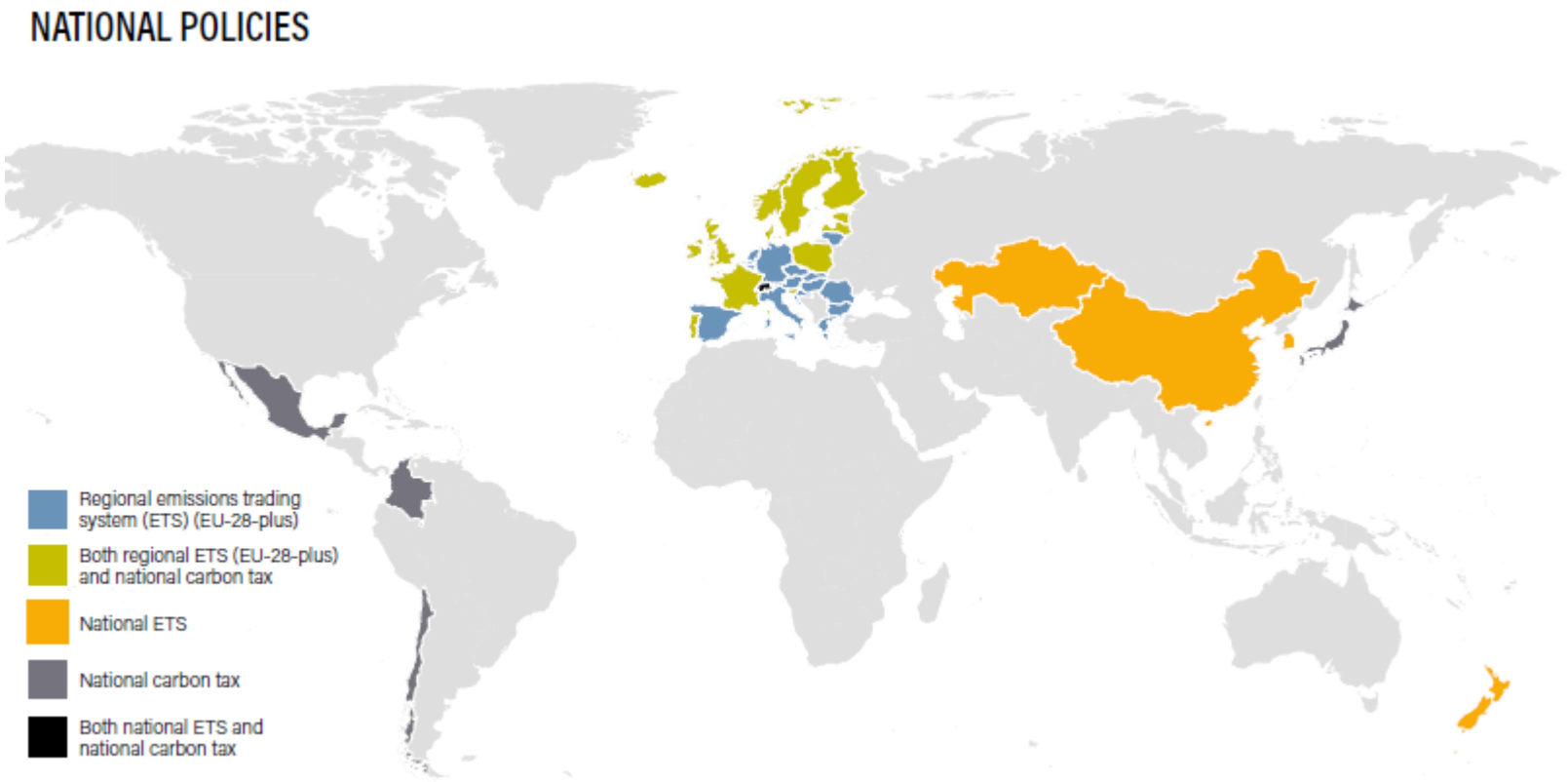
Figure 7.3 ▷ **Average annual change in final energy consumption in selected regions in the New Policies Scenario, 2016-2040**



Energy efficiency halts demand growth in advanced economies

- Global energy intensity improved by 2% in 2016, twice the average of the past decade, but then declined in 2017
- Mandatory efficiency regulation now covers 30% of global final energy use, across all end-use sectors
- Increasing energy efficiency must play a key role in reducing climate change, potentially halving demand growth by 2040
- Energy taxes (especially a CO2 tax) can help with this, but many countries have been reluctant to impose a levy

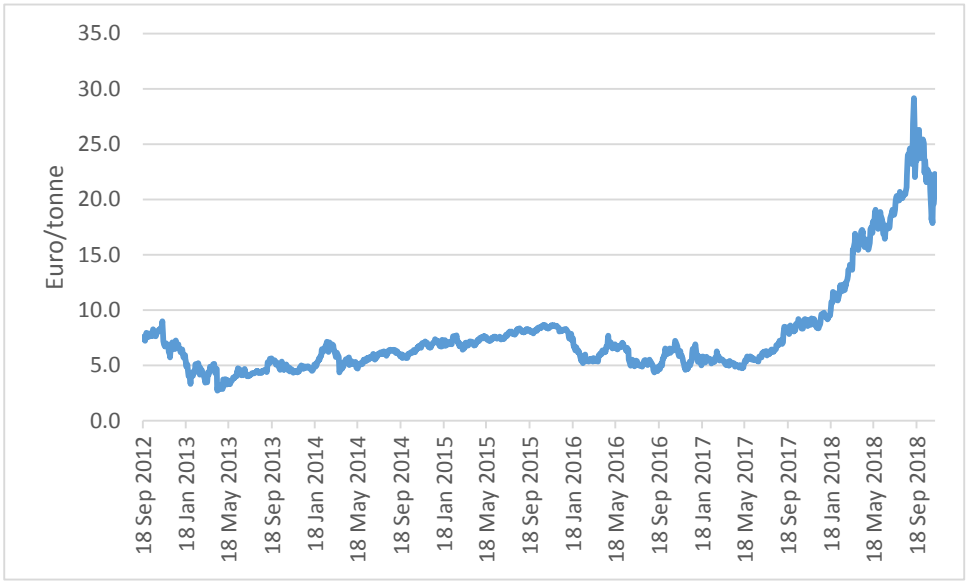
Carbon Tax Policies



- Carbon taxes are not widespread across the globe
- Countries are concerned about the impact on economic competitiveness
- Australia introduced a carbon tax and then removed it when a new government was elected

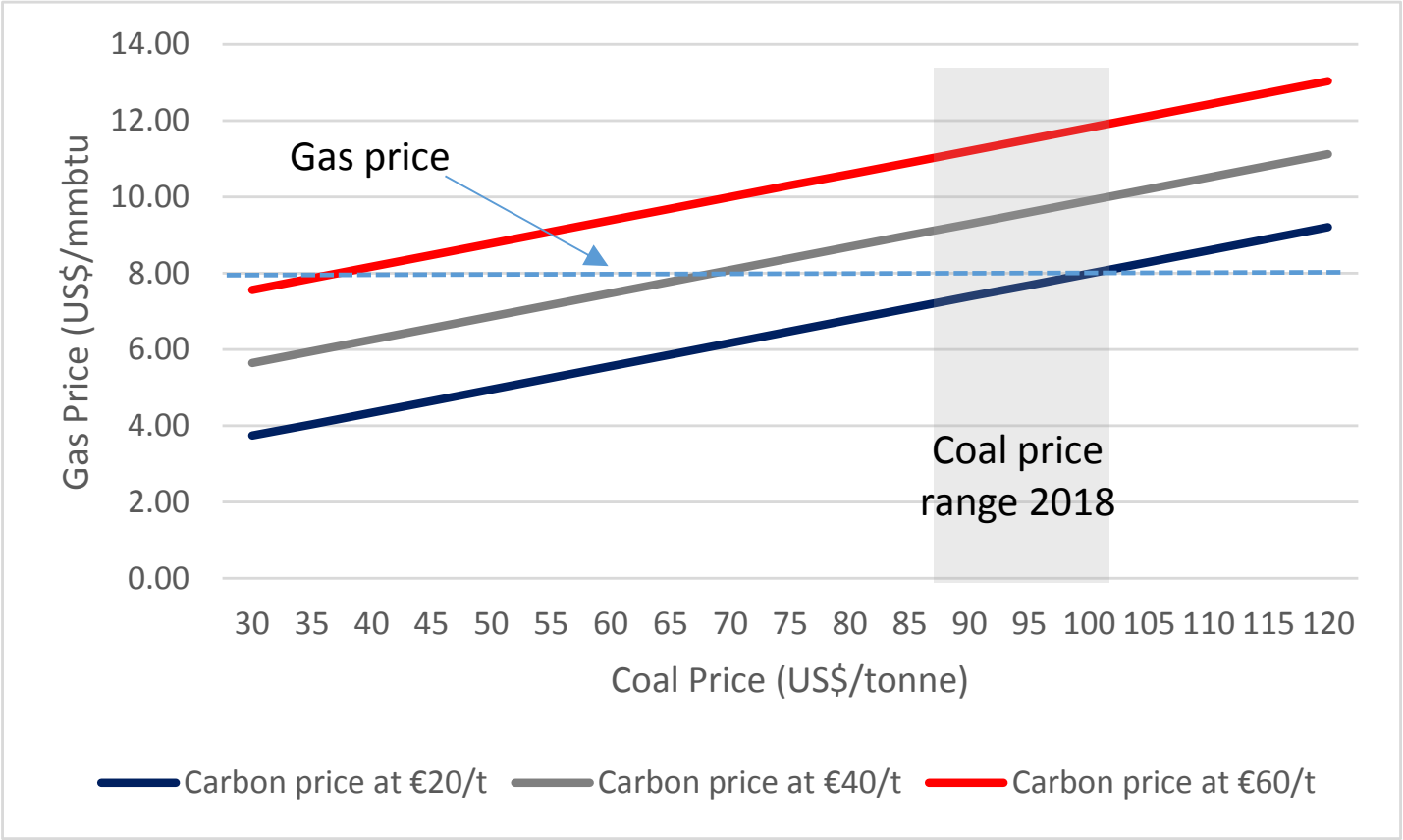
European carbon price has recovered dramatically

Europe Carbon Price (2012-2018)



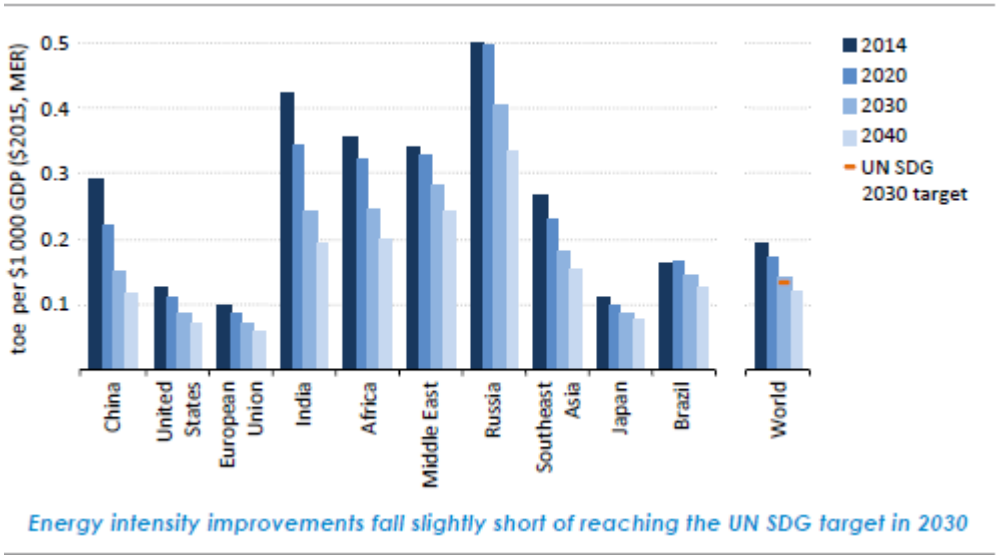
- European allowances for carbon were introduced in a traded market (the ETS) in 2006
- Unfortunately, the economic crisis in 2008 led to an oversupply and the price collapsed
- Adjustments are set to be made in the 2020s, and in advance the price has recovered significantly, helping coal to gas switching

Switching occurs when the cost of gas-fired generation is below the cost of coal-fired, adjusted for carbon



- Gas and coal fired power plants have different efficiencies and carbon emissions
- A carbon tax can therefore boost the commercial incentive to burn gas, as it emits less carbon and therefore pays less tax
- The UK government has introduced a carbon-floor price, which essentially mandates a “top-up” payment above the EU ETS

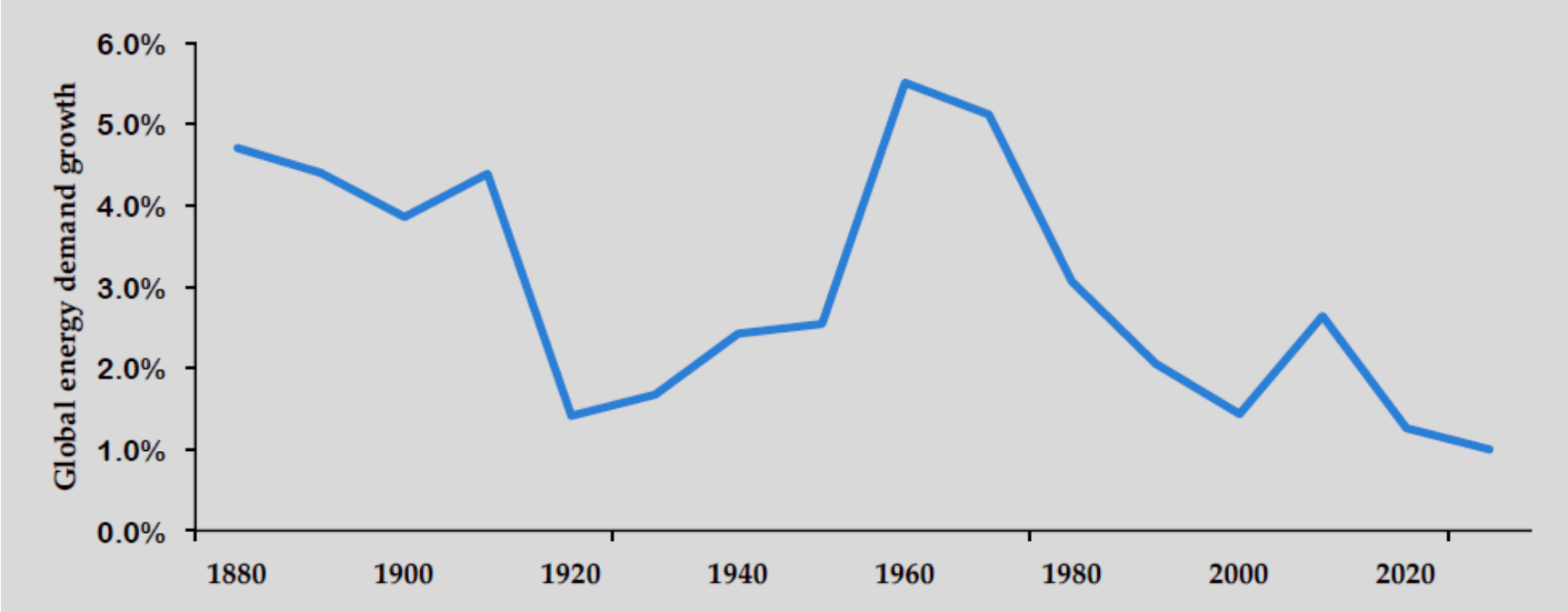
Continuous improvement expected



Energy intensity improvements fall slightly short of reaching the UN SDG target in 2030

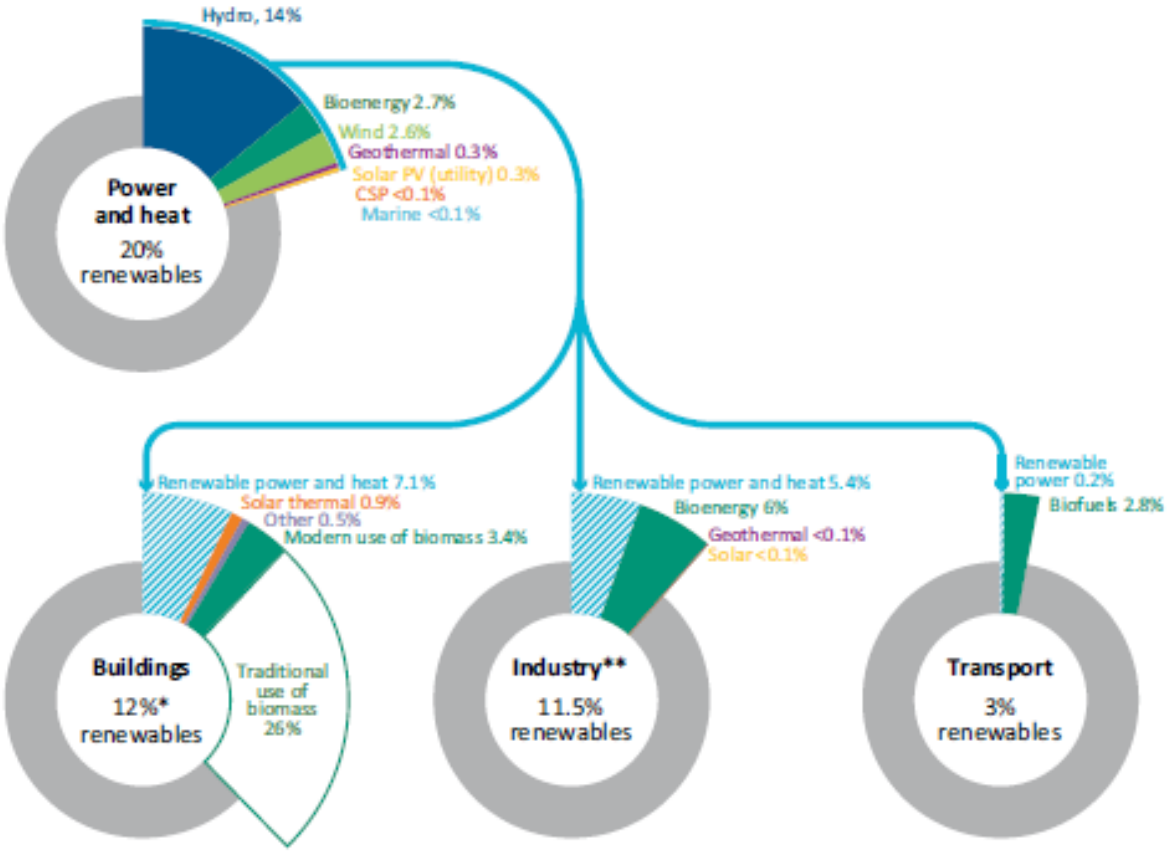
- The IEA expects energy efficiency to increase by 1% p.a. in its base case scenario, helped by a global move away from heavy industry
- Electric motor use is set to rise dramatically, and efficiency regulation is expanding in this area, covering 90% of new motors
- $300 billion is expected to be spent on efficiency in this area to 2040, although this would be offset by a $450bn saving in new power generation requirements
- Most efficiency gains will be made in non-OECD countries as their energy economies mature (China could improve by 3.5% p.a.)

Global Energy Demand Growth To Slow



- Overall conclusion is that global energy demand growth with slow
- In a world where GDP growth averages 3-3.5% p.a. energy demand growth is likely to be closer to 1%
- The key question is how much of this growth will be accounted for by renewables?

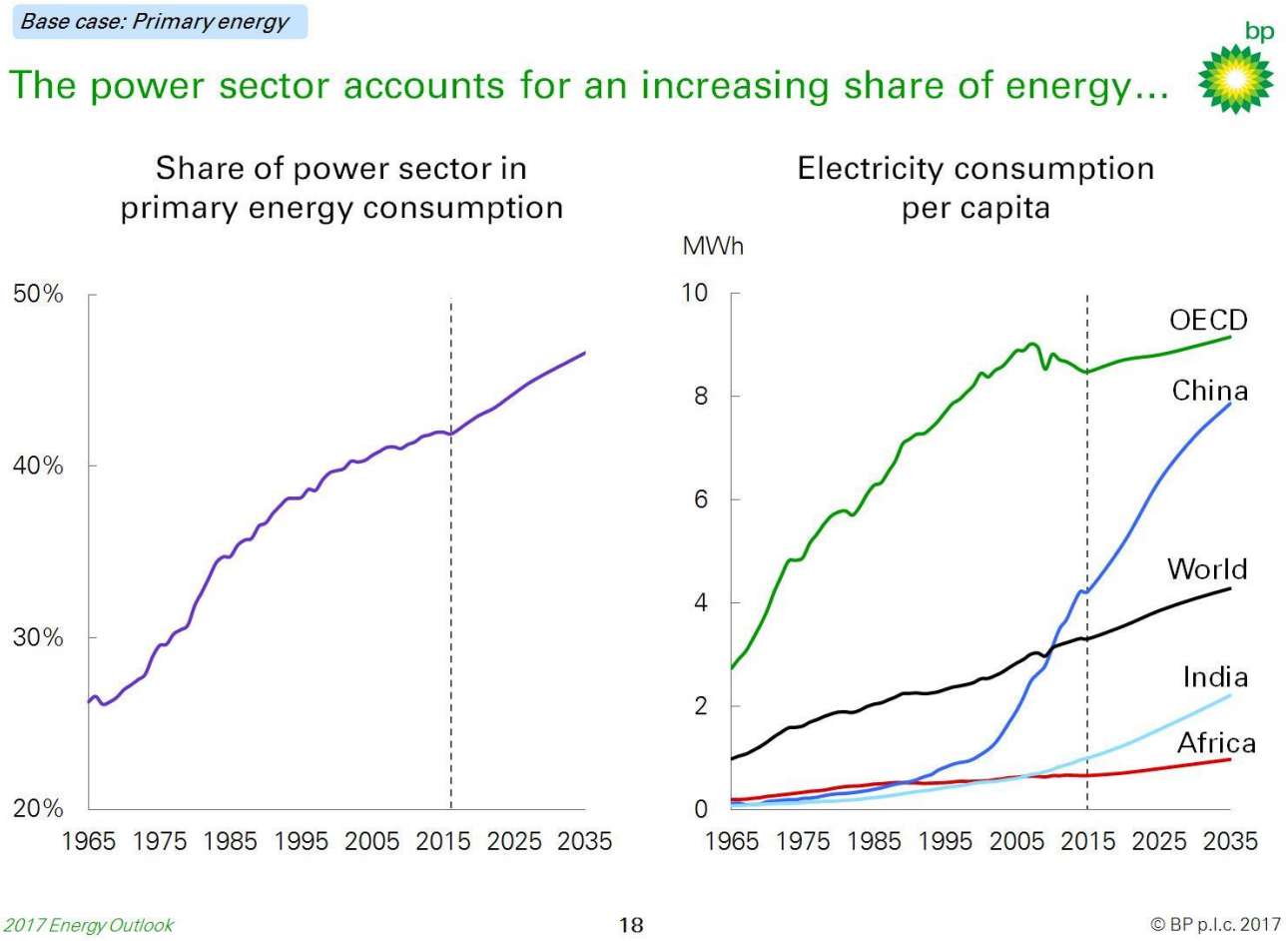
Power sector leading the way with renewables



Power is leading the transition to renewable energy; other sectors lag behind

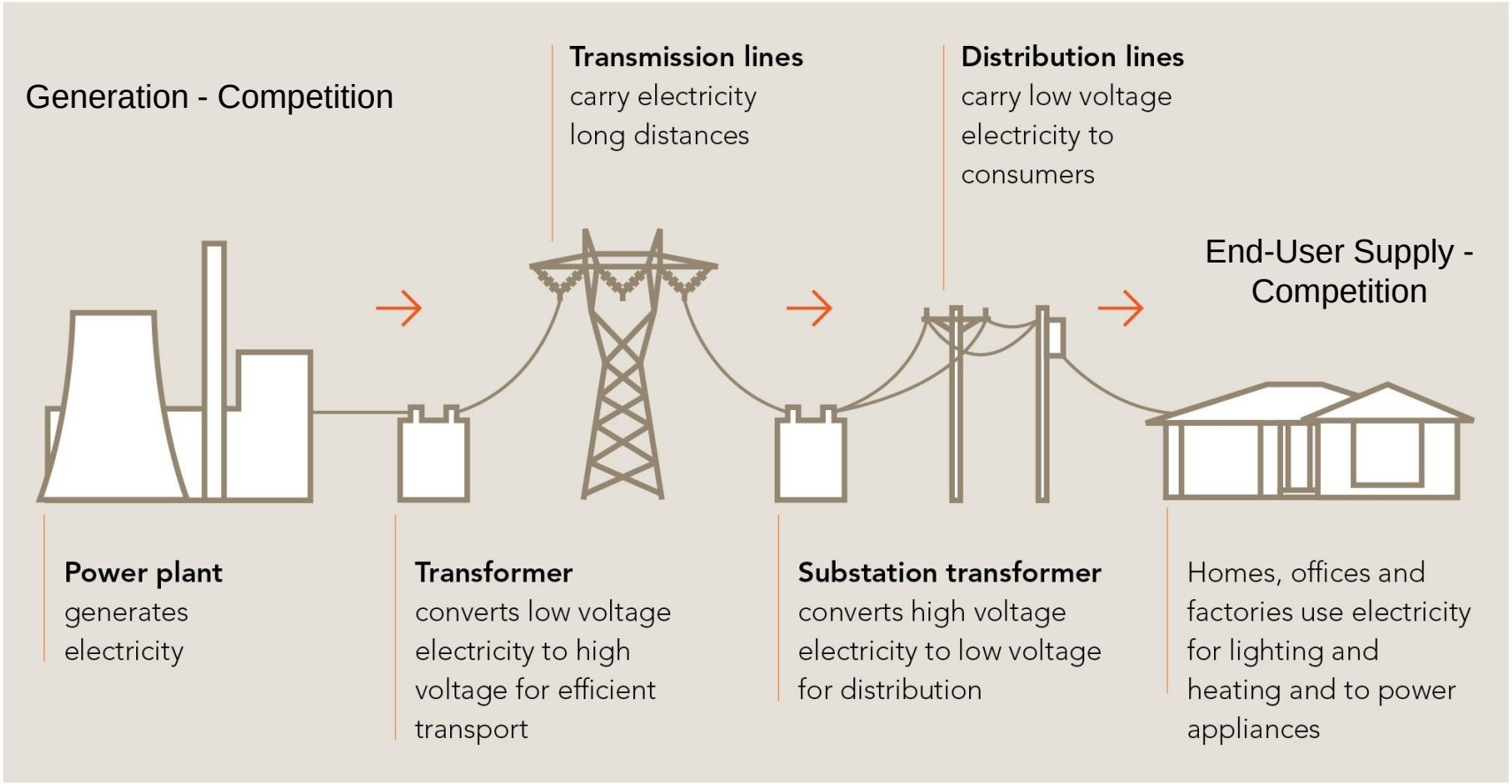
- Power generation is currently the most advanced in terms of introduction of renewables
- The heat sector in buildings will become vital post 2030, while industrial decarbonisation will also be key to meeting climate goals

Electricity consumption is set to rise



- Electricity demand is likely to rise as part of a decarbonisation strategy
- As a result, the focus of the energy economy will be on how power stations are fuelled, with the assumption that renewables will grow
- Key question for fossil fuels – how fast will the decline be?

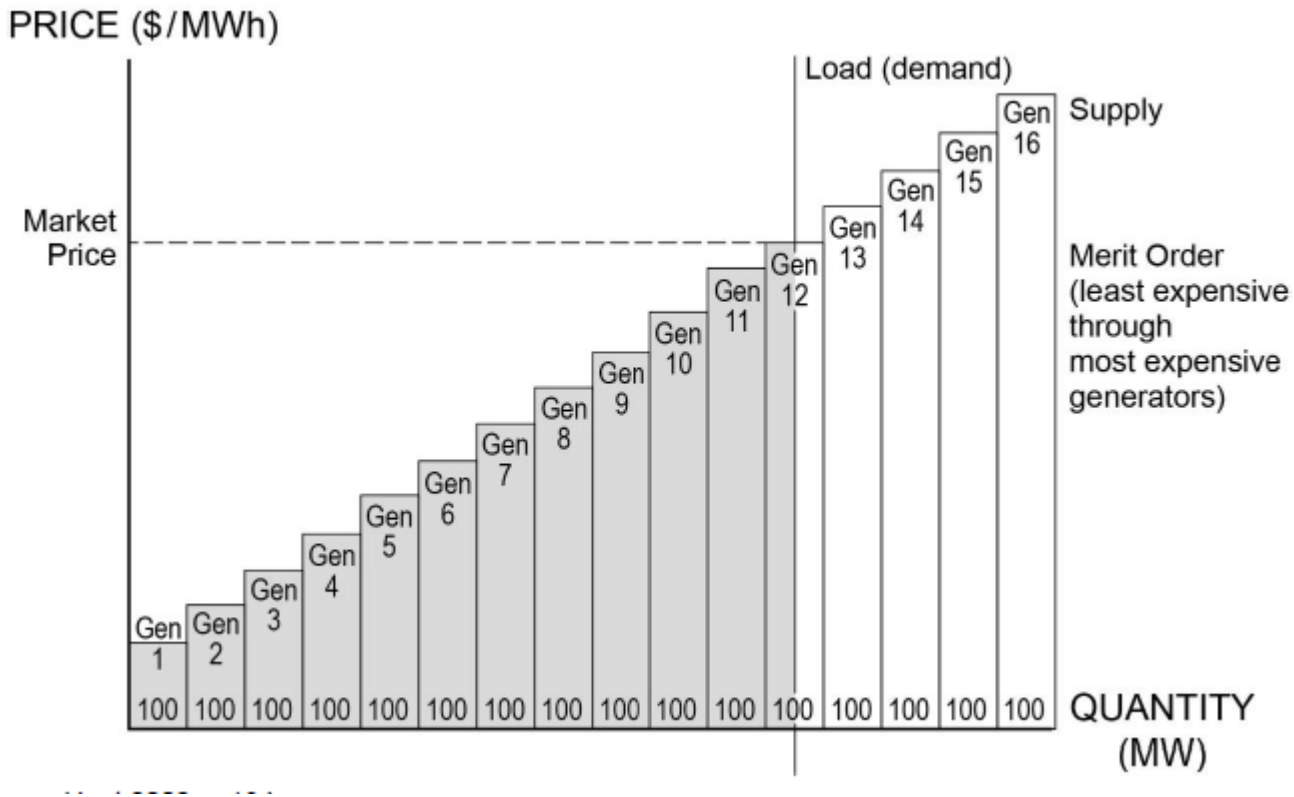
The Electricity Sector Value Chain



Transmission and Distribution – Regulated

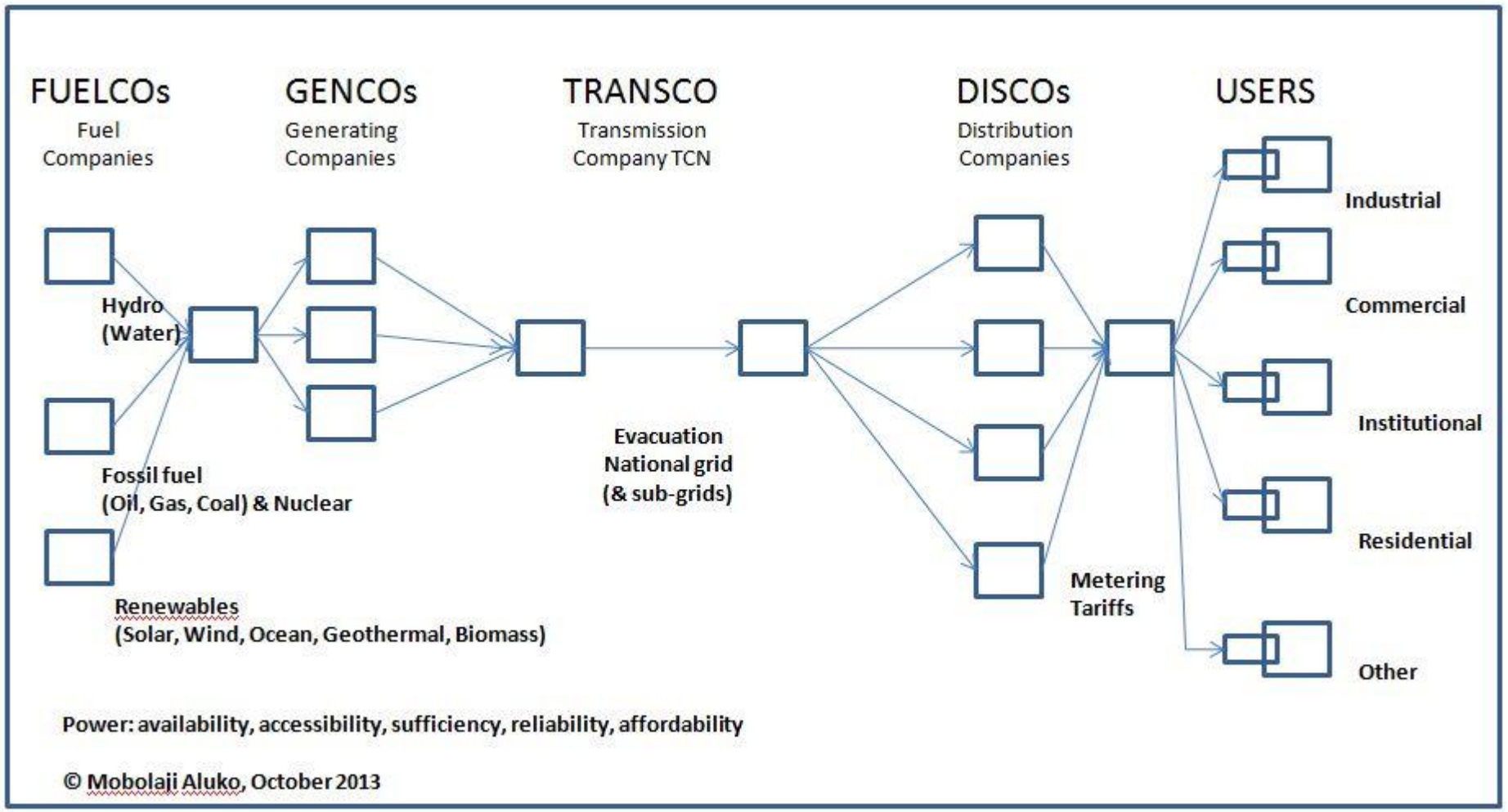
- Electricity sector is a mixture of regulated and unregulated segments
- As renewable energy is introduced, and as demand patterns change, the complexity for energy companies in all parts of the chain increases

Stylised merit order for power generation



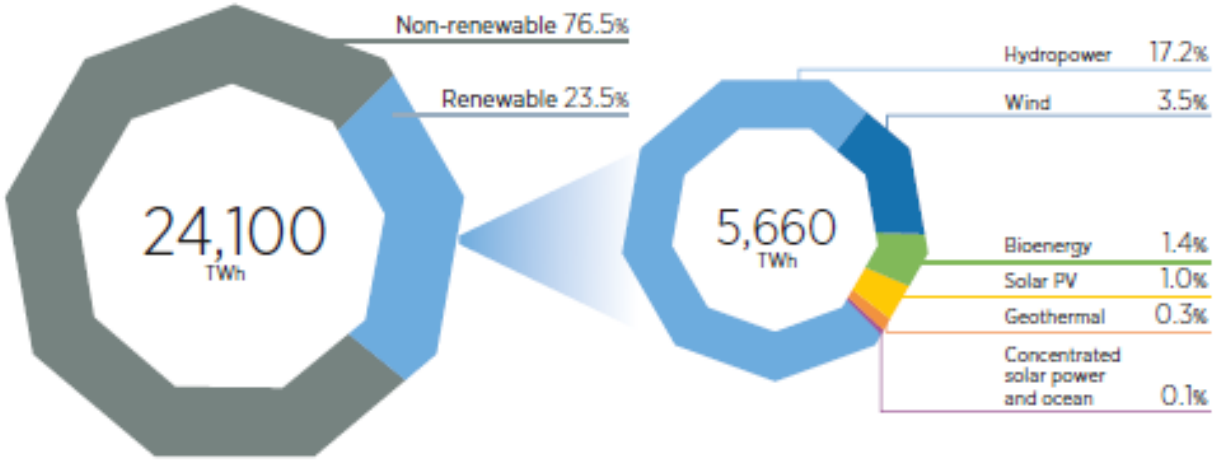
- Historically generating companies have competed on the basis of a merit order of generating costs
- The market price is set at the marginal price, which is paid to all power producers who are called upon to dispatch electricity

The key players across the power generation sector



- Implications of renewable intermittency, decentralisation of power and grid integration felt across the value chain
- Fossil fuel providers of fuel input face a much more volatile and uncertain future

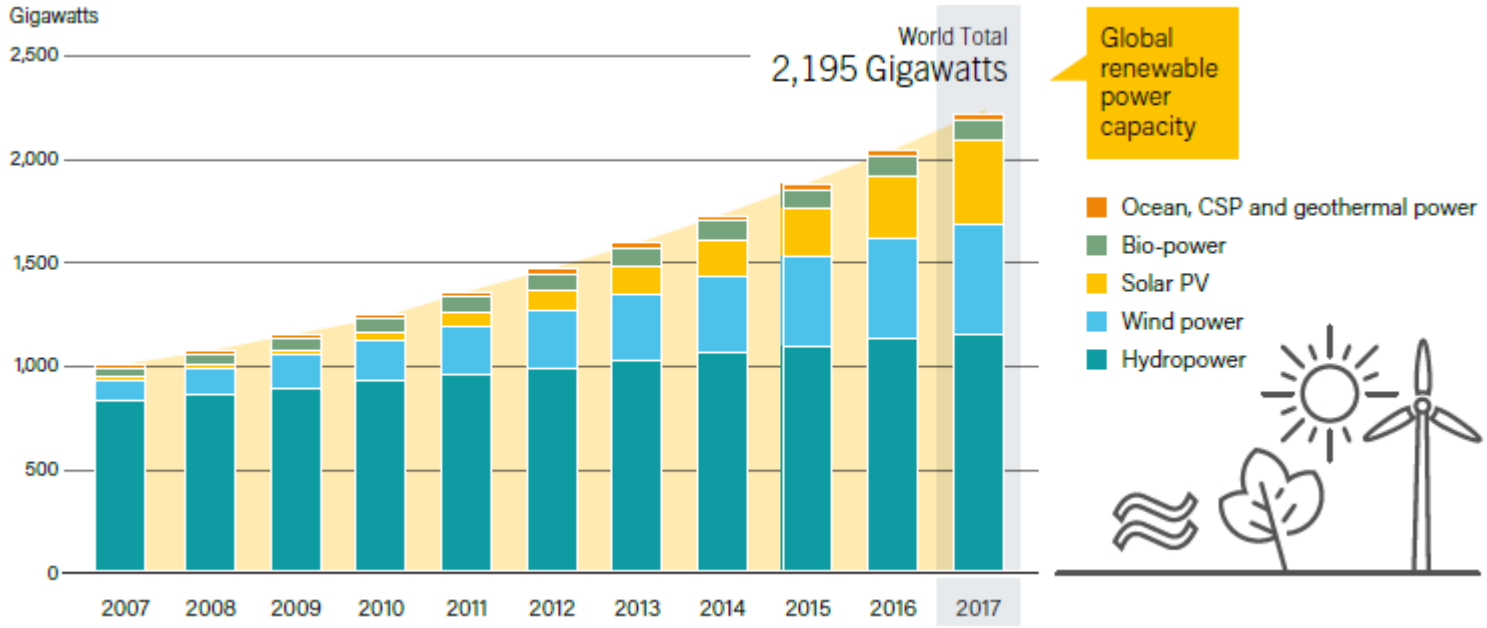
Global electricity generation by source



Source: IRENA, 2016a and 2016b

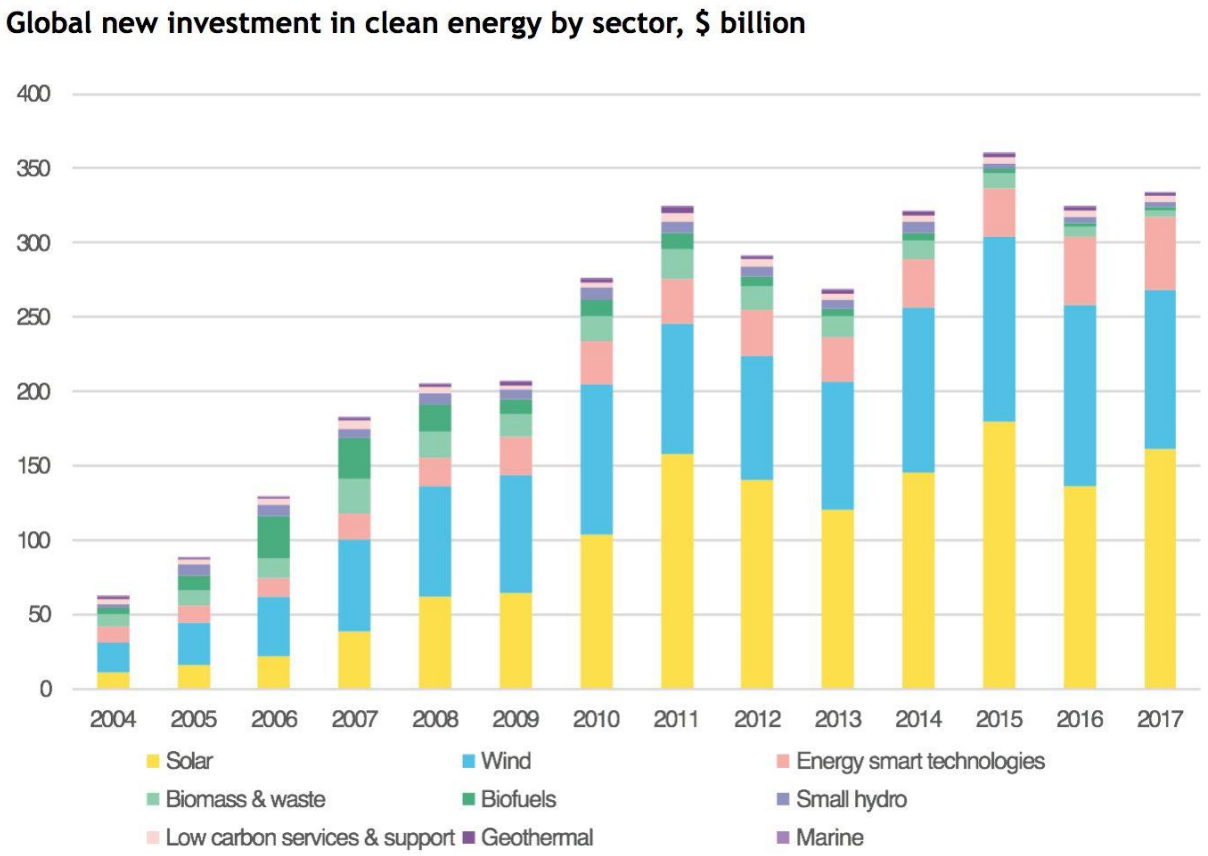
- Renewable energy currently accounts for 23.5% of global electricity output
- However, most of this is accounted for by hydro, which tends to be a very controllable source of electricity
- Wind power is the largest source of new renewables
- There is no doubt that the future must contain more renewable energy, and that it will change the structure of the global energy economy

Renewable power capacity and annual growth rate, 2007-2017



- Growth in renewable energy accelerated in 2017, to 9%, adding 175GW of capacity
- Majority of additions in wind, solar PV and hydro, with the former two now growing faster than the latter in absolute terms
- Since 2007 renewable capacity has more than doubled
- By the end of 2015, renewable capacity reached 2,195GW – enough to supply more than one quarter of the world's electricity needs

Investment in renewables is growing, especially in Non-OECD



Source: Bloomberg New Energy Finance. Note: Clean energy covers renewable energy excluding large hydro, plus energy smart technologies such as efficiency, demand response, storage and electric vehicles.

- Share of investment in Non-OECD has exceeded 50% of total from 2015
- China accounted for 36%, as it expands it production capability
- Will there be a step change in energy output in Non-OECD that by-passes fossil fuel transition?

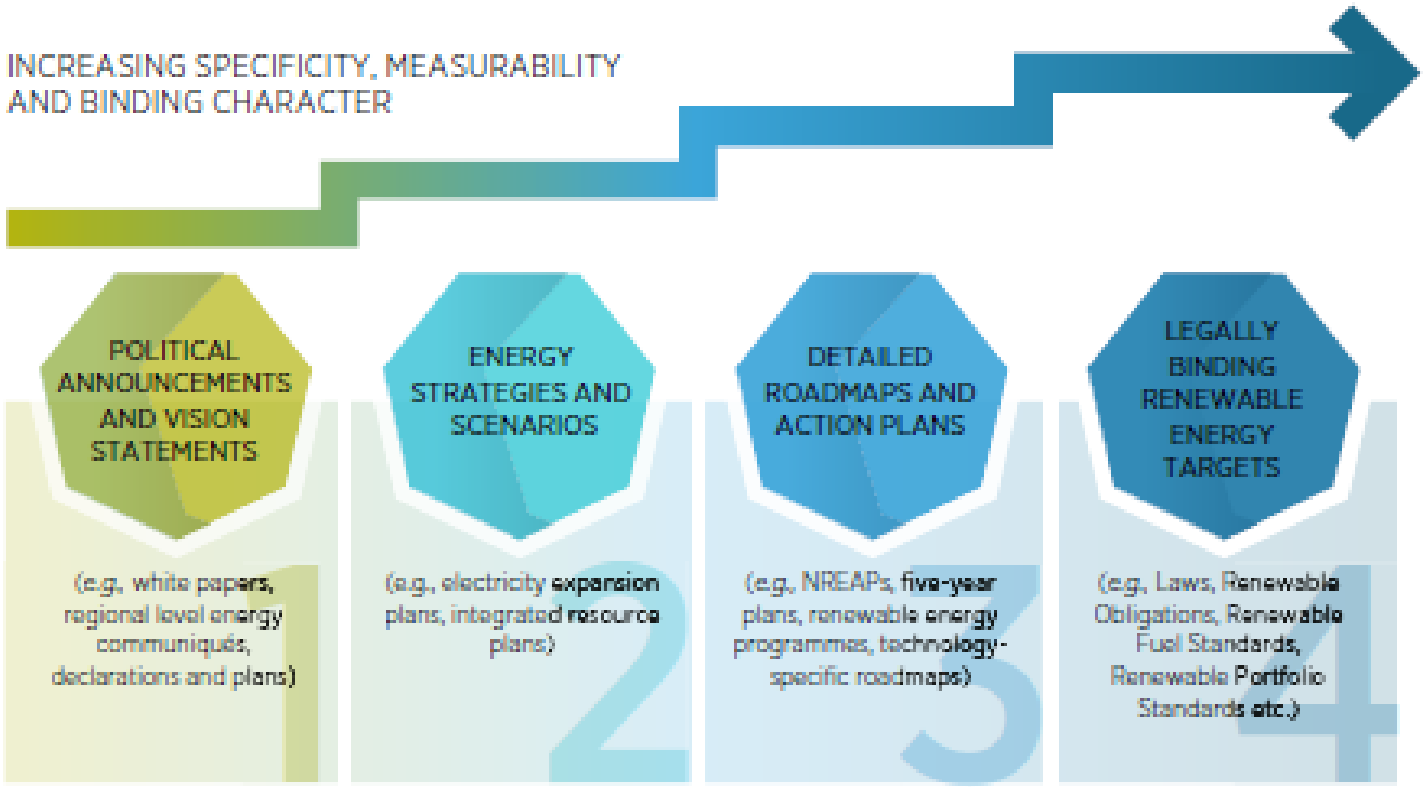
Shift in the Power Sector Business Model

OLD PARADIGM	NEW PARADIGM
Baseload	Variable renewable energy
Centralised grids	Decentralised smart grids
Spinning reserve	Flexibility
Network planning	Big data
Energy-only markets	Energy and capacity markets
Must-run	Curtailment
Rising electricity costs	Falling electricity costs
Energy security	Domestic resources and interconnectors
Air pollution	NIMBY and environmental trade-offs

Source: IRENA

- Electricity sector participants are facing a major shift in their business model
- Previous status quo is being challenged and companies are having to adjust dramatically – e.g. E.ON and Uniper split
- Changes will accelerate as technology continues to improve

Turning policy into action – the ultimate challenge



Note: NREAP: National Renewable Energy Actions Plans.
Source: IRENA, 2015a

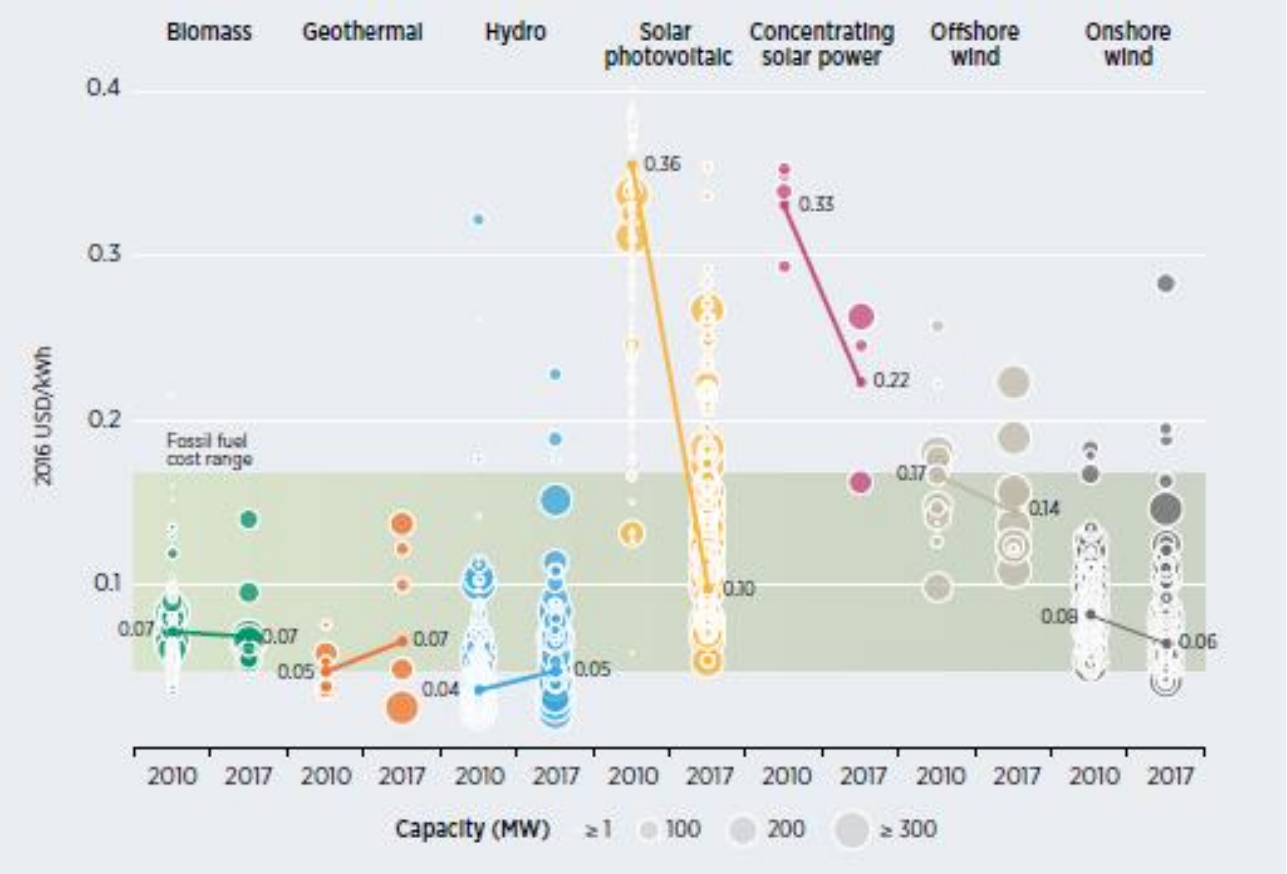
- The key question for incumbent suppliers is whether action will follow policy statements
- Countries have committed to change, but specific actions are less clear
- Companies are being forced to bet on outcomes that may be the default result of governments failing to achieve goals

Barriers to renewable energy deployment

SECTOR & BARRIERS	COST BARRIERS	REGULATORY BARRIERS	MARKET ENTRY BARRIERS	TECHNICAL BARRIERS	OTHER BARRIERS
POWER	Relatively high initial capital costs for some technologies; subsidies for fossil fuels and nuclear power; unfavourable power pricing rules	Non-existent or insufficient legal framework for independent producers; restrictions on siting, construction and transmission access; arduous permitting processes and utility interconnection requirements; inadequate market operation rules	Lack of access to credit; higher cost of capital due to lack of experience; perceived technology performance uncertainty and risk; lack of technical or commercial skill and information	Integrating high shares of variable renewable energy (VRE) into existing grids	
HEAT	High initial capital costs compared to well-established conventional systems, such as gas boilers; subsidies for fossil fuels	Arduous permitting processes	Lack of access to credit and financial incentives; lack of local technical or commercial skills; insufficient public awareness of available technologies and the broad spectrum of application options	Integrating renewable heating and cooling systems into existing infrastructure; distributed nature of consumption; fragmentation of heating and cooling markets	Competition for investment dollars from other renewable energy technologies in the power sector (particularly solar PV) and from heat pumps and energy efficiency measures
TRANSPORT (BIOFUELS)	Higher costs relative to conventional fuels, in some markets		Lack of government policy to set up charging infrastructure; cumbersome permitting process for setting up charging stations	Immaturity of third-generation technology	Adverse effects such as indirect land-use change (ILUC) and further social/environmental concerns
TRANSPORT (ELECTRIC VEHICLES)	High cost for renewable energy technologies in personal vehicle transport relative to existing technologies	Lack of government policy to set up charging infrastructure; cumbersome permitting process for setting up charging stations	Lack of energy infrastructure (e.g., electric vehicle (EV) charging stations)	Immaturity of technology; relatively short vehicle range	

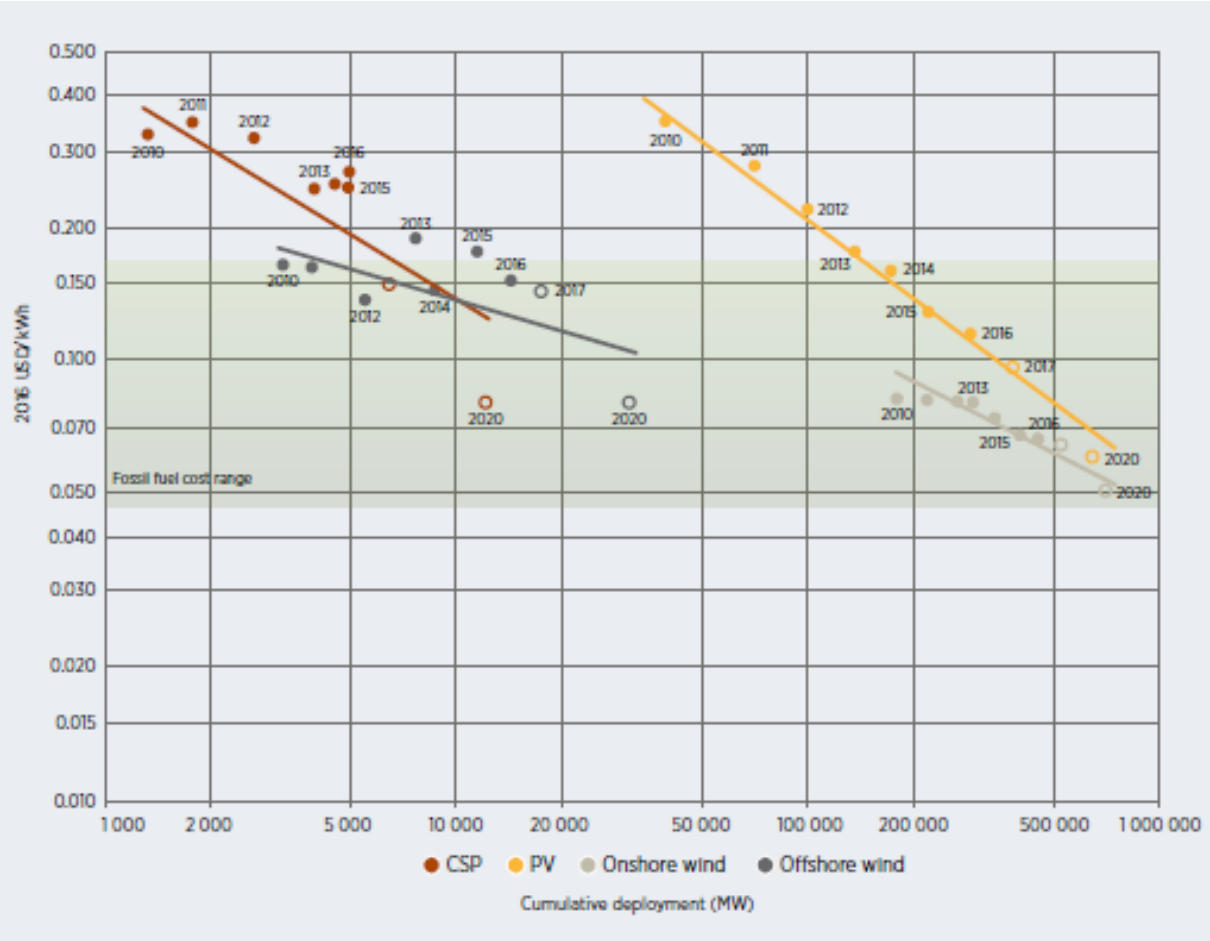
Source: adapted from IRENA 2012a; Beck and Martinot, 2004; IEA-RETD, 2015; Wiederer and Philip (n.d.)

Cost of Wind and Solar falling over time



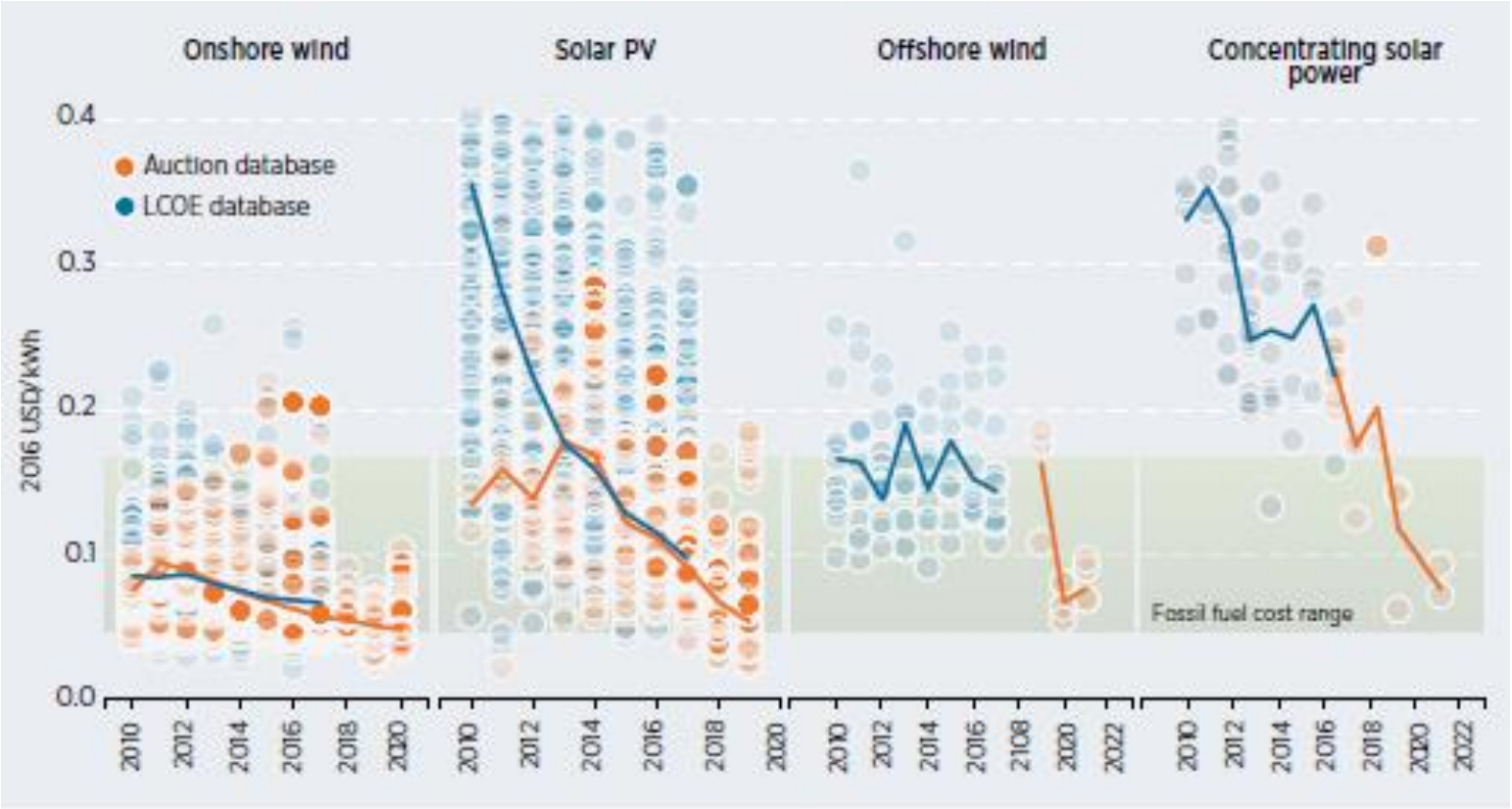
- The costs of both wind and solar power have declined rapidly in a very short period of time
- At the lower end of the spectrum cost competitiveness without subsidy is possible in some countries

Renewable cost learning curves



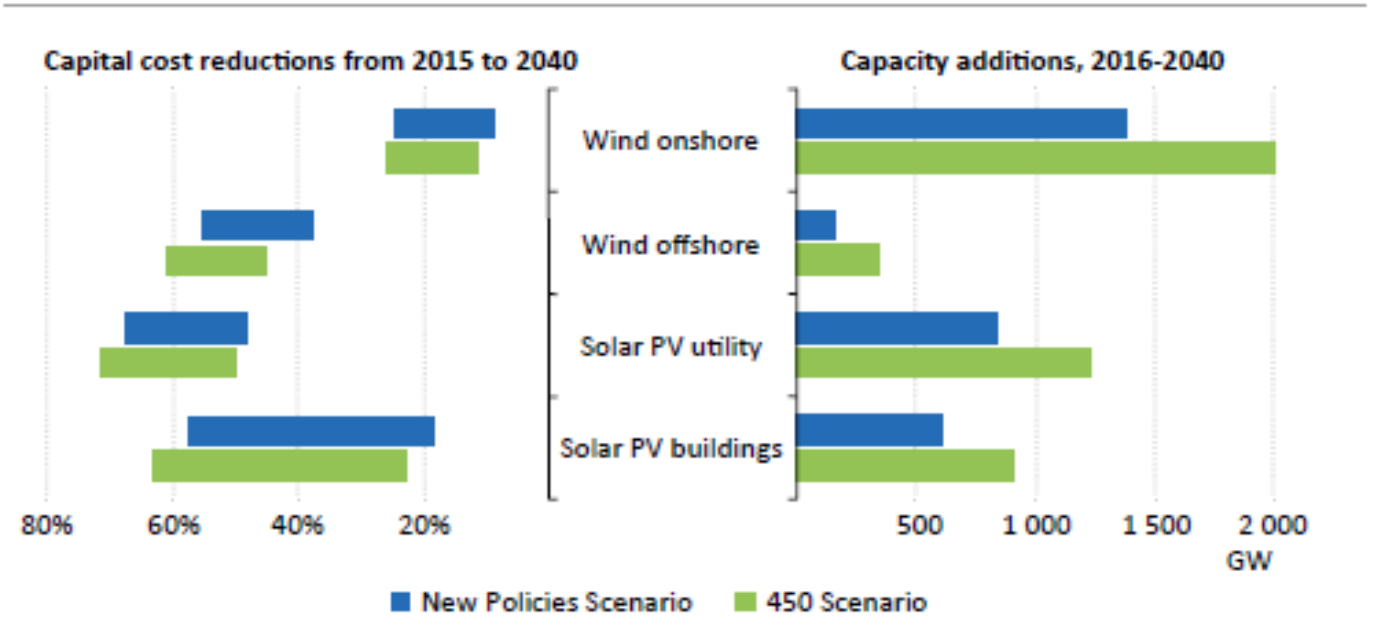
- Renewables costs continue to fall sharply as technology improves
- Most sources are now well within the fossil fuel cost range, if one ignores system costs

Outlook for costs based on auctions



- The cost of renewable energy is falling fast, and is getting very close to the range of fossil fuel generation
- Once subsidies are no longer required, a tipping point could be reached
- Key question revolves around the cost of intermittency and the need to provide back-up capacity

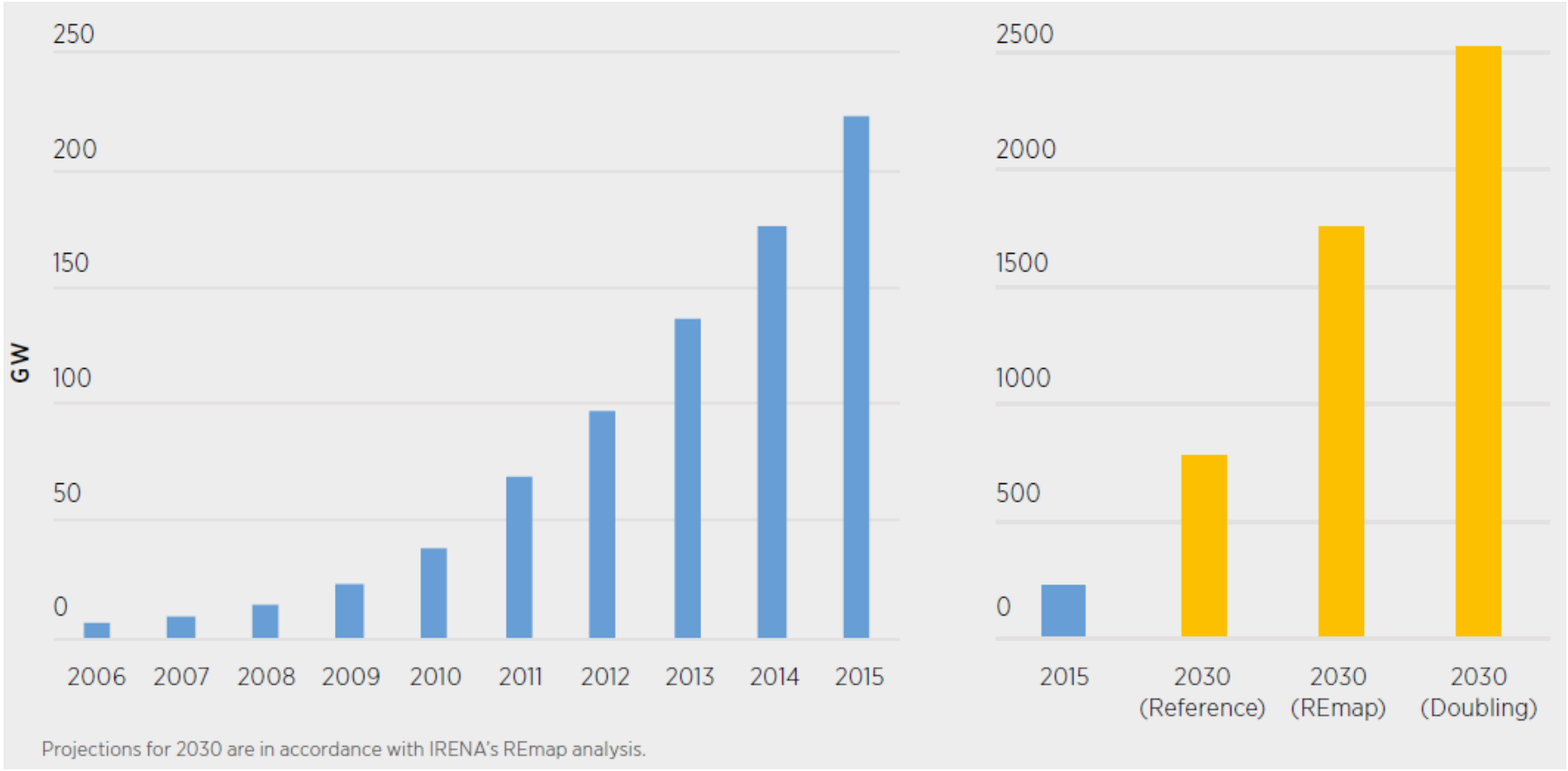
Capital cost reductions expected as capacity additions rise



The cost to build wind projects is projected to fall by 10-60% by 2040, while solar PV capital costs decline by 20-70%

- Cost reduction trends are expected to continue as synergy benefits increase
- Onshore wind has least far to fall because it is already competitive
- Solar is expected to benefit from the opening of new regions of the light spectrum

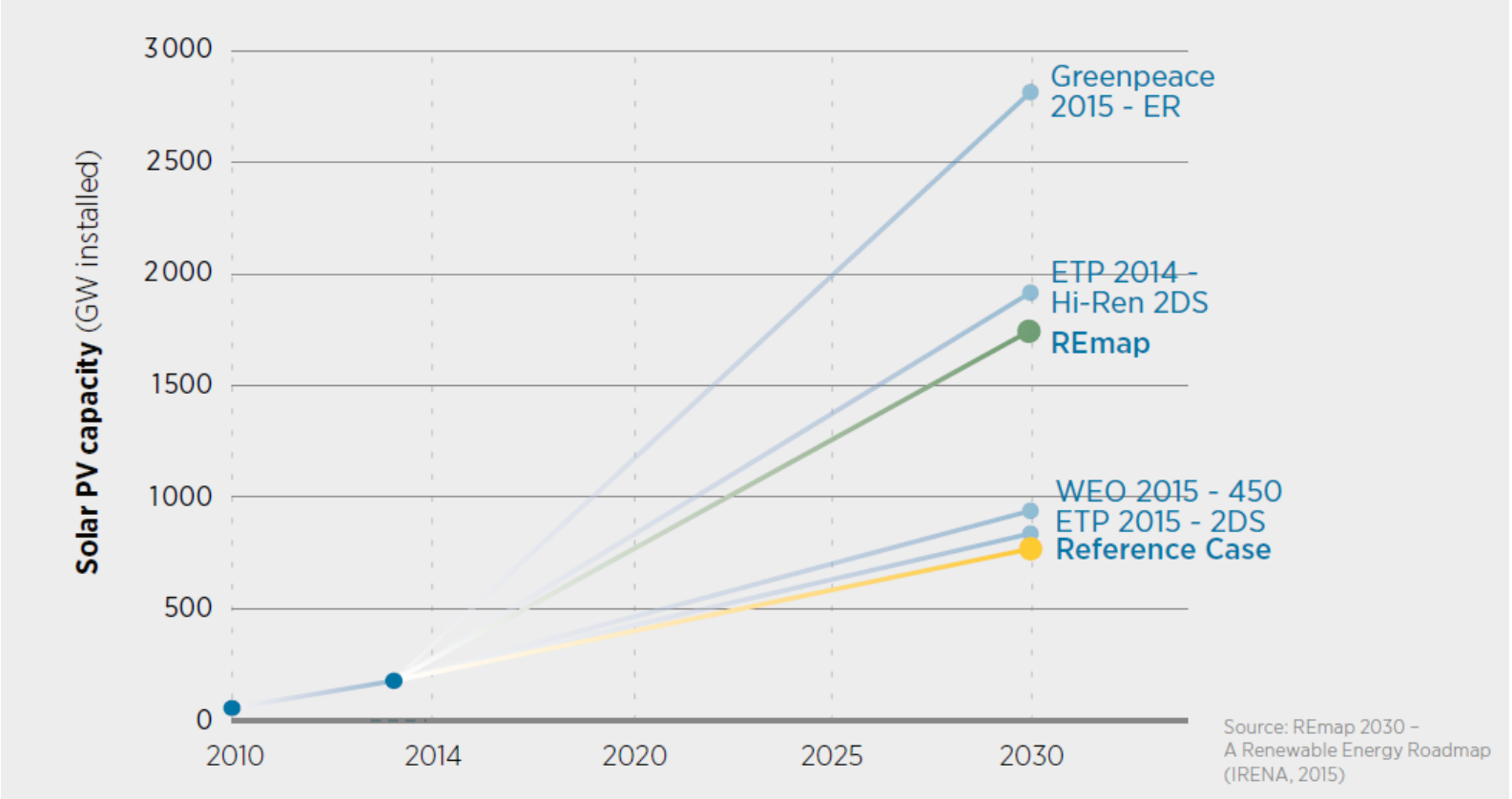
Solar PV Installed Capacity and Potential Growth to 2030



Source: IRENA

- The growth in solar PV capacity has been dramatic, but is expected to continue to be rapid
- Under some scenarios solar could account for around 40% of global generating capacity by 2030

Solar PV Outlook – a variety of projections

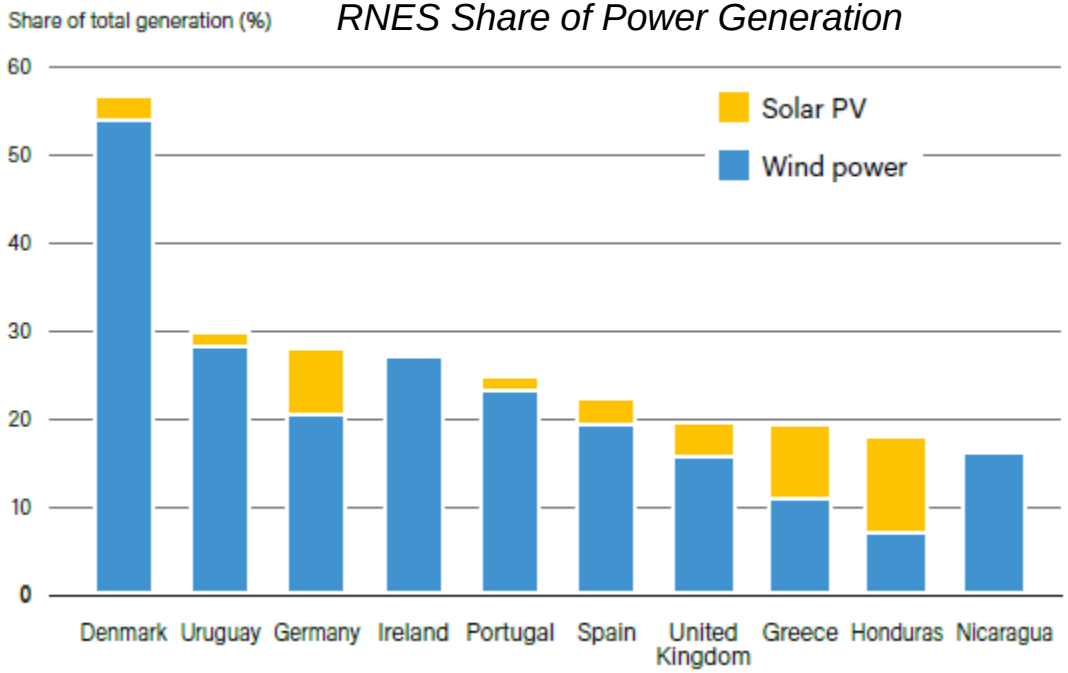


Source: IRENA

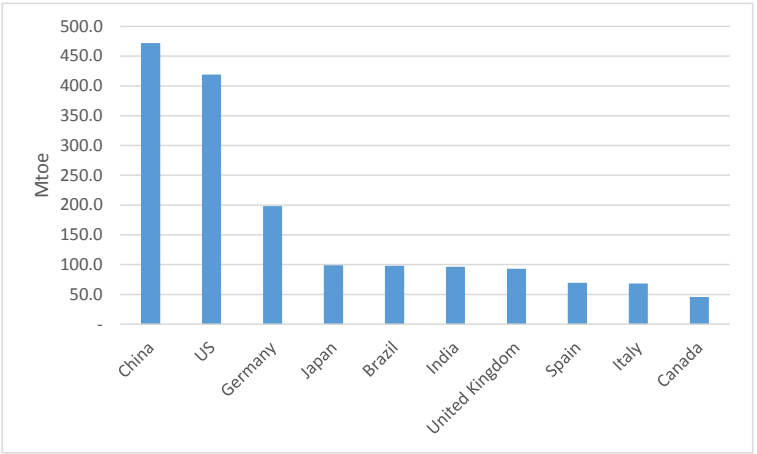
- There is a wide range of scenarios, however, underlining the huge uncertainty involved in the development of the global energy economy
- To an extent policy makers appear to be relying on the Bill Gates axiom:
  - **"We will always overestimate the change that will take place in the next two years and underestimate the change that will occur in the next ten."**

The country impact of renewable energy

RNES Share of Power Generation

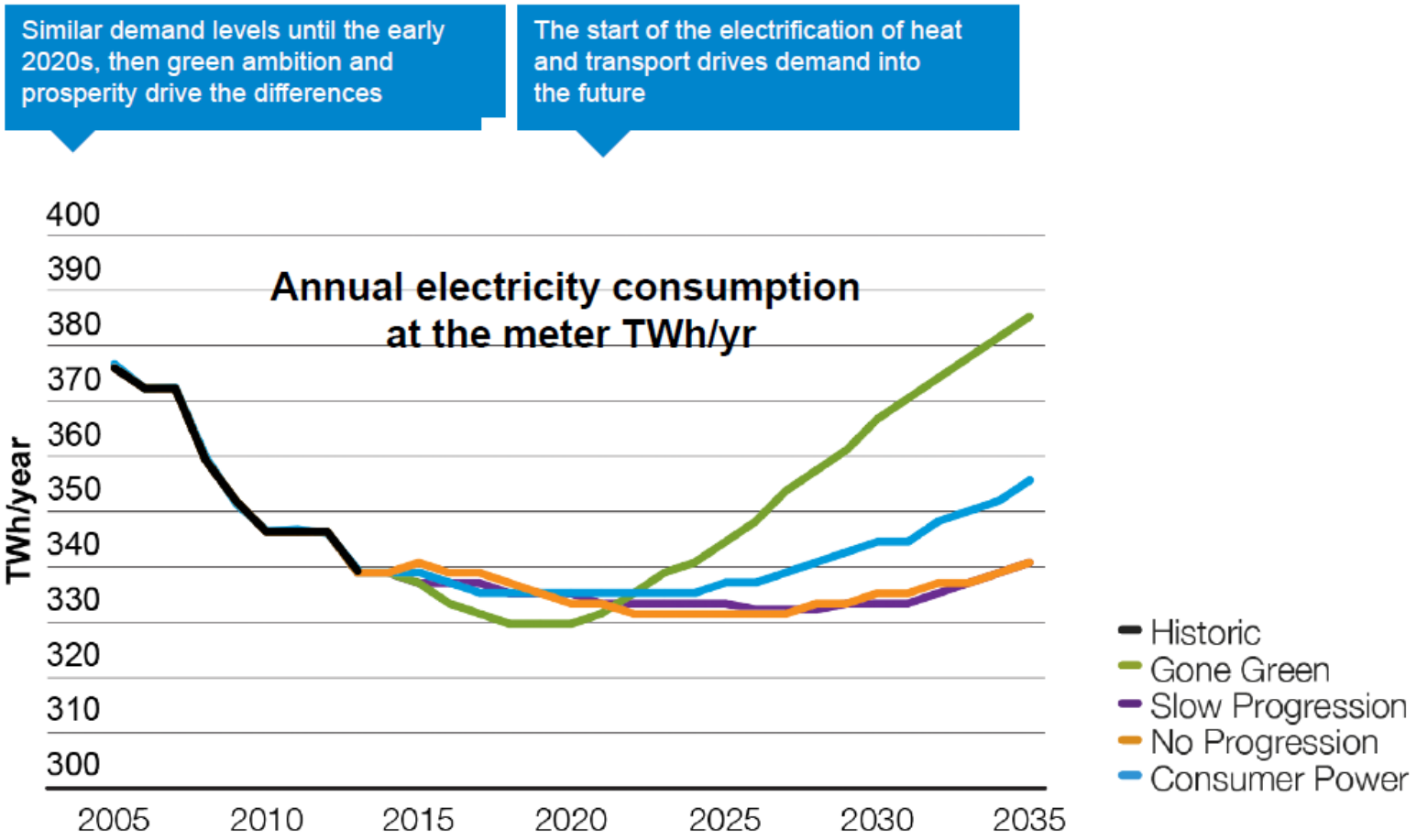


Total RNES Demand (ex-Hydro)



- European countries continue to lead the way in terms of renewables penetration
- China and the US are the largest by volume of renewable energy
- Prevalence of renewables in a power system does create significant challenges

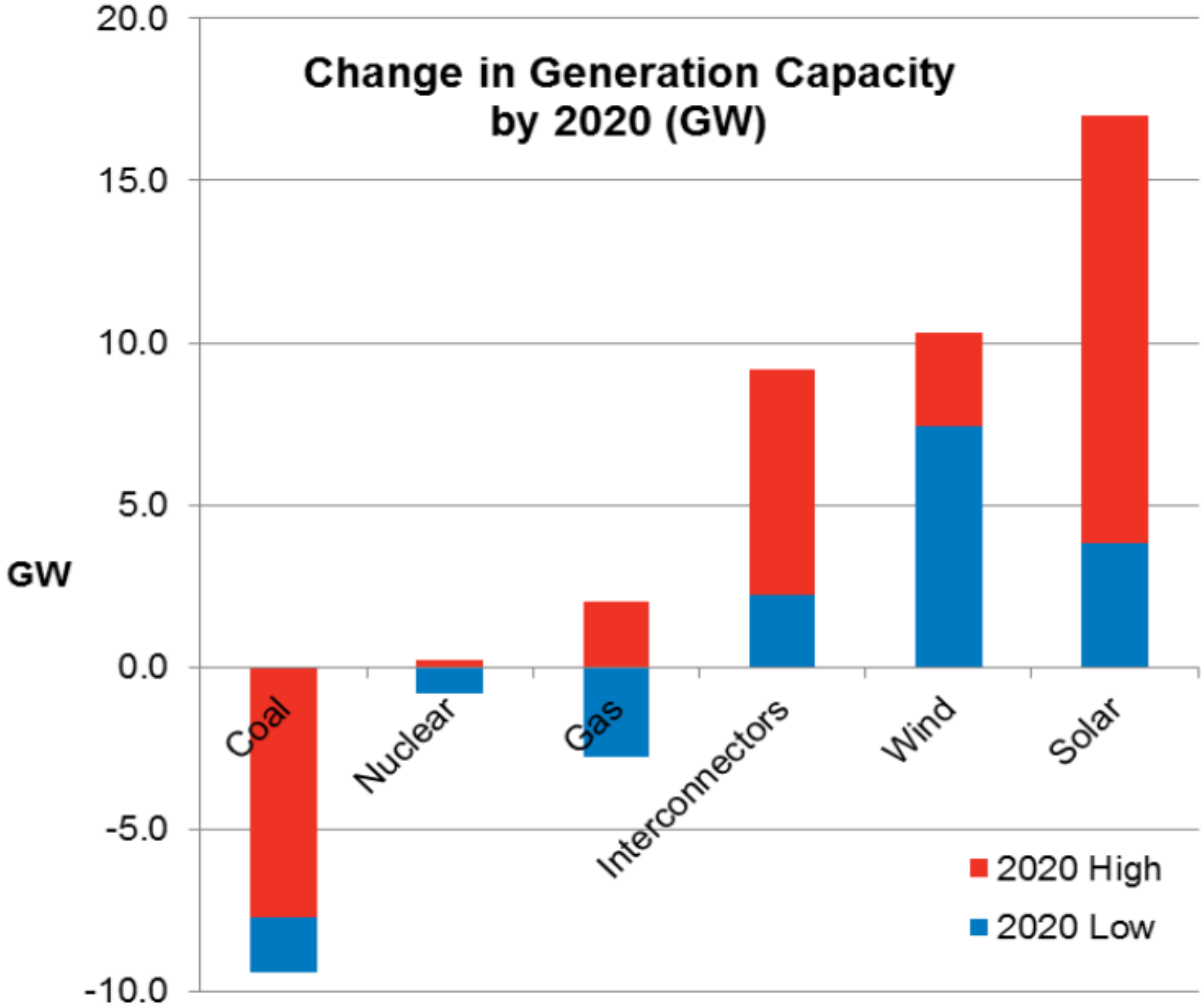
Wide Range of UK Electricity Demand Scenarios



Source: National Grid

- Electricity demand scenarios vary significantly depending on progress towards decarbonisation goals
- Electrification can be a key objective if renewables come to dominate the power sector – but is it the most cost efficient outcome?

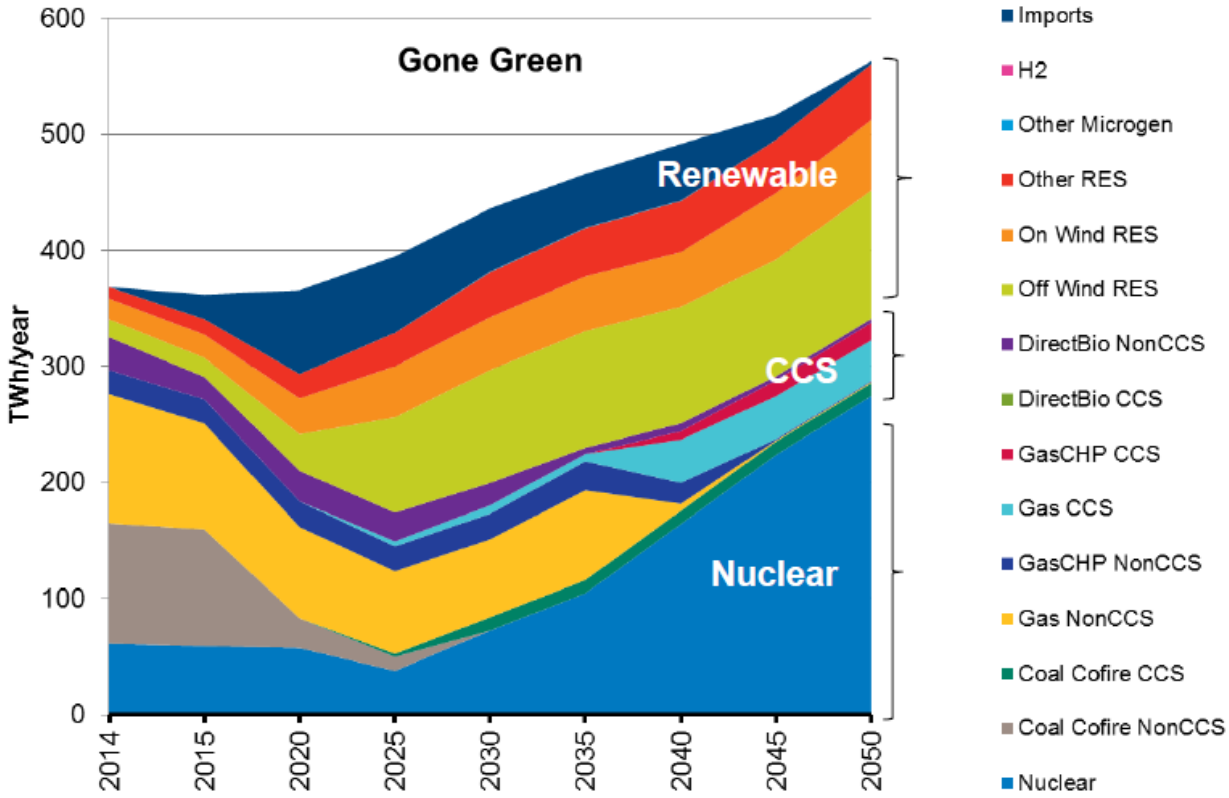
UK Generating Capacity Outlook Uncertain Even By 2020



Source: National Grid

- Renewable generation will certainly increase, and coal should fall, but the outlook for gas producers is much less clear
- How do gas producers and power generators invest with this uncertainty?

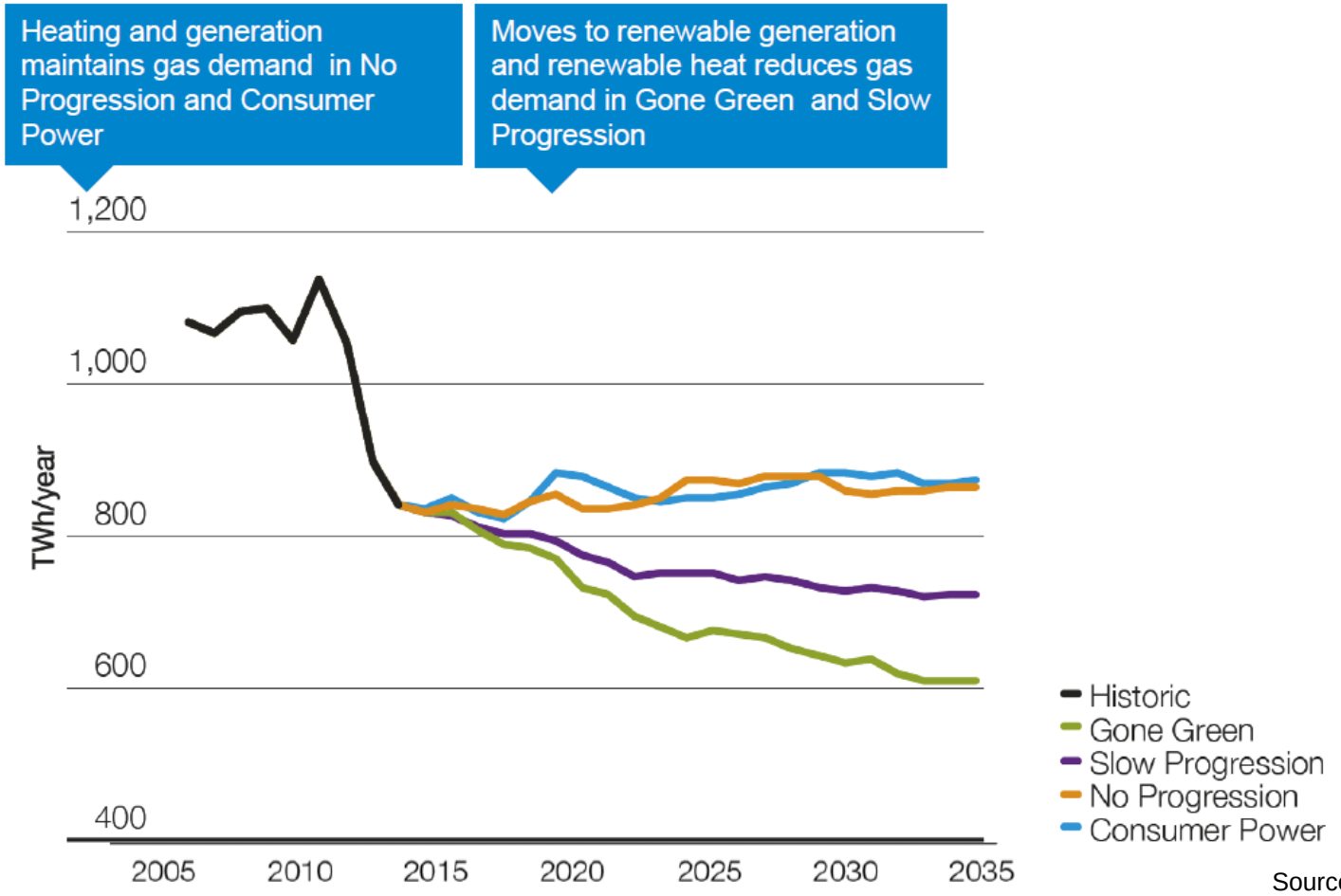
UK Fuel Inputs for Power to meet Carbon Targets



Source: National Grid

- If the UK is to meet its carbon targets then nuclear will play a much more important role, coal will disappear and gas will rely on CCS
- Renewables will obviously be a large share of the total, with wind leading the way
- This could all change, though, if nuclear becomes less popular – what is the alternative, and who will invest for it?

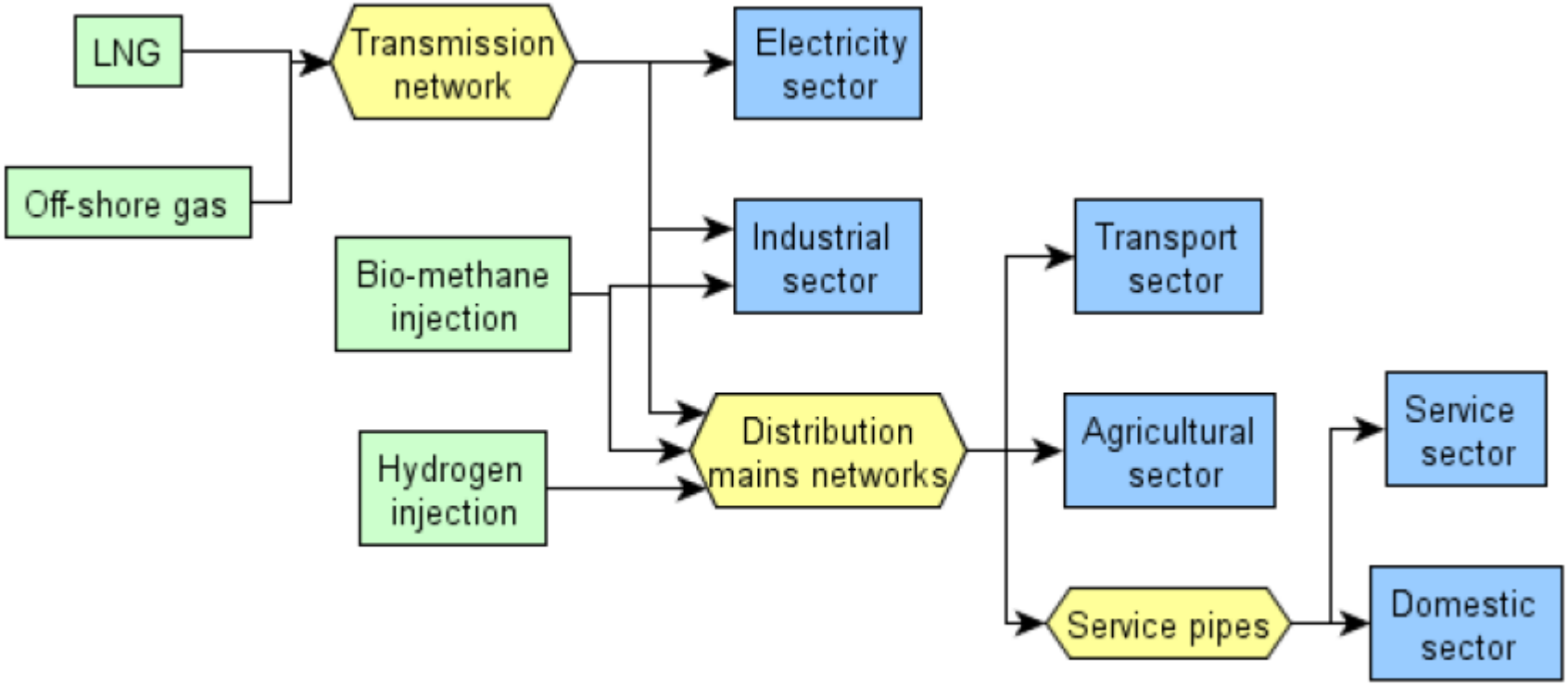
Impact on gas demand could be very profound



Source: National Grid

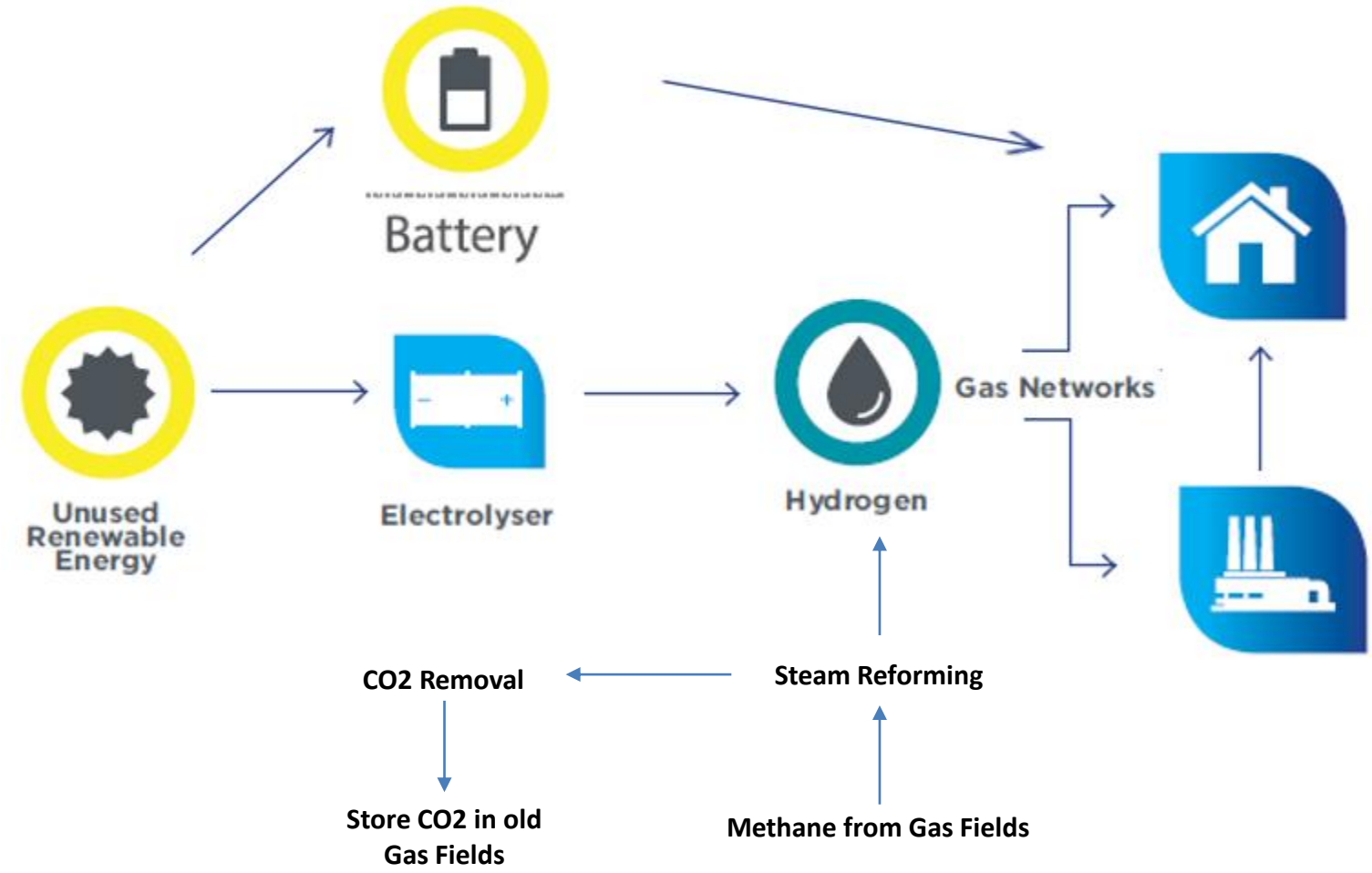
- Gas demand could fall very sharply in a green scenario
- However, if there is less renewable progress, then gas is seen as the default fuel
- This could create major security of supply issues

Stranded assets in the Gas Sector



- What to do with all the pipes that may not be used?
- Dismantle them or find another use?
- Companies are searching for lower carbon options to use gas networks – green gas

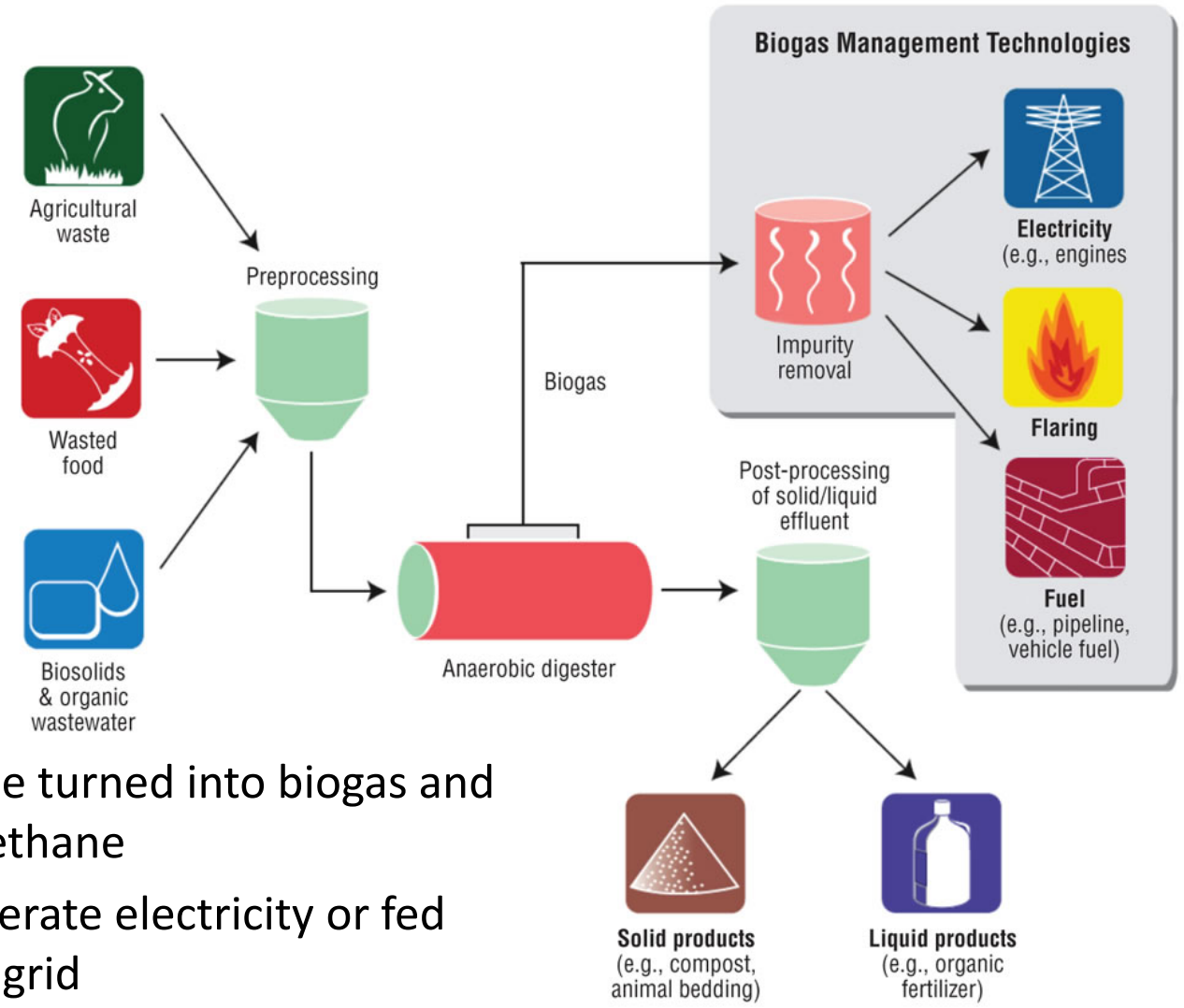
Creating a Hydrogen Network via “Sector Coupling”



- Finding ways to make cheap hydrogen which can be put through existing gas networks, while using cheap renewable electricity

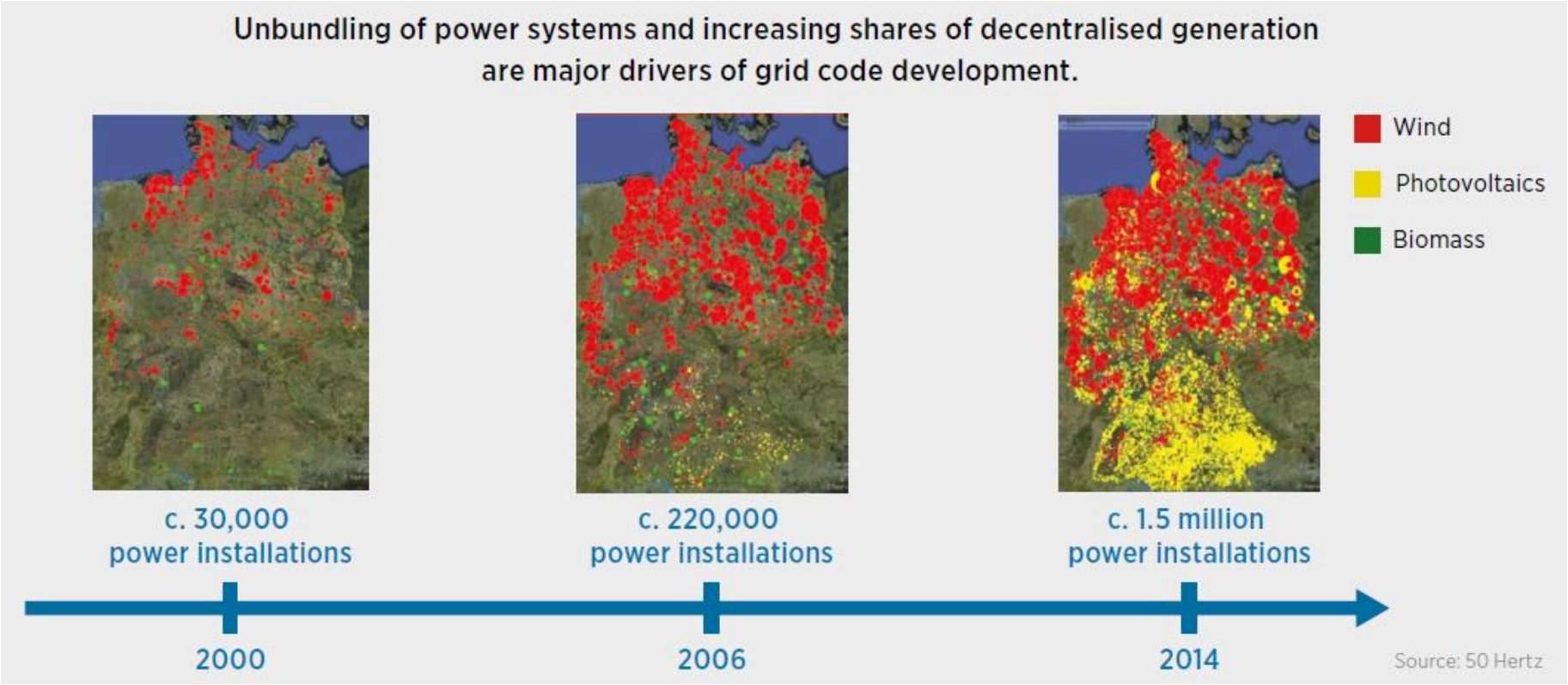
Biogas from waste products is another “green” alternative

Figure 1. General biogas production and use pathway schematic



- Waste can be turned into biogas and even bio-methane
- Used to generate electricity or fed into the gas grid
- Tends to be a local system, mainly for agricultural waster

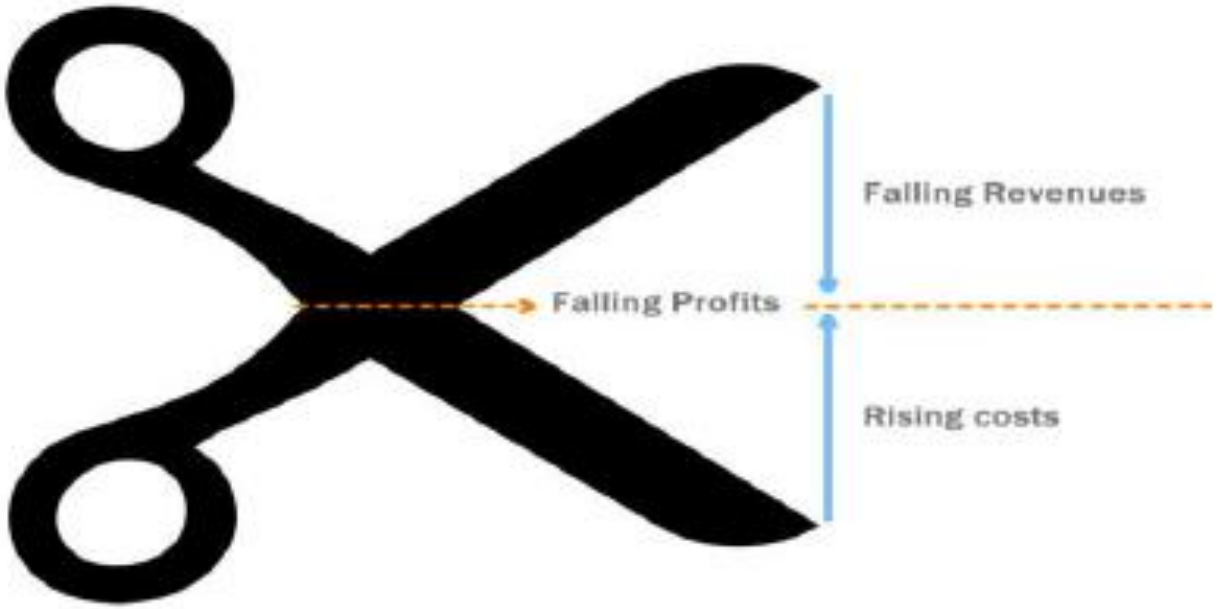
Expansion of decentralised power in Germany



Source: IRENA

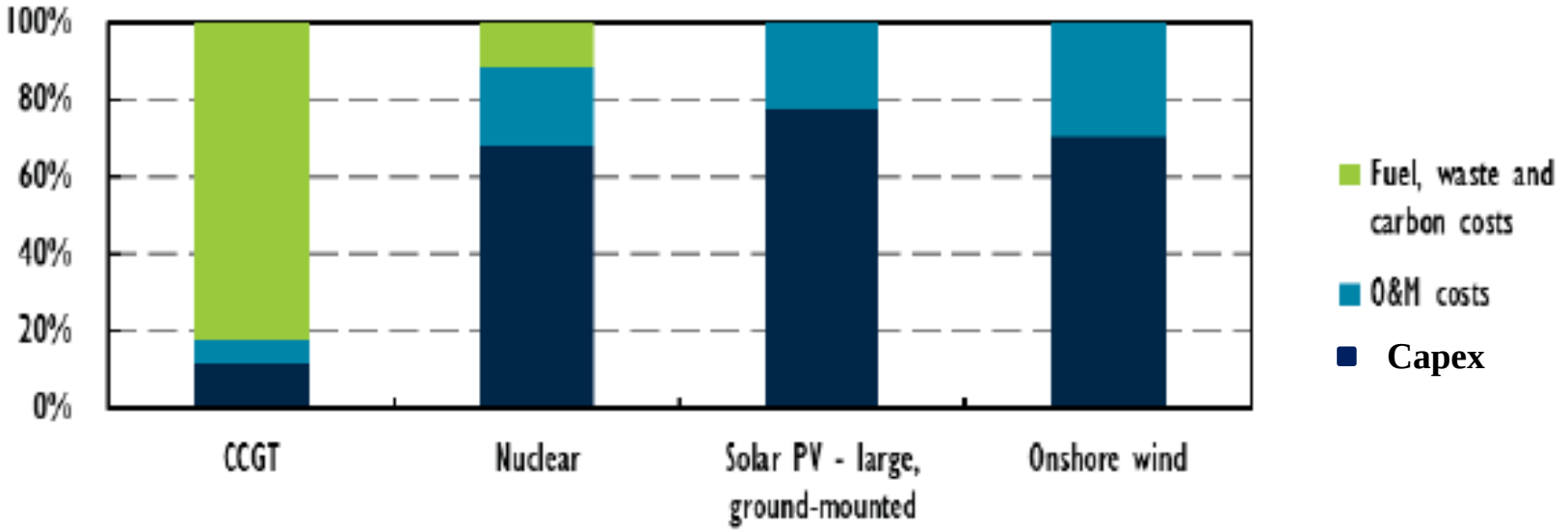
- Germany is a prime example of decentralisation in action
- Centralised power generators and distributors are left with reduced overall demand but the potential for big spikes when the sun does not shine
- Who pays for the back-up capacity?

The Scissors Effect on European Utilities



- The change in the electricity sector is having a dramatic impact on utility companies in Europe
- Wholesale prices for electricity are falling thanks to the low marginal cost of renewables
- Costs are rising because of low capacity utilisation of non-renewables
- Consumer prices are rising because of renewable subsidies, dampening demand

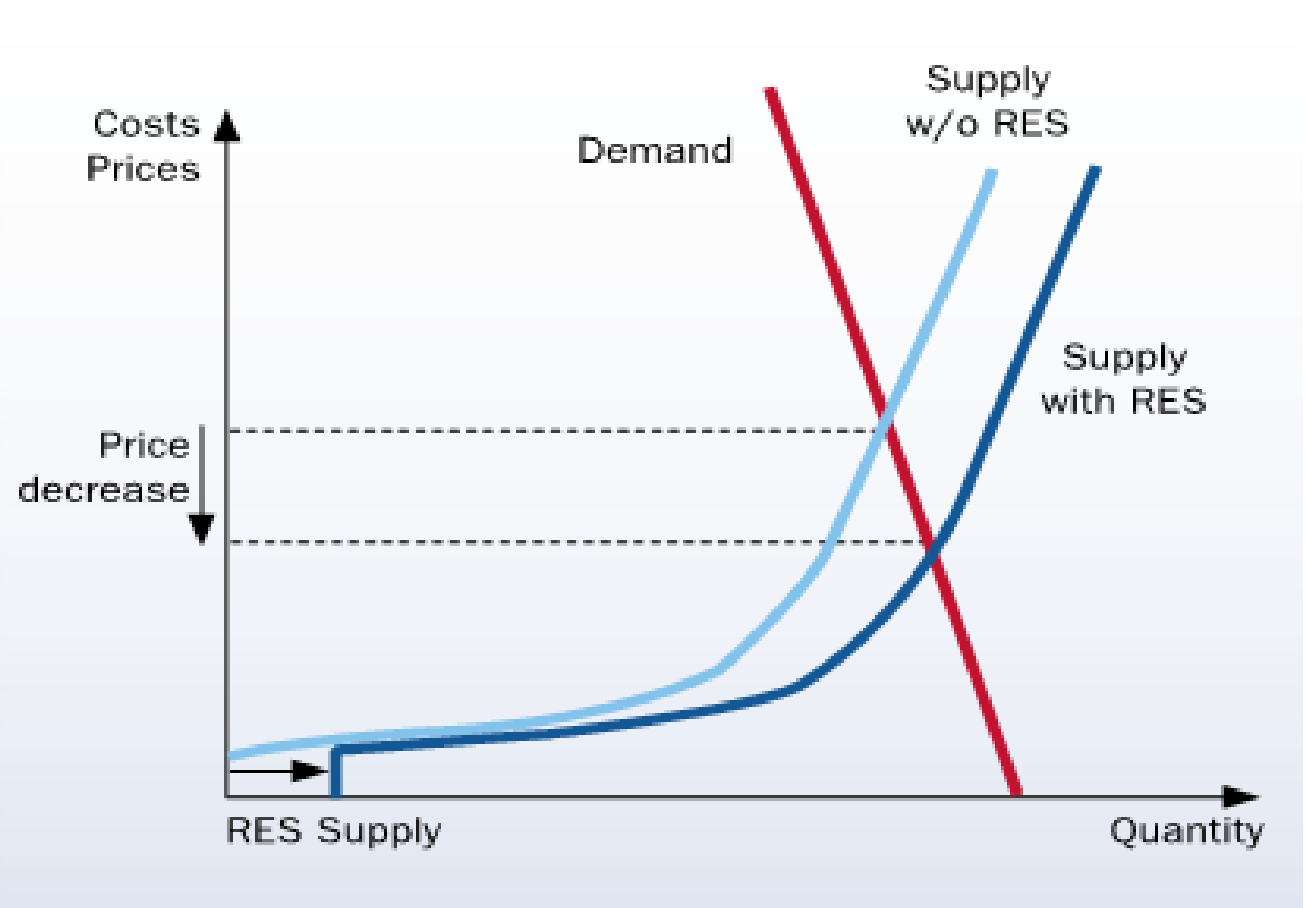
Breakdown of levelised costs for different power technologies



- The cost breakdown of renewables is very different from most fossil-fuel and nuclear technologies
- High capital costs necessitate government support via subsidies to ensure a rate of return for the developer
- Low operating costs mean that short run marginal costs are very low, so that a low price can be bid for dispatch
- Effectively, when the wind blows strongly or the sun shines brightly the price of excess renewable energy can be zero or even negative

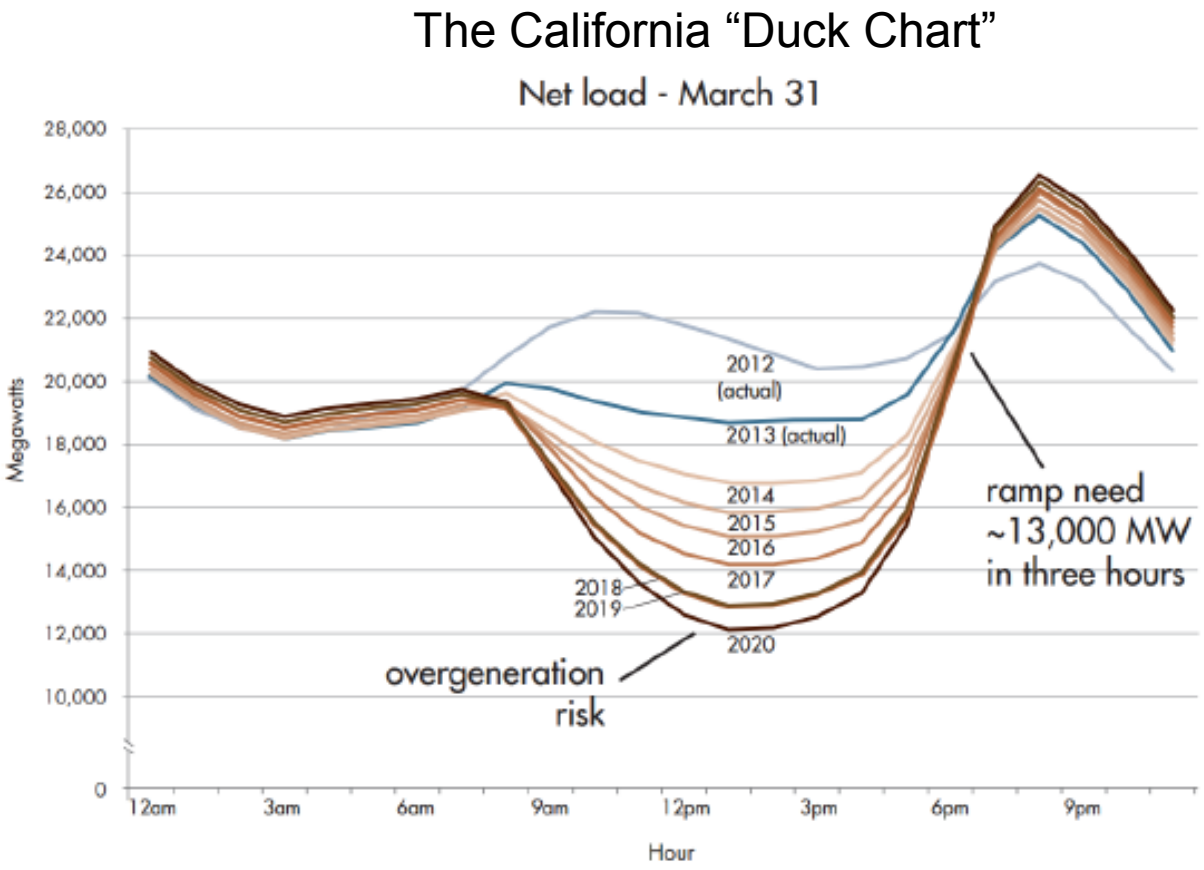
Renewables and the merit order effect

Introduction of renewables alters supply curve



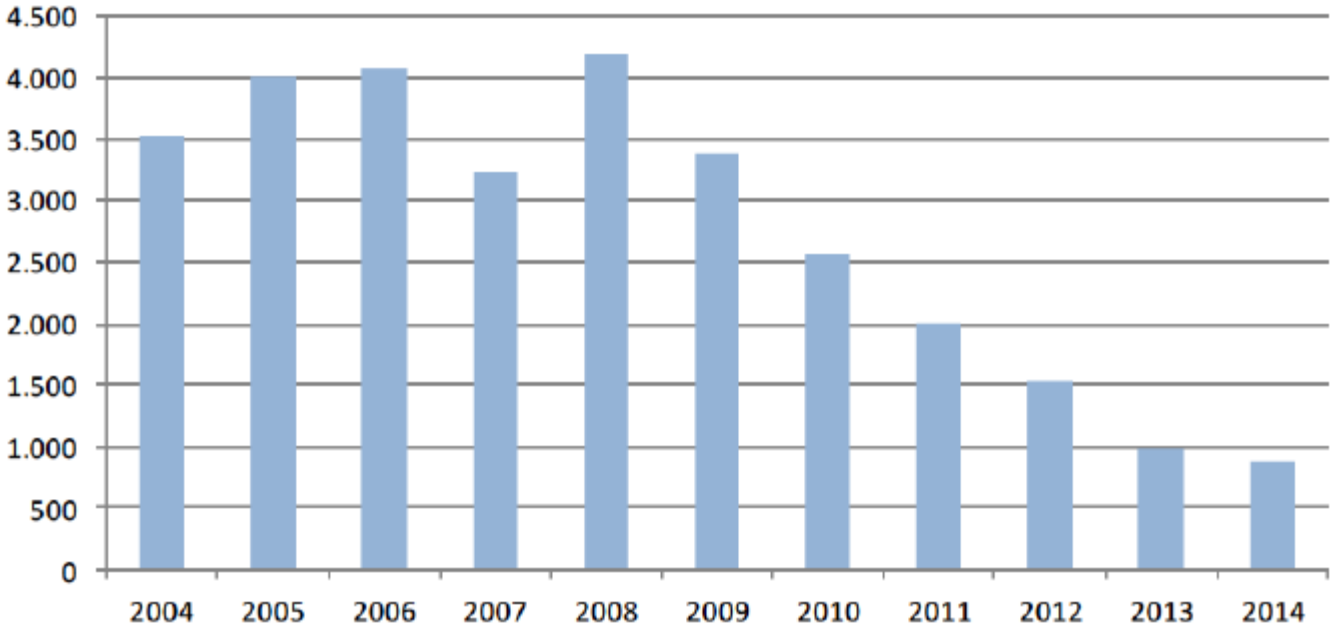
- Renewable energy has guaranteed dispatch, and so moves all higher cost supply out
- The wholesale price declines as demand is satisfied at a lower level

Renewables create over-generation risk



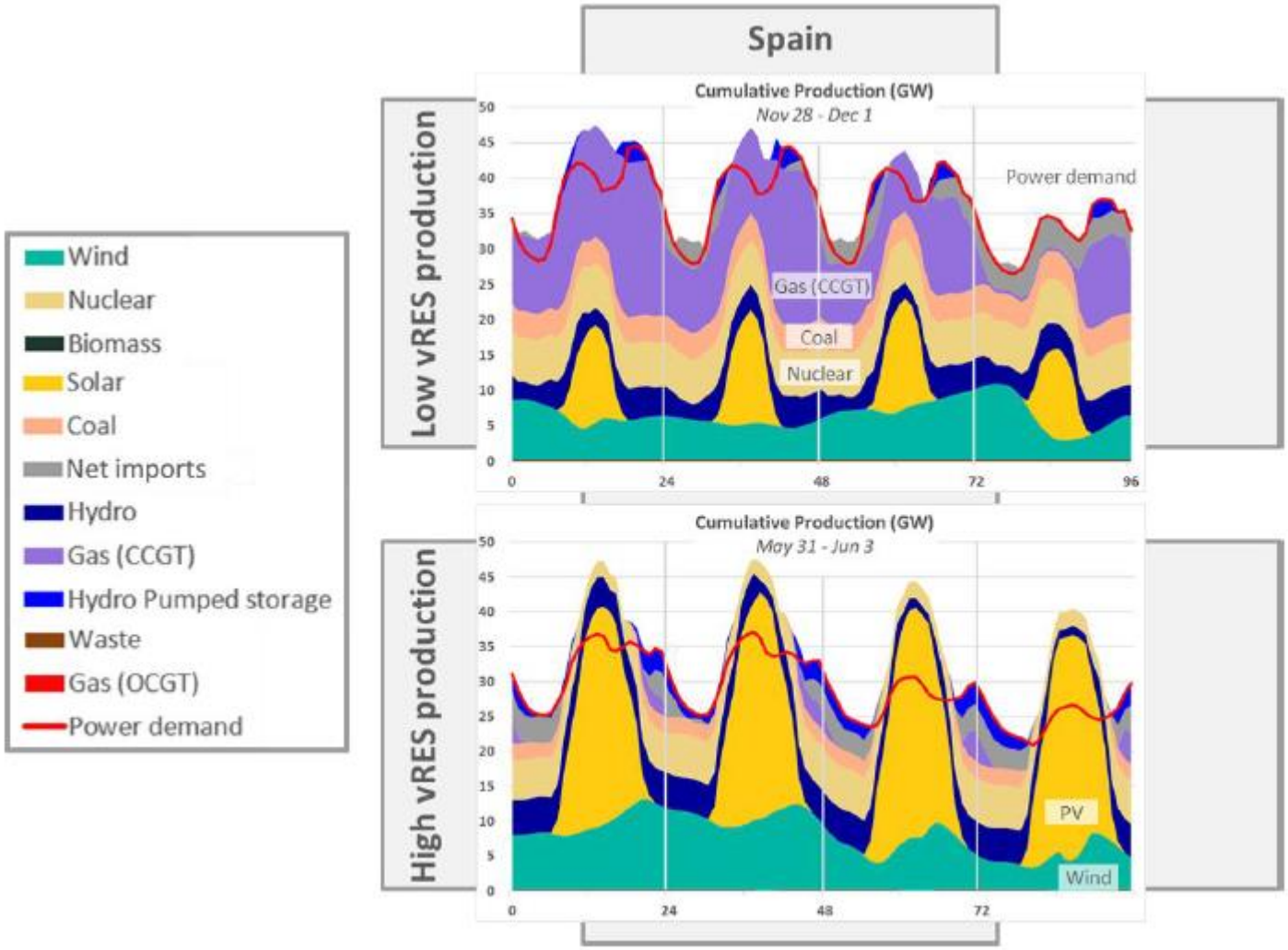
- Net load (total electricity demand less generation from wind and solar PV) varies dramatically according to weather
- As renewable generation increases, so low point gets lower, increasing the risk of having too much base load capacity
- In a worst case scenario curtailment is required, undermining project economics

Hours of effective operation by Gas-Fired Plants in Spain



- The Spanish market provides a good example of the impact of renewables of fossil fuel generation
- Gas-fired plant utilisation has fallen to below 20% on average, and many station have been mothballed of shut down
- Low coal prices have also encouraged a renewables-coal mix, which has also been seen in Germany

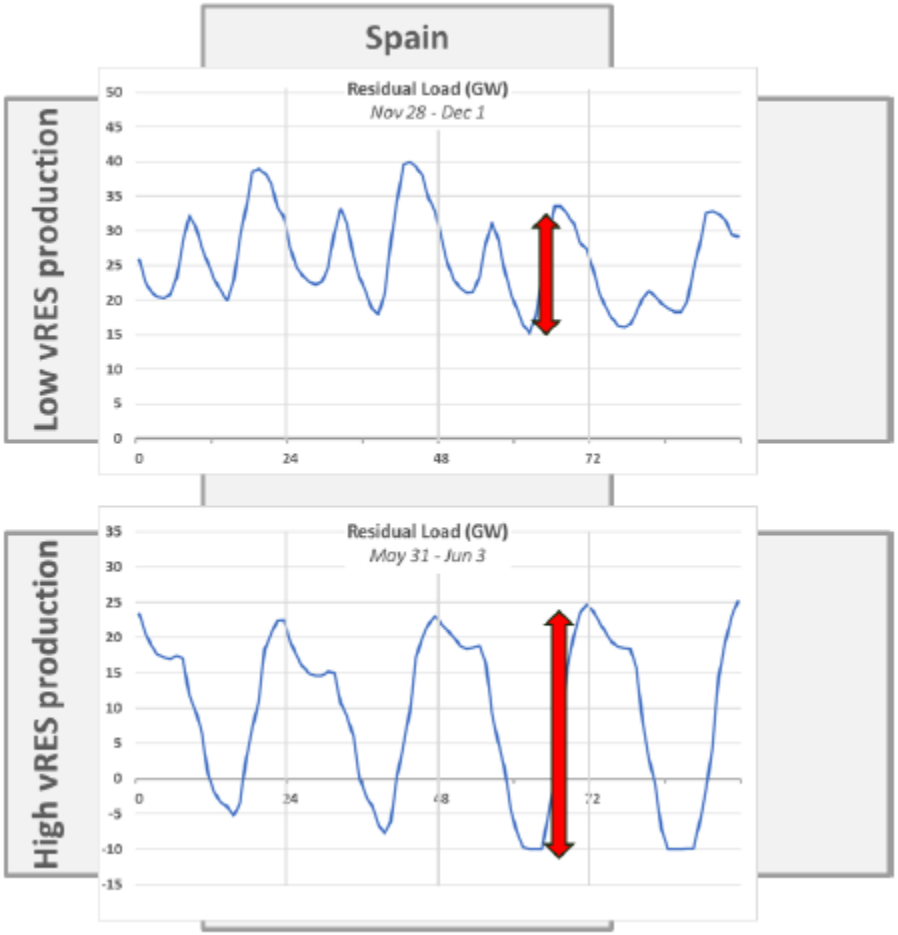
The impact of renewables on fuel inputs for power generation



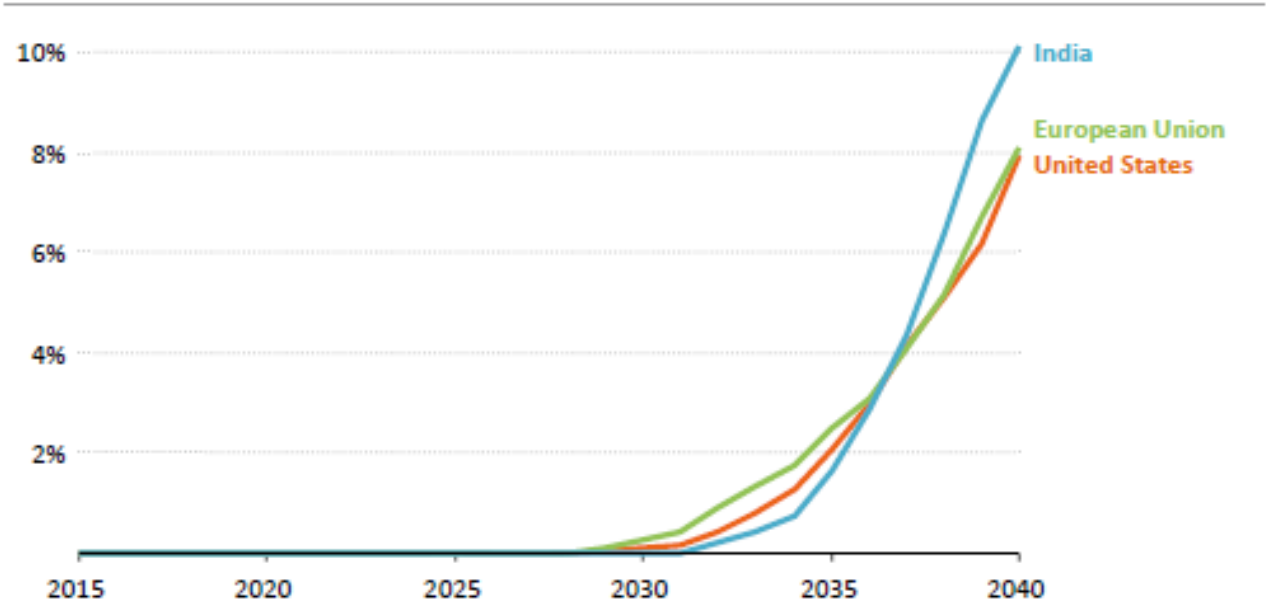
- Dramatic difference in fossil fuel use between seasons
- What incentives are needed to keep a fossil fuel plant open?

Residual Load = Power Demand less Renewables Production

$$residual\ load = power\ demand - vRES\ production$$



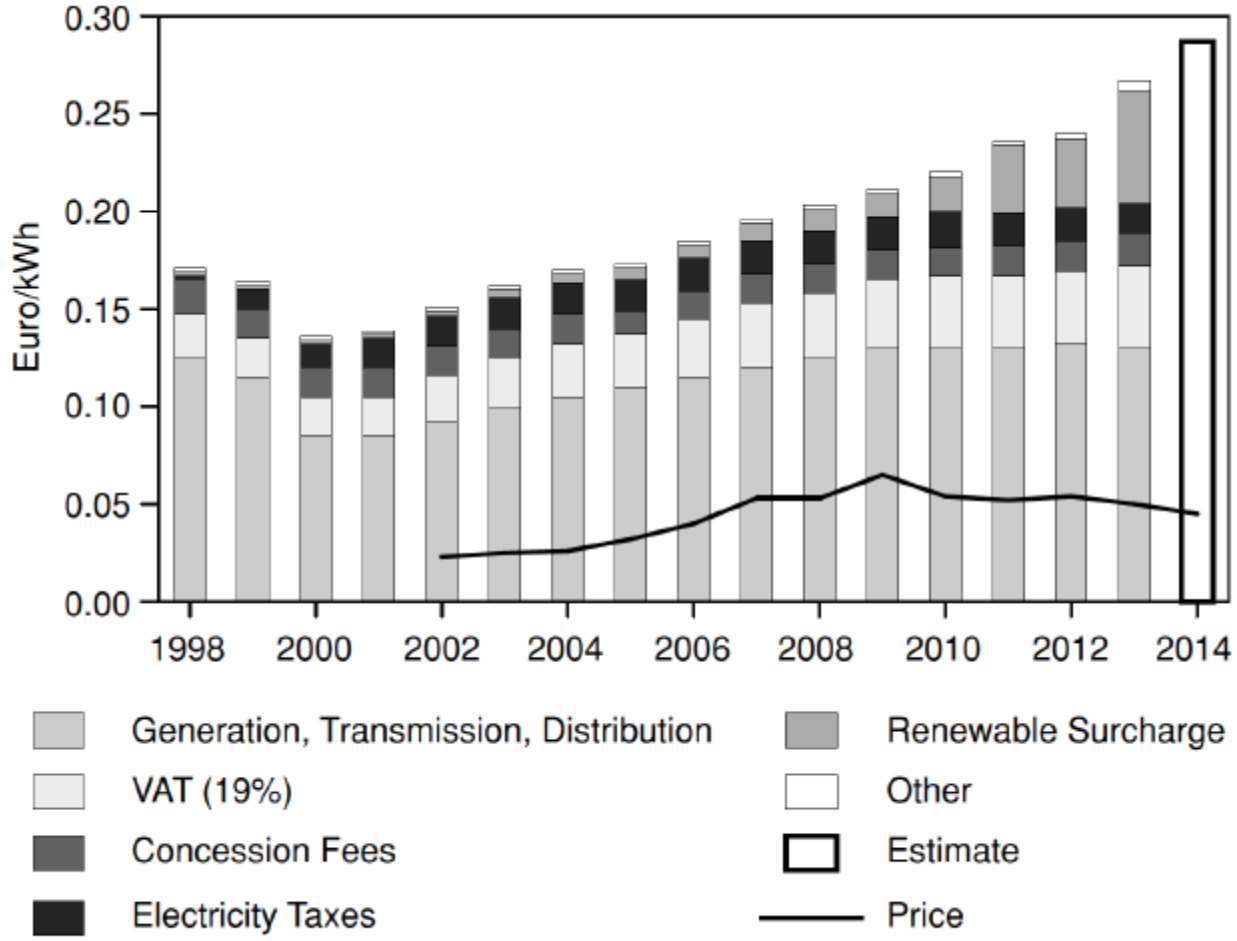
Share of hours in year with Electricity Price at Zero



Hourly market prices near zero become increasingly common in the 450 Scenario, but would occur much more often without demand response and energy storage

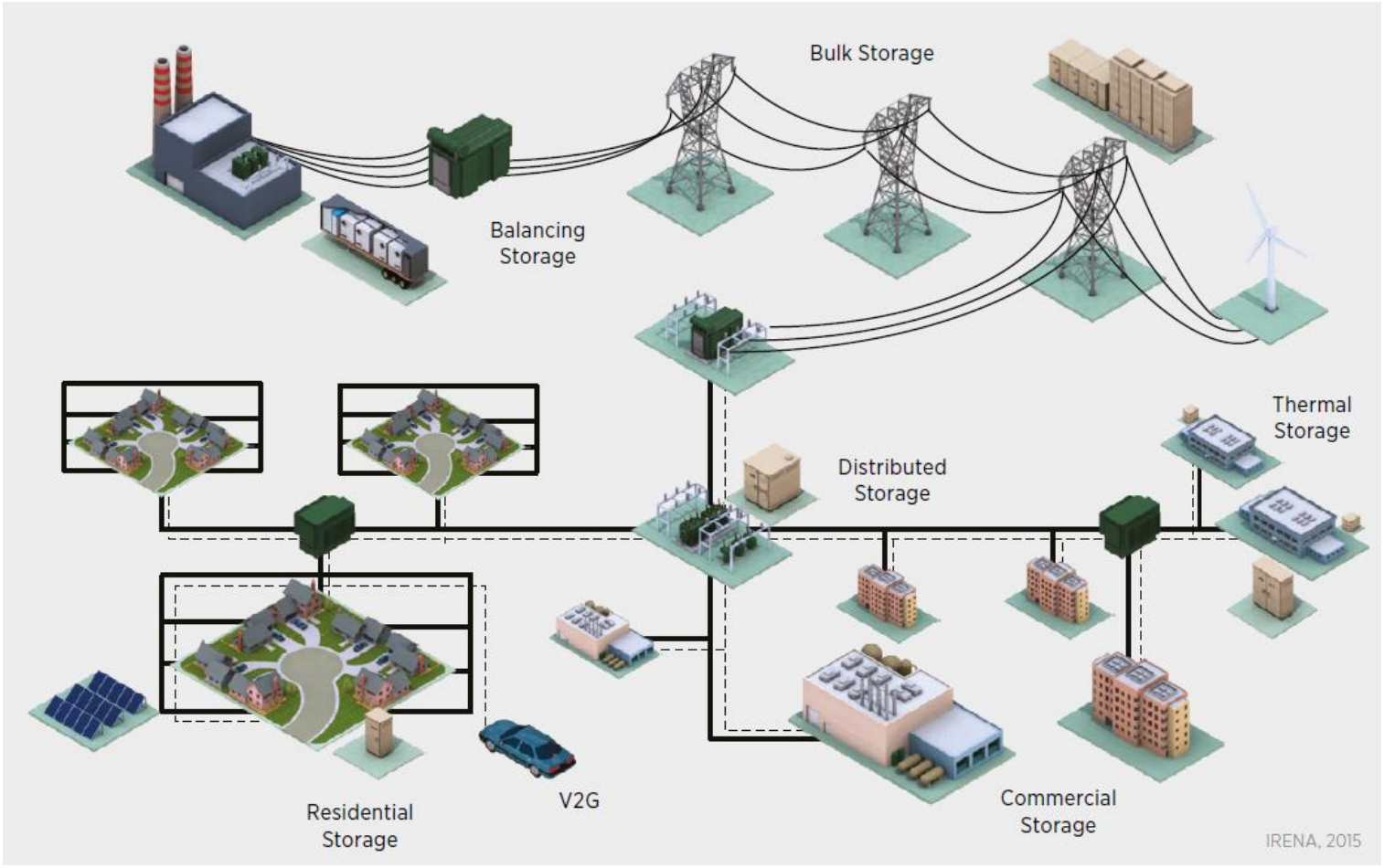
- To date sub-zero prices have only occurred in Germany, the UK and the US
- However, as the volume of low cost generators rises they will become increasingly prevalent in highly decarbonised economies
- The levels shown above rely on demand side management and storage, and would be much higher in an “energy only” market
- Zero prices create a clear problem covering power system costs

Prices declining while costs are rising



Source: BDEW, Moody's

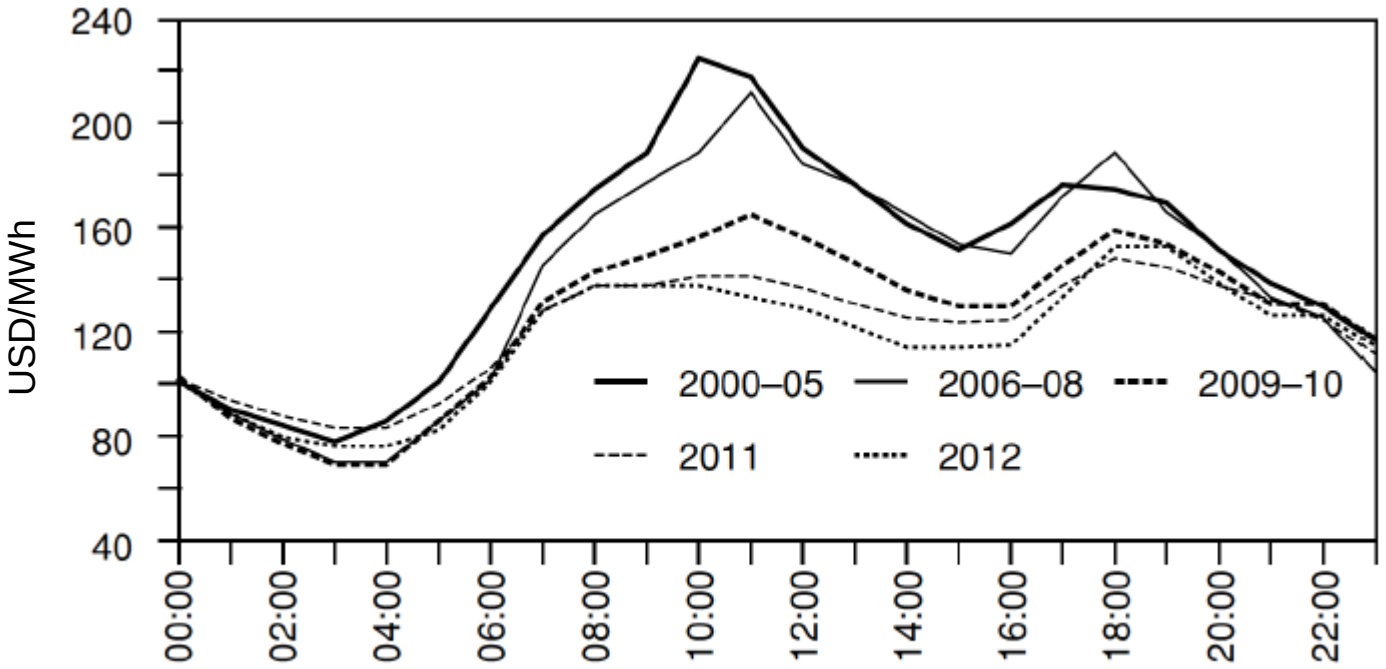
Storage options are likely to increase



Source: IRENA

- Multiple storage options are being explored to reduce volatility of renewables
- A breakthrough in battery technology is the “black swan” for fossil fuels

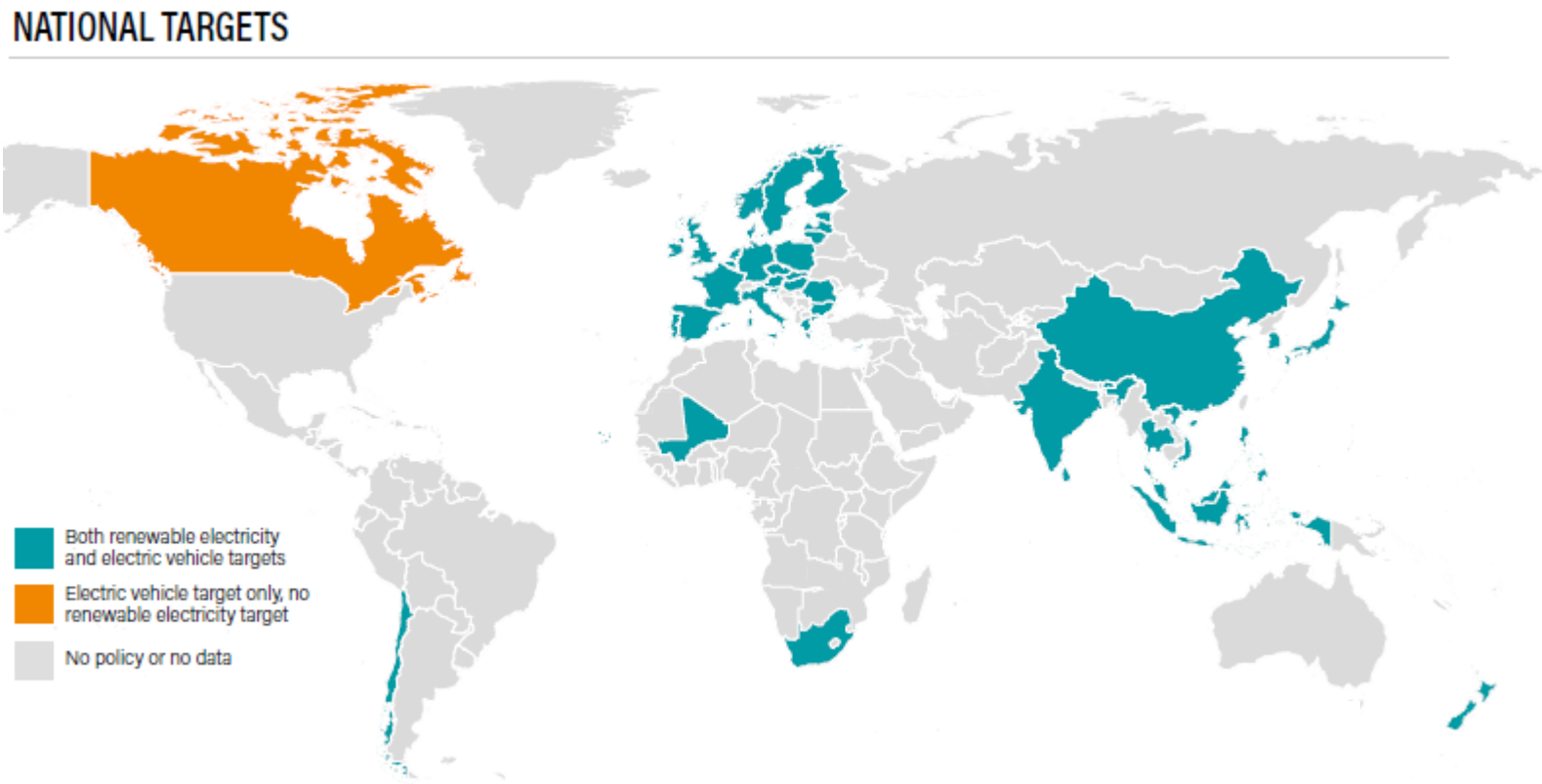
Intraday price curve has flattened as storage and demand-side management improves



Source: Bloomberg

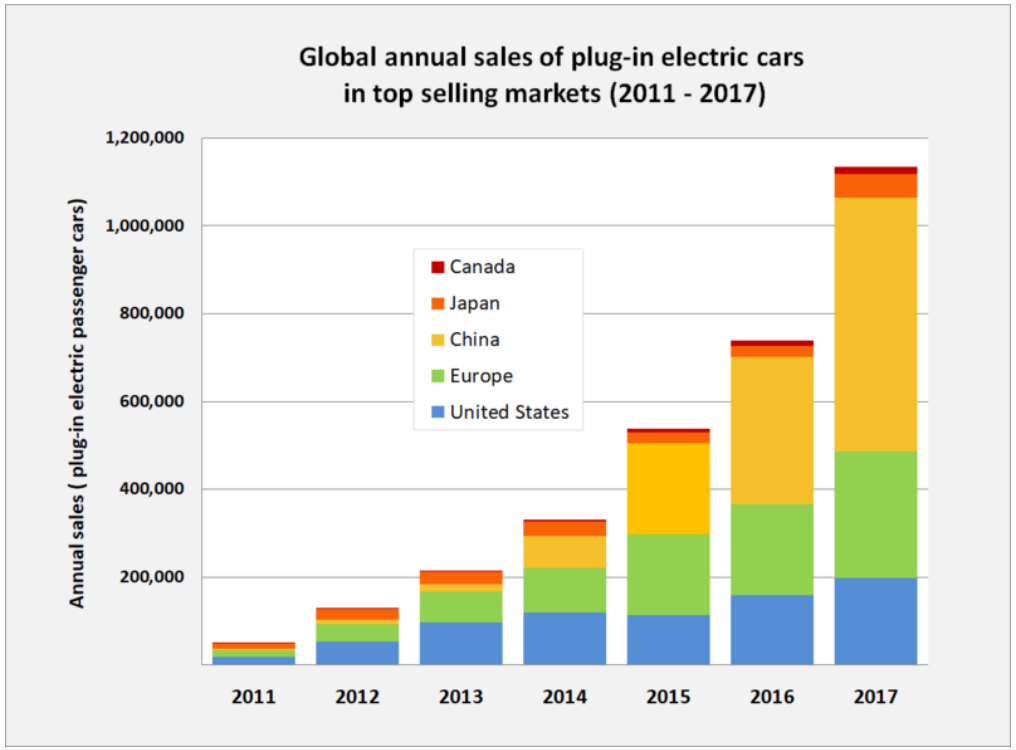
- During specific periods the weather can create huge volatility
- However, renewables can also smooth the demand curve on an intra-day basis, especially when combined with demand side management
- This reduces the volatility in prices that provides one of the few incentives for generators who are no longer base load

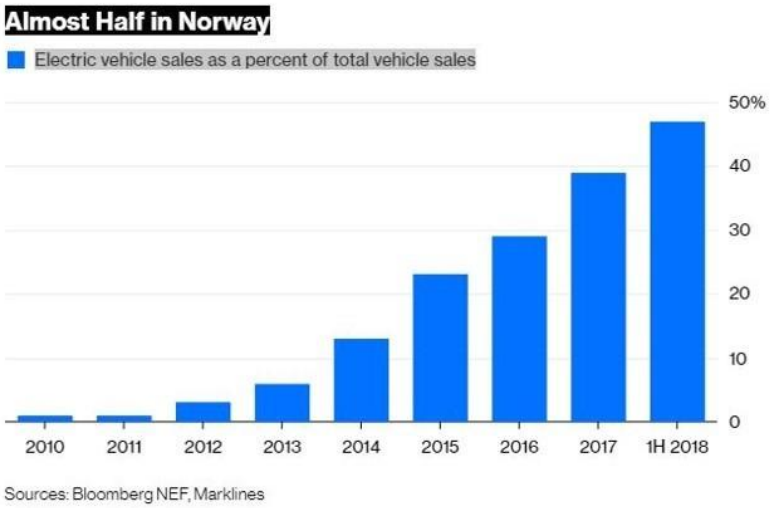
Electric vehicle targets



- A growing number of countries have targets for electric vehicle usage
- US and Norway are leading the way, but China could catch up quickly
- Car manufacturers will play as important a role as the sellers of electricity
- Infrastructure for charging and storage will be key

Electric vehicles could have a big impact in the transport sector

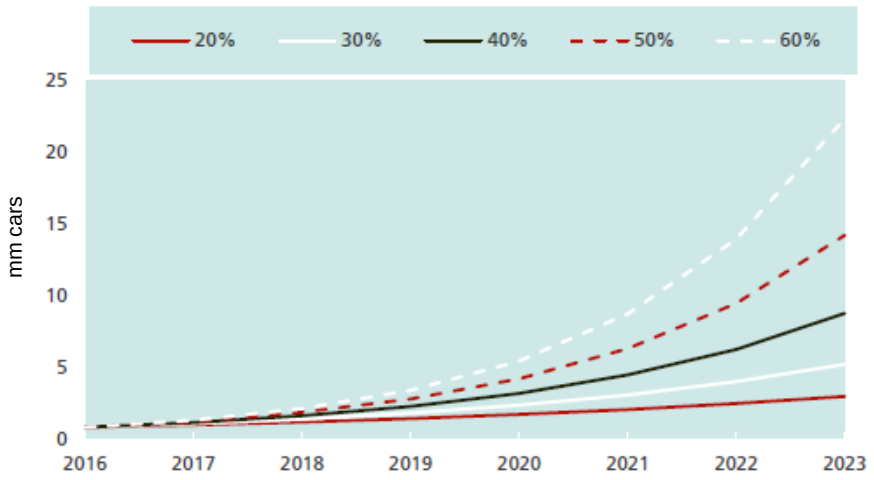




- Total EV sales reached 1.1 million in 2017, up from 0.3 million on 2016
- Compound annual growth has been 75% since 2011 (growth in 2017 was 53%)
- China is now the largest market, with a CAGR of 100%
- In Norway EVs account for almost half of all vehicle sales

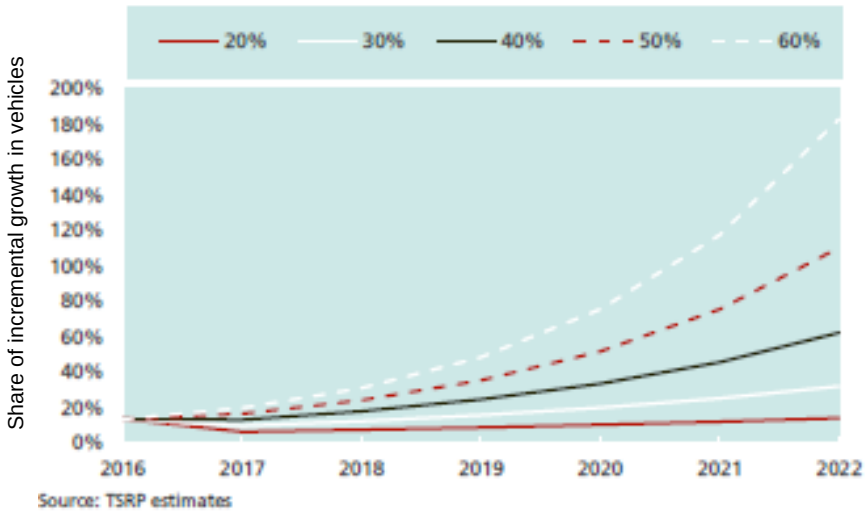
EV impact on car sales growth

Total EVs at different growth rates



Source: TSRP estimates.

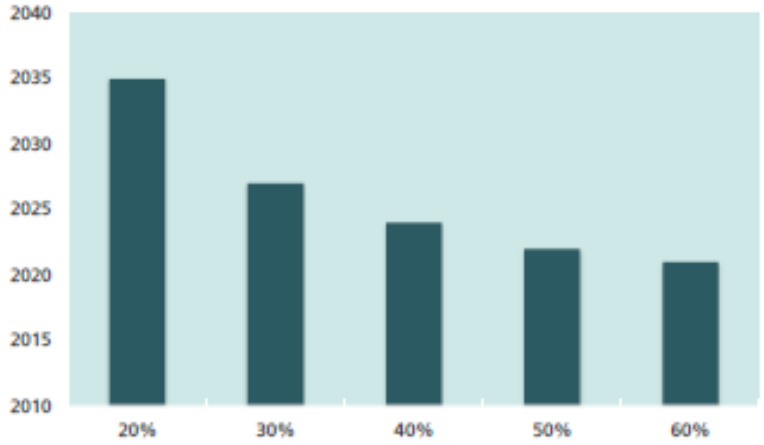
Share of EVs in incremental growth



Source: TSRP estimates

- A key argument for fossil fuels is when the tipping point for growth is reached
- Electric vehicles can provide a good example: at what point will EVs account for all incremental growth in car sales
- At a 60% growth rate it could be as early as 2020

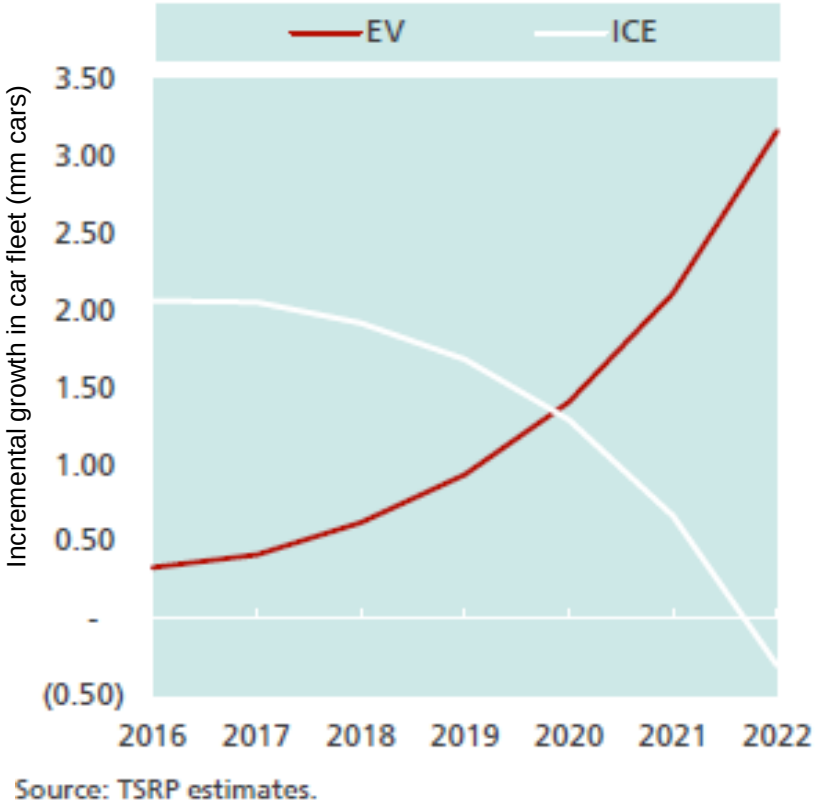
Year of tipping point



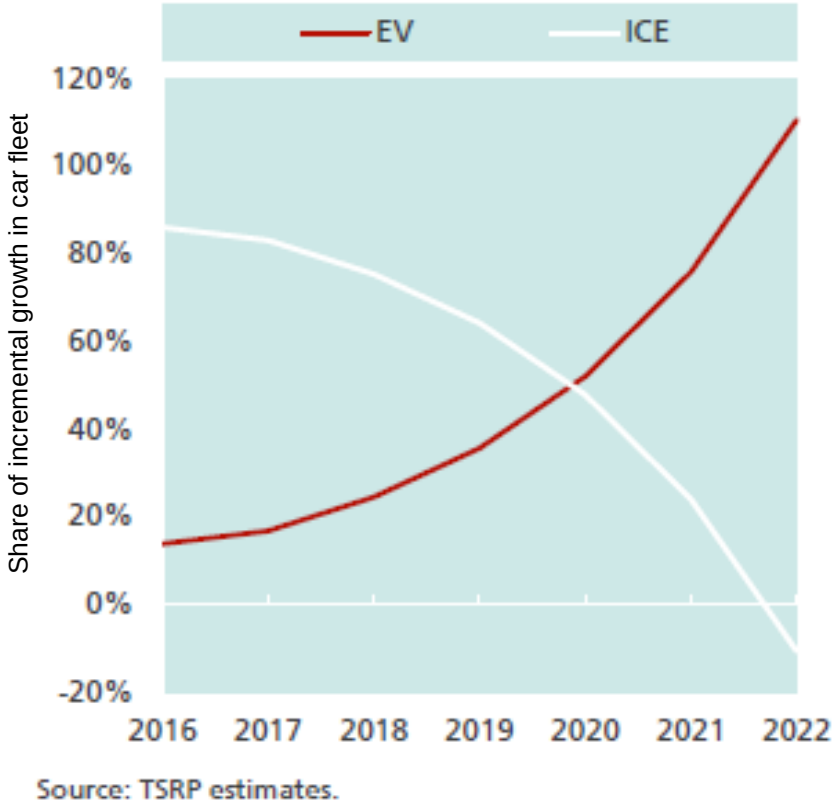
Source: TSRP estimates.

If EVs grow at 50% per annum, car manufacturers and oil producers have some serious thinking to do

The car market if EVs take off



Source: TSRP estimates.

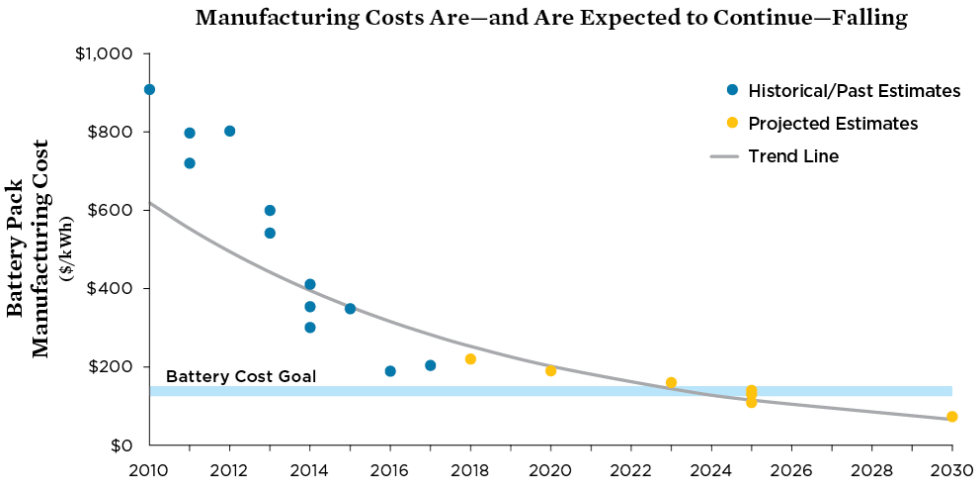


Source: TSRP estimates.

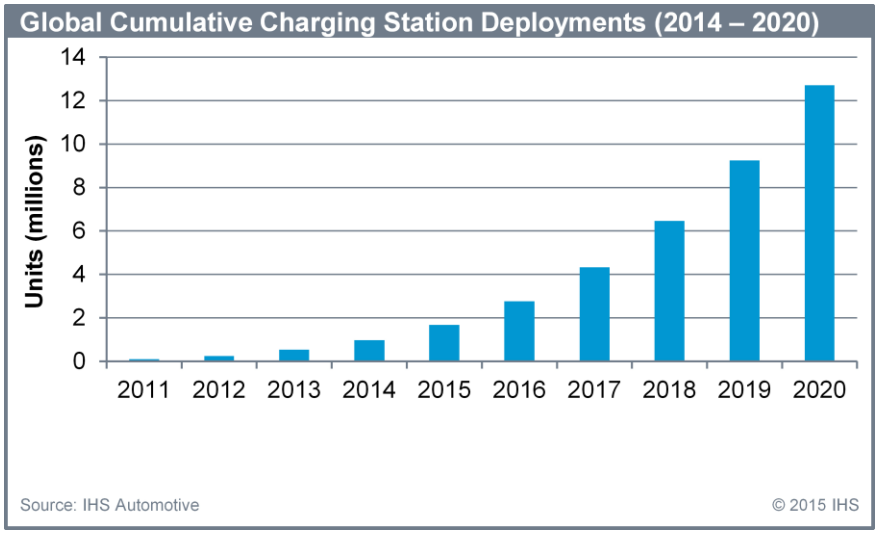
- Once the growth in ICE vehicles comes to a halt, vehicle manufacturers will accelerate production and development of EVs
- This will create an unstoppable momentum towards an electric world of transport

Some infrastructure and technology issues

Battery prices ($/kwh)



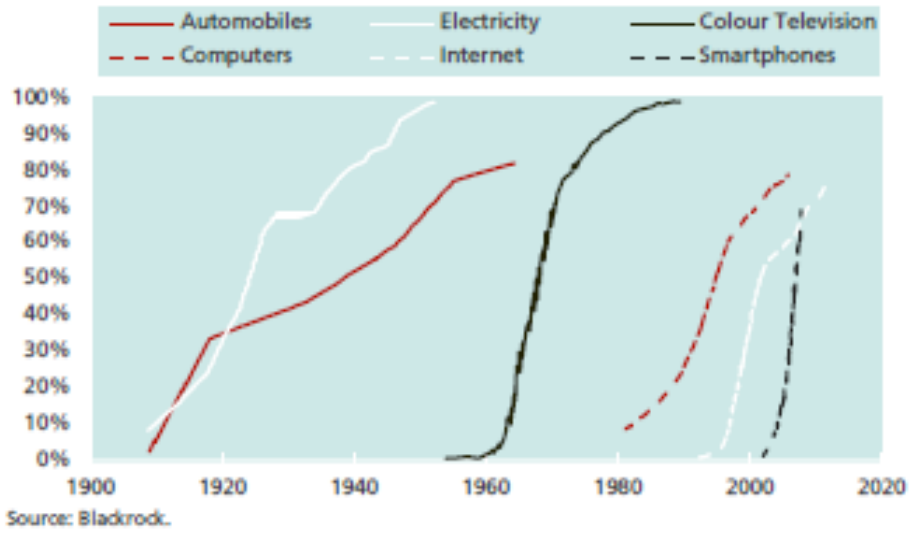
Charging stations worldwide ('000)



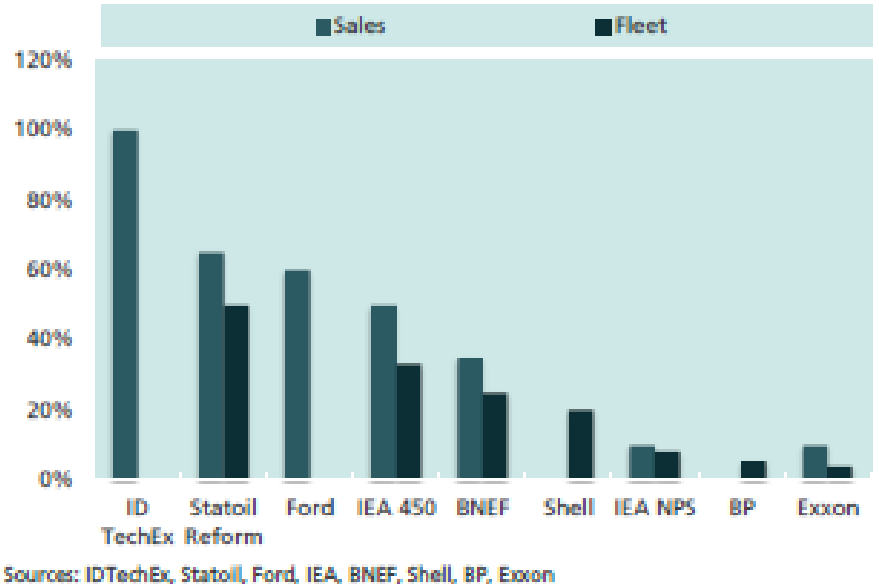
- Battery prices have been falling at 21% p.a. since 2008
- They could reach $150/kwh by 2023-24, at which point a car battery would cost around $6-8,000
- Charging infrastructure has also expanded rapidly, doubling every year since 2010
- Policy plays a key role – China has plans to build 5 million charging points by 2020

Behavioural economics could suggest rapid growth

US household penetration of new technologies



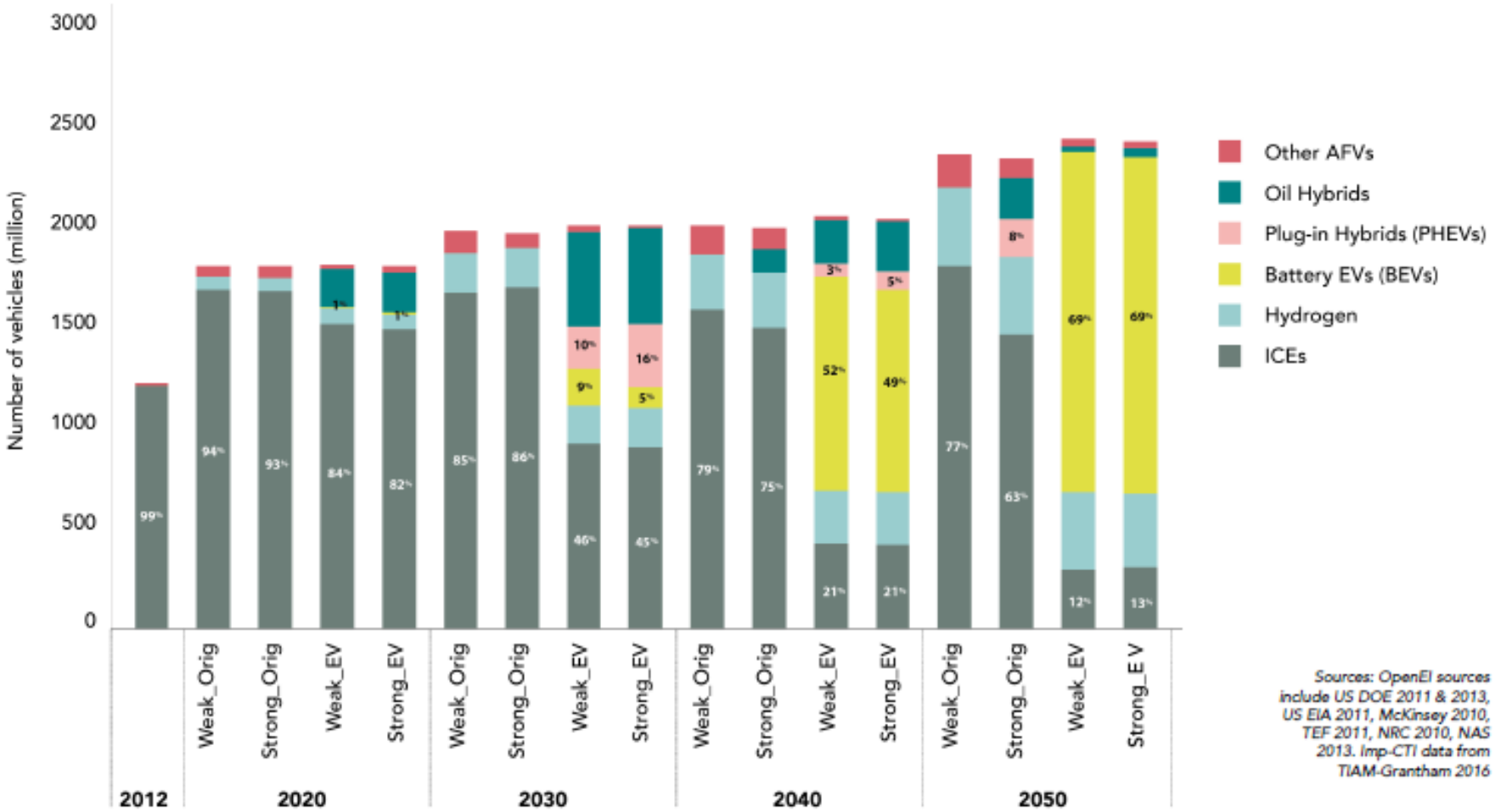
EV share of sales and fleet, end of period



- 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

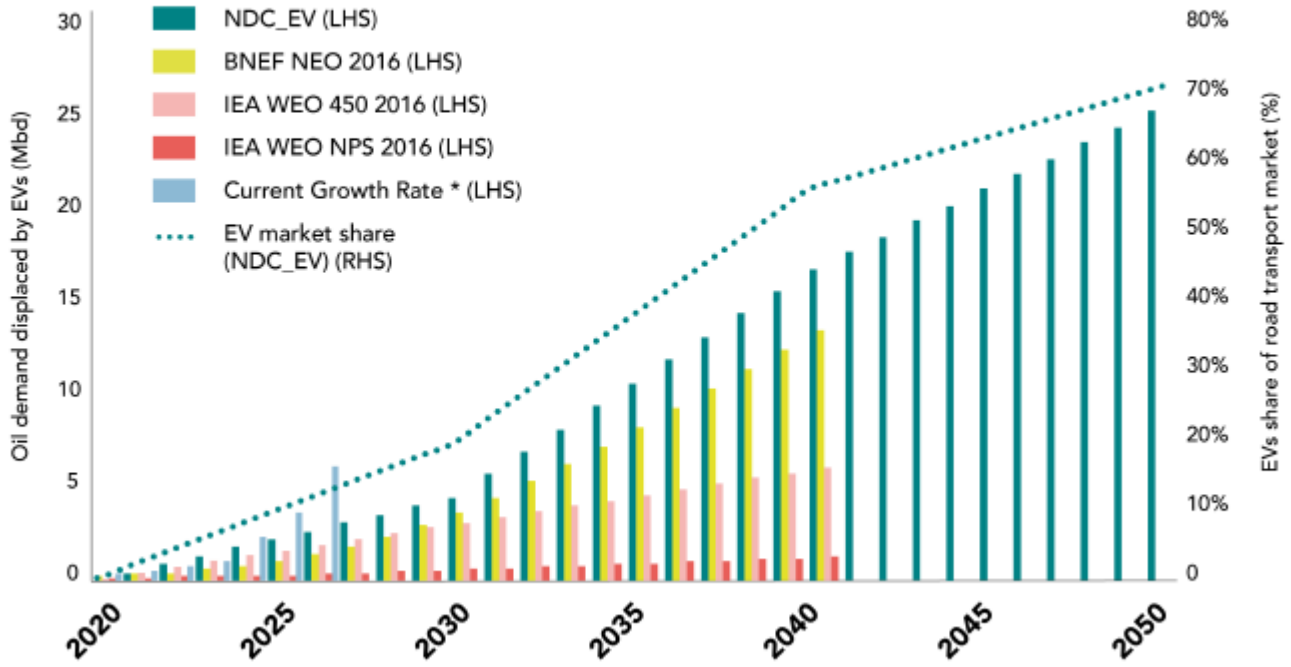
Figure 9: The share of road transport met by different vehicle technologies under original and lower EV costs, and varying climate policy effort[4]



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

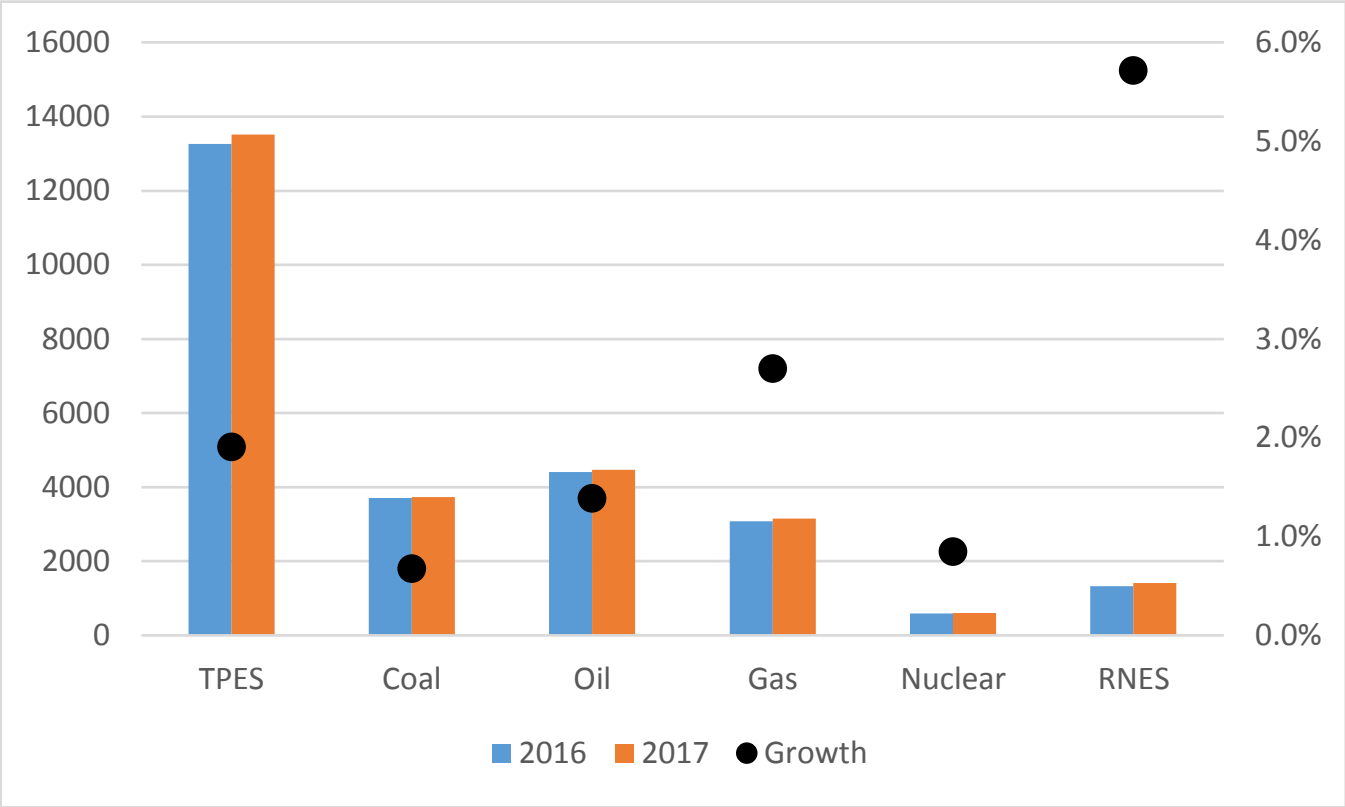
Figure 10: Comparing levels of oil demand displaced by EVs across institutional projections[4]



- 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?

Demand and change in demand for fossil fuels

Total global energy demand grew by 127mtoe in 2017, of which renewables accounted for 30%

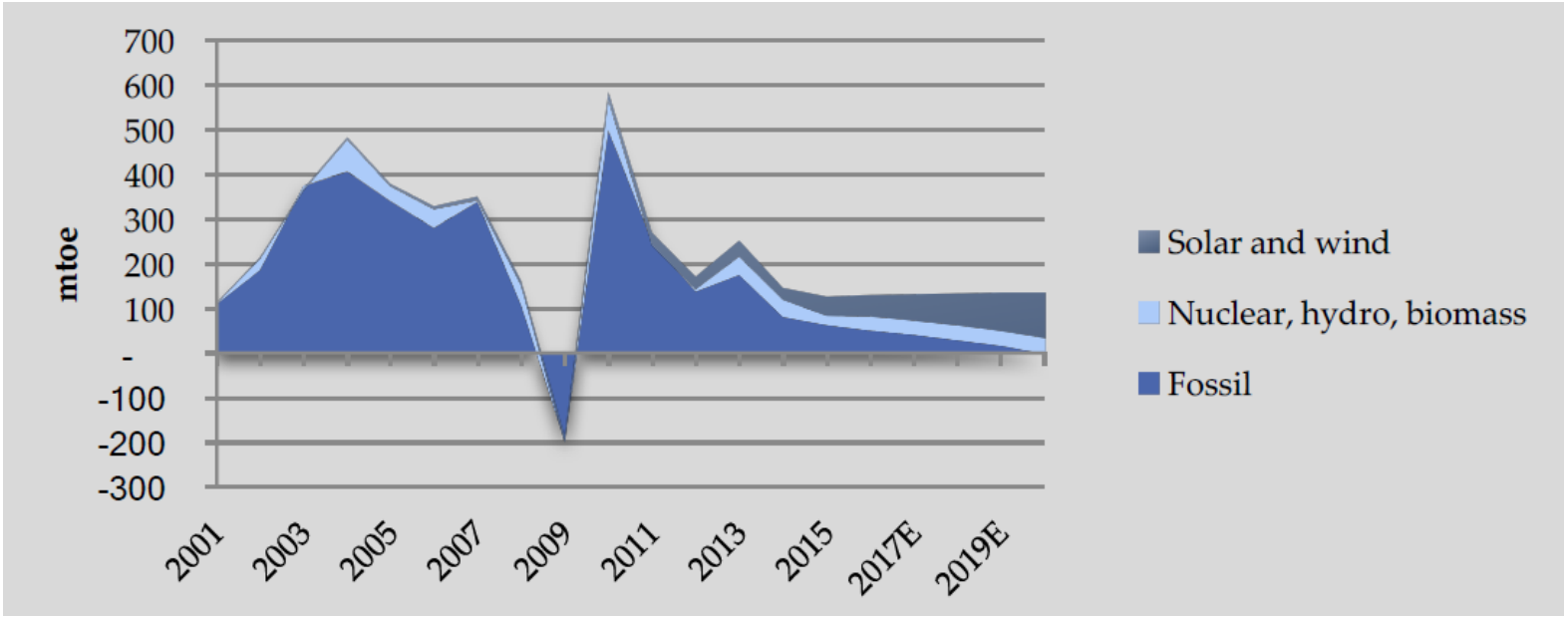


Source: BP (2018)

- Oil, coal and gas continue to dominate the energy mix, and will do so for the next two or three decades
- All forms of fuel consumption grew in 2017, reversing the 2015-16 trend
- However, the incremental change in energy demand is increasingly being filled with alternatives

Marginal demand growth for fossil fuels could end as early as 2020

Marginal supply of energy (mtoe)



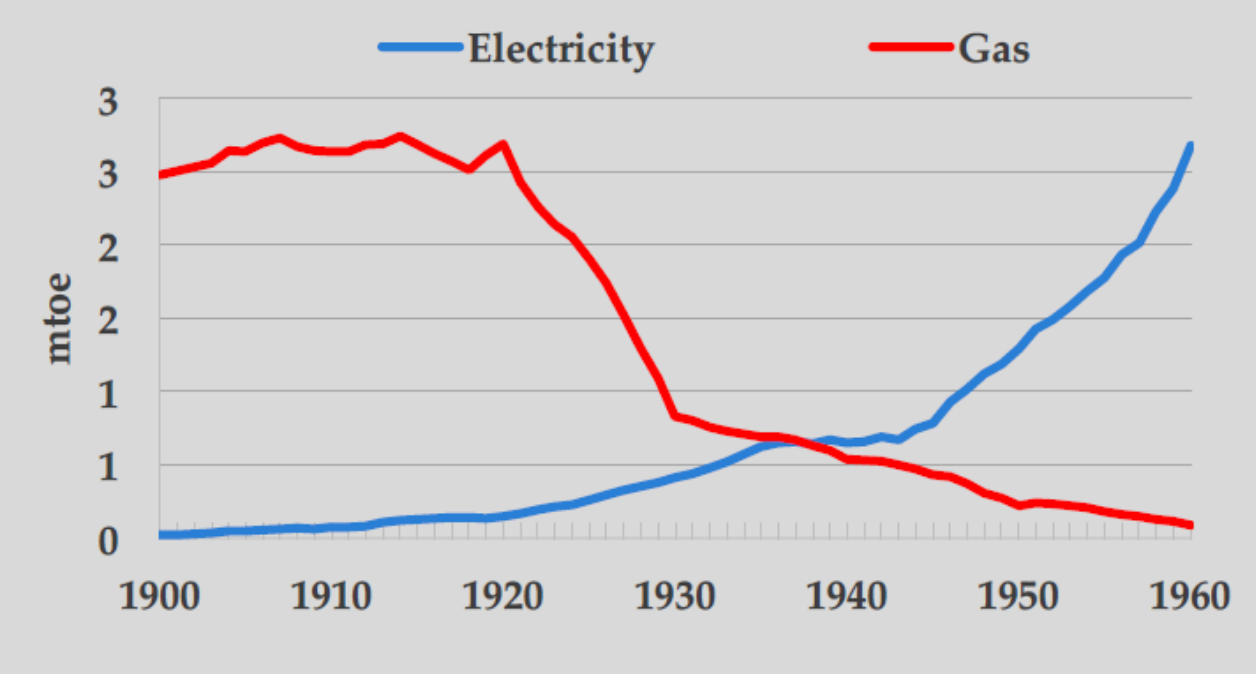
- On the assumption that global energy grows at 1% per annum and that solar and wind maintain existing growth rates, renewables could account for all marginal growth in energy demand by 2020
- There is clearly flexibility around this date – if global energy demand grew at 2% and renewables by 10% the tipping point would be 2046
- However, given the increased focus on energy efficiency and the global policy switch to renewables, sooner rather than later seems likely

Examples of Change in the UK Energy System

New energy sources had very small market share when "old" energy demand peaked

Area	Energy Source		Date of peak 'old' demand	Market share at peak demand	
	Old	New		Old	New
Power	Steam	Electricity	1907	84%	3%
Transport	Coal	Oil	1913	94%	2%
Light	Gas	Electricity	1914	69%	3%
Heat	Coal	Gas	1940	88%	6%

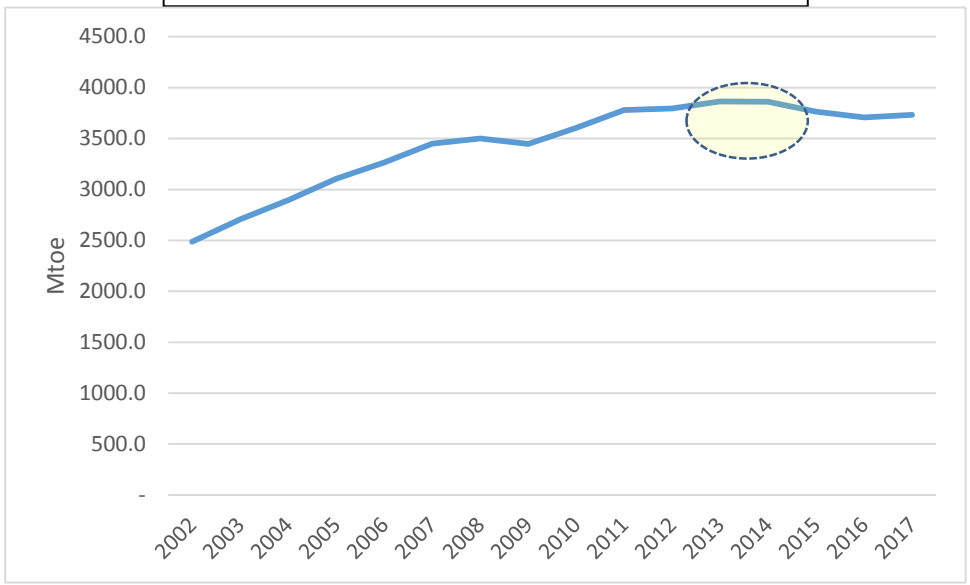
Energy Consumption for Lighting



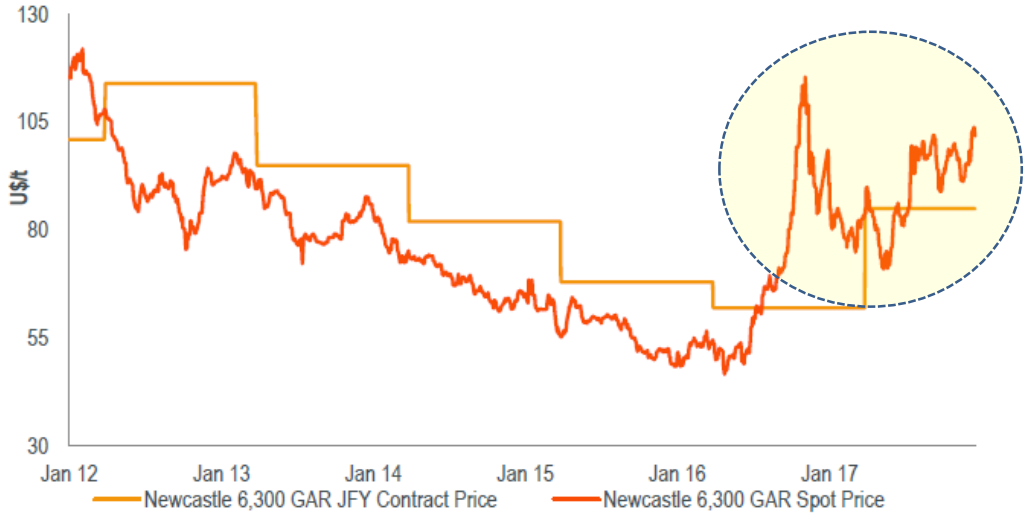
The UK provides some good examples of rapid shifts in energy use due to new technology

The Example of Coal – as a fuel dies its price collapses

Coal demand peaked in 2014…



…but the price has been falling since 2010, with some significant volatility

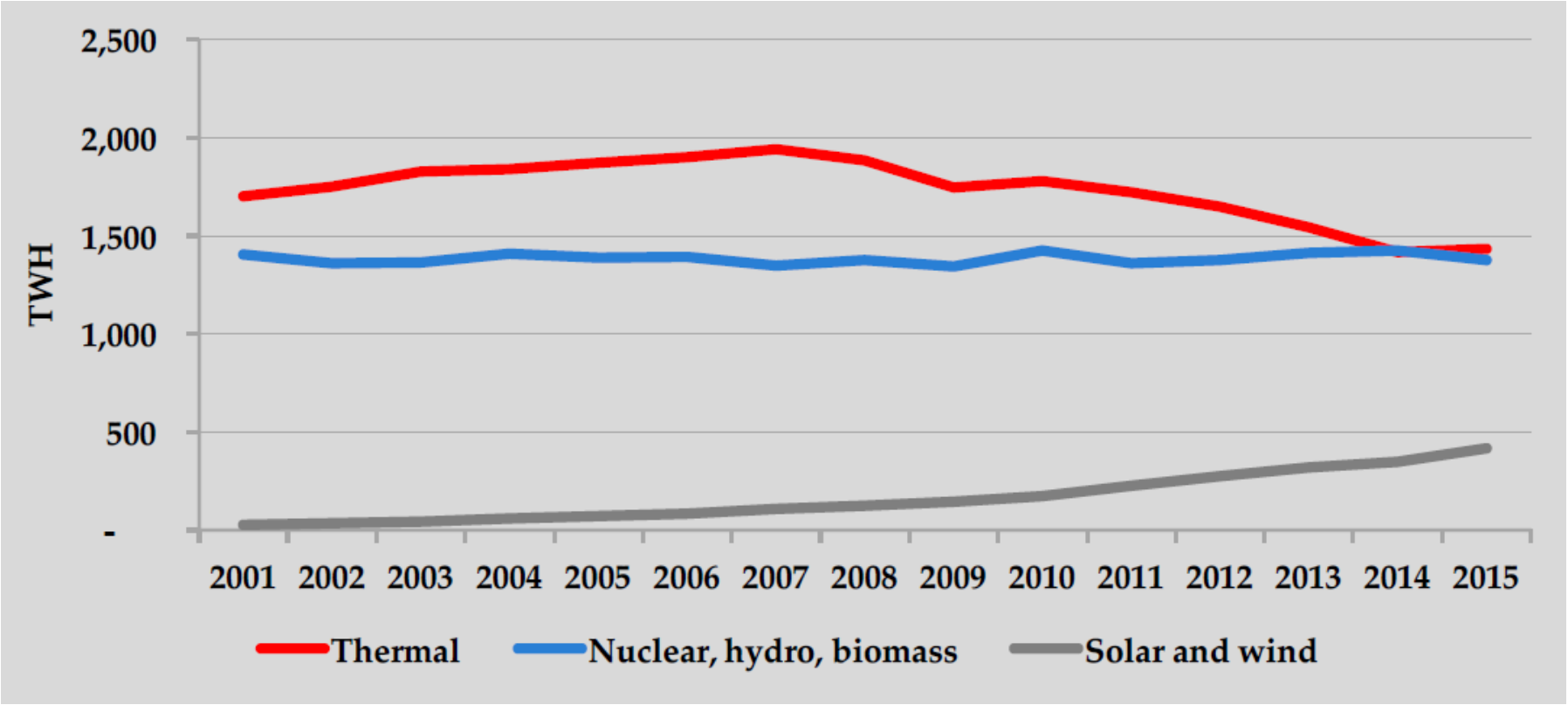


Volatility around China's coal production strategy

Source: AME

European Electricity sector is another example

European electricity supply by source



- The European electricity sector is another example of ongoing change
- Demand for fossil fuels peaked in 2007, prices peaked in 2008 and the major utilities have now had to undergo major restructuring
- Total demand is only 5% off its peak, but the combination of a slight slowdown and a radical change in the mix has caused major turbulence

Various scenarios for coal and gas in the power sector

Figure 6: Comparing projections for coal's share of power generation

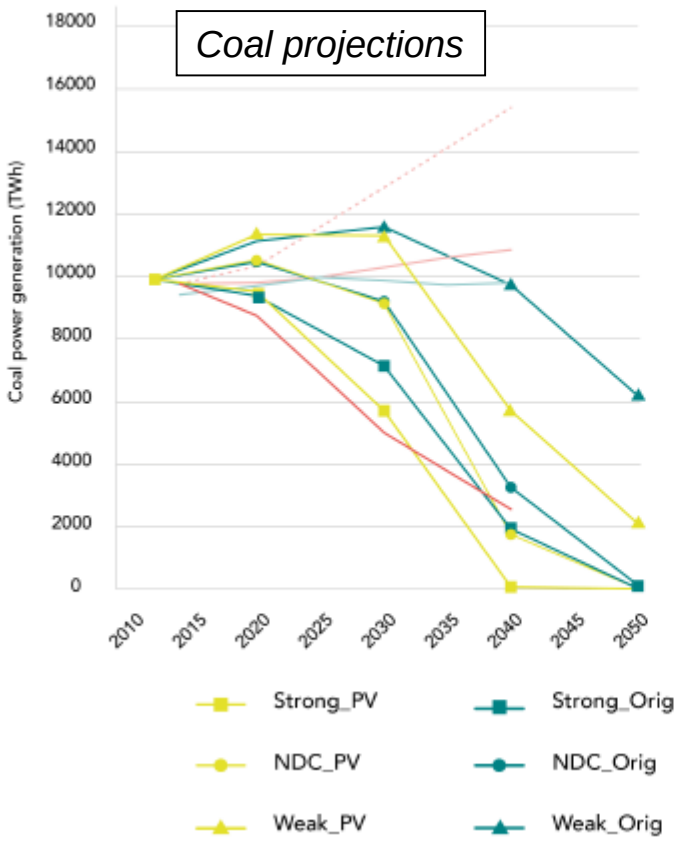
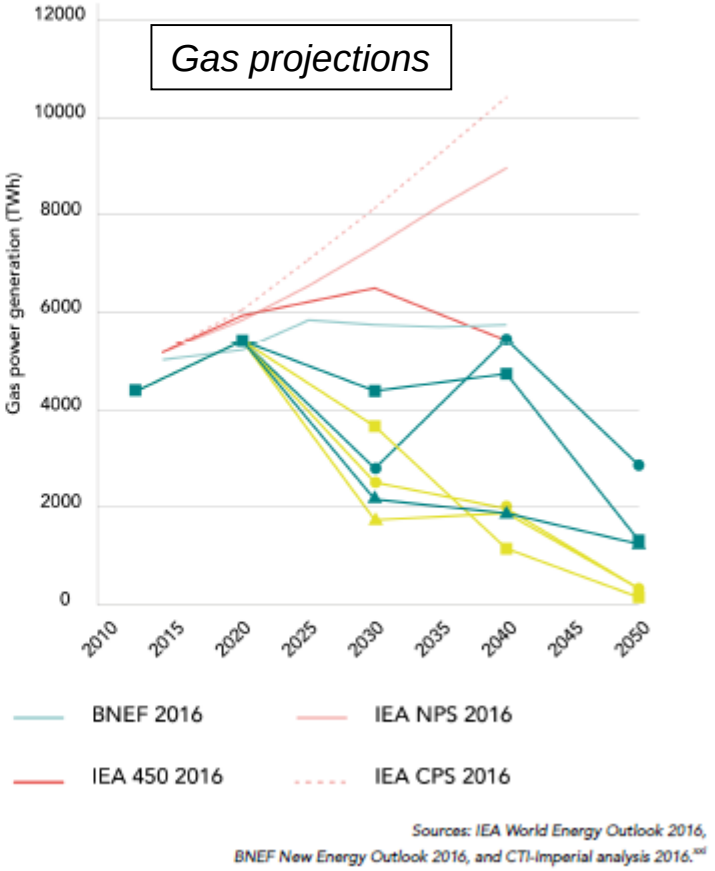


Figure 7: Comparing projections for gas's share of power generation

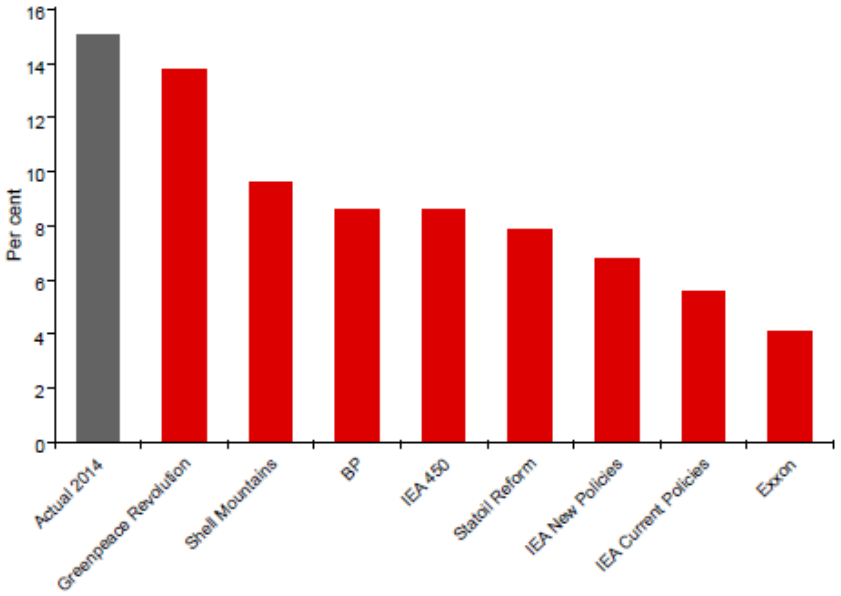


Sources: IEA World Energy Outlook 2016, BNEF New Energy Outlook 2016, and CTI-Imperial analysis 2016.[xxi]

- In the status quo scenario, demand for both gas and coal grows sharply to 2040
- However, in a decarbonising world, the opposite is true
- When will we know which scenario we are on?
- And how will producers react when we do?

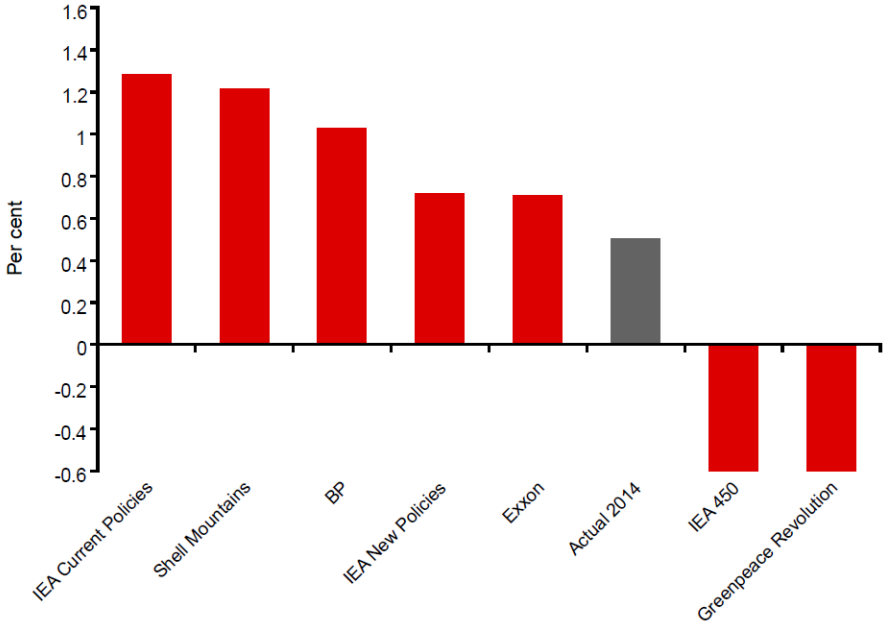
Differences of opinion on energy outlook

Estimates of growth in Wind and Solar Power



Sources: BP, Shell, IEA, Exxon, Statoil, Greenpeace.

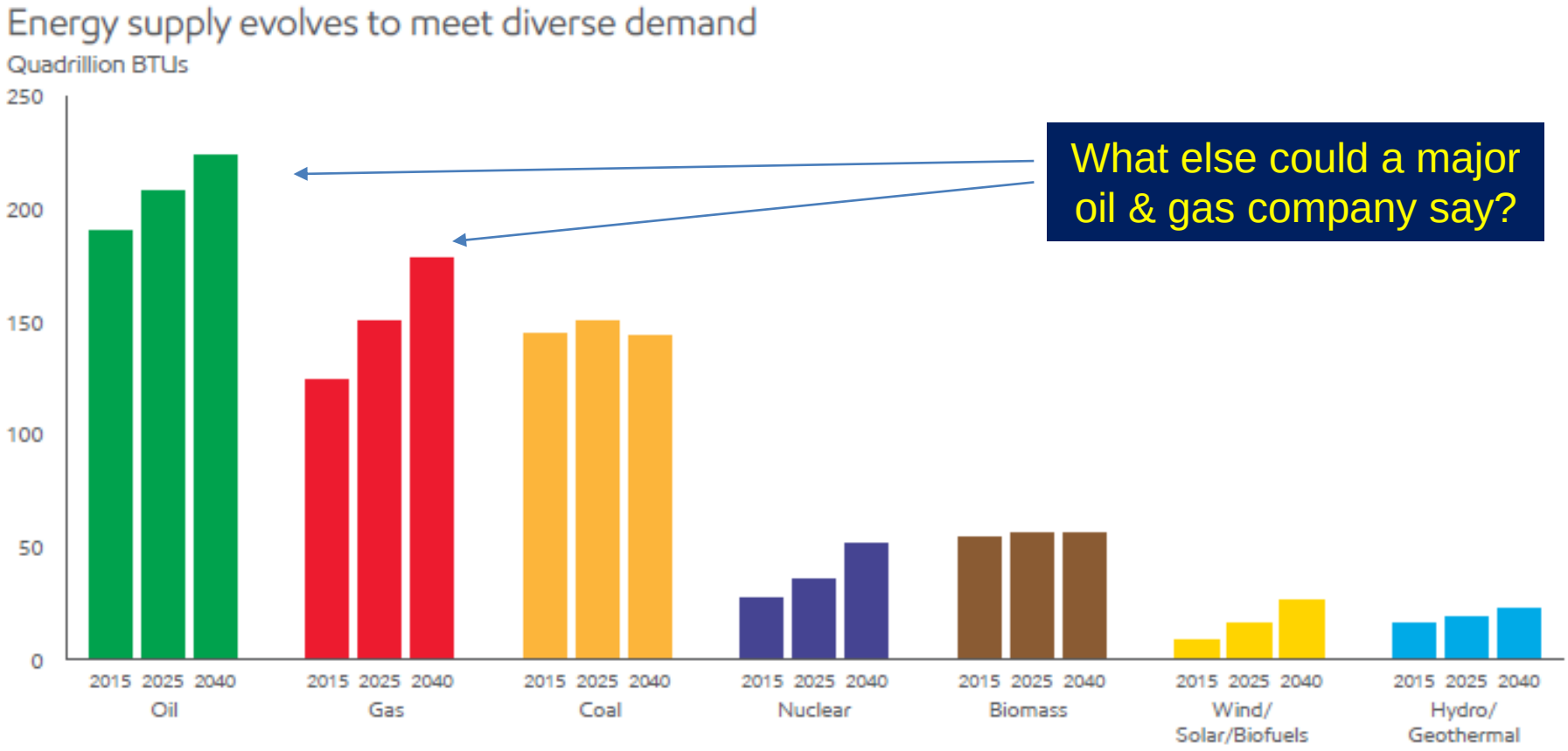
Estimates of growth in Fossil Fuels



Sources: BP, Shell, IEA, Exxon, Statoil, Greenpeace.

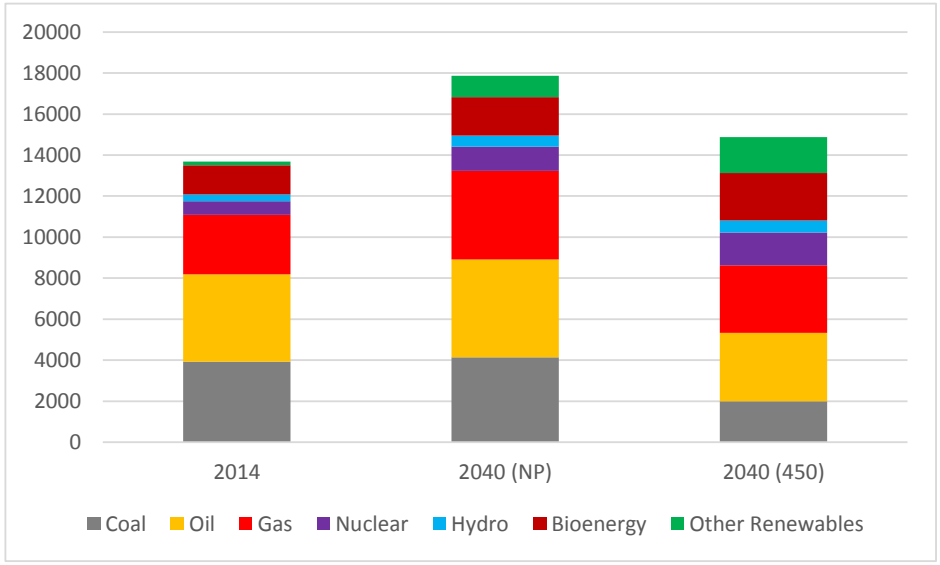
- There are numerous outlooks for world energy, all produced by bodies with different vested interests
- However, one thing is clear – the level of uncertainty over the outlook for the global energy economy has rarely been higher
- Timing, rather than direction of travel, is the key issue

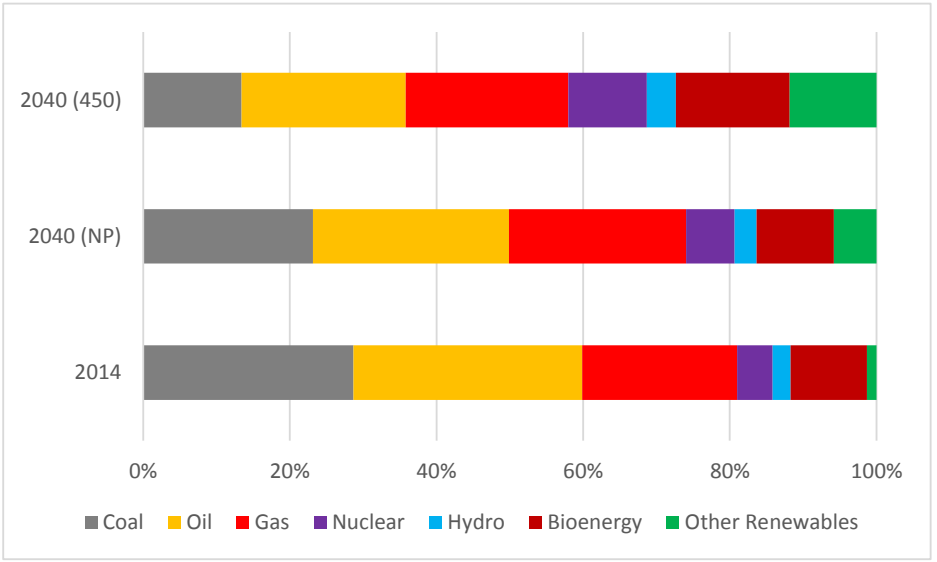
ExxonMobil Outlook presents an Oil Company view



- Presented as a realistic version of the likely outcome – nothing will happen as fast as expected, despite policy objectives
- Oil and gas demand continue to rise, coal demand peaks and renewables grow rapidly from a low base
- However, climate targets are missed by a long way

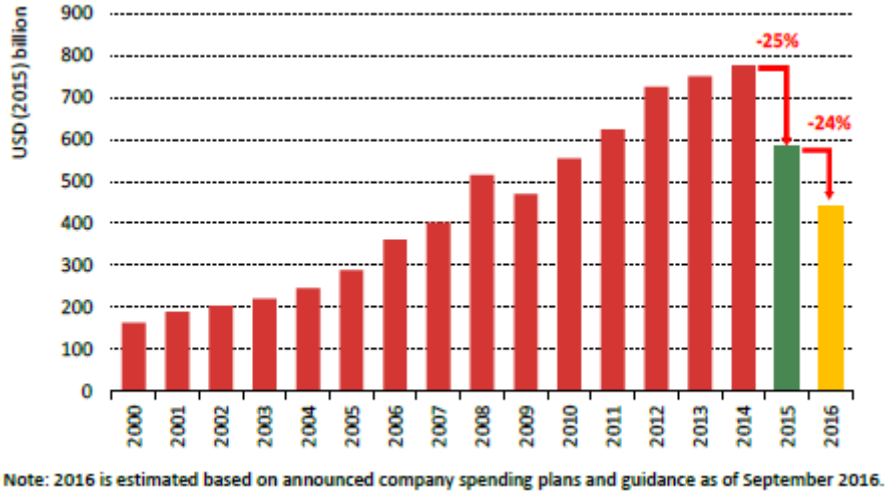
IEA scenarios show an alternative vision based on keeping temperatures down



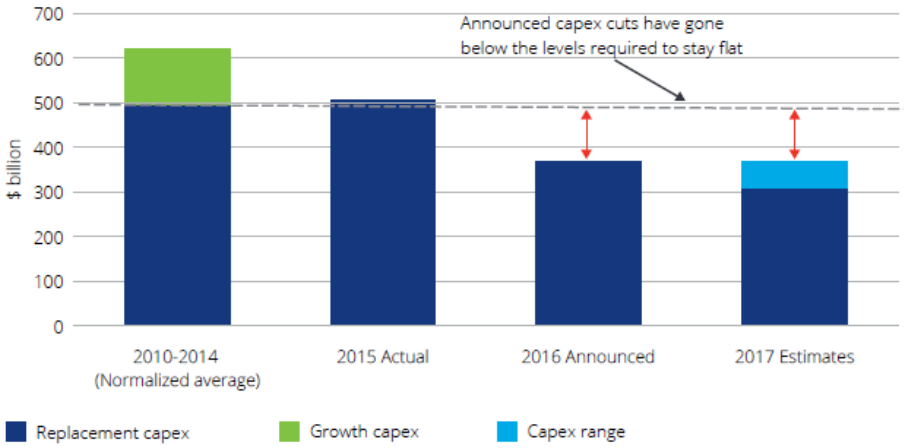


- The IEA presents an alternative view, contrasting existing policies with a 2 degree temperature growth scenario
- Overall demand grows much more slowly
- The contrast in coal, gas and oil shares is stark – all are in decline by 2040
- However, fossil fuels still account for 58% of the mix in 2040, even in the “450” scenario

Sharp capex cuts in oil and gas industry in 2016 and 2017



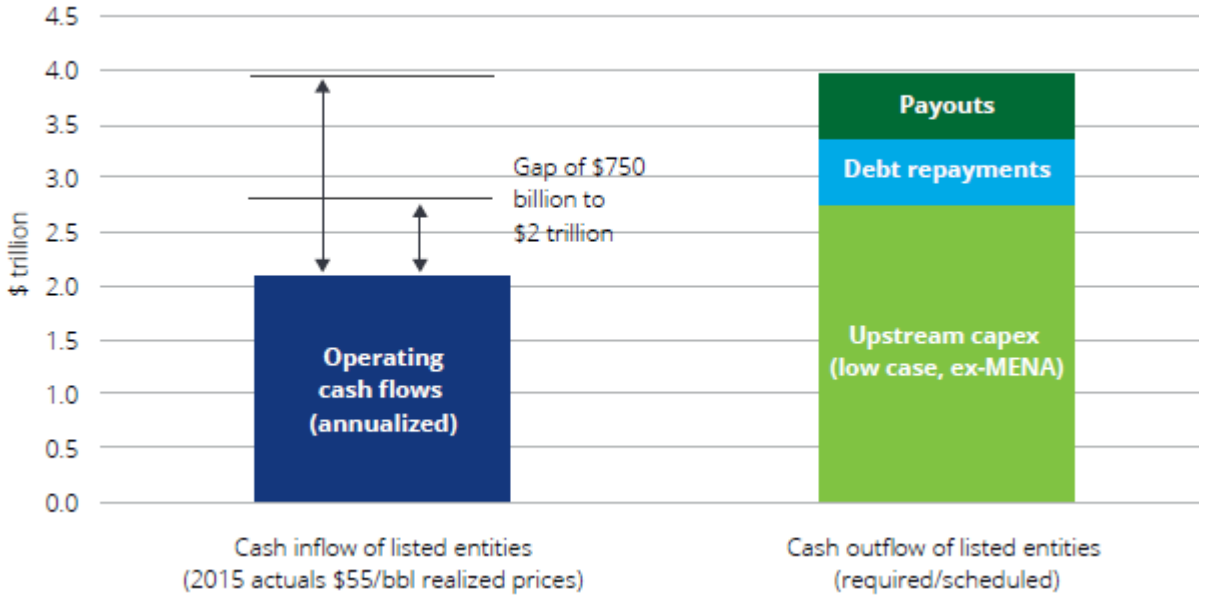
Note: 2016 is estimated based on announced company spending plans and guidance as of September 2016.



- Lower oil price and uncertainty over future leads to cuts in spending
- Short-term risk of under-investment and resultant supply shortage
- Companies struggle to balance long-term investment projects with short-term demand requirements
- Price spikes could be an inevitable consequence if supply does not keep up with demand
- Who are the main short-term winners and what are the implications for security of supply?

How will oil and gas companies use their money?

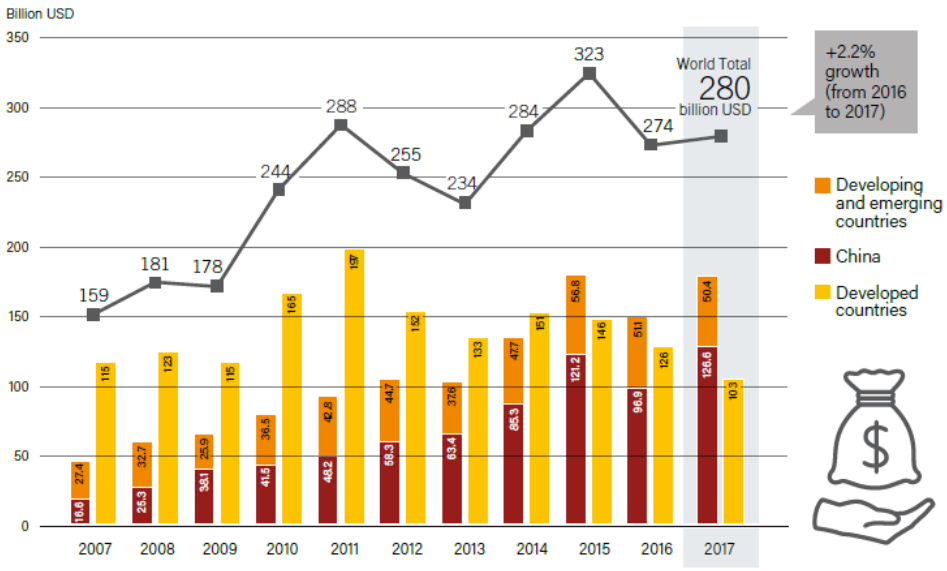
Oil company sources and uses of fund (2016-2020)

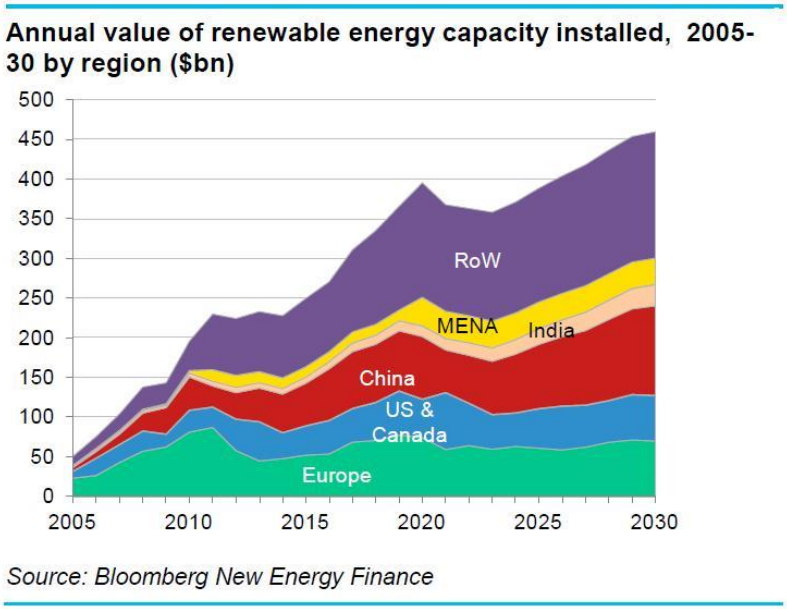


Source: IEA

- The managers of oil companies have some key questions to ask about how they use their diminished operating cashflow
  - New investment
  - Pay down debt
  - Dividends for shareholders
- A key question for shareholders and directors is what is the purpose of oil and gas companies going forward
  - Growing corporate entities?
  - Dividend paying utilities?

Annual investment in renewables must double to meet targets

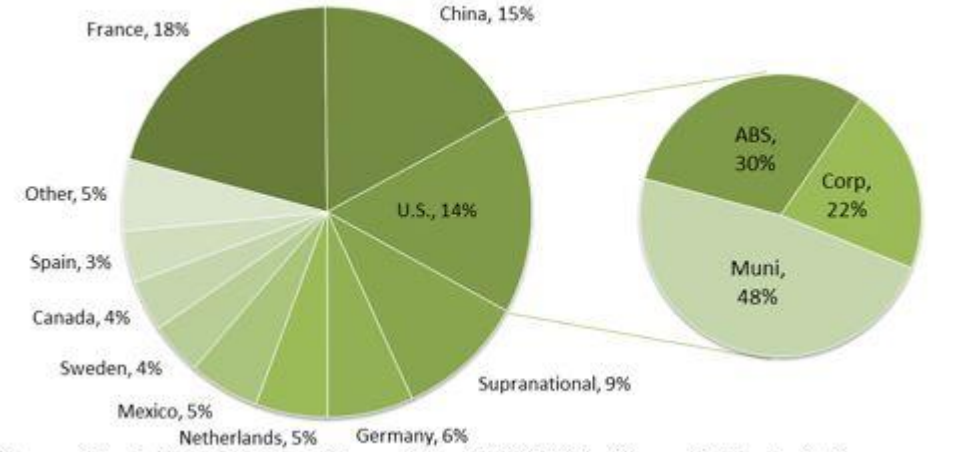




- Investment in renewables rebounded to $280 billion in 2017, although this remains below the 2015 as some countries remove subsidies
- Solar and wind continue to receive the most capital, and China dominates
- Overall investment must rise to $450 billion p.a. to meet temperature targets
- Furthermore, the balance of investment must move away from Europe and North America towards the developing world

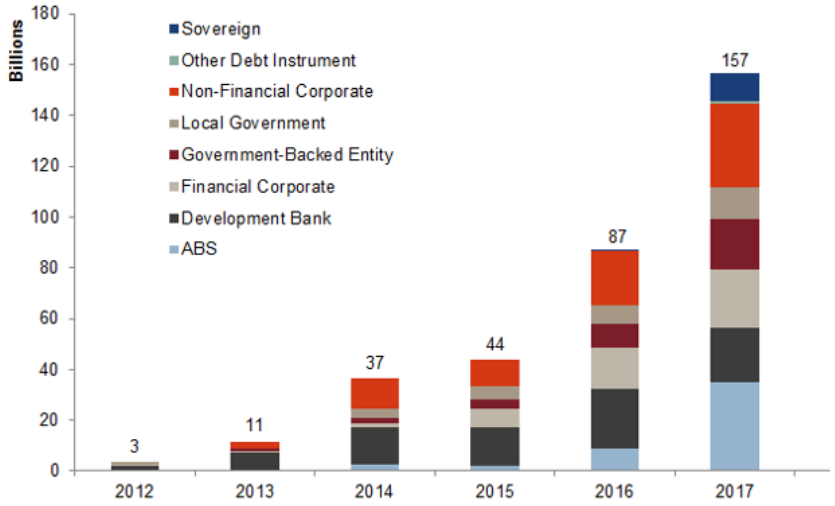
Innovative financing is starting to emerge

Exhibit 2: Green Bond 2017 Issuance by Country



Source: Climate Bond Initiative. Data as of Sep. 29, 2017. Chart is provided for illustrative purposes.

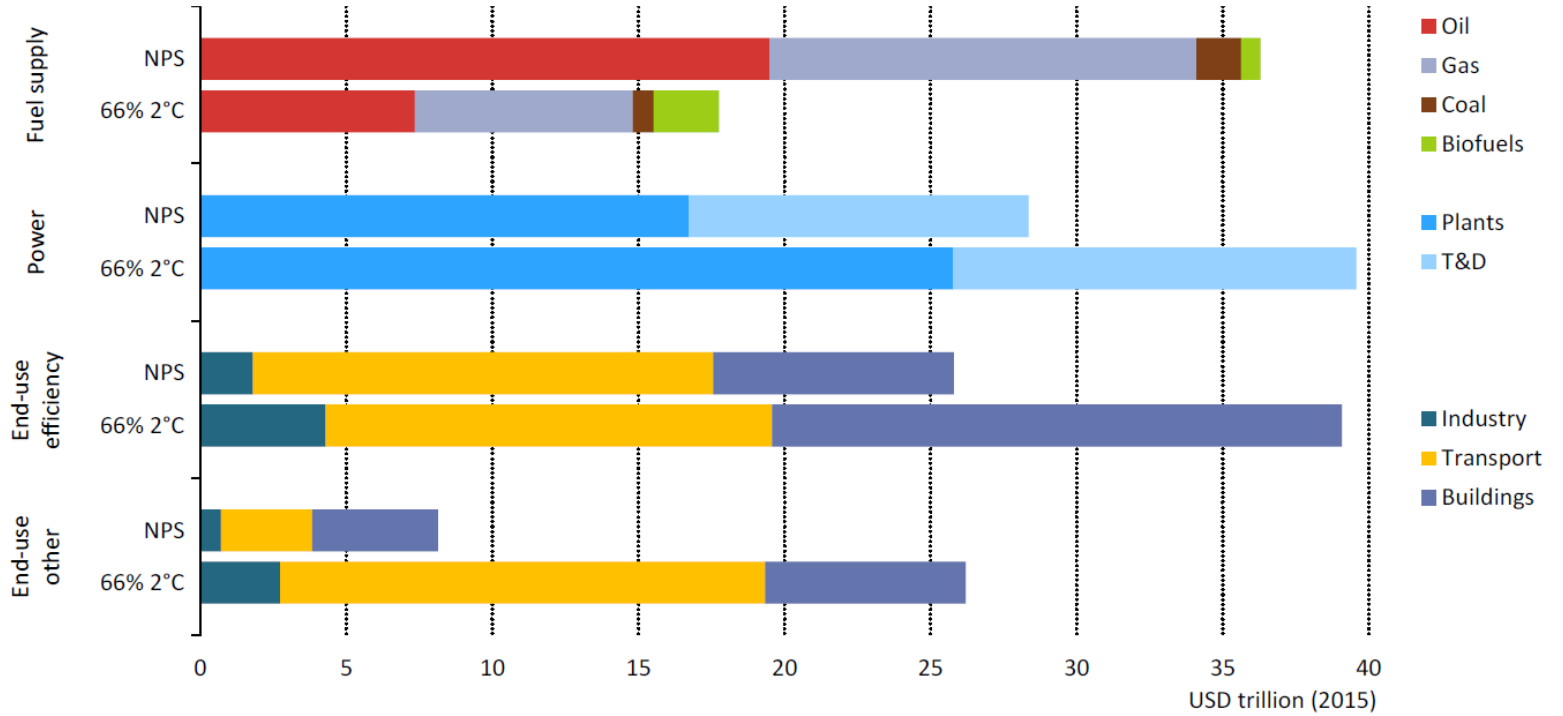
Exhibit 1: Green Bond Annual Gross Issuance



Source: Climate Bond Initiative. Data as of Feb. 14, 2018. Chart is provided for illustrative purposes.

- To date asset financing has been the most prevalent source of investment (loans backed by collateral)
- As subsidies are gradually removed / become less necessary, more innovative forms of financing will be required
- Private equity and venture capital have played a role, and green bonds have been introduced as a more general form of debt for a wider investor base

Differing investment requirements depending on policy outcomes



Notes: NPS = New Policies Scenario; T&D = transmission and distribution. "End-use other" includes investment in road transportation, CCS and direct renewables in industry and buildings.

- IEA scenarios highlight the key issue – where to put investment dollars
- Annual investment in fossil fuels collapses in "green" scenario, but when will we know what to spend – decisions need to be made in the next few years
- Even green investments carry longer-term risk – will they be overtaken by new technologies

Conclusions

- The direction of travel is clear, the speed is not
- There is a long-term future for oil and gas, but at what price and with what levels of volatility?
- Investment decisions with a long-term timescale need to be made soon, when the view is very unclear
- The result could be a lack of short-term investment that could cause greater price volatility
- Fossil fuel companies and banks are very unsure how to invest capital – should it just be returned to shareholders?
- For renewables, the key issue is financing in a world where subsidies are still needed but can be withdrawn at any time (e.g. UK)