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Future of Energy



Lilian Macleod, Future Transmission Networks, National Grid

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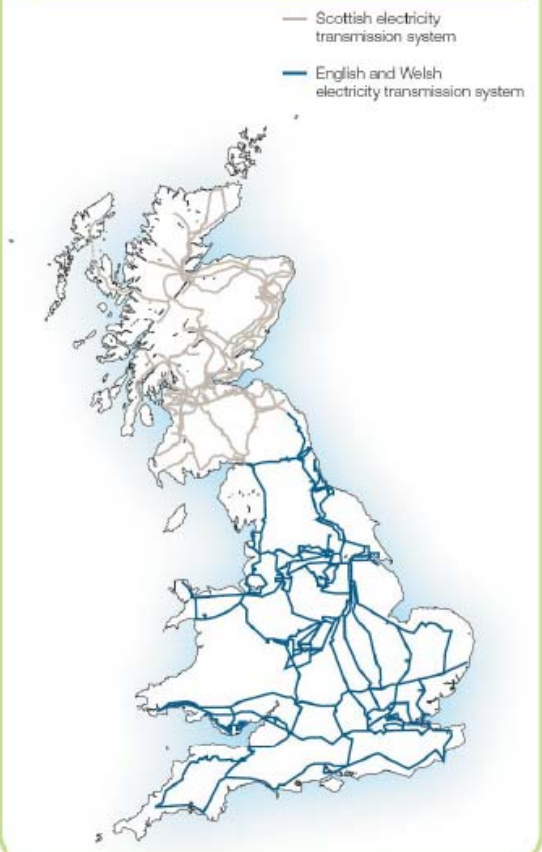
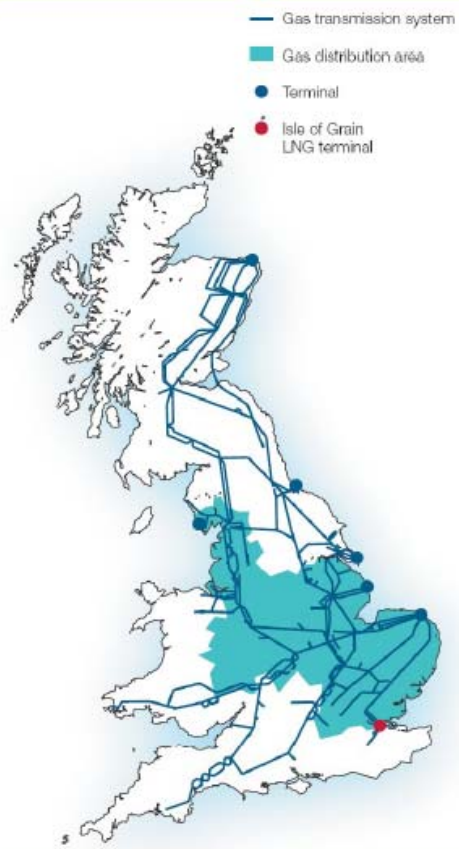
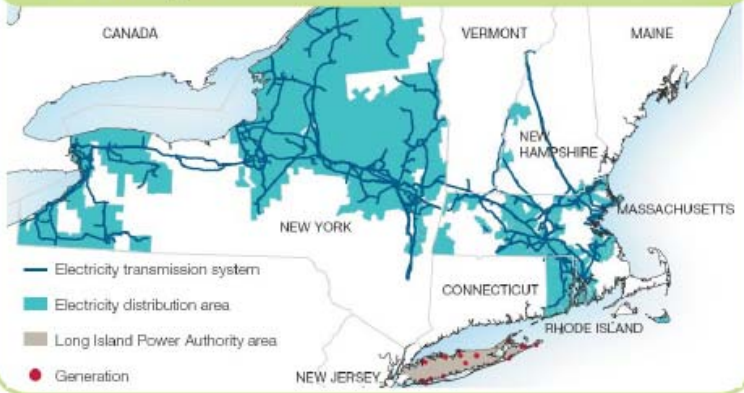
Electricity – UK



Gas – UK



Electricity – US



Gas – US

UK and US

Electricity and Gas

Transmission & Distribution

UK Business

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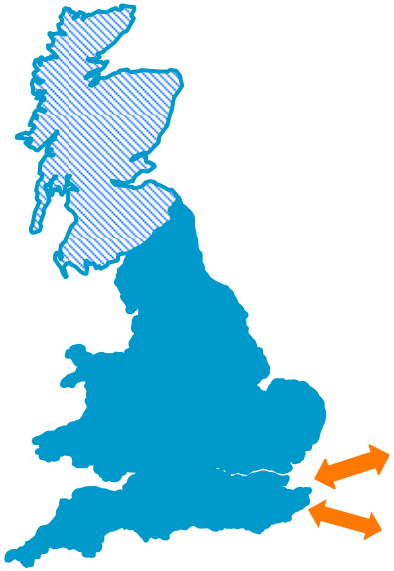
Electricity Transmission



Transmission Owner
England and Wales System Operator GB and Offshore

- 7,000 km of HV overhead line
- 700 km of underground cable
- 338 substations located at 242 sites
- Anglo-French Interconnector
- BritNed Interconnector

Gas Transmission

GB Transmission System Owner & Operator
Grain LNG import terminal
LNG storage

- 7,500 km of high-pressure pipeline
- 23 compressor stations
- 7 coastal terminals

Gas Distribution

Gas Distribution Transmission Owner & Operator (4 DNs)
National Grid Metering

- 132,000 km of pipeline
- 10.8 million end-users
- 18 million meters

Cautionary Statement

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Unless otherwise stated, all financial data of National Grid contained in this presentation is as reported under IFRS. This presentation contains certain statements that are neither reported financial results nor other historical information. These statements are forward-looking statements within the meaning of Section 27A of the Securities Act of 1933, as amended, and Section 21E of the Securities Exchange Act of 1934, as amended. These statements include information with respect to National Grid's financial condition, results of operations and businesses, strategy, plans and objectives. Words such as "anticipates", "expects", "intends", "plans", "believes", "seeks", "estimates", "may", "will", "continue", "project" and similar expressions, as well as statements in the future tense, identify forward-looking statements. These forward-looking statements are not guarantees of National Grid's future performance and are subject to assumptions, risks and uncertainties that could cause actual future results to differ materially from those expressed in or implied by such forward-looking statements. Many of these assumptions, risks and uncertainties relate to factors that are beyond National Grid's ability to control or estimate precisely, such as delays in obtaining, or adverse conditions contained in, regulatory approvals and contractual consents, unseasonable weather affecting the demand for electricity and gas, competition and industry restructuring, changes in economic conditions, currency fluctuations, changes in interest and tax rates, changes in energy market prices, changes in historical weather patterns, changes in laws, regulations or regulatory policies, developments in legal or public policy doctrines, the impact of changes to accounting standards, technological developments and the ability to access capital markets and other sources of credit in a timely manner on acceptable terms, especially considering the recent deterioration of market conditions in the global economy and financial markets. Other factors that could cause actual results to differ materially from those described in this presentation include the ability to integrate the businesses relating to announced or recently completed acquisitions with National Grid's existing business to realise the expected synergies from such integration, the availability of new acquisition opportunities and the timing and success of future acquisition opportunities, the timing and success or other impact of the sales of National Grid's non-core businesses, the failure for any reason to achieve reductions in costs or to achieve operational efficiencies, the failure to retain key management, the behaviour of UK electricity market participants on system balancing, the timing of amendments in prices to shippers in the UK gas market, the performance of National Grid's pension schemes and the regulatory treatment of pension costs, and any adverse consequences arising from outages on or otherwise affecting energy networks, including gas pipelines owned or operated by National Grid. For a more detailed description of some of these assumptions, risks and uncertainties, together with any other risk factors, please see National Grid's filings with and submissions to the US Securities and Exchange Commission (the "SEC") (and in particular the "Risk Factors" and "Operating and Financial Review" sections in its most recent Annual Report on Form 20-F). Except as may be required by law or regulation, National Grid undertakes no obligation to update any of its forward-looking statements. The effects of these factors are difficult to predict. New factors emerge from time to time and National Grid cannot assess the potential impact of any such factor on its activities or the extent to which any factor, or combination of factors, may cause results to differ materially from those contained in any forward-looking statement. The contents of any website referenced herein do not form part of this document.

Where does our energy come from today?

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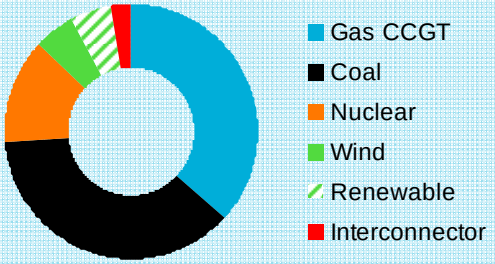
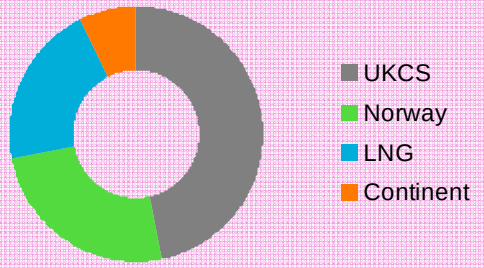
Electricity

Carbon intensity (kg CO_2 / MWh) **499**



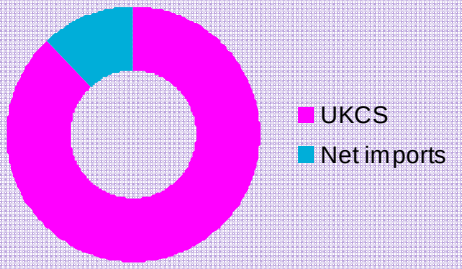
Gas

Carbon intensity (kg CO_2 / MWh) **184**

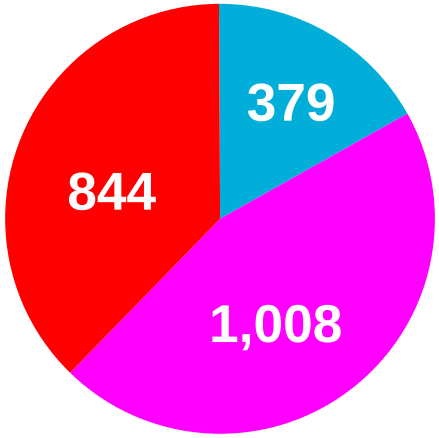


Oil

Carbon intensity (kg CO_2 / MWh) **247**



Annual Demand (TWh)



Electricity
Gas
Oil

Carbon intensity data from DEFRA: www.defra.gov.uk/environment/business/reporting/pdf/101006-guidelines-ghg-conversion-factors.xls

Energy Density

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Total energy use*
49 to 170 kWh / day / household

*Electricity** 5 to 24 kWh / day*



*Transport*** ~4½ to 6 kWh / day*



Gas ~40 to 140 kWh / day



* Average across a year
** After diversity maximum demand 1.5 to 3kW
*** Kinetic energy – i.e. ignoring well to tank and heat loss, average journey 13.6km (93% less than 40km)

Photos courtesy of: Filomena Scalise, Michelle Meiklejohn, Salvatore Vuono, EA, posterize

The future – efficiency, decarbonisation and electrification

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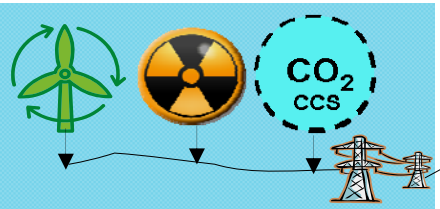
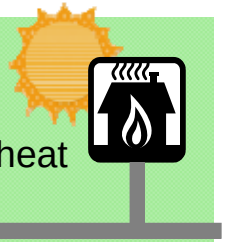
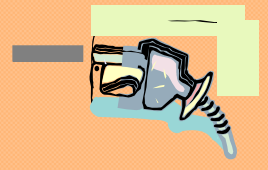
Electricity	Heat	Transport
 Smart Meters & Appliance efficiency	 Insulate and reduce	 Efficiency and innovation
 Decarbonised electricity…	 Heat pump new homes & retrofit	 and decarbonise transport
Gas backup & embedded 	Biomethane  De-carbonise heat	CNG 

……so what are the drivers for the supply chain?

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Demand Responsiveness

- Efficient use and TOU of energy
- Integrating flexible demand

Decarbonising electricity

- Integrating inflexible generation
- Integrating Intermittency
- Integrating embedded generation

Electrifying heat and transport

- Increased demand:
  - Electric vehicles – PHEV, EV
  - Heat pumps

Efficient and reliable network invest & operation

- Timely capacity – planning & consent / supply chain
- Driving harder through complexity and automation
- Providing flexibility and avoiding stranding assets
- Secure and Affordable

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The power of action:

….whilst minimising environmental and societal impact

Smart(er) grids

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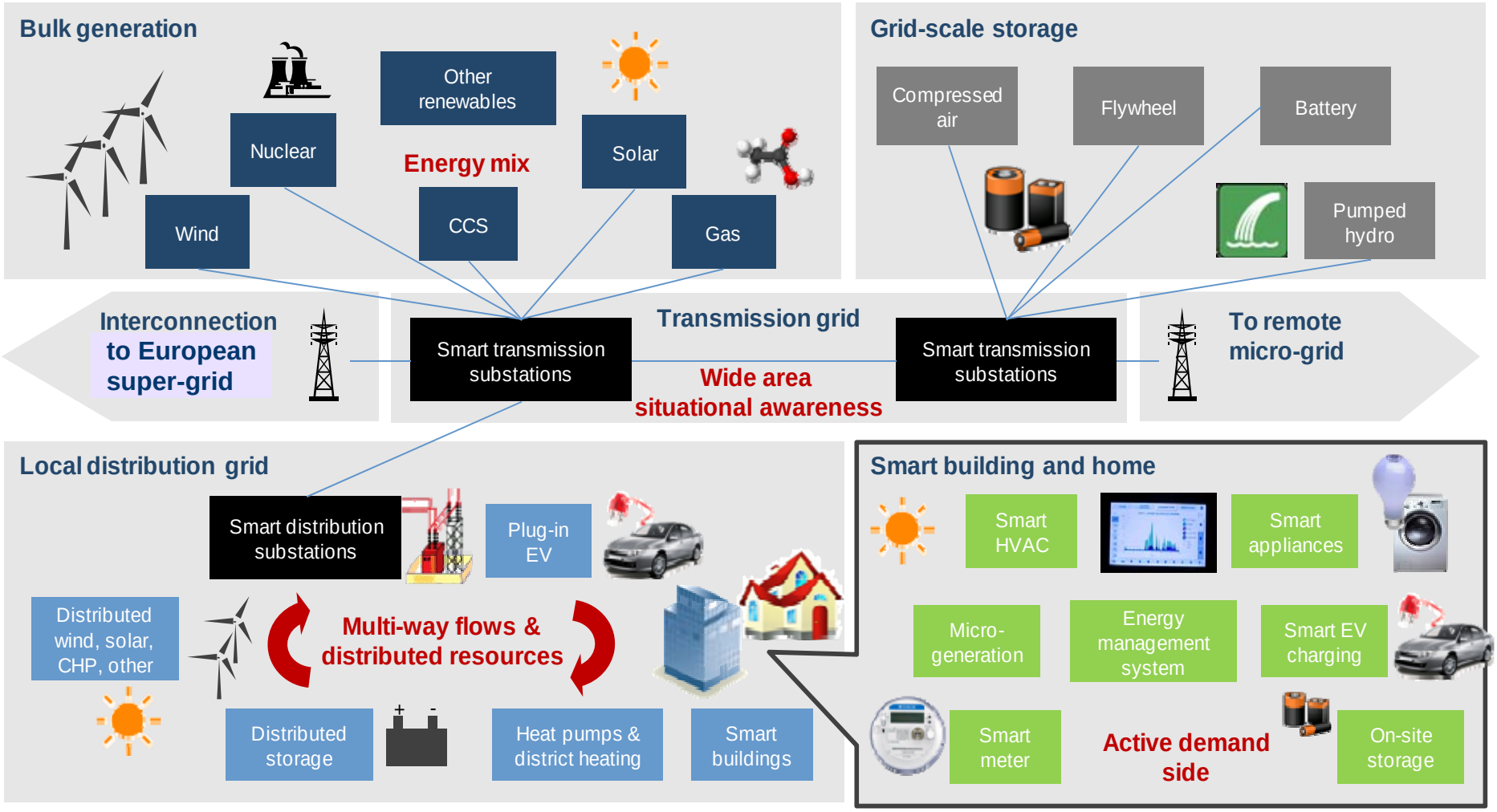

Source – Bloomberg Consortium on Digital Energy 2010

The Need For Change

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	2010	2020	2050
	No renewable target	15% of energy from renewables	No renewable target
	22% reduction in CO_2 emissions vs 1990	34% reduction in CO_2 emissions vs 1990	80% reduction in CO_2 emissions vs 1990
Electricity	% of end use energy 15% Carbon intensity ($kgCO_2$/MWh) 499	% of end use energy ~20% Carbon intensity ($kgCO_2$/MWh) ~200	% of end use energy ~50% Carbon intensity ($kgCO_2$/MWh) ~15
Gas	% of end use energy 42% Carbon intensity ($kgCO_2$/MWh) 184	% of end use energy ~40% Carbon intensity ($kgCO_2$/MWh) 184	% of end use energy ~35% Carbon intensity ($kgCO_2$/MWh) 184
Oil	% of end use energy 43% Carbon intensity ($kgCO_2$/MWh) 247	% of end use energy ~40% Carbon intensity ($kgCO_2$/MWh) 247	% of end use energy ~15% Carbon intensity ($kgCO_2$/MWh) 247

End use oil & gas excludes oil and gas used in power generation

The next 40 years in brief…

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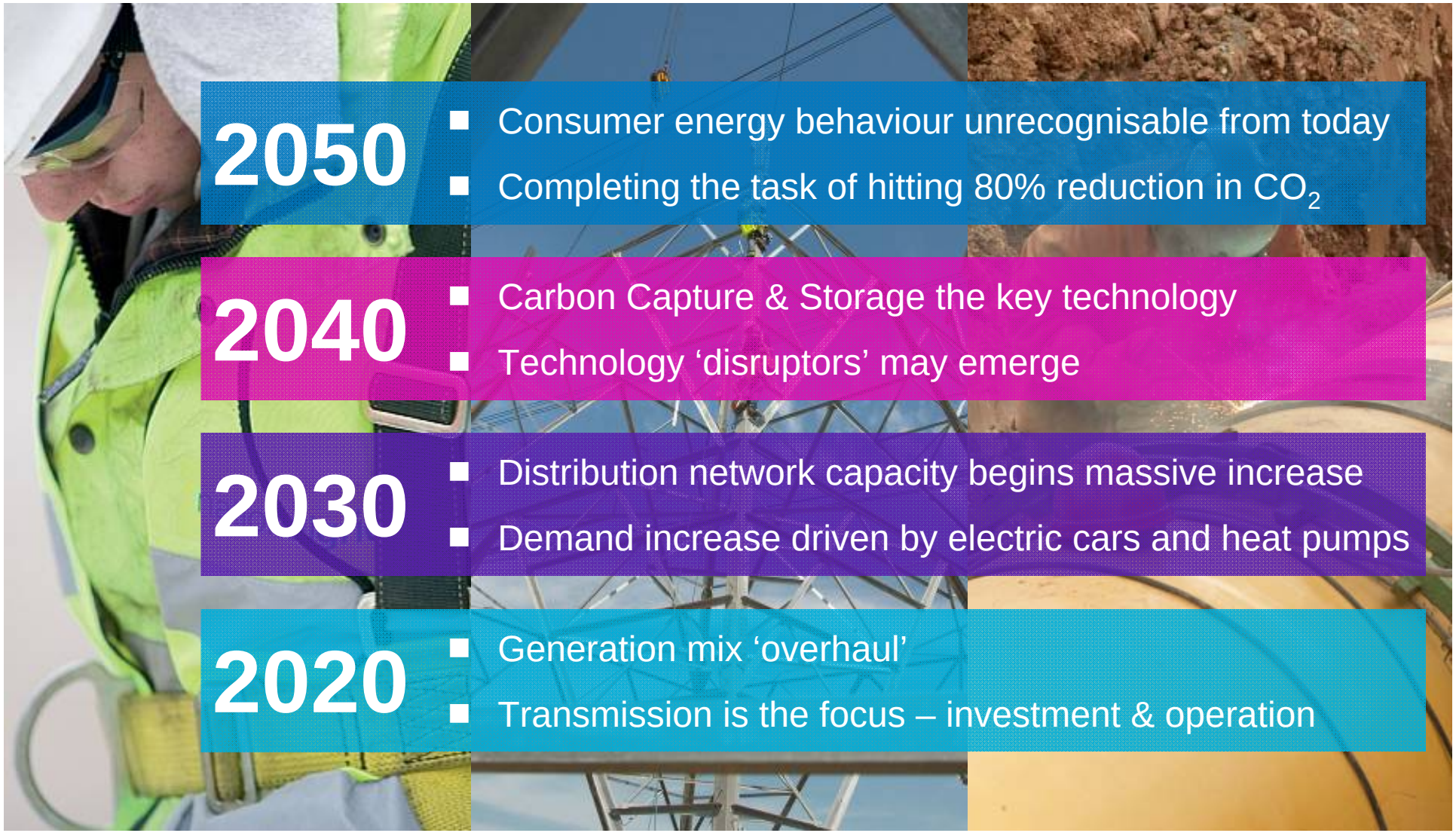

2050

- Consumer energy behaviour unrecognisable from today
- Completing the task of hitting 80% reduction in CO_2

2040

- Carbon Capture & Storage the key technology
- Technology ‘disruptors’ may emerge

2030

- Distribution network capacity begins massive increase
- Demand increase driven by electric cars and heat pumps

2020

- Generation mix ‘overhaul’
- Transmission is the focus – investment & operation

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2040 – 2050

Consumer & Completion

2050

‘Consumer behaviour key to a low carbon energy future…’

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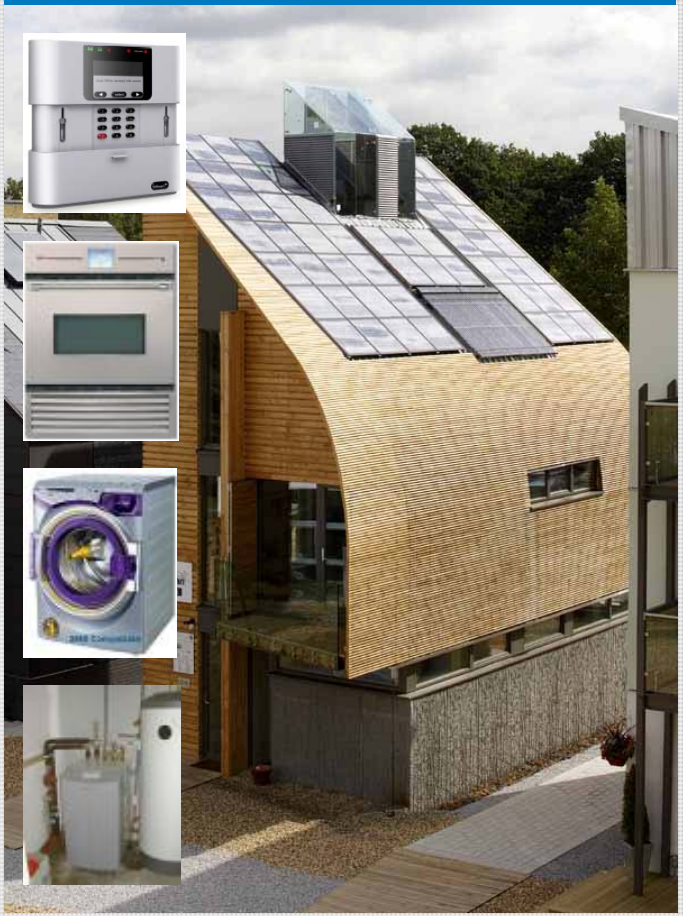
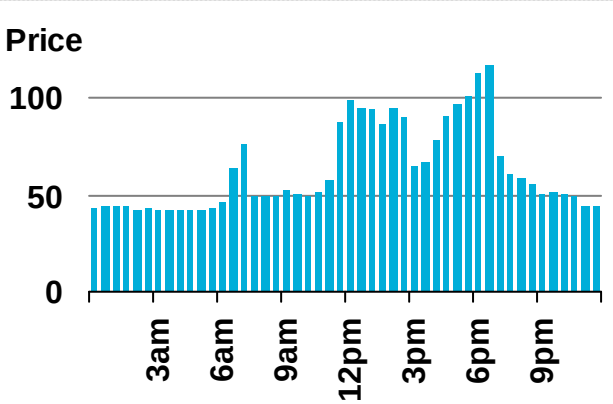
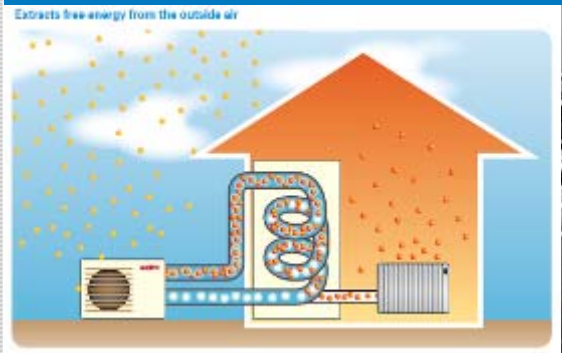
Homes and appliances will be smarter



Consumers will flex their energy use in response to price signals



Some heat and most transport electrified



~20m homes will have a heat pump

~30m electric cars on the road

2050

Where will our energy come from?

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~50% from electricity at ~15g CO_2(e) / kWh

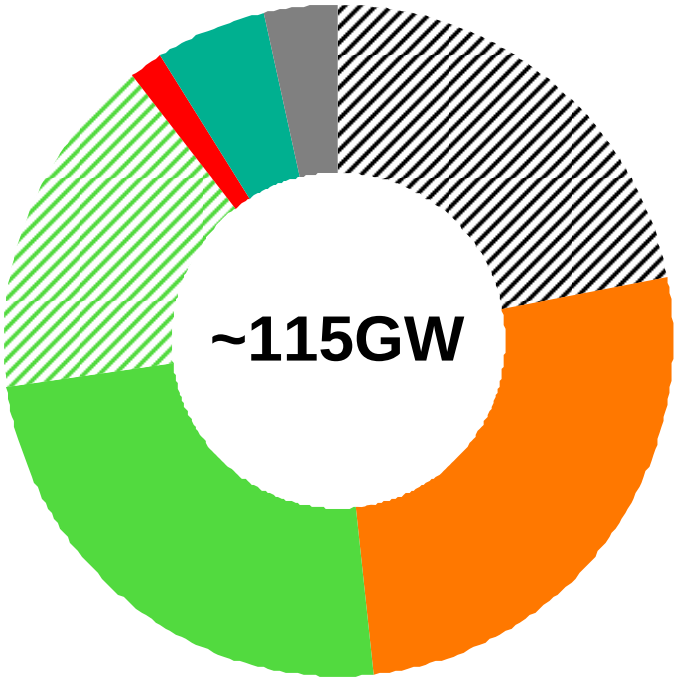
- Wind, nuclear & CCS dominant at ~25GW – 30GW each
- ~20GW other renewables
- ~15GW interconnection
- ~20GW embedded generation

~35% from gas at ~185g CO_2(e) / kWh

- LNG & continental imports
- Bio-methane

~15% from oil at ~245g CO_2(e) / kWh

Generation capacity mix



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2030 – 2040

Carbon Capture & Technology

2040

‘To capture or not to capture? …that is the question’

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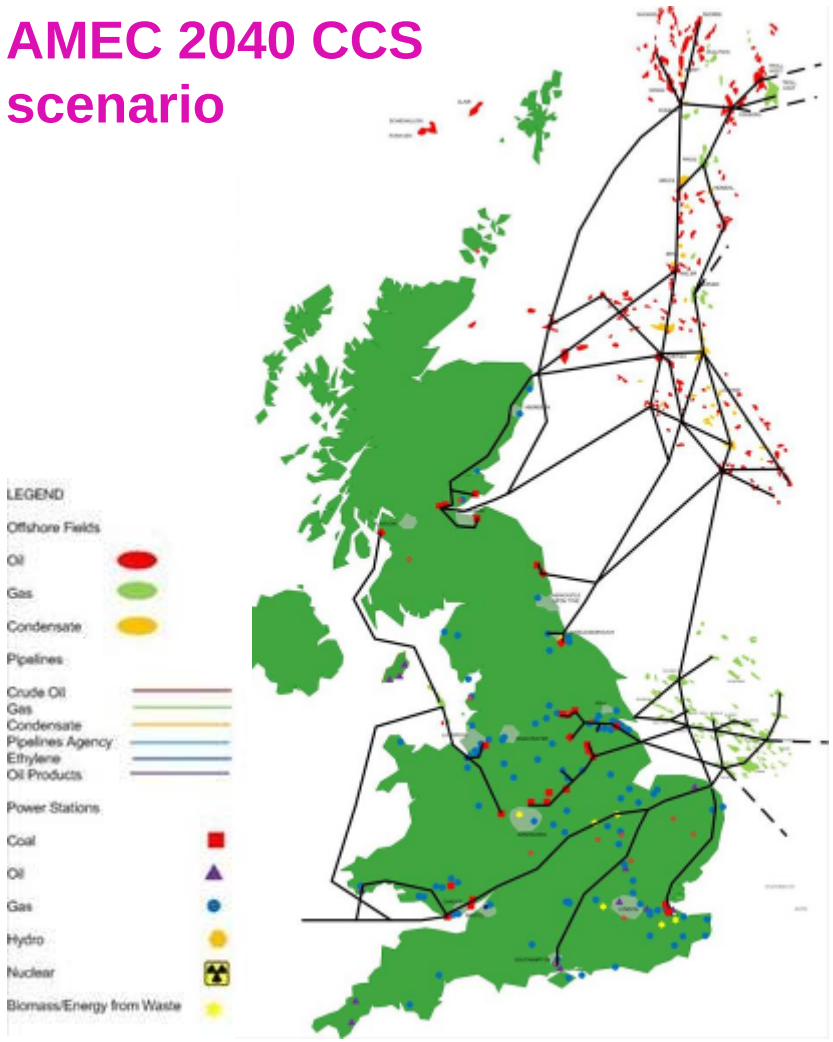
AMEC 2040 CCS scenario



Carbon Capture & Storage the key technology

- Trials in the late 2010s / early 2020’s
- Projects in planning and development in the 2020s
- Large scale deployment in the 2030s

Other developments

- ‘Replanting’ of wind generation
- ~10m additional electric vehicles
- ~6m additional heat pumps
- Bio-methane injection common-place
- Norwegian gas supplies near zero

‘Disruptive’ technology emerges?

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2020 – 2030

Distribution & Demand

2030

‘every DN has it’s day…’

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Peak electricity demand in the home increases significantly

- **~2.5kW peak appliance demand for an average house in 2010**
- **~3kW charge for an electric car**
- **~3.5kW demand for a heat pump**

- **~9kW potential total demand**

Distribution networks will need to double their capacity

	2010	2030	2050
Household demand*	~2.5kW	**~4.7kW**	~7kW
Embedded generation	~8GW	**~15GW**	~20GW
Network loading (kW/km)	~75	**~170**	~300
Network scale		**X2.3**	**X4.0**

** After diversity average peak demand*

Network scale vs 2010 levels

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Now – 2020

Generation & Transmission

2020

‘Generation, generation, generation…’

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~20% energy from electricity at ~200g CO_2(e) / kWh

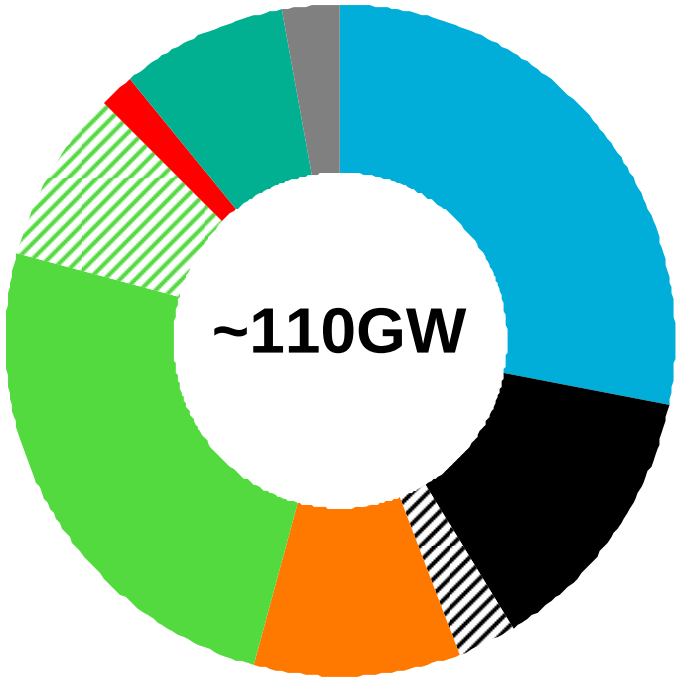
- Wind, gas dominant at ~30GW each
- ~11GW nuclear
- Some unabated coal
- ~10GW interconnection
- ~14GW embedded generation

~40% from gas at ~185g CO_2(e) / kWh

- LNG & continental imports increase
- UKCS & Norwegian gas decline

~40% from oil at ~245g CO_2(e) / kWh

Generation capacity mix



2020

EVs and heat pumps – new, exciting, but less significant

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Heat pumps

~1,200,000 In homes

~1–4GW peak demand

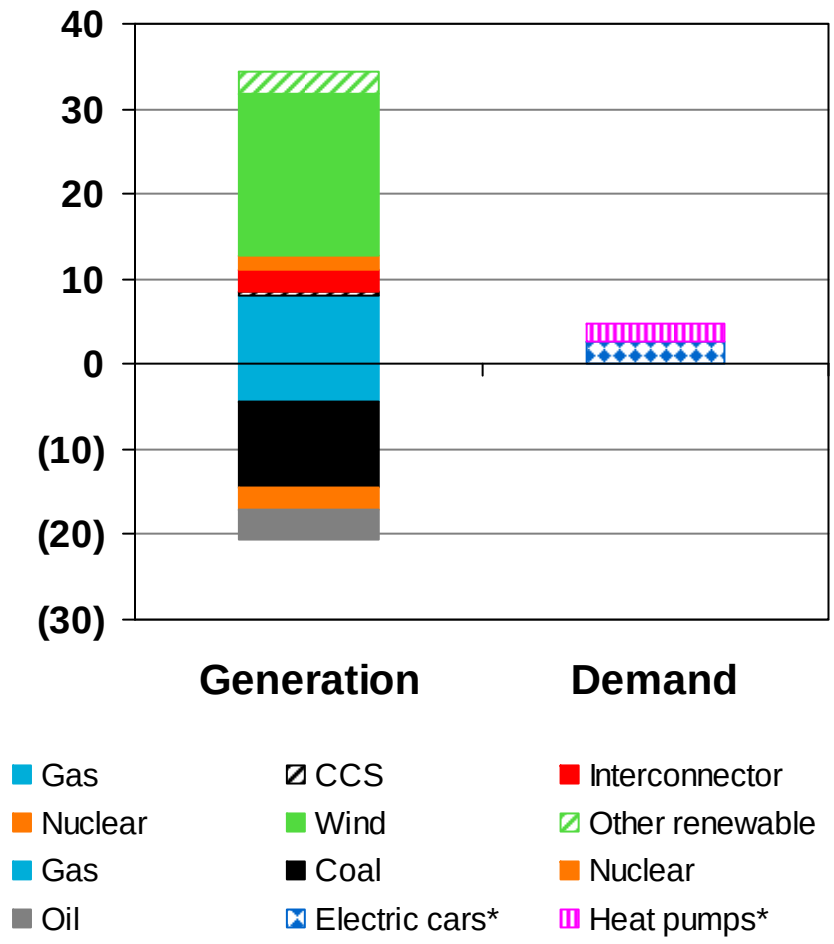
- Properties insulated for efficiency
- ‘Hot-spots’ of demand will emerge
- Evening peak impact mid-decade
- Time of use tariffs & smart metering enable peak management by 2020

Electric vehicles

~1,700,000 on the road

~1–5GW peak demand

- 13A plug-in home charge dominant
- ‘Hot-spots’ of demand will emerge
- Evening peak impact mid-decade
- Time of use tariffs & smart metering enable peak management by 2020



* Electric vehicle and heat pump at mid-range peak demand.

2020 Meeting the renewable energy target

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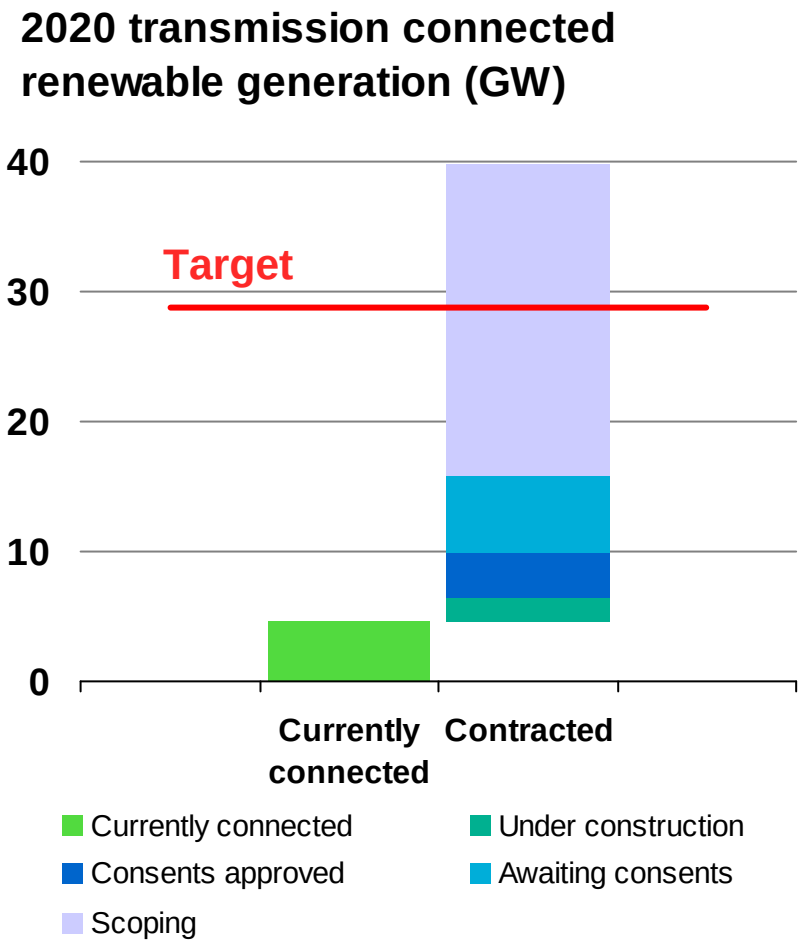
Renewable targets	20-20-20
	2050
EU and National policy	Third Energy Package Energy Strategy 2020 Energy Infrastructure Package 2050 Roadmap
	Renewables Obligation Certificates EMR
WIND	



Data source: National Grid TNQCU – August 2011; National Grid 2011 SYS. Connected renewable generation excludes pumped storage.

2020 Key regulatory debate: offshore transmission

- Designing and building networks is complex
- Scenarios are uncertain
- Securing consents will be difficult
- Extensive supply chain relationships will be required
- A need for extensive co-ordination of active ‘through routes’ to make sure it works
- Substantial value left behind if complexity not dealt with properly

40GW
offshore wind in 2030

~£6.9bn
integration savings

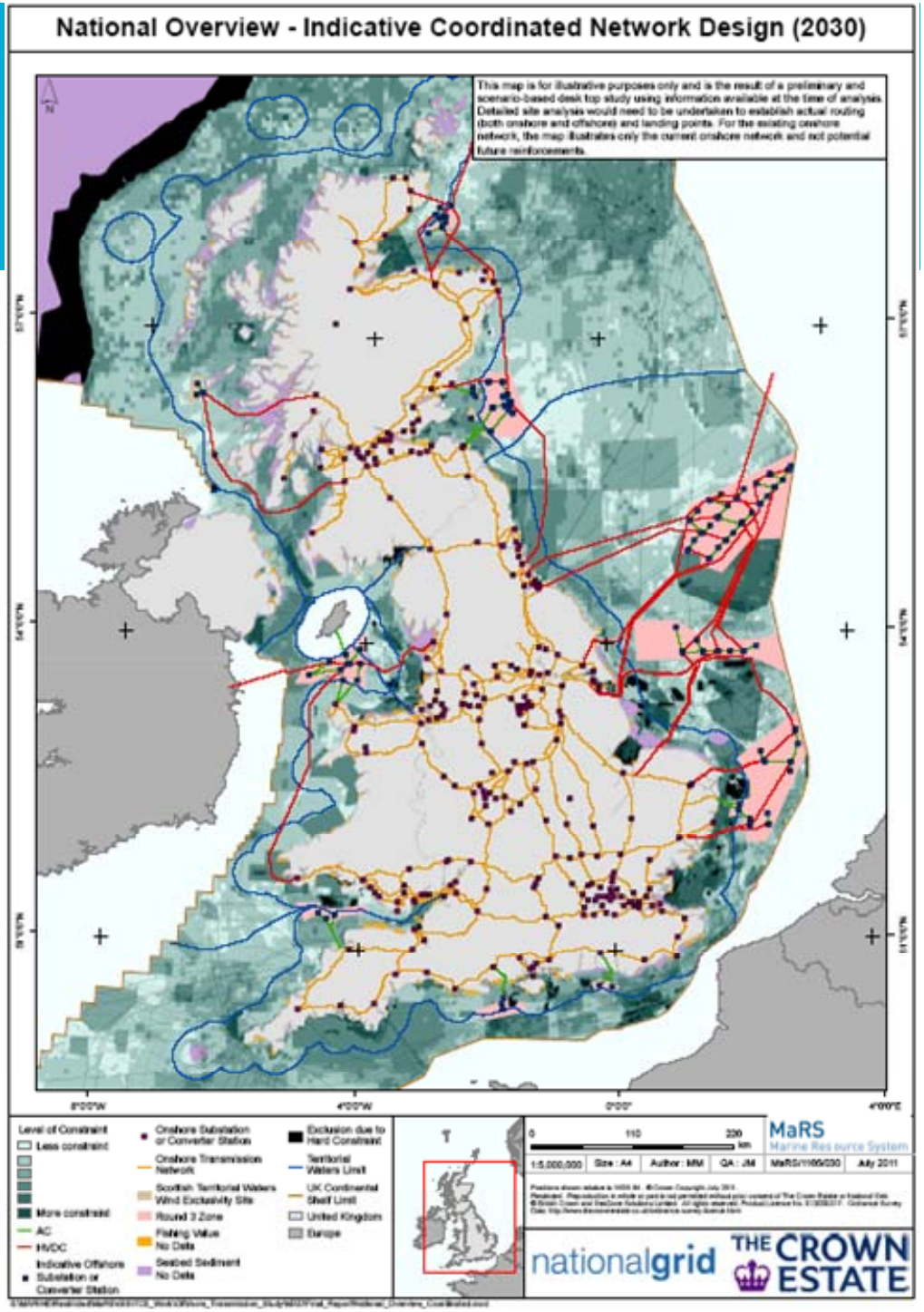
5,216km
HVDC cable

43
cable landing sites

110
offshore platforms

126km
new onshore AC lines

Data source: National Grid & The Crown Estate Offshore Transmission Feasibility Study – Accelerated Growth scenario



2020

The delivery challenge: inter-regional transmission

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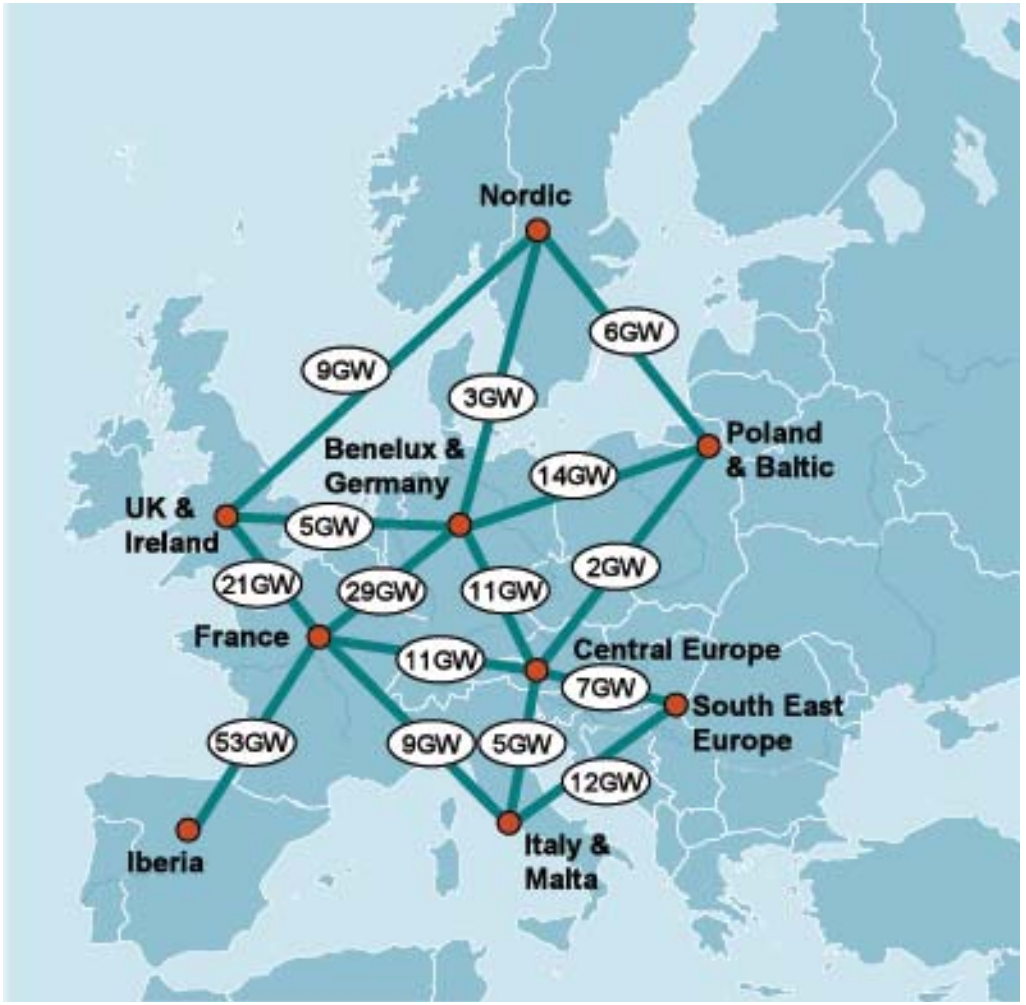
34GW
in 2010

~160GW
by 2050

equivalent to adding over 125 BritNed's



Data and map source: European Climate Foundation Roadmap 2050, assuming 80% RES

2020

The transmission delivery challenge: electricity

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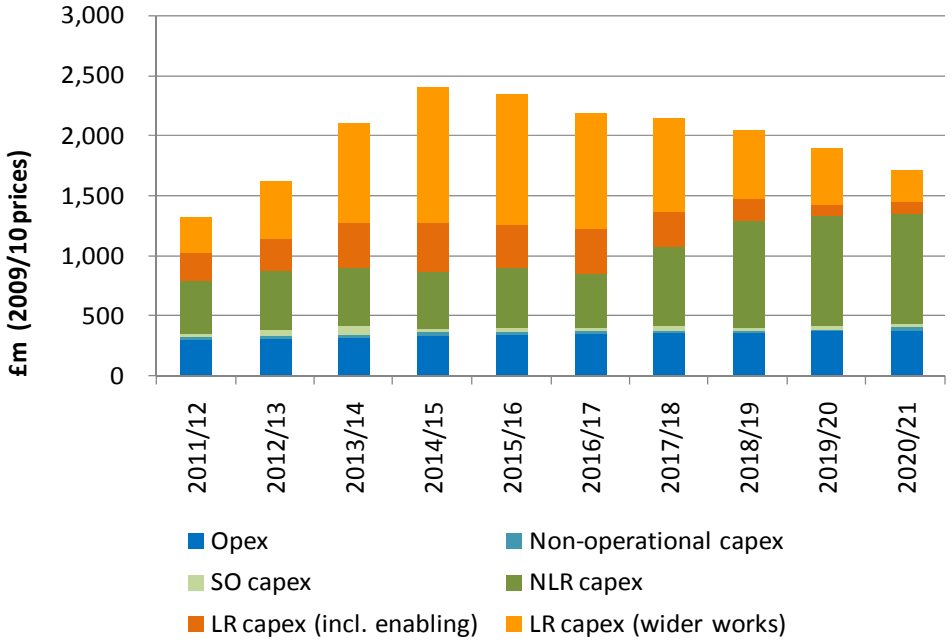

Capex		Opex		'Totex'
£14bn	+	£2.8 bn	=	£16.8 bn

2020

Transforming our electricity network to meet customer needs

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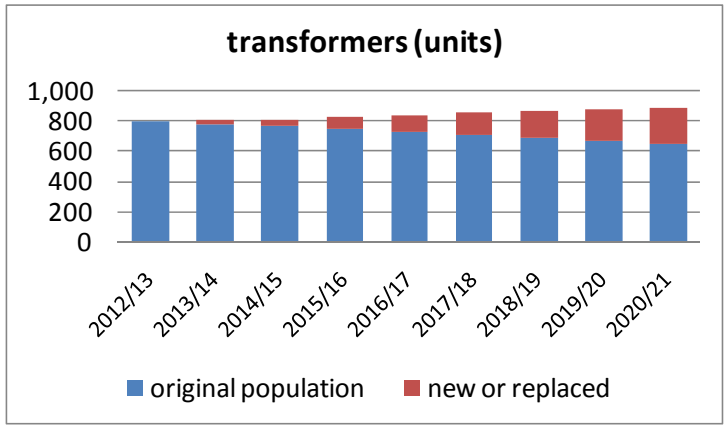
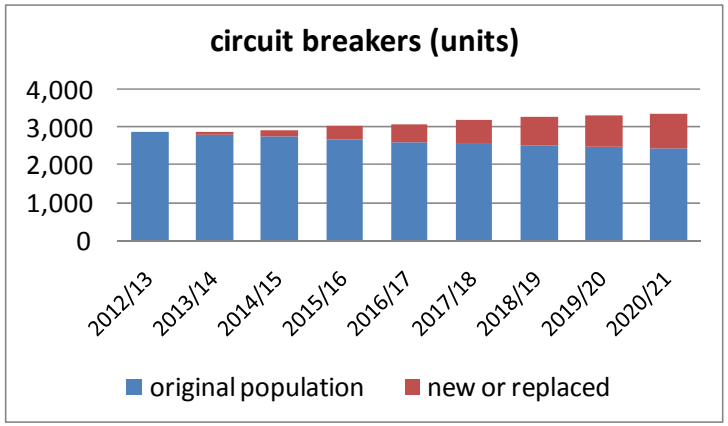
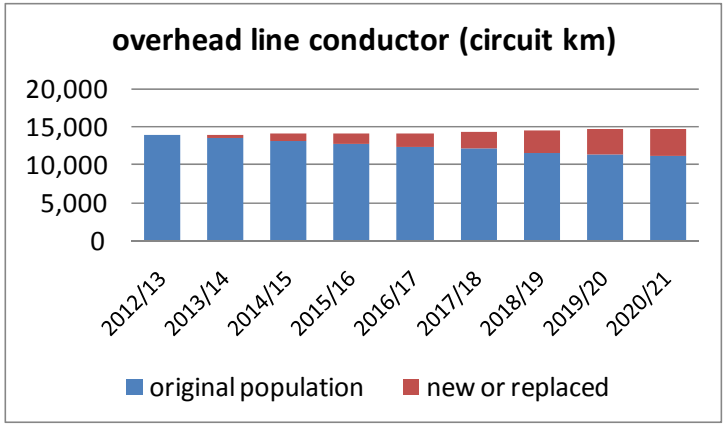
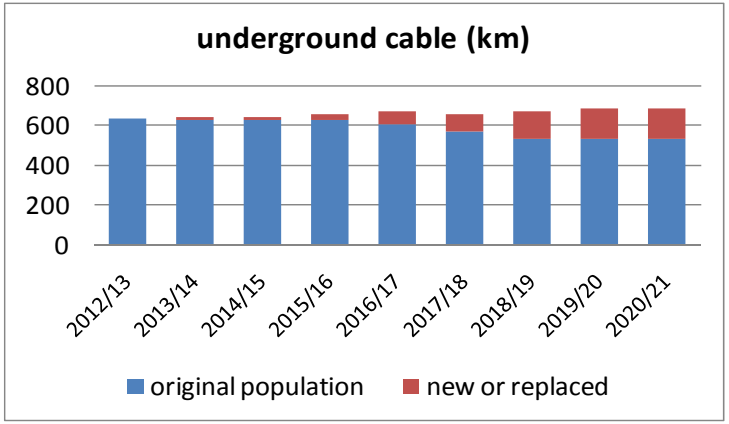




Our total load- and non-load related investment will extend, reinforce and replace our existing asset base





2020

The transmission delivery challenge: uncertainty mechanism

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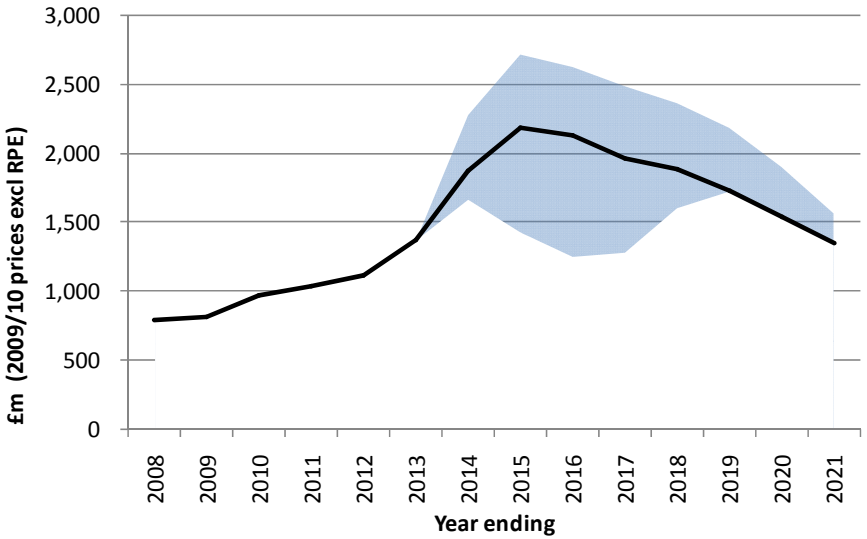
Our baseline RIIO-T1 plan is only one view of the future…



Mechanisms we proposed:

- allow the regulatory control to adapt to an uncertain future
- ensure the RIIO-T1 package remains appropriate across a wide range of potential outcomes
- allow us to deliver desired outputs in future scenarios outside what is currently considered credible through the use of specific and targeted ‘re-openers’

2020

How will we balance supply and demand?

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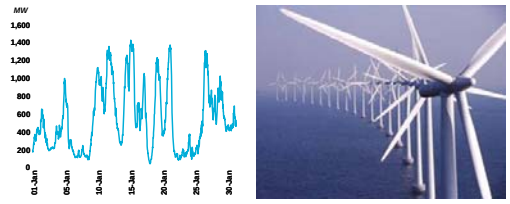
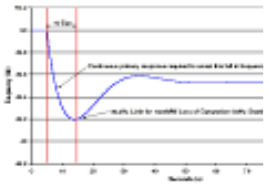
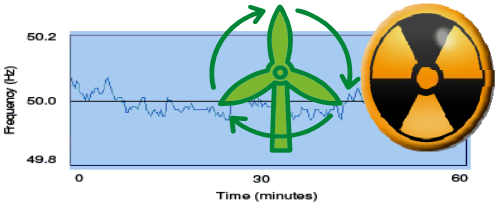
Variable generation

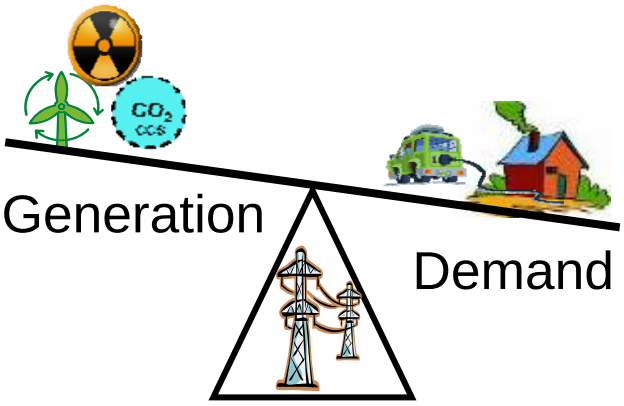


Large generation



Inflexible generation





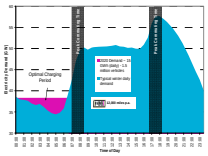
Smarter transmission

Smart zones
HVDC
Series compensation

Active distribution networks

Smart(er) grids & meters, energy storage

Active demand



Time of use tariffs

Distributed generation

2020

Indicative Short Term Operating Reserve Requirements

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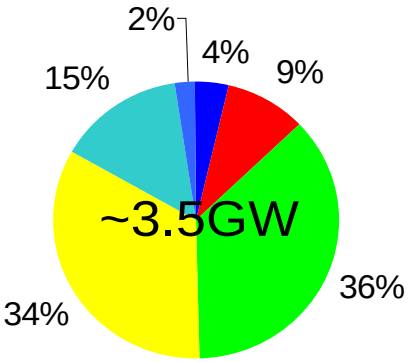
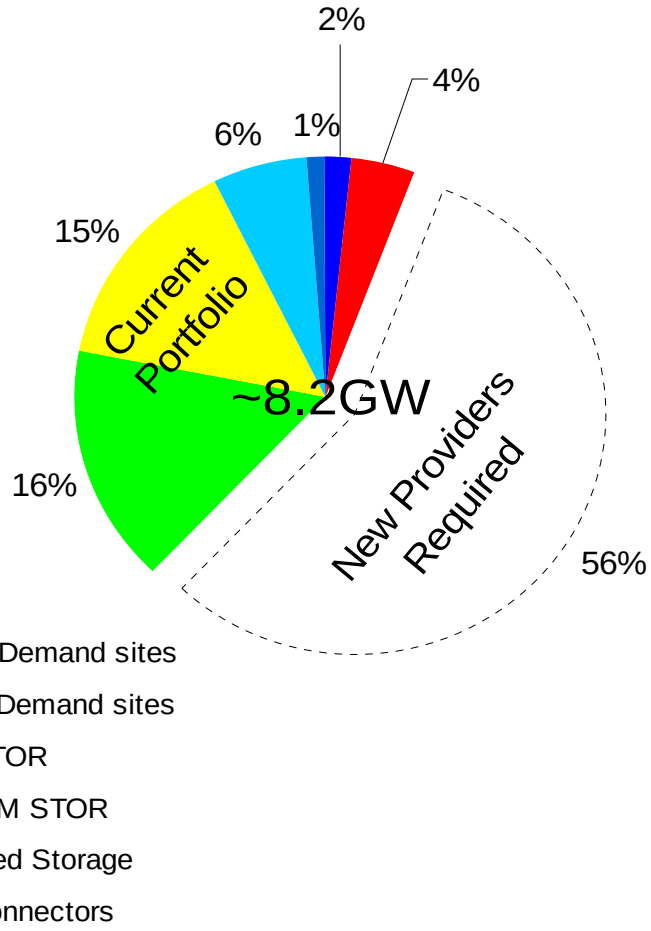
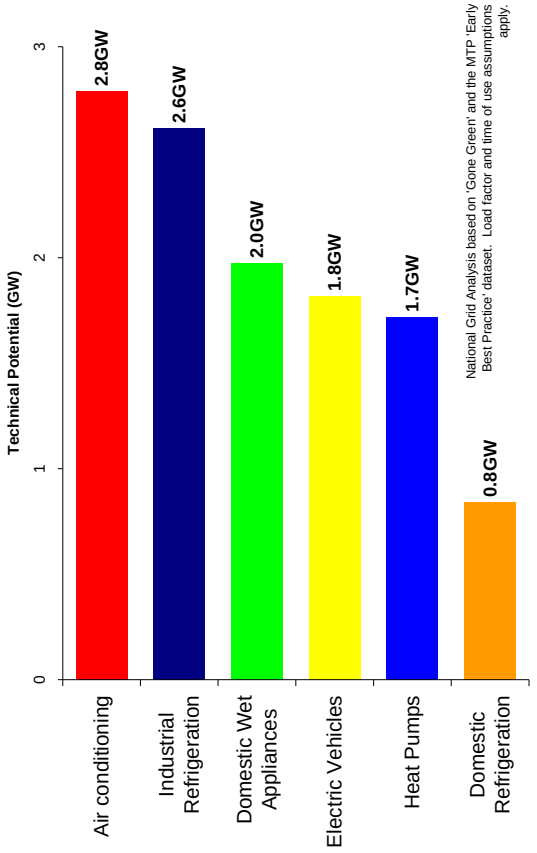
Typical Current Winter Reserve Provider Breakdown



Potential Opportunity for New Reserve Providers in 2020





2020

Key policy debate: the balance between gas and electricity

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Electricity demand

~1,000 GWh / day

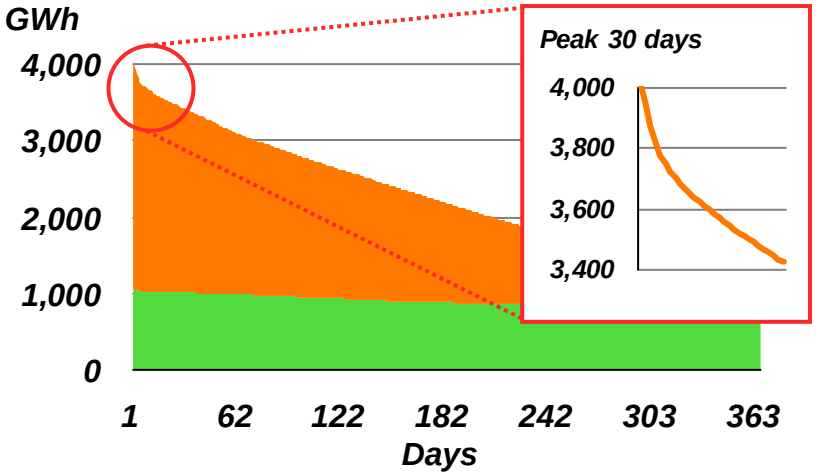
(avg. November day)

Gas demand

~4,000 GWh / day

(avg. November day)

Energy use is 'peaky'…



Full electrification of heat: what you have to believe…

~150 GW of heat electrified =

Nuclear?	**~45 sites at 3.3GW / site**
Renewables?	**~30,000 wind turbines at 5MW / turbine**
CCS?	**~75 sites at 2GW / site**
Solar PV?	**~40m homes at 17m² / home**
Inter-connectors?	**~150 BritNed's at 1GW each**

…even after significant energy efficiency

2020

Gone Green Installed Capacity

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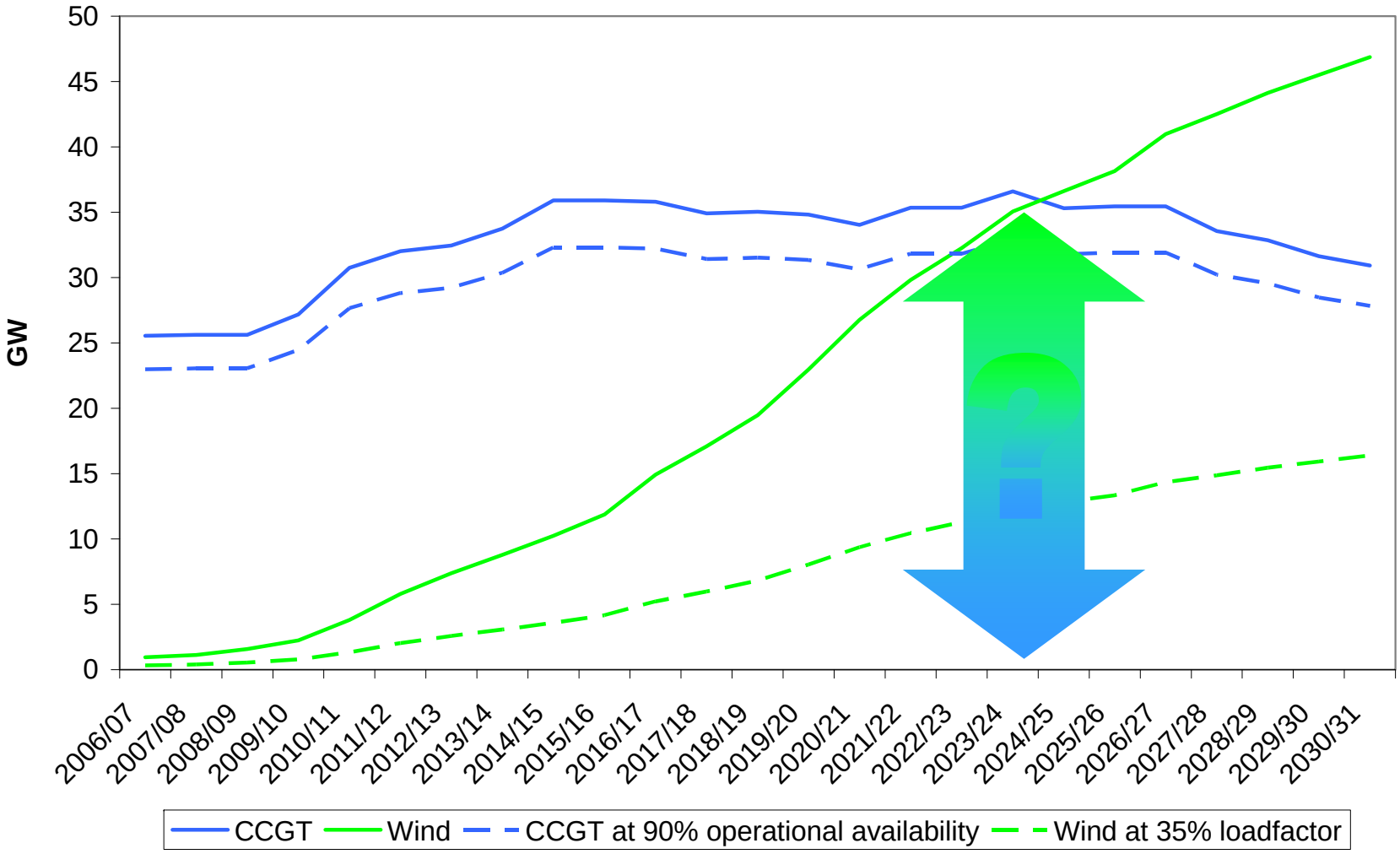

2020

82 year daily wind loadfactor

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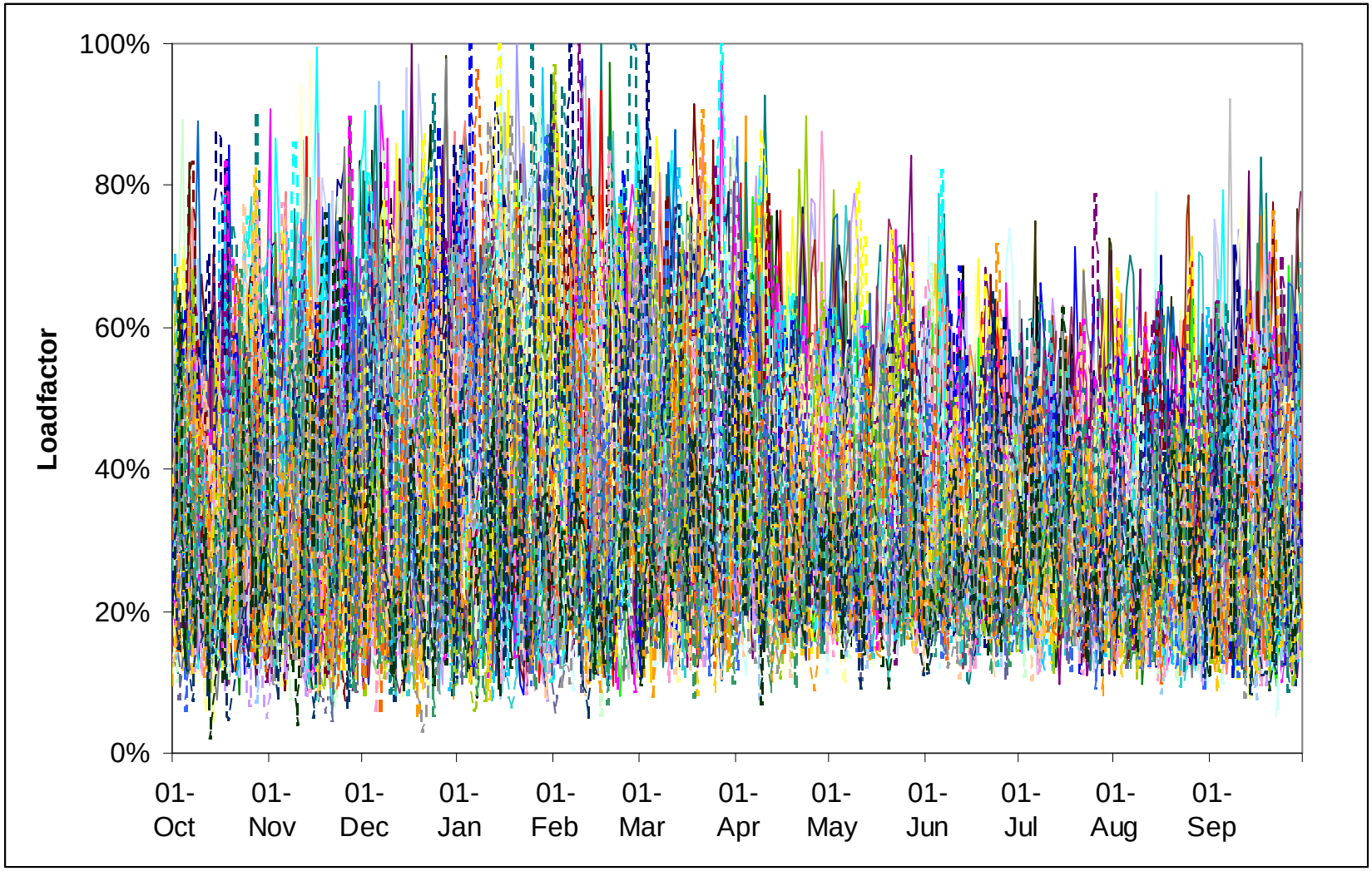

2020

2010/11 with 1989/90 weather

(a windy winter) 5GW wind capacity

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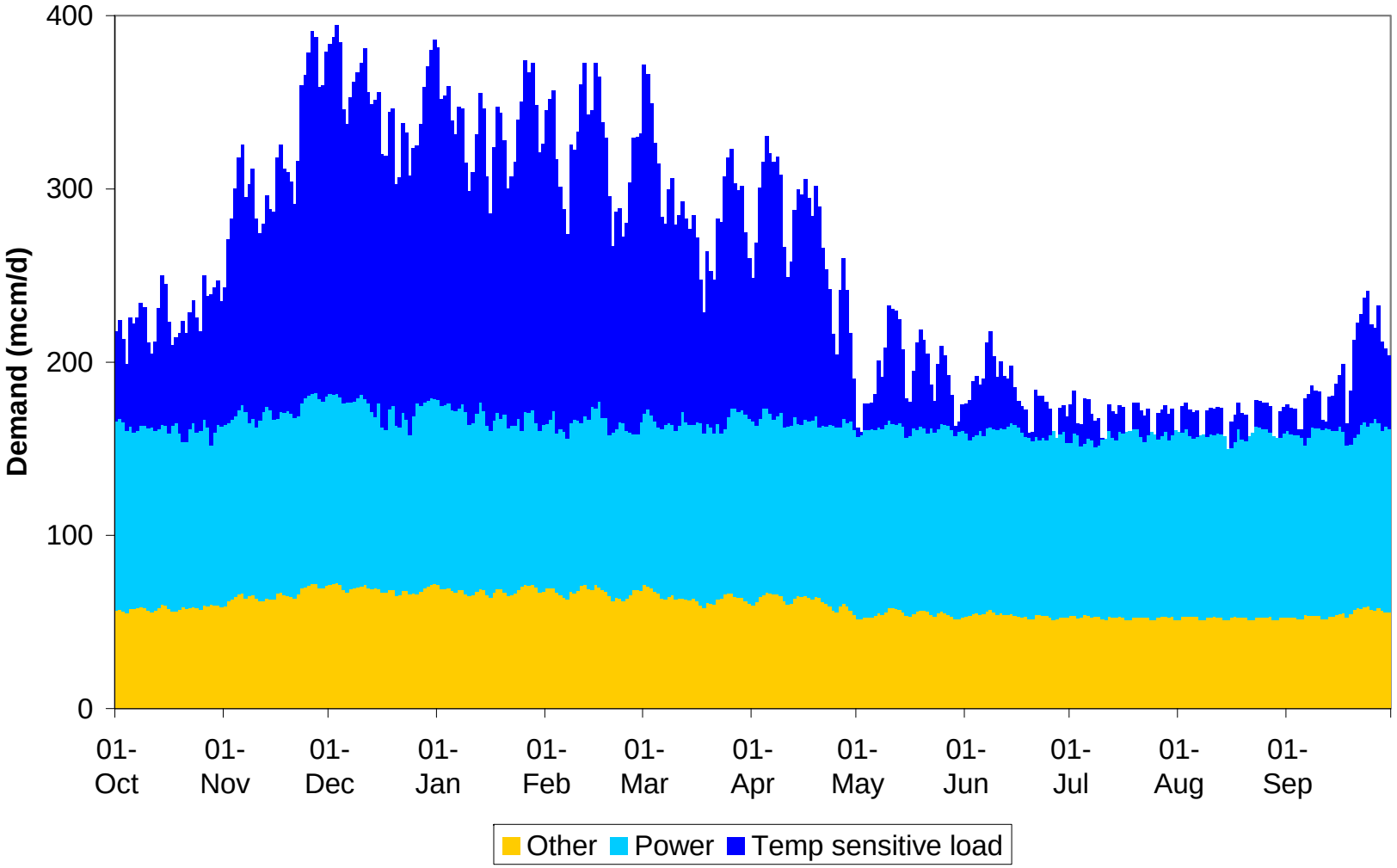

2020

2020/21 with 1989/90 weather

30GW wind capacity

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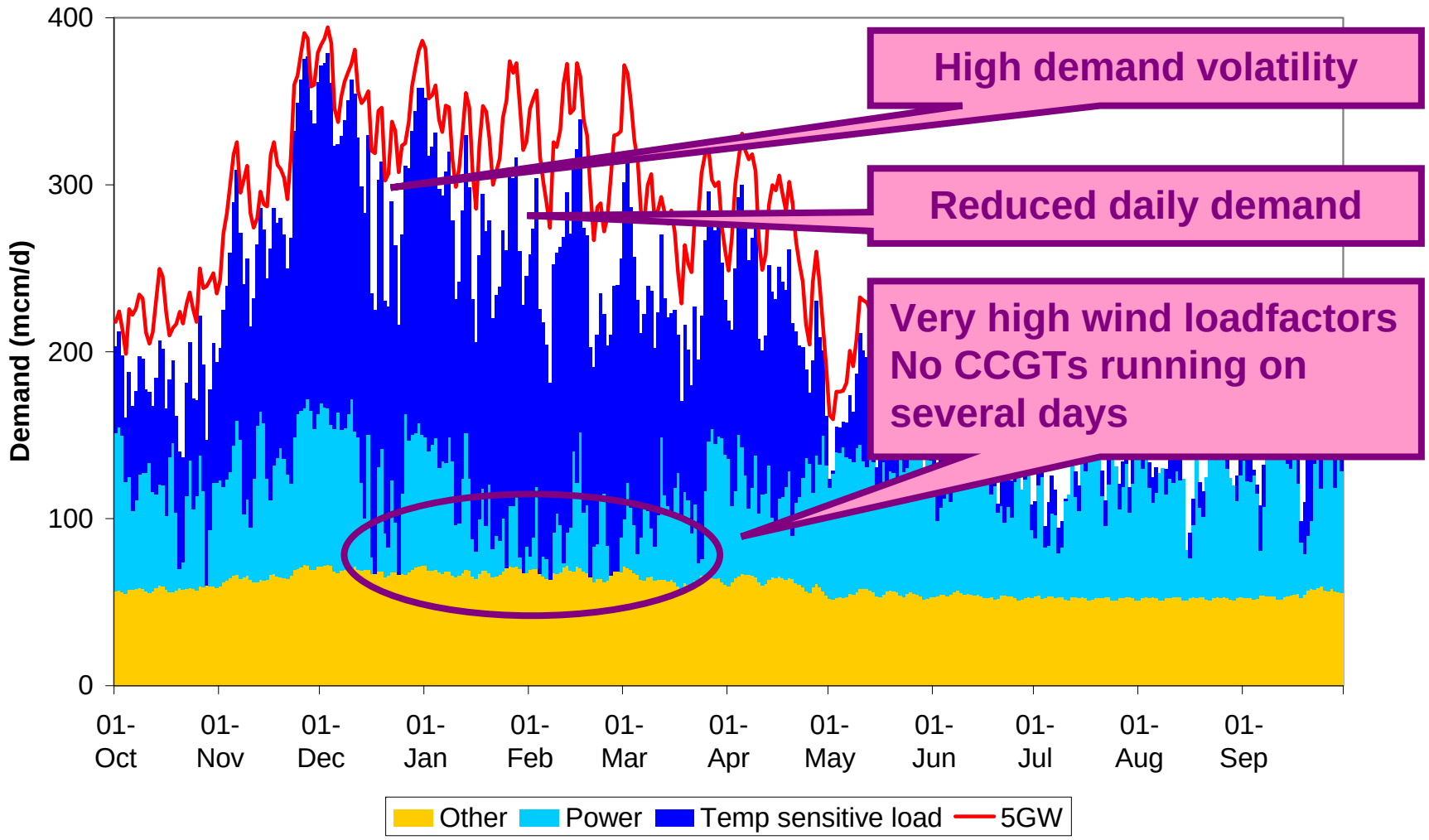
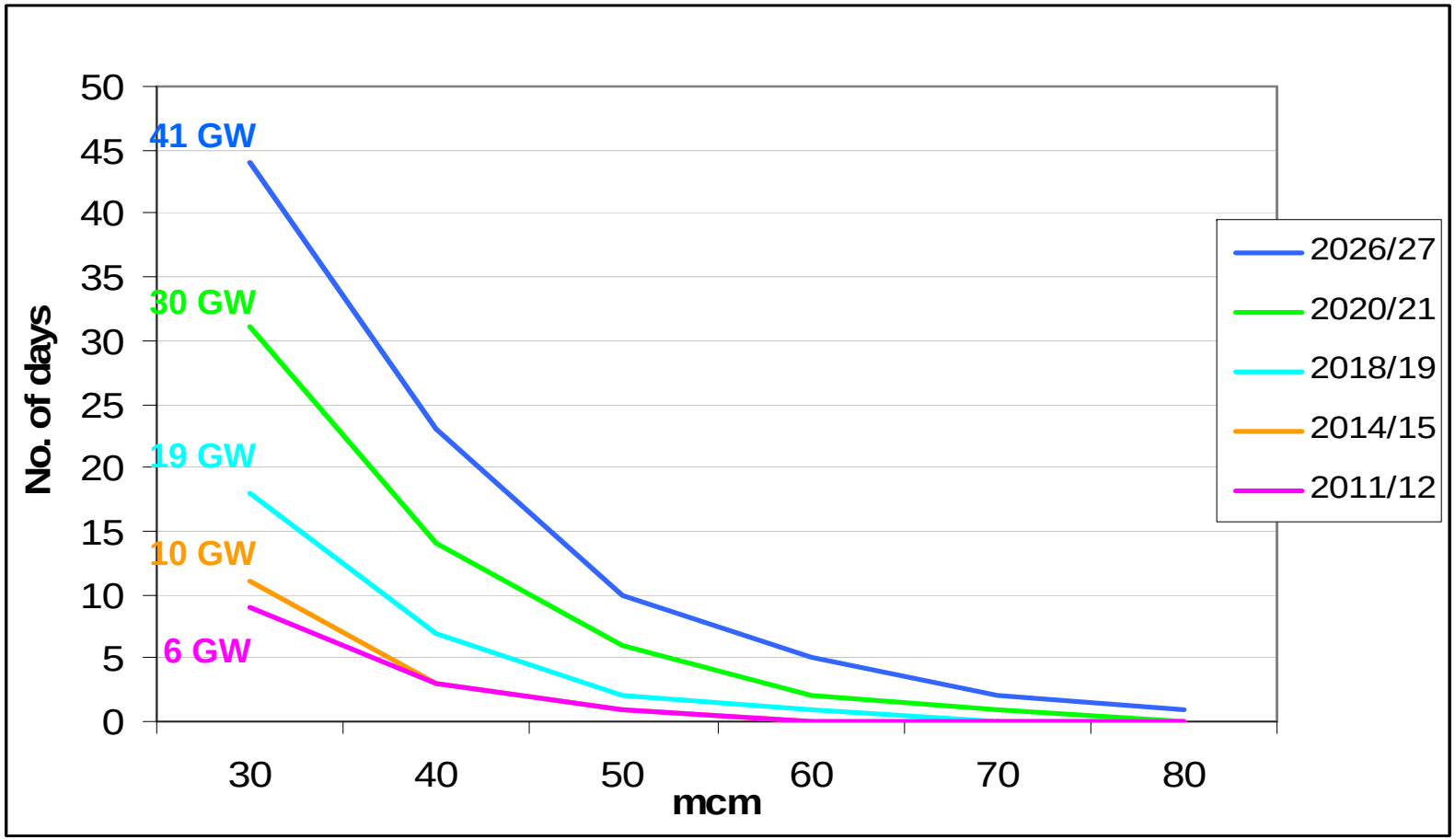


2020

Day to day demand variations



- **E.g. for 41GW in 2026/27 ~45 days with day to day demand variation above 30 mcm, i.e. nearly one a week**

2020

A very rare, extreme event

2020/21: 30GW wind capacity

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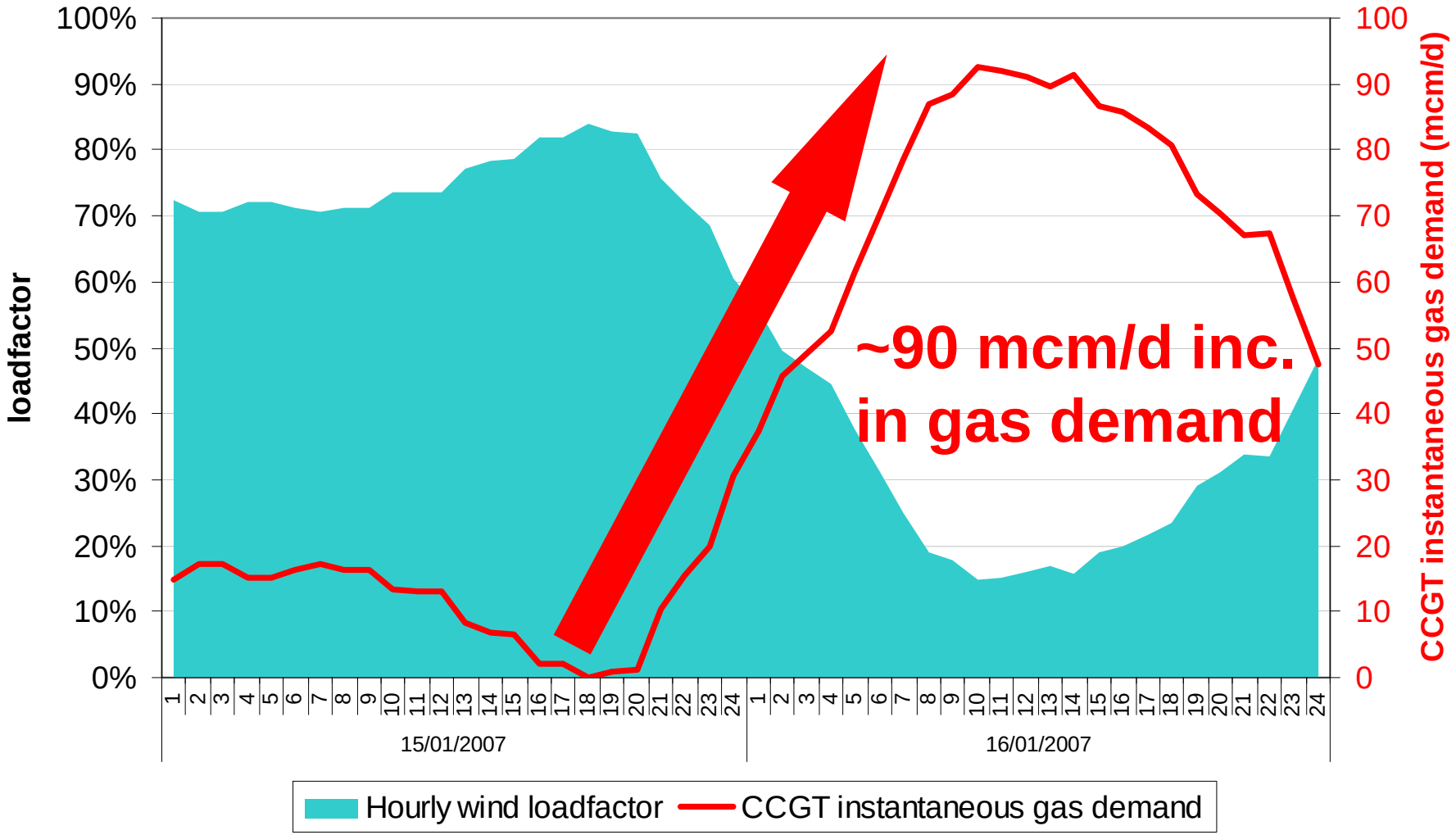

2020

Where will our gas come from?

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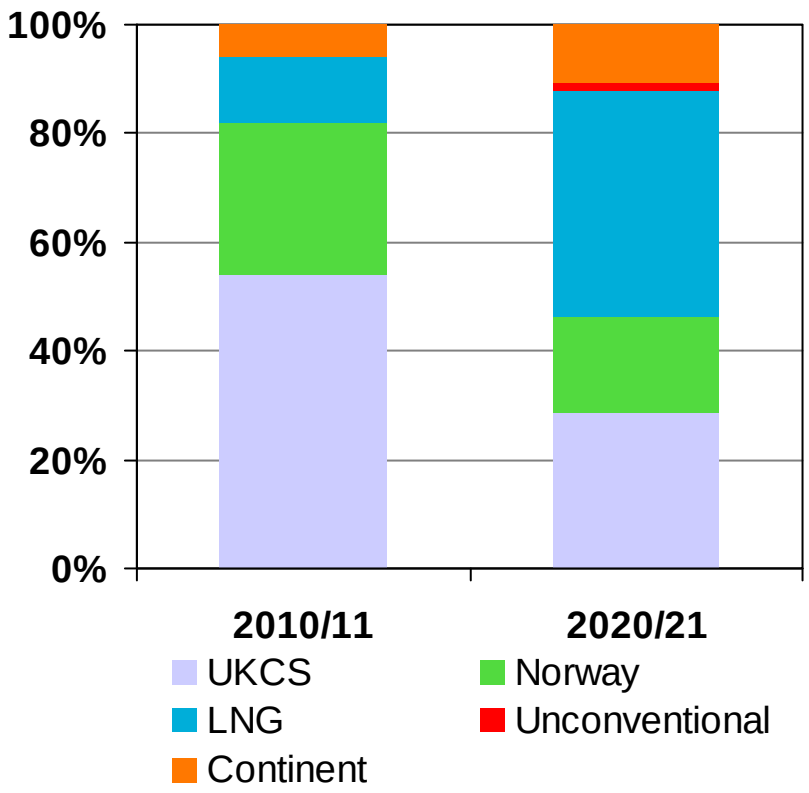
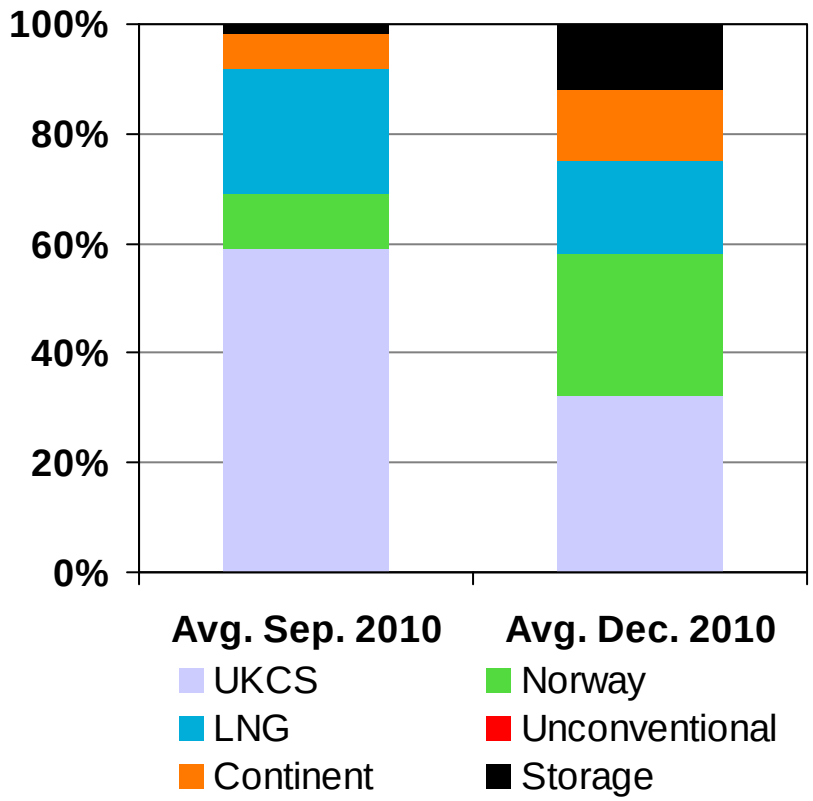
Sources of gas change significantly



Day to day variability could increase



2020

The transmission delivery challenge

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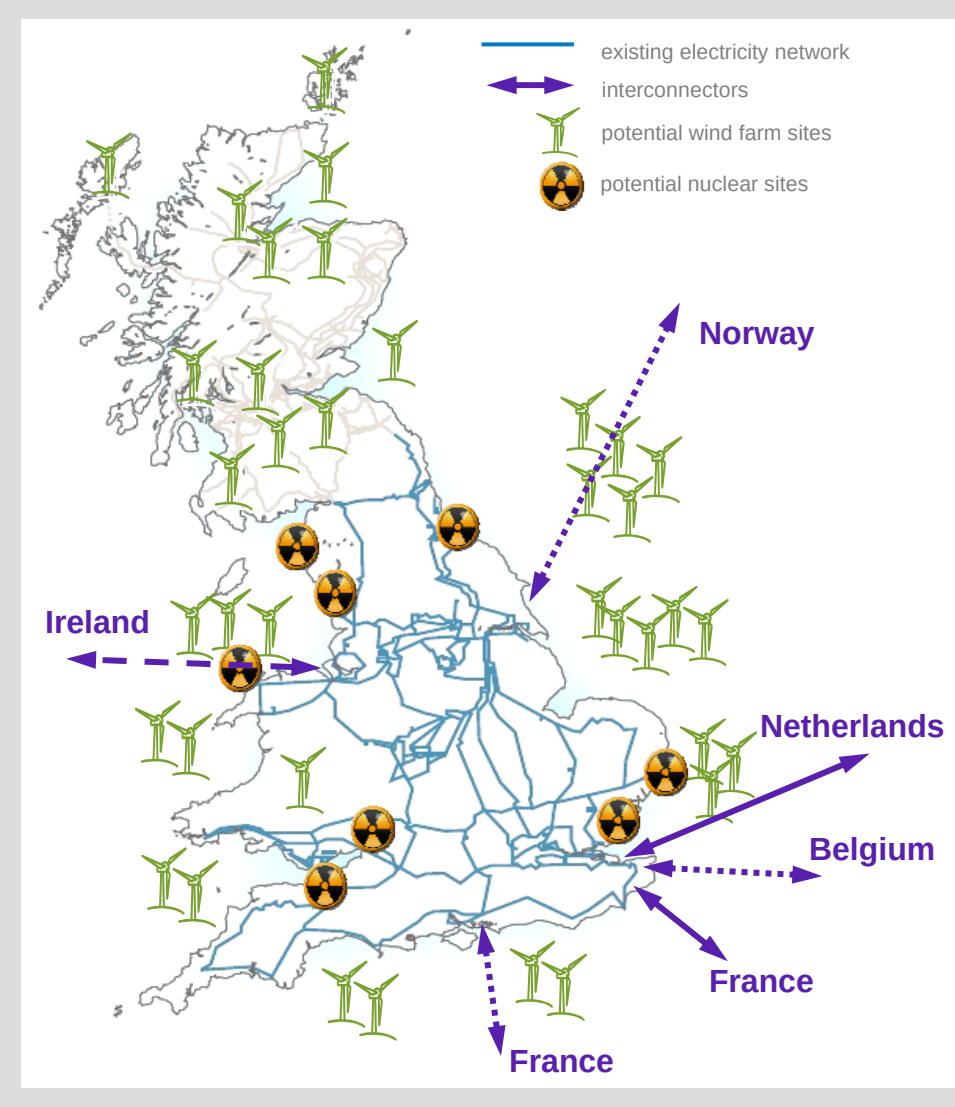

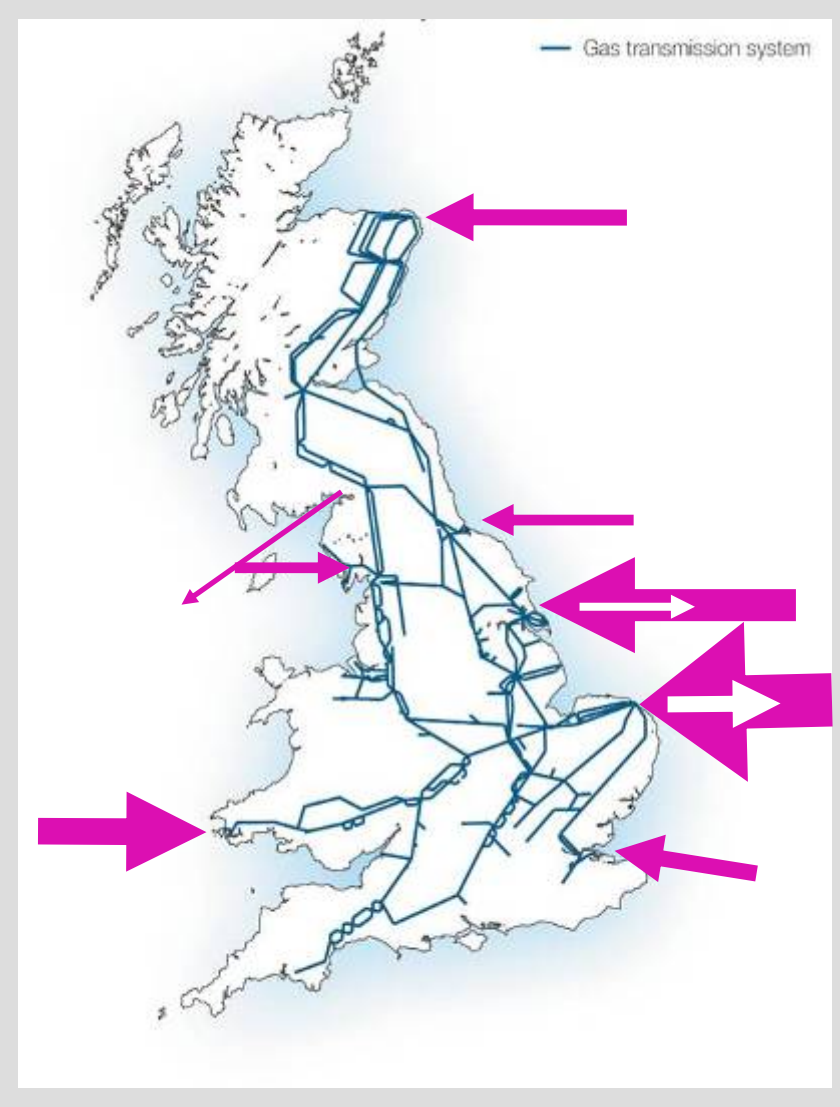

The next 40 years in brief…

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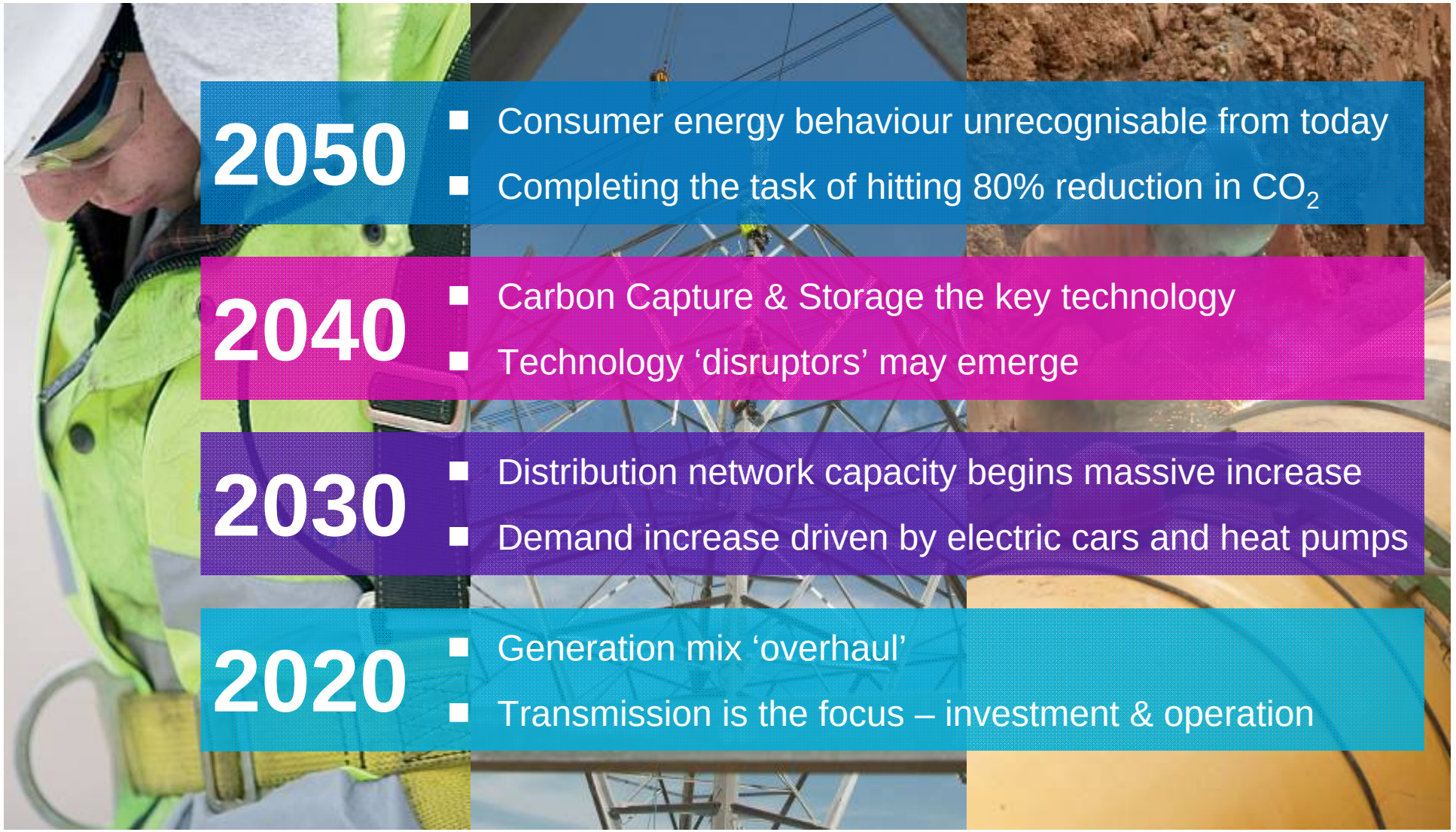

2050

- Consumer energy behaviour unrecognisable from today
- Completing the task of hitting 80% reduction in CO_2

2040

- Carbon Capture & Storage the key technology
- Technology ‘disruptors’ may emerge

2030

- Distribution network capacity begins massive increase
- Demand increase driven by electric cars and heat pumps

2020

- Generation mix ‘overhaul’
- Transmission is the focus – investment & operation

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Thank you