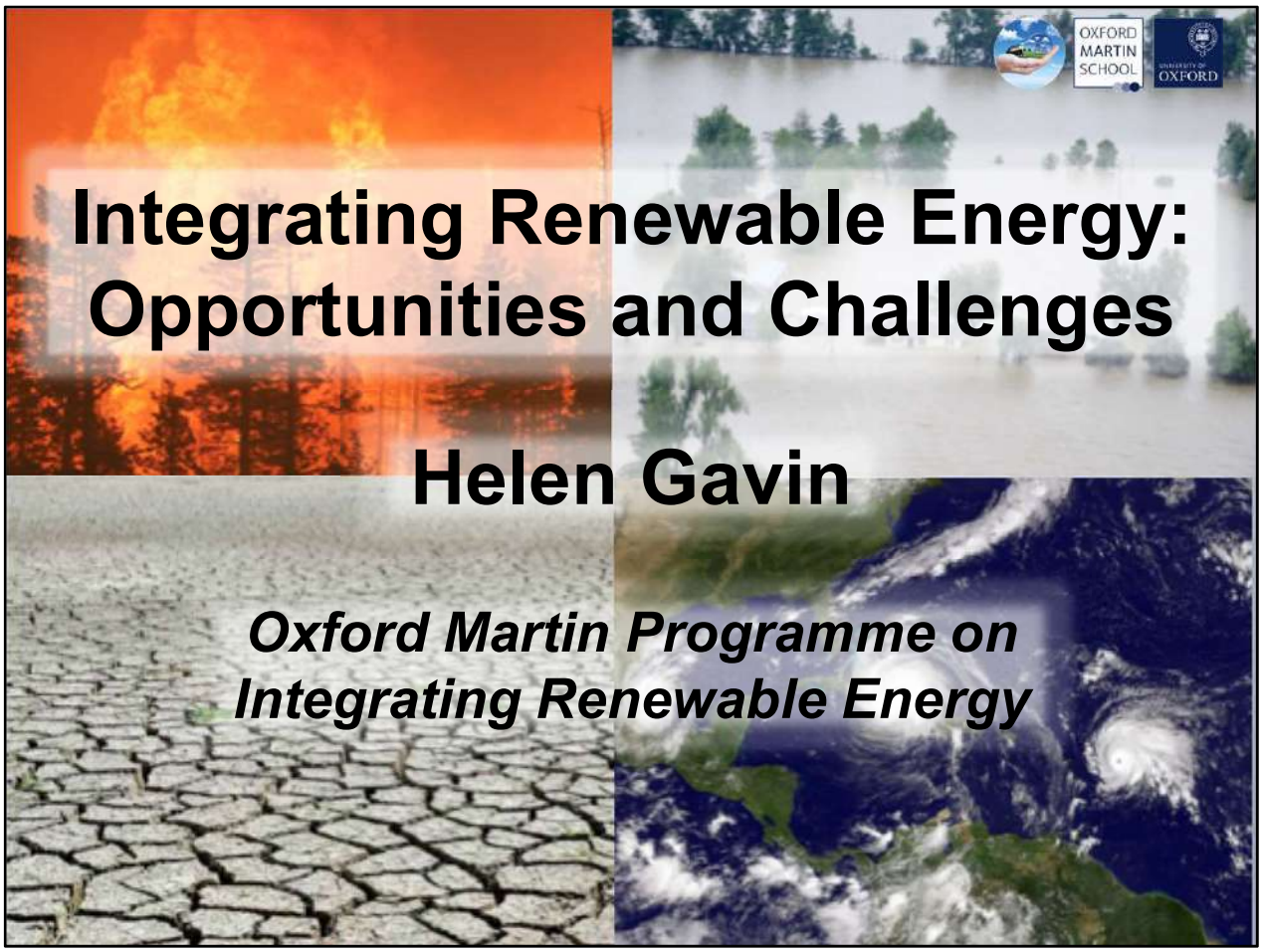
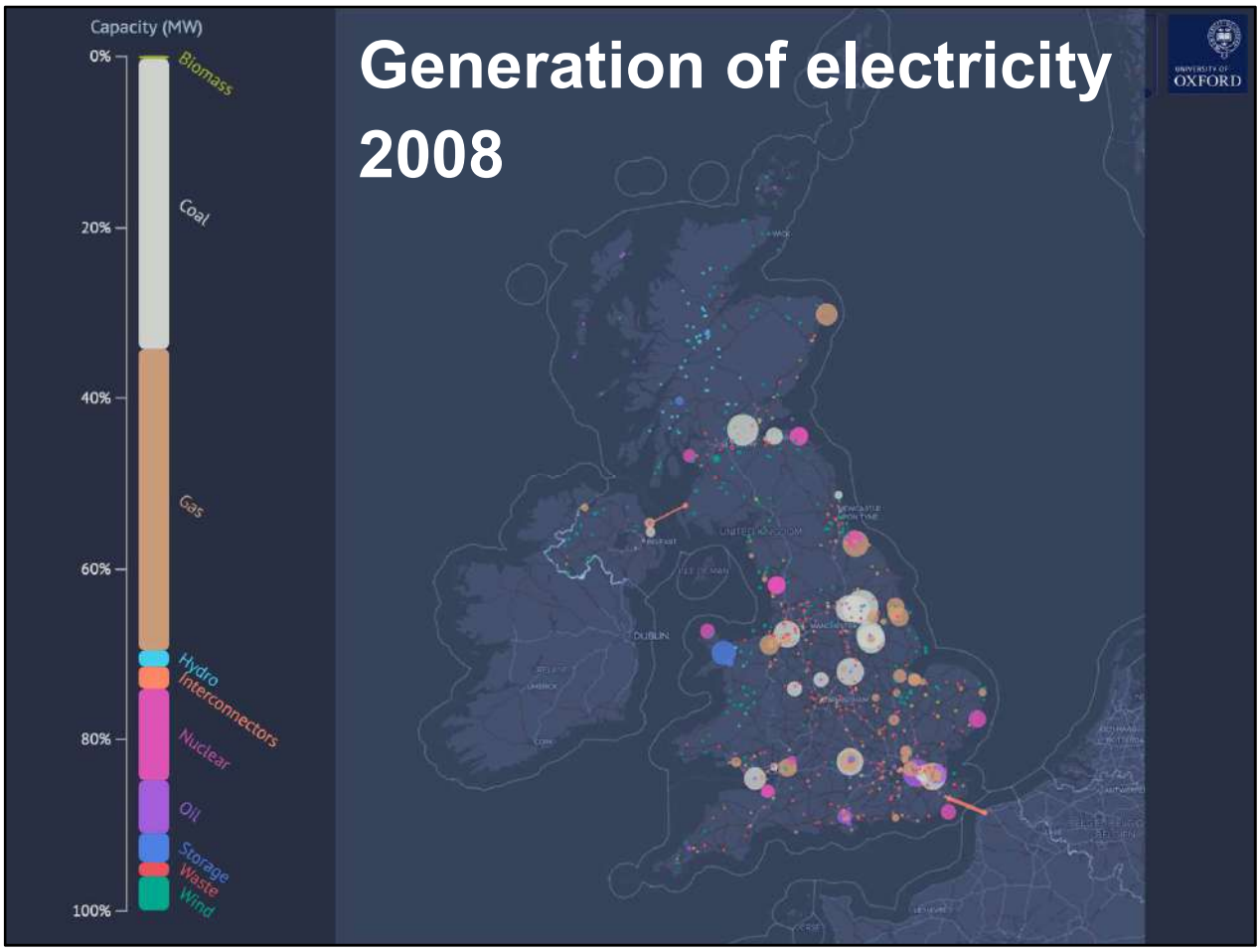
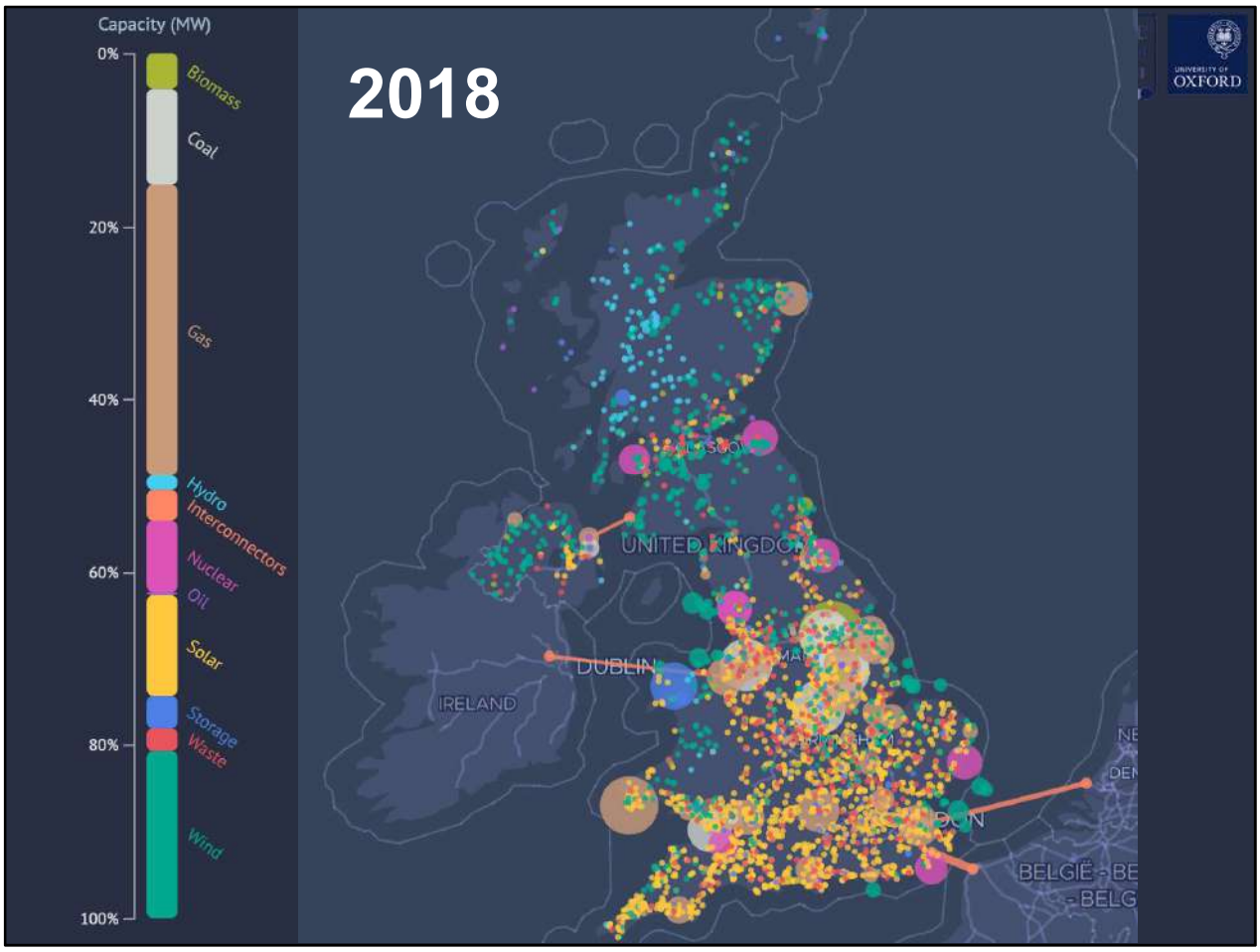


Useful video to watch: https://www.youtube.com/watch?v=5uz6xOFWi4A



https://interactive.carbonbrief.org/how-uk-transformed-electricity-supply-decade/



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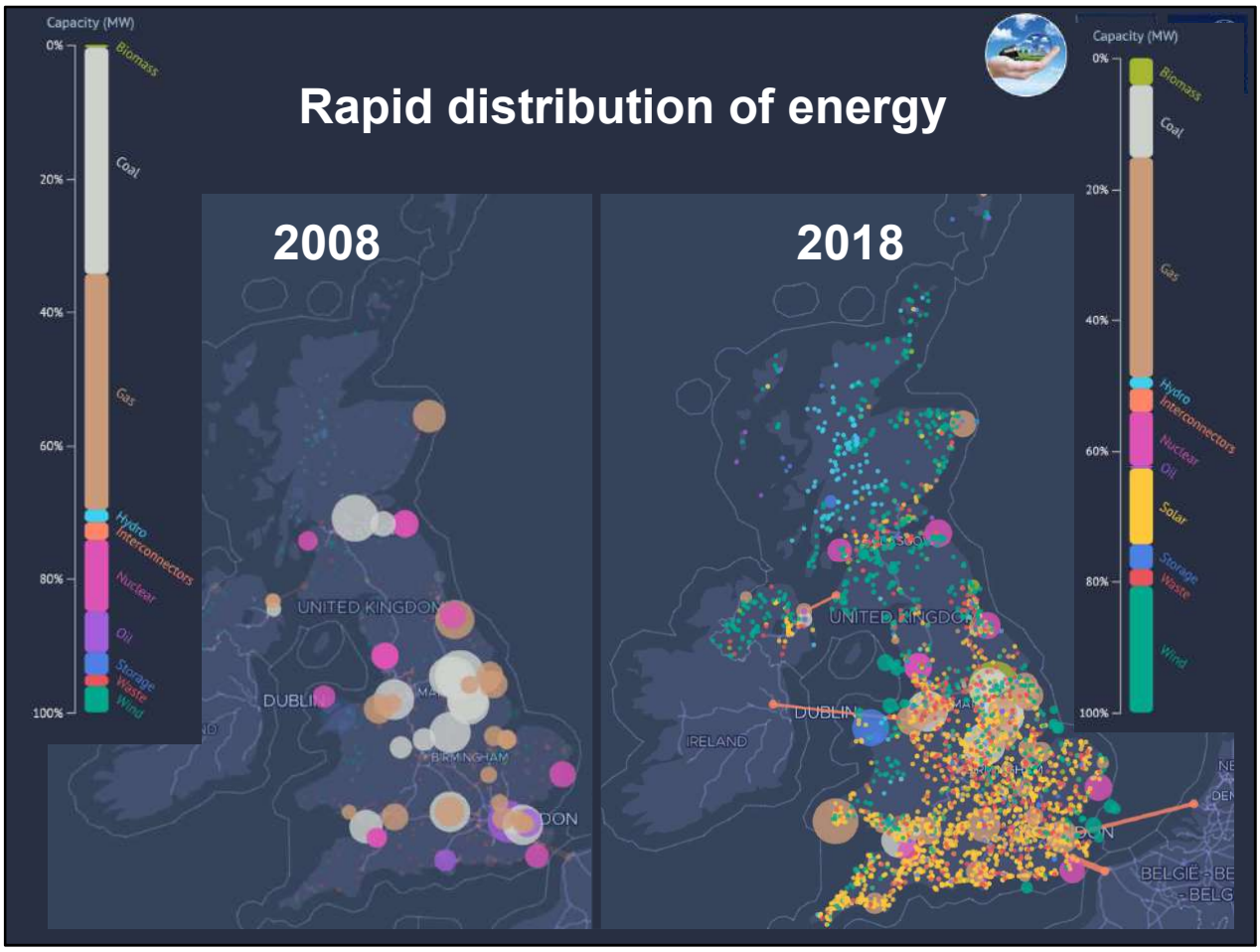
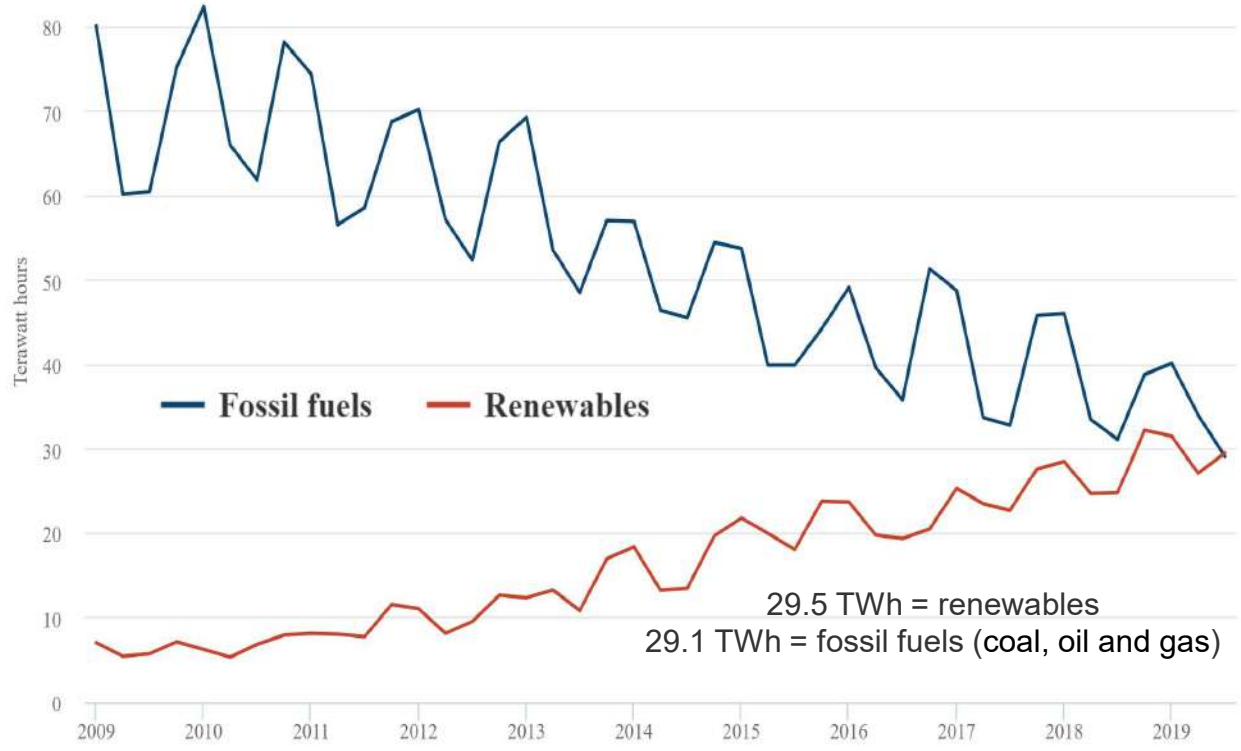


https://interactive.carbonbrief.org/how-uk-transformed-electricity-supply-decade/

2019: UK renewables generate more electricity than fossil fuels for first time (July-Sept)



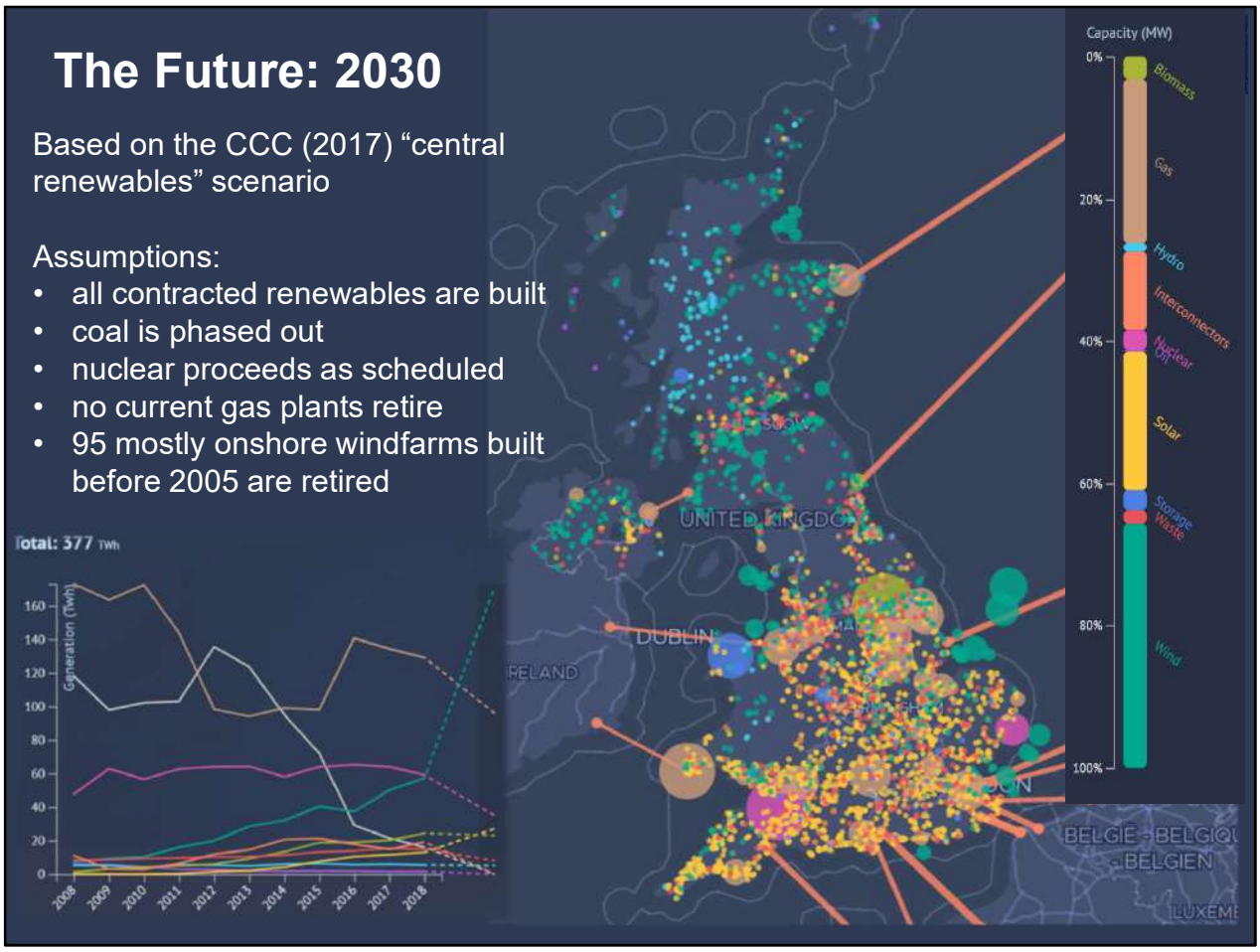
https://www.carbonbrief.org/analysis-uk-renewables-generate-more-electricity-than-fossil-fuels-for-first-time
https://cbhighcharts2019.s3.eu-west-2.amazonaws.com/q3-2019-electricity/renewables-beating-fossil-fuels-uk.html

The Future: 2030

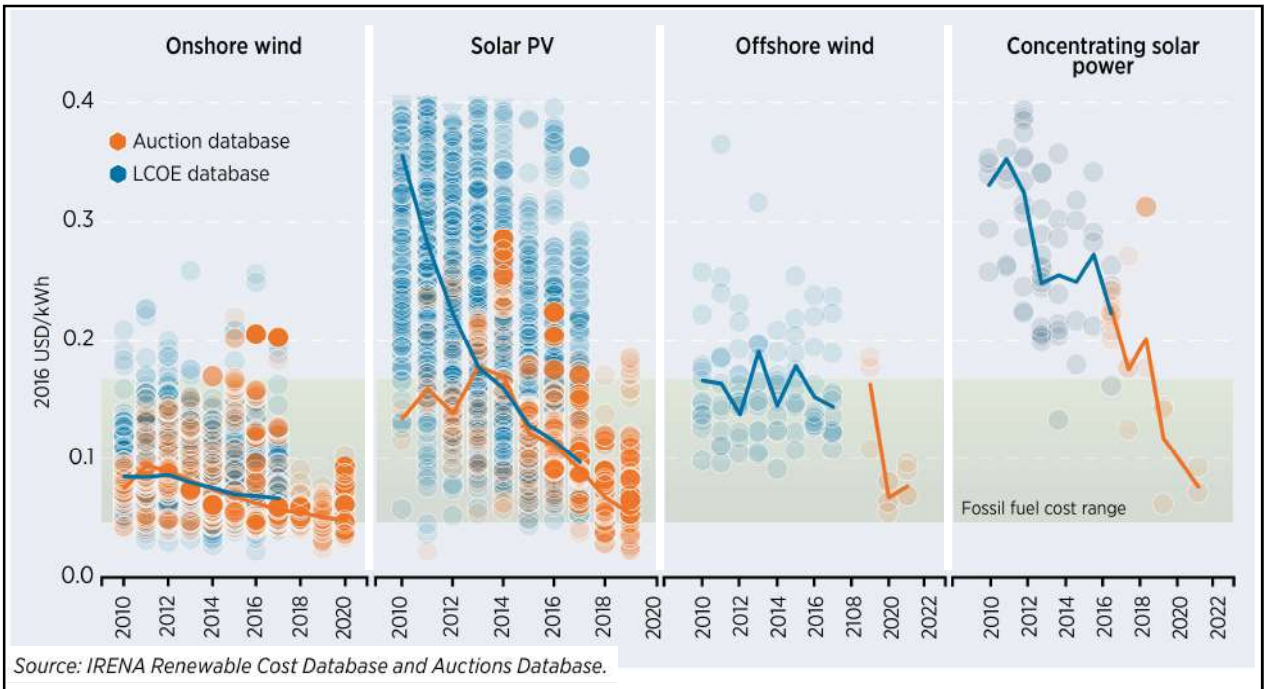
Based on the CCC (2017) “central renewables” scenario

Assumptions:

- all contracted renewables are built
- coal is phased out
- nuclear proceeds as scheduled
- no current gas plants retire
- 95 mostly onshore windfarms built before 2005 are retired



https://interactive.carbonbrief.org/how-uk-transformed-electricity-supply-decade/



Solar and wind electricity costs are lowest yet seen.
These are **modular** technologies that can be deployed around the world

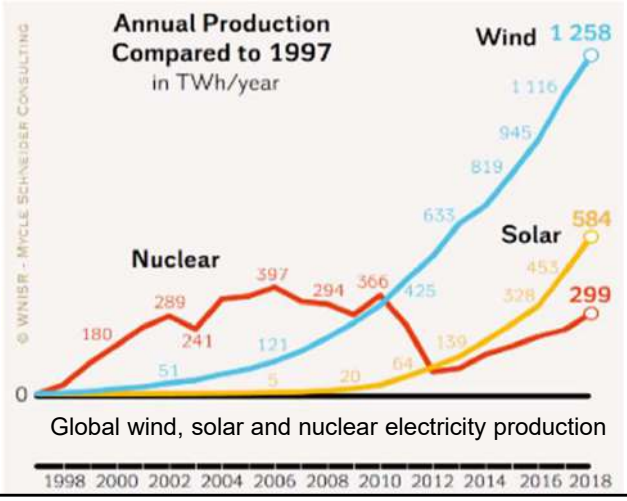
Renewables can undercut fossil fuel electricity **without financial support**.
With the right regulatory & institutional frameworks, competitiveness can only improve.

From https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2018/Jan/IRENA_2017_Power_Costs_2018.pdf

"Nuclear power... meets no technical or operational need that renewable competitors cannot meet better, cheaper, and faster"

We must meet climate targets using *least-cost* & *in-least-time* principles.

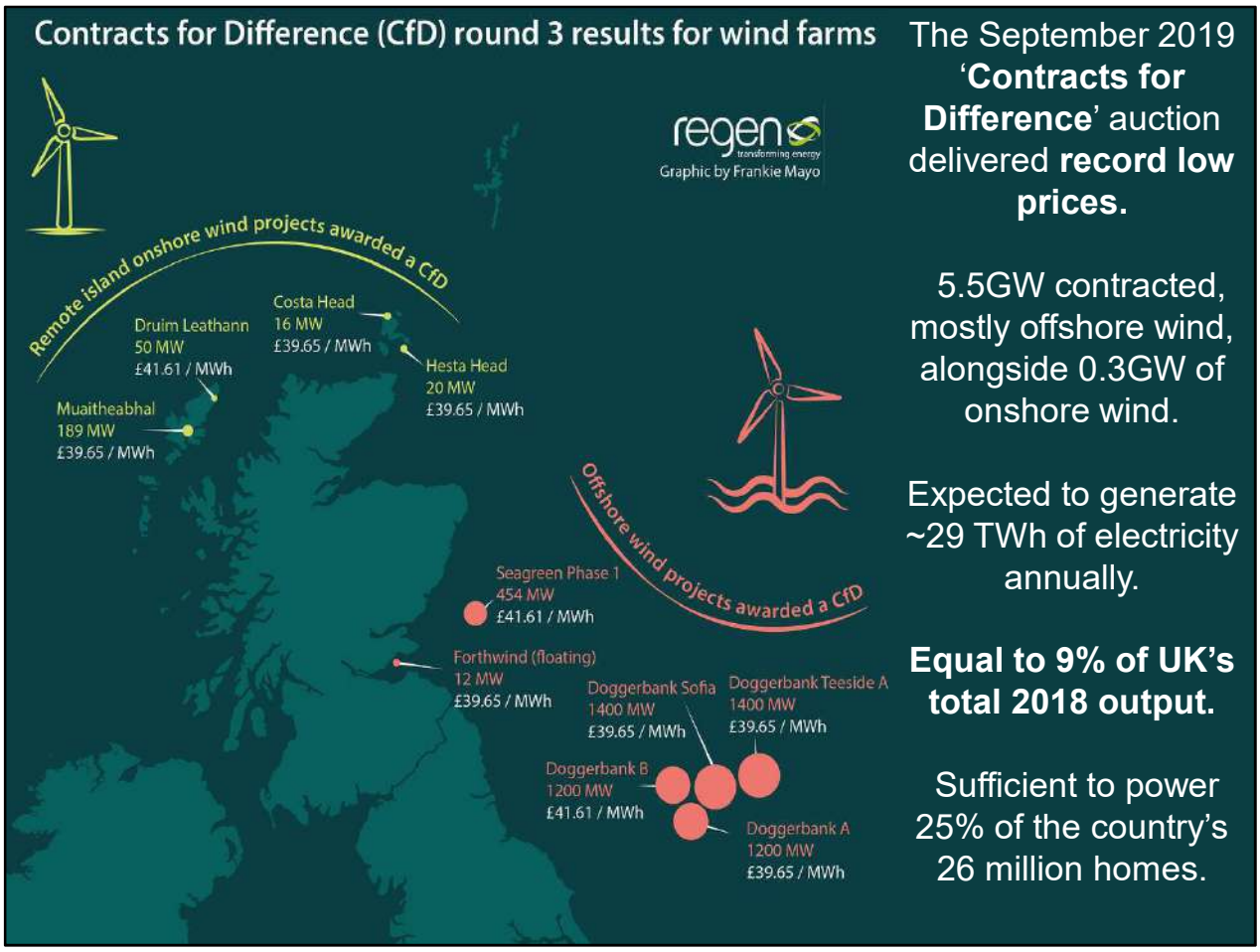
This means using non-nuclear options to save most carbon per dollar & per year



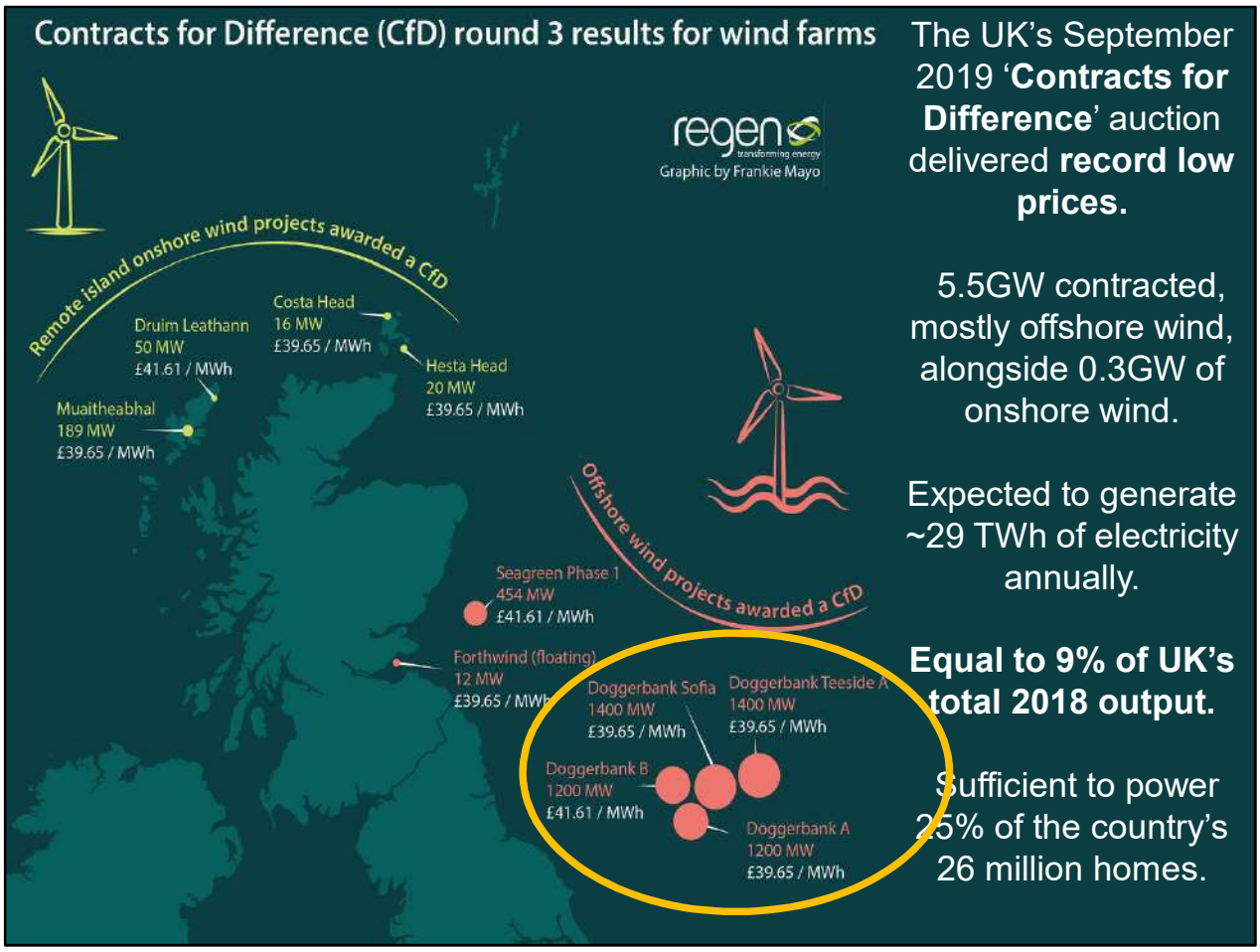
Global wind, solar and nuclear electricity production

https://www.worldnuclearreport.org/The-World-Nuclear-Industry-Status-Report-2019-HTML.html

Centrale nucléaire de Fessenheim. Photo Credit: Florival, Fr.
https://commons.wikimedia.org/wiki/File:Centrale_nucl%C3%A9aire_de_Fessenheim2.jpg
https://www.pv-tech.org/news/france-chooses-first-crop-of-names-for-pv-repowering-of-nuclear-site



Prices have fallen with each CfD auction: round 1 = £114 per MWh (operation start year 2018/19)
round 2 prices = £58 per MWh (2022/23)
round 3 = average £41 per MWh (for project starting in 2023/24 and 2024/2025)
(all costs are stated at 2012 prices for continuity).



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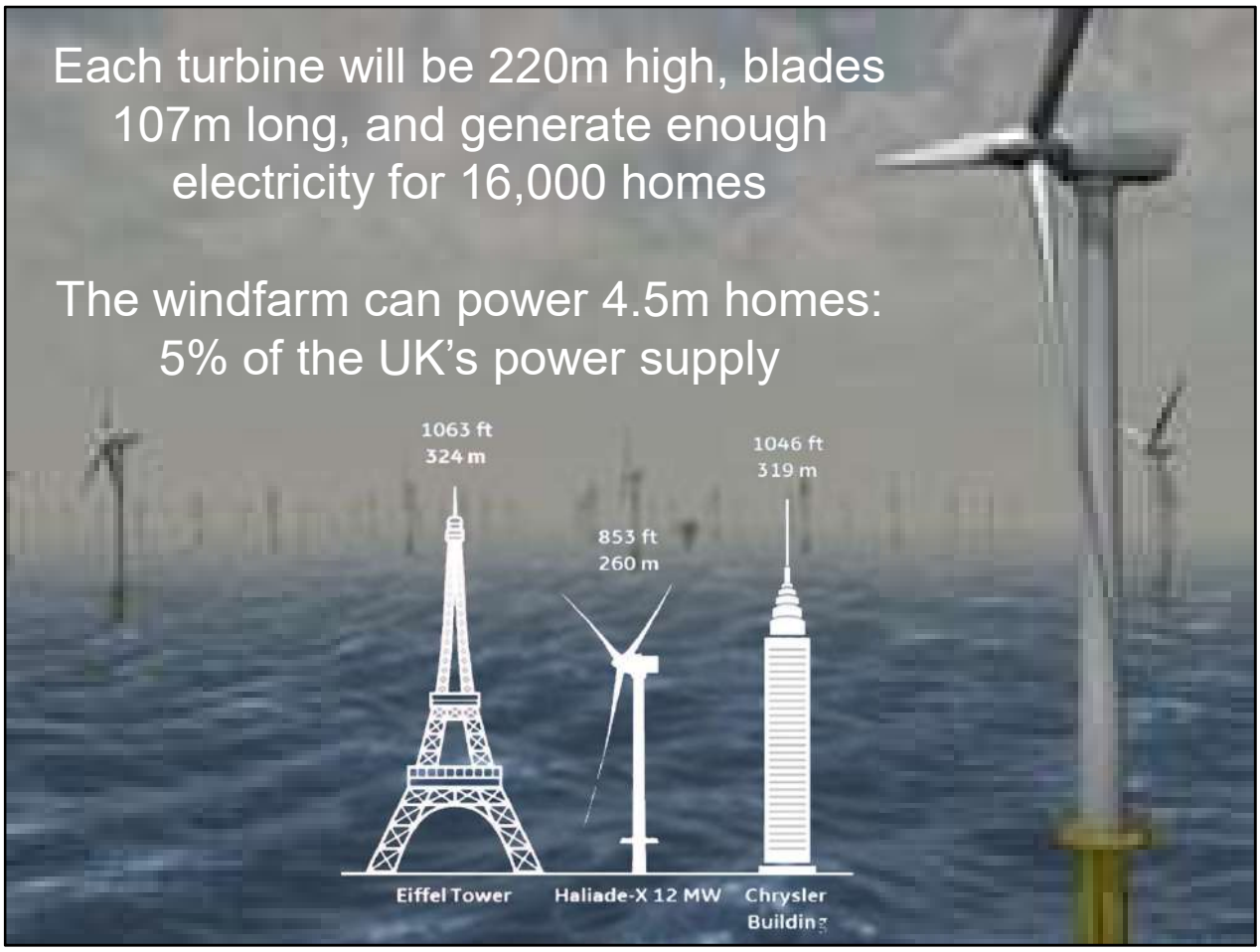
(all costs are stated at 2012 prices for continuity).

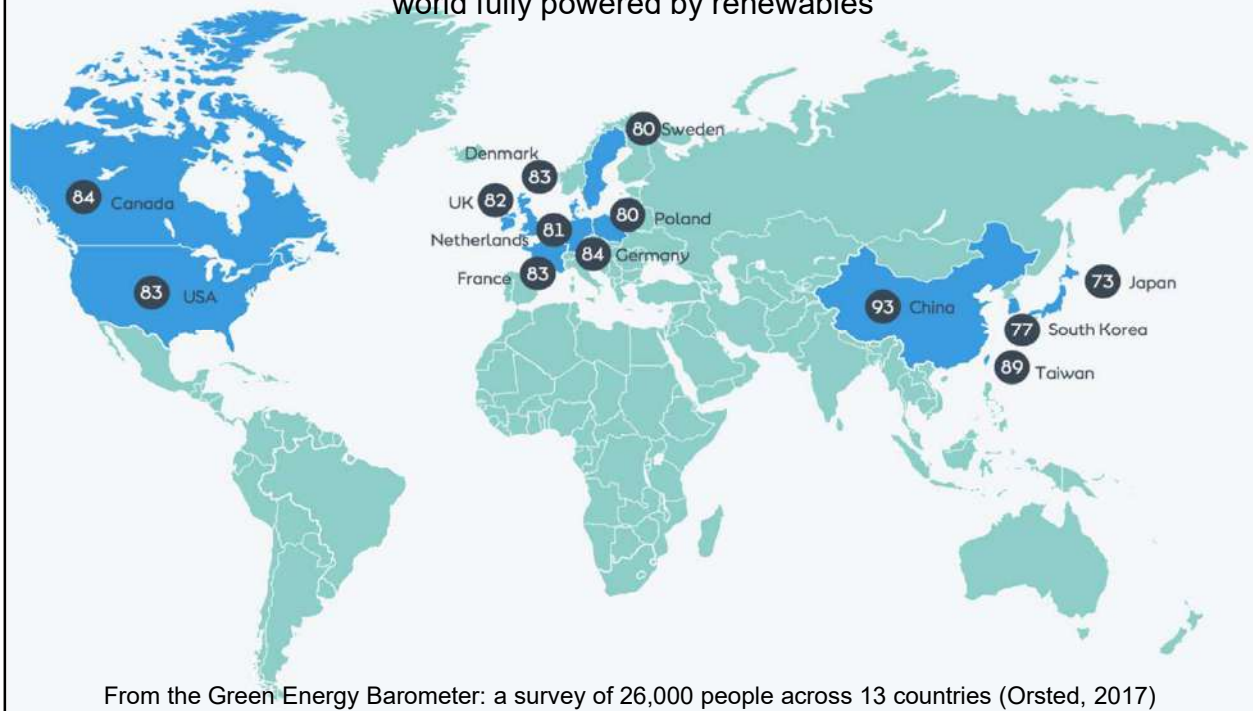
https://www.theguardian.com/environment/2019/oct/01/worlds-largest-wind-turbines-to-be-built-off-yorkshire-coast
https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine



https://www.theguardian.com/environment/2019/oct/01/worlds-largest-wind-turbines-to-be-built-off-yorkshire-coast
https://www.ge.com/renewableenergy/wind-energy/offshore-wind/haliade-x-offshore-turbine

People believe it is important to create a world *fully* powered by renewable energy

People across all ages, education levels and political standpoints are in favour of a world fully powered by renewables



From the Green Energy Barometer: a survey of 26,000 people across 13 countries (Orsted, 2017)

https://orsted.com/en/Media/Newsroom/News/2017/11/New-survey-shows-strong-global-support-for-green-energy
https://orsted.com/en/Barometer

People support renewable energy for several reasons:
Concerns about climate change- Climate change is considered the second most pressing challenge the world is facing (after terrorism)
- Perceived economic benefits- 73% believe building and producing

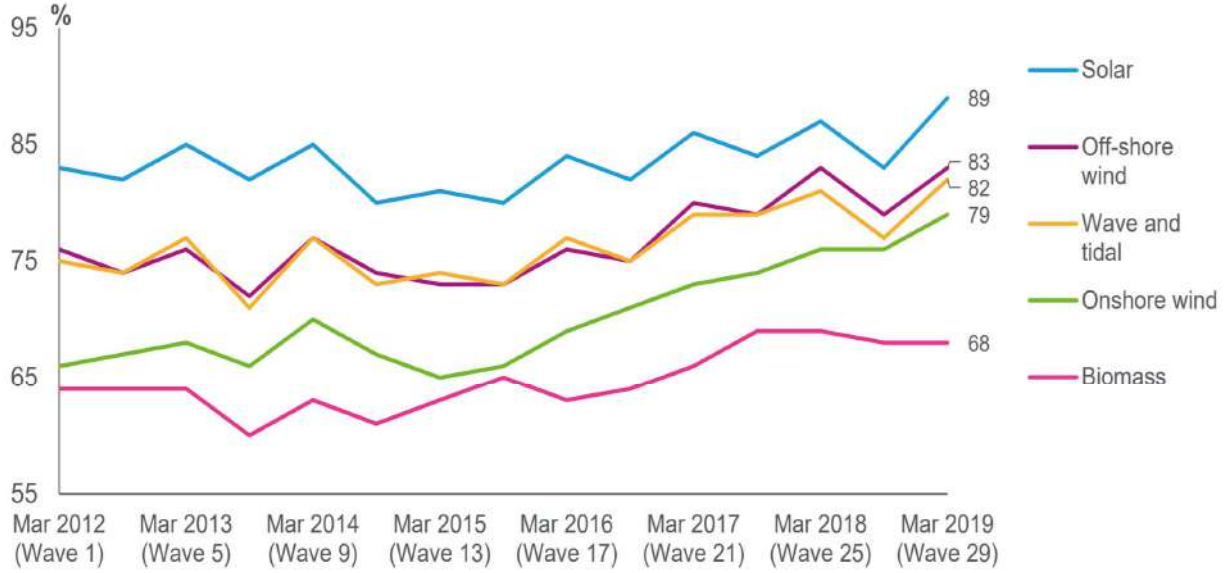
more green energy will boost economic growth
- Perceived societal benefits- 53% think there will be a reduction in health issues due to pollution if their country is a world leader in green energy

BEIS Wave Tracker

Support for all forms of renewable energy was 84% in March 2019.

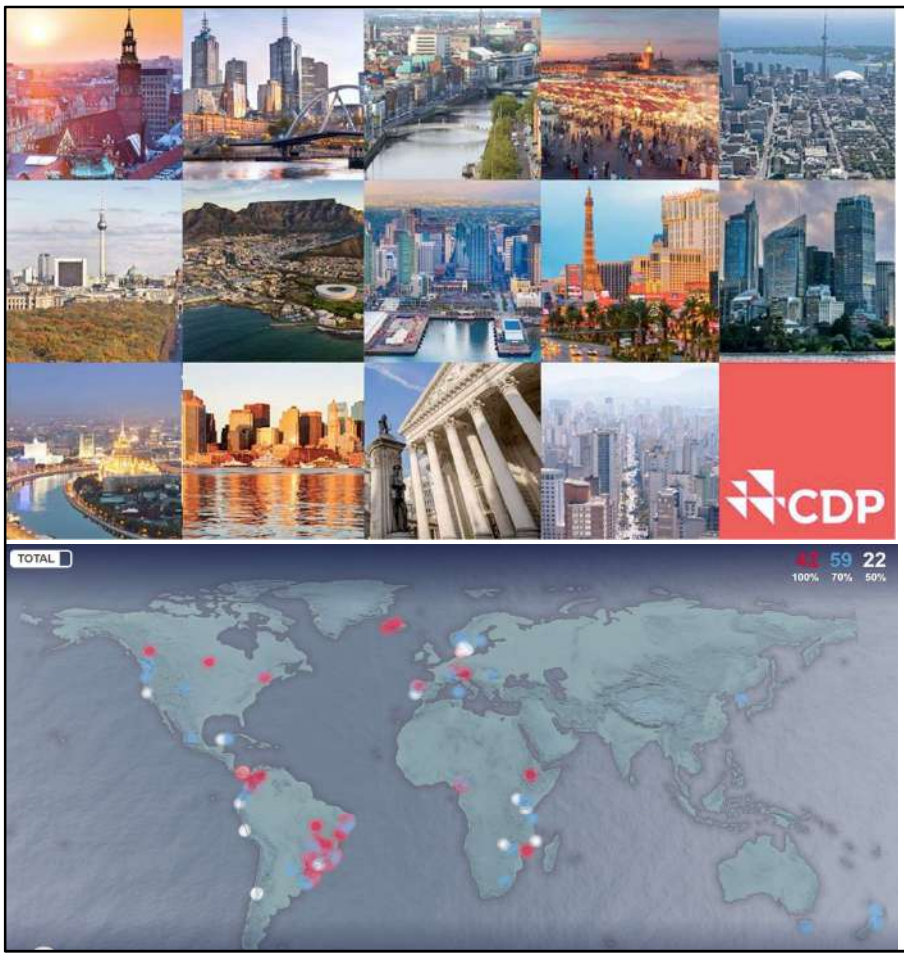
Opposition remains low at 3%, with only 1% strongly opposed.

Support for renewable energy remains high and keeps rising.



This is a survey on attitudes towards the department's policy areas and runs 4 times a year. Data is collected through face-to-face in-home interviews with approximately 4,000 households in the UK.

Figure 15: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/800429/BEIS_Public_Attitudes_Tracker_-_Wave_29_-_key_findings.pdf



OXFORD MARTIN SCHOOL

UNIVERSITY OF OXFORD

2018: 42 cities are 100% renewably powered

101 are 70% renewably powered

22 are 50% renewably powered

From 570 cities reporting to CDP

http://www.theguardian.com/cities/2018/feb/27/cities-powered-clean-energy-renewable

CDP See: cities https://www.cdp.net/en/cities/world-renewable-energy-cities

Akureyri, Iceland; Alba-Iulia, Romania; Alcaldía de Córdoba, Venezuela; Angra dos Reis, Brazil; Aparecida, Brazil; Aracaju, Brazil; Arendal, Norway; Aspen, USA; Assis, Brazil; Asunción, Paraguay; Auckland , New Zealand; Bærum Kommune, Norway; Bangangté, Cameroon; Basel, Switzerland; Belém, Brazil; Belo Horizonte, Brazil; Birigui, Brazil;

Bogotá , Colombia; Bolzano, Italy; Braga, Portugal; Brasília, Brazil; Brotas, Brazil; Brusque, Brazil; Burlington, USA; Cabreúva, Brazil; Cajamar, Brazil; Campinas, Brazil; Campos de Goytacazes, Brazil; Canoas, Brazil; Capivari, Brazil; Cascais, Portugal; Caxias do Sul, Brazil; Cerquilho, Brazil; Chorrera, Panama; Curitiba, Brazil; Dar es Salaam, United Republic of Tanzania; Estância Climática de São Bento do Sapucaí, Brazil; Estância Hidromineral de Águas de São Pedro, Brazil; Estância Turística de Guaratinguetá, Brazil; Estância Turística de ITU, Brazil; Eugene, USA; Extrema, Brazil; Fafe, Portugal; Fernandópolis, Brazil; Florianópolis, Brazil; Foumban, Cameroon; Gladsaxe Kommune, Denmark; Goiânia, Brazil; Harare, Zimbabwe; Hobart, Australia; Ibagué, Colombia; Inje , South Korea; Jaboatão dos Guararapes, Brazil; Kapiti Coast , New Zealand; Kisumu, Kenya; Lausanne, Switzerland; León de los Aldamas, Mexico; Limeira, Brazil; Lorena, Brazil; Maceió, Brazil; Mairiporã, Brazil; Medellín, Colombia; Moita, Portugal; Montes Claros, Brazil;
Montreal, Canada; Nairobi, Kenya; Nakuru, Kenya; Niterói, Brazil; North Vancouver, Canada; Nova Odessa, Brazil; Nyon, Switzerland; Oristano, Italy; Oslo, Norway; Palmas, Brazil; Porto, Portugal; Prince George, BC, Canada; Quelimane, Mozambique; Quito, Ecuador; Reykjavík, Iceland; Salvador, Brazil; Santiago de Cali, Colombia; Santos, Brazil; São Caetano, Brazil; São Gonçalo, Brazil; São João da Boa Vista, Brazil; São José do Rio Preto, Brazil; São José dos Campos, Brazil; Seattle, USA; Stadt Zürich, Switzerland; Stockholm, Sweden; Tatuí, Brazil; Temuco, Chile; Uberlândia, Brazil; Vancouver, Canada; Vinhedo, Brazil; Vitória, Brazil; Wellington, New Zealand; Winnipeg, Canada;

UK100

94 cities and towns have signed up to the UK100 local government network's target of 100% clean energy by 2050

https://www.uk100.org/

Opportunity Checklist:

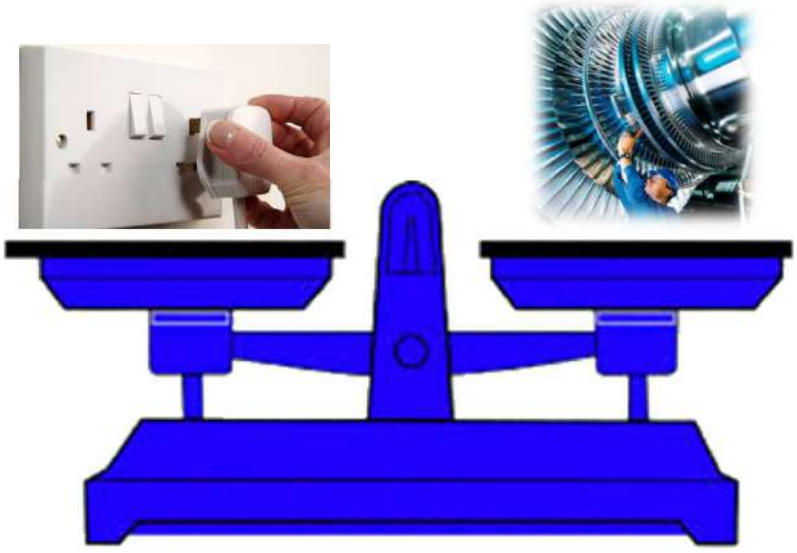
- ✓ Cost
- ✓ Capacity
- ✓ Public support
- ✓ Energy security
- ✓ Reduces pollution
- ✓ Address climate change

So what are the challenges?

Challenge 1

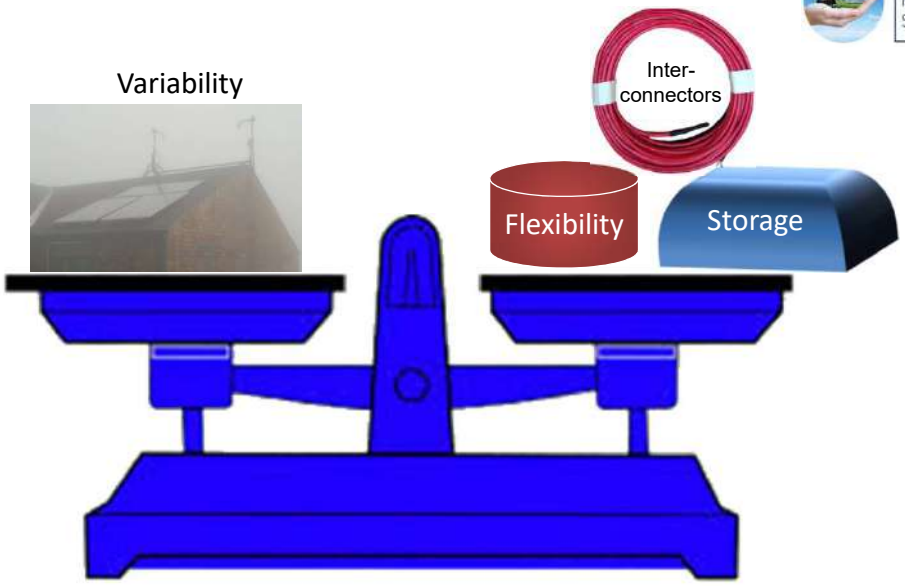
Variability

How to balance demand and supply?



Variable generation raises problems for balancing supply and demand on different timescales (from seconds to seasons) and different spatial scales

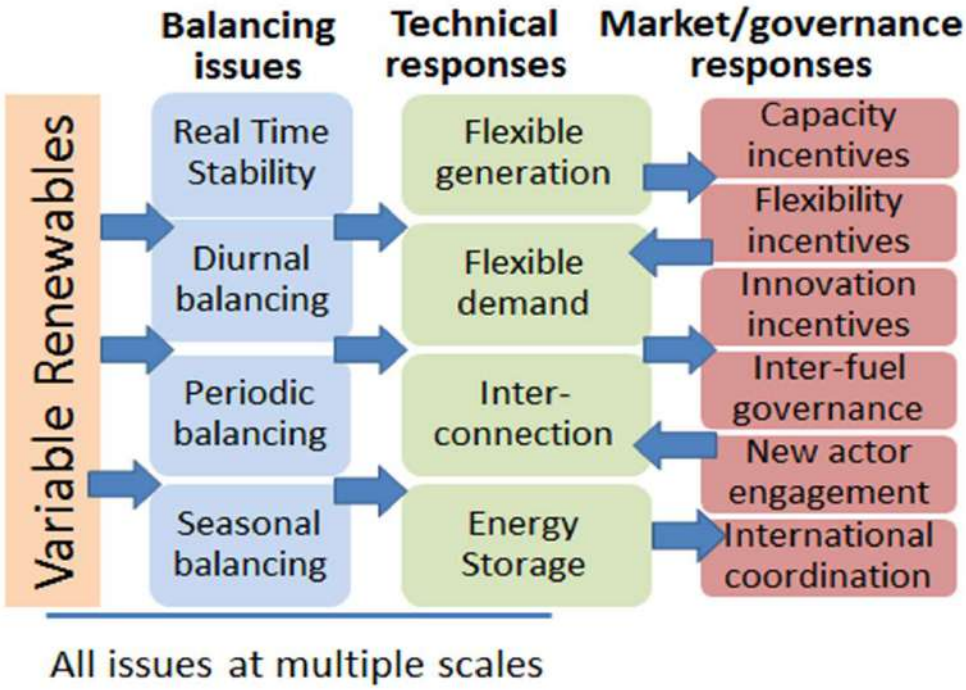
By Siemens Pressebild, http://www.siemens.com - Photo taken from [1] with the friendly permission of Siemens Germany by Christian Kuhna, E-Mail: christian.kuhna/klammeraff/siemens/dot/com, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=442598



- We need to integrate variable generation into existing electricity systems
- But also change these systems to be decentralised and integrated to maximise renewables
- The solution is a mix of flexible generation & demand, interconnections and storage
- This requires change to electricity market design, regulation and governance.

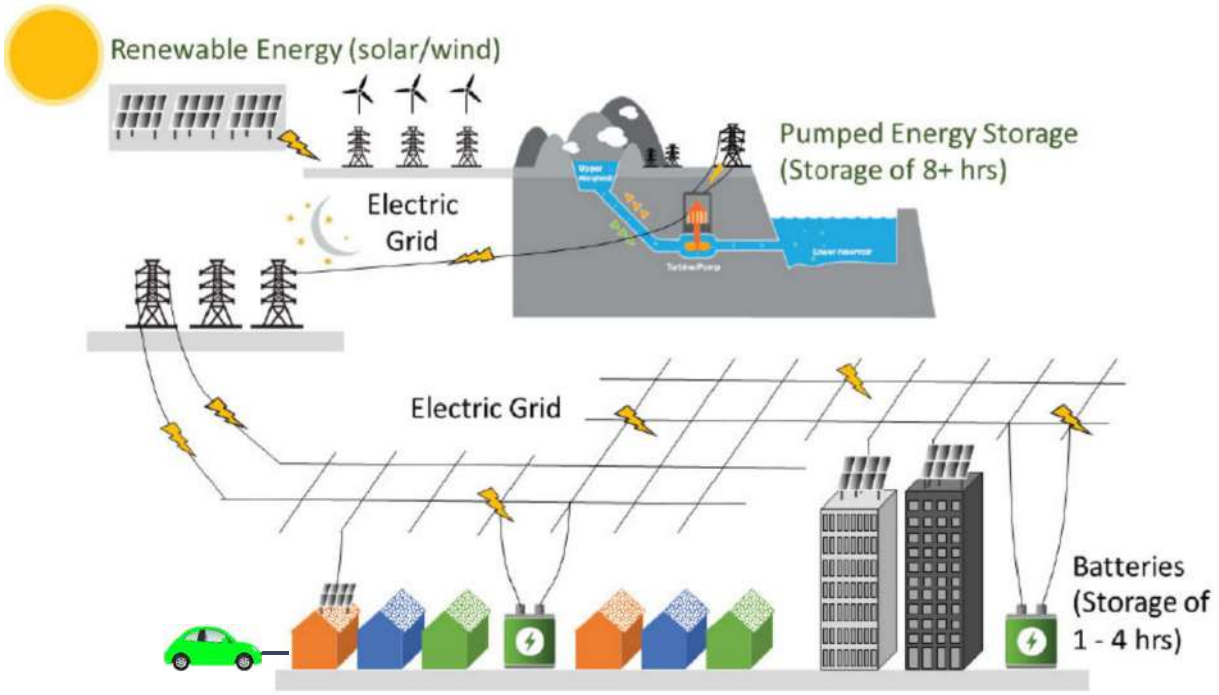
By Siemens Pressebild, http://www.siemens.com - Photo taken from [1] with the friendly permission of Siemens Germany by Christian Kuhna, E-Mail: christian.kuhna/klammeraff/siemens/dot/com, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=442598

Variability: issues and responses



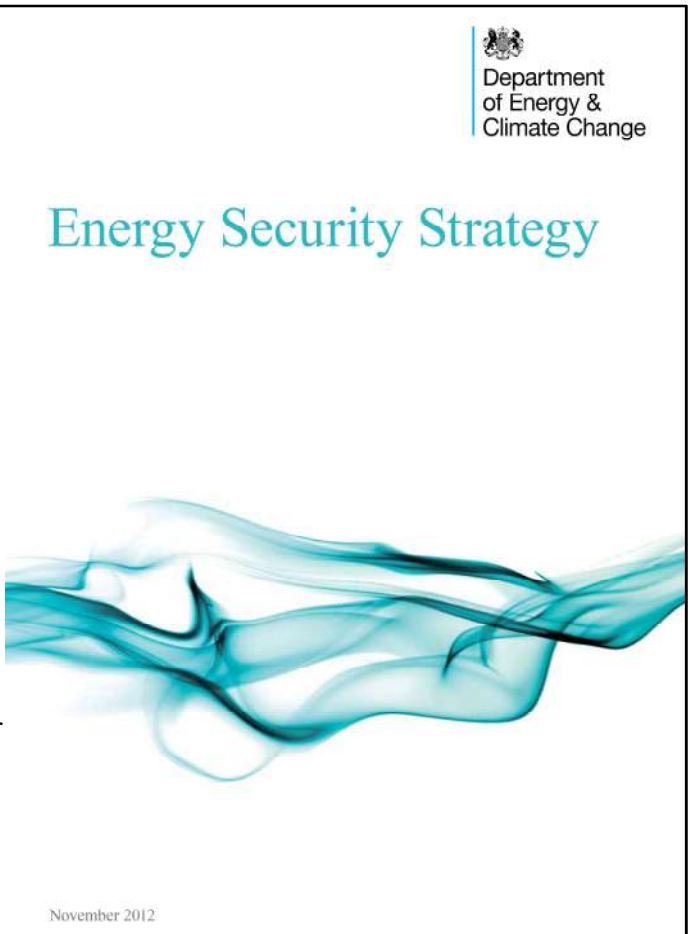
Flexible generation and energy storage

The ability to quickly supply power, over different timescales

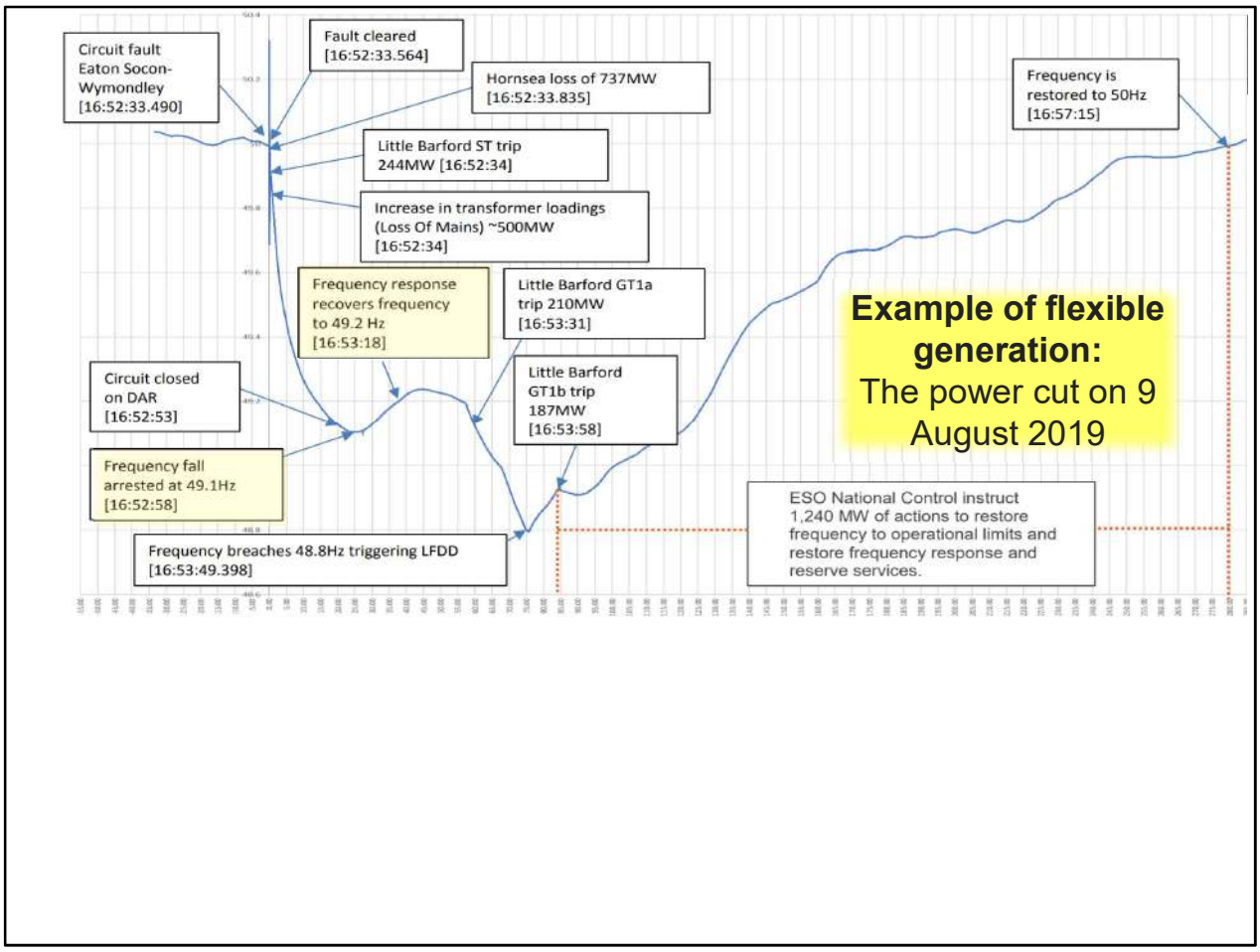


The Capacity Market

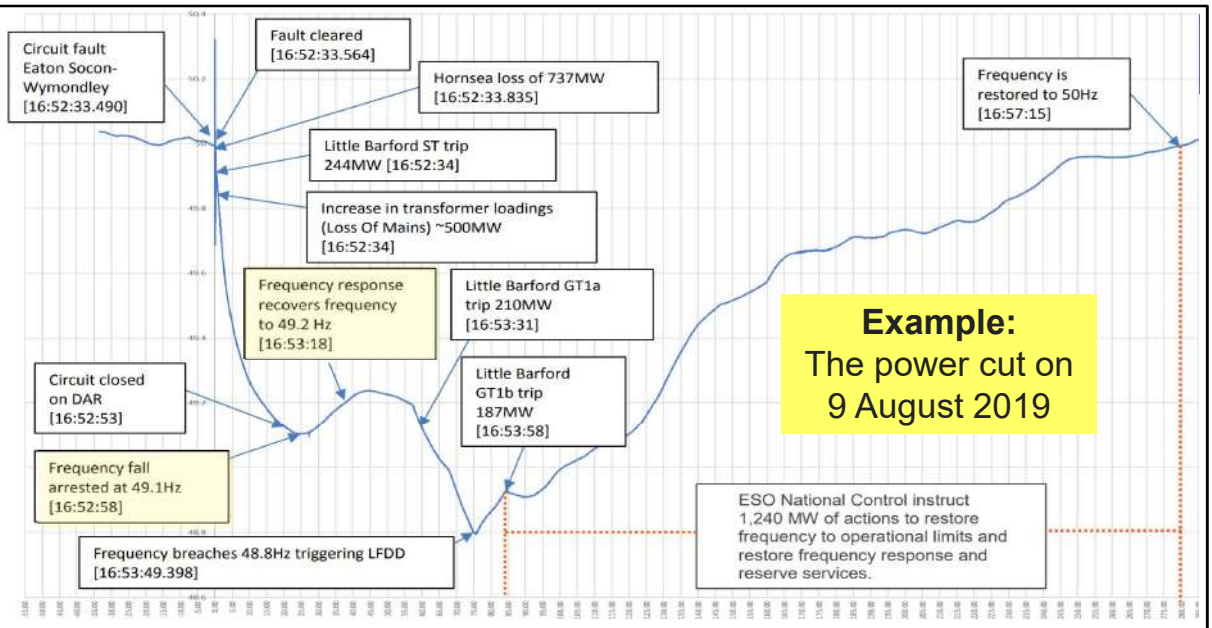
- Introduced by Energy Act 2013, implemented in 2018
- Aims to ensure sufficient investment in energy generation to meet ongoing reliability standards
- Capacity is guaranteed by agreement holders at times of stress
- Providers receive fixed income to cover some costs not recoverable via energy market
- Criticised for prolonging the life of fossil fuel generators & not fully supportive of DSR and hydropower
- *Currently on hold due to the EU challenge over state aid rules*



https://www.gov.uk/government/collections/electricity-market-reform-capacity-market
http://www.engie.co.uk/wp-content/uploads/2016/07/capacitymarketguide.pdf
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/65643/7101-energy-security-strategy.pdf



https://www.nationalgrideso.com/information-about-great-britains-energy-system-and-electricity-system-operator-eso



Reserve capacity (1 GW (475MW batteries) called upon to:
(1) provide power when following the loss of the first generator
(2) to absorb excess power, when the grid cut off part of the network.

How to we avoid such power cuts?

Greater battery reserve capacity – doubling this would be cost-effective compared to the level of economic disruption: +£2 to average energy bill (£10 for Hinkley C nuclear plant)

Further decentralisation - *need DNOs to act as system operators*

https://www.nationalgrideso.com/information-about-great-britains-energy-system-and-electricity-system-operator-eso

Flexible demand

not using electricity at certain times: "*demand side response*"

Technical potential is huge

The economic potential is being increased by IoT

It requires:

- Energy users to shift their demand in real time, in response to price or other signals
- Energy users agreeing to allow others (e.g. suppliers) to control some of their energy

https://www.energyinst.org/barometer/2019#policy-section

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UK Energy Institute Barometer: 2019 survey

https://www.energyinst.org/barometer/2019#policy-section

Example of flexible demand

Commercial refrigeration units need a daily defrost.

Asda is working with National Grid to use fridges in 300 stores & 18 depots as a decentralised, virtual, 13MW inverse “battery”.

Tesco’s fridges could provide 25-50MW.

Algorithms will match the defrost timing to grid surges, and the thermal inertia of the fridges to negate any food safety threats.

The UK food retailing sector uses 3.4% of total electrical consumption per year; ~29% used by in-store refrigeration units.
Smart meters and the IoT could also mean this is rolled out domestically too.

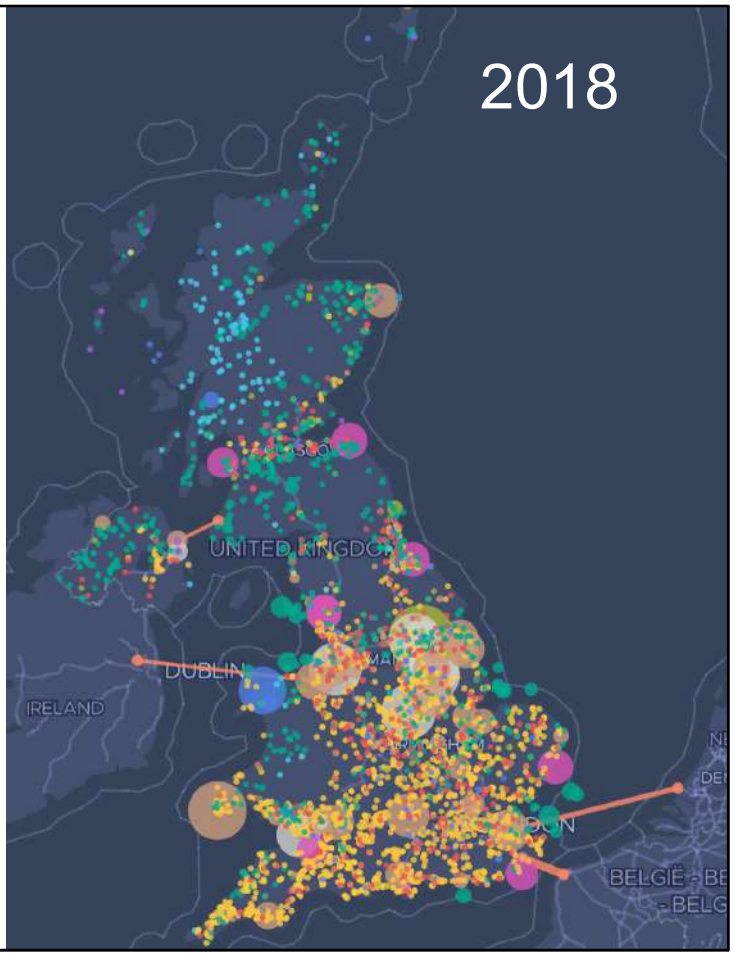
Interconnections

Cables that physically link different areas and allow electricity to be transported to demand centres.

The UK is part of the EU Single Market and the Internal Energy Market which makes imports and exports tariff-free.

Northern Ireland is part of the Single Electricity Market covering the island of Ireland.

Interconnectors transport ~6.6% of the UK's electricity



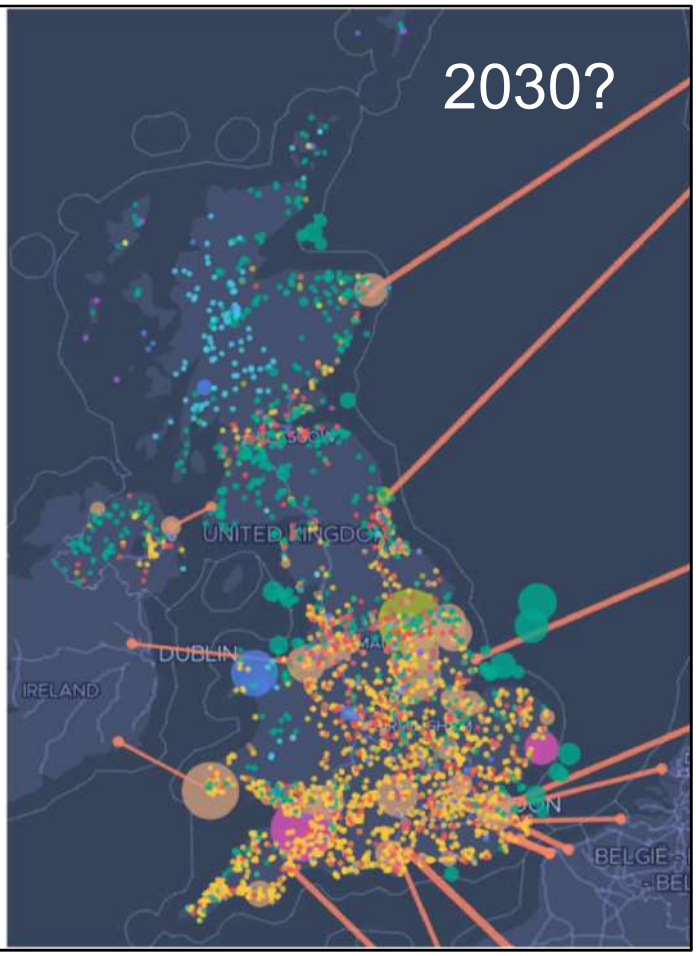
https://www.havenpower.com/news/how-will-brexit-affect-the-electricity-interconnectors/
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/671187/Updated_energy_and_emissions_projections_2017.pdf
https://www.gov.uk/government/publications/trading-electricity-if-theres-no-brexit-deal/trading-electricity-if-theres-no-brexit-deal

Interconnections

The plan was to have many interconnectors both to buy and sell electricity.

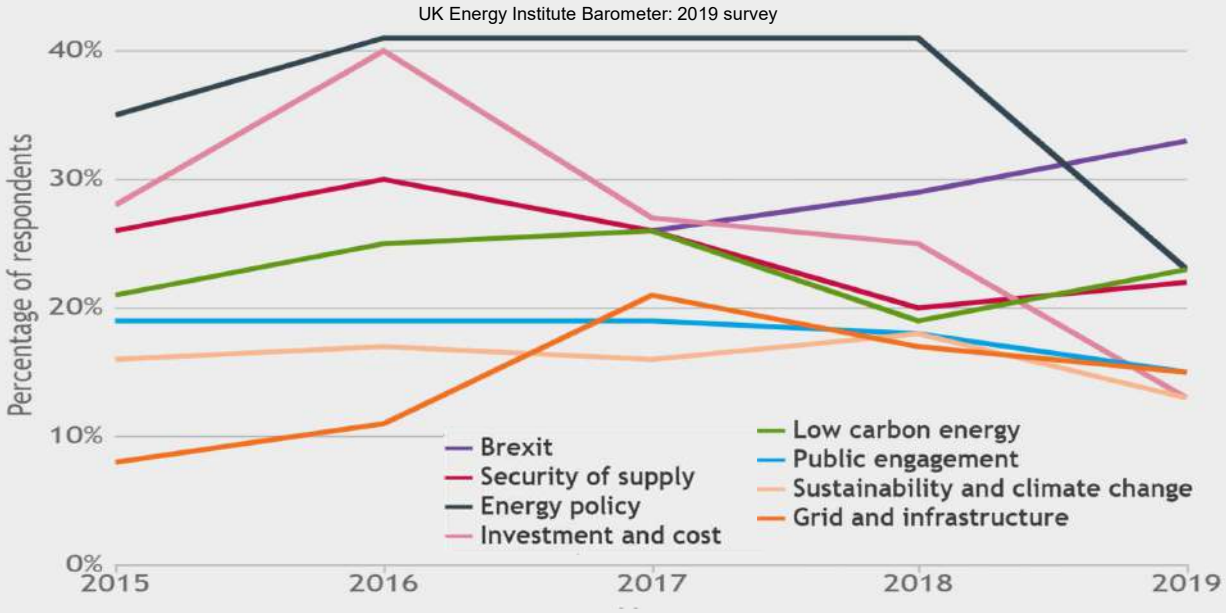
BEIS (2017) estimated 22% of our energy could come from interconnectors by 2025 due to plans for 11 new connections.

Brexit = uncertainty over how many will be built.



https://www.fieldfisher.com/media/5313890/interconnectors-brexit.pdf

QU: What do you think is the biggest challenge for the energy industry?

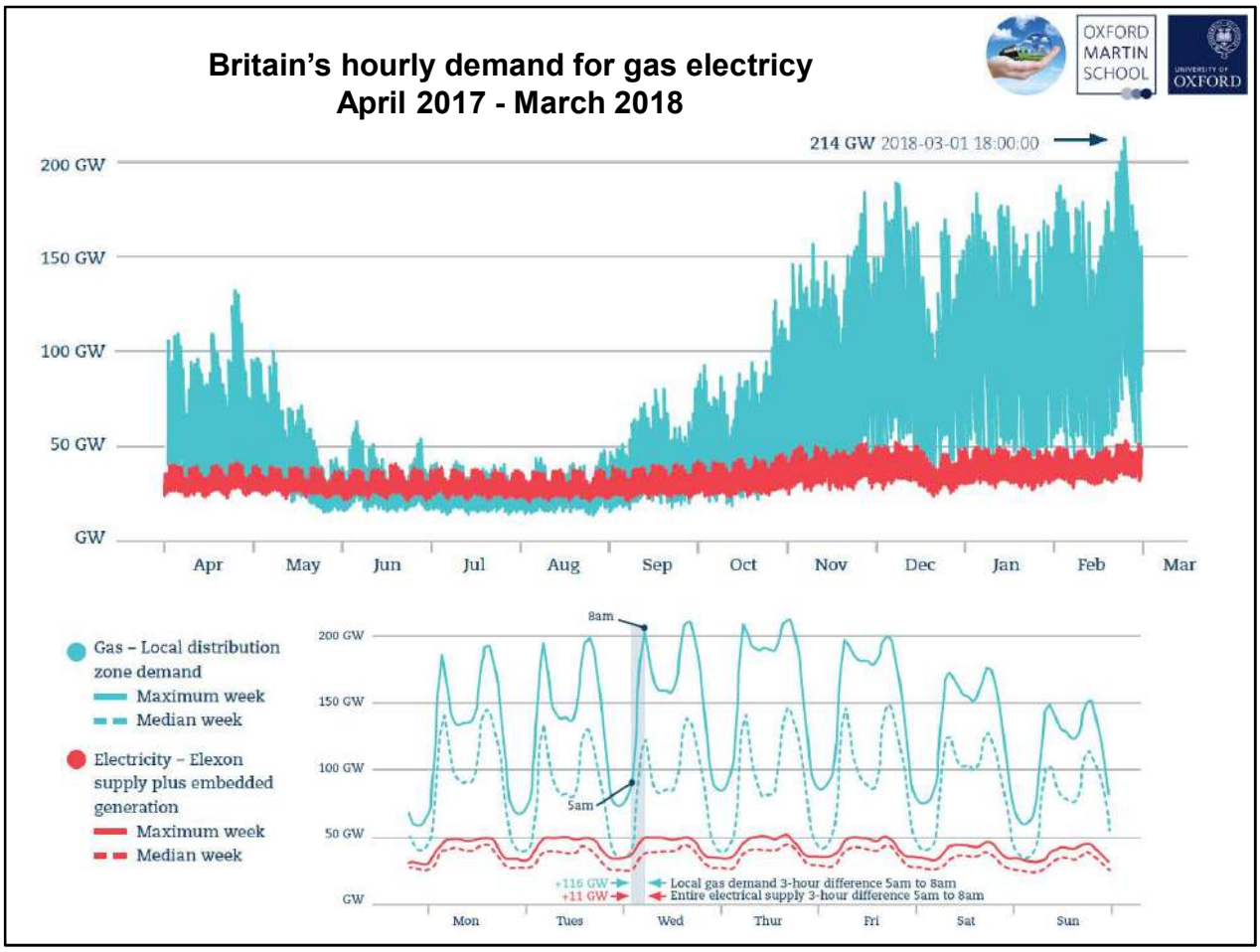


No Deal = trade implications between GB & Single Electricity Market via interconnectors. EU rules will cease to apply in Northern Ireland, leaving key elements of the SEM without any legal basis.

https://www.energyinst.org/barometer/2019
https://www.gov.uk/government/publications/trading-electricity-if-theres-no-brexit-deal/trading-electricity-if-theres-no-brexit-deal

Challenge 2

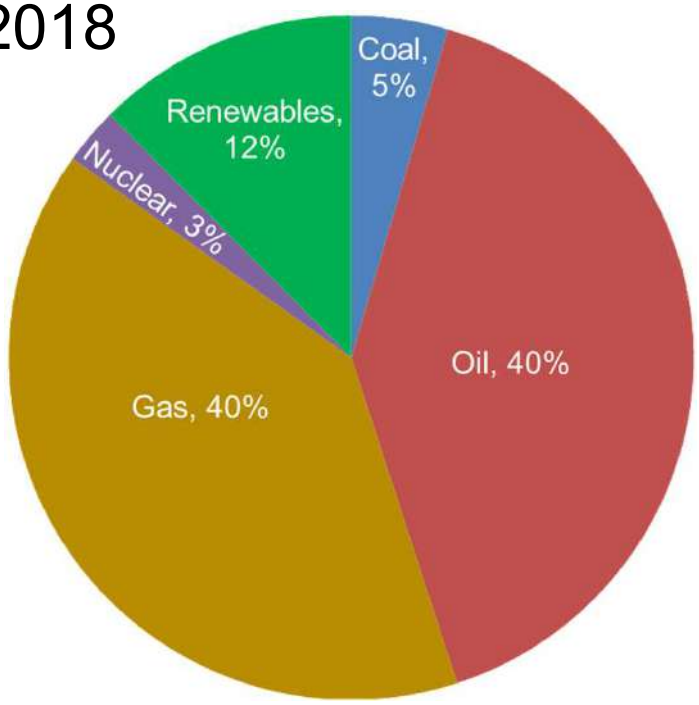
How do we use renewables for low cost *energy,* not just electricity…?



http://www.ukerc.ac.uk/publications/local-gas-demand-vs-electricity-supply.html

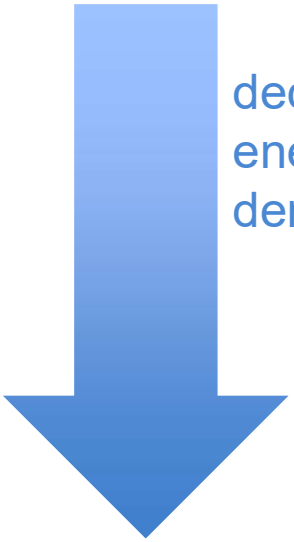
This is how we generated energy in 2018

82% of emissions are from our energy use

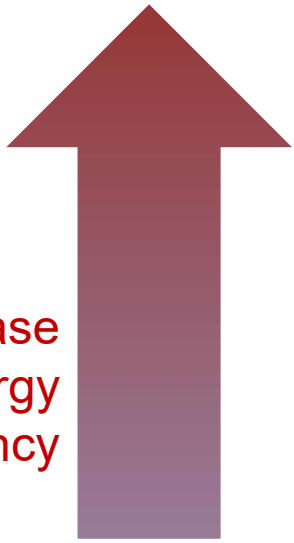


2019 DUKES

We need to:



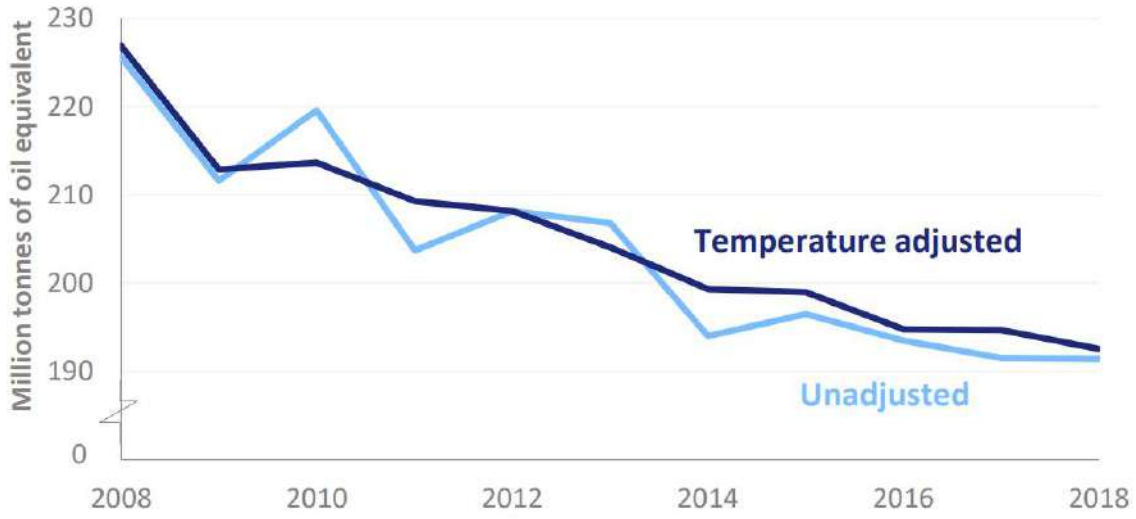
decrease energy demand



increase energy efficiency

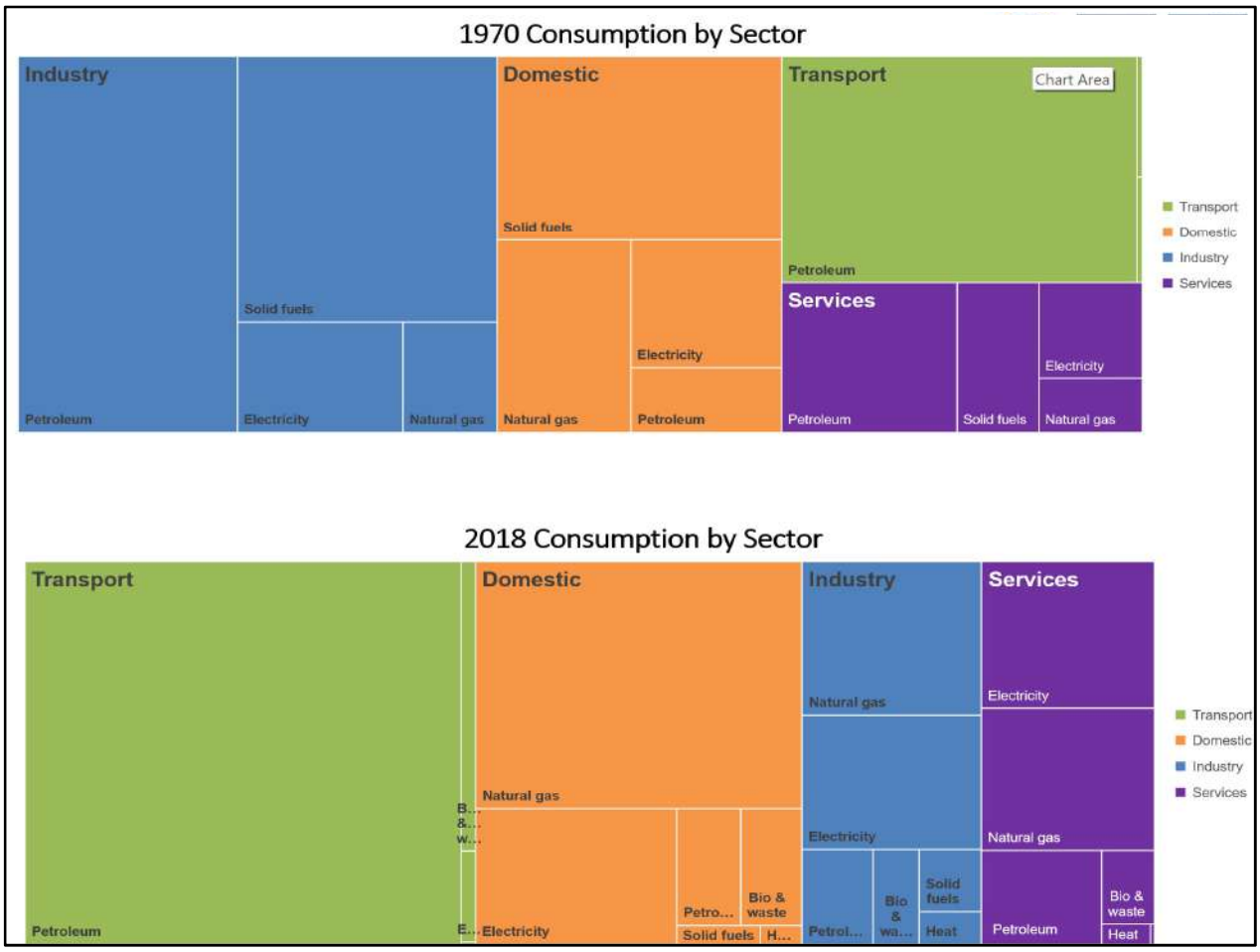
Demand is falling

Primary energy consumption 2008 – 2018



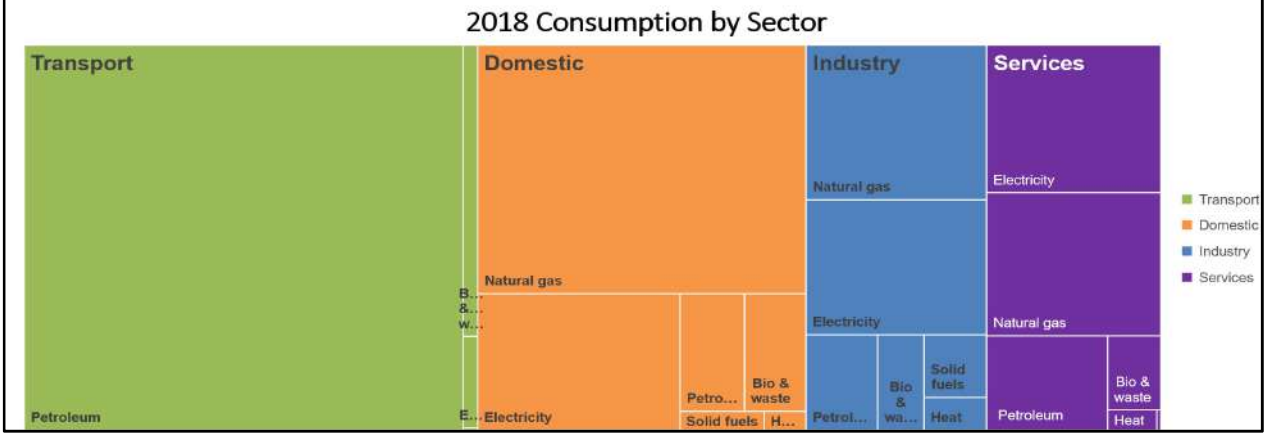
BEIS, DUKES 2019

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/840015/DUKES_2019_MASTER_COPY.pdf



https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

We critically need to reduce energy use from transport & households



https://www.gov.uk/government/statistics/energy-consumption-in-the-uk

Energy Efficiency

*"When asked which measures the UK Government should pursue in order to reach emissions targets cost-effectively… **energy efficiency** improvements [have been] in the top spot for the past three years.*

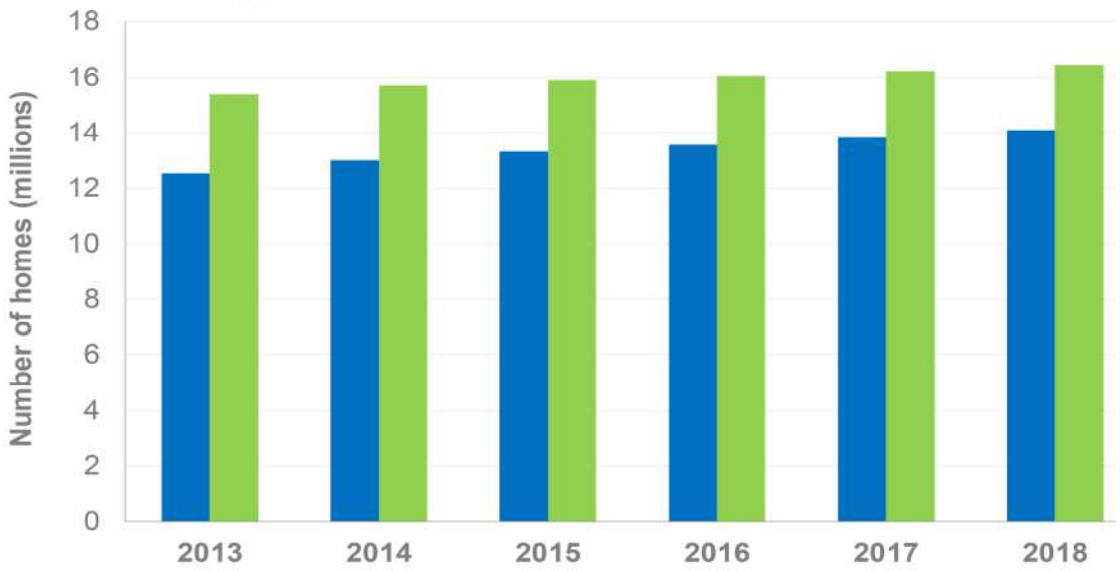
It is seen across the board by respondents, regardless of their area of energy or career stage, as vital to a productive economy and to cutting carbon emissions without unnecessary cost."

Energy efficiency is key to ensure '*capacity adequacy*'

Energy Institute's Barometer survey, 2019

https://www.energyinst.org/barometer/2019#policy-section

Home energy efficiency measures



69% homes have cavity wall insulation (14.1m of possible 20.3m with cavities)

66% have insulation to a depth of at least 125mm (16.5m out of total 25m)

11% of homes are classed as being in fuel poverty (2017)

Fuel poverty = when household has a required fuel costs above average and when residual income (after having paid housing, energy, tax and National Insurance) is less than 60% of the national median

P37

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819511/UK_Energy_in_Brief_2019.pdf

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/829006/Annual_Fuel_Poverty_Statistics_Report_2019__2017_data_.pdf

- Reduce demand for space heating:
  - Insulation for existing buildings
  - ‘Passive House’ quality for new builds

Norwich City Council’s award winning social housing. Energy bills of £150/yr

https://www.theade.co.uk/assets/docs/resources/Heat%20Networks%20in%20the%20UK_v5%20web%20single%20pages.pdf

How could renewables provide energy?

- Use of solar for hot water (*heating hot water is the second most intensive use of energy in the home*)
- Long term storage of renewable electricity (eg thermal or chemical)
- Alternatives to natural gas:
  - Hydrogen
  - Ammonia
  - Green gas from biomass
- Deploy heat networks: 17,000 exist supplying 2% of heat demand – could be more

Challenge 3

Changing minds

A number of market failures are a major barrier to use of renewable energy

Market failure	Intervention required
Free use of the atmosphere as a sink	Pricing carbon
Unpriced benefits of technological innovation	Support for innovation - R&D and early movers
Barriers to the implementation of distributed technologies	Product regulation, new business models, advice, engagement etc.
Specific issues in system balancing and electricity network operation	Electricity system policy and regulation

Water sector pledges net-zero carbon emissions by 2030

Purton WTW delivers ~30% of water supplied by Bristol Water.

It has a PV array of ~1 GW and also draws ~27GW from the grid

The company will build gas plants at Purton to generate electricity.

Rationale: Gas is less efficient than electricity but cheaper (retail price)

Context: the company spends £millions per year on energy costs

Can we have a "*contracts for difference*" type of arrangement to bridge the difference between electricity and gas prices until the electricity retail price reflect the increasingly low cost of renewables, and an adequate carbon levy is applied?

Lots of things are needed, or need to change, for renewables to fully play its role

Adequate carbon tax

Stop subsidies to fossil fuels

Willingness to change

Consumer acceptability

Providers

Businesses' ability to change

Demonstrator projects

Consumer's ability to change

Regulation

Power market reform

Clear playing field

Funding

Advice Centres for consumers, industry, and business

Political support

Bridging loans

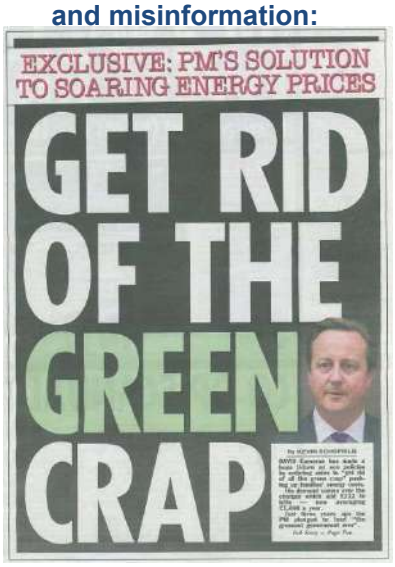
Social attitudes

Help for installers

Green New Deal

Skills and apprenticeships

Stop adverse policy changes and misinformation:



Long term Government support for all renewable and energy efficient technologies

Thank You

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Find out: grid.iamkate.com

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