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Supergen Energy Networks Hub Workshop
Stakeholder Engagement for Markets and Regulation - 14th May 2019,
University of Bath, Level 6, 83 Pall Mall, St James's, London SW1Y 5ES

Network Access and Charging Challenges from New Markets and Regulation

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The energy system is changing – we need to change the way we regulate, and potentially what we regulate to manage emerging challenges

KEY NEEDS ACROSS AN EVOLVING ENERGY SYSTEM

Independent decision making

- Decarbonisation and wider heat policy
- Whole energy system optimization (heat, electricity, gas)
- ‘Rational’ co-development of power, transport, waste etc
- Code development and evolution
- Data architecture; development of digital twin

Broader consumer protection

- Product complexity – DSR, cross-vector purchases, multi-utility bundles, embedded energy products
- Intermediaries
- Platforms
- Understanding/measuring consumer protection (e.g. Local energy markets might see higher prices, no switching, but high engagement/active choices)

Greater use of markets: price signals, cost-reflectivity

- Constraints
- Time of use/peak usage
- Intermittency
- Ancillary services
- Whole systems
- Carbon
- Heat, gas, electricity (waste, transport, ..) optimisation

Key Need: Better use of markets to drive lower costs for consumers

Currently many key aspects of energy markets are not fully captured. Costs are often:

- **socialised** (e.g. constraint costs at transmission level; increasing renewables penetration leading to increasing ancillary services costs),
- **missing** (e.g. carbon emissions, constraint costs at distribution level)
- **captured inefficiently in markets** (e.g. ancillary services – 6 services 20 plus markets , intermittency, loss of largest load, cost of nuclear clean-up),
- or **benefits are dispersed amongst too many players** (energy efficiency, whole system benefits).

We will need to make better use of markets if we are to enable robust, low cost, decarbonised energy.

Fixing some of these missing markets will enable other markets to work better.

In electricity, how do our current markets stack up?

Product	How does the market operate?	Market assessment
Power @ 35% of the bill	Driven by scarcity, and mix (underlying marginal costs) and to some extent intermittency (e.g. discounts on PPAs); scarcity pricing attenuated by capacity markets (to fix "missing money" problem)	Workably competitive
Ancillary Services @ 4% of bill (but growing)	Range of markets (~20), mixed of mandated provision and competition; increasing need for ancillary services as the challenge of keeping networks stable, managing intermittency and constraints increases, partially offset by better (but still limited) AS markets	Workably competitive, but mandated participation; market fragmentation
Retail @ 10%	'Supplier hub' model reinforces the dominance of large suppliers; stifles competition, limits innovation. Significant portion of consumer body disengaged. Price competition for engaged customers at expense of disengaged. Has led to introduction of (temporary) price cap. Retails mediate price signals consumers see.	Not workably competitive, price cap
Networks @ 25% bill	Administratively set on the basis of LRMC. Ofgem determines the framework, uses competitive processes: for access and forward looking, tries to reflect underlying costs in a manageable way; for residual, tries not to distort behaviour. Limited locational/time of use signals	Some competitive processes, but not market prices

Ofgem has already recognised that the current network access and charging arrangements are not set up to address the challenges of the energy transition

- The energy system is going through a radical transformation.
- These changes could create challenges and opportunities for our electricity networks.
- Current network access and charging arrangements are not set up to address these changes. We have two linked reviews underway to develop reform proposals:
  - The **Targeted Charging Review** (TCR). This seeks to remove some of the remaining embedded benefits and to allocate fairly the residual charges, which should not send signals and which are there for recovery of the allowed revenue for the network companies. Our consultation on our draft conclusions closed in February.
  - **Access and forward looking charging reform**. We want to ensure that electricity networks can be used more efficiently and flexibly – so that users can have the access needed, and benefit from new technologies and services, whilst avoiding unnecessary costs. We formally launched this review in December, and have set up a Delivery Group and a Challenge Group to support us in developing and assessing options.

Price Signals: how can locational price signals be made more efficient?

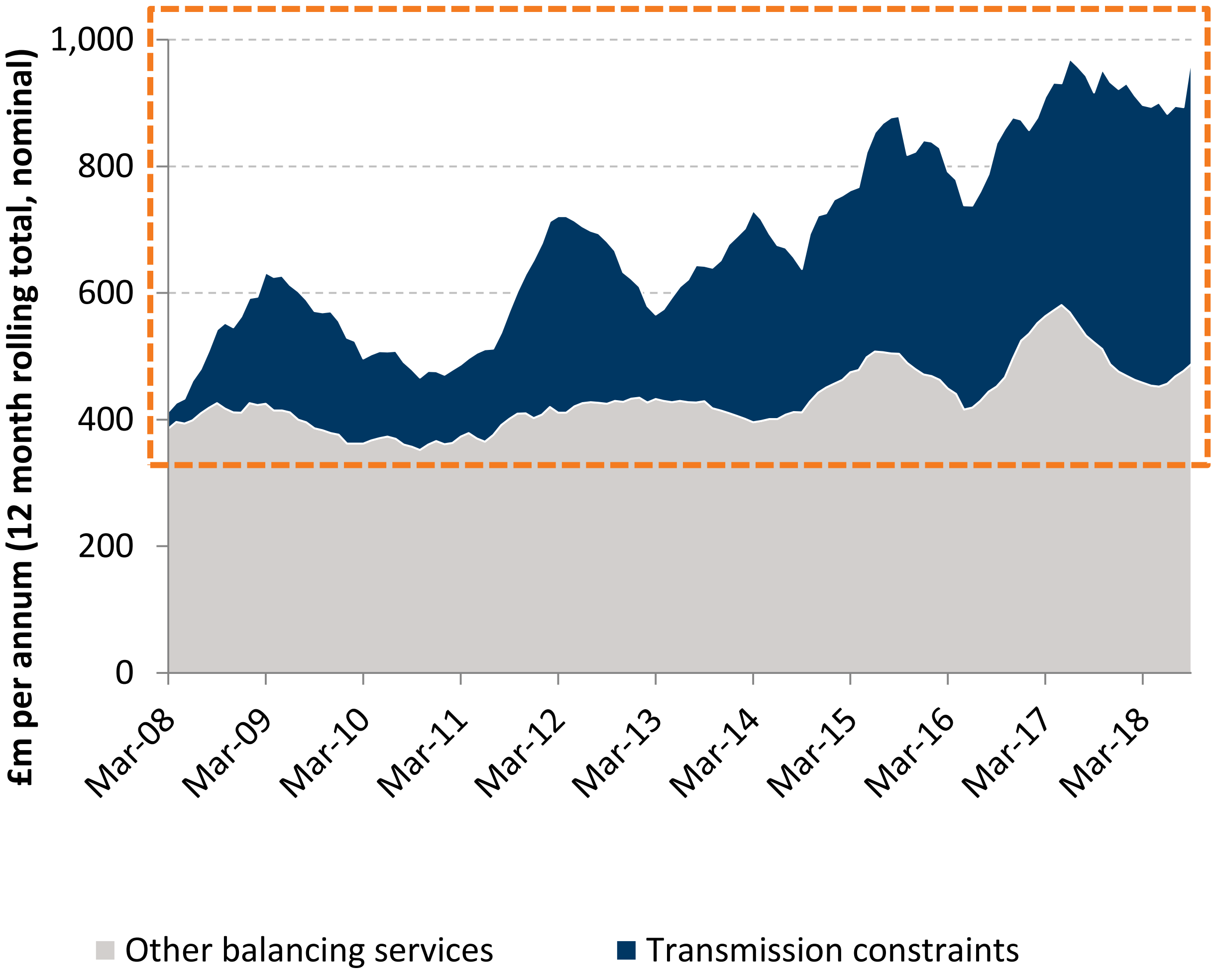
Problem

- Under the GB market design, there is a lack of locational price signals on the transmission level (a single wholesale price is formed across GB, **without reflecting congestion**)…
- …this is mitigated partially through transmission charges but is still at £400-500m p.a. (see blue area in the figure on the RHS), reaching £100m in Sept 2018 (i.e. one month alone)
- As decentralisation increases, **locational price signals at the local level** become important

Current progress

- Ofgem is currently reviewing network and access charges. Providing more granular locational and temporal price signals to charges is one of the questions of the review.
- In the future, should decentralisation begin to feature more strongly, there may be a case for providing more granular price signals.

Historical spend on balancing services (rolling annual total, £m)



Above graph does not show the cost of distribution constraints (not priced in)

Markets transmit information to inform decision making – what information is required for networks?

What are the signals needed for electricity networks?

- Signals for **short-term operation** to effectively manage congestion which need to be dynamic as network use variable
  - co-ordinating demand and supply effectively behind a constraint;
  - informing individual customer decisions around buying electricity in or storing it, and load shedding or load displacing;
- Signals for **long-term investment,** where, and how much capacity to add (and in what form)

How do these network signals interact with wholesale power prices (particularly as renewable penetration increases:

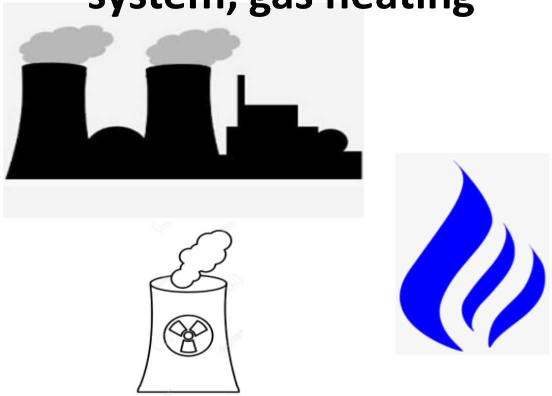
- might have longer periods of time where wholesale price is low, **operational decision-making** probably needs to be more informed by network costs, **signal on network usage might need to dominate**
- For longer term investment decisions, power prices should inform new generation requirements (ignoring the missing money, or in conjunction with CM), network price signals should provide information on (ideally) where to install generation, and inform investment decisions on whether to increase network capacity (or storage provision) – can short-term prices be used to inform longer term investment decisions?

And other markets?

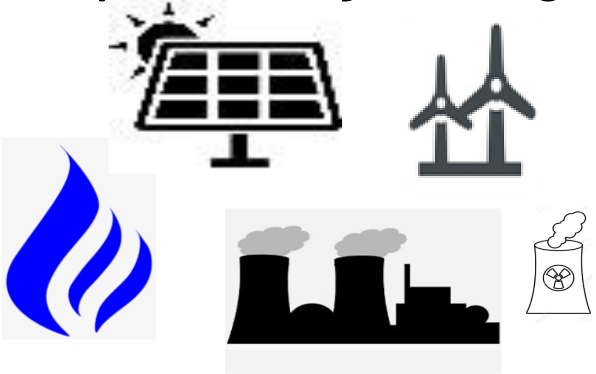
- Security of supply currently managed by capacity markets (but assumes national provision). What good is spare capacity behind a constraint?
- Ancillary services, having network access enables firms on distribution level to participate

Does the energy transition change the relative importance of key components that need to be priced in?

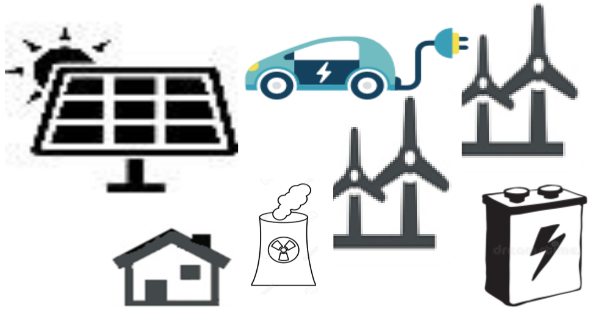
1990s Coal dominated power system, gas heating



2010s Gas, nuclear, renewables split system, gas heating



2030s Electrified Heat and Transport, high renewables



Operations
<u>Power</u>: One way power flows, static peak pricing ("economy 7") for domestic consumers; Large consumers on ToU
<u>Networks</u>: Limited mostly static locational signal

Investment: <u>Power:</u> Large units of generation needed strong signals from power markets, the government; <u>Networks:</u> Investment driven by demonstrated need, funded through price controls, and recovered through charging

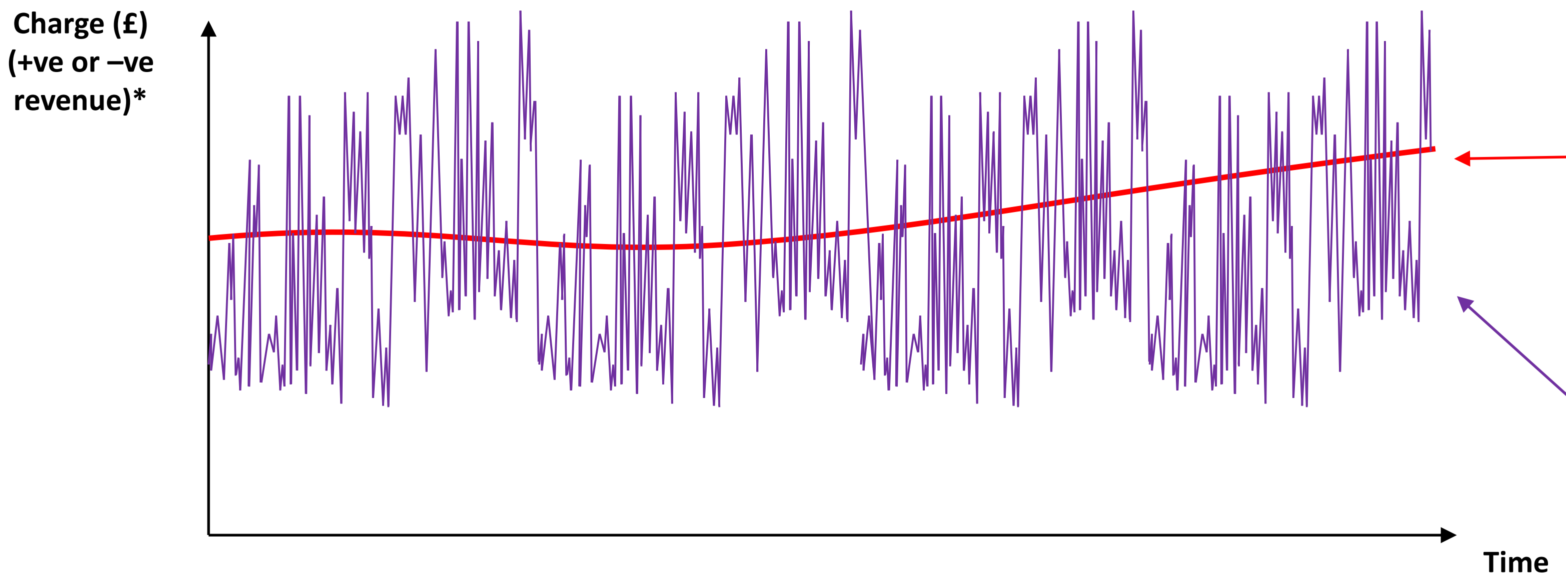
Operations:
<u>Power:</u> Large customers on ToU, some domestic customers too; greater use of ancillary services to manage complexity
<u>Networks:</u> Sometimes bi- directional flow, DNOs seeking flexibility products to manage constraints; localised constraints; nascent DSO markets

Investment: <u>Power:</u> Capacity markets to manage "missing money" problem, subsidy programmes (CfDs, Ros) to promote renewables; <u>Networks</u>: as before

Operations:
<u>Power</u>: Time of use power prices, local matching of demand and supply, using AI/algorithms to optimise demand, locally differentiated security of supply;
<u>Networks:</u> Heavily constrained; actively managed, dynamically reconfigured; strong flexibility markets; high penetration of storage
Investment: <u>Power:</u> Smaller scale units, with shorter paybacks might not need as strong signals????;
<u>Networks:</u> ***If*** *short-term operations become relatively more important, how is long term investment effectively signalled*

Is there an increasing need for dynamic price signals to optimise short-term network use?

Long Run Marginal Cost (LRMC) versus Short Run Marginal Cost (SRMC) Charges



Long Run Marginal Cost (LRMC)
Based on costs incurred over the long term. All factors of production are variable, including investment decisions (such as investments in additional network infrastructure).

Short Run Marginal Cost (SRMC) Based on costs incurred over the short term (close to real-time). Network capacity is fixed and decisions are purely operational.

Long-Run Marginal Cost

Factors that could be considered include:

- whether demand is located close to generation (or vice versa)
- the marginal cost associated with an increment of generation/demand. This could be based on the drivers of network cost that are associated with reinforcement, asset replacement and the availability of spare capacity.

Short-Run Marginal Cost

Factors that could be considered include:

- whether or not the network is constrained in real-time (or close to real-time) and cost of managing this constraint in terms of the
- the degree to which adding (or removing) a MW at each location on the network will alleviate/exacerbate the constraint

*Note that graphical representations in this presentation are for illustrative purposes only.

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If we are not economically ‘pure’ - there are a range of methods that might be able to send the signals around network operation and investment

Zonal Pricing –

- Zones can reflect constraint boundaries
- Resources can trade bilaterally

BUT

- Zones generally too big to be useful to manage constraints, particularly in a dynamic world where we need signals to bring forward resources to optimise network use at peak times of the day
- Difficult to regulate??

Nodal Pricing

- Dynamically optimises power and networks,

BUT

- Less clear investment signals, and signals can be distorted by market power
- Liquidity challenges particularly at lower voltages
- For Dx, would require substantial improvements to network data/modelling and institutional change (and would need LMP at transmission level also)

“Telecoms”

- Network company sets price within regulatory framework,
- 3rd parties access part of the incumbent network,
- regulator “monitors”
- Greater competition in distributed generation Micro-grid / private wires as alternatives to incumbent distribution

BUT

- Is it possible?
- The physics might be challenging - electricity takes the path of least resistance, difficult to tell it where to flow (Kirchhoff’s law)

Shadow pricing

- Possible use of power flow models used to determine short term operations for all connected players;
- would probably need a long term contracts, with ex-post charging, so users would not be responding to price, but modelled network congestion

BUT

- Not sure this is in any way possible

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If we are not economically 'pure' - there are a range of methods that might be able to send the signals around network operation and investment (2)

Status Quo/ Administrative price setting

- Regulator sets pricing framework based on LRMC

BUT

- Lack of dynamic signal which might become an issue in a highly decarbonised world with high penetration of renewables

Aggregators on Flexibility Platforms (such as Green Sync)

- Aggregator provides services to DNOs, the cost of service is essentially a "price for congestion"
- Might provide dynamic price/congestion information (but would depend on platform design and contracts)

BUT

- Could result in very complex and conflicting price signals
- Would depend on operational rules

Congestion Feedback

- Relies on the creation of some feedback system – for instance physically sampling flow on key parts of the network
- Idea would be to approximate something like the internet (as the error rate increases, transmission rate decreases until acceptable), or road traffic (try to move travel time decisions away from peaks)

BUT

- Is it possible?
- At the limit looks like a bit like "shadow pricing" using power flows

Access Markets (what do you bid in to use part of the network)

- Create defined access rights for network
- Can buy and sell, prices set in the market

BUT

- Not dynamic – more akin to property rights

How should we price in constraints?

- Will constraints become more important? How can we use markets and price signals better to better use resources?
- Does the required approach to pricing in constraints change over time as the system changes? Does it depend on what sort of system we end up with? What charging regime will be required for the 2030s?
- If local/micro-grids become a dominant feature of future energy systems, does it change the relative importance between power and network signals?
- Do you need dynamic pricing, or will other signals work (for instance access rights, flexibility market platforms)?

- ANNEX – SLIDES I AM LIKELY TO DELETE

Ok, am stopping here

Network charging in GB currently creates distortions, and is relatively static

Networks are monopolies, so in the UK we regulate, and set prices for use of networks

Pricing essentially administratively set (need a way of recovering the money from network users to pay network companies):

- Access and Forward Looking charges – relatively static estimate of the long run marginal cost of connection, additional cost impact of deeper network expansion
- Residual charge – designed to try not to distort behaviour

We can, and are making these charges better, but are there/will there still be **important** gaps between how we price, and how a market might? (and is this question relevant or pertinent even in electricity markets, where things happen more quickly than trading can reflect? Where we have to some extent separated out the physical operation of the moving electricity from producers to consumers from the financial data flows)

What are some of the relevant trends?

Declining costs for PV and storage

Relatively static or increasing network costs (although might decrease with a fair RIIO2 settlement)

Increasing distributed generation (

Potential increase in EV load, and heating load

Increasing penetration of home heating systems (Tado, Nest)….

NG FES "Community Energy Scenario" – by 2030 has *11m Evs, 15m homes with electric heating, x GW storate (check numbers)*

For the slides that follow – lets imagine a world where:

- 80% electrification of heat;
- DG rises from 35% now to 55%, coupled with rise in storage to x GW

Constraints need to be managed at distribution level

Competition in the fixed-line telecoms sector

- The GB telecom experience provides precedent for alternative third-party competitive models. There are two broad models:
  - First, the construction and use of competing infrastructure which bypass the incumbent "parallel networks"; and
  - Second, accessing part of the incumbent network under a controlled tariff.

Opportunities for the energy sector?

- Greater competition in distributed generation (with greater and easier rental access for local distribution lines)
- Micro-grid / private wires as alternatives to incumbent distribution / IDNOs

However the energy sector is different to telecoms in the following ways:

- Difficult to have large own-generation disconnected from the main grid (due to balancing requirements)
- Harder to share separable 'portions' of the incumbent network (e.g. in telecom, some infrastructure is more likely to be shared (ducts and poles) than others (fibres)
- Harder to switch electricity networks on/off due to Kirchhoff's law – electricity flows through path of least resistance
- Relatively unsophisticated metering / equipment control on distribution network and consumers (however this is changing with Smart Metering)
- Lesser change / innovation in products and services in electricity compared to telecoms

Assuming beneficial to consumers, how should policymakers 'push' for deregulation?

- Analyse potential bill impact
- Ensure network charging arrangements are cost reflective to limit barriers to entry
- Greater locational pricing on the distribution level
- Encourage small-scale entry / trials / innovation spending
- Regulation around customer outcomes, protection and non-discriminatory access
- Potential reconfiguration of the ownership of incumbent assets (i.e. allow new entrants to buy parts of the incumbent network)

Lessons for the electricity sector: Conditions necessary to enable infrastructure competition between Networks

Condition	Situation in telecoms	

Capacity need/ increasing demand	In telecoms the constraint was insufficient network capacity in combination with demand for novel services	• Could electrification of heat & transport provide the stimulus?
		• Can we see increasing need for novel services in energy, such as
		  • increasing need for ancillary services, or
		  • the threat from cyber,
		  • or the need to incorporate renewables and other DER)

Ability to segment market	Telecoms networks could be contestable in densely populated regions (not all areas are contested)	• Could see growth of competing electricity networks spinning off from IDNO networks, or micro-grids, or Local Authority facilities (e.g. waste to gas, or CHP plants)
Ability to attract investors	Early cable television investors in the 1980s lost did not receive returns, consolidation and an acceptance of longer term returns followed	• Development of infrastructure for a dedicated major consumer could provide a basis for supporting investment (microgrid, business park, solar and storage provider, LA)

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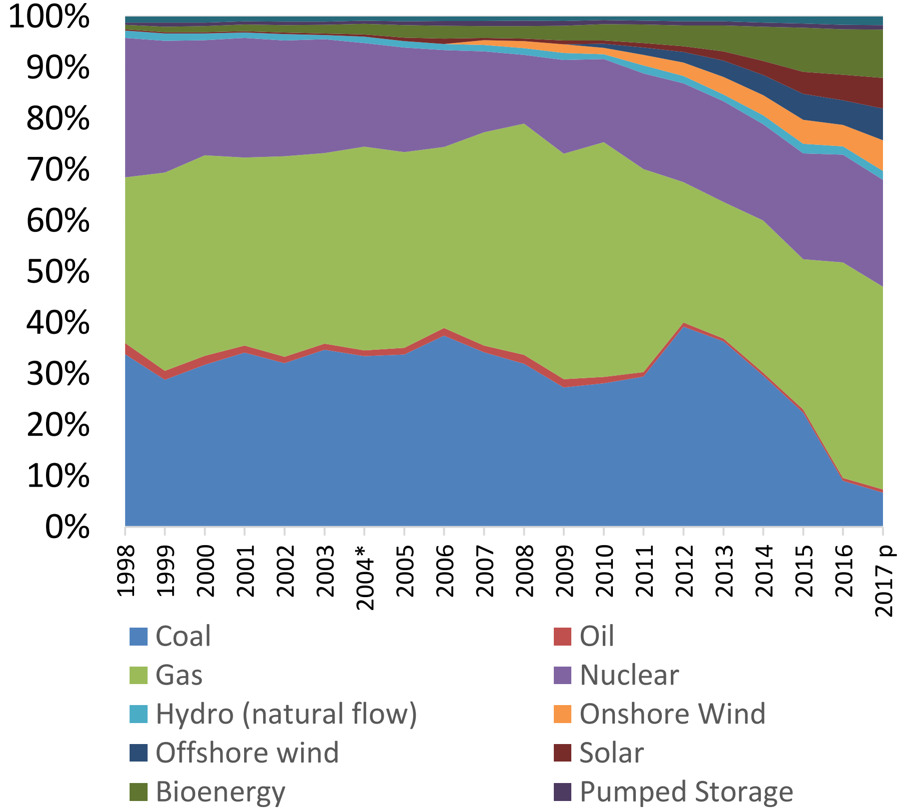
The generation mix has changed significantly – becoming more intermittent, greener and increasing connected at distribution level

In a little over 10 years renewables have increased from below 5% of total UK to around 33%*

Fuel used in electricity supplied

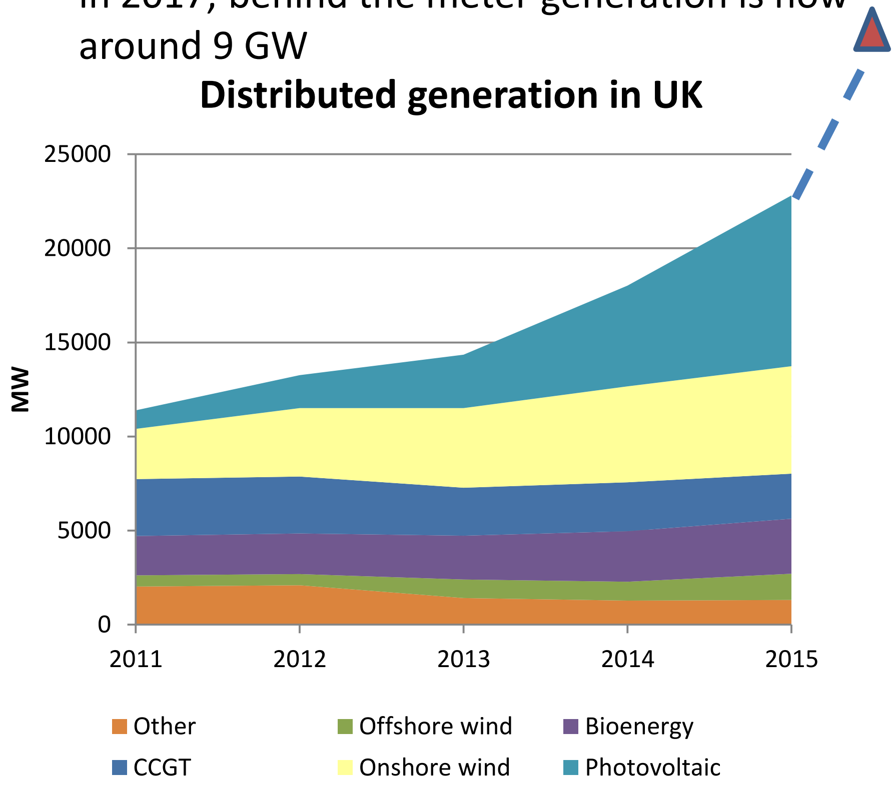


*Renewables' share of electricity generation increased from 30.0 per cent in 2017 Q3 to a record 33.1 per cent in 2018 Q3.

Source: DUKES
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766383/Renewables.pdf

Electricity Generation connected to the distribution network is increasing, doubling from just over 11 GW in 2011 to over 32 GW in 2017; behind the meter generation is now around 9 GW

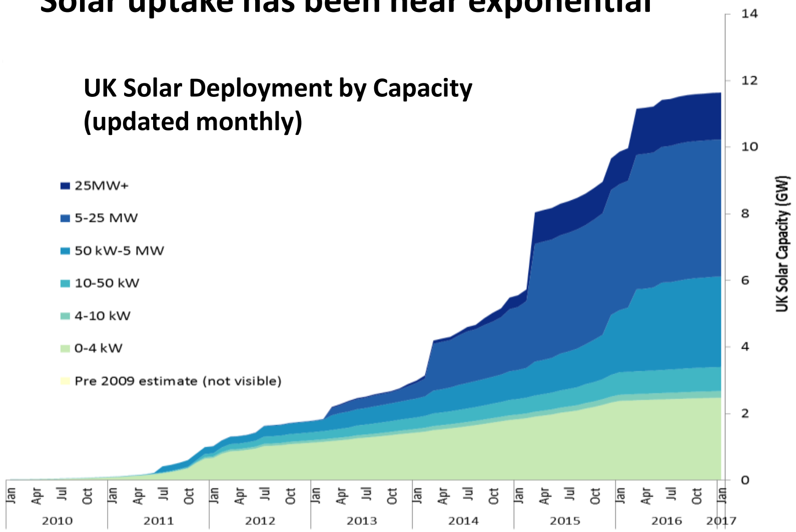
Distributed generation in UK



Source: BEIS, DUKES (2016) – updated figures from **Digest of UK Energy Statistics (DUKES): electricity 2018**

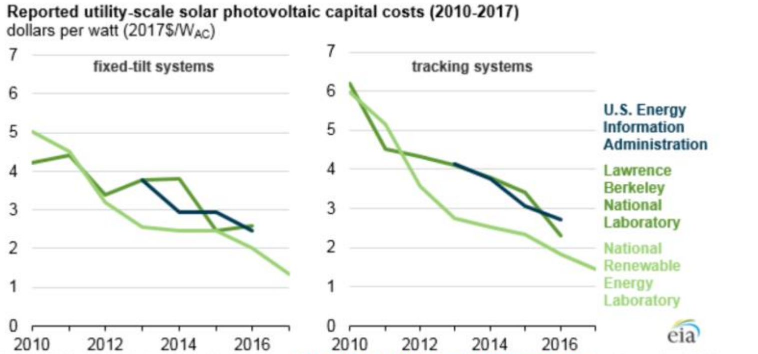
Uptake of new technologies has been quicker and cost declines have been faster than predicted…

Solar uptake has been near exponential



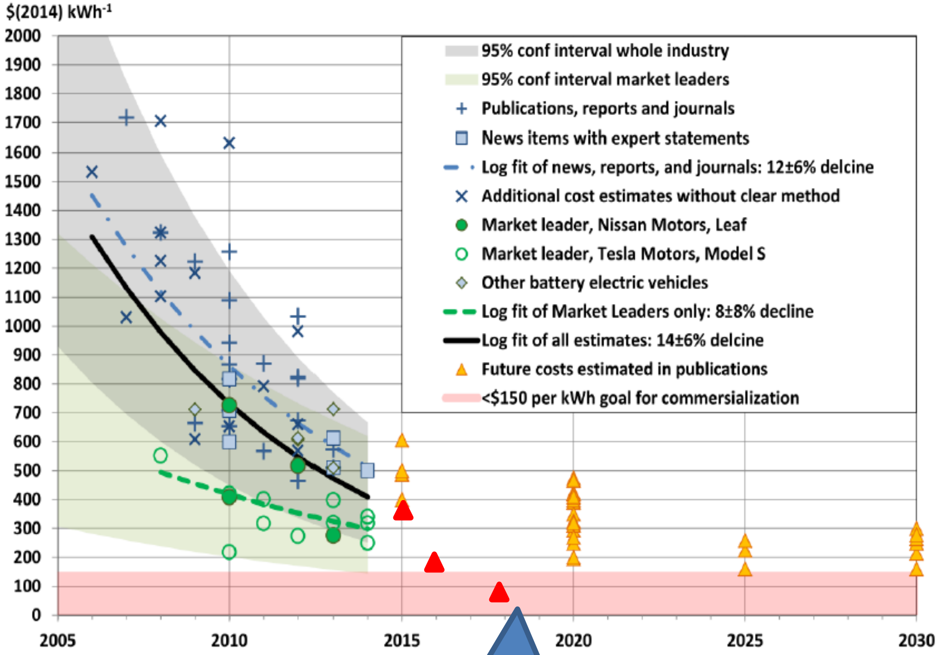
Source: ONS

Solar photovoltaic costs are declining, but estimates vary across sources



Source: U.S. Energy Information Administration, Form EIA-860 Annual Electric Generators Report, and based on LBNL, Utility-Scale Market Report 2016, and NREL, U.S. Solar Photovoltaic System Cost Benchmark: Q1 2017
Note: EIA values for 2016 are preliminary. Values shown for EIA and LBNL are the capacity-weighted values. LBNL also publishes other cost metrics in their report, including median and range values.

Battery costs are falling rapidly, exceeding forecast declines



Source: Nykvist and Nilsson, 2015

In 2016, Tesla's battery packs were priced at $190/kWh, down from $350/kWh in 2015,
By 2018, this had fallen again to $106/kWh

Source: Bernstein Research: Electric Revolution 2019: One Step Beyond…

Solar and wind cost declines have been between 60-80% over 7 years

Unsubsidized Levelized Cost of Energy—Wind/Solar PV (Historical)

Over the last six years, wind and solar PV have become increasingly cost-competitive with conventional generation technologies, on an unsubsidized basis, in light of material declines in the pricing of system components (e.g., panels, inverters, racking, turbines, etc.), and dramatic improvements in efficiency, among other factors