FLEXIBLE FUTURES

OCTOBER 2019

REPORT

Flexible Futures

Using data to understand and navigate the new power market

A joint **REA** and **ElectraLink** initiative

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Introductions from the REA & ElectraLink

Stuart Lacey, Chief Executive at ElectraLink

ElectraLink welcomes the opportunity to partner with the REA on this industry-essential Flexible Futures Report. As the UK's Energy Market Data Hub, we have unparalleled visibility, through our wealth of data, of a market in transition. Today's energy market needs to transform to accommodate a changing landscape of demand, storage and generation and to serve the best interests of the customer. ElectraLink sits at the heart of this transformation. By making our data open, transparent and available, we are able to offer a raft of products and services to enable this energy revolution. We will continue to deliver data-driven innovation and governance across network operators, energy suppliers and all market participants, working together to ensure a brighter and more sustainable energy future for everyone.

www.electralink.co.uk

Dr. Nina Skorupska CBE FEI, Chief Executive at the REA

As the UK's largest trade association for **renewable energy and clean technologies**, the **REA** is pleased to partner with ElectraLink to add new information to the Net Zero debate and draw attention to their extraordinary data resource which can now be utilised by project developers, energy suppliers, and a host of others. Decarbonising the energy sector will require significant new generation to be deployed in the coming decade, and achieving this will require new collaborations and new ways of addressing old problems. The distribution networks will play a central role in procuring flexibility, connecting new generation sites, and facilitating the transformation of the energy sector and by putting robust data at the heart of decision-making we can expedite the journey towards a more sustainable future.

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Eaton has been working closely with the REA to advocate for a truly **flexible energy system**, as technologies and business models that promote flexibility can help smooth out variability of renewable energy supply and avoid higher system costs. Eaton and the REA have collaborated on a respective industry white paper "Developing flexibility: the new cornerstone of the grid" that highlighted the most important deficiencies where regulatory action could make the biggest immediate positive impact. For more information, visit Eaton.com/EnergyTransition.

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Photo shot by Querbeet of 'House with solar panels' on iStock

Executive Summary

To meet the UK's new ambitious target of Net Zero greenhouse gas emissions by 2050, significant amounts of renewable power will need to be deployed in the coming years to not only replace existing capacity but to cover new demands from the electrification of heat and transport.

Renewable forms of power generation have already made a significant contribution to power sector decarbonisation to date, and represent some of the lowest-cost forms of new generation in the country today. As much of this is variable in nature, greater power system flexibility will be needed to balance trends in supply and demand. As renewables are often more distributed, with smaller generation capacities compared to their fossil equivalents, much has been connected at the lower-voltage distribution network level, rather than the high-voltage transmission network. Given the imperative of delivering Net Zero, and the low-cost nature of many renewable technologies, the trend towards distribution network-connected generation is likely to continue.

Several landmark documents have emerged which chart a pathway to deliver the greater flexibility on the networks required to accommodate this shift. This includes the National Infrastructure Commission's Smart Power report and the joint Government and Ofgem Smart Systems and Flexibility Plan. Additionally, in 2017 and 2018 the REA and members Eaton commissioned Bloomberg New Energy Finance to identify both the basis of, and solutions to, the flexibility gap in Great Britain (GB). Several distribution networks (DNOs) have also started on the journey to transform into Distribution System Operators, and released market products to procure flexibility.

However, in order to fully prepare for a more flexible system market information is needed for stakeholders (including policy-makers, project developers, and investors) to better understand what has happened at the distribution-level to date, how different consumers are engaging with this system, and to develop a common language for understanding flexibility customer types.

To deliver this insight, the REA and ElectraLink have partnered to produce the Flexible Futures report. Using data from ElectraLink who manage the UK Energy Market Data Hub that includes the Data Transfer Service, and analysis from the REA, this report seeks to broaden the UK power sector's understanding of the electricity sector to date and going forward.

The report uses data from ElectraLink to highlight how consumers are becoming more engaged with the electricity sector through switching. It highlights exactly how much distribution-connected generation and export there is in Great Britain, which was previously not publicly known. It additionally proposes a new classification system for the increasingly-engaged customer base, with the aim of encouraging people and businesses to adopt flexible energy technologies such as energy storage.

Overall, the report concludes that the built environment represents a significant and largely untapped generation and flexibility resource, which should be urgently developed.

The report identifies that whilst there is increasing engagement with the power sector, evidenced in increased switching, and the system is becoming somewhat more flexible, evidenced by increasing deployment of battery storage, clear market-based incentives for homes and businesses are needed if they are to install and deploy the flexible energy technologies needed to ensure Great Britain decarbonises in line with Net Zero commitments.

More specific conclusions include:

Energy supply switching:

- Three million people are now on a '100% renewable' electricity supply tariff (please see our explanatory note on REA & ElectraLink definitions relating to this) which represents around 25% of 'engaged' customers
- The proportion of green customers (on a 100% renewable electricity supply) is rising, showing greater public awareness and engagement with the green agenda
- Between May 2012 and March 2019, 5.2 million premises have at some point been on a green electricity supply
- Over 16 million premises have switched energy suppliers at least once since May 2012

Generation:

- 45TWh generation was exported onto the distribution network in 2018, double that of 2012
- 39.8TWh of the total 45TWh exported is from renewable sources, ranging from wind to waste-to-energy
- The proportion of variable generation (compared to dispatchable generation) is increasing
- Policy has a clear impact on generation trends and the reduction in policy support for renewable generation from 2015-2018 is clearly discernible from the data
- A considerable and growing amount of fossil generation exists on the distribution network
- The active involvement of Commercial and Industrial (C&I) locations in the energy system is increasing, evidenced in their increasing contribution to electricity exports onto the networks
- Significantly more embedded generation can be expected in the 2020's if the UK is to be on track to meet Net Zero targets

Five Flexibility Customer types:

- Battery developers are targeting those already with solar photovoltaics (solar PV) technology, and those with solar PV are more interested in taking up a flexibility technology such as a battery
- New structures for understanding customer types are needed in order to engage the public in flexibility products and services
- For the Commercial and Industrial sector (C&I), adoption of a '100% renewable electricity' supply tariff may be a leading indicator of future low-carbon and flexibility technology adoption
- For the general population there is not a clear correlation between increased engagement with the electricity sector (evidenced by switching rates and adoption of green tariffs) and the adoption of a low-carbon technology. However, this finding is influenced by the consumers automatically switched to 'renewable' (REGO) supplies by their supplier, rather than choosing to switch themselves
- Stalled small-scale low carbon technology (LCT) deployment, following changes to the Feed-in Tariff indicate that there needs to be a clear financial case for people to install an LCT, and by extension storage / flexible energy technologies. The proportion that will do this regardless of policy (e.g. on green merits alone) is quite small

These conclusions inform a series of short and medium-term REA policy recommendations to facilitate greater flexibility, covered in **Chapter 5**.

Over the next thirty years, decarbonisation will be a prevalent theme and impact all those working in the energy sector. It is the joint REA and ElectraLink belief that, armed with timely, robust, and accurate data, UK industry will be well equipped to expedite the journey to a sustainable future.

Glossary of commonly used terms:

Aggregator – A company or organisation that combines capacity or generation from numerous, separate generation or flexibility provider sites, to offer a larger pool of services to customers and markets. Can help bring the benefits of flexibility to the energy system.

Co-located – Generation and energy storage located at the same 'site' (as defined by Ofgem metering, grid connection and wiring requirements).

Decentralised power – Technologies such as solar PV, biogas, micro hydro, and small onshore wind which are connected at a distribution level. We acknowledge some renewable power technologies (e.g. biomass power and offshore wind) are more large-scale, and some decentralised power technologies are polluting (e.g. diesel generators). For the purposes of the report we are talking about those technologies that are both decentralised and renewable.

Dispatchable generation – Electricity generation from sources that are more dispatchable, such as fueled technologies that are more easy to ramp up or down in terms of exports.

Distribution network – Medium and low-voltage electricity network infrastructure, managed by six regulated monopoly Distribution Network Operators in GB.

Embedded generation – Generation that is connected to the distribution networks and is often smaller in capacity than that which is connected at the transmission level.

Exports – The amount of generation from a site supplied onto the grid network, either at Transmission or Distribution level. This report covers exports to the distribution network.

Feed-in Tariff (FiT) – A government subsidy scheme, closed to new applicants in April 2019, which was designed to support the deployment of small-scale renewable power generation in the UK. The scheme paid a subsidy for each kWh of power generated and was accompanied by a smaller export tariff for each kWh of power not consumed onsite and exported to the grid.

Flexibility – Technologies and techniques that help manage supply and demand for electricity, and for the purposes of this report, particularly those deployed at a more local level.

Generation – The power produced by a generator site, which could be used on-site, diverted into energy storage, or exported onto the grid.

Low Carbon Technologies (LCT) – For the purposes of this report, low carbon technologies refer to those that can support the decarbonisation of the energy and transport system such as electric vehicle chargers, heat pumps, solar PV panels, micro-hydro and wind, and energy storage. Most being deployed are connected to the distribution networks.

Ofgem – The Office of Gas and Electricity Markets (Ofgem) is the independent regulator for the electricity and downstream natural gas markets in GB.

Renewable Energy Guarantee of Origin (REGO) – An EU-wide renewable electricity certification scheme, which proves to customers that a given unit of electricity produced was from renewable sources.

Smart Export Guarantee (SEG) – The Government's proposed replacement to the Feed-in Tariff, intended to be implemented from January 2020, which compels energy suppliers to offer a tariff for generation sites (below 5MW) exporting power back to the grid.

Transmission System – The high-voltage electricity network infrastructure, managed in GB by National Grid.

Variable Generation – Electricity generation from sources that are influenced by weather patterns, such as those from the wind or sun.

1. Introduction

1.1 Background to power sector flexibility

The electricity sector is changing. In 2018, one-third of power generated in the UK was from renewable sources such as wind, solar, and bioenergy – up from under 3% in 2000.[1]

Having once represented the majority of national electricity production, since the mid-2000s generation from large, centralised coal power stations has plummeted. The share of nuclear power, a relatively inflexible source of electricity, has remained relatively constant but is likely to decline as stations are retired and new sites struggle to secure financial backing. The decline in more traditional forms of power generation closely aligns with the rise of renewable energy and improved energy efficiency on the grid. It is also, to a certain extent aligned with the growth of gas generation, which in 2018 provided 10% more power generation than in 2015 and presently is a source of relative energy system flexibility.[2]

Variable sources of generation such as wind and solar are amongst the lowest-cost forms of new power production in the UK today, and are modeled to undergo continued price declines.[3] However, their deployment represents a structural change compared to how the electricity system previously functioned. Such forms take only months to build and are often much smaller scale in capacity than traditional fossil-powered plants. Going forward, they are expected to make a significant contribution to generation by 2050 in order to meet the UK's now legally-binding Net Zero greenhouse gas emission targets.[4]

This transition from a small number of large, centralised power stations to one of millions of smaller points of generation, be they solar, wind or bioenergy facilities, is historic. It is causing significant changes to how the nation's electricity grids and system are managed. Electricity is becoming more localised, with an increasing contribution from homes and businesses.

To cope with this shift, grids are taking a more active role in managing both the distribution of electricity but also its demand and storage, including the deployment of nearly one million solar PV installations on homes and businesses supported by the Feed-in Tariff. As much of this change is on a more local scale than large coal-powered generation sites, the lower-voltage distribution networks are finding themselves on the front lines of navigating this new system.

Simultaneously in the energy supply sector, the Government and regulator's programme of reform and liberalisation has seen the emergence of a host of new suppliers and an increased public engagement with the sector.

In 2016 the National Infrastructure Commission (NIC) released Smart Power as a response to many of these developments. The landmark report provided the modeling, analysis, and ultimately the justification for moving towards a smarter, more flexible energy system in GB. Smart Power argues that as much as £8bn in savings per year is achievable by 2030 if several mechanisms are introduced and flexibility fully emerges.[5] The document inspired the joint Government and Ofgem Smart Systems and Flexibility Plan of 2017, which laid out some clear policies to advance power system flexibility.[6]

1.2 Purpose of the Flexible Futures report

Given the trends in both supply and demand and Government interest in delivering greater flexibility, this report is designed to provide insight into the growth of decentralised energy and future requirements for flexibility. Real-world data provided by ElectraLink on what is taking place on the distribution networks in GB informs this document. The report uses this new customer data to gain an insight into current trends to help industry and policymakers adapt for the future.

The ElectraLink dataset, which is underpinned by their management of the Data Transfer Service (DTS), encompasses nearly every communication, supplier switch, and settlement on the distribution networks since 2012. It is presently a little-known resource but could be a valuable tool for policymakers, project developers, and manufacturers in the years to come.

1.3 Report structure

This document is divided into several parts. The Context section focuses on changes the electricity system is going through at present and the future need for flexibility in light of Net Zero, the Smart Power report, and the Smart Systems and Flexibility Plan. Following this, ElectraLink data informs a number of new market insights, focusing on:

- Understanding renewable energy supplier switching
- Trends in electricity generation and flexible energy technology deployment on the distribution network
- Proposing a new classification system for flexible customer types, and examining trends to date

In its conclusion, the report proposes several policy and industry measures to facilitate what ultimately will lead to a more decarbonised, lower-cost power sector.

2. Context

Enhanced competition in electricity supply, the introduction of legally binding emissions reduction targets, and the emergence of smart and decentralised low-carbon technologies have all significantly changed the British electricity sector. Much more change is expected in the years to come in order to hit our new Net Zero targets. The Government's 2019 commitment to Net Zero greenhouse gas emissions by 2050 and the existence of legally binding five-year 'carbon budgets' will require policy support for low carbon technologies in the coming decade.

Solar PV and onshore wind are now amongst the cheapest forms of new power generation in Britain.[7] Continued price declines mean that focusing on renewables has become the most economical way to ensure our decarbonisation targets for electricity are met. Simultaneously, as we move down the path of decarbonisation the Government's energy supply reform and switching agenda is resulting in an increasing level of consumer engagement with the power system.

The UK Government's Digest of UK Energy Statistics (DUKES) shows that renewable sources generated 110TWh of electricity in 2018, equivalent to around one-third of the total.[8] This generation is underpinned by policy-led support schemes such as 'Contracts for Difference' auctions and the 'Renewables Obligation' on large energy suppliers, which requires them to source a portion of their power from renewable sources. Of 2018's overall generation, variable sources, including solar PV, onshore wind, and offshore wind, made up the majority. More dispatchable forms of generation, such as that from bioenergy, comprised nearly 32% of the contribution from renewables.[9]

This is important, as most onshore wind, solar PV, and some bioenergy generation is being connected at the distribution, rather than the transmission, level. It marks a shift in that the share of distribution-connected 'variable' generation is now greater than that from fossil and bioenergy sources.

The national move towards renewables has already had numerous impacts on public and private life. In the corporate world, many traditional energy utilities have seen erosion of market share and some have refocused their businesses or restructured. A host of new energy supply and infrastructure developers have entered the market. Even oil majors have elected to enter the market and have purchased companies across the value chain.

Consumers have seen a different side. Solar panels and wind turbines are now a common sight when driving across England, Scotland and Wales. The Feed-in Tariff, introduced by the Government in April 2010, has supported the significant deployment of solar PV, small-scale wind, biogas, micro hydro, and other small-scale renewable power technologies.

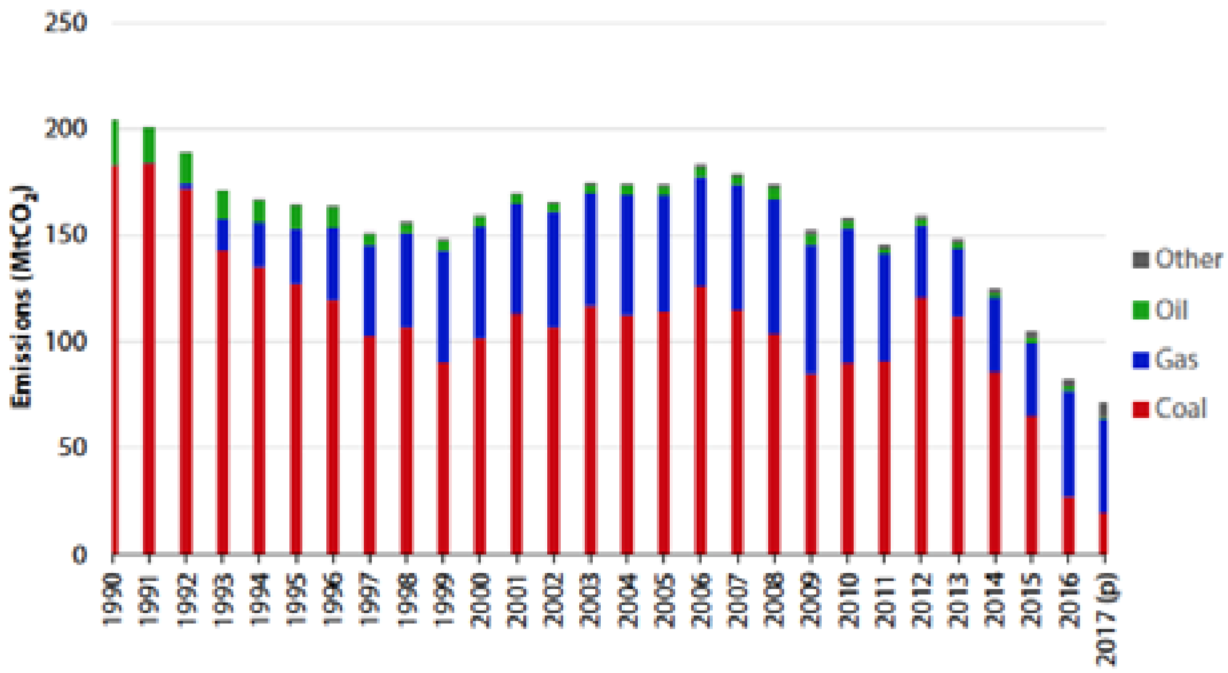
Around 900,000 solar PV sites have been registered under the Government's Feed-in Tariff (FIT) scheme, and more are estimated to have been installed without registering for the subsidy.

For households, this means the prospect of lower electricity costs and the ability to take personal action on climate change. Businesses have also engaged with this change, with around 200,000 of the total solar PV FiT installations being developed on commercial rooftops and sites.

2.1 Towards Net Zero

Ultimately, these trends have resulted in significant decarbonisation of the power sector. Figure 1 outlines the substantial fall in power-sector CO_2 emissions, largely due to a reduction in coal generation.

Figure 1: Emissions from the power sector since 1990



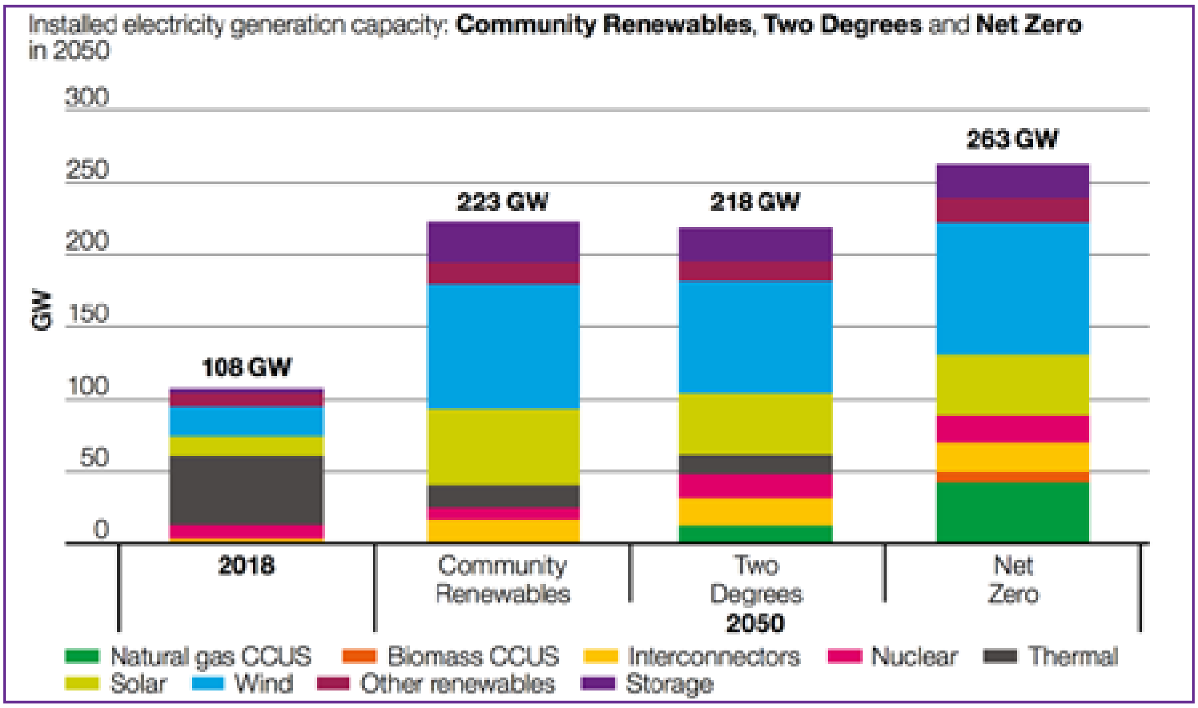
Source: CCC analysis based on BEIS (2018) *UK Greenhouse Gas Emissions 1990-2017* and BEIS (2018) *Energy Trends: Table 5.1.*
Notes: 'Other' includes emissions from municipal solid waste.

Source: Committee on Climate Change[10]

The UK Government's commitment to a Net Zero greenhouse gas emissions target by 2050, now enshrined in legislation,[11] will require continued decarbonisation of the electricity sector. As coal generation is phased-out by 2025, much of the UK's existing stock of nuclear generation reaches the end of its life by 2032. As new demands from vehicle and heat electrification hit the electricity system, significant new renewable generation capacity will be required.

National Grid's annual Future Energy Scenarios (FES) publication signals how the power sector might achieve these reductions. In their 2019 report, they produced a 'Net Zero' scenario for how the UK's energy sector could decarbonise in line with the Committee on Climate Change's recommendations. Their scenarios increasingly reflect that significant decentralisation of the electricity system will take place.

Figure 2: Installed electricity generation capacity: National Grid FES Community Renewables, Two Degrees, and Net Zero in 2050 Scenarios.



Source: National Grid Future Energy Scenarios 2019[12]

The Net Zero model for electricity outlines that annual demand increases considerably (to 491TWh per year by 2050) and as a result, will require significantly more generation capacity. In this model, peak electricity demand by 2050 is almost double that of today. Such a high-renewable power system will require a significant growth in storage capacity.

REA View: Given the increased generation and capacity requirements, and that the technologies deployed to meet those requirements (such as onshore wind and solar) are likely to be primarily connected at the distribution level, assessment and analysis of how DNOs are managing decentralised generation and flexibility today are crucial areas for industry analysis.

2.2 Renewable power deployment in the 2020s – technologies at play

The actual deployment of solar and other renewable energy technologies has dramatically reduced since Government cuts to support mechanisms throughout 2015 and 2016. Over a dozen negative policy changes were implemented, impacting everything from tax and energy supplier obligations to direct subsidies. Whilst the Feed-in Tariff was only formally closed to new entrants this year, from 2017 it was reduced for many technologies to a tariff level where new deployment was uneconomical.

During this time, many project developers, generators, researchers, and analysts shifted course. Numerous energy storage, aggregation, smart grid management and smart electric vehicle charging companies have all emerged, partly as capital and talent shifted into new sectors. In many respects, the UK is now at the fore of many of these markets. British battery companies have developed projects in Japan and oil majors have purchased start-up aggregators.

The REA and FES are aligned in thinking that some of the key technologies available that will allow the UK to meet its Net Zero electricity targets include solar PV, wind (onshore and offshore), bioenergy, deep geothermal power, and wave & tidal. Analysis of these technologies and trends can be found in the Appendix.

2.3 The value of flexibility

2.3.1 What is flexibility?

Flexibility is commonly defined as 'modifying generation and/or consumption patterns in reaction to an external signal (such as a change in frequency or price) to provide a service within the energy system'. Or more simply, flexibility is the extent that generation and demand is able, and incentivised to, quickly respond to changing market conditions.

These flexibility services include:

- Inertia and frequency response to maintain frequency of the system within operational limits
- Balancing to match constantly changing generating and consumption requirements
- Voltage support to maintain system volatge within operational limits

To date, large transmission connected synchronous generation has typically provided some ancillary services such as rotating mass needed by the power system, but the overall volume of this is decreasing as large fossil-fuel synchronous generation continues to close.

But new ways of providing these flexibility services are emerging, especially at a local level:

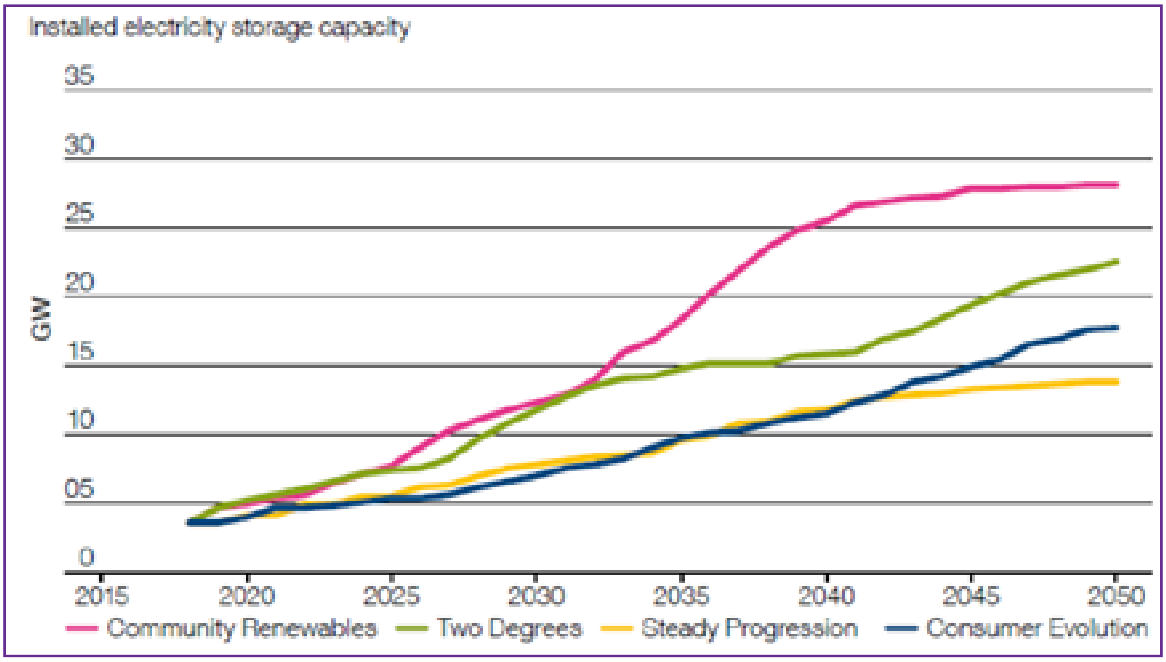
- **Demand-side response** – Consumers can change how and when they use electricity
- **Energy storage** – Batteries or other forms of storage can store energy when it is plentiful and discharge it when it's needed
- **Distributed generation** – such as rooftop solar panels

These new flexible resources can help meet the needs of the changing energy system and provide some of the services previously provided by large synchronous generators.

2.3.2 Future flexibility forecasts

The National Grid FES study for 2019 examines the potential demands for flexibility through to 2050. It states that reaching net zero by 2050 is 'achievable' with the right mix of technologies, including storage in all forms, such as batteries, power to gas and hydrogen. Electricity storage and interconnectors are forecast to be the primary sources of power system flexibility by 2050. In its four scenarios (see Figure 3), the FES sets out a projection for electricity storage that increases to between 14 and 28GW by 2050, up from the roughly 4GW that is in place today.[13]

Figure 3: National Grid FES 2019 forecasts for installed electricity storage capacity, 2018-2050



Source: National Grid, Future Energy Scenarios 2019

2.3.3 Case study for role of flexibility: the 9th August 2019 UK blackout

On 9th August major disruption resulted from a loss of some 1200MW of transmission connected generation following a lightning strike. The rapidly falling frequency and voltage led to the additional loss of some 500MW of distributed generation which led to a rapid frequency drop. The remaining generation was unable to compensate for this loss and low frequency demand disconnection was triggered to prevent a whole system failure.

The incident is still being investigated but the initial recommendations from the Energy System Operator (ESO) include:

- A review of the grid security standards (SQSS) to determine whether it would be appropriate to provide for higher levels of resillience in the electricity system. This should be done in a structured way to ensure proper balancing of risks and costs
- A review of the timescales for delivery of the Accelerated Loss of Mains Change Programme to reduce the risk of inadvertent tripping and disconnection of embedded generation, as GB moves to ever increasing levels of embedded generation
- Assessing whether it would be appropriate to establish standards for critical infrastructure and services setting out the range of events and conditions on the electricity system that their internal systems should be designed to cater for

The increasing levels of embedded generation mean that there is a changing risk profile in the future, but also an opportunity for distributed generation or demand response to help prevent such failures in the future.

The rapid response of numerous energy storage projects helped prevent wider system failures and negative impacts, leading to calls for significantly more such capacity to be procured by the System Operator.[14]

If distributed generation or demand (distributed energy resources) were given a route to market, to provide ancillary services– for example inertia, frequency response, reserve, voltage support - then this would help prevent such failures in future.

While the investigation is not yet complete, this event serves as an example of the need for flexibility services in the UK and the practical implications if they cannot be provided.

2.3.4 Recent progress in establishing flexibility needs and markets

In 2017, the ESO published a System Needs and Product Strategy (SNAPS) to set out a roadmap covering the future system needs in an environment where traditional generators and their ability to provide essential system services were rapidly declining. The roadmap identified what system services were needed, e.g. inertia, frequency response and how they could be provided.

The ESO is implementing a programme to address these future needs. In its 2019 operational strategy report, progress was being made in the following key areas, according to the ESO:

- Frequency control, encompassing response, reserve, balancing markets and the wholesale market structure. The ESO is developing new products and markets for frequency response and opening up access to balancing markets to new participants

- Voltage control. The ESO is seeking new sources of reactive power and enabling wider participation in reactive power provision. Initial contracts have been agreed and pathfinder requests for information are underway

- Restoration. The ESO is developing new approaches to restoration and gaining new providers

- Stability. The ESO is seeking new sources of stability or inertia and developing procurement methods. It is also seeking to ensure that loss of mains protection on distributed generation is appropriately applied

- Thermal. The ESO is seeking to ensure that constraints due to electricity network physical limitations are kept to a minimum. This work has included collaboration with DNO's in developing Regional Development Plans. This is expected to lead to new providers participating in commercial constraint management services

DNOs have also been taking action to address their local system needs. Platforms for local flexibility service procurement have been established, and the first auctions have been successfully completed.

While progress is being made, there remains much to be done to deliver the vast increase in flexibility services required by the mid 2020s.

2.3.5 Nord Pool as an example

A market for flexibility akin to that created by Nord Pool, based in Norway, would be very welcome in the UK. The Nord Pool market procures all power and ancillary services in an open and transparent way, which makes it easier to build business models and credible revenue projections, while providing and collecting useful data.

Crucially, this market offers variable rates for small and larger units, allowing behind the meter assets to compete (and at odds with the Capacity Market) with low thresholds to take part in Frequency Regulation markets. This standardised, transparent approach, with consideration of different flexibility providers, is valuable as it reduces the costs for market participants and should drive the most competitive prices for the system.

2.4 The Smart Power report as providing a pathway for flexibility

The National Infrastructure Commission's (NIC) Smart Power report of 2016 was a crucial document in justifying the move towards a smarter, more flexible energy system in GB. It leverages the 2015 Imperial College/NERA report for the Committee on Climate Change.[15]

In total, the Smart Power report argues that as much as £8bn in savings per year is achievable by 2030 if a number of mechanisms are introduced.

In summary, they assume that the following measures offer greater flexibility and lead to reduced new gas (largely) generation capacity costs:

1. Increased demand-side response
2. Increased energy storage (grid-scale and decentralised behind the meter)
3. Increased generator flexibility (both conventional and renewable) both grid-connected and decentralised
4. Increased interconnection, grid-connected
5. Reduced frequency response requirements and improved system management

This Flexible Futures report is designed to address a number of aspects of this larger move towards Smart Power, namely looking at items 1-3 above that relate to decentralised energy. By providing useful information trends, the report informs our understanding of what's happened in the past few years and what can be done to further these developments.

2.5 Flexibility and facilitating a low-carbon grid

Independent research from Bloomberg New Energy Finance (BNEF), commissioned by REA member Eaton and published in 2018, outlined the need for flexibility in ensuring emissions-reductions in a high-renewable power system. Figure 4 shows how a system with 'low flexibility,' with few services procured from sources such as smart charging, demand response, interconnection and energy storage, results in a higher grid CO_2 intensity due to the requirement to procure (largely) gas capacity as backup.

Figure 4: Summary analysis from modeling by Bloomberg New Energy Finance on Flexibility Solutions for a high-renewable energy system in GB (2030 and 2040)

Table 1: Summary of scenario outcomes in 2030

Scenario	System cost	Emissions	Fossil capacity as share of peak demand	Renewable share of generation	Zero-carbon share of generation
NEO (base case)	32.8 GBPm/TWh	16.8 MtCO2	49%	74%	88%
Relative change vs NEO					
Low-flex	3%	9%	10%	-1%	-1%
High uptake of EVs	2%	-19%*	0%	1%	0%
High uptake of EVs and flexible charging	0%	-30%*	-7%	2%	1%
High uptake of storage	-2%	-13%	-12%	1%	1%
High uptake of flexible demand	1%	1%	1%	0%	0%
Interconnection to the Nordics	-2%	-25%	-11%	3%	3%

*Source: BloombergNEF. Note: Colour scales differ between columns, but in all cases green is desirable. *Emissions for EV scenarios include a negative contribution from emissions displaced in the oil sector.*

Table 2: Summary of scenario outcomes in 2040

Scenario	System cost	Emissions	Fossil capacity as share of peak demand	Renewable share of generation	Zero-carbon share of generation
NEO (base case)	39.8 GBPm/TWh	11.6 MtCO2	34%	80%	94%
Relative change vs NEO					
Low-flex	13%	36%	45%	-1%	-2%
High uptake of EVs	4%	-88%*	3%	1%	0%
High uptake of EVs and flexible charging	4%	-96%*	0%	1%	0%
High uptake of storage	0%	1%	-1%	0%	0%
High uptake of flexible demand	-5%	2%	-10%	0%	0%
Interconnection to the Nordics	-2%	-24%	-10%	2%	2%

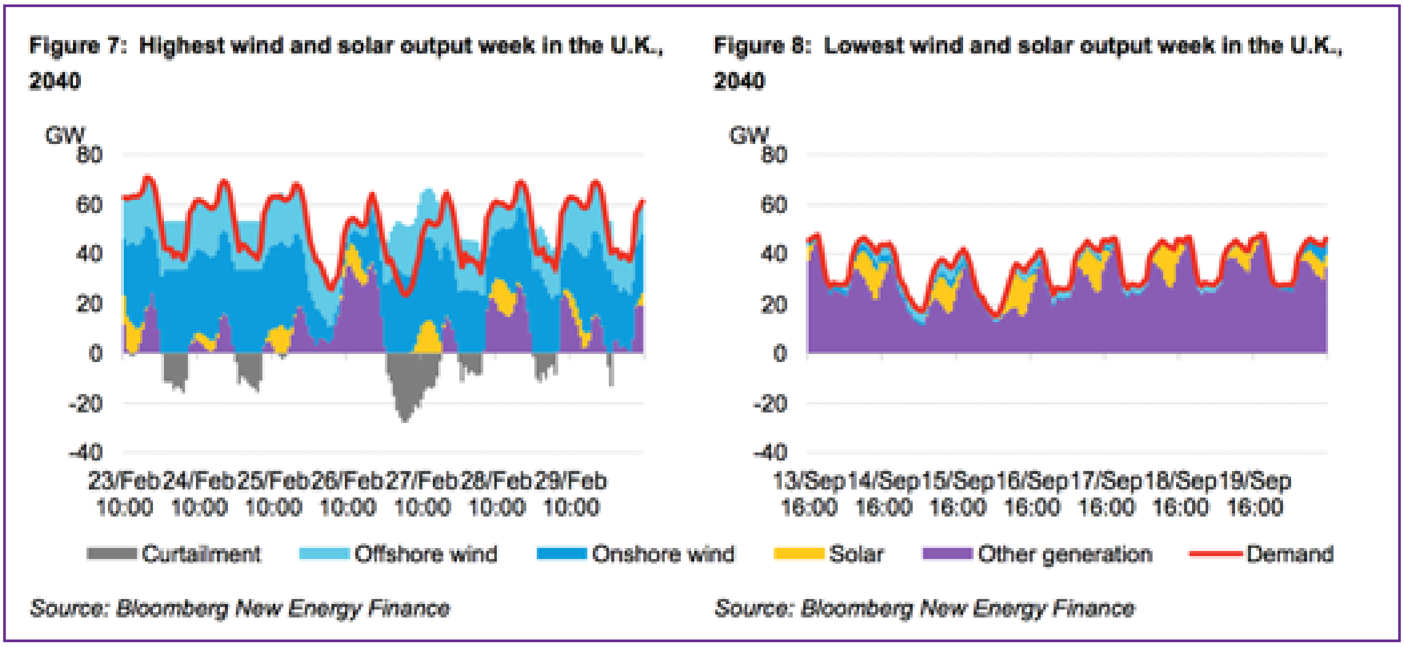
*Source: BloombergNEF. Note: Colour scales differ between columns, but in all cases green is desirable. *Emissions for EV scenarios include a negative contribution from emissions displaced in the oil sector.*

Source: Bloomberg New Energy Finance 2018[16]

Previous analysis from BNEF in 2017 indicates the demand for system flexibility in a high-renewables deployment scenario in the UK. They flag that total back-up capacity from technologies such as dispatchable generation, storage, demand response and interconnection needed by 2040 will likely be similar to the levels presently in place today – about 70GW – for times of low solar and wind generation. This capacity, however, will be used less and less often.

In this analysis, ramp-up rate requirements become a particular challenge. In 2017 they identified the maximum UK ramp up rates to be 10GW/hour up and 11GW/hour down. By 2040, this is estimated to be at 21GW/hour up and 25GW/hour down. Fast-acting technologies such as energy storage and gas become particularly valuable in this scenario, matched by demand response such as smart electric vehicle charging.[17]

Figure 5: Highest wind and solar output week in the UK, 2040 (left) and Lowest wind and solar output week in the UK, 2040 (right)



Source: Bloomberg New Energy Finance 2018 [18]

2.6 Changing grids – Distribution Network Operator (DNO) to Distribution System Operators (DSO)

The grid networks are critical to the clean electricity transition and increasingly recognise the need to change. The six network operators in GB jointly issued a 'flexibility commitment' in 2019.[19] The pledge prioritises the procurement of flexibility rather than reinforcing the overhead line network as their first option for tackling constraints.

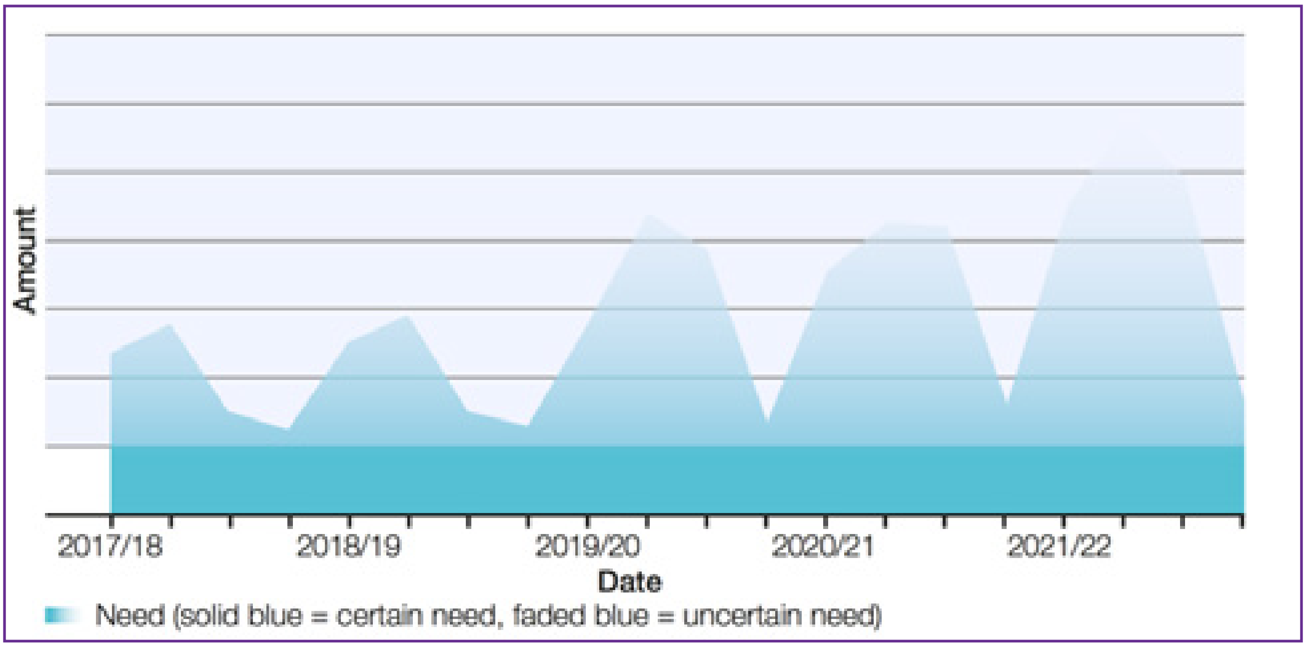
Western Power Distribution (WPD), as outlined in their DSO Strategy (December 2018), is re-engineering their network to accommodate as much as 40GW of embedded generation by 2030, 8GW of energy storage, and 1.6 million domestic EV charge points.

WPD, Scottish Power Energy Networks (SPEN), and UK Power Networks (UKPN) have now launched tools for procuring flexibility. WPD's Flexible Power platform identifies specific local areas on their network and times of peak demand where demand response or storage can be deployed, along with an associated payment regime for applicants.[20]

At a national level, the National Grid Electricity System Operator (ESO) aligns with this trend. In their System Needs and Product Strategy, they state: "in general, system needs [for flexibility] are increasing, most notably at the extremes. The volatility of the extremes is also increasing. Currently we access the flexibility required to manage the extremes and volatility, near real time, in the BM [Balancing Market]."

They go on to argue that more 'firm' future flexibility needs are fairly certain over the next five years, but "as the energy mix changes, the availability of flexibility in the BM is reducing or is becoming increasingly costly to access. Therefore routes to market must be created for all providers to offer flexibility across the [ESO's] range of requirements." [21] Going forward, the National Grid ESO is proposing a series of harmonised and simplified flexibility market products that can be offered to procure flexibility, particularly at the 'extremes' of demand.

Figure 6: Illustration of balancing services trend showing the need for more flexibility



Credit: National Grid ESO, System Needs and Product Strategy 2017

A further piece of work in this space, conducted in partnership between National Grid ESO and UK Power Networks, is the Power Potential project. This pathfinder initiative is seeking to create a new reactive power market for distributed energy resources (DERs) and generate additional capacity on the network.[22]

2.7 Low-carbon flexibility technologies for the distribution network

2.7.1 Energy storage – batteries and beyond

Depending on price, duration, and response rate requirements, a host of energy storage technologies are available in the UK today. For longer duration storage, new pumped hydro and compressed air energy storage sites are being investigated, as are flow machines and cryogenic and gravity-based storage systems. There is increasing recognition of Power-to-Gas (such as biomethane and hydrogen) as an attractive option for longer duration storage, with more research required. For very fast-acting storage that can participate in ultra-fast frequency response, batteries (primarily Li-ion) are becoming the primary technology at this stage and costs are declining, with further reductions expected.[23 24]

2.7.2 Energy storage behind the meter

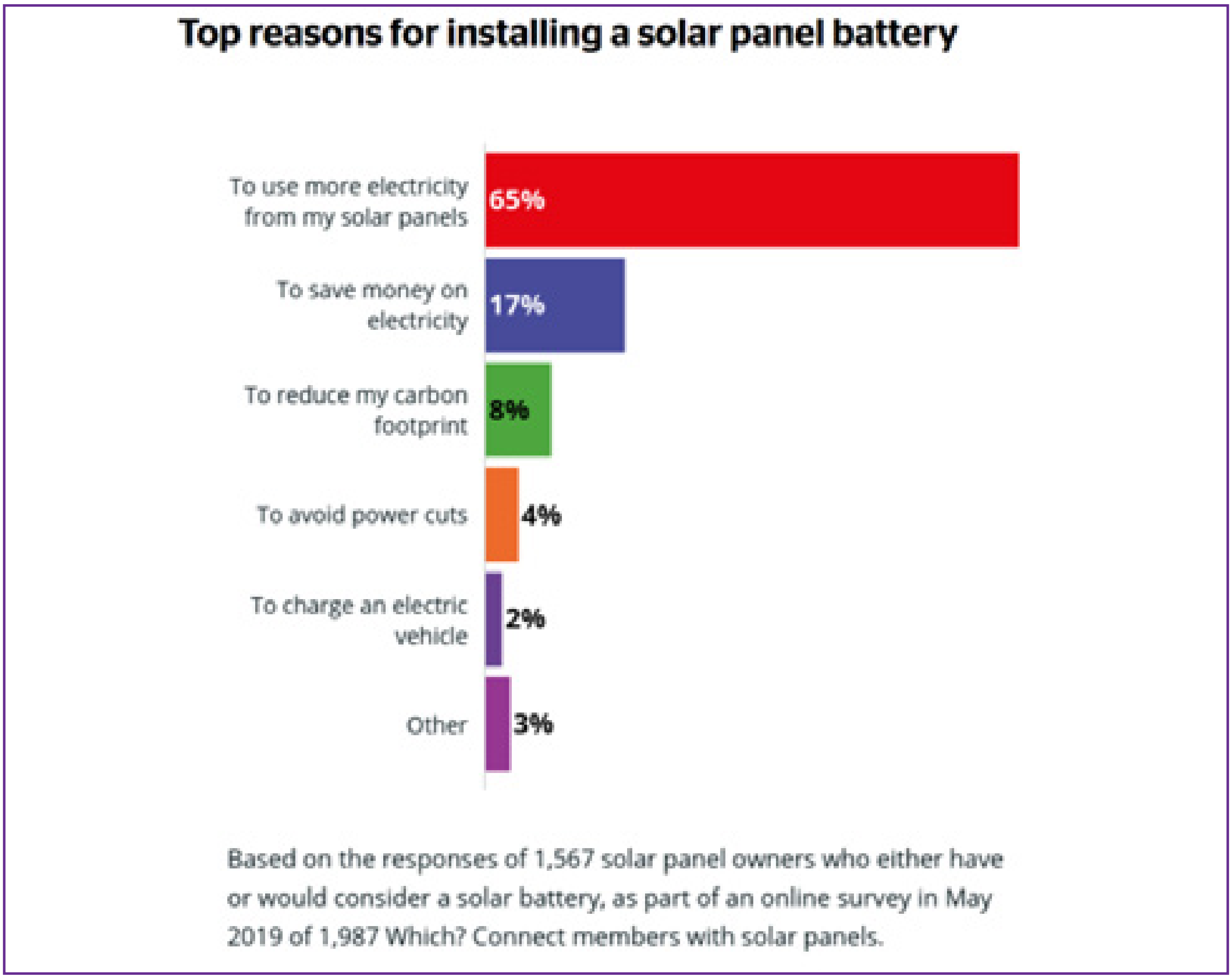
Despite the anticipated growth in the behind the meter storage sector in 2019, few companies the REA surveyed are expecting significant deployment until the early 2020s. Barriers identified include:

- Brexit (as people are holding back on investments until clarity is ascertained)
- A fluid regulatory regime (including the drought of support between the closure of the Feed-in Tariff and introduction of the Smart Export Guarantee)
- Regulatory ambiguities, for example around double charging of grid fees on exports from batteries

Evidence from the REA's 2019 survey of energy storage companies shows that consumers and businesses who have installed solar (supported by the FIT) are being targeted by installers for an energy storage unit.[25] These customers are perceived by developers to be much more likely to install a battery unit than those without solar PV.

Evidence from a 2019 survey by Which? indicates that the targeting of Feed-in Tariff customers by battery storage developers may be a welcome trend. Of customers with a solar PV system supported by the Feed-in Tariff, 6% said that they had already installed a battery storage unit, and 74% would consider doing so (up from 60% a year previous).[26] Figure 7 highlights the core reasons for buying a battery to complement a solar PV system.

Figure 7: Which? Survey results of why customers would buy a battery



Source: Which? 2019

REA View: The findings of the Which? survey are important because they show that consumers understand the benefits of these technologies and can be encouraged to adopt them. This creates a link between those who self-generate their own power and those who could provide system flexibility in the future.

2.7.3 Energy storage co-located or standalone grid-connected

Grid-scale storage is forecast by the REA to be installed at a number of locations in the next decade. This includes co-located with solar PV and onshore wind sites (at the distribution level), directly connected at the transmission-level, deployed behind the meter in homes and businesses and co-located with electric vehicle charging stations.

A significant pipeline is building up for standalone grid-scale storage and that co-located with existing solar and wind sites. Data from The Renewable Energy Planning Database provided by the Department for Business, Energy & Industrial Strategy (BEIS) (as of June 2019) indicates that 184 energy storage projects are in the planning pipeline. Five of these are pumped hydro and the remainder are battery storage projects. There are currently 154 projects that have received planning permission and are awaiting construction. Only three are under construction, all battery sites.[27]

REA View: The size of the pipeline 'awaiting construction' (although not all of which will be built) highlights both the extent of commercial interest in the storage sector, and the significant number of projects which have won planning consent but are holding off on formal construction. REA discussions with industry indicate that this is likely due to developers waiting for clarity around the future grid charging regime and market incentives, as well as technology costs.

Of the installed storage capacity, pumped hydro makes up the vast majority of installed and operational capacity in GB in capacity terms. Most of these sites, primarily in Scotland and Wales, were constructed in the 1960s and 1970s.

*2.7.4 **Eaton Case Study:** Amsterdam Arena – Fair access to grid services markets boosts the business case for large-scale battery storage*

Eaton and its commercial partners last year commissioned a 3MW energy storage system, comprising new and used Nissan EV batteries, in Amsterdam's Johan Cruijff ArenA. The arena is the home for AFC Ajax, and the stadium for the Dutch national team, as well as for concerts, dance events and business meetings. The 3MW battery is coupled with a 1MW roof-top solar system.

The business case of the 3MW battery has been boosted by multiple revenue streams.
The primary role of the battery-solar PV system is to provide an uninterruptible power source (UPS) for the stadium, when in peak use, in the event of a grid emergency. It has the capacity to provide power for 1 hour of peak stadium demand, reducing the need for more carbon-emitting, on-site diesel generators.
When the stadium is not fully in use, the battery has three additional revenue streams.
First, it can sell frequency response services, via access to the Netherlands' frequency control (FCR) market.
Second, it increases the self-consumption of the on-site solar generation, thus increasing savings on more expensive grid electricity, while exporting the surplus. And third, it can achieve power price arbitrage, between cheaper, off-peak and more expensive peak demand periods.

2.7.5 Demand response

Aggregators, companies who aggregate flexible assets into larger units of capacity which can be used to balance electricity supply and demand, are playing a pivotal role in driving flexibility through either the management of batteries or the utilisation of (mostly commercial and industrial) demand response. Open Energi, for example, has contracts for GB student accommodation locations where they employ demand response and manage a battery installed by Pivot Power at Arsenal Stadium.

2.7.6 Charging 'smart' and vehicles as sources of flexibility

Following the UK Government's ban on the sale of conventional petrol and diesel cars and vans by 2040, electric vehicles are expected to be deployed in significant numbers. The target is 60% of new car sales being electric by 2030. The increase in new sales represents a significant new load on the grid, with the ability for companies to deliver 'smart charging' services being core to the system going forward. Policy will force smart charging to become widely deployed. In July 2019 the Office for Low Emission Vehicles released a consultation proposing to legislate that all chargers in private locations (e.g. homes and workplaces) are 'smart'. This implies chargers capable of being controlled remotely, responding to signals and incorporating cybersecurity standards.

Research programmes such as Electric Nation have shown that smart EV charging can help manage stresses on the grid network at peak times and avoid or defer network upgrades. Having in the future millions of EVs capable of monitoring and responding to data and price signals creates significant opportunities for flexible capacity. In addition, 'vehicle to grid' (V2G) offers significant potential for cars to not only charge at the 'right' times, but for them to provide power back to the network when required at times of highest system stress. The UK Government has invested around £30 million into trials so far.

2.7.7 The role of the commercial and industrial sectors

Industrial energy users are a prime first target for flexibility, with the emergence of the smaller-scale residential market following shortly thereafter. For background to the value of flexibility to UK industry, Aggreko surveyed 200 energy decision-makers in May 2019. Their results indicated a 37% increase in energy costs for UK manufacturers in the past five years. 26% reported that energy costs represent 10-20% of their operating costs and that over half believe energy prices impact their competitiveness.[28] Many companies are offering C&I focused products such as demand response and storage to help businesses reduce their exposure to this shift. Action in this segment is already well established, through the 'TRIAD' grid charging regime (although TRIADs are likely to shortly disappear as part of Ofgem's Targeted Charging Review proposals, closing off a valuable source of revenue).

2.7.8 Bundling and emerging models for clean energy and flexibility deployment

For homes and workplaces, technologies such as solar, energy storage, and smart EV charging are likely to be increasingly offered as a bundle, akin to how telecoms consumers can lease a physical phone and a service plan for a fixed price per month. Market movement is noticeable, which indicates interest from both domestic and corporate-facing companies in offering both a tariff and physical low carbon technologies such as a smart electric vehicle charger, solar PV, and a battery storage unit. For example, in partnership with the software platform Kaluza, OVO Energy has announced their intention of offering a membership-scheme to deploy hardware and energy saving kit into their customers' homes.[29]

Behind the scenes, the managers of these technologies will be in a strong market position to provide grid services as a revenue stream, in addition to those revenues coming in from consumers paying off their hardware costs.

Innovation in the utility business model is only one element; automotive manufacturers are also becoming involved. Honda's investment in battery storage and energy management software company Moixa highlights the ambition for car companies also to sell home hardware and software. Both Tesla and Nissan currently offer home storage and solar PV, and the launch of Volkswagen's subsidiary Elli goes a step further with the offer of 100% renewable electricity supply in some markets with a customer's new electric car.

The regulatory regime governing 'bundled' energy products is still emerging, with an active debate as to a supplier's ability to 'lock-in' customers via hardware, or the length and types of appropriate contracts offered to customers.

2.8 Introduction to trends in renewable electricity supply switching

The electricity supply sector is getting smarter and more diverse. Following the implementation of a suite of reforms to the energy supply market in the early 2010s by Ofgem, the energy regulator, the number of utilities offering gas and electricity tariffs operating in GB has rapidly expanded to around 50. The diversity of tariffs on offer to consumers has correspondingly increased, and a number of suppliers now offer a 100% renewable electricity supply tariff. The increased competition has driven down the number of customers with a 'Big Six' supplier as companies compete on price, environmental credentials, and service. The increased 'smartness' in the market and increasing deployment of large new loads at a household level (e.g. an EV) have also resulted in a greater focus on price-reflective tariffs, such as the Agile Tariff offered by Octopus Energy, as the industry moves closer to half-hourly metering.

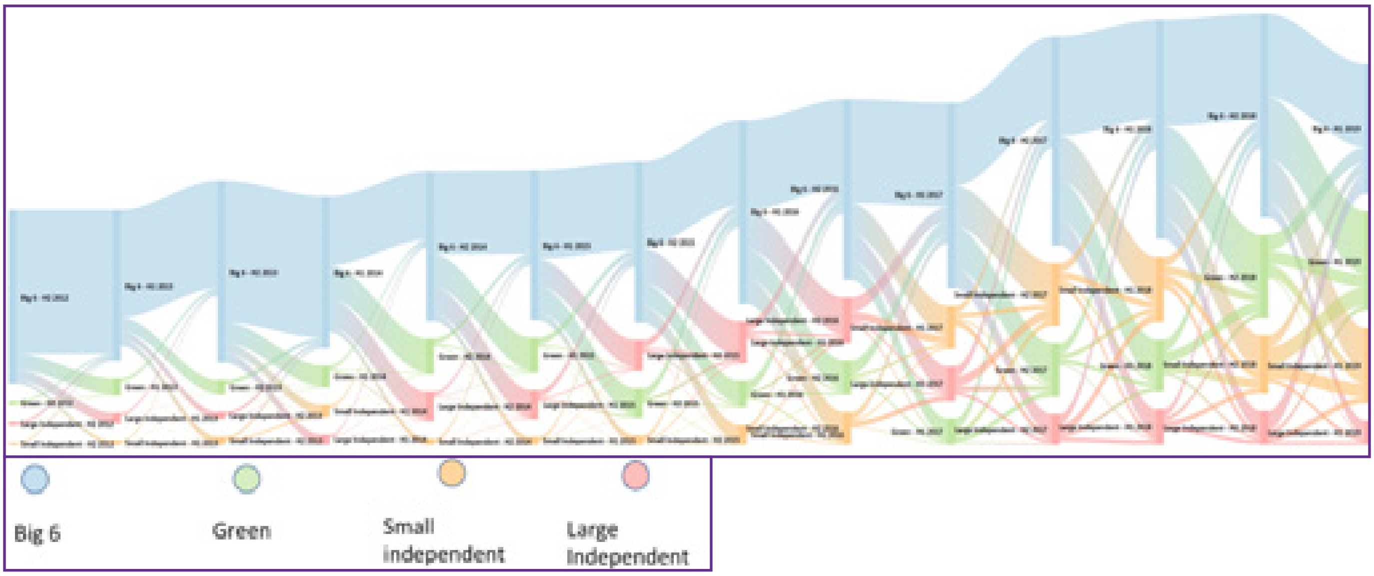
Whilst we may have seen a peak in the number of suppliers operating in the sector, we are likely to see more tariffs introduced that reflect greater consumer (both domestic and corporate) engagement with a 'smart' energy system. These includes time of use tariffs tailored at electric vehicles or Smart Export Guarantee-linked tariffs designed for future solar PV (and energy storage) owners who wish to make a return exporting power to the grid.

Overall, the data confirms that there are presently over 3 million customers on a 100% renewable electricity supply tariff in GB and that between May 2012 and March 2019, 5.2 million people have at some point been on a green electricity supply. See our note in section 2.8.1 on definitions of renewable supply tarrifs.

Figure 8 shows the extent of switching since 2012, and the increasing prevalence of smaller and independent suppliers – note that this shows only those who switch and where those who switch move to, not total customer numbers with each segment. It highlights the flow of customers from various supplier cohorts on a half yearly basis. Most switches are away from the 'Big 6' suppliers to the other supplier groups with suppliers tagged as 100% renewable energy suppliers ('green') picking up more and more customers each month – this has been in part driven by the growth of the new entrants that have 100% renewable electricity supply tariffs sourced by Renewable Energy Guarantees of Origin (REGO) certificates.

Note that customers tagged in our methodology as green are those who are with a company that only offers 100% renewable power supply tariffs. Customers with a company that offers both 'grey' tariffs and 100% renewable tariffs are not included in the banding.

Figure 8: Switching trends between electricity suppliers in GB (Small Independent, Large Independent, Green, and Big 6) H2 2012 to H1 2019. Note: This shows only those switching, not total customer numbers

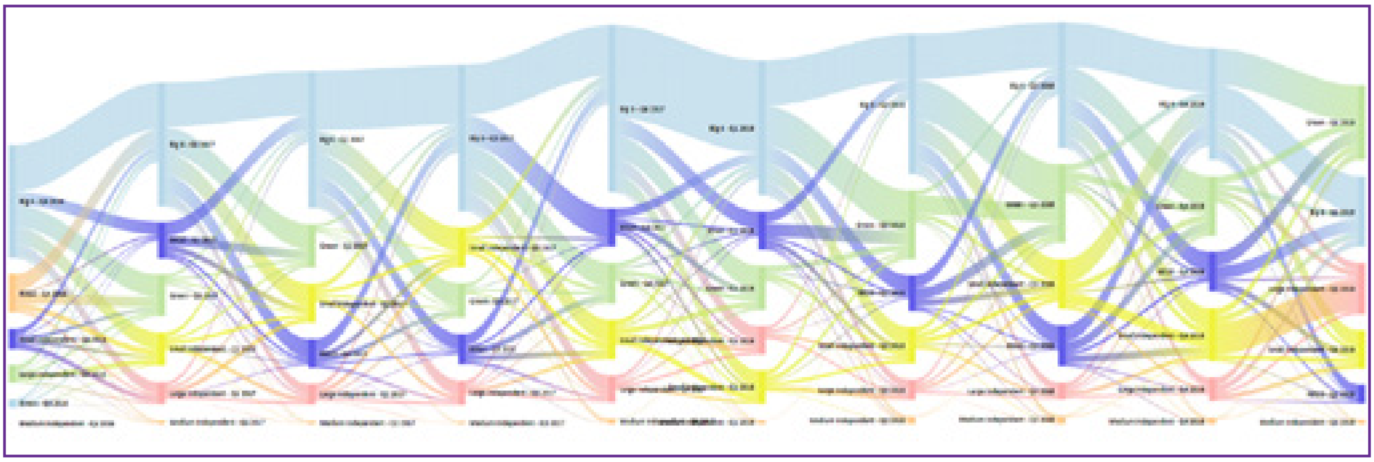


Source: ElectraLink

To develop this analysis, ElectraLink has visualised (Figure 9, following page) the total number of switches between Q4 2016 and Q1 2019, but with those suppliers who procure 100% renewable power from REGOs pulled out. It shows a clear trend towards consumers preferring 100% renewable power supplies procured from non-REGO suppliers.

Figure 9: Switching trends between suppliers (Small Independent, Large Independent, Green, Green REGO and Big 6) Q4 2016 to Q1 2019.

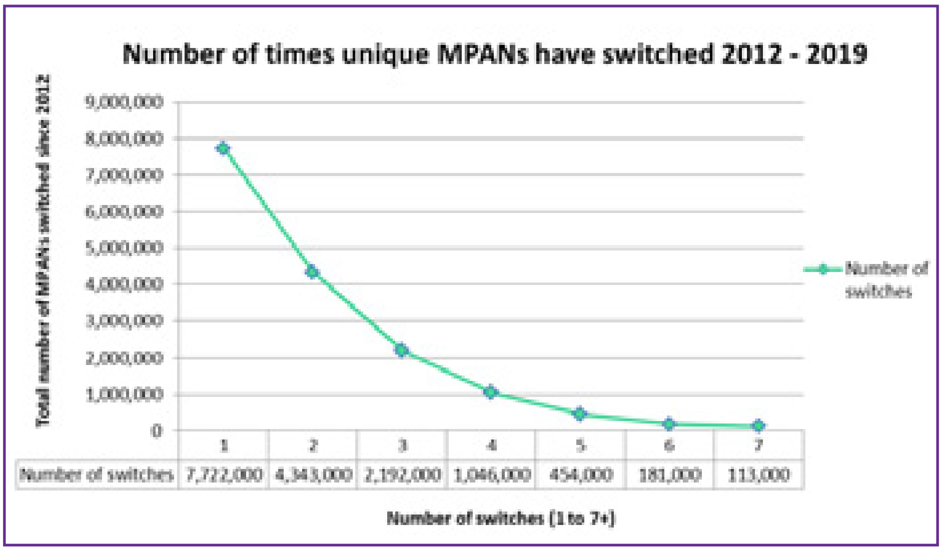
Note: This shows only those switching, not total customer numbers.



Source: ElectraLink

Figure 10 below shows the number of times customers (including domestic, SME, and C&I customers) have switched since 2012. It highlights that just under 8m customers have switched only once, around 4.5m customers have switched twice with just under half a million customers having switched 5 times, and so on. This is important as it shows that whilst a significant portion of the population have switched at least once, those who are more engaged with two or more switches are significantly fewer. X axis shows the number of times an individual customer has switched supplier (1 to 7+) and the Y axis is the number of MPANs that fall into this bracket.

Figure 10: Switching rates (1 switch to 7+) for all GB MPANs (May 2012 – March 2019)



Source: ElectraLink

2.8.1 Renewable Supplies – A note on REGOs

Data from ElectraLink shows around 3 million consumers on renewable electricity tariffs in the UK. This may be higher than some expected and is down to the different ways of meeting '100% renewable' – via direct procurement of renewable power straight from renewable projects, or via Renewable Energy Guarantees of Origin (REGOs) certificates, both of which are included in this data as '100% renewable power' as per ElectraLink classification.

Renewable Energy Guarantees of Origin (REGOs) have become a controversial, yet widely used, policy tool in renewable electricity. REGOs are certificates attached to each MWh of power generated from renewable sources. They used to be traded only in combination with the renewable power units generating them, but can now be purchased separately from the power. This has become notable as suppliers have used REGOs to match customer demand with REGO certificates, as opposed to matching customer demand with supplies directly generated from another arm of the company or from direct Power Purchase Agreements (PPAs). The difference is that direct support can be seen to create 'additionality' by directly funding the creation of new renewable projects, whereas REGOs are argued not to directly create any new capacity and therefore is counter to this principle.

Some market commentators have therefore split 100% renewable electricity tariffs into those delivered via power purchase agreements (PPAs)/direct procurement of generation, and those delivered by purchasing REGOs. A member company of the REA has suggested an alternative system of green electricity certificates - the "GREEn" (Green Energy Endorsement certificate") whereby certificates directly support the generation of new renewable power.

3. Methodology

3.1 Building the Flexible Futures Report

The 2016 Smart Power report signalled the benefits that may be realised from flexible power. However, the path to achieving this still appears slow and uncertain.

To address this, the REA and ElectraLink have formed a partnership to produce and launch this Flexible Futures report - a new document that uses ElectraLink's dataset to understand the changes to date and REA expertise to chart ways ahead for the next decade.

The report builds on the skill demonstrated in ElectraLink's work with National Grid, partnering with them to give the Electricity System Operator sight of what is taking place on the distribution network at a previously unprecedented level through on-going provision of embedded generation data.[30] It is also informed by the outcomes of the ElectraLink LCT Detection Project, delivered for Western Power Distribution with IBM. Using AI and advanced analytics, the project identified indications of 15,000 previously unknown solar PV and electric vehicle charging installations on the Western Power Distribution network, equating to a 13% uplift in EV and solar PV visibility for the DNO, at a household level.[31] The report additionally draws on the experience the REA has built up in this sector, in its advocacy for, and management of, the solar, energy storage, smart grid, and electric vehicle charging sectors in the UK.

This report draws on data from ElectraLink, primary research from the REA, external research that the REA has been involved in, and analysis from the REA and ElectraLink teams. The data concerns renewable energy switching, trends around generation and exports on the distribution network, and proposes a new system for the categorisation of customers (or market segments) in the energy industry.

3.2 About the ElectraLink dataset

ElectraLink was created in 1998 by the energy industry to provide an independent, secure and low-cost service to transfer data between the participants in the deregulated GB electricity market. This resulted in the formation of the Data Transfer Service (DTS).

The DTS is a regulated service owned by the energy industry, for the benefit of the energy industry. It is used to share essential business process data on a 24/7/365 basis by over 270 electricity and gas parties across Great Britain. The DTS underpins the competitive UK energy market, enabling participants to work together to exchange information about customers. This information interchange facilitates a wide range of business-critical processes including how energy is paid for by suppliers (settlement), change of supplier and metering. In 2012, ElectraLink was granted permission to access the data that is transferred across the DTS under the governance of the Data Transfer Services Agreement (DTSA) to monitor and identify trends in the energy market, improve transparency and provide insight into the challenges and opportunities faced by the industry.

The data ElectraLink holds is based on billions of messages flowing across the DTS that require significant data processing in order to organise the data and leverage its value for the industry. Industry processes are mapped and refined into datasets by ElectraLink to provide clear analysis on industry process activities at a meter point (associated with an address) level. These processes include (but are not limited to) switching supplier, registering energy consumption (including Supplier Volume Allocation (SVA) registered generation) and managing site activities such as meter installations and site visits. ElectraLink is the only central source that has access to the data flows that underpin these processes.

Further details about the methodology used to determine Chapter 4 can be found in the **Appendix**.

Photo shot by Mimadeo of 'Renewable energy with wind turbines' on iStock

4. Key Findings – Distributed generation and flexibility customer types

This chapter highlights trends and conclusions derived from REA analysis of the ElectraLink dataset, particularly focusing on decentralised generation and identifying a methodology for assessing flexibility customer types.

4.1 Generation and flexible resources on the distribution network

4.1.1 Introduction - understanding trends in distributed electricity generation and export

During the era of peak renewable power deployment under the Feed-in Tariff and the Renewables Obligation, concern was voiced in the industry about the impact this was having on the distribution networks. However, there is a lack of data available to the energy sector about the strains experienced by the networks during this time. The Government's Digest of UK Energy Statistics (DUKES) document, for example, outlines the growth in renewable electricity generation overall but does not break down into any significant detail which aspects of the network have been most significantly impacted.

In light of the UK's commitment to Net Zero, and the likelihood that our achieving it will require the deployment of significantly more distribution-connected renewable generation, it is now even more important that the industry investigates generation in this area to date, and going forward.

This chapter outlines overall and technology-specific electricity export trends. It also highlights the growing proportion of renewable electricity on the distribution networks compared to fossil fuels.

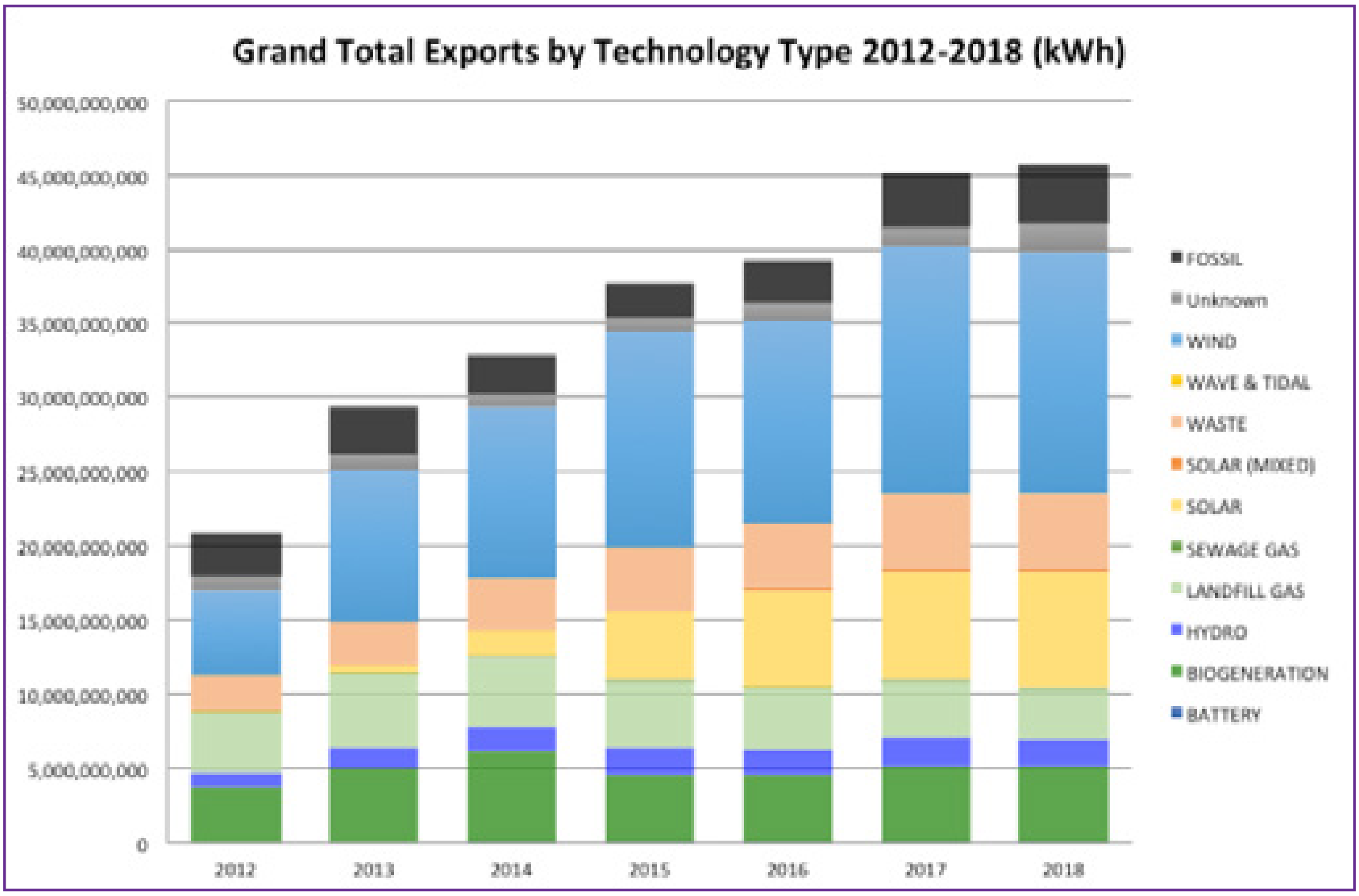
This new information reinforces the need for DNOs to be taking a more active role in the electricity system, particularly by actively procuring flexibility and conducting reinforcement where appropriate.

A note about this chapter: these data cover exports (which may be less than total generation) onto the distribution network rather than the transmission network. As mentioned in the Appendix, the ElectraLink dataset, informed by their management of the DTS, has visibility on SVA-registered generation sites (see Appendix for definition). Most CVA sites are excluded, however very few distribution-connected sites are registered in this way. Importantly it also does not cover private wire agreements, in which a consumer who is typically near to a generating site exclusively uses the site's power. These are becomingly increasingly common in the industry but are far from yet being widespread. Analysis of network losses following the export of electricity onto the network is excluded from scope.

4.1.2 Understanding GB-wide trends in distribution-connected generation

As detailed in Figure 11 below, data from ElectraLink indicates that generation and subsequent export onto the distribution network doubled between 2012 and 2018 in Great Britain. DUKES data shows that national (transmission and distribution) generation (across the UK) was 333TWh in 2018, of which we now know 45.58TWh was exported to the GB distribution network. Whilst still a minority of overall electricity production, it is a sizable and growing contribution which is likely to be an increasingly prevalent reality for the DNOs.

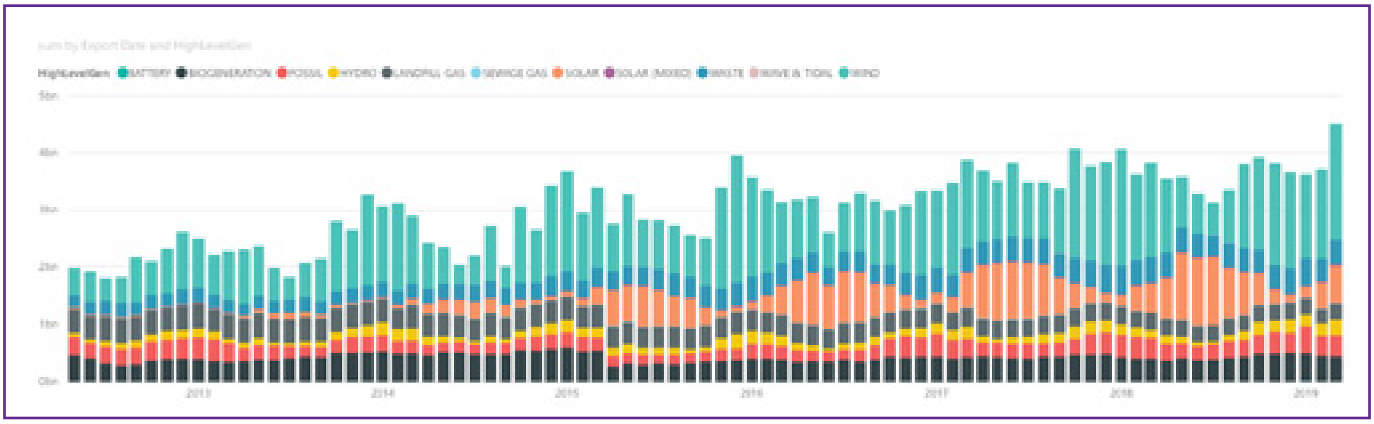
Figure 11: Total electricity exports by technology type, Annually 2012-2018 (kWh)



Source: REA based on ElectraLink data

Figure 12 below emphasises this growth and highlights some monthly variability in export levels.

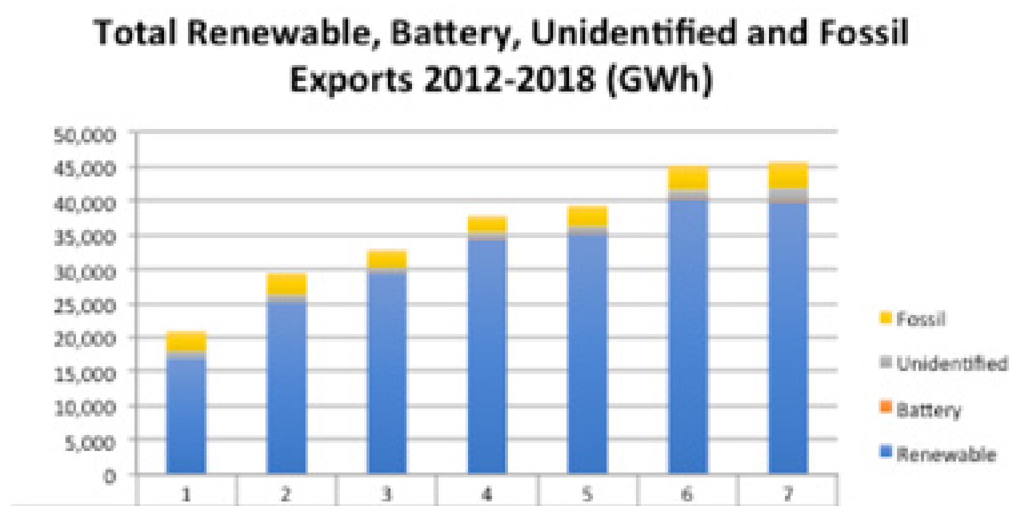
Figure 12: Exports onto the distribution networks by quarter by technology type, Monthly 2012-February 2019 (kWh) and Annually



Source: ElectraLink

Of the overall figure of 45.58TWh, Figure 13 highlights that 39.8TWh of export onto the networks is from renewable sources, ranging from sewage gas to onshore wind and waste-to-energy. This is a significant increase on 17TWh in 2012. Nearly 2TWh is from sources currently unidentified on the DTS.

Figure 13: Total Renewable, Battery Storage, Unidentified, and Fossil Exports 2012-2018 (GWh)



	1	2	3	4	5	6	7
Fossil	2,837	3,142	2,541	2,341	2,977	3,569	3,808
Unidentified	984	1,101	920	919	1,115	1,361	1,957
Battery	0	0	0	1	1	7	49
Renewable	17,009	25,132	29,337	34,432	35,136	40,160	39,767

Source: REA based on ElectraLink data

REA View: A pause in new generation capacity coming online, which can be directly attributed to a change in policy direction in 2015, can be seen in the figures for years 2017 and 2018.

Whilst this 'pause' in growth will likely also be borne out in 2019 and 2020 (considering little new policy has emerged to support renewable energy deployment), subsidy-free solar generation, borne out of the emergence of new economic models such as the growth in onsite storage, is likely to result in fresh growth from 2021, and grids need to be adequately prepared to manage this.

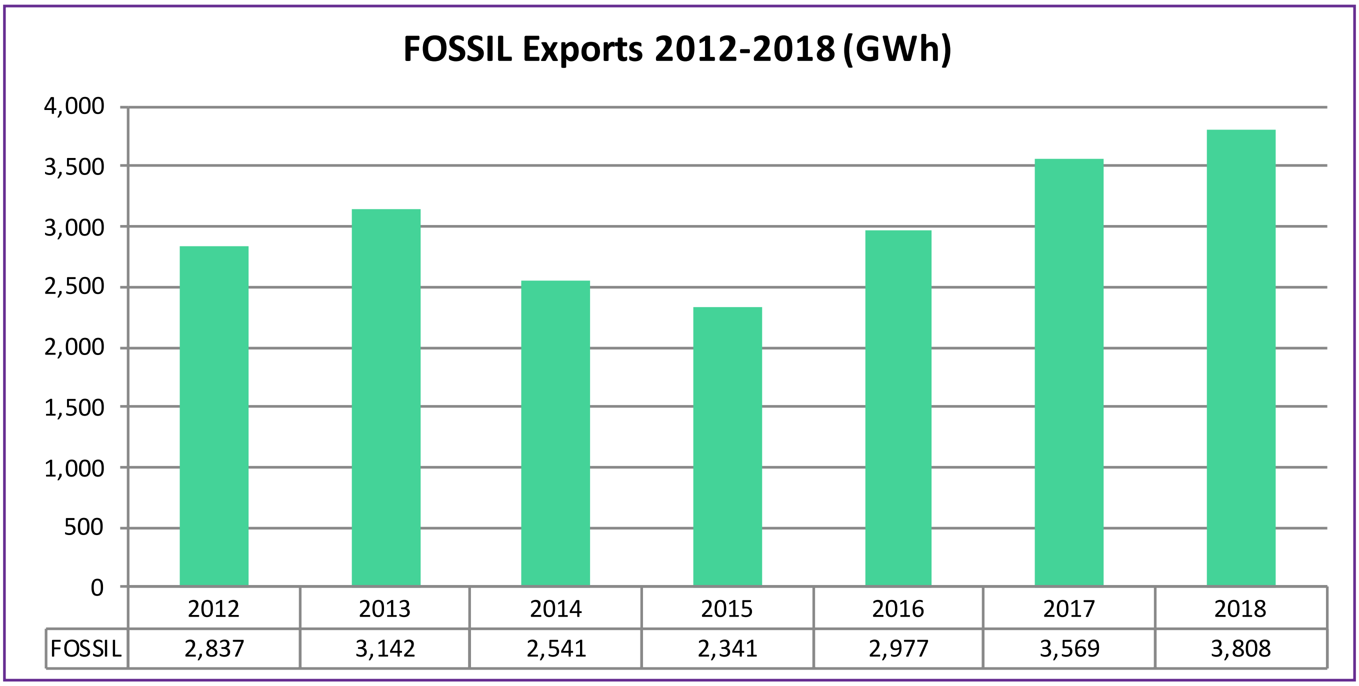
Energy markets need to be prepared for lower cost renewables. A level playing field is needed to speed up deployment and new policy should encourage a mix of generation types onto the system. Interconnectors receive incentives through cap and floor regulatory arrangements, and the most recent Contracts for Difference auctions saw offshore wind developers bidding in at below-wholesale electricity price cost levels for projects starting in 2025,[32] meaning they will in effect be paying the Government for the revenue certainty their contracts offer them. If onshore wind and solar were to be included in these auctions, it is likely there would be a similar result.

4.1.3 Fossil fueled technologies

Whilst it is clear that more power is being exported to the distribution networks, Figure 14 shows that it is not completely the result of new renewable sources coming online. A net increase of fossil-fuel based generation and export took place between 2012 and 2018, with exports in the final year amounting to 3.8TWh. Technologies encompassed by 'fossil' in the ElectraLink dataset include diesel reciprocating engines, gas Open Cycle Generation Turbines (OCGT), and electricity generated from coal-mine methane.

Whilst most of this new capacity is likely the result of diesel generators procured in the Capacity Market auctions, the majority overall supply is from coal-mine methane and gas Combined Heat and Power (CHP) units. Diesel, OCGT, and other forms of fossil generation represent the minority of this production.

Figure 14: Fossil-fueled generation exports 2012-2018 (GWh)



Source: REA based on ElectraLink data

4.1.4 Renewably-fueled technologies: sewage gas, landfill gas, waste-to-energy

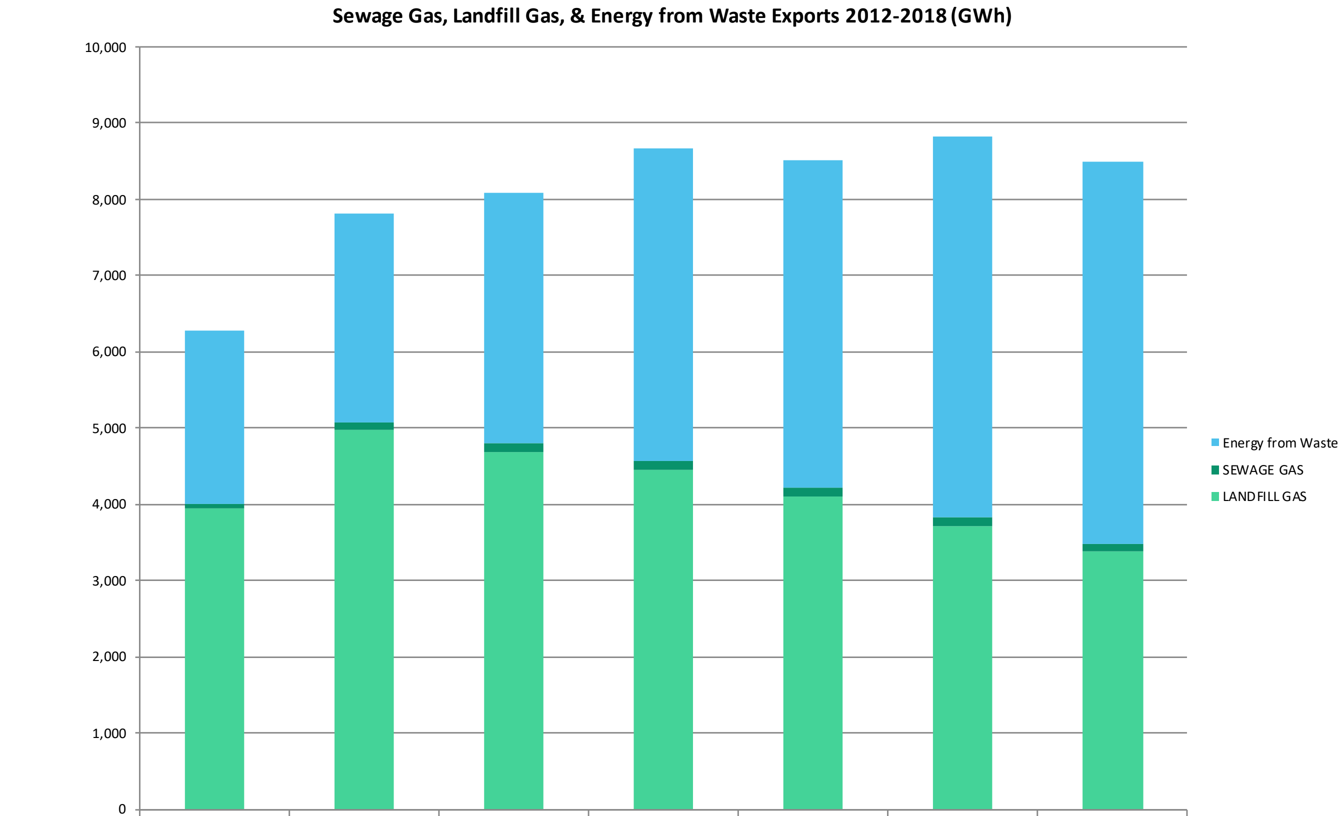
Looking at Figure 15, it is clear that fueled technologies from renewable sources make up a larger portion of generation than fossil-fueled technologies.

The landfill gas sector is one of the UK's longest standing sources of renewable energy, and in the early 2000s represented the largest source of renewable power produced. However, output from this source of power is in decline, confirmed in this data. DUKES reports that 2018 saw 3.9TWh of electricity generation from landfill gas, with 3.38TWh reported in the ElectraLink dataset, indicating that some is connected at a transmission level, is CVA registered, or is exported via private wire agreement.[33]

Making up for this decline, exports from waste-to-energy sites have more than doubled since 2012. The REA expects this trend to continue as there is presently strong investor interest in growing the UK's waste-to-energy pipeline of projects, in part due to the landfill tax, and also its perception as an efficient and proven technology.

Exports from sewage gas have increased, and are expected to continue to do so, as water companies are increasingly active in the biogas and microgeneration sectors.

Figure 15: Sewage Gas, Landfill Gas, and Waste-to-Energy Exports 2012-2018 (GWh)



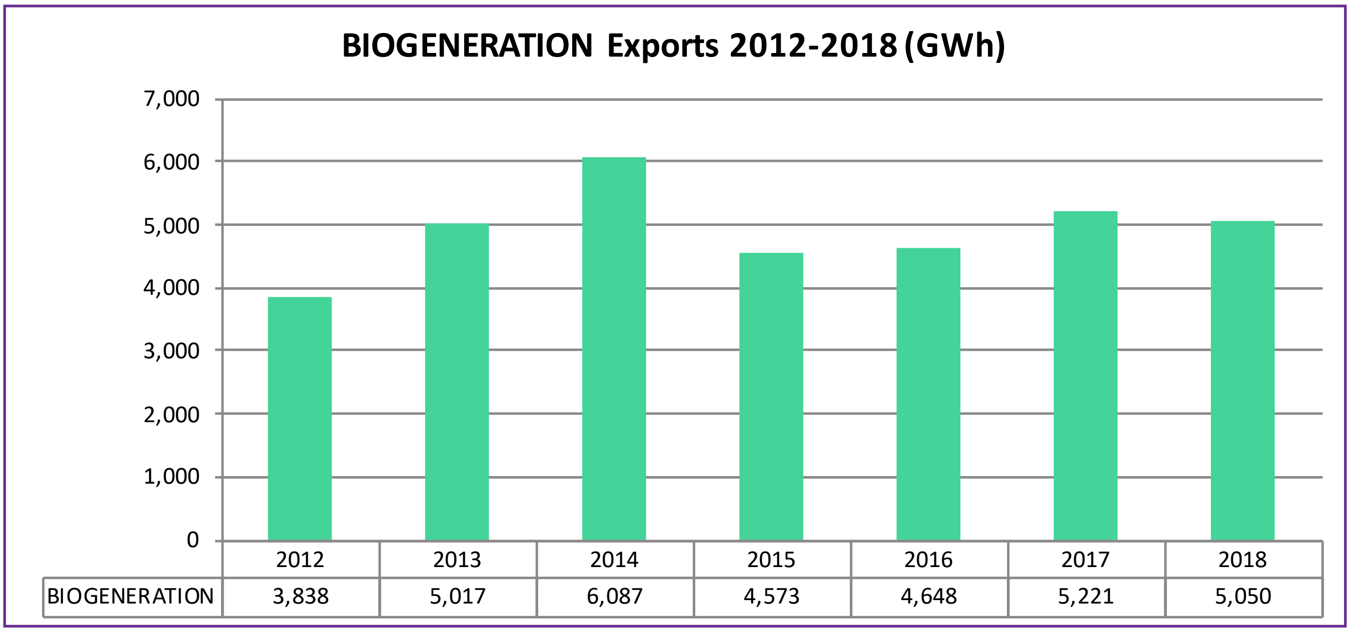
	2012	2013	2014	2015	2016	2017	2018
Energy from Waste	2,277	2,751	3,301	4,109	4,290	5,007	5,016
SEWAGE GAS	61	88	108	110	116	117	92
LANDFILL GAS	3,939	4,980	4,684	4,455	4,100	3,709	3,385

Source: REA based on ElectraLink data

4.1.5 Bioenergy

Bioenergy, encompassing biogas, biomass CHP, and dedicated biomass power generation, are a set of fueled renewable energy technologies which should also play a greater role in the UK's generation mix. Figure 16 suggests that there has been very modest growth in their contribution to the power generation mix on the distribution network since 2012. This may in part be as biogas developers are increasingly favoring biomethane injection into the gas grid rather than burning biogas onsite for their own heat and power purposes.
Exports for this group reached 5.05TWh in 2018.

Figure 16: Biogeneration Exports 2012-2018 (GWh)



	2012	2013	2014	2015	2016	2017	2018
BIOGENERATION	3,838	5,017	6,087	4,573	4,648	5,221	5,050

Source: REA based on ElectraLink data

REA View: The industry-led 2019 REA Bioenergy Strategy provides pathways for future bioenergy heat, power, and transport deployment and should be embraced by policymakers.[34] Bioenergy technologies are regulated by a robust sustainability regulatory and reporting system and can provide a major contribution to achieving Net Zero, particularly when combined with Bioenergy with Carbon Capture and Storage (BECCS)

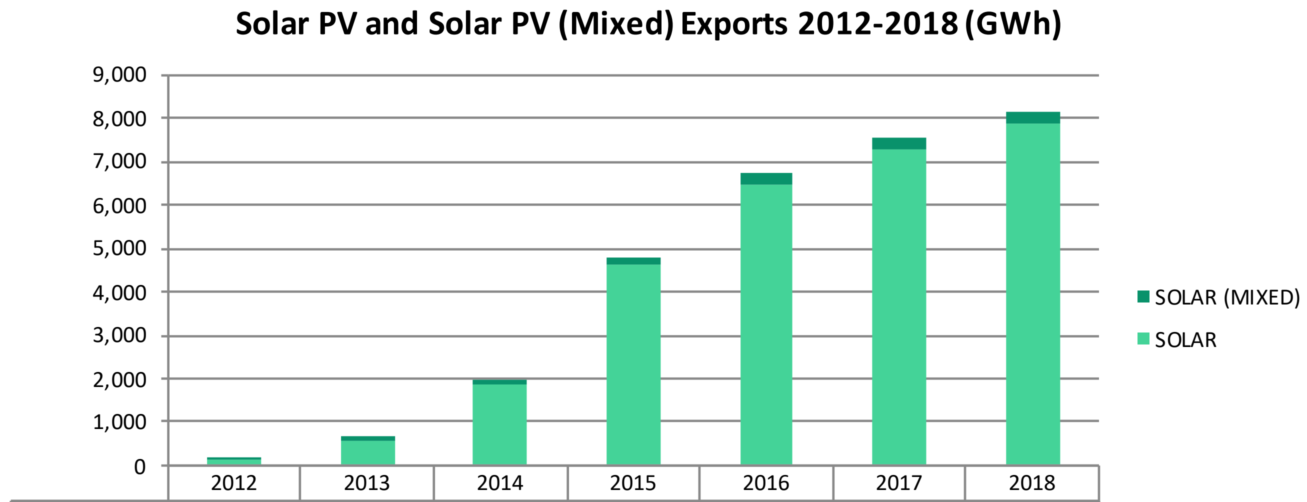
4.1.6 Solar PV deployment

The rapid growth in solar PV deployment, and subsequent halt following policy changes enacted in 2016 and 2017, is clearly visualised in Figure 17.

ElectraLink's dataset records two types of solar PV connected to the distribution network. 'Solar' refers to conventional solar PV, which can be observed on their system. 'Solar (mixed)' refers to what they know to be solar but does not behave as such with its exports, given known weather patterns. This implies that there may be otherwise unseen on-site energy storage or other forms of generation, such as diesel generation sets, at these sites.

Between the two types, there is an extraordinary growth of solar PV exports from 194GWh to over 8TWh in 2018.

Figure 17: Solar PV and Solar PV (Mixed) Exports 2012-2018 (GWh)



	2012	2013	2014	2015	2016	2017	2018
SOLAR (MIXED)	44	84	137	205	218	249	250
SOLAR	150	574	1,853	4,611	6,497	7,294	7,888

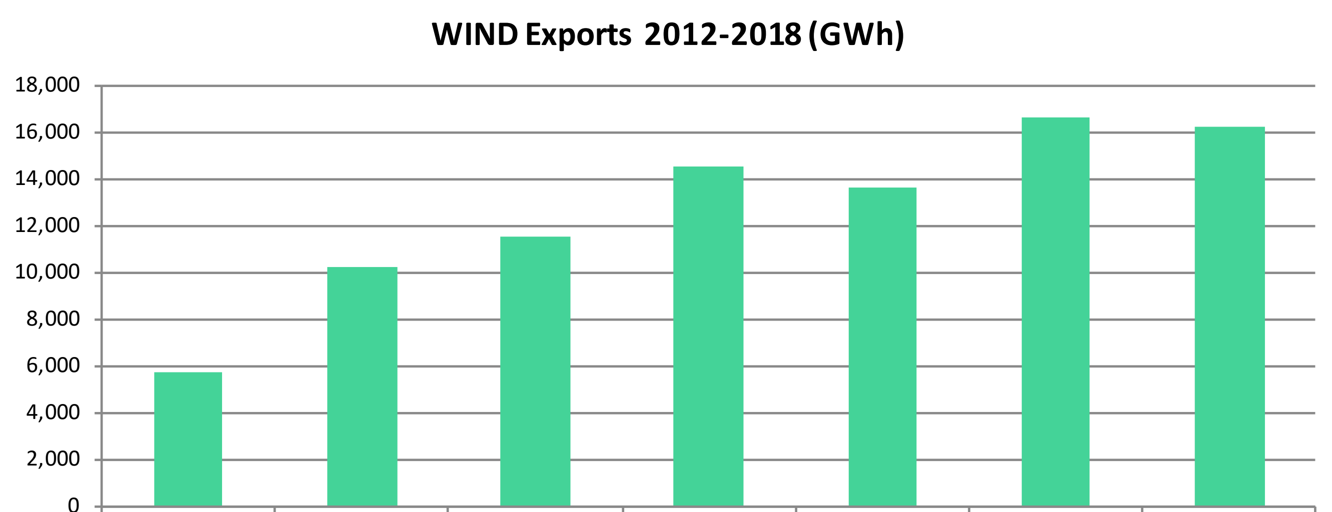
Source: REA based on ElectraLink data

4.1.7 Wind exports

A similar pattern of growth followed by a stalling of onshore wind generation can be seen in Figure 18. Due to supportive policy resulting in the expansion of new generation capacity, a remarkable trebling of generation exports to the system took place between 2012 and 2018, with the latter seeing over 16 TWh sent to the distribution network. The slight fall in 2018 exports over those in 2017 can likely be attributed to the change in policy and declining wind speeds, which were reportedly 1.6 per cent lower in 2018 than in 2017.[35]

Note that this data includes a small amount of distribution-connected offshore wind, likely from deployments early in the development of the industry. It also does not capture all the onshore wind that is distribution-connected, particularly as there may be larger sites that are CVA-registered in Scotland.

Figure 18: Wind (offshore and onshore) Exports 2012-2018 (GWh)



	2012	2013	2014	2015	2016	2017	2018
WIND	5,724	10,270	11,495	14,537	13,614	16,628	16,251

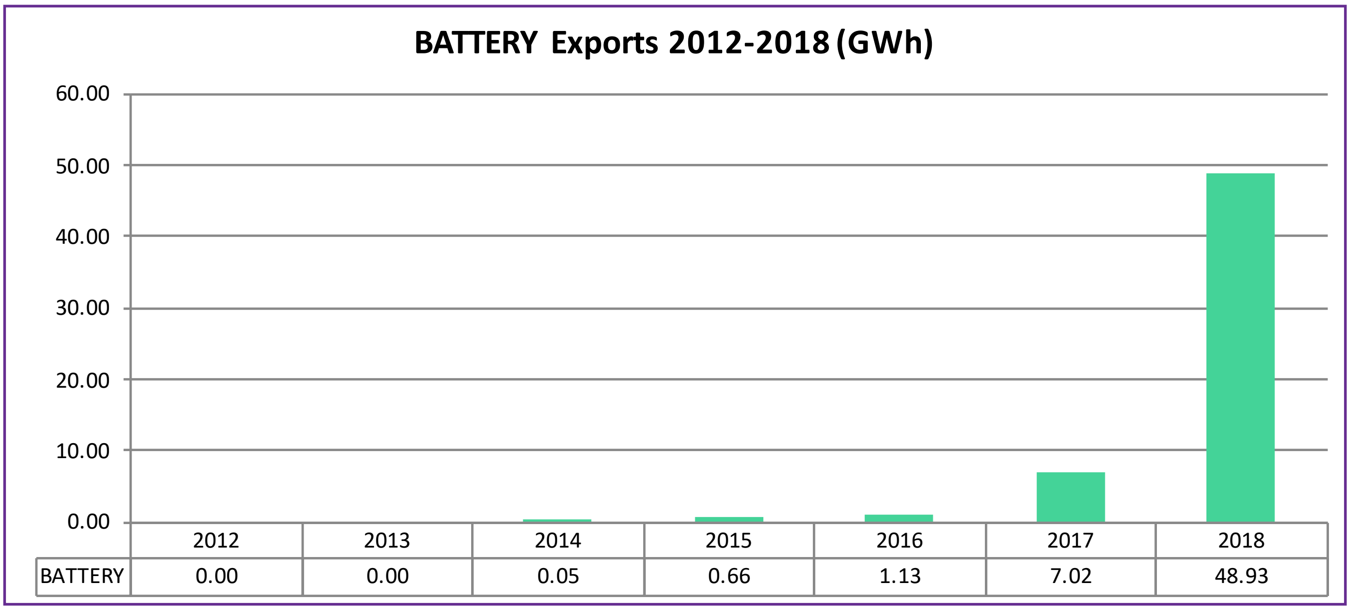
Source: REA based on ElectraLink data

4.1.8 Battery energy storage exports

There are numerous energy storage technologies, each of which is very valuable to the system, but the ElectraLink data only recognises battery storage sites so this is what our data covers. Batteries, which encompass energy storage technologies such as Li-ion batteries, flow batteries, and other battery chemistries are growing, but from a very small base. Battery storage exports in 2018 rose to nearly 49GWh up from 50MWh in 2014. This data, as it only covers exports to the distribution network may not encompass all battery storage-related activity. This is because, a significant amount of battery storage activity is likely driven by maximising self-consumption of onsite generation or providing price arbitrage services in commercial and industrial locations behind the meter. Its profile in some cases may also be masked in the ElectraLink dataset, resulting in its inclusion in the 'unknown' category.

However, this ElectraLink data does bear out several known market developments. The first significant exports coming online in 2014 coincide with the beginning of the trial by UK Power Networks from what was the UK's first grid-scale battery storage facility at Leighton Buzzard.[36] Significant price declines for electricity storage technologies, the tendering for 200MW of 'Enhanced Frequency Response' capacity in 2016,[37] and increasing attractiveness of storage co-located at variable wind and solar generation sites have all grown the market.

Figure 19: Battery storage exports 2012-2018 (GWh)

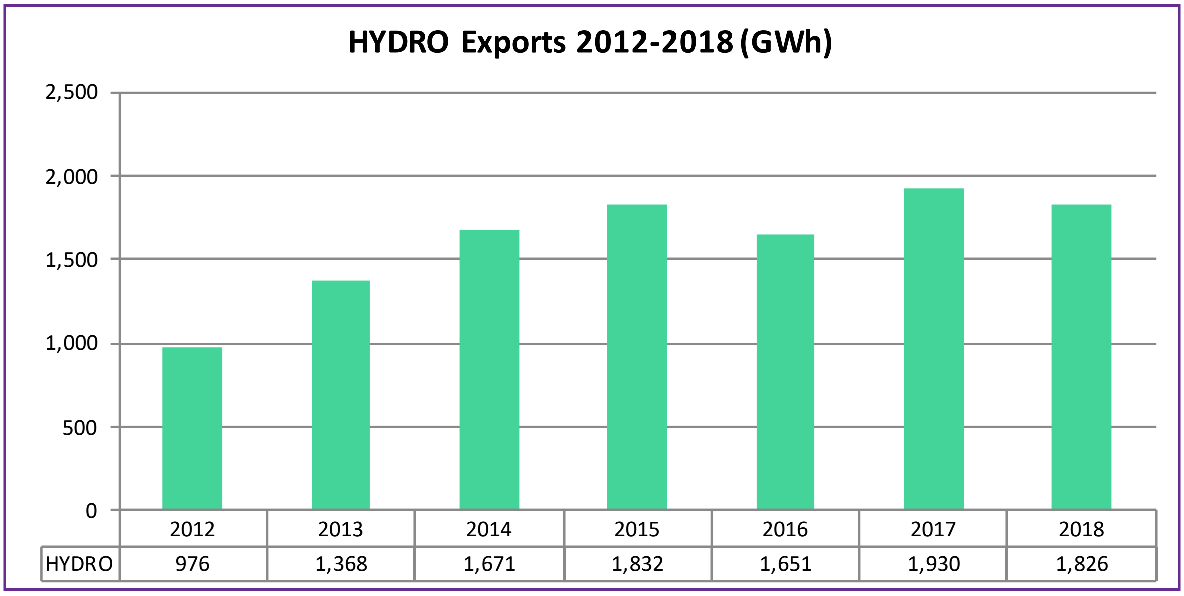


Source: REA based on ElectraLink data

4.1.9 Hydro exports

Hydropower is a longstanding renewable energy technology with a long lifespan. Much of the UK's large-scale hydro capacity was built out in the 1960's and 1970's, but microsites were also supported under the Feed-in Tariff. Such support has likely led to the increase in exports since 2012, outlined in Figure 20. 2018 saw exports of 1.8TWh, up from just under 1TWh in 2012. Variation in the years in between is partly due to rainfall levels and resultant flow rates.

Figure 20: Hydro Exports 2012-2018 (GWh)



Source: REA based on ElectraLink data

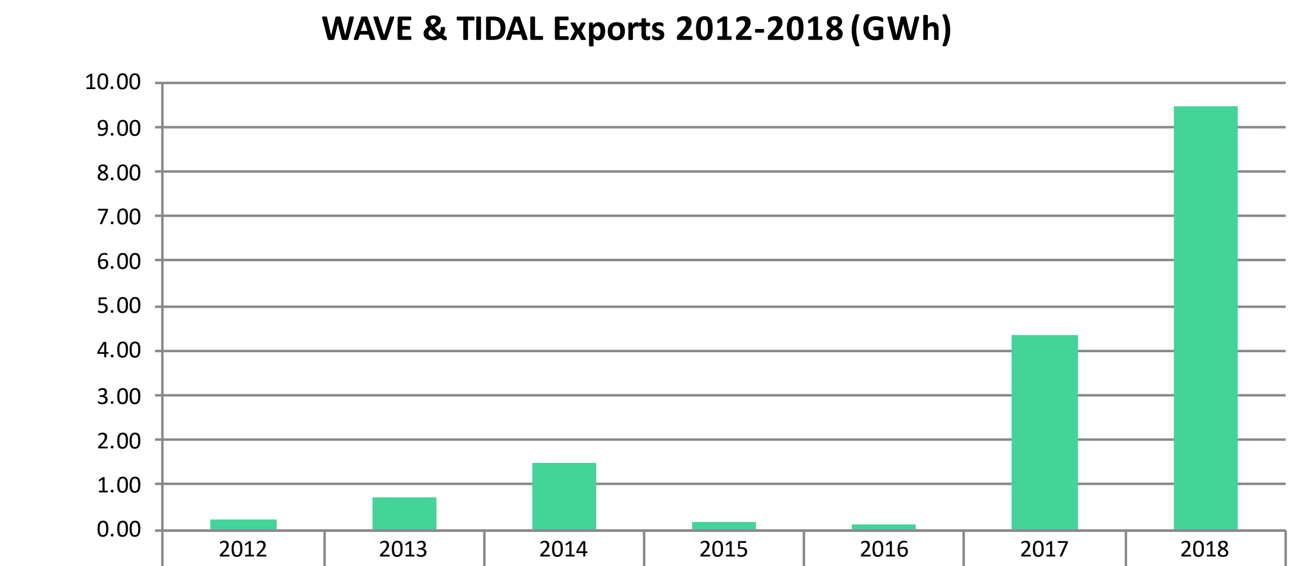
4.1.10 Wave and Tidal exports

As wave and tidal technologies are at an earlier stage of their deployment, and over the past decade much of the deployment has been short-term and related to product trials and testing, exports are understandably more varied and at a lower level than other generation technologies. Figure 21 highlights this, with exports rising from 240MWh in 2012 to 1.48GWh in 2014, then falling to 90MWh in 2016 and returning to 9.48GWh in 2018.

Stop-start policy support, including the exclusion of specific 'ring fenced' funds for wave and tidal in the Contracts for Difference (Pot 2) auctions after the first such auction in 2014 resulted in stalled deployment and in part resulted in two UK marine energy developers falling into administration in 2015 and 2016.

Some fresh life has recently been given to the sector with the securing of development funds from the European Union by several marine energy companies.

Figure 21: Wave and Tidal Exports 2012-2018 (GWh)



	2012	2013	2014	2015	2016	2017	2018
WAVE & TIDAL	0.24	0.70	1.48	0.16	0.09	4.38	9.48

Source: REA based on ElectraLink data

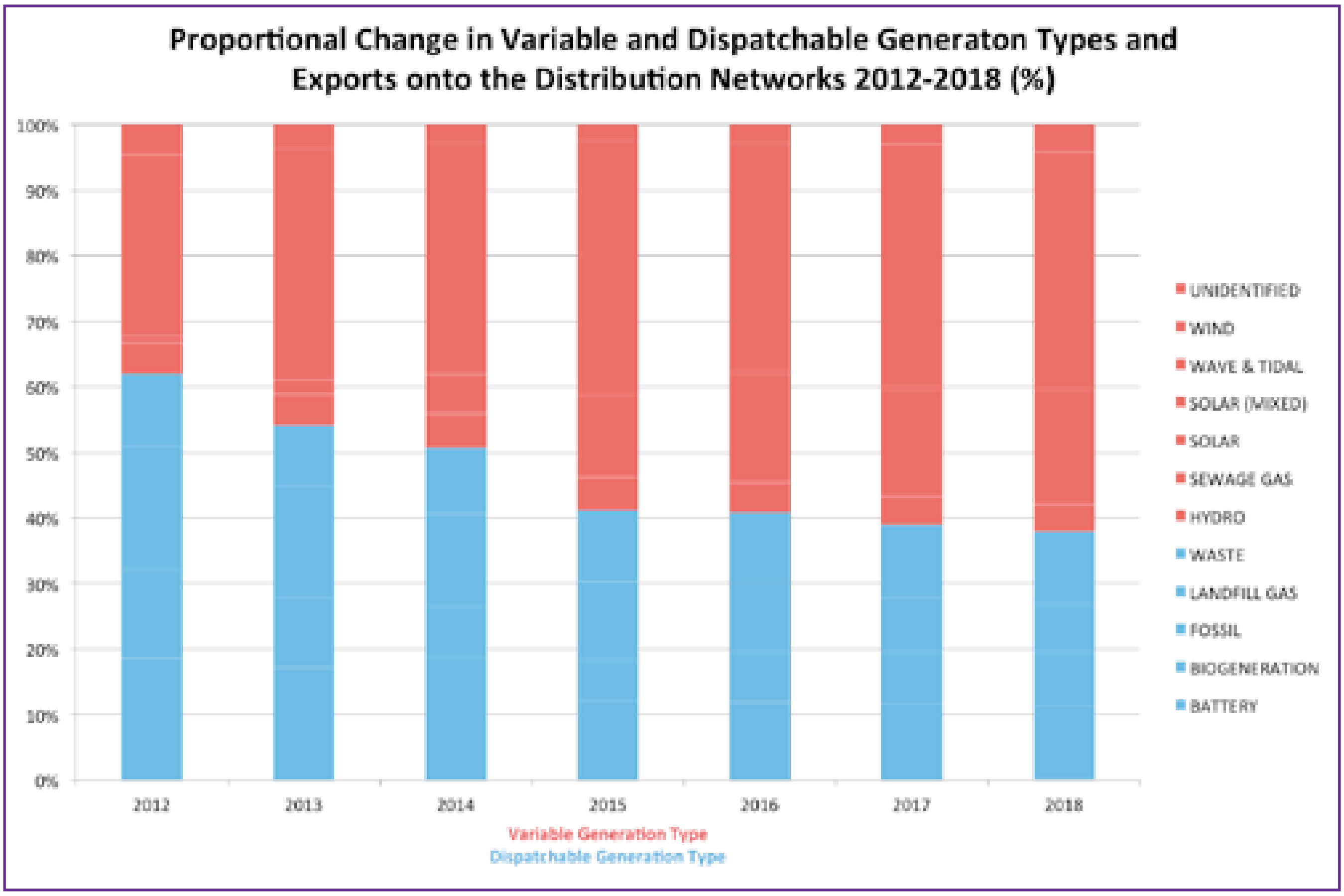
4.1.11 Dispatchable and variable generation technologies on the network

The paragraphs above have clearly highlighted that the volume of power being exported onto the distribution networks in GB is increasing overall. Figure 22 adds nuance to that, and highlights a challenge – that overall the proportion of exports that come from more dispatchable sources, meaning that they are more likely be able to increase or decrease their output on demand at given times (although some of this is unlikely to be able to play into relevant flexibility markets), is decreasing. Variable sources, such as wind and solar, are becoming more prevalent.

Less dispatchable sources, such as those driven by wind and solar, are becoming more prevalent. Technologies included as 'variable', with less flexibility in their output include those whose output is directly influenced by weather, as well as those that have a generation profile that is more static (including hydro). Unidentified exports by default are included in variable. Technologies included in 'dispatchable' include those that are fueled and are more likely to be able to increase/decrease their ramp rates as required, including biogeneration, landfill gas and waste-to-energy.

REA Analysis: As outlined earlier, wind and solar PV generation are amongst the lowest cost forms of new generation capacity in the UK today, as evidenced by a small number of 'subsidy free' sites being built today. More deployment can be expected in the coming years, whether this is envisioned by the networks or not. This chart highlights the imperative that DNOs evolve into DSOs and ensure products are in place that support demand-response and storage technology deployment.

Figure 22: Proportional Change in Variable and Dispatchable Generation and Export onto the Distribution Networks 2012-2018 (%)

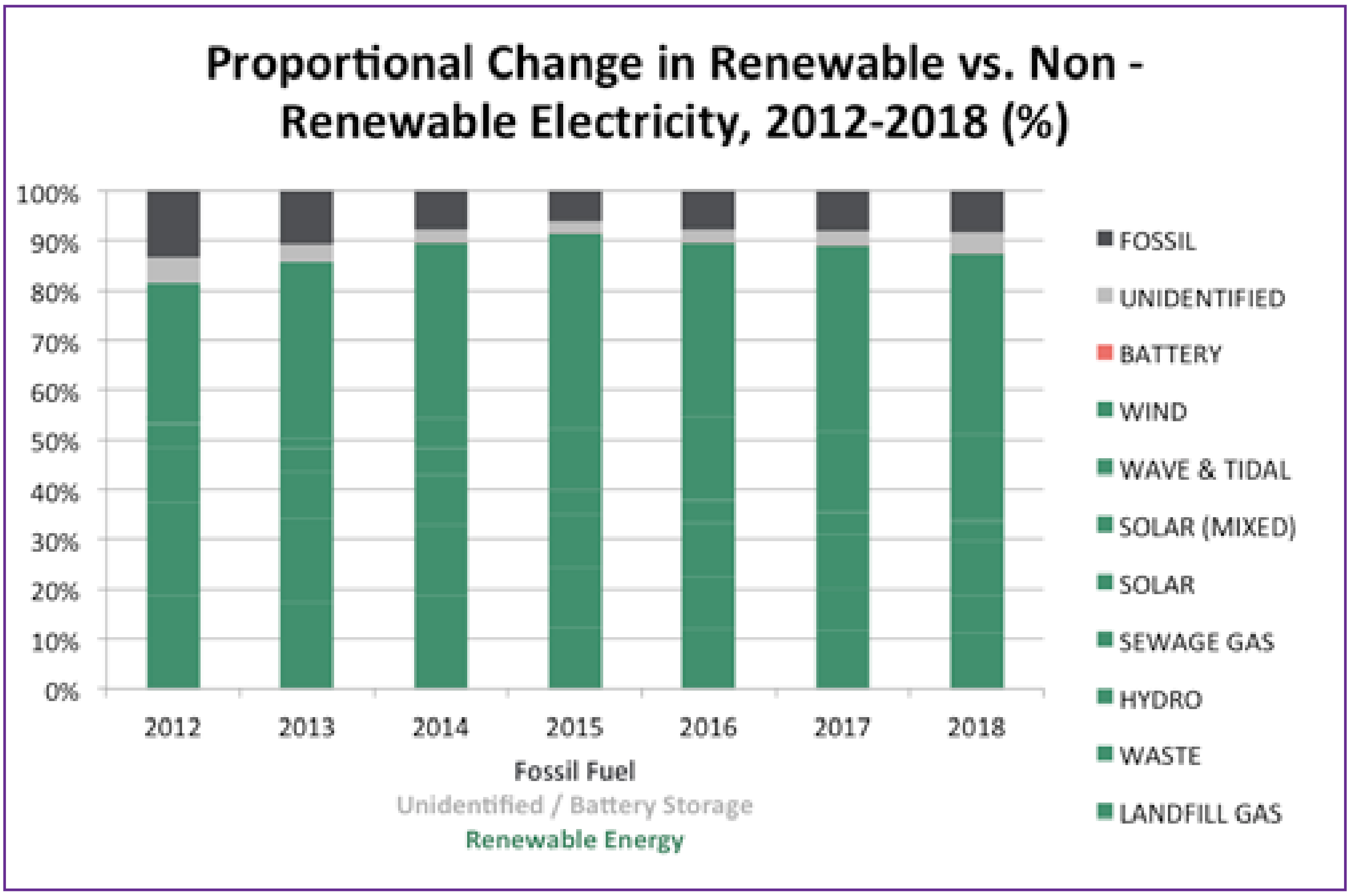


Source: REA based on ElectraLink data

4.1.12 Proportional change – renewable energy and non-renewable energy

Despite fossil-fueled generation being supported by Government incentive schemes (i.e. the Capacity Market), an encouraging trend highighted in Figure 23 is that the overall majority of distributed generation and electricity exports are from low or zero carbon renewable sources. This trend was increasing following strong policy support for new renewable generation until 2016, but there has been a small decline since reaching over 90% renewable in 2015. Declines in landfill gas output and increases in fossil generation since 2015 are likely drivers of this shift.

Figure 23: Proportional Change in Renewable vs. Non – Renewable Electricity, 2012 – 2018 (%)

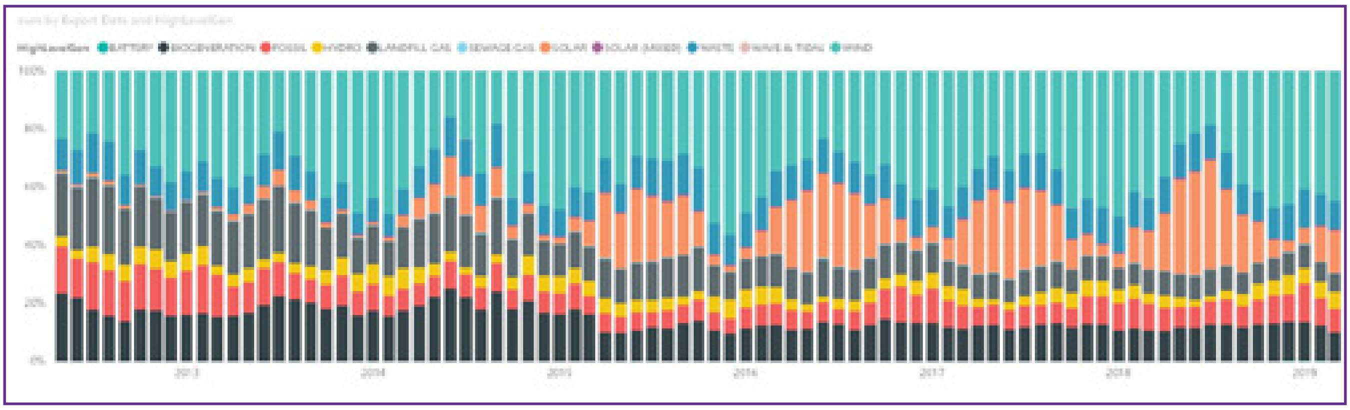


Source: REA based on ElectraLink data

4.1.13 Complementary generation trends – wind and solar

The complementary nature of wind and solar generation is highlighted in Figure 24. On a month-to-month basis, generation and export from wind sites supplements times when solar PV generation is low. Correspondingly, solar PV output is stronger in summer months when wind speeds are slower. The net result is some variability but a much more stable profile than considering a single technology alone.

Figure 24: Export trends by technology, Monthly January 2012 to February 2019 (%)



Source: ElectraLink

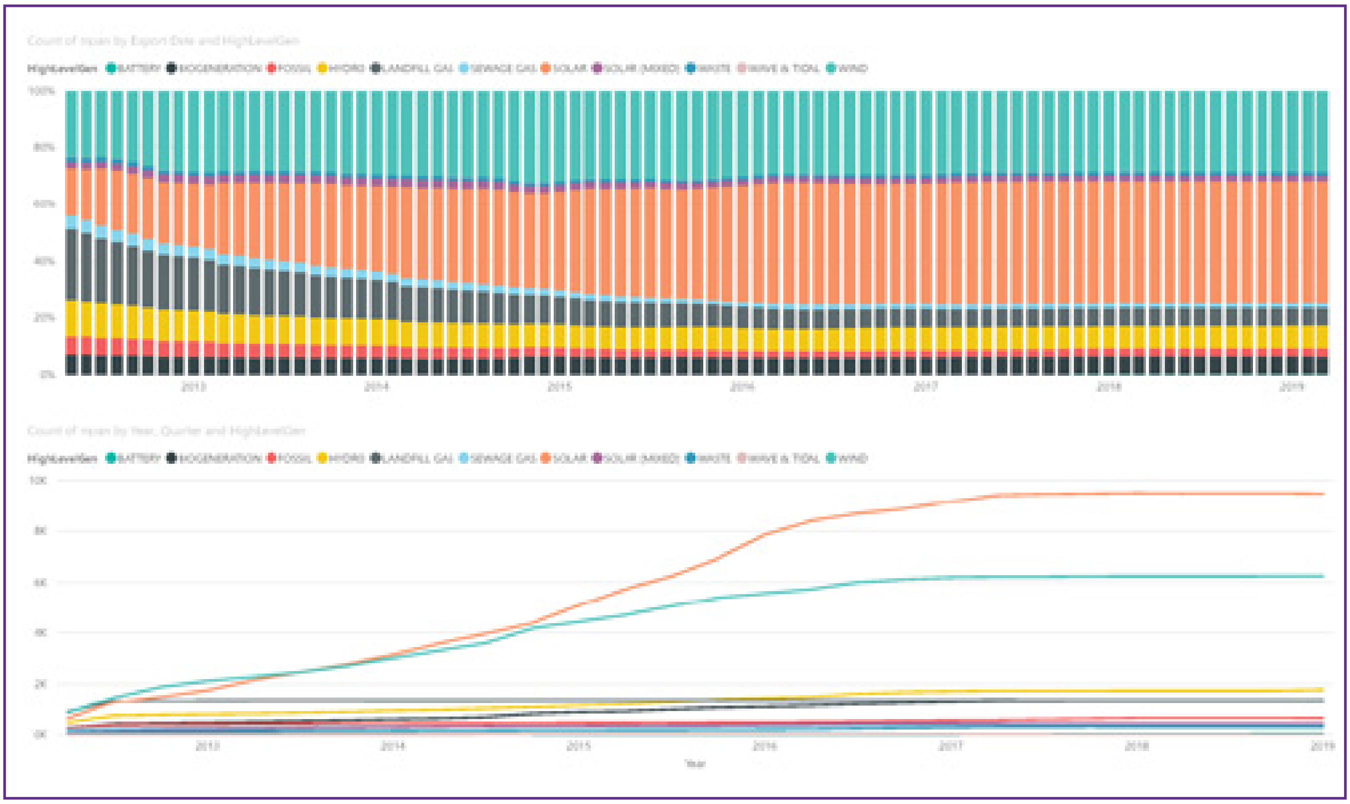
REA View: The balance between wind and solar, complemented by fueled renewable technologies, is achievable from an overall supply perspective. However, the electricity system, including distribution networks, must be flexible enough to cope with days when wind and solar is fully available, and days when it is not. This is why we need more national and local flexibility capacity.

4.1.14 The role of businesses in the electricity sector – exports from C&I locations

Over the past decade, in part spurred by rising commercial electricity prices and in part supported by the availability of the Feed-in Tariff, energy managers in commercial and industrial (C&I) locations have been engaging with renewable energy developers to accommodate and benefit from near and onsite renewable energy generation. The success of the solar PV development sector to date is evidenced below, with Figure 25 highlighting the growing proportion of solar exports from C&I locations. It also shows nearly 10,000 C&I MPANs with solar PV, up from less than 1,000 in 2012.

Note that this does not cover SMEs, which have also seen a surge in onsite generation. C&I is defined as Profile Classes 5-8.[38]

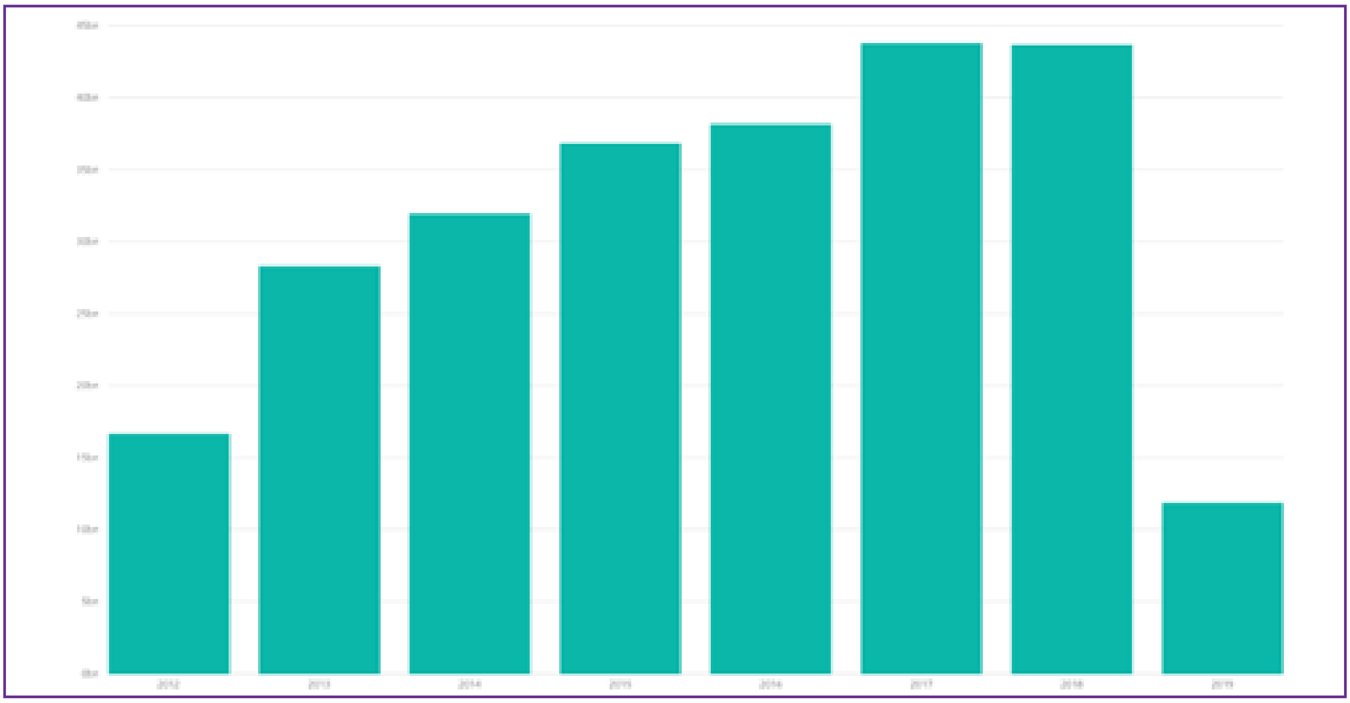
Figure 25: Exports from Commercial and Industrial (C&I) locations in GB by technology (% of total Exports) (Total MPANs by Technology) 2012-Q2 2019



Source: ElectraLink

Whilst it is clear that the number of C&I generation sites is increasing, so is the overall electricity export from these locations. Figure 26 on the following page highlights C&I exports onto the distribution network from 2012 to Q1 2019 (defined as Profile Classes 5-8, and Class 0). Given these sites exported over 43TWh in 2018, and total exports onto the distribution networks were just over 45TWh in 2018, this highlights the limited levels of export from domestic and SME customers and likelihood that the majority of their generation is being self-consumed.

Figure 26: Exports from C&I locations in GB (profile classes 5-8), 2012 to Q1 2019 (kWh)



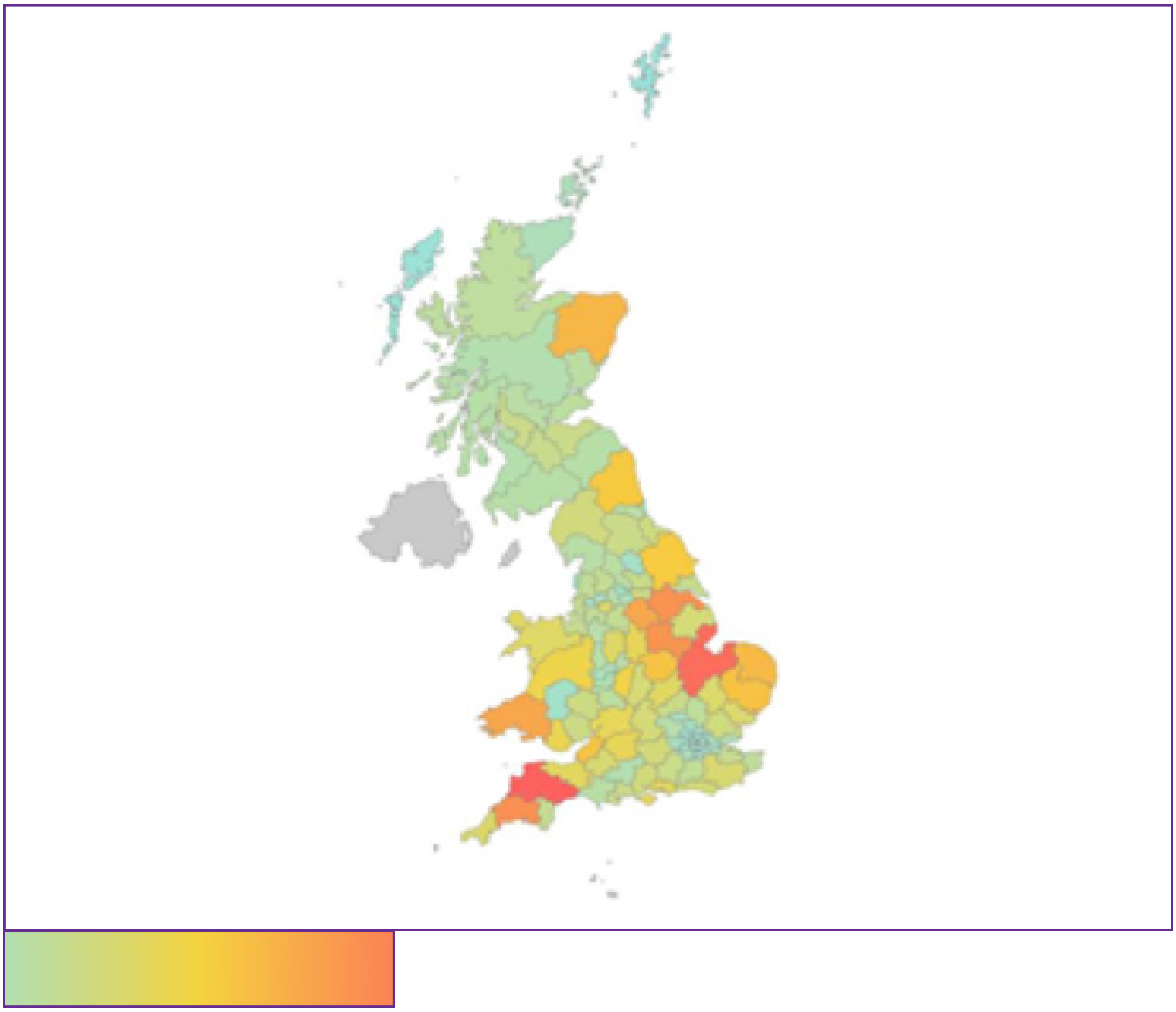
Source: ElectraLink

4.1.15 Regional distribution of embedded generation

The rise in distributed generation is not impacting all areas in GB evenly. Figure 27 visualises this, and in particularly identifies Cornwall, Norfolk, and Lincolnshire as being particularly high areas of deployment, according to the ElectraLink dataset. Exports in the south-west are understood to be largely due to solar PV deployment. Exports in the Norfolk and Lincolnshire areas are understood to be from onshore wind and the small amount of distribution-connected offshore wind. Note that this chart only covers grid connections at the distribution-level, and by GSP. Scotland seems to have low levels of distribution-connected generation which is counterintuitive. This may be explained by onshore wind in Scotland being connected at the transmission level, and some 50MW+ sites being registered as CVA (rather than SVA), which the DTS may not have sight of.

For further information relating to CVA and SVA site registrations, see Appendix 6.1.

Figure 27: Heat map distribution of embedded generation in GB (by GSP area)



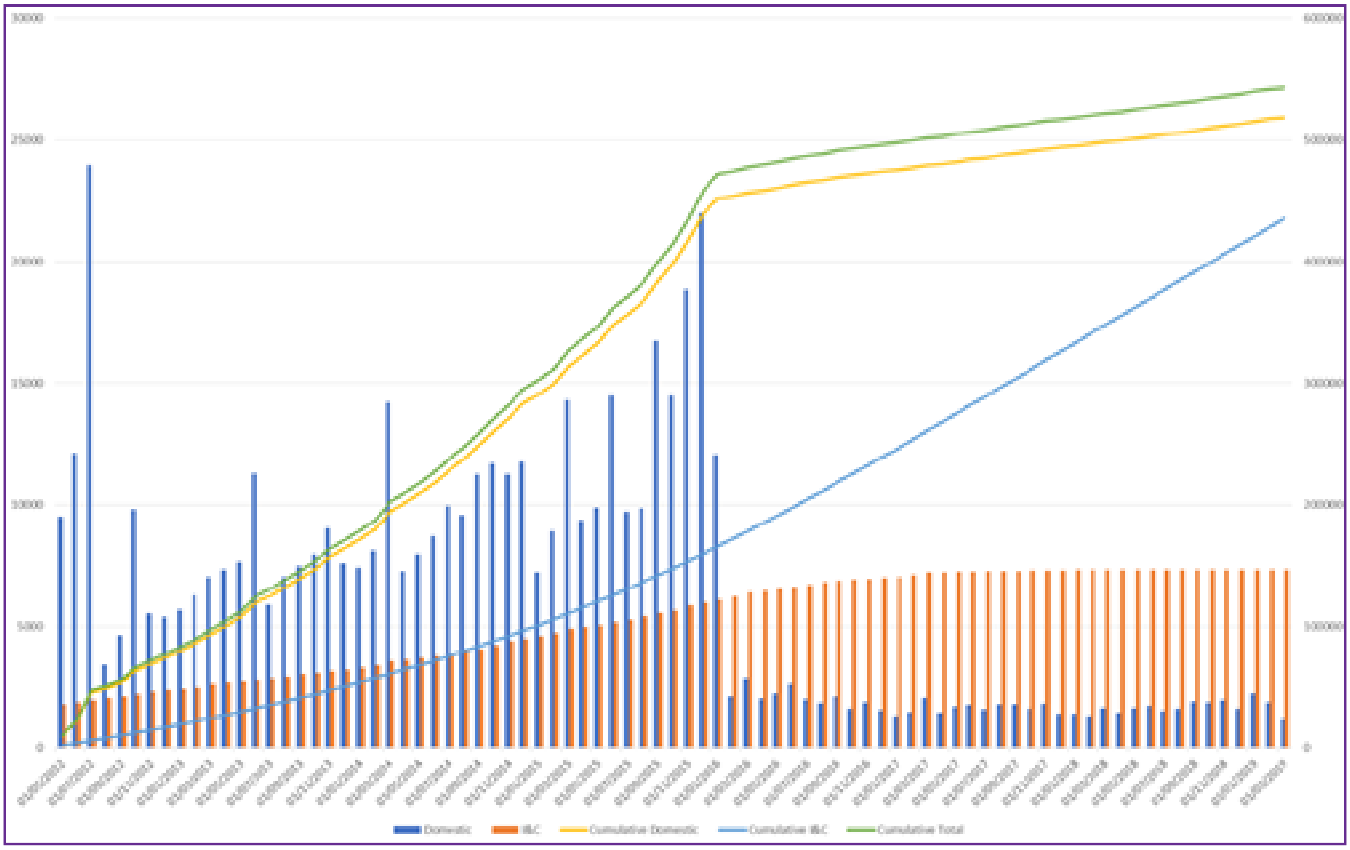
High (Red) is 130MW +, Medium (Yellow) is ~60MW, and Low (Blue) is 50MW and below

Source: ElectraLink

4.1.16 The role of policy in supporting deployment

Figure 28, below, starkly shows the extent to which supportive policy (though not necessarily subsidy) and market incentives are crucial for ensuring domestic, SME, and Commercial and Industrial (C&I) customers engage with self-generation and flexibility. The left axis shows number of installations related to the bar chart (monthly). On the right axis is the cumulative number of installations related to the lines. Domestic refers to LCT installations relating to the Feed-in Tariff, and the C&I line relates to other forms of embedded generation.

Figure 28: Deployment of LCT in domestic and C&I locations, by monthly installations and cumulative, May 2012 to March 2019.



Source: ElectraLink

REA Analysis: This chart clearly highlights the impact of policy changes relating to the Feed-in Tariff had on encouraging greater domestic deployment of LCT. As policies such as the Renewables Obligation and tax support were withdrawn, a similar trend can be seen for C&I generation deployment.

4.2 Proposing a new system for understanding flexibility customer types and analysis of the distributed flexibility market

4.2.1 Introduction

This section provides an introduction to power system flexibility and future needs, and the implications for the GB power system as more and more renewable and distributed energy generation sites become operational.

Over recent years, the power system has seen huge growth in distributed energy, especially renewables. But little is known about the characteristics of the customers that own or trade distributed energy demand, generation and storage, commonly known as distributed energy resources (DER). These could offer significant flexibility capability for the power system.

We will present and examine the actual data that ElectraLink has available for distribution connected customers. A market segmentation methodology has been developed to highlight the forms of engagement that these customers have demonstrated with the power system. We are seeking to assess the growth of distributed energy resources and their potential for providing flexibility services. Note that this analysis is informed by the ElectraLink dataset between 2013 to 2019.

4.2.2 Our approach

Our analysis of distributed energy resources has concentrated on the data that ElectraLink is able to collect from customer meters on the distribution system, to look at the levels of distributed energy resources that are available for flexibility purposes. This data has been collected by ElectraLink since 2012.

We have segmented the distributed energy market as follows:

Segment A – not engaged. This refers to the portion of the population with the least engagement with the electricity system, those who have not installed a low carbon technology nor switched suppliers since 2012.

Segment B – somewhat engaged. This portion of the population has switched supplier at least once since 2012 and has likely done so on the basis of price and/or service. This group has not adopted a renewable power supplier.

Segment C – green consumers. This group has adopted a green electricity supply tariff since 2012 and remains on one as of December 2018. As 100% renewable power tariffs are often marginally more expensive than non-renewable ones of a similar type,[39] this group are happy to pay a premium for a 'green' product and are engaged beyond just price. Our definitions here exclude customers on a 100% renewable power tariff offered by a supplier that does not exclusively offer 100% renewable power supplies.

Segment D – Low Carbon Technology (LCT) investors. This category distinguishes itself from those from Segments A and B, as those that have adopted a low-carbon electricity technology such as a solar PV system for their home or business.[40]

Segment E – green consumer and LCT investor ('Eco Engaged'). This category identifies those who both have a 100% renewable power supply tariff and a low-carbon technology. These 'early adopters' may be more likely to adopt other flexible energy technologies in the future.

Our hypothesis in defining these segments was that the data would show an increasing likelihood of customers participating in distribution flexibility services as they move 'up the scale' to greater uptake of green electricity and low carbon technologies. We expect, over time, that customers will move up the various segments if both the opportunity to participate and financial benefit from participating in flexibility services increases.

We consider that customers in segments D and E are the most likely to participate in flexibility services. They will have installed a Feed-in Tariff technology and have done so for a combination of engagement with the low-carbon agenda and for savings on their energy bill. It is also assumed that this group is a more likely target for future low-carbon technology deployment, e.g. an electric vehicle charger or an energy storage unit. This is borne out by responses to surveys in the energy storage sector (REA research) and research from Which? referenced in Chapter 2.

This assumption was supported largely by evidence from REA members but is being tested with the ElectraLink dataset. REA surveys of battery storage members indicate a perception that those with solar PV are much more likely to install a battery storage unit than those without PV.

The following sections describe the results for each of these market segments, but before doing so, there are a number of factors that may influence the results that should be taken into account. These include:

- As low carbon technology prices decline and marginal generation costs remain flat, they will become more attractive to consumers and be increasingly adopted on the basis of both their returns and their carbon-reducing qualities. This should increase the numbers in segments D and E.

- Post Feed-in Tariff and with the introduction of the Smart Export Guarantee, even with lower solar PV module prices, returns on exporting solar PV generation (the most common LCT) to the grid are likely to be lower into the early and mid-2020's than previously seen under the FIT. This creates a greater incentive for self-consumption, likely through the adoption of a battery storage unit. This may impact segments D and E.

- 'Bundled' products will become increasingly common and offered by a range of market actors. For example, a supplier (domestic or corporate) may offer hardware such as an EV charger or battery along with a tariff. Automotive manufacturers may also offer low-carbon flexible energy technologies along with the purchase of a vehicle.[41] This may increase the numbers in segments D and E.

- The model at present only includes Feed-in Tariff supported technologies and other forms of embedded-generation. Future work will need to be done to include those with electric vehicle chargers. To more easily track trends, a register of non-Feed-in Tariff supported renewable power technologies should be created as more and more LCT's are deployed in the early to mid-2020s without a subsidy. The inclusion of these additional LCT's could result in an increase in the numbers in segments D and E.

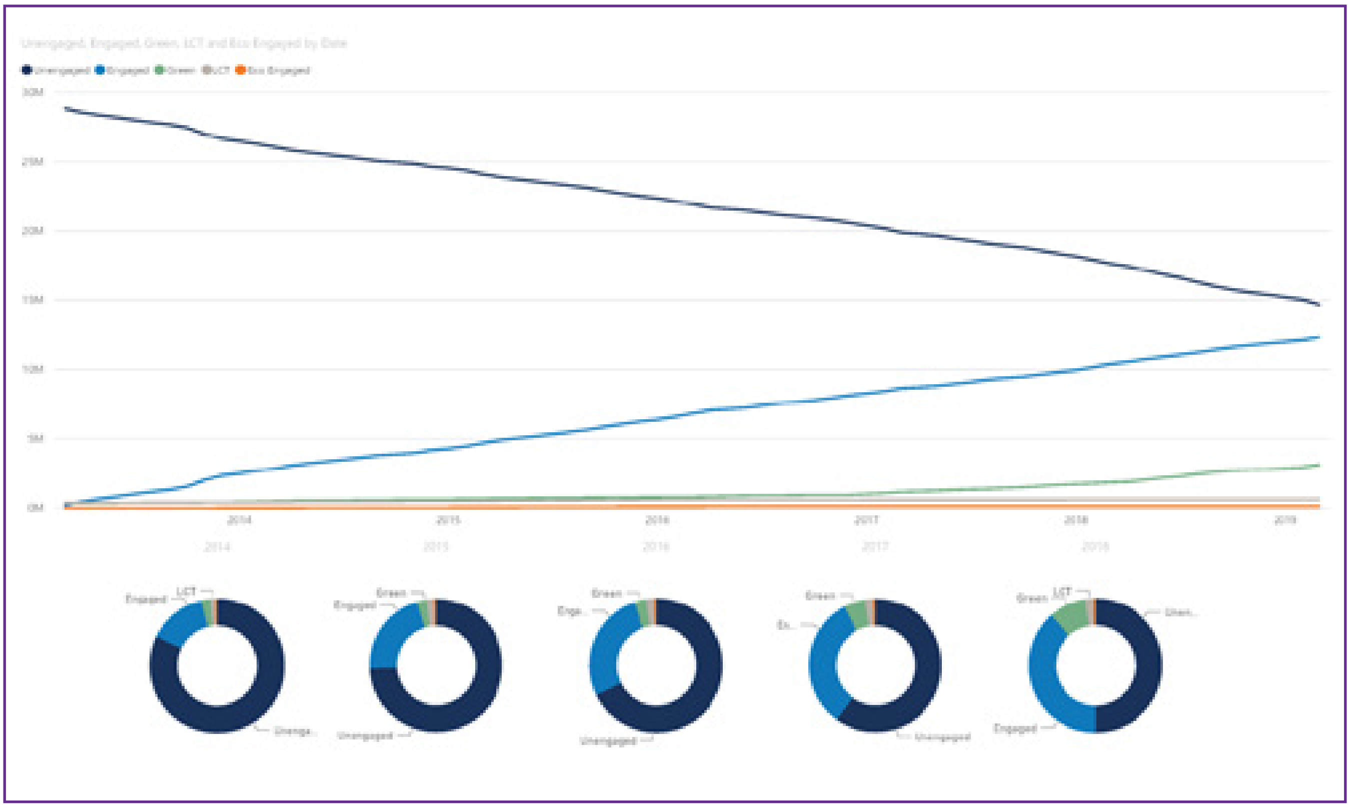
- Renewable / Green power supply covers those companies where all their tariffs are '100% renewable power'. Those companies that achieve this through the purchase of Renewable Energy Generation Obligation (REGO) certificates compared to those who either self-generate or secure their power directly through Power Purchase Agreements (PPAs) with renewable power generation sites are all assumed to be 100% renewable (see note on REGOs – 2.8.1)
- The model includes all MPANs covering profile classes 1-8 [42]

4.2.3 Market analysis

a) Overview of segments A to E

The following chart (Figure 29) sets out the data from 2013 for the five market segments described above, based on all the GB MPANs. The vertical axis shows the number of distribution consumers for each segment.

Figure 29: Overall MPANs, flexibility customer types (segments A-E) (by number of MPANs and with proportional visualisation)



Source: ElectraLink

The key features that may be observed from this chart include:

- **Segment A – disengaged consumers.** This shows that almost 50% of consumers have not switched supplier at all since 2012. However, this number is steadily decreasing and may accelerate with the continuation of the smart meter rollout and other measures to increase retail competition.

- **Segment B – somewhat engaged consumers.** This is the converse of segment A and shows that nearly 50% of consumers have switched at least once since 2012. Again, this is increasing steadily and may be expected to accelerate with smart meter rollout, and retail competition.

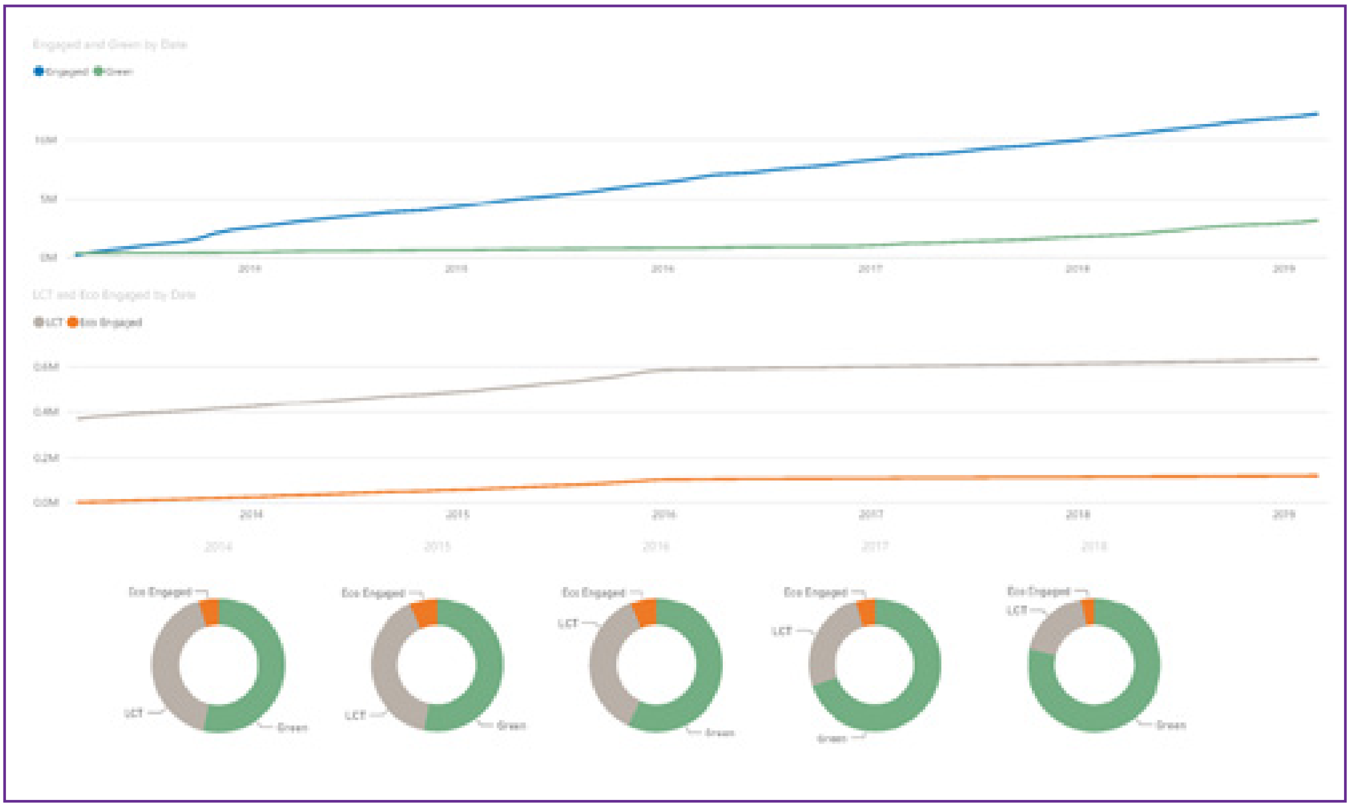
  This figure is higher than other industry estimates of engaged customers at about 30% because it includes not only customers who have switched multiple times but also those who have switched just once.

- **Segment C – green consumers.** This segment has grown slowly between 2012 and 2017, reaching around 1 million customers by 2017. Since 2017, the growth rate has increased and now comprises around 3 million consumers. Some of these results may have also been influenced by the overnight move by two large suppliers to being a 100% renewable electricity provider through the purchase of REGOs.

- **Segments D (LCT investor) and E ('Eco-Engaged')** have grown at much lower levels than segments B and C. These segments are examined in more detail below.

Overall, this chart illustrates the growth of competition in the energy market as the proportion of completely unengaged customers has fallen steadily to around 50% - a considerable shift. It also shows that the number of consumers choosing a green tariff has increased significantly.

Figure 30: Overall MPANs, flexibility customer types (segments B-C and segments D-E) (by MPAN and by proportions)



Source: ElectraLink

The above charts examine whether the growth in green tariffs is consistent with the growth in somewhat engaged customers and look at the profiles of Segments D (LCT investor) and E ('Eco-Engaged').

Turning first to the link between 'somewhat engaged' customers and 'green consumers'; since around 2017 these do seem to have been increasing at a similar rate, with green consumers forming around 25% of all engaged consumers. This would appear to indicate a consistent customer interest in green energy supply, alongside other factors such as price and quality of service.

With regard to the growth of LCT investors and the 'Eco-Engaged', the following observations may be made:

- **Segment D – LCT investors.** This segment has reached 600,000 customers by 2019, with most of the growth taking place prior to 2016 when higher Feed-in Tariffs were available. Growth has been very slow since then

- **Segment E – green consumers and LCT investors ('Eco-engaged').** This segment has only reached 100,000 customers by 2019. It exhibits a similar profile to LCT investors, again reflecting the availability of Feed-in Tariffs.

Overall, it appears that around a quarter of engaged customers are taking up green tariffs and this has been relatively constant for the last three years. However, the growth in LCT investors appears to be more directly linked to the availability of subsidies and financial returns, and is not growing as quickly. Only around 15% of LCT investors also have green tariffs.

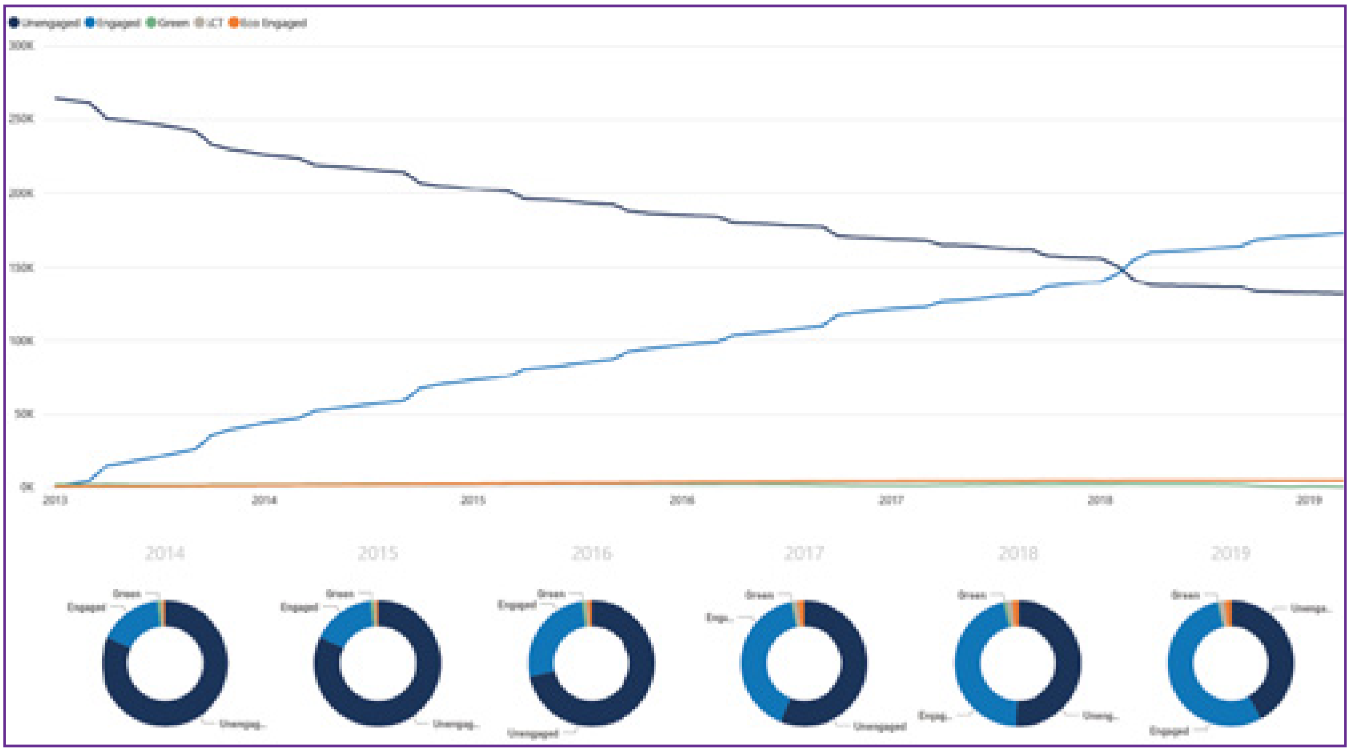
Overall, this analysis would appear to indicate that there is a growing appetite for consumers to become involved in decarbonisation through green tariffs, but that investment in low carbon technologies is largely driven by the financial returns. However, if flexibility services can provide a return then there is a growing group of consumers that could provide a valuable resource for the market.

The above charts have considered all distribution customers – the following analysis goes on to examine if there are any differences in the Commercial & Industrial sector.

4.2.4 5 Flexibility Customer Types focusing on Commercial and Industrial sites

Given the size of energy loads in C&I sites, the REA and ElectraLink chose to specifically focus the 5 Flexibility Customer Types model on C&I (Types 5-8) MPANs. For a full analysis of how this model was built, see Appendix 6.1.

Figure 31: C&I MPANs, five flexibility customer types (2013 – March 2019) (segments A-D, line chart and by annual proportion).

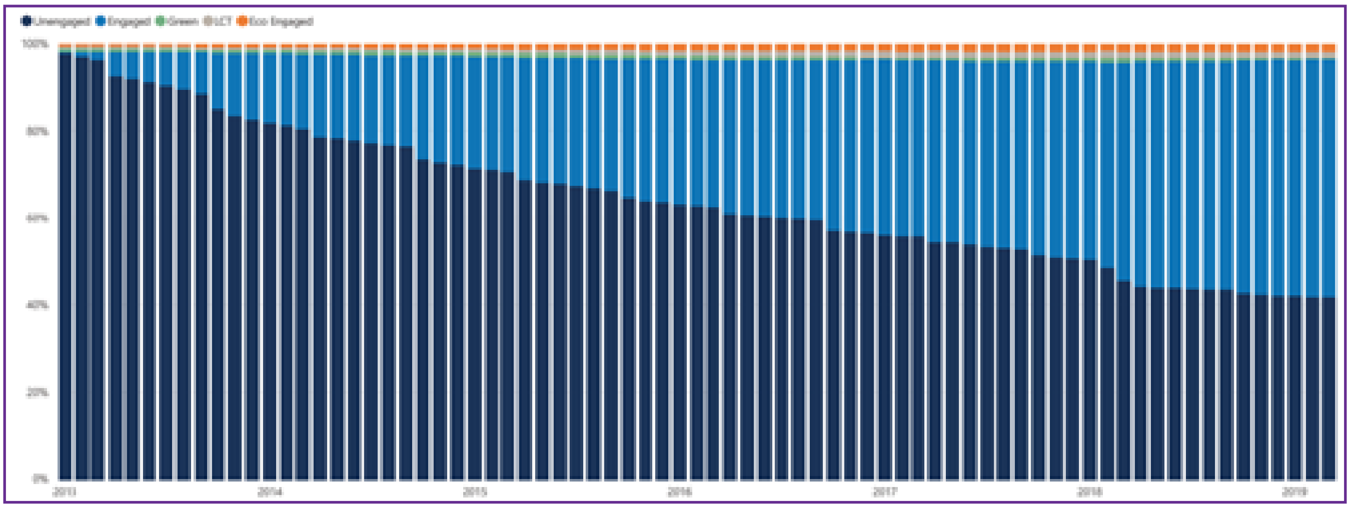


Source: ElectraLink

Figure 31 above highlights how C&I engagement with the switching agenda is steadily improving. However, the adoption of LCT through a Feed-in Tariff or another scheme remains extremely low. Last year for the first time 'engaged' became the largest category.

Figure 32 on the following page displays the proportional change between the categories and emphasises this trend, this is important to highlight as over time above 40,000 C&I meters have been connected to the SVA network. This allows us to compare the 5 types against the same metric as time goes by.

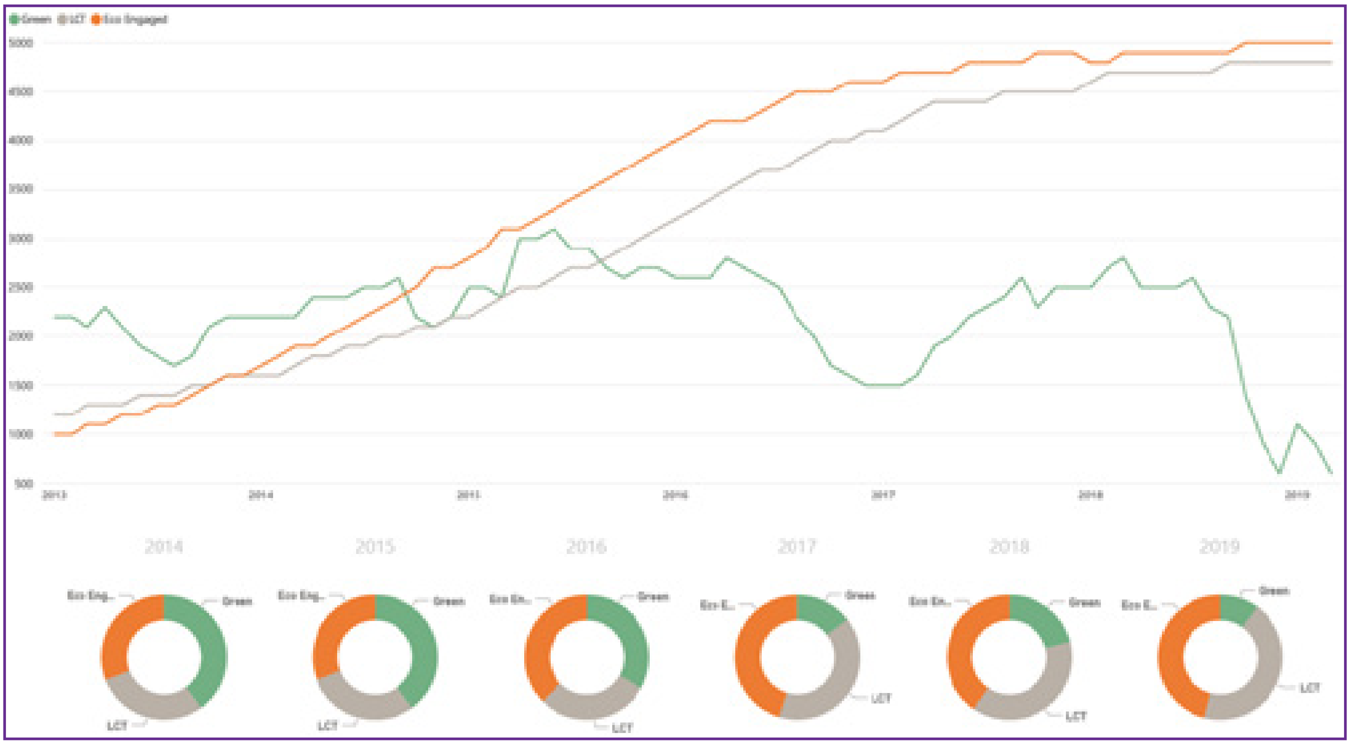
Figure 32: C&I MPANs, five flexibility customer types (2013 – March 2019) (segments A-D, annual proportional change).



Source: ElectraLink

Useful trends can be identified, however, by focusing on those sites that are engaging with LCT and green tariffs. Figure 33 below focuses on these customers.

Figure 33: C&I MPANs, five flexibility customer types (2013-March 2019) (focus on green, LCT investors, and 'Eco-Engaged') (line chart and by proportion)



Source: ElectraLink

Figure 33 shows a slow increase in categories D and E (LCT investor and 'Eco Engaged') even after subsidies have been curtailed or ceased. The growth in C&I LCT, and therefore also flexibility potential, is growing faster than the domestic sector. While the level of C&I green consumers only appears quite volatile, our supporting analysis also shows a majority of categories D and E (i.e. C&I low carbon technology) were initially connected through a green supplier. This may be due to green C&I suppliers explicitly concentrating on tariffs that support LCT.

This appears to indicate that there is a progression for a number of C&I customers to migrate from a green tariff to installing low carbon technology. If this is the case, then the level of C&I customers on a green tariff may be a useful leading indicator for the take-up of distributed low carbon technologies. If there were to be a direct correlation, then the drop of customers on these green tariffs in 2019 may indicate a future fall in take up of distributed LCT and flexible technologies.

REA View: Whilst there is not a clear correlation between green supply and LCT deployment for the overall population, (although this is influenced by the REGO issue) it is encouraging to see that there appears to be a relationship between C&I sites, the adoption of a green supply, and the subsequent likelihood of deploying an LCT (and by extension possible flexibility product in the future). As C&I sites are more likely to have a dedicated energy manager or other staff tasked with managing energy costs, and such sites likely have higher energy demands than domestic or SME locations, it makes sense that this would be the first area for us to find such a correlation.

With the green tariff, LCT deployment, and C&I link established, and given the trend towards energy suppliers to offer 'bundled' green products to domestic customers, we may see a similar green tariff, LCT, and in the future flexible energy technology deployment in domestic settings borne out in the data in the future.

4.2.5 Flexibility customer types – findings

As outlined earlier in this report, flexibility will need to play a crucial role in supporting the continued decarbonisation of the electricity system. The growth of flexibility needs can introduce new business opportunities and new products for consumers to engage with. Understanding how customers are engaging with this system is therefore of crucial value to the industry and to policymakers.

This report has used a new methodology for understanding the types of customers in this new energy system. It examines five different levels of engagement with a flexible energy system. We believe that if a common language is developed businesses and investors will be better able to understand the changes the market is going through and policy makers will be better able to target interventions that encourage flexibility and choice at different consumer types.

The key findings from our analysis of these five market segments are:

- Customer engagement with the energy sector is deepening, with around 50% of consumers having switched at least once since 2012
- Of these c. 12m customers who have switched, around 5.2 million have chosen a 'green supplier' at least once since 2012, with over 3 million presently 100% renewable supplier. The increase in green tariff customers seems to be running at the same pace as wider engagement
- The number of customers investing in low carbon technology has been relatively flat since 2017 when subsidies were removed
- The adoption of a green tariff can be a leading indicator of LCT, and by extension flexibility, adoption at commercial and industrial sites
- However, for the overall population despite significant growth in customers engaging in decarbonisation through green tariffs, there seems to be little evidence of a linkage between customers choosing a green tariff and then investing in LCT. This may be due to the data being somewhat influenced by large suppliers switching existing customers to REGO backed tariffs overnight

While many industry participants recognise the current revolution to a decentralised, digitised and decarbonised electricity sector, there is little evidence from the above analysis that the customers most likely to participate in flexibility services are currently doing so. This is despite the huge potential for distributed energy resources to provide flexibility services.

For example, there are currently some 3 million customers that are on 'green' electricity tariffs. If one third of these consumers were to engage further by engaging with flexibility services, for example by installing a 4kW battery at home, then this could offer 4GW of flexibility capacity to the power system. Based on the current green tariff growth profile, this level could double by 2025 to 8GW or more.

But our research shows that LCT installation is not currently growing at this rate. This is likely to be due to a number of barriers faced by customers, including:

- High cost of flexibility assets
- Lack of investment capital
- The absence of accessible and effective markets for trading small scale flexibility services
- The time and effort required to understand and navigate these markets
- The risk of low or no returns on investment

If the huge potential for distributed flexibility resources is to be realised, then these barriers must be addressed. Some will be improved through technology developments, falling equipment costs, and new business models. Others will require regulatory and market changes. Once these barriers are removed, then customers will be able to realise both financial and decarbonisation benefits from participating in flexibility markets. Subsidies should not be required and competition can determine the best value solutions.

The analytical approach that REA and ElectraLink have developed will allow progress of these distributed flexibility resources to be monitored as they emerge.

Further research can be done on these customer types, for example by specifically looking at profile Classes 1-4, or by pulling out MPANs that are purely buildings (as opposed to standalone generation sites) from the commercial and industrial profile Classes 5-8.

5. Conclusions and Recommendations

This report has used ElectraLink data relating to switching, smart meters, and exports onto the distribution networks to try and identify key trends, customer types for flexibility products, and assess the extent of the flexibility market to date.

Overall, the report concludes that the built environment represents a significant and largely untapped generation and flexibility resource, which should be urgently developed.

The report identifies that whilst there is increasing engagement with the power sector, evidenced in increased switching, and the system is becoming somewhat more flexible, evidenced by increasing deployment of battery storage, clear market-based incentives for homes and businesses are needed if they are to install and deploy the flexible energy technologies needed to ensure Great Britain decarbonises in line with Net Zero commitments. Specific conclusions include:

Energy supply switching:

- Three million people are now on a '100% renewable' electricity supply tariff (please see our explanatory note on REA & ElectraLink definitions relating to this), which represents around 25% of 'engaged' customers
- The proportion of green customers (on a 100% renewable electricity supply) is rising, showing greater public awareness and engagement with the green agenda
- Between May 2012 and March 2019, 5.2 million premises have at some point been on a green electricity supply
- Over 16 million premises have switched energy suppliers at least once May 2012

Generation:

- 45TWh generation was exported onto the distribution network in 2018, double that of 2012
- 39.8TWh of the total 45TWh exported is from renewable sources, ranging from wind to waste-to-energy
- The proportion of variable generation (compared to dispatchable generation) is increasing
- Policy has a clear impact on generation trends and the reduction in policy support for renewable generation from 2015-2018 is clearly discernible from the data
- A considerable and growing amount of fossil generation exists on the distribution network
- The active involvement of C&I locations in the energy system is increasing, evidenced in their increasing contribution of electricity exports onto the networks
- Significantly more embedded generation can be expected in the 2020's if the UK is to be on track to meet Net Zero targets

Five Flexibility Customer types:

- Battery developers are targeting those already with solar photovoltaics (PV) technology, and those with solar PV are more interested in taking up a flexibility technology such as a battery
- New structures for understanding customer types are needed in order to engage the public in flexibility products and services
- For the C&I sector, adoption of a '100% renewable electricity' supply tariff may be a leading indicator of future low-carbon and flexibility technology adoption
- For the general population there is not a clear correlation between increased engagement with the electricity sector (evidenced by switching rates and adoption of green tariffs) and the adoption of a low-carbon technology. However, this finding is influenced by the millions of consumers automatically switched to 'renewable' (REGO) supplies by their supplier, rather than choosing to switch themselves
- Stalled small-scale low carbon technology deployment (LCT) following changes to the Feed-in Tariff indicate that there needs to be a clear financial case for people to install an LCT, and by extension storage / flexible energy technologies. The proportion that will do this regardless of policy (e.g. on green merits alone) is quite small.

Only a stable, mature policy and regulatory framework that supports flexibility, alongside technologies at the right price, will enable the widespread growth of the future low-carbon energy system we require. Onsite generation is limited in its present scope, and engagement with flexibility provision even more so, and policy needs to emerge to support these sectors.

The Smart Systems and Flexibility Plan created the much needed ground work for how to start to achieve this, and this needs to continue to progress, with a greater emphasis on the timelines involved. As such, a follow up roadmap to 2040 could be produced, with interim targets for 2025 (when coal will be completely off the system), 2030, and 2035 – to give investors and developers more certainty and visibility on the future market development.

Other recommended policy changes to encourage flexibility include:

- Further research is needed to look at customers with a larger load profile such as C&I sites (and by extension possibility for greater flexibility services engagement than a typical domestic customer) to understand their emerging behaviour. If a strong correlation between green tariffs and LCT deployment can be replicated, a targeted campaign at C&I sites to 'go green' is recommended

- A dedicated definition for energy storage in primary UK Legislation, to smooth out a number of issues regarding grid charges, planning, and regulatory treatment of storage devices

- Ensure a level playing field with diesel generator and gas peaker plants and continue to implement progressive emissions thresholds in future Capacity Market auctions

- Ofgem should revisit the damaging proposed grid charging changes, specifically the Targeted Charging Review (TCR) which would act as a considerable disincentive to flexibility, while ensuring that the Access and Forward-looking charges review introduces adequate flexibilty incentives

- Ensure the roll out of regional Distributed System Operator (DSO) flexibility markets nationwide, following the pathfinder Power Potential project

- Government or other funding for best practice documentation and the development of industry standards, is necessary to develop the market

- A single asset registry is required for the post Feed-in Tariff/post electricity 'subsidy' world, in order to track installations and net generation in one central location

- Continue progress on simplified planning regimes for energy storage, EV charging and other flexibility assets - again this could be aided by a definition for energy storage in primary legislation

- Continue the progress to enable Half Hourly Settlement and encourage suitable sites to opt in (with any wider roll out the subject of more detailed discussions in due course)
- DNOs should adopt proposals to allow energy storage projects to move 'up the grid connections queue' and therefore free up capacity for other generation projects while avoiding or delaying network overhead line upgrades
- Continue to legislate to ensure EV chargers are all smart and genuinely interoperable in their nature, allowing them to participate in dynamic pricing markets best able to shift consumer behaviour to benefit the system
- Standardise flexibility products and reduce barriers to product entry akin to the 'Nord Pool' model in Norway
- Government could offer interest-free loans for domestic solar and storage installations, akin to those introduced in Scotland
- Create transparent flexibility markets, akin to Nord Pool

We hope that these data and conclusions constructively add to the discussion about Net Zero in the UK, and the role flexibility, decentralised renewable power generation, and the distribution networks need to play for us to achieve it.

6. Appendix

6.1 Methodology – about ElectraLink and determining the data as seen in Chapter 4

About ElectraLink overall

ElectraLink was created in 1998 by the energy industry to provide an independent, secure and low-cost service to transfer data between the participants in the deregulated GB electricity market. This resulted in the formation of the Data Transfer Service (DTS).

The DTS is a regulated service owned by the energy industry, for the benefit of the energy industry. It is used to share essential business process data on a 24/7/365 basis by over 270 electricity and gas parties across Great Britain. The DTS underpins the competitive UK energy market, enabling participants to work together to exchange information about customers. This information interchange facilitates a wide range of business-critical processes including how energy is paid for by suppliers (settlement), change of supplier and metering. In 2012, ElectraLink was granted permission to access the data that is transferred across the DTS under the governance of the Data Transfer Services Agreement (DTSA) to monitor and identify trends in the energy market, improve transparency and provide insight into the challenges and opportunities faced by the industry.

The data ElectraLink holds is based on billions of messages flowing across the DTS that require significant data processing in order to organise the data and leverage its value for the industry. Industry processes are mapped and refined into datasets by ElectraLink to provide clear analysis on industry process activities at a meter point (associated with an address) level. These processes include (but are not limited to) switching supplier, registering energy consumption (including Supplier Volume Allocation (SVA) registered generation) and managing site activities such as meter installations and site visits. ElectraLink is the only central source that has access to the data flows that underpin these processes.

Switching – as described in Chapter 2

ElectraLink has a full view of every flow associated with the energy supplier switching process, which are transmitted across the DTS. This starts with the D0055, the flow that the new supplier registers with the Meter Point Administration Service (MPAS) to request the ownership of the meter. ElectraLink captures and processes every D0055 sent (as well as all the other flows associated with the process). After this flow has been sent and the Change of Supplier process has been instigated, a series of industry processes are also captured through the transmission of data flows across the DTS. These include the rejection of a registration request by MPAS and objection by the previous supplier, as well as the rare occurrence whereby the incoming supplier cancels the registration attempt. 100% of these flows pass across the ElectraLink network. By processing these files in the agreed industry methodology, ElectraLink has a view of all the meters that have switched supplier since 2012.

In addition to this, for those meters that have not switched since 2012, ElectraLink also process industry data flows including the D0030 (Aggregated DUoS Report), D0041 (Supplier Purchase Matrix Data File) and D0036 (Validated Half Hourly Advances for Inclusion in Aggregated Supplier Matrix) and D0081 Supplier Half Hourly Demand Report. Using these flows ElectraLink is able to monitor every switch, as well as the market share of all suppliers in the market, to capture those that have not switched. This enables ElectraLink to identify switching and customer behaviour at the most granular level, and accurately track changes from 2012 to the present day.

Embedded Generation – as described in Chapter 4

ElectraLink process all the D0036 and D0275s (Half Hourly consumption values for use in Supplier and Distributor billing) that transfer across the DTS for SVA settlement purposes. The sites identified in the analysis will be SVA connected generating sites and not the larger Central Volume Allocation (CVA) connected generating sites. These SVA sites are collectively known as "embedded generation" sites as they are connected to the distribution network. The data flows associated with these sites register the energy that large SME and I&C sites consume and generate at a half-hourly level. These sites are connected below a 132,000V Voltage level and have a capacity of up to 50MW. For embedded generation, the settlement process and the flows that ElectraLink can monitor ensure that generation is considered in settlement and the generator can get paid.

ElectraLink processes this data in line with settlement processes to create a dataset for each MPAN, for each half hour. ElectraLink has also matched each MPAN to its generating type. ElectraLink has completed this in line with the publicly available data (informed by Ofgem's Renewable Obligation Register, Capacity Market Registers from EMR Settlement, and BEIS' Renewable Energy Planning Database), a team of analysts using Google maps to identify the generation type, where possible, and finally, using machine learning algorithms to match generating patterns with already matched sites to match the unknown sites. This has enabled ElectraLink to type 96% of all generated energy within its dataset. ElectraLink does not have visibility of CVA connected sites as the data associated with this is not passed across its network.

Five Customer Types – as described in Chapter 4

ElectraLink has worked with the REA to identify a new categorisation of customer, based on ElectraLink's unique data set and using data collected for unique MPANs (note differentiation between unique customers and unique MPANs)

ElectraLink has considered five types of customer in this matrix.

1. Unengaged Consumers. There are several definitions of unengaged customer. ElectraLink has taken a view in line with the data that it holds that an unengaged customer is someone that has not switched since ElectraLink began processing and analysing data flows in April 2012. ElectraLink has access to all market shares of every supplier at this point as well as all the switches since this point (as well as a small percentage of new connections), to identify when customers become engaged (first time switching).

2. Somewhat Engaged Consumers. These are customers that are not captured by any of the other remaining three customer types (green/LCT/Eco) and have switched more than once since 2012. ElectraLink understands that the industry and Ofgem have other views on engaged. ElectraLink has taken this view as it is the in line with the data it collects. ElectraLink does not have access to tariff data where we might be able to identify customers who remain on Standard Variable Tariffs (SVTs) or switch tariffs with the same supplier.

3. Green Consumers. These are customers who are registered with a supplier that identifies as 100% green, meaning it is a supplier of 100% renewable electricity. This does not include suppliers that offer a mixture of green and non-green tariffs (such as OVO Energy).

4. LCT Investors. ElectraLink has used the data within the embedded generation dataset and FIT register to match (where the data supports it) LCT customers that are not with an 100% green energy supplier. We then fuzzy matched the data against our switching and metering data to identify customers that have a registered LCT and are highly unlikely to be supplied by a green supplier. Fuzzy matching refers to a situation where the data is not 100% matched, but matched to a degree of accuracy that is sufficient for the analysis based on other factors.

5. Green Consumers and Investors ('Eco-Engaged'). ElectraLink has used the data within the embedded generation dataset and FIT register to match (where the data supports it) LCT customers that are being supplied by a 100% green energy supplier.
Electralink then fuzzy matched the data against their switching and metering data to identify customers that have a registered LCT are highly likely to be supplied by a green supplier.

Five Customer Types – Commercial and Industrial Sites.

ElectraLink has a record of every switch and new meter connected to the grid since 2012. To identify the fact that a meter is an C&I meter ElectraLink used the industry standards of profile class and HH metering. The industry considers PC1-2 as domestic, PC3-4 as SME and PC5-8 (Which is increasingly HH metered) as well as true HH meters as C&I. Using switching, consumption and generation data transferred across the DTS and combining this with the C&I meters identified using profile class information on the DTS.

Over time ElectraLink tracked the characteristics of each meter and began graphing the changing behaviour of the C&I market in relation to the 5 flexibility types that were identified. As can be identified, we can see that being supplied by a "green" only supplier declined at a far greater rate than in the domestic market. This was of interest. So we asked ElectraLink to build a few additional models. One model identified a trend that we didn't initially predict. Working with newly connected meters since 2012 we reviewed how many were connected by green suppliers vs how many were connected by non green. We identified that the reason for the large percentage of LCT technology in the C&I sector being supplied by a green supplier was due to the fact that over 50% of the newly connected green technologies were initially connected by a green supplier. Given the relative market shares of green suppliers vs non-green suppliers this helped us conclude that the growth in C&I LCT and flexibility is being led by green suppliers and that a business looking into flexibility or LCT is more likely to choose a Green supplier to connect and supply them. This is worthy of additional investigation to find out the reasons for this in future studies.

6.2 REA Energy Storage Survey Methodology

In February to May 2019 the REA conducted a survey of members and non-member companies operating in the UK energy storage market as a project developer, manufacturer, or energy supplier. The anonymous survey was the third such survey run by the REA, and asked questions pertaining to market trends, regulation, and deployment levels. The survey was confidential and anonymised results inform this report.

6.3 Electricity generation technologies on the distribution network

Below is a short overview of some of the key technologies that will be important to the UK meeting it's Net Zero targets and trends impacting them, the main non-renewable sources are also discussed.

6.3.1 Solar PV

Globally, module prices for solar PV continue to fall. Specifically in Europe, the REA understands there to be particularly sharp cost declines as Chinese modules are redirected following the USA's introduction of minimum import prices on Chinese modules, and the European Commission's 2018 removal of such a policy.

The British large-scale solar sector, recently dormant domestically and focused on projects abroad, is beginning to re-hire and 2020 could be a significant year for the emergence of standalone subsidy-free large scale solar, often complemented with battery storage. Many existing solar and wind project owners are also in the process of installing batteries and other forms of storage alongside their existing renewable power assets.

The timing and scale of uptake, however, depend on what decisions will be made on a series of proposals from the energy regulator Ofgem for new costs to connect to, and use, the grid.

A September 2019 report from Aurora Energy Research highlights these themes. It outlines that subject to forthcoming changes in grid charging, and given cost declines in solar PV and battery storage, a new era of subsidy-free solar (particularly those projects co-located with battery storage) will emerge in the early 2020s.[43]

The further deployment of small-scale domestic and commercial solar has also been in a period of hiatus. Cuts to the Feed-in Tariff (FIT), which paid small-scale generators for the power they produced and exported, largely stalled deployment from 2016. The scheme closed entirely in April 2019.

The re-emergence of small-scale renewables, such as solar PV, will be linked to the roll-out of the Smart Export Guarantee (SEG) – a policy designed to replace the Feed-in Tariff (FIT) by placing an obligation on energy suppliers to pay those homes and businesses who export their own power. Whilst there is no minimum price for power that suppliers are obligated to offer, multiple suppliers have already announced or actively rolled out tariffs. The policy will be in place from 1st January 2020 but is much less attractive to generators than the FIT.

6.3.2 Wind (Onshore and Offshore)

Onshore wind, despite its promise as a low-cost and near zero-carbon generation technology, presently faces significant barriers. However, in the medium to long term with supportive policy, it is expected to form a significant portion of new generation. Onshore wind represented a quarter of all renewable power generation in 2018 (CITE DUKES). Since 2015, planning rule changes and exclusion of the technology from Government Contracts-for-Difference (CfD) auctions all but halted new deployment.

A 2019 report from Vivid Economics, commissioned by RenewableUK, indicates that the deployment of onshore wind instead of gas could reduce electricity costs by 7% by 2035. As of the 2017 general election, all the main political parties except for the Conservatives were in favour of reversing the 'onshore wind ban'.[44]

Offshore wind is also expected to make a significant and growing contribution to new low-carbon generation capacity but as most new capacity is transmission-connected, discussion and analysis of it is largely excluded from this report.

6.3.3 Bioenergy

Renewable forms of bioenergy are also expected to see further deployment. Whilst there is no major policy so far post 2021 for the decarbonisation of heat (a major driver for many such plants), the UK has built out over 400 biogas plants, many of which are combined heat and power units. Partly following China's dramatic waste import ban in early 2019, there is a continued interest by developers and financiers in high-efficiency waste-to-energy plants. The REA's 2019 Bioenergy Strategy demonstrated industry commitment to building out such technologies.[45] It has provided a pathway for the UK to produce 16% of energy demand from bioenergy sources, which is crucial as the nuclear development pipeline declines.

6.3.4 Deep Geothermal Power

The UK is also developing its first deep geothermal power station in Cornwall with support from the European Regional Development Fund.[46] If economic feasibility for deep geothermal power can be demonstrated in the UK, the REA expects several new projects to go ahead (which will also likely be distribution-network connected). A 2013 report commissioned by the REA indicated that up to 20% of UK power could be sourced from deep geothermal generators with a supportive policy framework,[47] and the kind of early-stage demonstration funding now provided by the EU.

6.3.5 Wave and Tidal generation

Wave and tidal generation are arguably the 'missing piece' in UK generation at present - offering considerable benefits from a dispatchable, baseload generation profile for tidal power, through to Industrial Strategy jobs and investment as the UK currently has a leadership position in the technologies. One such example is SIMEC Atlantis's Meygen project in Scotland, which has now exported multi GWh of generation and is the first project of its kind to do so.

6.3.6 Non-renewables on the distribution network

Non-renewable generation sources connected to the distribution networks include fossil generation from coal-bed methane, diesel, and gas (including CHP).

The deployment of diesel generation sets is significant. There has been much public concern, borne out in publications such as The Guardian (see Figure 34), around the Government effectively procuring new fossil generation capacity via the Capacity Market as the emission levels linked with the market rules are too loose to negate fossil fuel participation.

Figure 34: Headline from The Guardian, 17 October 2019

Diesel farms set to win lucrative contracts to back up National Grid

Deals worth millions of pounds to help keep UK's lights on over 15-year period spark anger among environmental groups

▲ The diesel farms will be on standby in case there is a shortfall from electricity power sources such as coal, gas or wind. Photograph: Andrew Milligan/PA

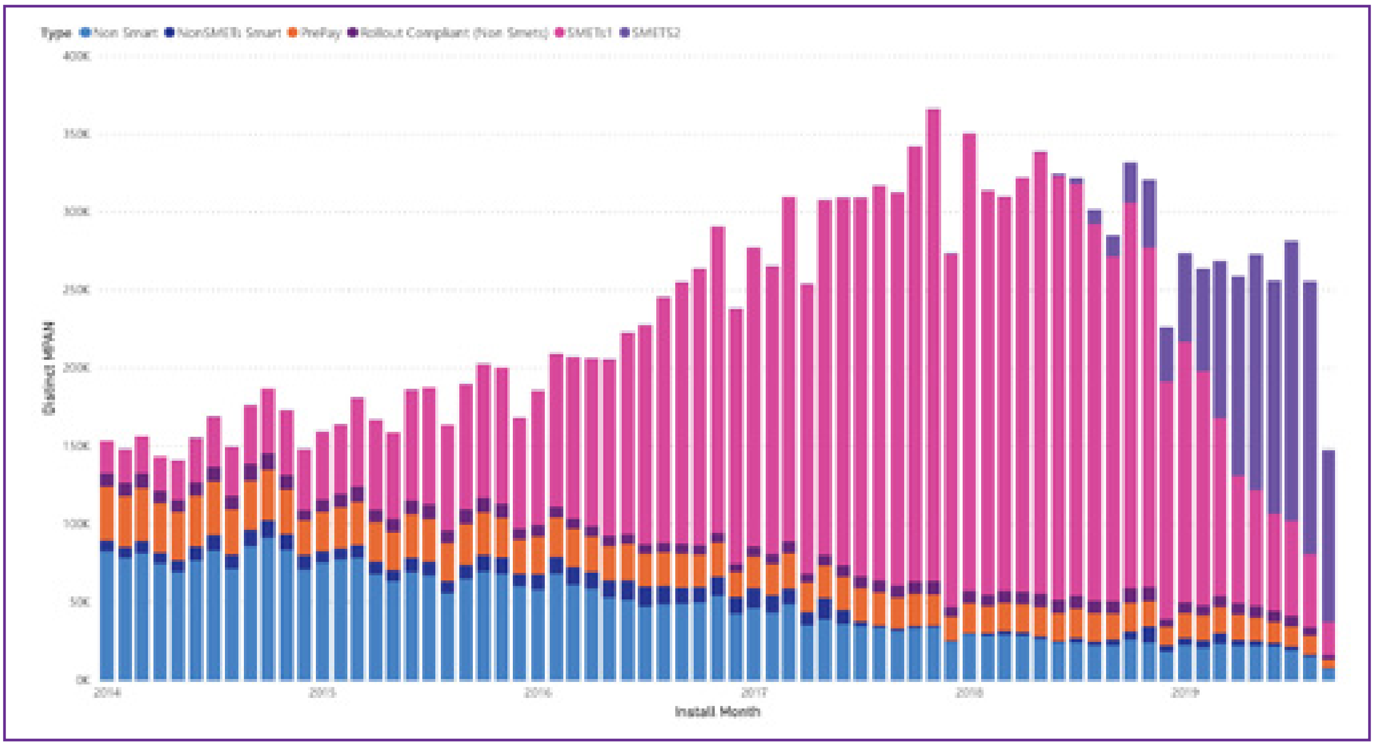
Source: The Guardian, 2016 [48]

This is important as it shows the value of dispatchable generation (implying it is more able to respond to supply and demand trends) and rising concern about its comparative decline in relation to other forms of generation. To meet Net Zero targets, however, the procurement and deployment of diesel will need to be curtailed via emissions limits in favour of other technologies that can provide flexibility, such as energy storage and demand-response.

6.4 A note on smart meter deployment

The deployment of smart meters by type is visualised in Figure 35 below.

Figure 35: deployment of smart meters in GB based on meter type, 2014–2019



Source: ElectraLink

Whilst increasing deployment of the more-enabled SMETS 2 meters may be welcome, the plateauing deployment overall needs to be significantly corrected if we are to respond to a system that delivers more price-reflective, and more flexible, tariffs and product offerings nationwide.

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