piclo®

Energy On Trial

Piloting a flexibility marketplace to upgrade our energy system

Supported by

Department for Business, Energy & Industrial Strategy

Preface

This report has been produced by Piclo as part of a project for the Department of Business, Energy and Industrial Strategy's (BEIS) Energy Entrepreneurs Fund (EEF).

It follows the conclusion of a trial of Piclo's Flex Marketplace in 2019.

This report is part one of the following series:

Energy On Trial: Piloting a flexibility marketplace to upgrade our energy system

Flexibility & Visibility: Investment and opportunity in a flexibility marketplace

Any queries, please contact the team on flex@piclo.energy.

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Foreword

Our electricity system is undergoing fundamental change. Its past was defined by centralised, static generators powered by fossil fuels. Its future will be decarbonised, decentralised and digital.

We are already on the road to decarbonisation with low-carbon energy poised to overtake fossil fuels as Britain's largest electricity source for the first time in 2019[1]. Demand is increasing, too - electric vehicles (EVs) are increasingly widespread, and electric heat may soon follow. Meanwhile, the rapid global deployment of solar is fuelling the democratisation of energy supply worldwide. And roadside EV charging points and household batteries are set to become part of a distributed (and for the first time, mobile) energy future.

This is mostly good news for efforts to prevent climate breakdown, and consistent with the UK government's pledge to become the first major economy to pass net-zero emissions into law[2]**.** But the speed of the build-out and the projected increase in demand in the decades to come brings with it new issues for our electricity network.

At the heart of the challenge is the transmission and distribution system that underpins our electricity grid - a system that was designed for centrally-controlled generation assets. Congestion on the grid seems almost inevitable without major expensive upgrades.

This means that there is rising pressure on the Distribution Network Operators (DNOs) who manage the local grid. Not only to support the growth of renewables without impacting the reliability of the grid or increasing customer bills but also to accommodate a range of new devices and other fast-emerging technologies.

The response to many of these changes will be digital. Smart distribution networks will play a fundamental role in managing the efficient connection and operation of decentralised energy resources. And so the technology solutions used by the DNOs must progress apace with the rapid changes in supply and demand while keeping costs down.

Piclo believes that energy flexibility will be at the heart of efforts to offset the need for costly grid reinforcements. By creating a marketplace for energy flexibility trading in the UK - working with all six of the licensed distribution networks - Piclo has created a single place for DNOs to source flexibility from the rapidly growing number of providers and help to achieve their crucial goal of supporting a net zero-carbon economy.

This report includes results and analysis from Piclo's 2018/19 trials of an online platform for DNOs to launch auctions for flexible capacity from a range of providers including demand-response aggregators, electricity suppliers, generators, battery operators, industrial and commercial (I&C) customers, local authorities, community groups and electric vehicle charging operators.

[1] Britain's clean energy system achieves a historic milestone in 2019. Published 21 June 2019, by National Grid.
[2] The UK becomes the first major economy to pass net-zero emissions law. Published 27 June 2019, by Department for Business, Energy & Industrial Strategy and Chris Skidmore MP.

Key messages

The projected growth of low-carbon and decentralised generation means the electricity network must be transformed. An open and transparent market for flexibility services will catalyse this change.

Trends

- Demand for electricity in Great Britain is projected to increase from 292 TWh to 440 TWh by 2050 largely due to the electrification of transport and heat[3].

- Renewable and low-carbon sources of energy are expected to supply 95% of electricity in Britain by 2030, up from 66% today[4].

- The expected level of intermittent and inflexible generation from renewables will result in periods of oversupply alongside the anticipated increase in demand across the grid. Happening in parallel, these measures demand that more flexibility is built into the system.

- A more flexible, more efficient energy system could save Great Britain £17-£40bn across the electricity system cumulatively to 2050[5]. Industry and government are looking to DNOs and the Electricity System Operator (ESO) to support and incubate new initiatives to balance the grid and accelerate the rate of change, all while keeping costs down.

Opportunities

- **Flexibility** Assets that can adjust their energy generation and/or patterns of consumption in response to external signals are fundamental to a transforming energy system.

- **Neutrality** A neutral and transparent online platform for trading flexibility will power the growth of this emerging market by creating a level playing field for participation by households, businesses, energy technologies and services.

- **Innovation** The growth of a marketplace for flexibility will not only support the growth of existing businesses and emerging technologies but also create new opportunities and add-on services for innovators in energy.

[3] Future Energy Scenarios (Community Renewables Scenario). Published July 2019, by National Grid.

[4] Future Energy Scenarios (Community Renewables Scenario). Published July 2019, by National Grid. This report assumes, conservatively, that net energy imports via interconnectors are not low carbon.

[5] An analysis of electricity system flexibility for Great Britain, Carbon Trust & Imperial College, 2016.

Energy On Trial

In Great Britain, the demand for electricity is projected to grow significantly to 2050. In some scenarios, it is projected to grow more than 50% - an increase from 292 TWh today up to 440 TWh by 2050[6].

In response to the UK government's commitments under the Paris Agreement - that seeks to hold the increase in global temperatures to less than 2°C above pre-industrial levels - National Grid outlined a number of Future Energy Scenarios (FES) in July 2019 to facilitate the decarbonisation and decentralisation of energy in Britain. National Grid's stated ambition is to be able to operate the electricity system at zero-carbon as soon as 2025[7].

The speed of decarbonisation will impact how our electricity mix evolves, but no matter the scenario, our electricity networks will be under new and increased pressure. Even the most modest scenarios outline a future in which system operators have to substantially increase capacity, while simultaneously balancing the grid to cope with new technologies.

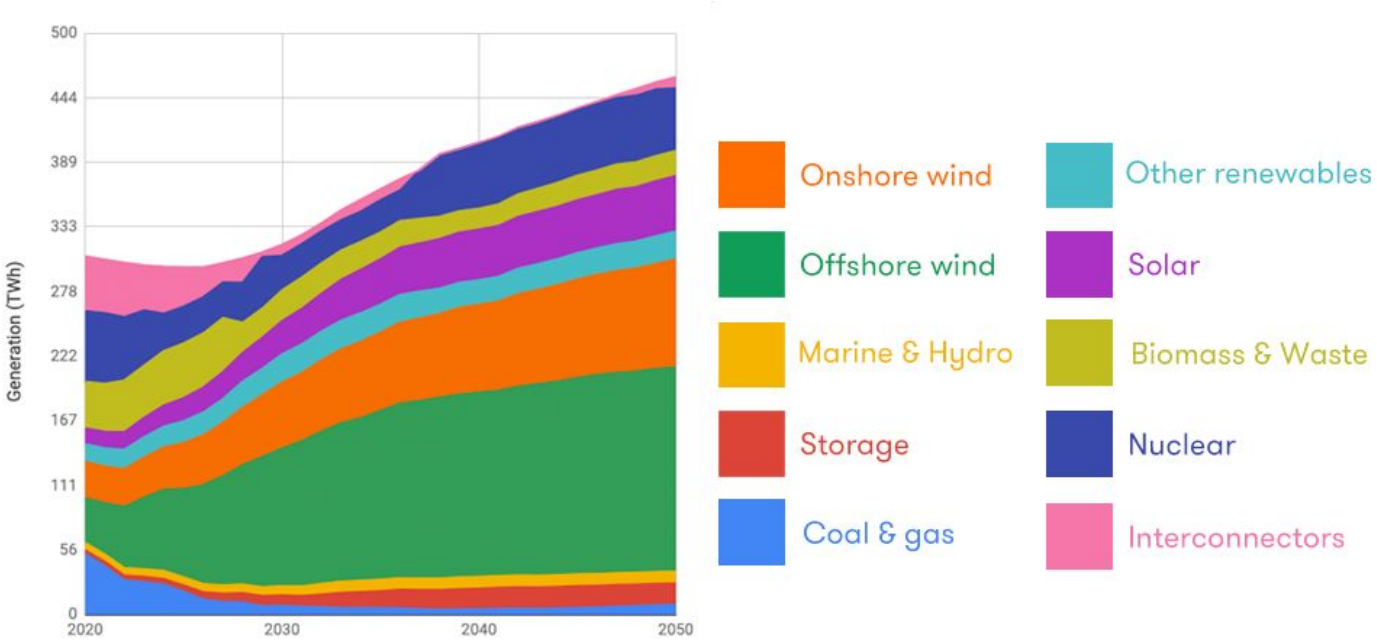

Fig 1. Projected changes in generation mix under the 2019 National Grid Future Energy Scenarios - Community Renewables Scenario

Because renewable and other low-carbon sources of energy are expected to supply a growing amount of electricity in the UK, the level of intermittent and inflexible generation will result in periods of oversupply alongside increased demand across the grid.

A range of electricity storage solutions will form part of efforts to support renewable generation and meet the increased demand from electrified transport (and before long, electric heat). But alongside smart technologies, flexible operation of the electricity network is crucial. Without it, expensive

[6] Future Energy Scenarios (Community Renewables Scenario). Published July 2019, by National Grid.
[7] Future Energy Scenarios, Published July 2019 by National Grid.

system upgrades and reinforcement are more likely across the grid as the ageing infrastructure struggles to keep up with the rapid changes in supply and demand.

Assets that can adjust their energy generation and/or patterns of consumption in response to external signals are fundamental to this transforming system. In particular, flexibility assets that are connected to the grid, such as demand-response technologies, small-scale storage and generators ('gensets') can support constraint management and respond to local congestion, contributing to balancing the grid nationwide. And yet, currently, the process of procurement, dispatch and distribution is outdated, with several barriers for participation.

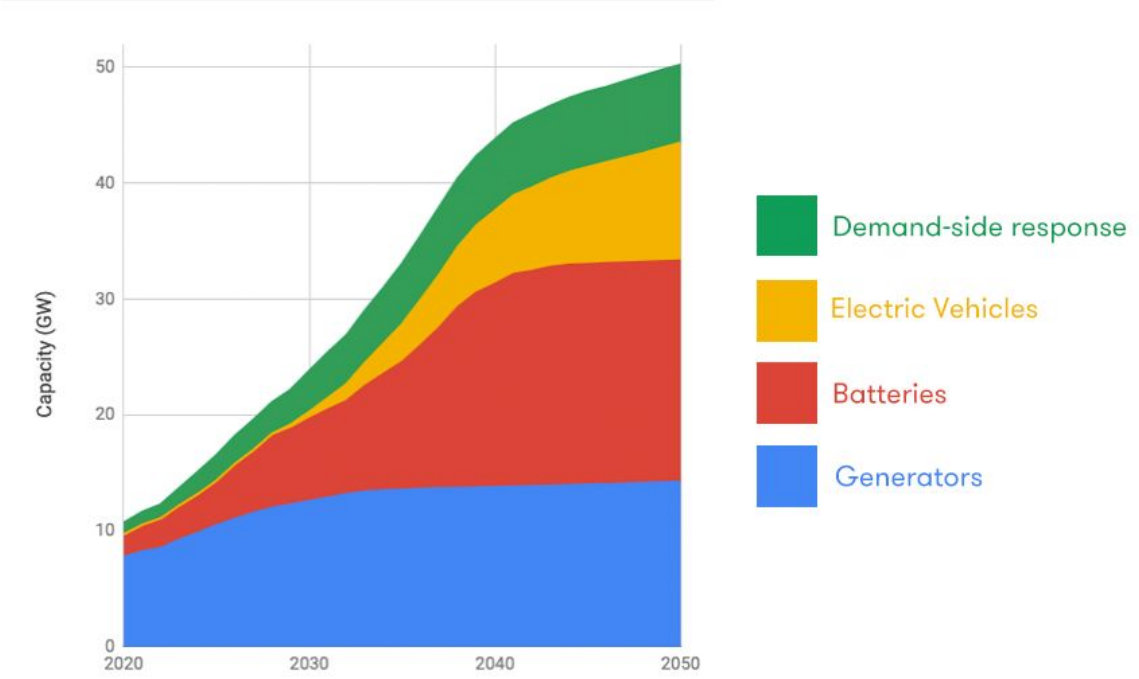

Fig 2. Required growth in decentralised flexible capacity to meet the 2019 Future Energy Scenarios - Community Renewables Scenario.

System Operators have a responsibility to ensure that whatever the generation mix, electricity is always available when it's needed. But the cost to consumers - who are likely to foot the bill for inefficient reinforcement of huge parts of the grid to balance the system - must and can be kept to a minimum. The UK Government estimates that enabling a more flexible, more efficient energy system could save the UK £17bn-£40bn across the electricity system to 2050[8].

With decarbonisation and cost-saving measures in mind, accelerating the transformation of our energy systems and incubating emerging markets has become part of the Department for Business, Energy and Industrial Strategy (BEIS) Energy Innovation Programme. It was in this context that Piclo set out to trial innovative approaches for trading flexibility in the UK electricity system.

The aim of the trial was to demonstrate the viability of a marketplace for trading flexibility across the UK and prove that a smarter grid, supported by digital innovations, can more efficiently respond to the new patterns of energy supply and demand in the transition towards net zero. This is the first of a two-part series that lays out the context and objectives of the Piclo's trial and discusses the results that lay the groundwork for the UK's first operational flexibility marketplace.

[8] An analysis of electricity system flexibility for Great Britain, Carbon Trust & Imperial College, 2016.

Piclo's vision: a flexibility marketplace

Piclo's vision is of a marketplace where thousands of small-scale assets or organisations that generate their own energy or reduce consumption on-demand, can trade flexibility to manage local network constraints and help to defer expensive reinforcement.

Until recently, the National Grid Electricity System Operator (ESO) was effectively the only buyer of flexibility. The centrally-managed grid ensured the supply of electricity from static generators to homes and businesses, with the flow of energy in one direction only. Now, the emergence of DNOs as flexibility buyers presents an opportunity for flexibility providers to spread risk and maximise revenue potential.

In this new landscape, there is a need for an open and transparent market for flexibility services that creates a level playing field for all energy technologies and services to be traded and procured competitively.

Competition is highlighted by BEIS and Ofgem as one of the guiding principles in their Smart Systems and Flexibility Plan.[9] But an independent flexibility marketplace also has the potential to streamline and optimise trading between buyers and sellers and create new opportunities (even new business models) that facilitate the frictionless integration of renewable supply and energy storage to the grid.

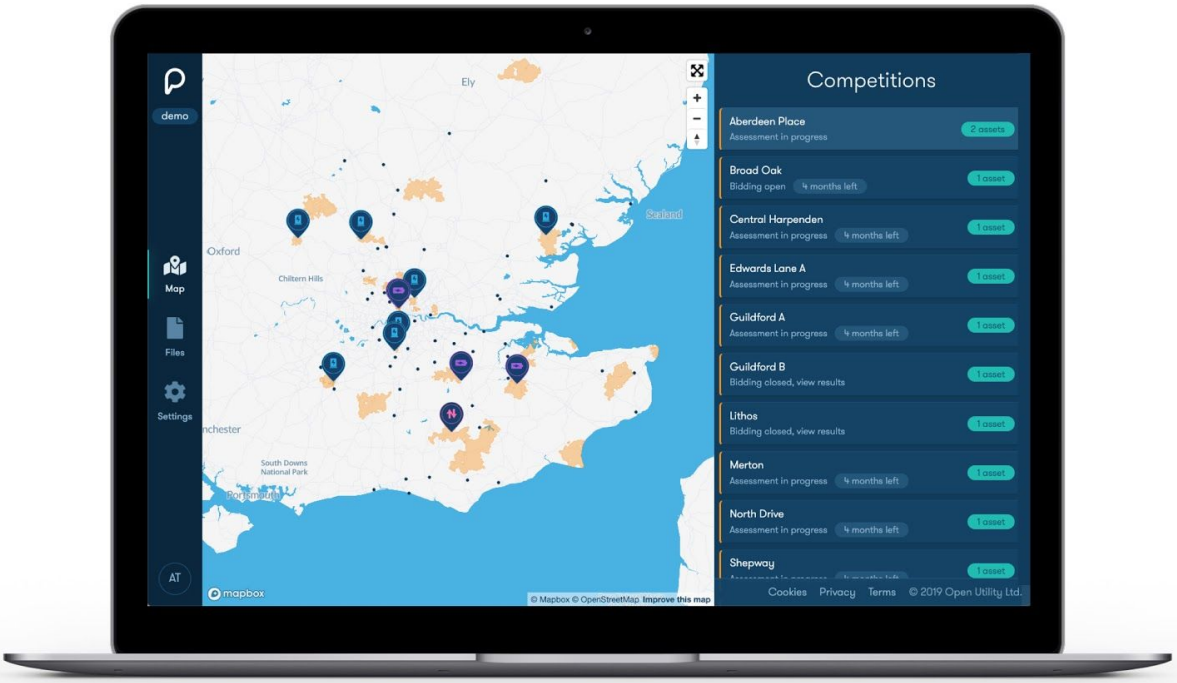

Fig 3. Piclo's vision for a flexibility marketplace.

Locally, a marketplace for flexibility creates opportunities for small-scale assets to trade effectively on an equal footing with bigger players. Nationally, data from the emerging marketplace can demonstrate the changing nature of electricity supply and demand and contribute to better decision

[9] Upgrading our Energy System: Smart Systems and Flexibility Plan, Published July 2017, by Ofgem.

making for future grid reinforcement. And globally, smart grids that operate efficiently can ease the transition to renewable energy production for the greater good of combatting climate change.

The benefits of building an open digital platform for trading flexibility are specific to different users, but cumulatively help our energy network to transition towards the goal of a decarbonised system. Piclo identified the following benefits for the primary users of its platform:

Seller benefits	A platform for flexibility opportunities nationwide, regardless of size. Standardisation of data, simplification of search and transparent commercial terms unlock the potential of providers without the resources for bilateral contract negotiations.
Buyer benefits	System Operators can access a liquid market where it is possible to source flexibility with highly specific locational, technical and temporal requirements.
System benefits	Visibility, transparency and multi-buyer coordination. Flexibility can be scaled up to support low-carbon technology at a lower cost to consumers.

Our trial in action

In advance of the trial, Piclo identified the assets and organisations - the buyers and sellers - that seek to aggregate and trade flexible capacity. Understanding their need for flexibility enabled us to build a more useful platform.

Flexibility buyers

There are seven organisations that own and operate public electricity networks across Great Britain. Of these, National Grid traditionally has had the greatest need for flexibility due to its historic position in the market.

Since 2017 National Grid has been acting as two legally separate entities: the Electricity System Operator (ESO) which manages national system balancing and Electricity Transmission (ET) which owns and maintains the transmission network in England and Wales. In 2018/19, the ESO procured or facilitated approximately £1.2bn of flexibility services, of which £680m was spent to manage network constraints[10].

The ESO's total flexibility spend is expected to grow to £2bn by 2021[11]. These flexibility services help manage fast-rising transmission network capital costs, that are projected to rise from £900m in 2007 to £3.8bn in 2021[12]. This makes the ESO a significant player in any flexibility marketplace but by no means the only buyer.

In addition to the ESO, there are six DNOs licensed in Britain to distribute electricity in 14 geographically defined areas. Their need for flexibility has been less than that of the central system operator, but their role will become more important as a more decentralised system is embraced as part of the drive towards a low-carbon electricity grid.

Under all the scenarios for a decarbonised energy system outlined by National Grid, network and system operators will come under pressure to meet increased electricity demand from electric vehicles and electric heating as well as connecting many new low-carbon devices to the grid, all without increasing customer bills or sacrificing network reliability. Traditional network reinforcement is expensive, slow and inflexible so DNOs are looking for smarter alternatives.

[10] Monthly Balancing Services Summary 2018/19, Published March 2019 by National Grid ESO.
[11] Power 2.0: the next stage of the energy transition will trigger £6 billion investment in flexible power generation assets to 2030, Published October 2018 by Aurora Energy Research.
[12] Stage 02: Workgroup Consultations, CMP264 and CMP265, Published August 2016 by National Grid.

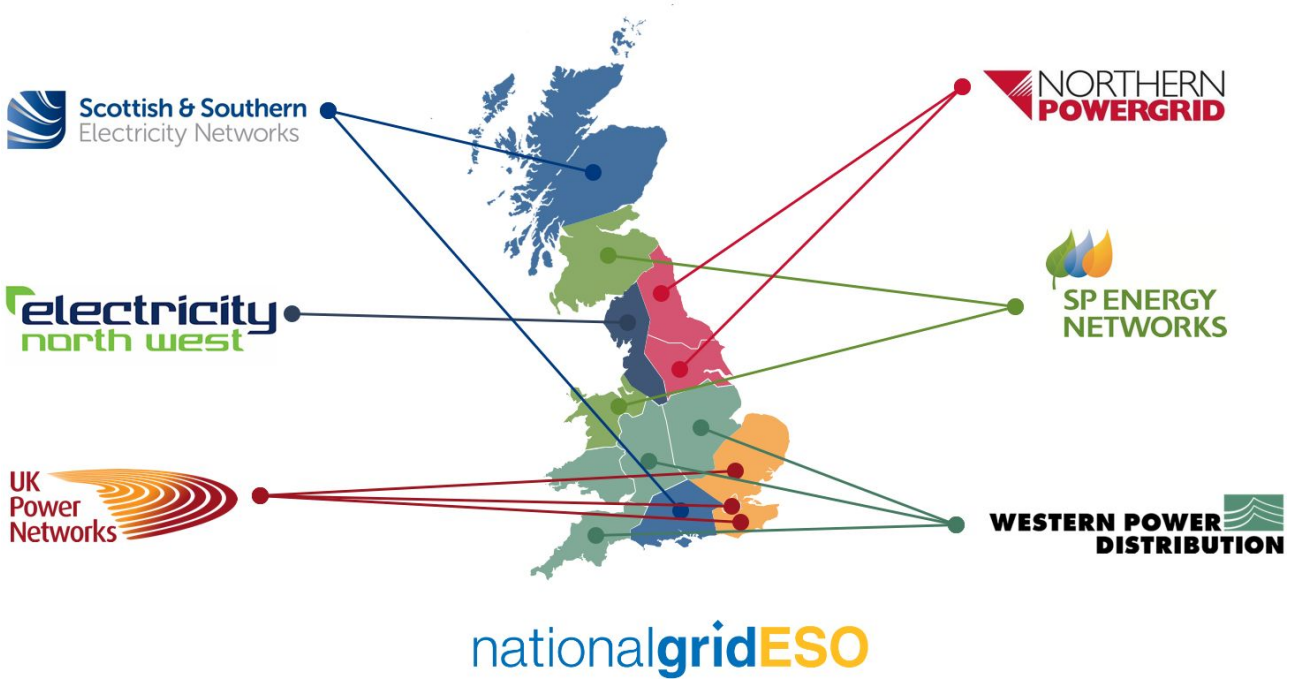

Fig 4. System Operators in Great Britain.

It is within this context that DNOs need to develop into Distribution System Operators (DSOs) and support a shift to a decentralised system that enables a range of new energy technologies that generate, consume and manage electricity. A key pillar of the DSO model is the active procurement of locational flexibility services to solve local network constraint issues.

Flexibility sellers

There are hundreds, if not thousands, of organisations that own or operate flexible assets nationwide. These range from traditional demand-response aggregators (those that can turn demand up or down e.g. by toggling refrigeration or air conditioning on/off), operators of dispatchable generators, battery operators and electricity suppliers, EV charging managers, community groups, local councils and industrial and commercial customers. There are also a number of flexibility advisory firms, brokers and investors that play a key role in the flexibility ecosystem.

Currently, organisations with flexible assets on the grid can seek opportunities to sell flexibility to National Grid, DNOs or through market arbitrage and government capacity contracts. This market is currently worth more than £2.2bn[13] every year (not including market arbitrage). But there are many barriers to entry related to procurement as well as operational challenges. These challenges are more pronounced for small-scale assets seeking to trade flexibility. Currently, these operational challenges make participation at a residential scale almost impossible.

The increase in renewable energy production, as well as growth of EV and household energy storage, will see a marked increase in the number of assets and non-traditional energy market participants that have the flexibility to trade. This means that there now exists a window of opportunity to create a marketplace that reduces barriers to entry and creates a level playing field for these new players.

[13] Monthly Balancing Services Summary 2018/19, Published March 2019 by National Grid ESO.

Challenges and analysis

Procuring flexibility

The first step in developing a flexibility marketplace is to simplify and standardise the process for the procurement of flexibility services.

Based on this understanding of market needs, Piclo launched its trial of an online marketplace for local flexibility in September 2017, and sought to demonstrate that a digital procurement platform could:

- Improve transparency and visibility
- Increase participation
- Reduce the administrative costs associated with procuring flexibility

All six of Britain's DNOs participated in the Piclo Flex trial to learn about the practical steps needed to procure flexibility via a platform. This allowed them to gather tangible evidence for the Energy Networks Association (ENA) pan-industry Open Networks Project and demonstrate their 'flexibility-first' commitment.

Each of the DNOs used the platform in different ways, summarised below. Some simply used the visibility features to enhance existing processes while others made use of the functionality to run auctions.

Distribution Network Operator	Use of feature
UK Power Networks (UKPN)	Visibility and auctions
Scottish and Southern Electricity Networks (SSEN)	Visibility
Electricity North West (ENWL)	Visibility
SP Energy Networks (SPEN)	Visibility and auctions
Northern Powergrid (NPg)	Visibility
Western Power Distribution (WPD)	Visibility

Fig 5. The utilisation of Piclo platform by DNOs during Piclo Flex trial, 2019

Flexibility requirements

As part of the trial, six DNOs published their requirements in a standardised format on Piclo Flex. Though not all participants ran live auctions, the data revealed that each DNO has locational, technical and temporal requirements for flexibility.

Fig 6. DNO flexibility needs across GB from Piclo Flex trial, 2019.

Throughout the trial in 2018-19, Piclo signposted demand for more than 456MW of flexibility from six DNOs via its online platform. Though it represented only a fraction of Britain's total needs for flexibility in the same period, the platform demonstrated its potential to create a heat-map of areas of network congestion. Matching these opportunities with flexibility providers will create opportunities to leverage demand-side-response, batteries and behind-the-meter generation to minimise bottlenecks in the network.

This is the first time that nationwide flexibility data from multiple DNOs have been available via an open, online platform and represents an opportunity for energy suppliers, aggregators and demand-side response technologies to consider the potential of their assets beyond the traditional model of procurement.

The type of requirement for flexibility varied but the greatest single greatest need was due to reinforcement deferral (45.2%). This demonstrates the potential for DNOs to utilise flexibility services to reduce the short-term costs associated with increasing capacity.

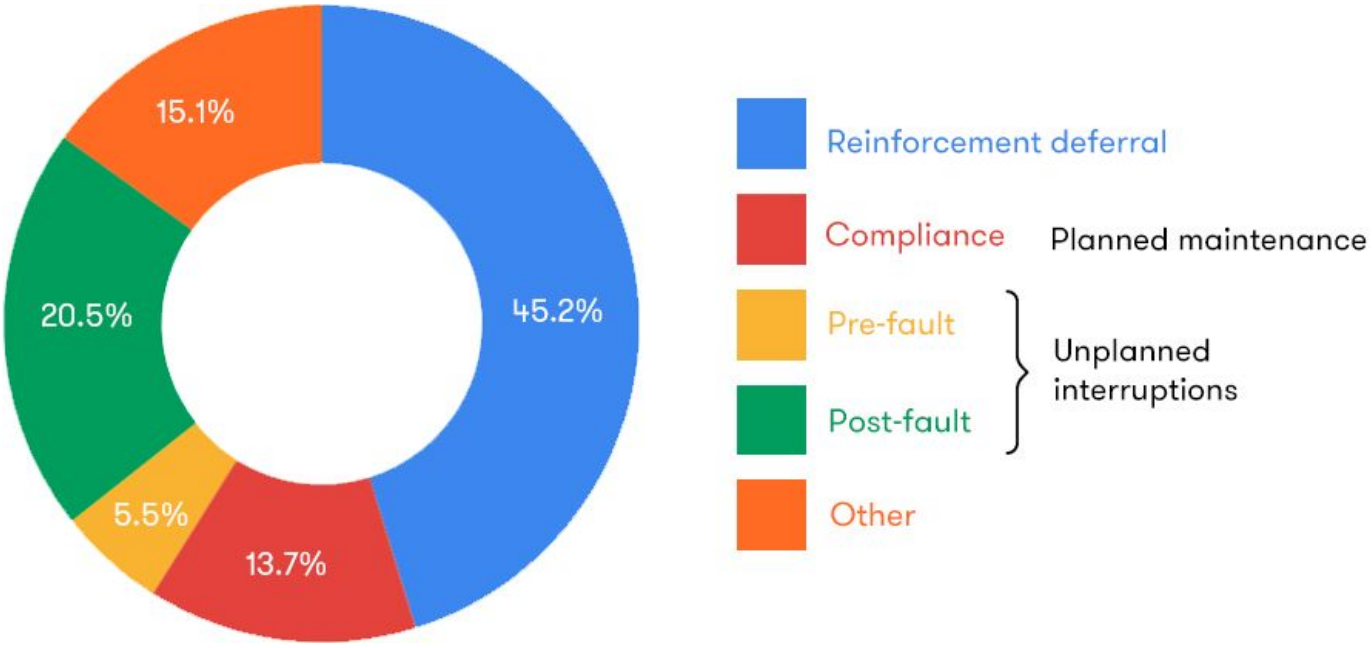

Fig 7. Breakdown of flexibility requirements during Piclo Flex trial, 2019.

Traditional substation reinforcement was straightforward when long-term forecasts of incremental demand were predictable. With the transition towards decentralised energy, net demand on the grid is far less predictable with a conflict between energy efficiency, renewable energy and electrification of heat and transport and increased digital demand.

It has become valuable to defer long-term decisions (distribution assets have planned lifetimes of 40 years) in order not to have 'stranded' oversized grid assets in the future. DNOs want to have an 'option' for flexibility in heavily constrained areas which can be called upon during when thermal or voltage limits in substations are breached.

The second-largest requirement was for unplanned interruptions, both pre- and post-fault. In this case, flexibility contracts are used to manage networks during abnormal conditions, for instance when a fault leads to a localised blackout and the neighbouring network has to compensate.

Planned maintenance, represented here as 'compliance' are works that are focused on maintaining the security of supply standards before reinforcement works are complete. This planned maintenance, to manage temporary network constraints, represented a small but not insignificant proportion of flexibility needs during the trial.

Capacity and scale of flexibility competitions

During the trial period of the Piclo Flex platform, a total of 456MW of capacity was uploaded across the UK. The data revealed significant variance in the need for flexibility advertised by the DNOs.

DNO	Flex requirements uploaded	Total Capacity advertised (MW)
UKPN	28	103
SSEN	6	50.5
ENWL	5	8.4
SPEN	11	116
NPg	10	12.5
WPD	13	165.4
Total	**73**	**455.8**

Fig 8. Snapshot of capacity uploaded by DNOs during Piclo Flex trial, 2019.

Data uploaded during the trial of flexibility competitions revealed a huge variation in the scale of individual competitions advertised by the DNOs. From 0.2MW advertised for compliance on winter weekday evenings in Reed (Hertfordshire), to 72MW for unplanned interruptions - one of two similar requirements - in South Hampshire.

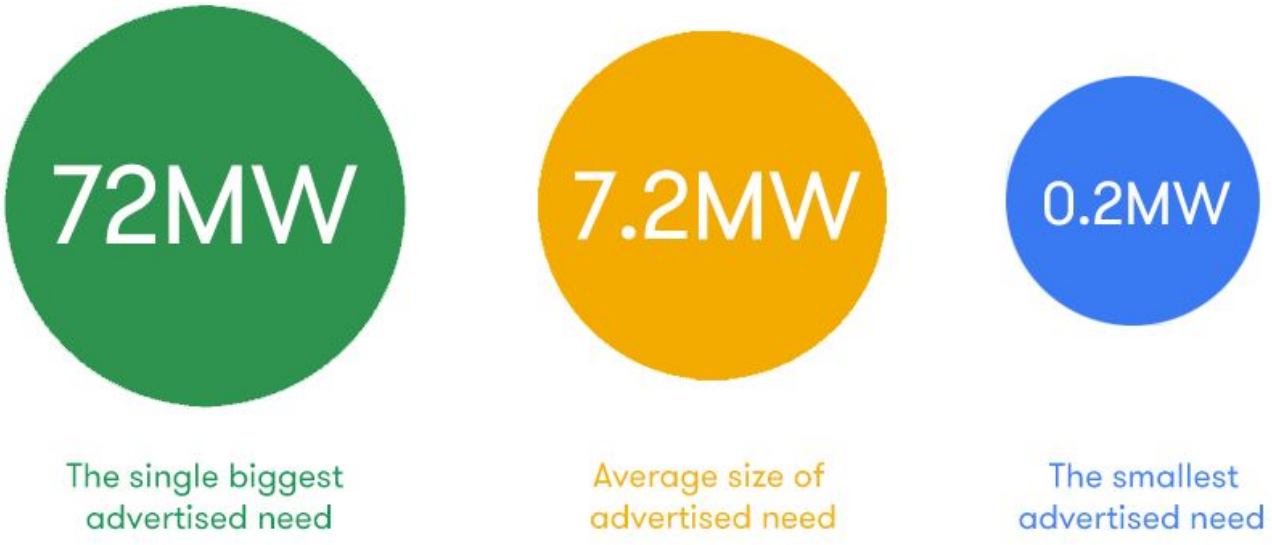

Fig 9. Data from Piclo Flex trial, 2019.

This means that the type of solutions could also be very different. A low level of need such as 0.2MW could be met on a hyper-local level by ~50 residential batteries for example. This could be met by the massive projected growth of batteries (residential and utility-scale). At the other end of the scale, a 72MW requirement would need close to 20,000 residential batteries to meet such a demand. This makes it much more likely that this demand would be met by a small number of utility-scale batteries or generators.

Flexibility Revenue Ranges

The revenue potential that the opportunities presented for flexibility providers during the trial proved to be highly dependent on the location and nature of the demand. UKPN published revenue ranges for their areas of anticipated constraint on Piclo Flex[14], allocating a total budget of approximately £12 million across all areas.

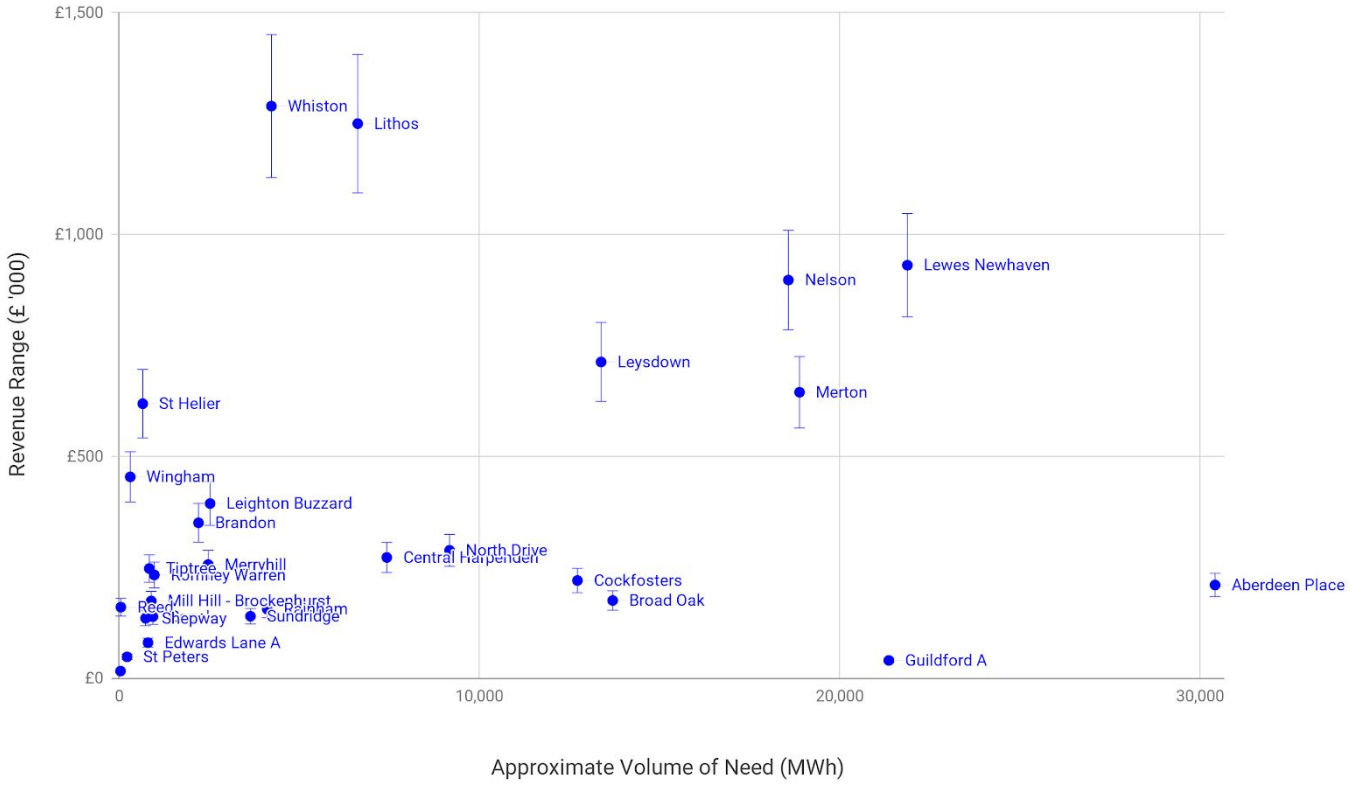

Fig 10. Revenue range per area, published by UKPN 2019, versus volume of advertised need from Piclo Flex trial, 2019.

The data reveals the significant variance that can exist between the volume of need and revenue ranges across different constraint areas. UKPN was the first DNO to publish pricing signals to accompany their competitions, but we can expect others to follow suit. More data is expected to reveal the trends and patterns associated with these variances as a route to inform investment decisions.

Flexibility needs at different times

In spite of the differences between the requirements and individual constraint areas for each DNO, trends are already emerging in the new market for flexibility services. These typically reflect the natural cycles of demand which correspond to the daily lives of people in Great Britain.

The data for competitions uploaded during the trial reveals a difference between the capacity requested during the week and on weekends. However, the timing for that demand was broadly consistent across DNOs and regardless of the size of the demand.

[14] Flexible Zones - Revenue Range per Area, published by UKPN 2019.

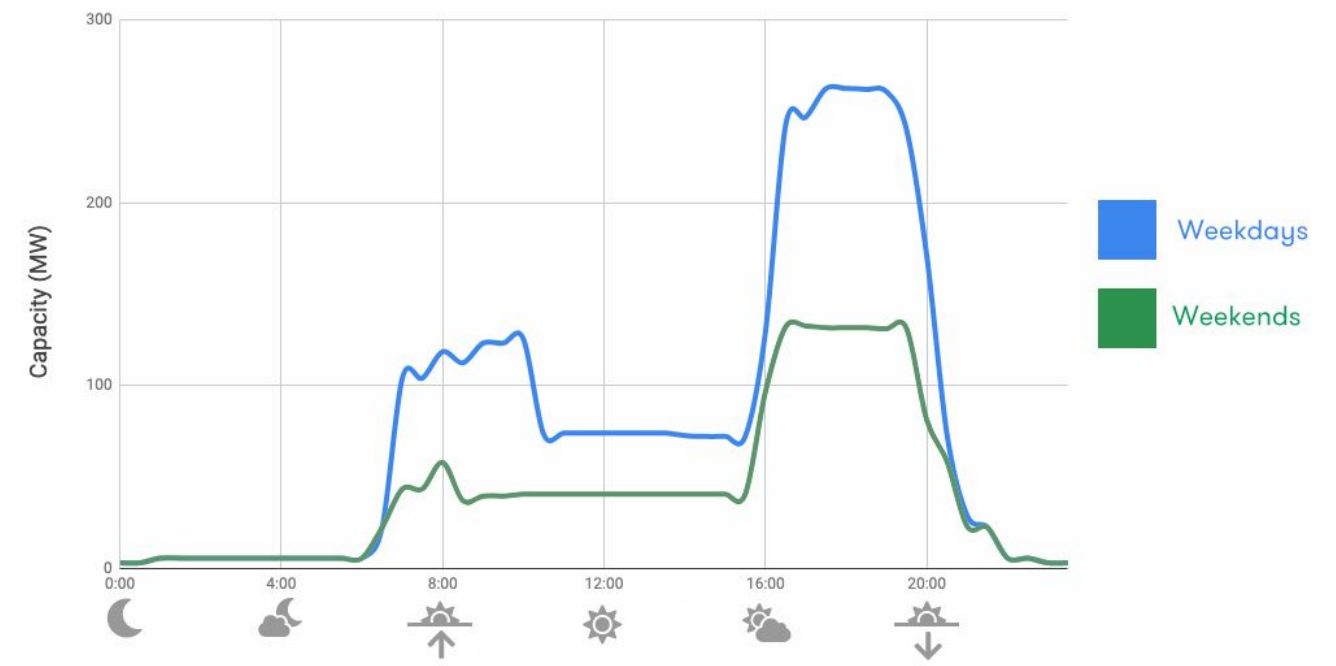

Fig 10. Data from Piclo Flex trial, 2019

Piclo expects to be able to provide more granular indications of the demand for flexibility as the market matures, and the numbers of competitions increases. With this information, DNOs and flexibility providers will be able to make better-informed decisions about investment and reinforcement deferral based on seasonality, time of day, and the type and volume of demand. In turn, this digital and more agile approach to flexibility will enable optimisation of the whole energy system.

Credits

Production & authoring team

Piclo (Author)

Piclo has been at the forefront of innovation in the fast-changing energy industry since 2013. Previously trading as Open Utility, Piclo's mission is to power the world with cheap, clean and abundant electricity and to accelerate the decarbonisation of our energy systems. Read more about Piclo's story.

Piclo project funders

Energy Entrepreneurs Fund, Department for Business, Energy & Industrial Strategy

The Energy Entrepreneurs Fund (EEF) is a competitive funding scheme to support the development of technologies, products and processes in energy efficiency, power generation and storage. The overall aim of the BEIS Energy Innovation Programme is to accelerate the commercialisation of innovation cheap, clean, and reliable energy technologies by the mid-2020s and 2030s.