EnergyREV

POLICY & REGULATORY LANDSCAPE REVIEW SERIES

Working Paper 2: Digital energy platforms

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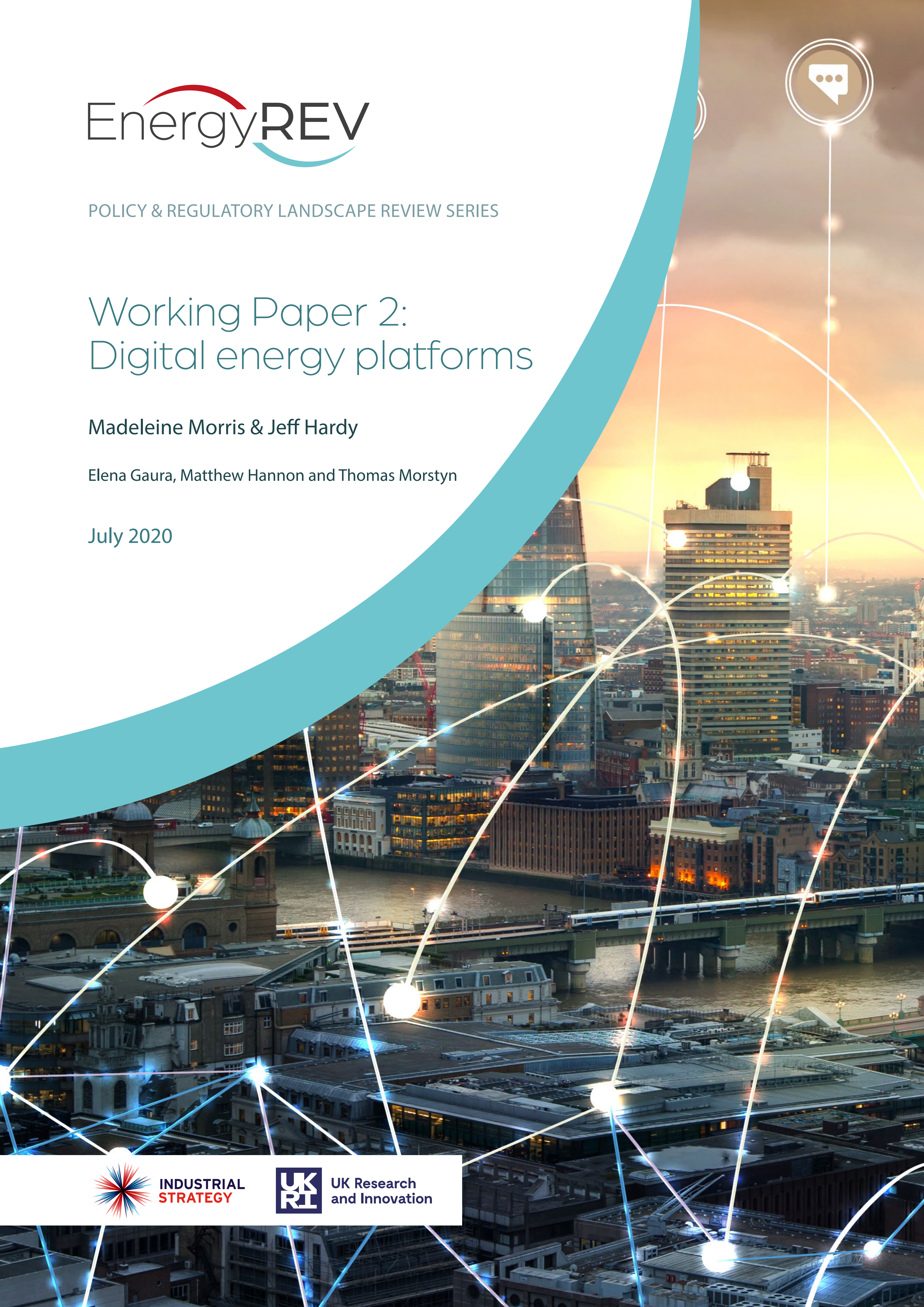

INDUSTRIAL STRATEGY

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Reviewers & contributors

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Acronyms

ANM	Active network management
BEIS	UK Department for Business Energy & Industrial Strategy
BSC	Balancing and Settlement Code
DAPF	Data Access and Privacy Framework
DCC	Data Communications Company
DER	Distributed energy resource(s)
DNO	Distribution network operator
DSR	Demand side response
DSO	Distribution system operator
ESO	Electricity system operator
GDPR	General Data Protection Regulation
HEMS	Home energy management system
ICT	Information and communications technology
LEM	Local energy market
P2P	peer-to-peer (energy trading)
PFER	Prospering from the Energy Revolution
SLES	Smart local energy system
SO	System operator
SSFP	Smart Systems and Flexibility Plan
TSO	Transmission system operator
VES	Virtual energy system
VPP	Virtual power plant

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About this report

The policy and regulatory review series

As our energy system undergoes a transition to a decarbonised, digitalised and decentralised one, it is vital that we understand how smart local energy systems (SLES) could provide a more efficient, safer and better experience all round.

Our team are focused on understanding the policy, regulatory and market frameworks in which SLES in the UK can operate optimally in the future. In order to understand where (and whether) changes need to be made, it is important to have a baseline of what today's arrangements are.

The purpose of this review series is to analyse the evidence and gaps in the policy and regulatory landscape of today's (smart) local energy systems in the UK.

We are conducting this review in a series of 'sprints' each of which will have a particular focus. The first report, published in September 2019, was a review of the policy and regulation related to electricity storage and electric vehicles. The findings of this, as well as more information about the review, can be found in our first working paper: Working Paper 1: Electricity storage & electric vehicles. This second report focuses on **digital energy platforms**. The methodology used for this review can be found in the Appendix.

Your feedback

The aim of conducting this review in a series of sprints is to produce useful and usable outputs to our stakeholders as soon as we have the information. We're seeking your feedback on how useful and informative our outputs are so that we can improve future reports. We would like your feedback on the following:

- Have we captured all the relevant information – if not, what have we missed?
- How could we improve the presentation of the information?
- How could we improve the clarity of the information?
- How can we best keep these outputs live and relevant – are you aware of approaches we could draw inspiration from?

Please send feedback to policy@energyrev.org.uk.

We will use this feedback to continually improve our outputs to provide the most useful and usable resources on policy and regulation related to SLES. At the end of the wider review process we'll tie together the findings from each sprint into one comprehensive snapshot of today's policy and regulatory environment.

Executive Summary

This report on digital energy platforms is the second of our EnergyREV smart local energy systems policy and landscape review series. Digital energy platforms are used by all the Prospering from the Energy Revolution (PFER) demonstrations projects and the recently funded detailed design projects. The report presents the systematic review of literature gathered through systematic searches and crowdsourcing from expert stakeholders and networks. The structure of this summary and the report was guided by the analysis of the literature.

The Universal Smart Energy Framework (USEF) define platforms as:

> "…digital spaces where users can communicate and interact with each other and get (temporary or permanent) access to products, services, or more broadly 'resources' provided by peers or organisations."

The trend of digitalisation has driven the emergence of digital platforms across many sectors. Digital energy platforms, such as active network management, exist today in the energy sector, but are yet to have the disruptive effect seen in other sectors. This puts the energy sector in a position to be able to learn from other sectors on issues such as regulation and benefits and impacts of such platforms.

Whilst digitalisation is the primary driver of digital energy platforms, decarbonisation, decentralisation and democratisation are also important factors. Together these drivers combine to create a niche for digital energy platforms to emerge. In our review we identify six emerging types of digital energy platforms: Peer-to-Peer; Home Energy Management Systems; Active Network Management; Virtual Power Plants/Virtual Energy Systems; Local Energy Markets; and Flexibility Platforms.

Our review uncovered three broad areas where digital energy platforms interact with policy and regulation – data, markets and roles and responsibilities. We highlight our nine key conclusions within the summary of each section below.

Data and digital energy platforms

Increased availability of data is a driver of digitalisation which in turn is a driver of digital platforms in other sectors. Digital energy platforms require access to data of sufficient quality including data on time- and space-resolved energy generation and consumption, energy system state and weather.

There are energy data issues caused by how data is collected, stored and processed. So, whilst the data might exist, it isn't interoperable (or even sometimes accessible) between actors. One of the Energy Data Taskforce's key recommendations was to "digitalise the energy sector and evolve its culture to embed the values of 'presumed open'". This will require a paradigm shift in the way data sharing is valued; making energy data accessible and interoperable is expected to be beneficial for stakeholders across the energy sector. Another important aspect of data interoperability is that it can support other types of interoperability, including commercial and consumer interoperability. Provisions must exist for consumers to switch between different commercial offers and technology choice. Without this provision, consumer choice would be restricted as they find themselves locked-into particular platforms.

Unless the energy industry fully embraces the recommendations of the Energy Data Taskforce, then Government and regulators will intervene; either route will affect the emergence of digital energy platforms.

Platforms also create value through producing new or improved data, for example about customer energy usage and preferences, and this has value within and outside of the energy sector. This raises issues of data protection, both in terms of protecting the energy system (for example from cyber-attack) and protecting consumer's data. Whilst these issues are not unique to the energy sector, there may be additional challenges because of low levels of consumer trust in the sector. This low-level of trust could in fact be an opportunity for digital energy platforms to increase transparency and provide better control for consumers over their data.

Approaches on protecting energy system and consumer data could affect, positively or negatively, the viability of some digital energy platforms.

Markets

Many digital energy platforms are marketplaces, for example through which local energy or flexibility services are traded. The value of these energy platforms is in providing connections between those who can offer products or services and those who seek to buy them. We have identified several barriers to such platforms. These include: A lack of a level playing field (e.g. DER cannot currently realise the value of black start services to National Grid); problems with revenue stacking (e.g. only recently has it become possible for assets to participate in both the Capacity Market and balancing services markets); and issues with current regulation (e.g. peer-to-peer energy can only proceed through a licensed energy supplier).

Within the myriad proposed changes to policy and regulation of actors, markets and networks, there needs consideration of how these affect incumbent and emergent energy actors, such as digital energy platforms.

Roles and responsibilities

The transition to zero-carbon, smart and increasingly local energy systems will see the emergence of new actors and institutions, and changes to the roles of those that exist today.

Digital energy platforms create opportunities for an increased role of rapidly growing distributed energy resources, such as solar energy, batteries and electric vehicles in homes and businesses. These resources, currently pretty much invisible to the wider energy system, have the potential to provide multiple energy system services through most of the digital energy platforms we have identified.

For consumers and distributed energy resource owners to engage in digital energy platforms they will need to be convinced that there is value is providing energy system services. Also, and perhaps more importantly, there needs to be trust in the protections that participants are afforded and that the platforms are safeguarding participant data, being transparent and that there are provisions for participants to switch between both different commercial offerings and technology choices.

Digital energy platforms need to earn the trust of their participants, and failure to do so will result in them being more stringently regulated.

Some consumers may be left behind in the digital energy transformation due to being excluded from participating in digital energy platforms. This could be because they cannot access them or perhaps their services are not valued by the platforms. Thus, they are harmed because they cannot access the benefits of digital energy platforms. In addition, some consumers who can engage with digital energy platforms could become vulnerable as a consequence.

Without consideration of inclusion in their design that digital energy platforms could exacerbate existing fairness and distributional issues and may cause new vulnerabilities to emerge.

The roles of the Electricity System Operator (ESO) and Distribution Network Operators (DNOs) are expected to change as the energy system becomes increasingly decarbonised, decentralised and digitalised. Both currently operate digital energy platforms to procure services like flexibility, and the demand for such services is likely to increase going forwards. In the future, it is uncertain how the roles of the ESO and DNOs will evolve. For example, DNOs could become Distribution System Operators, taking an increasingly active role in managing their network including procuring flexibility services via digital energy platforms acting as a neutral market facilitator. Alternatively, the ESO may increasingly reach down into local networks and undertake activities currently in the purview of the DNOs.

Regardless of how the roles of network and system operators evolve, it is critical that there is good communication and transparency between these roles and the platforms used to avoid conflicts or duplication of effort.

Government has an important role to provide vision for the net-zero transition. This might involve stepping in where barriers and/or market failures have been identified. There is also an important role for Government in legislating to clarify issues (for example definitions of key actors), introduce fit-for-purpose governance or change rules to create space for energy business model innovation. There is also an important role for Government to consider policy and regulatory challenges of digital platforms that are cross-border.

Government has an important role in setting the vision for the net-zero transition and creating space for digital energy platforms to emerge; the forthcoming energy white paper is an opportunity to start this journey.

The regulator, Ofgem, has several important roles to play and for digital energy platforms to emerge it will need to change both what and how it regulates. Ofgem is already gathering valuable insight into what platforms are emerging from trials in its regulatory sandbox. It is also exploring a range of reforms to regulation including the smart meter rollout, supplier hub model, industry code governance, network charging, roles of network and system operators. Ofgem is considering how digital energy platforms could be regulated. So far Ofgem has resisted applying formal regulation, such as licences for digital energy platforms and the industry has put in place a voluntary code of conduct for aggregators (who both run and operate through platforms). This could change as the markets and platforms evolve.

Ofgem has a balance to strike between allowing digital energy platforms to emerge and protecting the interests of consumers. Ofgem should continue to look to other sectors and countries for lessons to be learned on anticipatory, information- and principles-based regulation.

Digital energy platforms require new skillsets to be brought into the energy sector, such as information technology, data science, machine learning and artificial intelligence. This is important for businesses themselves, but also for those setting policy and regulation of the sector. The skills required in smart local energy systems are being explored elsewhere within our EnergyREV programme.

Industry, Government and the regulator will need to upskill to prepare for, and keep pace with, the smart local energy system transition.

1 Context and structure of this report

The Prospering from the Energy Revolution (PFER) projects have been tasked with illustrating 'how integrated intelligent local systems can deliver power, heat and mobility to users in new and better ways.'[1]

All four of the PFER funded demonstrators, and many of the design projects, involve the use of digital energy platforms, reflective of the government's drive towards a smarter, more flexible energy system (BEIS, 2019b). Given their emergent nature, the policy and regulatory landscape for smart local energy systems digital energy platforms has some gaps.

Identifying the role of, and how the current environment helps or hinders, digital energy platforms is essential for understanding how they can contribute to the success of not only the PFER demonstrator projects, but also clean affordable and secure future energy systems.

This report is the result of a quick scoping review of literature gathered through both systematic searches and through crowdsourcing from expert stakeholders and networks (see Appendix for more information on the methodology).

The structure of this report was guided by the outcomes of the review. We start in Section 2 by looking at how digital platforms have emerged in and impacted other sectors of the economy, then explore specific drivers for digital platforms in energy in Section 3. Digital energy platforms are introduced in Section 4 where we look at definitions and examples of existing and emerging platforms in the context of smart local energy systems, including case studies. Section 5, Section 6 and Section 7 then detail the policy and regulatory landscape of the three main issues that emerged in this review: data, markets, and roles and responsibilities, respectively. We conclude in Section 8 with the policy implications for digital energy platforms in a smart local energy context.

1 The four projects funded in April 2019 are a) The Energy Superhub Oxford, b) ReFLEX Orkney, c) Project Leo (Local Energy Oxfordshire) and d) Smart Hub SLES (West Sussex).

2 Introduction to digital platforms

Platforms have previously been described as:

> "…digital spaces where users can communicate and interact with each other and get (temporary or permanent) access to products, services, or more broadly 'resources' provided by peers or organisations." (Kloppenburg and Boekelo, 2019).

The concept of digital platforms is not new; the trend of digitalisation (explored more in Section 3.1) has long been seen across the economy, which has contributed to the emergence of innovative digital platforms in many sectors, including mobility (e.g. Uber and BlaBlaCar, founded in 2009 and 2006, respectively), accommodation (e.g. Airbnb, founded in 2008), retail (e.g. eBay founded in 1995) and finance (e.g. Kickstarter, founded in 2009) (World Economic Forum and Accenture, 2016). One of the defining characteristics they share is that, rather than focusing on owning the means of production, they create the means of connection. Digital platforms are also typified by the fact that they benefit from 'network effects'; the more active users in a platform's network, the more useful that platform becomes to all its users (Zui and Iansiti, 2019). Many of these platforms are considered to have caused significant transformations in their respective sectors; an example of how Uber changed the taxi industry is given in Box 1.

Whilst digital platforms are not an entirely new phenomenon in energy (some, such as active network management and home energy management systems, covered more in Section 4, are relatively well-established), they haven't yet had the disruptive impact seen in other sectors. This puts the energy sector in a position to be able to learn valuable lessons from the sectors which have already had experience, such as the consequences of gaps in regulation (more in Box 1) and about what makes a platform successful (or not).

As digitalisation of the energy sector picks up pace, the emergence of digital platforms can be observed in this sector (Kloppenburg and Boekelo, 2019). We explore this and other energy-specific drivers – decarbonisation, decentralisation and democratisation – for platforms in Section 3. In Section 4 we outline the specific challenges that some of the types of digital energy platforms that already exists and that are emerging and look at their distinguishing features.

Box 1: Uber – a digital platform for mobility

Uber disrupted the taxi industry with a new business model which takes advantage of digital technologies and decentralisation of ride-hailing.

Before Uber was introduced (in 2009 to the US, reaching the UK in 2012), the taxi industry was dominated by a relatively small number of providers which were, to some degree, centralised in nature; vehicles were associated with a given minicab company, and users contacted that company to request a service, which was coordinated by a central dispatcher.

Uber identified inefficiencies in the utilisation of existing assets; privately owned vehicles had a huge amount of down time when owners weren't using them, which could be used to provide mobility services. Rather than buying a fleet of vehicles, Uber realised the potential of coordinating owners of vehicles and connecting them with users who needed a ride, using an algorithm to match the nearest car to the nearest rider. This model allowed Uber to provide services at a lower cost than incumbents could, while providing vehicle owners with an additional source of income. Using digital technology (a smartphone app), Uber improved the efficiency and experience of that service for many (e.g. by removing the need for cash payment and improving transparency by using geolocation to allowing users to track where their ride before and during the ride). 'Surge pricing' was introduced to better manage supply and demand, incentivising users to delay their rides when possible to avoid higher fares.

While industry incumbents (like black cabs in the UK) are heavily regulated, Uber is not; drivers are not required to pass any tests to become qualified, nor are they limited by a cap on licence allocations (as is the case in some cities, like New York). This means that the company has, and continues to, come up against local authorities and regulators. In London, for example, the company has been banned from operating; In 2017 Transport for London (TfL) decided to not renew Uber's licence, citing a 'pattern of failures' which put passenger safety at risk (Transport for London, 2019). It found that unauthorised drivers were able operate using the platform, estimating that there were at least 14,000 fraudulent trips in the city in late 2018 and early 2019. Uber's appeals against the decision were not successful. Some countries have banned the company fully (The Independent, 2017; The Telegraph, 2018).

Despite some setbacks, Uber is expanding beyond ride-hailing; it has moved into food delivery and freight spaces and is developing autonomous (self-driving) vehicle and technology (Uber). It is also looking to replicate its ride-sharing potential in aerial transportation (Uber, b).

3 Drivers for digital energy platforms

Digitalisation is considered a key driver of the emergence of digital platforms which is common across the economy. This is also the case for the energy sector; without digitalisation, the functionality of and need for digital platforms would be severely reduced. However, the energy sector is undergoing a major transition, and other more specific trends – including decarbonisation, decentralisation and democratisation – are also driving the emergence of digital energy platforms.

In this section we look at how these trends are driving, and in some cases enabling, the emergence of digital energy platforms, and the opportunities that platforms have to contribute to the transition.

3.1 Digitalisation

The declining costs and increased performance of information and communications technologies (ICT)[2] is resulting in a shift towards digitisation of many sectors, including energy. Digitisation can be described as the conversion of analogue ('paper') data to digital data, but doesn't describe any changes in processes (IEA, 2017). The term digitalisation, on the other hand, is the concept of embracing and using digital technologies and digitised data to transform processes (e.g. system operations) and ways of working (e.g. business models) to achieve desirable outcomes.

In a recent briefing paper, the Energy Futures Lab defined digitalisation of energy as:

> "…the act of incorporating digital systems and information and communications technology (ICT), along with the new business models and interaction opportunities these support, into the energy system." (Woodhouse, 2018)

Digitalisation cannot happen without digitisation, but the former, crucially, is about extracting value from data, not simply migrating from paper to electronics. The Council of European Energy Regulators (CEER) describe digitalisation as:

> "…not an objective in itself, but a means to deliver benefits for the energy system and ultimately for energy consumers." (CEER, 2019)

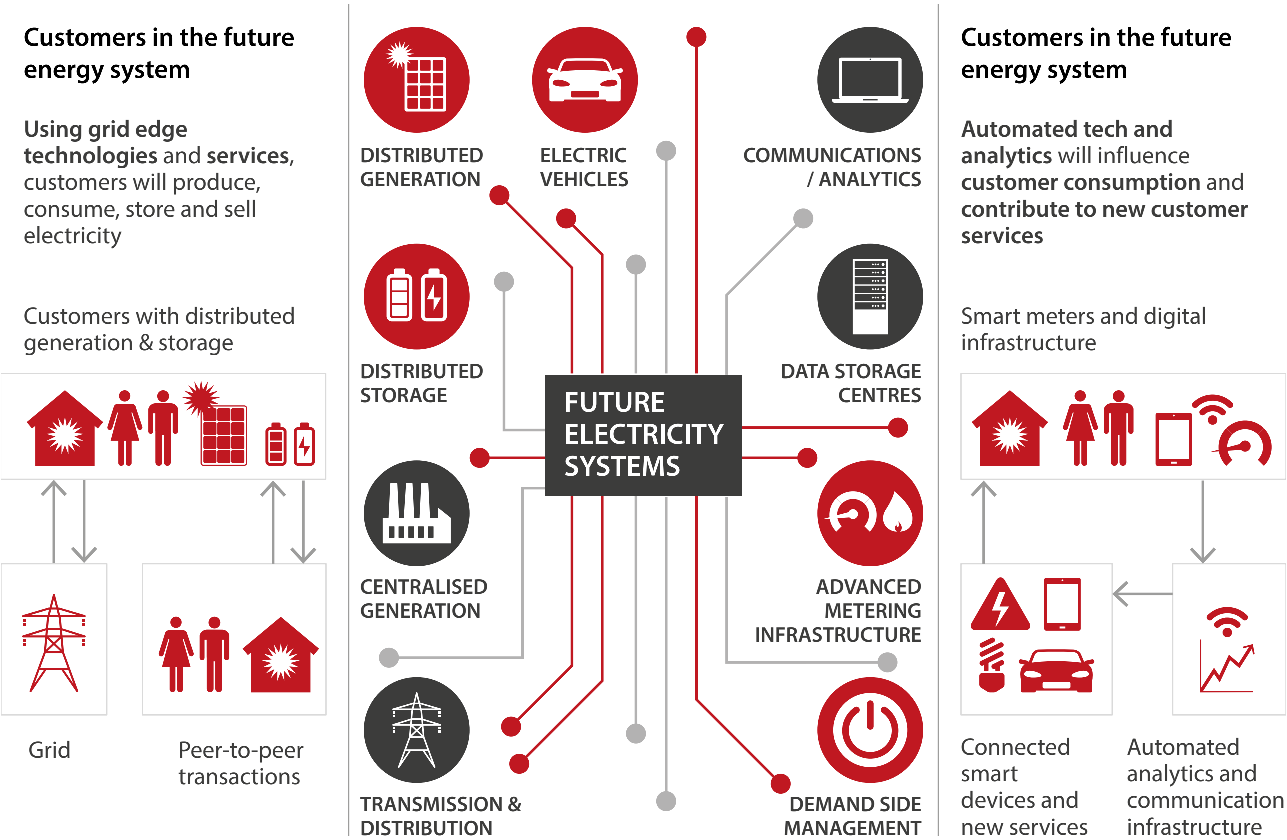
The creation of value from energy data could come in many forms. For example, at the system level the use of data could enhance efficiencies though improved knowledge of asset availability and status, and through better coordination between transmission- and distribution-level operators, as well as suppliers (who have the most complete, yet not comprehensive, consumption records, see Frerk, 2019), contributing to better balancing of supply and demand. This energy system data is increasingly important given the move towards a more decentralised network, with millions of currently 'invisible' assets (both supply and demand) connecting to the network. This is illustrated in Figure 1 (World Economic Forum, 2017).

2 Information and communications technology, which is a broad subject but generally covers all uses of digital technology that exist to help individuals, businesses and organisations to use information. In this context, the 'information' (see Box 1 for more on the meanings of data and information) relates to the entire energy system, from how the energy is generated to how it is transmitted and distributed to how it is used.

Improved system efficiencies could then translate to cost savings for end users, however perhaps as significant are the improvements in user experience, convenience and engagement that could come from digitalisation; smart use of data has the potential to improve understanding of consumer needs and preferences, which could in turn lead to disruptive business models which provide better services and more comfortable homes and offices (CEER, 2019; Energy Systems Catapult, 2018a). This is explored further in Section 5.

Digital energy platforms, such as those described in Section 4.3, aim to deliver these benefits. For example, platforms providing grid and flexibility services could improve system efficiencies, while P2P platforms could result in increased levels of consumer engagement (Morstyn et al, 2018). The value can only be realised if energy data[4] is available, accessible and of good enough quality. In many cases, however, none of these requirements are yet met, and the data landscape has been cited as a barrier not only to existing operational inefficiencies, but to new entrants who could develop the solutions and business models to address these (Energy Systems Catapult, 2018a). This is explored more in Section 5.

Figure 1: Future decentralised energy system[3] – redrawn from World Economic Forum, 2017.



3 The future electricity system is likely to see more decentralised energy assets and resources – including generation, storage, and electric vehicles – connected to the network. Digitalisation of this network will allow data, communications and analytics to be used to improve the efficiency, resilience and experience of the energy system. Customers are likely to have a more active role than they do today; individually owned assets can provide flexibility to the system, and new markets could allow trading between households or communities. Black and red represent old/existing and new/future components of the system.

4 Defined by the Energy Data Task Force as "Facts and statistics collected together in an accessible digital format which describe the Energy System and its operation (current, historic and forecast), including: the presence and state of infrastructure, operation of the system, associated market operations, policy and regulation." (Energy Systems Catapult, 2019c).

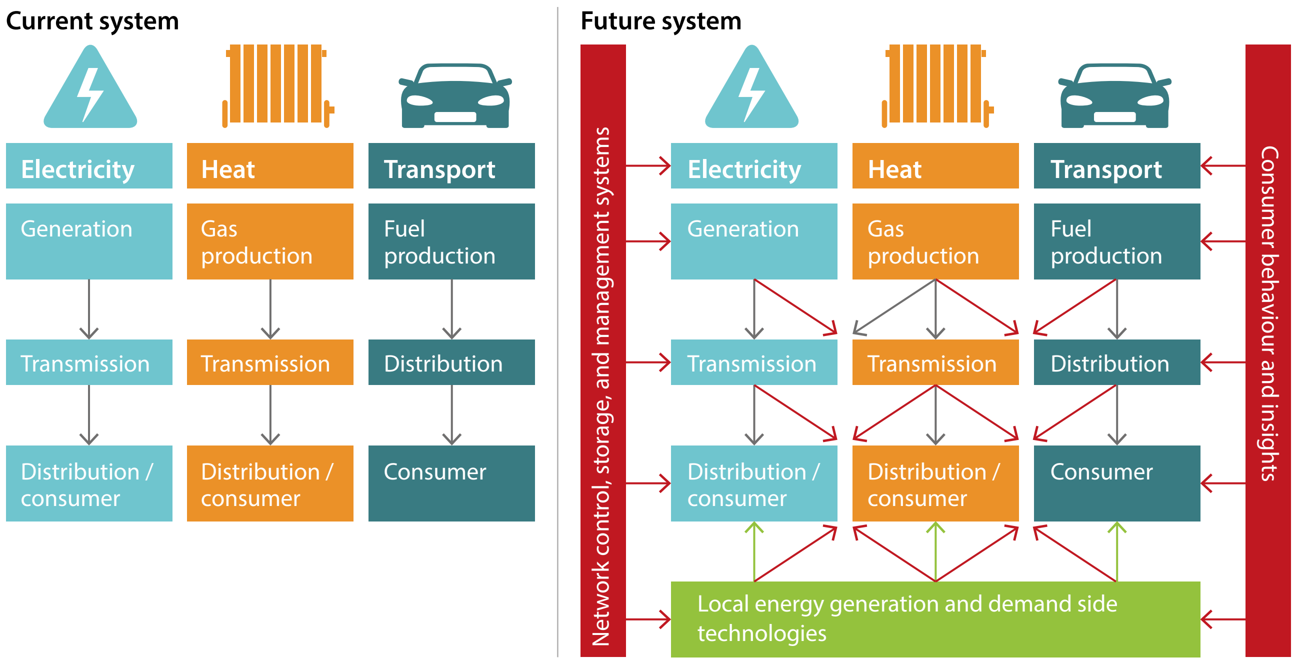
3.2 Decarbonisation

Following the Government committing the UK to a legally binding target of net zero emissions by 2050 (HM Government, 2019), the aim to decarbonise should underpin every decision made in the energy system. In February 2020, Ofgem released its first ever decarbonisation action plan, outlining nine actions the regulator will take over the subsequent 18 months to lead the sector further towards the net zero target (Ofgem, 2020d).

Progress in decarbonisation of the UK's power sector has been made possible largely because of the rise of renewable energy technologies, such as solar and wind power, which in 2019 accounted for almost half of electricity in the UK (Ofgem, 2020d; Staffell et al, 2019; Committee on Climate Change, 2019). However, other areas of the energy sector – most notably heating and transport – have yet to see meaningful progress, with low carbon sources responsible for just 5% of energy used to heat homes, (Ofgem, 2020d) and battery electric vehicles holding a market share of less than 1% in 2019 (SMMT, 2019). As progress is made in these energy services, there will be a trend towards a more integrated energy system where the boundaries between the electricity, heat and transport sectors become blurred (Figure 2), and which will demand a much more flexible, sophisticated and responsive whole energy system, including energy. See Box 2 for more information about flexibility in an energy context.

A 'systems thinking' approach – that is, one that considers interrelationships and patterns across different elements of the energy system, rather than static and individual parts (Energy Systems Catapult, 2018c) – will be required to fully decarbonise the sector. A significant increase in capacity of renewable generation technologies is likely, and thus the energy system must become much more flexible and responsive to manage variability of the output, and maximise utilisation of available renewable resources (Energy Systems Catapult, 2018c).

Figure 2: The current energy system is siloed, whilst the future energy system must become more integrated and multi-vector. Adapted from Energy Systems Catapult image (German, 2017).



The UK Government published its Smart Systems and Flexibility Plan (BEIS, 2019b) in 2017, and a progress update the following year. (BEIS, 2017b) Ofgem's decarbonisation plan includes steps to improve flexibility in the electricity system partly through the use of technology which facilitate flexibility, automated demand-side response, storage, aggregation and trading (Staffell et al, 2019).

Digital energy platforms are considered one of these enabling technologies as they can facilitate the trading and dispatch of flexibility (Ofgem, 2019c). The types of platforms that are emerging vary depending on which energy system trends and requirements they are driven by. The types and roles of digital energy platforms are explored more in Section 4.3.

Box 2: Flexibility in an energy context

Flexibility is defined by Ofgem (the energy regulator) as

> "…the ability of users on the network to quickly change their operations (e.g. modifying generation and or consumption patterns) in reaction to an external signal (e.g., change in price) in order to provide system services." (Ofgem, 2020d)

These services include things like supporting system balancing (matching supply and demand) and managing network constraints (congestion).

Traditionally, the main source of flexibility in the energy system is on the supply side, through generation; when demand is higher than supply, generators are asked to turn up their output (or switch on), and when demand drops they turn down (or off) (Ofgem, 2020b). Supply follows demand. As the generation landscape changes – i.e. we increasingly switch to variable energy sources – this option becomes insufficient on its own.

Demand side flexibility (DSF), or demand side response (DSR), is an option which flips the supply/demand relationship so that demand instead follows supply – we make the most of times when we generate more than we need and find ways to reduce our usage when generation levels are low. It requires end users to change their patterns of consumption in response to a signal (e.g. price).

Energy storage (including batteries) can also deliver flexibility services by charging up when electricity is abundant (and hence cheap) and used at a later date.

Cross-vector flexibility is the concept of using more than one energy 'vector' (e.g. electricity, heat, gas) to better manage fluctuations in supply and demand. This type of flexibility will become increasingly important as traditionally distinct components of the sector (e.g. electrical power, transport, heating) become more integrated (Energy Systems Catapult, 2018b).

3.3 Decentralisation

Largely as a result of decarbonisation, the UK's energy landscape is becoming increasingly decentralised, meaning it is based at or near the energy user, usually connected to the local distribution network (Competition and Markets Authority, 2016). This is particularly notable in the electricity system, where distributed generation now represents over a quarter of total GB capacity, the majority of which is from renewable sources which tend to be less energy dense and more modular than fossil fuelled power stations (Bray et al, 2018; Ofgem, 2017). Energy assets are no longer solely the domain of large developers and suppliers; they are owned by individuals and communities in forms such as solar panels, electric vehicles and batteries.

Whilst decentralisation offers many opportunities (including decarbonisation and reduced transmission losses, see Association for Decentralised Energy), it also has significant implications for system balancing costs which have risen over time, with 2018-19 seeing the second-highest level at £1.19 billion[5] (Ofgem, 2019g). The Committee on Climate Change (CCC) estimate that improving the flexibility of the GB electricity system and making better use of low carbon generation could translate to system cost savings of £3–8 bn per year to by 2030 and £16 bn per year by 2050 (Committee on Climate Change, 2015).

The increased pressure at distribution level is driving the need for local balancing and grid management. Ofgem research has concluded that many of the assets[6] that are required to deliver such a system are already connected to the grid (Ofgem, 2019g). What is lacking, however, is the enabling technologies which will allow these distributed assets to feature positively in the system. Energy platforms such as virtual power plants, local energy marketplaces and flexibility platforms are examples of enabling technologies which could be used to defer or even avoid grid reinforcements, by supporting better utilisation of distributed energy resources (Ofgem, 2019c).

3.4 Democratisation

The final 'D' – democratisation – is partly the result of decentralisation and digitalisation, and is considered by some as a necessary mechanism for accelerating the transition (Burke and Stephens, 2017; Judson et al, 2020). It is the concept of including citizens in the energy system in an involved and active way.

In the current system, individuals are usually thought of as 'consumers' or 'end users', i.e. they sit at the end of the energy value chain and have few chances to influence how energy is generated, distributed or sold. However, the rise of smaller-scale distributed energy assets (such as rooftop solar panels, domestic batteries and EVs) owned by individuals or 'prosumers' means that the way that we interact with energy will need to fundamentally change (Ofgem, 2020d). The scale of the required behaviour change will be no easy feat considering the current high levels of disengagement in the sector (Competition and Markets Authority, 2016).

Civic engagement presents the chance to encourage the necessary behaviour change and accelerate the transition to a decarbonised sector. By providing new roles and pathways for citizens and communities to engage with their energy systems in a meaningful way, they are given the chance to have a level of control over how they use energy and thus take a lead in the transition (Ofgem, 2020d). This is discussed later in Section 7.2.2.

A rise in new digital energy platforms that can promote and enable civic engagement can be observed both within the UK and across the world, for example peer-to-peer trading (see, for example, Case study 1 and others[7]) and local energy marketplaces (see Case study 4) specifically designed to facilitate trading of energy by smaller players, including individuals, communities and regions (Burke and Stephens, 2017; Morstyn et al, 2018). The potential for civic engagement is also widening with the enhancement of home energy management systems (see Case study 2), which are giving more control to consumers.

5 2016–17 saw the highest ever electricity balancing costs at £1.21 billion (Ofgem, 2019g).

6 Including, at household level, rooftop solar panels, household batteries and electric vehicles (EVs), and also larger-scale distributed resources.

7 For example, the launch of the Global Observatory on Peer-to-Peer, Community Self-Consumption and Transactive Energy Models.

4 Introduction to digital energy platforms

4.1 The importance of definitions

Definitions are important. They provide a framework for a common language and vocabulary across and between sectors. They matter because they can affect how an asset or approach is treated from a policy and regulatory standpoint. For example, in our first review we found that definitions can affect how easy it is to deploy electricity generation assets; development of a generation project with a capacity of 50MW or above is classed as a 'nationally significant infrastructure project' and is subject to a different part of the planning system, causing a clustering of developments at 49.9MWs (Morris and Hardy, 2019).

Different types of digital energy platforms are emerging which vary according to characteristics including:

- Their purpose – what role they play and the functions they perform (for example whether they are a local or national platform).
- The users communicating and interacting over the platform (for example buyers and sellers).
- The drivers that led to the creation of the platform (For example specific aspects of decarbonisation, decentralisation, digitalisation and democratisation).

However, it became clear during this review that the lack of clear and widely adopted definitions of the different types of platforms is an issue in this area. This has been recognised by Ofgem who, in their recently published Future Insights paper on Flexibility Platforms in electricity markets, stated that:

> "There is a majority view of a level of uncertainty or a lack of clarity around the terminology being used when discussing Flexibility Platforms." (Ofgem, 2019c)

Ofgem has recommended that the industry work on creating these by building on existing work being done in the area, including that by the Electricity Networks Association Open Networks Project (ENA ONP), the Energy Data Task Force, and Regen.

In the absence of a widely adopted industry definition, within this review we adopt the definition of platforms as:

> "…digital spaces where users can communicate and interact with each other and get (temporary or permanent) access to products, services, or more broadly 'resources' provided by peers or organisations." (Kloppenburg and Boekelo, 2019)

The core concept of digital energy platforms remains the same as for other sectors; rather than business models based on owning physical assets and resources (like generation or network infrastructure), platforms provide connections between users who can offer products or services (like production or flexibility) and those who need them.

4.2 Progress of digital energy platforms

Overall progress in sector is lagging behind that of others; they have yet to influence business models and activities to the same extent as digital platforms in other sectors.

The value that platforms can bring has been described as coming "from ICT[8] and the associated complementary innovation that increases utility and attractiveness of the platform to all user groups". In energy, however, not all user groups have access to this ICT and innovation.

One of the barriers is current regulatory arrangements, specifically the 'supplier hub' model (Ofgem, 2018d). This positions a single energy supplier as the primary interface between a given customer and the system, limiting opportunities for that customer to influence how energy is generated, transmitted or consumed, instead being viewed principally as 'consumers' who sit at the end of the value chain (Ofgem, 2018d). Domestic consumers cannot, for example, interact with network or system operators (and vice versa). It also means that only holders of supply licences are allowed to sell energy to customers. Ofgem have recognised that the supplier hub model 'may not be fit for purpose for energy consumers over the longer term,' and that it can act as a barrier to consumers realising the full benefits of the increasing levels innovation, digitalisation and competition that are likely because of the energy transition (Ofgem, 2018d). It has now committed to exploring fundamental reforms to this model, but has admitted that, because of the scale of change, this is likely to be a lengthy process (Ofgem, 2018d).

Another barrier to the rise of digital energy platforms is the relatively slow speed at which digitalisation of energy is being realised across the sector. For example, the roll-out of smart metering in the UK, which would greatly improve data quality and access – and hence the potential for consumer benefit – is behind schedule and may not be enough to fill the gaps in data that support digital energy platforms (this is explored further in Section 5.1). Further, whilst smart meter data is, by default, shared with suppliers, DNOs must have a detailed data privacy plan approved by Ofgem before being allowed access, which currently limits DNO visibility of their own network (Ofgem, 2016). As of February 2020, two out of six DNO groups have had such approval (Ofgem, 2018a and 2020a).

Digital energy platforms may face additional challenges that other sectors do not; as an essential service, energy is heavily regulated to protect both the system and its users. However, the way in which this sector is regulated is prescriptive and process-orientated and is arguably no longer fit for purpose given the rapid transformations it is undergoing (Sandys et al, 2018). This paradigm of 'permission-based rules' has been cited as stifling innovation and competition that consumers and wider economy could benefit from (Grossman, 2015; Nesta, 2019). There are calls to move towards a more 'agile and risk reflective' approach which is grounded in information- and outcome-based rules, which could enable the energy regulator to be more future-facing and proactive, allowing emerging technologies, markets and business models to innovate. This is explored further in Section 7.3.

In the case of digital platforms, the energy sector's belated progress puts it in a position to be able to learn valuable lessons from the sectors who have already had experience, such as the consequences of gaps in regulation (more in Box 1) and about what makes a platform successful (or not).

4.3 Types of digital energy platform and their roles

Our review has identified several categories of smart local energy systems digital energy platform, summarised in Table 1 below. The consistency with which these are defined/described varies. In some cases, for example Active Network Management, the terms are well recognised within the energy system, whilst others which are emerging, for example Local Energy Markets, are not.

In Table 1 we present a typology of the digital energy platforms identified in this review. It includes their definition, purpose, key users and drivers. We also include short case studies of examples of the different platforms.

8 Information and communications technology, which is a broad subject but generally covers all uses of digital technology that exist to help individuals, businesses and organisations to use information. In this context, the 'information' (see Box 1 for more on the meanings of data and information) relates to the entire energy system, from how the energy is generated to how it is transmitted and distributed to how it is used.

Table 1: Typology of digital energy platforms

Definition	Purpose of DEP	Key actors	Key drivers
Peer-to-peer | Case Study 1: CommUNITY			
DEPs which facilitate energy trading between individual businesses or prosumers operating at local levels (Ofgem, 2019c)	Allows individuals (peers) to trade energy locally	• Platform operator • Peers (P2P traders) • Electricity suppliers	Growth in DER – particularly behind the meter (decarbonisation and decentralisation) Local and community energy and prosumers Democratisation of energy
Home Energy Management System (HEMS) | Case Study 2: ETI HEMS Trial			
A home energy management system (HEMS) is a technology platform comprised of both hardware and software that allows the user to monitor energy usage and production and to manually control and/or automate the use of energy within a household	The HEMS platform communicates with household devices and the utility, as needed, and receives external information (e.g., solar power production and electricity prices) to improve the energy consumption and production schedule of household devices. The HEMS finds the optimal operation schedule by using a scheduling algorithm, and dispatches signals appropriately	• HEMS owner (households) • HEMS operator (e.g. Nest, Hive, Tado, etc) • HEMS suppliers	Growth in connected devices, machine learning, etc (Digitalisation) Improved energy service (e.g. allows user to optimise in terms of cost, convenience and comfort)
Active Network Management (ANM) | Case Study 3: NINES Project			
In the context of this report, ANM is a digital energy platform that enables flexible network customers to autonomously and in real-time increase the utilisation of network assets without breaching operational limits, thereby reducing the need for reinforcement, speeding up connections and reducing costs	ANM is used to "manage network constraints", to "maintain networks within their normal operating parameters" or to "control and [manage] network equipment and the devices they serve in normal conditions to enhance the utilisation of the network assets and minimise the requirement for their reinforcement"	• Platform operator (DNO, DSO or third party) • Network customers (particularly distributed energy resources) • Future network connectees	Growth in DER (decarbonisation and decentralisation) Smart grids – including ICT, comms and automation developments (digitalisation)

Definition	Purpose of DEP	Key actors	Key drivers
Virtual Power Plant (VPP) / Virtual Energy System (VES, also known as an 'integrated energy system') | Case Study 6: ReFLEX Orkney			
Platform that enables the coordination of distributed energy resources to effectively make them behave like a single, large, predictable source (IRENA, 2019) VPPs tend to be electricity only, whilst VES are cross-vector (electricity, heat and transport for example)	Pooling or aggregation of output and demand from multiple DER to sell into energy or ancillary service markets (Bell and Gill, 2018).	• VPP/VES operator • DER owner/ operator • Aggregators[8] • Customers for energy and energy services	Growth in DER (decarbonisation and decentralisation) Increasing markets for energy system services (e.g. flexibility markets) Increasing need for integration across different energy sectors and vectors to balance and optimise the wider energy system (e.g. electricity, transport and heating)
Local energy market | Case Study 4: Cornwall Local Energy Market			
A virtual local marketplace that provides participants with a platform to buy and sell energy and flexibility both to the grid and the wholesale energy market	Allows trading and balancing of energy locally	• Platform operator • Electricity network and system operators • DER owners/ operators • Aggregators	Growth in DER (decarbonisation and decentralisation) Increasing markets for energy system services (e.g. flexibility markets) Increasing need for transparency national vs. local flexibility needs
Flexibility platform | Case Study 5: Piclo Flex			
An IT platform where the coordination, trading, dispatch and support services for Flexibility Markets take place' (Ofgem, 2019c)	Facilitates flexibility markets by providing a venue for buyers of flexibility to signal their needs and contract for services. Provides signals for investment, incentives for asset owners to make them available on the network	• Platform operator • DNO/DSO (buyer) • Flexibility asset owners/ coordinators/ operators (seller) • Aggregators	Growth in DER (decarbonisation and decentralisation) Increasing markets for energy system services (e.g. flexibility markets)

8 An aggregator is a company who acts as an intermediary between active parties such as distributed energy resources and active customers who can offer services, and System Operators who wish to obtain such services for efficient management of networks. (BEIS, 2017b)

Table notes:

In the table we introduce the terms DNO, DSO and ESO.
These are defined as the following:

DNO = Distribution System Operator – DNOs carry electricity from the high voltage transmission grid to industrial, commercial and domestic users (Ofgem, 2019h).

DSO = Distribution System Operator – securely operates and develops an active distribution system comprising networks, demand, generation and other flexible distributed energy resources (DER). As a neutral facilitator of an open and accessible market it will enable competitive access to markets and the optimal use of DER on distribution networks to deliver security, sustainability and affordability in the support of whole system optimisation. A DSO enables customers to be both producers and consumers; enabling customer access to networks and markets, customer choice and great customer service (ENA, 2018a).

ESO = Electricity System Operator – the electricity system as a whole is operated by a single Electricity System Operator (ESO). This role is performed by National Grid Electricity System Operator (NGESO). NGESO is responsible for ensuring the stable and secure operation of the national electricity transmission system (Ofgem, 2018f).

4.4 Case studies: examples of UK digital energy platforms

Case Study 1: P2P – CommUNITY

What?

EDF, Repowering London and UCL's Energy Institute are undertaking a trial called Project 'CommUNITY'[9] to enable Brixton residents at Elmore House to virtually access electricity generated from a solar PV system on the block's roof, store it in a battery and trade with one another.

Role of digital energy platform?

The proposed market is being trialled on a "live site" comprising a multi-tenant building.

Residents will be allocated a proportion of the energy from the rooftop solar PV system and the battery. They can trade or share energy with one another using a digital platform and a smart phone app.

Delivery of the project was possible after Ofgem provided a regulatory "sandbox". This was required because under current regulations, customers cannot buy from, or sell to, other consumers. The sandbox permits the consortium to work outside the current regulatory framework for the purpose of the trial

Impact

The trial could provide evidence of how peer-to-peer energy trading could fit within current regulations or the changes required to enable it. It also tests the use of virtual shared assets as a solution for residents of multi-occupancy buildings.

Case Study 2: HEMS – ETI HEMS Trial

What?

The Energy Systems Catapult undertook a trial of a consumer orientated Home Energy Management System (HEMS) funded by the Energy Technologies Institute.

The trial replaced the simple (on/off) control heating controls with sophisticated HEMS capable of multi-zone room by room control in 30 gas centrally heated homes. Qualitative and quantitative data was collected throughout winter 2017–18.

Role of HEMS?

The HEMS in-home hub connected sensors (temperature and humidity), wireless radiator valves (WRVs) and boiler controls in the home with the cloud-based control platform. Users sent heating requests via a web-based user interface, and the cloud control and in-home hub applied the required changes the heating in zones around the house via WRVs.

9 Community Urban Neighbourhoods Internal Trading of energY.

The in-home hub also sent data back to the cloud-control platform on temperature (air, radiator and pipe temperature), humidity and electricity and gas usage.

Impact

The trial provided important insight on consumers' heating preferences and building performance. This has been used to inform policy and help industry design high quality low carbon products and services.

The ETI funded work developed the initial concept of heat as a service and trialled the use of the HEMS platform with heat pumps. This was then built on as part of the Energy Systems Catapult Smart Systems and Heat Phase 2 programme2 where HEMS was developed to support a larger trial of the concept of Heat as a Service in 100 homes. The insight has been used to design an agile and scalable real-world trial and demonstration environment to provide innovators with a safe, affordable, space to test products, services and business models, with the aim of de-risking and scaling innovations for market.

Case Study 3: ANM – NINES Project

What?

The Northern Isles New Energy Solutions (NINES) project is situated on the Shetland islands. The islands are not connected to the national electricity network, and the power station which meets most of the current energy demand is ageing. This presents an opportunity to investigate how Shetland's energy demand can be met in a more efficient and sustainable manner.

Role of digital energy platform?

The Active Network Management (ANM) platform connects, monitors and controls several assets on the Island including a large-scale battery, energy storage and water heaters in homes, a thermal store associated with a district heating scheme and several MWs of wind turbines.

The ANM system enables connection of these technologies to the main network ensures they are fully integrated into the energy system and thus can be used in an efficient way, thereby reducing the need to invest in expensive energy network reinforcement.

It does this by taking continuous measurements necessary to automatically control demand and generation, whilst minimising network losses, stabilising the system and detecting faults.

Impact

A recent review of the Orkney ANM scheme identified a solution cost of £500k compared to the £30m alternative reinforcement cost.

Case Study 4: LEM – Cornwall Local Energy Market

What?

The Cornwall Local Energy Market trial (LEM) contains several elements. It is based in a place, Cornwall, in this instance. It has recruited 250 local homes and businesses with distributed energy resources to participate. It has a platform that is an auction-based Distributed Energy Resource flexibility market that allows Distribution Network Operators (DNO) and the Electricity System Operator (ESO) to simultaneously procure flexibility from local distributed energy resources. It has also trialled a blockchain based peer-to-peer energy trading platform to enable local participants (homes and businesses) to buy and/or sell energy within the local energy markets.

Role of digital energy platform?

Currently, the key platform operating in the LEM is Centrica's auction-based flexibility market. Through the platform the local DNO and national ESO can simultaneously procure flexibility from homes and businesses.

The platform allows the local DNO, Western Power Distribution and National Grid ESO to place bids for flexibility services at the same time, with the platform enabling the transmission and distribution networks to co-ordinate their procurement to avoid conflicting signals.

Impact

Centrica claim that this the first platform in the world where the local DNO and ESO are both procuring flexibility simultaneously via a single third-party platform.

Case Study 5: Flexibility market – Piclo Flex

What?

Piclo Flex describes itself as "The independent marketplace for trading energy flexibility online". It is a marketplace with the system operators on one side and flexibility providers on the other side.

Role of digital energy platform?

The Piclo Flex platform is a marketplace that connects buyers of flexibility with providers. For system operators, like Distribution Network Operators, it enables them to transparently and visibly communicate needs for flexibility requirements (such as reinforcement deferral, outages and network resilience) from local distributed energy resources. For local distributed energy resources, (including aggregators of such resources) it provides a route to market to sell flexibility services and lowers the barrier to entry (because it does not discriminate between asset classes).

Impact

To date Piclo has run competitions with most GB DNOs. This has registered more than 300 flexibility providers representing 6.5GW of assets.

Case Study 6: Virtual/integrated energy system – ReFLEX Orkney

What?

ReFLEX Orkney (Responsive Flexibility), one the PFER projects, aims to create a 'smart energy island' – developing a ground-breaking 'integrated energy system' in Orkney which will monitor generation, grid constraint and energy demand and then use smart control of energy technologies to manage and improve the supply-demand balance.

ReFLEX aims to demonstrate how this integrated energy system can incorporate renewable electricity, batteries, electric vehicles, heating systems, and hydrogen to interlink local heat, power and transport networks.

Role of digital energy platform?

Solo Energy, one of the project partners, will implement their FlexiGrid software platform enabling smart monitoring and control of the flexible technologies to charge during periods of peak local renewable generation, and release stored energy during times of peak demand. The project aims to demonstrate that the FlexiGrid software platform can be expanded to a multi-vector integrated energy system.

Impact

Through the project Orkney aims to maximise the potential of its renewable generation capabilities, help to ensure higher quality and more affordable energy services, as well as further lowering its carbon footprint by decreasing reliance on imported carbon-intensive grid electricity from the UK mainland.
It aims to export the integrated energy system model and associated integrated energy service supply framework to other areas across the UK and internationally.

5 Policy and regulatory issue 1: Data and digital energy platforms

5.1 The value of data

Data can be an enabler of change; increasing availability of data is a driver of digitalisation, which in turn is one of the drivers of the emergence of digital energy platforms (see Section 2) (CEER, 2019; IEA, 2017).

The use of energy data underpins the development of many of these platforms, as it is a crucial component for provision of products and services they can offer. VPPs use data relating to energy assets and resources (e.g. geolocation, capacity, current condition/state) in combination with historical household energy data to build prediction algorithms[10] that can improve efficiencies and outcomes (Kloppenburg and Boekelo, 2019). Data about market prices and grid balance can be used to automate processes such as steering energy flows to and from storage devices, an essential component of flexibility and ANM platforms (Kloppenburg and Boekelo, 2019). P2P and local trading platforms rely on production and consumption indicators to algorithmically match supply and demand. HEMS rely on precise consumption data to gain information about usage patterns and tailor services to suit individual users. As the proportion of energy demand met by intermittent renewables like solar and wind increases, weather forecasting data will also be essential to develop a smart and flexible energy system.

Ensuring that the energy data that is generated is accurate, precise and accessible is critical, so that the information gained from it can result in positive contributions to the energy system. A note explaining the meanings of 'data' and 'information' can be found in Box 3.

As well as requiring input data for development, the products and services that digital energy platforms provide can also create valuable new or improved data, for example about consumer usage and preferences or local system conditions and requirements.

Platform owners can use this data to improve their own businesses, but it also provides opportunities to create value for the wider energy system and across other sectors and systems (e.g. transport, health (Fell et al, 2017)) it interacts with. The business models of digital platforms in other sectors (e.g. social media, finance, mobility) often involve indirect monetisation from the value their data create elsewhere (e.g. advertising and marketing).

Ensuring that any data generated, stored and used by platforms – and any other stakeholders they share it with – is done so in a way that protects the systems (energy, and others it may relate to) and their users is essential for digitalisation activities across the sector.

10 Put simply, algorithms are step-by-step procedures for solving a problem or accomplishing some task, which are based on an initial situation (i.e. input data) (BBC Bitesize; Merriam-Webster).

Box 3: Data vs information

Crucially, 'data' and 'information' are not interchangeable, and their distinctions can have important implications.

Data are simply collections of recorded values – facts and figures. These facts and figures can take the form of numbers, dates, characters, Boolean (true or false) and more. Even voids (i.e. no data) can be important values. **Datasets** are structured collections of related data.

Only once **data** (or **datasets**) are processed, interpreted and presented in a specific situation can they become useful **information**, for example the answer to a particular question, or representation of a fact.

Extracting this information from **data** requires specialised **skills**.

For example, in the power sector, the recorded output values from individual generators at a given time (the data) makes up a dataset describing total electricity generation. Processing and interpretation of this alongside additional electricity consumption datasets gives the skilled System Operator vital information about whether the system is in balance or not, and what action needs to be taken.

It is therefore vital that the data is of high quality, but it is also vital that the data is accessible by organisations/actors who have the skills to extract useful information – and hence value – from it. This could be the data owner, but may alternatively be a third party actor.

As the use of data continues to transform the energy system – and other systems it interacts with– policy and regulation will need to keep pace to safeguard the interests of both the energy system and its users. Policies and regulations relating to data are likely to have significant impact on the development of digital energy platforms, potentially shaping how and whether they fit into the current system or are able to transform it.

The UK Government has recognised that increasing use of data will be fundamental to the future of our economy; it is now considered one of the four Grand Challenges in the Industrial Strategy, (BEIS, 2017a; Energy Systems Catapult, 2019c) and in 2018, the Government and Ofgem set up an Energy Data Taskforce to investigate 'how the use of data could be transformed across our energy system' (Ofgem, 2019a). In June 2019 the Taskforce released its first report which looked at the current state of data utilisation in energy, and found that a lack of sector-wide strategy has led to an energy data landscape which is extremely complex and fragmented, making it 'unsustainable' (Energy Systems Catapult, 2019c). It made a series of recommendations which are listed in Box 4.

Our review flagged a number of areas – consistent with those identified by the Taskforce – in which energy system data needs to improve for digital energy platforms to emerge and contribute to a transition in a net-zero context. These are outlined in the following sections.

Box 4: **Energy Data Taskforce recommendations**

1. **Digitalisation of the Energy System** – improving data quality, coverage and skills to enable more effective use of data that helps meet the demands of the future.
2. **Maximising the value of data** – Switch to a system of Presumed Open data (except where restrictions are justifiable) to support innovation, operational excellence and transparency.
3. **Visibility of data** – establishment of a Data Catalogue, with industry participation mandated by the Government and Ofgem.
4. **Coordination of asset registration** – establishment of an Asset Registration Strategy to coordinate registration of energy assets.
5. **Visibility of infrastructure and assets** – establishment of a unified Digital System Map to increase visibility of infrastructure and assets.

Implications for SLES

Many of the PFER projects include one or more digital energy platforms. In order to ensure they can progress beyond demonstration; the energy sector should adopt and implement the recommendations of the Energy Data Taskforce. The PFER programme is also important for producing new evidence and learning on the value of data and digitalisation of energy.

5.2 Missing data

For data to contribute to a smart and flexible energy system, it first must be generated and collected. (CEER, 2019) While the volume of energy system data is increasing, the quality is often poor, in some cases inaccurate, imprecise or party or wholly missing (CEER, 2019; Energy Systems Catapult, 2018a). This 'missing' data can include that which exists only in a non-digital format, that which has been collected but not stored for additional purposes, and that which simply hasn't been collected, and is an issue across the entire energy value chain, from production to transmission to consumption (CEER, 2019; Energy Systems Catapult, 2019c). The low quality of existing energy data has been in part attributed to the lack of incentives to create and maintain high quality data sets (Energy Systems Catapult, 2018a).

Smart metering

One of the biggest efforts to fill in the gaps in energy consumption and demand data is the introduction of 'smart meters'[11] in residential and small business properties. This rollout aims to fill some of the gaps in data by storing information about energy use every 30 minutes, bringing this in line with the timescales on which energy is traded in the market. The UK Government estimated that the rollout could achieve overall cost benefits of £19.5 bn by 2034,[12] including almost £1.4 bn due to demand shifting and £6.2 bn in consumer energy savings (BEIS, 2019d).

The EU's Smart Meter Rollout Directive, introduced in 2009, mandated that member states should achieve at least an 80% rollout of smart metering by 2020, but the more recent Clean Energy for all Europeans Package has proposed moving this deadline to 2024 (European Commission, 2019). The UK Government consulted in Autumn 2019 on proposals for a new regulatory framework to drive smart meter installations beyond the end of 2020 (BEIS, 2019c).

11 Smart meters can send meter readings electronically and automatically to energy suppliers. When paired with an in-home display device, customers can see near real-time consumption in terms of both energy usage (kWh) and cost (pounds and pence) (Smart Energy GB).

12 These benefits are relative to a counterfactual scenario defining a state of the world that was deemed 'mostly likely' in the absence of the smart metering programme (Energy Systems Catapult, 2019b).

Although the installation of smart meters is widely considered critical for the development of the sector, criticisms of the rollout programme include the delays[13] and rising costs (initially projected at £13.4 bn) (Data Communications Company; Energy UK, 2020; National Audit Office, 2018). There are also some concerns around the fact that customers are not obliged to provide half-hourly usage data to suppliers (Frerk, 2019); The half-hourly data can be collected by the Data Communications Company (DCC) once requested by an authorised user, and although the supplier has the right to access monthly data (higher resolution, with consumer consent (opt out)), third party users need both consumer consent and 'approved user' authorisation from the DCC to access the data (Energy Systems Catapult, 2018a). Some also believe that half-hourly data is not granular enough, and that the information needs to be much closer to real time; the European Commission aims to move to a settlement period of 15 minutes (European Commission, 2016a).

Asset and infrastructure visibility

Another category of 'missing' data is that of the location, capacity and state of existing energy assets (e.g. generation, storage) and infrastructure (e.g. transmission and distribution networks). The historically centralised nature of the system means that data for large generators and transmission network level assets is generally available (CEER, 2019). However, more and more assets are being connected at the distribution level, and in some cases – for example photovoltaics (PVs) and electric vehicles (EVs) – are owned by consumers and exist 'behind the meter' (i.e. onsite, on the users' side of the meter). An estimated 10% of assets are not visible to the electricity system operator, and this number is expected to grow as the number of distributed assets increases (Energy Systems Catapult, 2019c). Yet without this data, the risk to system stability becomes higher; visibility of assets, their operation and how they interact with each other at both local and national levels will be required to maintain or improve the operational resilience of the system (ENA, 2018d; Energy Systems Catapult, 2019c). This data will also be key to the success of digital energy platforms such as those based on aggregator and VPP/VES models. Currently, however, DNOs lack knowledge of their own networks; the current strategy of multiple asset registration portals – which lack interoperability between them – means that there are significant gaps in the coverage of assets captured in registration system, and system operators and regulators have little oversight over assets connected to their system (Energy Systems Catapult, 2018a and 2019a). Further, whilst smart meter data is, by default, shared with suppliers, DNOs wishing to access it must get Ofgem approval of detailed data privacy plans. To date, only two out of six DNOs have had such approval.

One of the Energy Data Taskforce's recommendations is increasing the visibility of infrastructure and assets through the creation of a 'unified Digital System Map' – a digital presentation of the energy system – that can be used to enable optimisation of the system and investments, and inform the creation of new markets (Energy Systems Catapult, 2019c).

Common standards

The Taskforce identified 'building blocks' required for achieving successful digitalisation of the energy sector, including the creation of a 'Data Catalogue', to provide visibility of energy datasets, and an 'Asset Registration Strategy' that is coordinated across the sector (Energy Systems Catapult, 2019c). Underpinning both of these, as well as concept of a unified system map, is the requirement for some level of common standards in the way data and assets are generated, recorded, stored and shared.

In Ofgem's Future Insights report on Flexible Platforms in electricity markets, it is acknowledged that 'standards and harmonisation' are becoming increasingly important, and some examples of types of standards are outlined[14] (Ofgem, 2019c).

13 As of end 2019, 30% of all meters were smart meters operating in smart mode or with advanced functionality (BEIS, 2020b).

14 Including common protocols for data sharing, and universal definitions of asset and product characteristics (Ofgem, 2019c). Other initiatives on standards are being driven by the European Commission, BEIS and the BSI (British Standards Institution, 2019a and 2019b; CENELEC, 2019).

It was also highlighted in this report, however, that developing standards in an area that is still emerging (and therefore changeable) can be risky. Standards developed by the regulator, particularly for a rapidly changing area, risk becoming obsolete and unfitting as the sector progresses.

On the other hand, an industry-led process risks monopoly powers developing from competing systems and standards, and could also create barriers to entry for new platform operators if cooperation with incumbents is required (Ofgem, 2019c). In the more recent decarbonisation plan, Ofgem pledged to 'work to promote the standardisation of products and processes and enhanced data management and data sharing to enable flexibility markets' (Ofgem, 2020d).

The Energy Data Taskforce take the view that, where the value of standardisation can be recognised, industry will be well-placed to lead development, with market goals used to push consistency and interoperability (Energy Systems Catapult, 2019c). In cases where the value to actors is either minor or unequally distributed, the Taskforce acknowledge that government or the regulator may need to step in to lead the development of standards, and also ensure their adoption where industry is reluctant or slow to do so. Common standards that enable interoperability are often viewed as a negative for businesses; this is also true for digital platforms who strive to develop a unique selling point, which may involve preventing integration with other platforms from other companies.[15] Identifying and understanding where there are opportunities for the entire the entire industry to benefit from common standards will therefore be key. Ensuring that standards do not stifle innovation will also be crucial. Energy can learn from other sectors; the telecommunications industry, for example, implemented a common framework to its core whilst still leaving room for entrepreneurship (GSMA, 2020).

The Taskforce called for establishment of a 'data catalogue' of standardised metadata of datasets across government, the regulator and industry, with mandatory participation for industry (Energy Systems Catapult, 2019c). They recommend that such a catalogue must be underpinned by a common glossary, demonstrating value in sector-wide agreement on definitions (see Section 4 of this report for more on definitions). It recommends creation of an 'Asset Registration Strategy' to coordinate the collection of this data, as well as a unified 'digital system map' of infrastructure and assets.

Data Interoperability

Interoperability – a theme which also came up in the first review in this series on EVs and electricity storage – has been identified as a necessity for successful development of a smart, flexible energy system. (CEER, 2019; ENA, 2019; Energy Systems Catapult, 2019b and 2019c; Mee, 2018; Ofgem, 2019c and 2019e; BEIS and Ofgem, 2017).

The current lack of common standards means that approaches vary not only across the industry, but sometimes even within companies (Energy Systems Catapult, 2019c). This means that although a large amount of useful data about the energy system does exist, it is not interoperable (or sometimes accessible) between different actors in the system. This is caused by variations in the way data is collected, stored and processed and is already an issue for current market participants (incumbents) in terms of collaboration and system optimisation, and is cited as a significant barrier to entry for innovators (CEER, 2019; Energy Systems Catapult, 2019c).

The concept of interoperability goes beyond whether physical elements and devices are compatible; the Energy Systems Catapult has defined 6 main types of interoperability illustrated in Table 2:

15 For example, Apple and Google both built operating systems (platforms) – iOS and Android, respectively – which have limited interoperability; app developers must build a different version for each platform, and they are not transferable between devices built by each of the companies. Devices running on one platform have limited capabilities to be integrated with those running on the other. This is a deliberate decision to encourage customers to be remain 'loyal' to either company by effectively locking them into one of the platforms.

Data interoperability is a crucial component of consumer, commercial, device and vector interoperability. As the lines between historically distinct sectors – such as heat, transport and power – become increasingly blurred, being able to use and extract value from different datasets becomes increasingly important (Energy Systems Catapult, 2019c). Often acting as third-party intermediaries, many digital energy platforms rely on network, usage, infrastructure and asset data to be able to deliver their products and services (e.g. grid and flexibility services, trading and exchange transactions) (Ofgem, 2019c). Building in a level of consistency to system data is critical to the efficiency and value of these platforms. It is also important for ensuring that technology neutrality and competition are promoted, and for avoiding the 'lock-in' of platforms with particular vendors (and vice-versa), or 'lock-out' of participants from certain markets.(CEER, 2019)

Innovate UK, supported by BEIS and Ofgem, established a funding competition – Modernising Energy Data Access – to create opportunities for innovators to test and deliver ways to ensure that digital energy information can be shared between energy organisations and with other stakeholders (Innovate UK, 2019; Ofgem, 2019).

Skills

The production and maintenance of high-quality data and information is not simply a technical issue; it requires development of skills and know-how within not only industry organisations but also the government and regulator.(CEER, 2019; Energy Systems Catapult, 2019c). Skills needed include understanding what data does and does not exist as well as being able to identify the importance of and extract value (the information – see Box 2) from datasets, which will become particularly important as the volume of collected data dramatically increases with smart meter installations.(CEER, 2019)

Table 2: Types of interoperability defined by the Energy Systems Catapult (Energy Systems Catapult, 2019b; Mee, 2018)

Interoperability 'type'	Description
Consumer interoperability	Ensuring that provisions exist for consumers to switch between different commercial offers and technology choices.
Commercial interoperability	Ensuring that incentives are aligned across the energy system to enable value can flow where it needs to, driven by market forces.
Data interoperability	Ensuring the sharing and portability of data between different systems.
Device interoperability	Ensuring that devices are swappable, replaceable and exchangeable, as needs change and technologies develop. Allow consumers to make informed choices between open and closed ecosystems.
Physical interoperability	Ensuring that energy systems function end-to-end, as compatible elements of a wider system.
Vector interoperability	Ensuring that energy provisions across gas, electricity, heat, transport fuels, etc. are compatible with one another and that coordination occurs in a timely fashion.

Implications

Missing data issues manifest particularly in local energy projects because these focus on areas where data is lacking such as distributed energy resources, distribution networks and end consumers. This presents challenges for such projects, but also opportunities to demonstrate new ways to improve visibility of assets and systems, for example through digital energy platforms. Consequently, PFER projects could be a beneficiary of the adoption of the Energy Data Taskforce recommendations. The projects could also provide important new evidence to inform policy and regulatory developments on data standards and interoperability.

5.3 Access, sharing and privacy

5.3.1 Industry data

Creation of high-quality energy system data is crucial, but its value to the system as a whole cannot be fully realised unless the data owners are willing to share it with multiple actors across the energy value chain. For digital energy platforms – especially those operating as third-party providers of products and services – access to system data can be crucial to business models and operations. In a local energy context, this dependency is likely to be even more pronounced; platforms creating local energy marketplaces, for example, will rely on access to asset and network data, while P2P platforms and those providing demand-side response services need data on individual consumer behaviour, which is currently held by the supplier.

It is widely recognised that in today's system, the amount of energy data that is open, searchable and understandable is insufficient, particularly at distribution network level. These flaws are cited as barriers to more integrated planning, efficient system operation and competition, but also to innovation. (Bell and Gill, 2018; Bray et al, 2018; CEER, 2019; Energy Systems Catapult, 2019c).

The value propositions from new products or services enabled by digitalisation of the sector may come from 'unexpected sources', including those not currently involved in the energy sector, and it is not necessarily the organisations who collect and control the data that are able to extract its full value.(CEER, 2019; Energy Systems Catapult, 2018a and 2019c). In other words, making energy data discoverable and understandable could enable innovative solutions and services to be developed by those who would otherwise not have access to it.

There is, undoubtedly, a technical component to creating an open access data landscape. Other than the complexity of implementing common standards and approaches in collecting the data (see Section 5.1), data protection regulations – including GDPR[16] and DAPF[17] – are often cited as explanations for today's closed data environment (Bray et al, 2018). However, in the ESC's Energy Data Review this stance was challenged, and it was argued that in fact 'overly strict' terms and conditions are limiting the ability of others to extract value (Energy Systems Catapult, 2018a). It was argued that commercial and political factors are likely to also be at play; data is a valuable asset already being used for commercial benefit by companies with access to it, and since sharing it can encourage and facilitate innovation – and hence market disruption – those companies may be reluctant to make their datasets accessible to others (Energy Systems Catapult, 2018a). A lack of clarity of how the wider system and its actors can benefit from sharing appropriate levels of data is hindering advancement of the sector.

16 The General Data Protection Regulation 2016/679 (commonly known as 'GDPR') is an EU law on data protection which came into force in May 2018.

17 UK Data Access and Privacy Framework – essentially the same as GDPR.

The Energy Data Taskforce therefore recommends that a core focus of the sector should be recognising that a shift to a system where data is 'presumed open'[18] will result in improvements in efficiency, competition and innovation across the board. It calls on government and Ofgem to direct the sector to adopt the principle, recognising that an industry-led approach may be too slow. Others have also called for government and Ofgem to provide regulatory clarify over what data should be considered a 'public good', and therefore be shared.

5.3.2 Consumer data

Access to (near) real-time consumer usage data will become crucial as the trend of decentralisation continues and the role of demand-side flexibility (see Box 1) increases. This access is not always currently available and this review has identified issues caused by regulations and by concerns over consumer privacy.

Settlement arrangements

One barrier to accessing necessary consumer data is the current regulatory arrangements with settlement meter data. Settlement is essentially the process of determining the difference in electricity bought (from a generator) and sold (to a consumer) by a supplier.[19] The regulatory process is currently compartmentalised by supplier; the sole supplier is responsible for a customer's settlement meter. This presents a barrier particularly to platform models based on P2P trading and demand-side flexibility; as it stands now, all participants of a given platform must share the same supplier for half-hourly usage data to be used (if available). This not only reduces the platform's access to the market and ability to provide useful services, but also limits customers' freedom of choice and convenience.

Ofgem are addressing this issue as part of the Settlement Reform Significant Code Review (SCR) by developing a Target Operating Model (TOM) (Ofgem, 2019b). One of the key requirements identified is the ability for more than one service (or supplier) to be associated with a single metering point. A code modification (see Box 5), P379 'Multiple Suppliers through Meter Splitting', was proposed in January 2019 which, if accepted, would allow consumers to be supplied by multiple suppliers, through the Balancing and Settlement Code (BSC) (ELEXON, 2019b). The modification was raised by New Anglia Energy, a new BSC entrant, with support from a range of other parties, including digital energy platform company, Verv,[20] who are not a BSC party. ELEXON, the Code Administrator of the BSC, are in the process of undertaking a cost benefit analysis for P379. An update was due in May 2020 but has been delayed by three months due to the COVID-19 pandemic (ELEXON, 2019b).

This code modification would allow customers to both buy and sell electricity from/to multiple providers, which could unlock value for digital energy platforms such peer-to-peer trading, local energy marketplaces, and those that focus on demand-side flexibility. It is also expected to create competition by removing the need to reach an agreement with a single default supplier.

18 Except where doing so would compromise consumer rights/protection or system security.

19 The settlement process is divided between Central Volume Allocation (CVA) and Supplier Volume Allocation (CVA). CVA is applied to parties with sites directly connected to the transmission network and are metered on a half-hourly basis, with centrally processed data. SVA is for parties connected to the transmission network via the distribution network, which is split into 14 regions ('grid supply point groups'). SVA site metering is not necessarily half-hourly – many sites have traditional meters with data collected by the suppliers' agent manually on a monthly, quarterly or even annual basis. The difference in energy bought and sold by the supplier is calculated using aggregated supplier meter volumes compared to the metered flows into the grid supply point group (Ofgem, 2019b).

20 Verv use artificial intelligence to gain data insights to optimise home appliances.

Box 5: Industry codes

What are industry codes?

Industry codes contain the contractual rules and governance agreements that underpin the operation of the energy industry in GB. They define the terms under which participants can access networks and operate in the market, and participants are required to become party to, or comply with, the codes that apply to their specific activities.

Although any amendments to the codes must be approved by Ofgem, modifications are initiated by industry stakeholders and facilitated by Code Administrators (who must, themselves, comply with the industry's Code Administration Code of Practice). The GB energy industry is therefore partly self-regulated.

Issues with industry codes

In 2018 Ofgem launched a review of energy codes following criticisms from industry about the system and governance, pointing out that it is (Ofgem, 2018c, Ofgem and BEIS, 2019):

- Slow to take decisions.
- Reactive to existing problems, rather than forward-looking in preparing the energy system for future changes.
- Overly complex, with the entirety of the codes estimated to run to over 10,000 pages and weighing 50 kg. This is a barrier to new entrants and to innovation.
- Resource-intensive, leading to a lack of representation from smaller and/or newer parties.
- Lacking coordination between the different code bodies.
- Fragmented, with a large number of code panels and bodies which provides for a complex institutional landscape, making it difficult to take forward systemic changes to the rules.

Consumer protection

The potential to misuse the high volumes and quality of consumer and system data has been cited as a key consideration in the development of mechanisms to allow the sharing of data both within the sector and beyond (CEER, 2019). The types of data held by energy suppliers, for example, includes that which is customer sensitive (e.g. banking and personally identifiable data) and commercially sensitive (e.g. trading). Protocols need to be developed which allow relevant actors to access suitable data without compromising consumer protection or privacy, and these protocols must be well communicated across the industry and to consumers.

In the current regime, consumers are protected by strong privacy protections through the Data Access and Privacy Framework (DAPF). As well as obliging suppliers to obtain consumer consent to obtain half-hourly consumption data, this requires network operators (both gas and electricity) to have Ofgem approval of privacy plans which detail how they will aggregate or anonymise data 'as far as is reasonably practicable'. WPD was the first DNO to have such a plan approved by Ofgem in June 2018, and it wasn't until February 2020 that the second DNO – UKPN – had its plan approved (Ofgem, 2018a and 2020a).

The Centre for Sustainable Energy and Sustainability First have set up a Smart Meter Energy Data Public Interest Advisory Group (PIAG) to investigate how to balance public interest in achieving better societal outcomes with individual rights to privacy and data security. In their final report of Phase 1 of the project, the PIAG concluded that access to smart meter data for public policy purposes is essential to enable policymakers to make appropriate decisions related to the energy transition, and that arrangements currently in place in other sectors could be used in energy to enable access to smart meter data whilst protecting privacy (Frerk, 2019).

Consumer attitudes

Smart metering is being rolled out as a tool to provide the necessary usage data but does not guarantee access to half-hourly meter readings. Firstly, customers are not obliged to accept the installation, and there are concerns that worries about privacy may lead to customers refusing them (Frerk, 2019). If they do, explicit consent must be given for the suppliers to access half hourly meter data, and customers can choose to only allow monthly meter reads.[21] Additionally, rights to access smart meter data, set by the GDPR (EU) and DAPF (UK), justifiably put the consumer in a strong position; usage data is the property of the consumer, and they have the right to control how it is shared (CEER, 2019). Some argue that the constraints are over and above those in place in other industries, such as for broadband and smart phone usage data, (Energy Systems Catapult, 2018a) and that this makes it difficult for utilities to access suitably granular smart meter data.

Regardless, the current rules mean that companies must work hard to ensure their customers trust them to access and use energy usage data to the benefit of the customer and safeguard it against misuse; public attitudes towards data sharing are complex and vary depending on the perceived sensitivity of the data to be shared and the level of trust in the organisation(s) with access to the data (Office for National Statistics, 2014). In 2019, the BEIS Public Attitudes Tracker survey found that 52% of respondents did not trust energy suppliers very much or at all (BEIS, 2019b). Whilst 53% of respondents said they trusted Ofgem (either a lot or a fair amount), around a quarter said they 'did not know' how much they trusted the regulator, potentially indicating a relatively low level of awareness of their role.[22] Reasons for lack of trust in the energy sector have previously been reported (Citizens Advice, 2015) to include:

- Increase in cost of bills
- Levels of profit in the sector
- Poor customer service
- Limited range of tariffs
- Low reliability of service.

Factors contributing to unwillingness to share data include concerns such as confidentiality, anonymity and control, but public acceptability tends to be higher when there is a good understanding of what the data will be used for and what benefits will arise (both personal and wider societal), and provided sufficient security and privacy safeguards are not only put in place but are communicated effectively (Office for National Statistics, 2014).

Encouragingly, public views do not tend to be static; they are shown to change as a result of available information and public debate. Ofgem's research suggests that consumers consider half-hourly energy consumption data to be 'low sensitivity' (compared to, for example, financial and medical records), indicating that the barriers to sharing it are not inherent to the type of data (Ofgem, 2018b). This suggests that, with a sector-wide effort to inform the public about the benefits of sharing data alongside their consumer rights, attitudes will improve. Importantly, financial drivers are not necessarily sufficient on their own to motivate people to share their data; Ofgem survey research found that 26% of participants would be unwilling to share their half-hourly smart meter data even if it meant seeing a discount on their bill (Ofgem, 2018b).

Suggested ways to overcome any actual consumer protection issues include aggregating and anonymising consumption data, introducing noise, redaction and allowing consumers to easily retract consent at any time. The Energy Systems Catapult are working to develop Data Best Practice Guidance (Energy Systems Catapult, 2020) which Ofgem plan to jointly own and iterate with BEIS (Ofgem, 2019i).

21 Daily meter readings can be accessed by suppliers as long as they provide customers with notice of this along with the option to opt out (BEIS, 2019c).

22 Participants were asked about other consumer organisations/groups including Citizens Advice, price comparison websites, trading standards and consumer groups (e.g. Which, Money Saving Expert).Ofgem received the highest proportion of 'don't know' responses at 26%; the next highest level of 'don't know' responses (for trading standards, consumer groups and price comparison websites) was 12%.

Implications:

All of the PFER projects are both users and generators of data. Through the programme that legal and structural barriers to data access are revealed. It is also important that the programme demonstrates the benefits of industry sharing data. As the PFER programme focuses strongly on end consumers it will and should be a source of evidence on the benefit case for accessing public data (like smart meter data). It also has important role in providing evidence of best practice to raise public trust in the energy sector through protecting consumers data and interests.

5.4 System security and resilience

As the trend of decentralisation continues and more assets are connected at the distribution level, ensuring security of supply becomes more complex. Co-ordination between system operators in the future will be key to agreeing processes for data exchanges that guarantee reliable, efficient and affordable operation of energy systems, particularly in the event of localisation of both infrastructure and markets. Flexibility and local energy platforms, for example, will require mechanisms to be in place that ensure interactions with the ESO or DSO do not create any harmful impacts on their respective grids or the wider energy system (ENA, 2019).

The move to make data open and accessible must not, of course, come at the expense of either consumer rights or system security. Both the Energy Data Taskforce and CEER consider that open data and system security are not mutually exclusive propositions, and that in fact in many instances openness of data can support a secure and resilient system. Provided robust security measures are put in place, full digitalisation of the sector could actually make the system more secure; it paves the way for future DSOs to be able to locate network failures or malfunctions more quickly, as well as providing the information required to fix the problem (CEER, 2019).

From a local energy perspective, digitalisation could also open up opportunities for local benefits to participation and support of the networks from local generators and users.

Cyber security will continue to be an important focus across the entire economy, and the UK Government consider the energy network as a 'critical sector', as it has seen regular penetration attempts by state and state-sponsored groups for political, diplomatic, technological, commercial and strategic advantage (HM Government, 2016). Improvements in security measures must therefore keep pace with the rapidly evolving energy sector and the increase in quality and quantity of data that results.

The Network and Information Systems (NIS) Directive was the first piece of EU-wide legislation on cybersecurity. It came into force in August 2016 and in May 2018 was transposed into UK law (European Commission, 2016b; Ofgem, 2020c). The National Cyber Security Centre (NCSC) was launched by the Government in 2016, alongside a five-year cyber security strategy, to build effective cyber security partnerships between government, industry and the public (HM Government, 2016). Ofgem and BEIS, as the identified 'Competent Authorities' for gas and electricity, are now tasked with understanding and responding to threats to system resilience, as the energy data landscape becomes more complex (Energy Systems Catapult, 2018; Ofgem, 2020c). They can engage directly with the NCSC for advice and support on securing networks and systems from cyber threats.

Implications:

The PFER programme has an important role to play in understanding and producing evidence on how smart local energy systems can support and enhance future net-zero energy system security and resilience. Local energy systems can also influence, and be affected by, approaches on cyber security.

6 Policy and regulatory issue 2: Markets

Digital energy platforms have the potential to deliver valuable flexibility services to the energy system, through both demand- and supply-side flexibility measures (see Box 2). Virtual energy systems (see Case study 6) and flexibility platforms (see Case study 5), for example, can unlock the flexibility potential of the vast and growing number of distributed assets on the system which, if business as usual continues, could otherwise be a burden on the system. P2P and local trading platforms could alter how energy is traded in local markets and between consumers. They can make more efficient use of local energy resources, and also provide incentives for consumers to be more engaged in their energy usage.

However, a major theme that emerged during this review was problems with how the flexibility and other services local digital energy platforms offer are valued by current markets. These issues were also prominent in our report on electricity storage and electric vehicles. A detailed account of the issues for storage can be found in our first Working Paper (Morris and Hardy, 2019).

For flexibility more generally, the issues are summarised in the sections below.

6.1 The value of flexibility

Although development of a smart, flexible energy system has been estimated to save up to £8 bn per year up to 2030 compared to an inflexible system (Committee on Climate Change, 2015; Strbac et al, 2016), the market for energy flexibility has recently been described as 'immature' in a joint report highlighting the potential benefits of flexibility by Energy UK,[23] the ADE[24] and BEAMA[25] (Energy UK, 2020). This report argues that more progress is required in key areas, including the wholesale market and balancing services. It calls for more action on flexibility to help the UK meet its fourth and fifth carbon budgets, which it is currently at risk of missing. To meet the updated net-zero emissions target, then, the UK will need to improve its commitment to flexibility; a flexible system can avoid curtailment of existing renewable generation, and is able to better absorb the required increase in intermittent renewables and distributed resources (such as electric vehicles and batteries) (BEIS, 2019b). Development of robust competitive markets for flexibility could both deliver value to consumers and ensure a secure, low carbon energy system by enabling the integration of more renewable generation and improving the efficiency of the system.

In the SSFP, Ofgem and the UK Department for Business, Energy & Industrial Strategy placed an action on network and system operators to 'open up new markets for flexibility, including as alternatives to network reinforcement', recognising that, by placing a monetary value on flexibility, they could help address constraints the electricity network is facing (BEIS, 2019b and 2017b; Ofgem, 2019c). The Open Networks Association have explored different scenarios in which the benefits of flexibility services can be realised with varying degrees of DSO and ESO involvement and coordination (ENA, 2018b).

23 Energy UK is the trade association for the GB energy industry

24 The Association for Decentralised Energy (ADE) is a UK trade association for decentralised energy

25 BEAMA is the UK trade association for manufacturers and providers of energy infrastructure technologies and systems

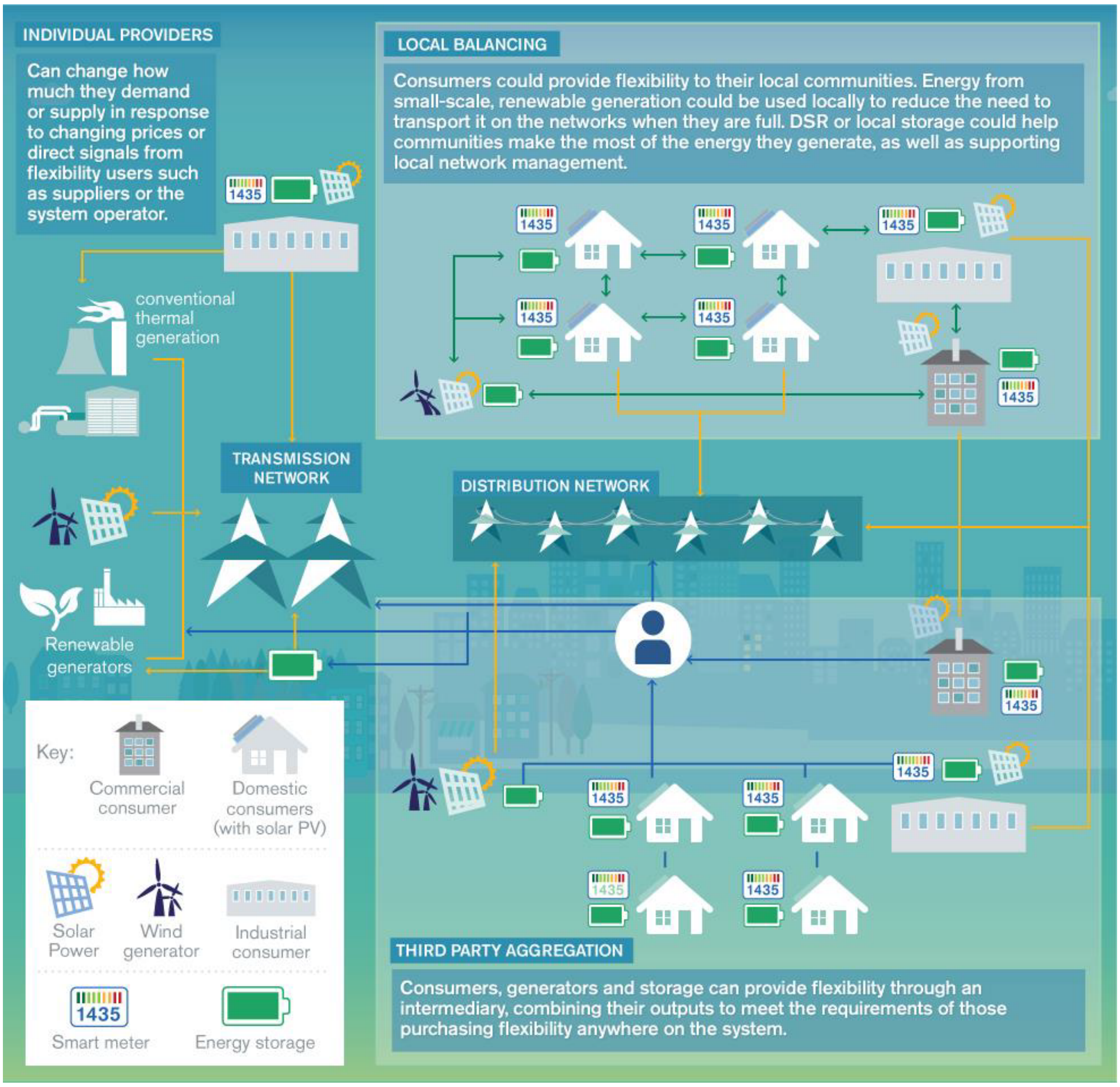


Figure 3: Flexibility in the future energy system[26] – source Ofgem, 2015.

6.2 Current markets

A major issue is that existing markets for flexibility services are at the national level, and were established predominantly for large generators and facilities (such as steel works) connected at transmission level (USEF, 2018). Existing markets tend to be difficult for non-traditional flexibility providers to participate in and earn sufficient revenue. The process of changing rules is difficult and lengthy, requires consultation with both incumbents and new entrants, and needs evidence to support the changes. Against the backdrop of increasing decentralisation of energy, the ability of distributed assets and resources to access markets is crucial for development of a smart and flexible energy system (Bray et al, 2018). There are therefore calls to accelerate changes to these markets to ensure a level playing field for new providers, and for all resources, and to ensure that barriers to entry – both real and perceived – are removed (Bray et al, 2018; CEER, 2019; ENA, 2019).

26 The future system will need to be characterised by the smarter and more efficient use of traditional and new flexibility sources, in order to benefit consumers as much as possible. This figure presents some roles that different sources of flexibility – including individual providers (e.g. consumers and prosumers), local balancing (e.g. local energy markets, P2P trading) and third party aggregation (e.g. VPP/VES, flexibility markets).

6.2.1 Barriers to entry

Wholesale Market

The main mechanism by which energy is bought and sold in GB is the wholesale market. This market remains 'difficult' for those with non-traditional assets to participate in (Energy UK, 2020). Currently, high costs and risks associated with trading in the wholesale market can be prohibitive for smaller providers (Bray et al, 2018; Bray and Group, 2019). More work needs to be done to incentivise flexible behaviour in wholesale markets in terms of increasing time and location granularity (which, in turn, is dependent on adequate data being available – see Section 4). For example, time-of-use tariffs,[27] schemes for self-consumption and enabling distributed energy resources to participate in wholesale markets through, for example, aggregators and VPPs, could motivate customers to alter their usage patterns (CEER, 2019; IRENA, 2019).

Capacity Market

In the SSFP, the Government identified that arrangements in the Capacity Market did not provide a level playing field for all technologies. It has been identified that relatively good progress has been made in this market in terms of encouraging the participation of distributed energy resources such as demand-side response and energy storage (Energy UK, 2020). In the first auction period after the UK Capacity Market was reinstated,[28] DSR technologies secured agreements for up to 533MW of capacity. This is particularly significant considering the suspension was driven by arguments that DSR was treated unfairly by only being eligible to bid for year-long agreements, compared to up to 15 years for new build generation.

The Government has now committed to allowing eligible DSR to access multi-year agreement lengths, levelling the playing field with other technologies competing in this market (BEIS, 2020a).

However, also notable is the fact that this relative success of DSR was partly due to battery storage assets listing as DSR, rather than as generation, as they had tended to previously. The move was made to side-step the de-rating factors[29] applied to batteries registering as generation, which reduced the business case. Whether this 'loophole' in regulation is allowed in future remains to be seen; the Department for Business, Energy & Industrial Strategy (BEIS) has already held a consultation on future improvements to the Capacity Market, which proposed amendments to the descriptions of DSR in the legislation that implements the Capacity Market (BEIS, 2020a). If passed, standalone batteries – i.e. those primarily charging from and discharging to the distribution network, rather than to an on-site customer – would be precluded from registering as DSR in this market, and be required to enter as generation assets (BEIS, 2020a).

This could have implications for digital energy platforms (such as VPPs, aggregators and flexibility platforms) who connect to and control storage assets connected to the distribution network. We covered the policy and regulatory challenges that electricity storage in our previous Working Paper (Morris and Hardy, 2019).

27 Time-of-use tariffs are those where the cost per unit of energy varies, often to reflect the level of supply and/or the 'real' value of energy in time (IRENA, 2019). Some suppliers already offer such tariffs to domestic consumers in the UK.

28 The UK's Capacity Market was suspended in 2018 following a legal challenge brought forward by Tempus Energy, a flexibility platform, and a subsequent ruling by the European Court of Justice that the European Commission had not properly assessed concerns regarding compliance with State Aid rules.

29 De-rating factors determine the level of capacity agreement – or expected level of contribution – that can be secured in the Capacity Auction by a given resource (DECC, 2015). In essence, in the 'normal' capacity market shorter duration batteries are more highly de-rated (for example a 0.5hr duration battery is de-rated to around 20% of its nameplate capacity). In the DSR side of the capacity market, a flat 86% de-rating factor is applied to all entrants.

Balancing services

These cover a range of services that National Grid, the Electricity System Operator (ESO), procures to balance supply and demand and to ensure the security and quality of electricity supply across the transmission system. This includes services such as DSR, frequency response, restoration and reserve services. National Grid provides a list of all its balancing services.

The Balancing Mechanism is one of the tools National Grid uses to balance electricity supply and demand close to real time (i.e. in each half-hour trading period of every day) (ELEXON, 2019c). Progress has been made by the ESO and ELEXON in widening access to the Balancing Mechanism; in December 2019, the first part – 'Widen Access' – of industry code modification P344 Project TERRE implementation into GB market arrangements was implemented. Prior to this modification, only energy suppliers and licensed generators were eligible for participation in the Balancing Mechanism. This modification introduced a distinct new category of BSC party – Virtual Lead Parties – which opens up participation to all flexibility providers, including, for example, aggregators and VPPs (ELEXON, 2018 and 2019a). This modification was first raised in June 2016, and there have been criticisms over the length of time it takes to make these kinds of changes (Box 5; Energy UK, 2020).

Another issue identified in this report was the allowed participation of a DNO in the balancing services market. For example, some DNOs own and operate energy storage as an artefact of innovation funding schemes. The circumstances under which this is permitted are outlined in Ofgem's Prohibition on Generating Licence guidance (Ofgem, 2018e). Also, Ofgem has recently confirmed that DNOs can continue to competitively sell the ESO balancing services through remote voltage management at substations (Ofgem, 2020e).

Implications:

Evidence shows that the size and value of markets for flexibility and other energy system services will grow as the energy system transitions to net-zero. Smart local energy systems have an important role in provision of essential future energy services and digital platforms are a key component of this. Whilst work is underway on widening access to different markets, progress is slow. This is an opportunity for PFER and other projects to demonstrate the value of smart local energy system services in future energy system management and push for more rapid and inclusive changes to wholesale, capacity and balancing services markets design.

6.2.2 Revenue stacking

A second issue with current market arrangements is the limited ability of flexibility providers to 'stack revenue' by participating in some combinations of markets (ENA, 2019). Digital energy platforms could provide multiple benefits to the energy system (see Table 1), but unless they are able to access and accumulate the value available in different markets, the business cases may not be viable. Stacking of services would for example allow flexibility providers to hold contracts for multiple different ancillary services, and potentially allow them to receive more than one payment per transaction event, provided that event had the ability to meet more than one contract requirement at the same time.(Bray et al, 2018) Delivery of multiple tasks by one provider could lead to efficiencies for the energy system, also (Ofgem, 2019c).

Revenue stacking should only be allowed where there is appropriate visibility and transparency about what actions were performed by whom, who benefits and how, and how much the provider was paid (as ultimately, it is the consumer who pays).

There is currently insufficient transparency, liquidity and co-ordination of existing markets (e.g. energy markets, capacity mechanism, balancing services, network constraint management services) which is a barrier to commercial exploitation of distributed generation, storage and other distributed energy resources (IET, 2017). Digital energy platforms could have a role to play in providing this transparency; successful digital platforms in other sectors (e.g. Uber, Airbnb) have often added value to both providers and procurers by improving the ability to track and view transactions. By providing this visibility, there is the opportunity to improve the process of price discovery which could – if implemented and regulated appropriately – result in fairer, more reflective cost distributions across markets. The Cornwall Local Energy Market (Case study 4) is an example of where this is being implemented.

National Grid ESO has produced guidance on current arrangements for service and revenue stacking. Some progress has been made since the SSFP was introduced; for example, when the Capacity Market was first established, it was not possible to participate both in that and provide ancillary services. This has since been remedied, but there are calls to ensure that diversification of revenue streams is not hindered in future by similar restrictions migrating into future market arrangements (Bray et al, 2018; ENA 2019).

Implications:

Assets within smart local energy systems can provide multiple energy system services, however due to market and contractual structures it is not always possible for this be realised. Digital energy platforms provide a conduit through which local assets could play in multiple market and are well placed to provide new insight and evidence into barriers or inefficiencies caused by current market design. The also could increase the transparency of current markets by providing insight into services being traded, including conflicts between, or duplication of, services.

6.3 Emerging and future markets

The drivers that are leading to the emergence of digital energy platforms – digitalisation, decarbonisation, decentralisation and democratisation – are also shaping the energy system into a new structure. The electricity system will become renewables dominated, which creates new challenges, such as forecasting future supply, maintaining power quality and inertia, moving power from local and remote renewables to where is needed, and sending price signals to end-consumers to follow available low-carbon supply (Kroposki et al, 2017). Increasingly, the energy sector must become cross-/multi-vector; that is, rather than operating as independent functions, constituent parts of the system (electricity, heat, transport etc.) will need to become much more integrated, enabling provision of services using multiple energy carriers (e.g. electricity, heat, natural gas, hydrogen gas, known as 'energy vectors') (Energy Systems Catapult, 2018b). Current market arrangements – even if they are updated to allow participation emerging technology like digital energy platforms – are arguably not sufficient for the type and scale of flexibility and integration that is required of the future energy landscape (National Infrastructure Commission, 2016). New markets will therefore need to emerge to realise the values (financial and otherwise) and efficiencies that the energy transition could bring.

In the context of smart local energy systems, the development of new markets will be enabled by advancements in digitalisation and data; improvements in the quality and transparency in time, location and service value data, for example, could allow much better price discovery (Energy Systems Catapult, 2019c). In many instances, digital energy platforms could support new markets; for example, by positioning themselves as a venue for both asset/resource owners to log availability and for buyers to signal their needs and to contract for services, they can facilitate the trading and dispatch of flexibility products and provide the incentives to do so (Ofgem, 2019c).

Market development is complex; demonstrator projects can aid in the design of new markets by trialling approaches. This can produce valuable evidence of how future energy systems could operate in both the near- and long-term future. There are now a number of UK projects which are testing and pushing the boundaries of today's market arrangements and generating new evidence and insights which will be crucial in identifying the strengths, weaknesses and gaps in the current landscape. Many of these are employing the use of digital platforms in their operations.

For example, until recently, there was no GB market for local flexibility trading, yet this kind of market is likely to be necessary given the increase in distributed assets and flexibility requirements.(Bray et al, 2018) The Cornwall Local Energy Market (see Case study 4) and Piclo Flex (see Case study 5) are examples of emerging markets for local flexibility. While peer-to-peer trading without the involvement of a licensed supplier is also not currently legal in the UK, projects such as CommUNITY (Case study 1) are trialling P2P models under regulatory derogations (Schneiders and Shipworth, 2018). The Government's Prospering from the Energy Revolution was established to fund projects that explore integrated energy systems that deliver power, heat and mobility across multiple vectors, with local energy demonstrators operating in real-world conditions (i.e. within existing regulatory regimes) and with real people to pioneer new energy systems and associated marketplaces (UKRI).

- ReFLEX Orkney is developing an AI-based 'virtual energy system' platform which aims to interlink local electricity, transport and heat networks, to create a 'smart energy island'.
- Project LEO (Oxfordshire) is taking a DSO-approach to develop a local energy marketplace which will enable virtual aggregation of loads, dispatching of flexibility as well as peer-to-peer trading.
- Energy Superhub Oxford is developing a trading platform to control a network of batteries and EV chargers so that they automatically use cheaper, cleaner electricity when available.
- Smart Hubs SLES (West Sussex) aims to balance local supply and demand for electricity by using demand side management techniques and time-of-use pricing in a Virtual Power Plant to shift electric demand from peak hours to times of excess supply.

In addition to the demonstrator projects, 10 detailed design projects have now been funded under the PFER programme to trial new technology for smart local energy systems (UKRI, 2020). These again have a focus on integrated, multi-vector systems, and the aim is to work up a portfolio of designs that are 'fully investible' by the mid-2020s (Knowledge Transfer Network, 2019).

There are also increasing opportunities for integration between energy and other sectors which have traditionally been separate. Synergies between energy and health, for example, have been considered; it has been proposed that smart meter energy data could possibly help to inform diagnosis of health conditions (by indicating, for example, unhealthy living conditions, periods of unexpected inactivity amongst those in vulnerable circumstances) (Fell et al, 2017), and a 'boilers on prescription' scheme was found to both reduce the number of GP appointments required by patients with poor living conditions and reduce their energy bills (Gentoo, 2016). As with digital platforms in other sectors (see, for example, Box 1), there are opportunities for the value of digital energy platforms to extend beyond the traditional boundaries of energy. This could be related to the products and services offered or to the data generated; data on home energy consumption patterns generated by HEMS (the providers of which often come from outside the energy sector, like Amazon and Google), could again contribute to public health insights and diagnoses, as well as inform smarter building design.

The full value of cross-vector and cross-sector integration, however, is not well understood, and current market arrangements do not adequately support these opportunities. Reforms to existing markets and new market development must therefore look ahead to a future where energy is more integrated with other sectors; arrangements must also become more flexible to allow for future innovation across and between sectors to be taken advantage of even if they have not yet been identified or predicted.

Implications:

The net-zero transition is one that could breach the traditional boundaries between energy services and indeed between energy and other sectors, like health. New non-traditional markets and demand for new services are ripe grounds for experimentation and learning for digital energy platforms and are areas that the PFER programme is already exploring. The projects are well positioned to contribute to market design, and, because they are working directly with assets and customers, could do so in a user-centred way. Across the wider Industrial Strategy, there may be additional opportunity to realise the value of energy data in other sectors.

7 Policy and regulatory issue 3: Roles and responsibilities

To enable the transition from a centralised, one-way system to a more complex distributed network, the roles of key market actors will need to evolve; who will control what, and how? (BEIS, 2019b; Bray et al, 2018). This section explores how digitalisation affects and changes roles of existing and emerging actors and how in turn that affects the role of policy and regulation.

A key tension is the emergent nature of digital energy platforms. Consequently, to a large extent, they are operating in a currently non-regulated space which is an opportunity for these businesses but can bring significant challenges and risks to consumer outcomes (Ofgem, 2019c). A key risk to businesses is that their business model, which works in the absence of regulation, becomes constrained or unviable when regulation arrives. However, without regulatory clarity, there is the risk of divergent standards and operations which come at the expense of wider system and consumer protection outcomes (Ofgem, 2019c). There is a balance to regulation though as regulating too soon risks affecting choices of technology and innovation opportunities without a full understanding of their potential impacts.

7.1 Data and digitalisation will change roles and responsibilities

In Section 3.1 we outlined that digitalisation is a key driver for the emergence of digital platforms, which in turn is driven by reductions in the cost of data and ICT. It is also in itself a driver for changes to governance and roles and responsibilities of existing and new actors.

Here we explore how access, interoperability and governance of data affects roles and responsibilities and the subsequent knock-on effects to digital energy platforms.

7.1.1 Access to and interoperability of energy data

A key finding of the Energy Data Taskforce is that:

> "[the Energy] sector should be Digitalising the Energy System and that in order to maximise value, Energy System Data should be Presumed Open." (Energy Systems Catapult, 2019c)

In their Energy Data Review report, the Energy Systems Catapult created an energy data landscape (Energy Systems Catapult, 2018a).They identified that energy system data is fragmented and that many organisations are involved in the transmission and storage of data with no central repository or coordinated data exchange methods. Addressing this issue will require leadership and appropriate governance.

The Taskforce proposes three building blocks to deliver on its key finding above:

1. A Data Catalogue to create visibility of existing and future Energy System Data.
2. An Asset Registration Strategy to coordinate new asset registration, improve user experience and ensure that data is captured effectively.
3. A Digital System Map of the Energy System to deliver system visibility and start the journey towards a Digital Model.

The Taskforce goals and building blocks are mirrored to some extent in the work of the Council of European Energy Regulators (CEER) on Dynamic Regulation to Enable Digitalisation of the Energy System (CEER, 2019).

Beneficiaries of digitalised energy systems include:

- Existing and new businesses and organisations (including DEPs) realising value from accessing energy system data (for example by driving energy system productivity and efficiency gains) (Energy Systems Catapult, 2019c).
- Government departments, regulatory authorities and public advisory bodies (such as the Committee on Climate Change) in enabling them to discharge their duties in an increasingly data driven energy system (Frerk, 2019).
- Enabling consumers to transition from being passive, captive actors into active players in the energy transition (IRENA, 2019).

7.1.2 Energy system data governance

The Taskforce principle that energy system data should be 'presumed open' creates several governance challenges that could affect roles and responsibilities of energy system actors. How these are resolved is important for emerging digital energy platforms as it could affect how they access data and operate.

It may be necessary for policy makers and regulators to show leadership, including by obligating institutions, organisations and businesses to adhere to and deliver on the principles recommended by the Taskforce. This could entail changes to licences by Ofgem, and/or changes to legislation by Government and/or changes to the industry codes (for example enshrining the principles of the Taskforce into the Code Administrator Code of Practice) (Energy Systems Catapult, 2019c). Where progress stalls, it may also be necessary for the regulator or Government to drive data standards development, including clarifying allowable costs for compliance. In spring 2020 BEIS and Ofgem are running a series of smart systems and flexibility policy development workshops, including one on data policy that will touch on some of the issues described here.

Alongside changes to processes and operations with energy system actors, the role and responsibilities of Government and regulators is likely to change in digitalised energy systems. For the regulator this could mean its duties are changed by Government so that they align better with a digitalised energy system. It is likely that a digitalised energy system will evolve quickly, making it hard for policy makers and regulators to keep up with the pace of change. This implies moving away from static, steady-state regulation to adaptable and agile regulation (CEER, 2019). It also implies new skills and capabilities being required in policy making and regulatory institutions in order to adapt to digitalised energy system, such as in information technology, big data, data science, artificial intelligence and behavioural insight (CEER, 2019).

New institutions are required in a digitalised energy system, and these may impact upon actors in the system. For example, the Centre for Data Ethics and Innovation has been created as an independent advisory body by Government to "connect policymakers, industry, civil society, and the public to develop the right governance regime for data-driven technologies" (Frerk, 2019). Similarly, the Geospatial Commission, an independent committee set up to maximise the value of data linked to location. A new Horizon Council has been formed to look at reforms to the UK's regulatory system and advise government on how to remove barriers to innovation, including those relating to emerging products, services and business models in the UK (such as DEPs). Finally, Government has announced that it will consult on a digital Regulation Navigator for businesses to help them find their way through the regulatory landscape and engage with the right regulators at the right time on their proposals (BEIS, 2019a).

Implications:

Enabling the digitalisation of the energy system, and thus unlocking opportunities for digital energy platforms is a challenge and balancing act for policymakers. The Energy Data Taskforce provide excellent recommendations for how this can be achieved, and in the first instance it is for industry to deliver on these. Slow and stalled progress in this space could mean that Government and / or Ofgem are forced to step to act, potentially through obligations or standards. Digitalisation entails changes to how the energy system is governed, including the creation of new intuitions and changes to regulatory approaches, from prescriptive to agile. The PFER programme has an opportunity to demonstrate best practice here and shape the sectors digitalisation journey and its governance.

7.2 Changing roles and responsibilities of energy system actors

The digitalisation of energy and emergence of digital energy platforms affects existing energy system actors. It also creates opportunities for new energy system actors to emerge or for existing actors to play different roles, including digital energy platforms. In this section we review how these trends affect a range of actors.

7.2.1 Role of Distributed energy resources

Distributed energy resources (DER) refers to energy resources (such as such as onshore wind solar PV and energy storage) that are directly connected to medium voltage (MV) or low voltage (LV) distribution systems, rather than to the bulk power transmission systems (Akorede et al, 2020). It constitutes assets connected directly to local networks as well as those behind the meter in homes and businesses. DER already represents around 30% of GB installed generation capacity (Bray and Group, 2019), and this will increase as the net-zero transition proceeds.

DER has traditionally been seen by the energy system as negative demand for transmission flows. As DER grows, its role and perception in the system could change (if there is value in doing so) to being considered an asset with a role in coordinating and balancing local and national systems (Bray et al, 2018). There are a number of services (roles) that DER can provide to the energy system. It can provide important grid services to distribution and transmission system operators and wider actors, such as suppliers (IRENA, 2019).Typically, DER will be delivering energy system services (directly or via aggregators), through platforms including peer-to-peer, flexibility platforms, local trading platforms (Ofgem, 2019c) and virtual power plants (VPPs) (Bell and Gill, 2018).

The role that DER plays in managing the future energy system depends on several factors. Consumers and asset owners need to be convinced of the case that their assets can be used flexibly (IRENA, 2019) and that there is value in providing services (Bray et al, 2018). DER assets must be visible and able to access markets, such as those for flexibility, balancing and ancillary services (CEER, 2019). Markets will need to be coordinated so that DER can realise value across multiple markets and so that system operators can avoid conflicts and issues – we discuss this further in Sections 7.2.3 & 7.2.4.

7.2.2 Role of consumers

The role of energy consumers (and prosumers[30]), both commercial and domestic, is likely to change with the emergence of digital energy platforms. Consumers are owners of important energy data (smart meter and asset data) and assets (like electricity generation, electric vehicles and energy storage). They can also be providers of value energy system services, like demand side response. They may also be customers of digital energy platforms, for example peer-to-peer energy platforms or aggregator led-platforms. They may also be excluded from participating because of their circumstances. These new roles could bring new benefits, but also new issues.

30 Domestic or commercial consumers who have energy generation or storage facilities.

Access to customer data and data protections issues are covered in Section 5. The key issue is that consumers will need to have trust in whom they share the data (like smart meter data) they own with, and that parties accessing consumer data must safeguard that data (Energy Systems Catapult, 2019c).

Consumers (and prosumers) are also asset owners who can choose to participate in digital energy platforms, for example to trade energy or to provide energy system services, such as flexibility. As discussed in Section 5, it is important that it is possible to register assets so that they are visible to wider energy system.

For consumers choosing to participate in digital energy platforms, for example through flexibility platforms, there should be provisions for consumers to switch between both different commercial offerings and technology choices (ENA, 2019). This is to avoid consumers being locked into particular platforms or locked out of other valuable uses of their assets.

Some consumers may choose to operate through multiple platforms (and possibly via multiple suppliers – see Section 4.2). For these consumers, where multiple organisations are communicating, it is important that consumers receive a consistent set of information (Ofgem, 2019f). The level of consumer protection will also need to be clear (Ofgem, 2019d). We touched on these issues in the context of interoperability, trust and consumer protection in Section 5.

Finally, some consumers may be excluded from participating in digital energy platforms because they cannot access, or their services are not valued by such platforms – in essence they are left behind in the digital energy transformation. In addition, some consumers who do participate may become vulnerable (for example being locked into a contract when their circumstances change dramatically). These are fairness and distributional issues that are being raised by consumer organisations and may need action by Ofgem (Citizens Advice, 2019).

However, data can also provide new information and insight on vulnerable consumers that could enable better and more targeted design of policy and regulatory interventions.

Implications:

The net-zero transformation entails a more active role for all customers and for distributed energy resources (DER). DER needs to become more visible to the energy system in order to provide valuable services such as flexibility and balancing. To do so, it will need to be able to realise its value and access markets easily. Consumers can also become much more active participants in the future through their patterns of energy use, their data and the assets they own.

Digital energy platforms will play an important role in all these aspects, but there are important caveats to their social licence to operate. They will need to be trustworthy custodians of data and share the value it unlocks. They must treat customers fairly and allow customers to switch between platforms. They must play their role in being inclusive so that consumers in vulnerable or other circumstances are not excluded or indeed become vulnerable through participation. These are all issues being examined through the PFER programme and can help shape how platforms develop in the UK.

7.2.3 Role of Electricity system operator

The GB Electricity System Operator (ESO), responsible for ensuring balance between the electricity supply and demand in the system (Bray et al, 2018), managing constraints and maintaining the electricity system within operating limits, has an critical role in the net-zero energy system transformation. Whilst there is agreement on the nature of the roles the ESO will play, the size and scope its role is somewhat contended in the literature. In part this is because of the uncertainty on the role of emerging digital energy platforms and Distribution System Operators (DSOs).

The ESO currently has a role operating digital energy platforms through its role as a neutral market facilitator for the competitive procurement of essential balancing and ancillary services (ENA, 2018c; Ofgem, 2019e) (discussed in Section 5.2). In this role, it is important that the ESO continues to ensure transparency of markets and actions and reduce barriers to entry for existing and new providers of energy system services, including digital energy platforms (Bray et al, 2018).

Whilst there is agreement that the need and volume of such energy system services will grow, there debate over the means through which these services are procured and delivered. The Energy Networks Association Open Networks project explored several future scenarios in which the role of the ESO expands or shrinks, for example where Distribution System Operators (see Section 7.2.4) or new "flexibility coordinators" undertake roles in place of or alongside the ESO (Bray and Group, 2019; ENA, 2018b). Thus, there is clarity over what future roles are required but not who should undertake them.

Whatever the future, it is clear that the ESO has several important roles in a net-zero future energy system. It will be an important route to market for flexibility services including those procured through digital energy platforms. It will need to communicate, exchange information and coordinate with multiple parties and platforms to ensure that solutions being planned and procured efficiently and in the whole energy systems interest (BEIS, 2019b; Bray et al, 2018; Ofgem, 2017). This includes increasing pan-European trading in energy system services, including System Operator to System Operator trades (Bray et al, 2018).

7.2.4 Role of Distribution Network Operators & Distribution System Operators

Electricity distribution networks carry electricity from the high voltage transmission grid to industrial, commercial and domestic users. Distribution Network Operators (DNOs) own, plan, build, operate and maintain distribution networks and connect new users and assets.

In the future, as DNOs transition to Distribution System Operators (DSOs), they are likely to become a critical route to market for DER to sell energy services locally and nationally.

Ofgem describe DSO as:

> "Distribution system operation (DSO) is the effective execution of a set of functions and services that need to happen to run a smart electricity distribution network in the interests of energy consumers." (Ofgem, 2019e)

As the number of distributed energy resources (DERs) grows, so too could the role of DNOs. They potentially become major operators in procurement services and system balancing in future (Bray et al, 2018). The future role of DNOs is seen is a critical factor in whether DERs are able to access new revenue streams and localised markets (Bray et al, 2018).

The future role of DNOs and their relationship with digital energy platforms is encapsulated in thinking about Distribution System Operators (DSOs). IRENA see the role of DSOs as "[managing] the distributed energy resources connected to their grid, enabling their integration into the grid and maximising the benefits they can provide" (IRENA, 2019). This includes procuring grid services from DER (potentially through platforms), acting as a neutral market facilitator to enable participation of DER in upstream service markets (for example ESO or wholesale markets) and, operation of DER (potentially through a platform) to optimise the use of existing grids and defer new investments. DSOs could therefore play a crucial role in both connecting and providing a route to market for the services DER can provide.

Ofgem, in their position paper on DSO see DNOs as being increasingly active managers of their networks with responsibility for coordination across boundaries (IRENA, 2019). Figure 4 below outlines Ofgem's functional breakdown of the DSO role.

Within this, there is an important question on whether DNOs are allowed to compete with other providers of energy system services – for example competing with DER. Ofgem notes that there may "be cases where best outcomes could be achieved by DNOs competing with one another and other parties to deliver services". An example of this is Ofgem's recent decision to allow DNOs to continue to competitively sell the ESO balancing services through remote voltage management at substations (Ofgem, 2020e). Government and Ofgem have made it clear that it is for network operators "address the conflict of interest that arises from them being the specifier of network requirements and a potential provider in meeting those requirements" (BEIS, 2017b).

Another question that may need to be resolved is whether and how the DSO is remunerated to reduce investment expenses of the grid by slightly increasing operational costs for the procurement of flexibility and indeed how the system discovers this value. Addressing this issue is potentially important in the context of price-based activation of flexibility, particularly in a whole-system context (Eid et al, 2016).

Implications:

The roles of the Electricity System Operator (ESO) and Distribution Network Operators (DNOs) will change as the energy system as the net-zero transition progresses. They operate and use digital platforms to procure balancing, ancillary and flexibility services and their demand for such services is set to increase. Their future system operation roles will be influenced by how smart local energy systems and digital energy platforms evolve. Greater emphasis on local energy systems could enhance the role of DNOs as distribution system operators (DSOs) including acting as neutral market facilitators for flexibility services. It is imperative that there is good communication and transparency between these system operators and digital energy platforms have an important role to play in this.

Figure 4: Ofgem's functional breakdown of DSO, informed by industry literature (Ofgem, 2019e).

Long term planning	Operations, real-time processes and planning	Markets and settlement
Network planning	Switching, outage restoration and distribution maintenance	Aggregation of DERs
Forecasting demand and generation and DER	Monitor parts of the Dx system under active network management	Design of principles of system access and trading arrangements
Connection studies and operation procedures	Supply of grid-operational services using DER assets	Operation of flexibility trading platforms and associated tasks
Integrated T-D planning	Supply of grid-operational services using DNO assets	
DER hosting capacity analysis	Identify DERs, ancillary service requirements and operation restrictions	
Emergency response planning	Data management and sharing	
Delivery of new investment	Coordination between T-D interfaces	
DER net local value analysis	Coordination of DER schedules	

Existing
Extended
New

7.3 Decisions required by Government and Ofgem

Unlocking the potential of energy system flexibility and digital energy platforms requires a number of decisions from Government and Ofgem. It also requires institutions to undertake new roles or change existing roles. This section explores these issues.

7.3.1 Government

An important role of Government in the transition to a net-zero smart and flexible energy system is to provide vision, strategy and guidance. The Smart Systems and Flexibility Plan (together with Ofgem) is an example of this (BEIS, 2019b; BEIS, 2017b), as is the forthcoming Energy White Paper. This includes Government stepping in when there are barriers are apparent. This review has outlined several such barriers to digital energy platforms where action is either being undertaken or the need for action identified.

Energy data availability and access is one such barrier. On data structure and interface standards, if industry stalls progress or perceives little value Government (or the regulator) may be required to step in to either enhance the business case (e.g. providing financial incentives) or drive the development of industry-wide standards (Energy Systems Catapult, 2019c).

A related issue is that decisions on the types of uses of smart meter data that are in the public interest should sit with BEIS and Ofgem. This includes the data that they will need for effective oversight of an increasingly data-driven sector – for market monitoring and for policy design and evaluation, including understanding distributional impacts, (Brown et al, 2019; Frerk, 2019). Such data may be required for Government to discharge its duties in an increasingly data-driven energy market.

Government may also be required to legislate to enable change in support of emerging business models and value propositions. For example, current legislation enshrine rules about switching between energy suppliers, which could put at risk long-term energy service based business models (like Energy Service Companies) (Frerk, 2019). Safeguards may also be required for customers of emerging business models, such as those trading energy through P2P platforms (Schneiders and Shipworth, 2018).

A final, but important issue is that many digital technologies are inherently cross-border, with firms able to switch between different jurisdictions at low cost while retaining a global customer base. BEIS and are working with the Organisation for Economic Co-operation and Development (OECD) to explore the cross- border regulatory challenges of the emerging digital economy (ENA, 2018b).

Implications:

Government has a key role to provide vision for the net-zero transition, including the role of smart local energy systems. This might entail stepping in where barriers and/or market failures have been identified. Government may choose to legislate to clarify issues (for example definitions of key actors, such as suppliers or indeed define digital energy platforms) or change rules to create space for business model innovation. There is also an important role for Government to consider policy and regulatory challenges of digital platforms that are cross-border, for example where such platforms have operations in the UK but are based in another country. The PFER programme has an important role in providing evidence on the role of and barriers to smart local energy systems.

7.3.2 Ofgem

Ofgem has an important role in the both creating space for and regulating digital energy platforms. It will have to change both how it regulates and what it regulates. Ofgem will also need to adapt as an institution to a digital energy system. Ofgem's role is itself defined by Government, as such any changes will need to be in consultation with Government.

Enabling digital energy platforms

Ofgem recently reviewed its regulatory sandbox process. It found that the majority of enquiries were from businesses that did not require a sandbox – their business model was already possible under current arrangements. In a limited number of cases Ofgem was unable to help the innovator because it could not affect the changes required under the sandbox structure. To address this Ofgem has recently announced that they are widening the scope of rules that can be relaxed for innovative trials beyond the Ofgem rulebook to cover some of the main industry codes. This includes the rules for electricity balancing and settlement (BSC), rules around the connection to, and use of, the electricity distribution networks (DCUSA), and code requirements relating to retail energy activities (REC). They are also proposing to adopt a more permissive approach including the number of rules that they can provide relief from .

Ofgem and Government are considering reforms required to allow a greater diversity in the types of companies operating in the energy retail market. Whilst there is already reform underway, through the rollout of smart metering, faster more reliable switching and the Energy Industry Code Review, depending on how the market evolves, further, more fundamental reforms to the structure of the market may be required in the longer term (BEIS and Ofgem, 2019). This includes understanding how the regulatory and customer protection frameworks could be changed to facilitate the launch of products and services that support decarbonisation, potentially including digital energy platforms.

Ofgem is also examining cost reflectivity within energy markets, in particular network tariffs. This is covered in Section 5 above and in our previous review on Electricity Storage and Electric Vehicles (Morris and Hardy, 2019). Encouraging or creating new markets, such as those for flexibility services, creates a route to market for digital energy platforms and DER (CEER, 2019). These reforms are also strongly linked with the changing roles of GB network operators including the ESO and DNOs/DSOs. These changing roles and the rationale behind them are outlined in Section 6.2 above.

Regulating digital energy platforms

Ofgem's key challenge is how to allow for the emergence of new products and services that benefit consumers (such as digital energy platforms) mindful their potential to negatively affect the interests of other existing and future consumers and the wider energy system, given that energy is an essential service (Ofgem, 2019d).

Third Party Intermediaries (TPIs), such as independent aggregators and emerging platform operators (for example flexibility platforms), are not subject to direct sectoral regulation in the same way as energy suppliers by Ofgem . They are subject to regulation under general consumer protection rules, and in some cases have signed up to voluntary agreements governing their business practices and interactions with consumers.

There has been some call for the role of independent aggregators to be formalised either through a mandatory Code of Practice or through an aggregators licence. The Association for Decentralised energy has published a Code of Conduct where aggregators will be able to sign-up to it under a scheme membership agreement called 'Flex Assure'. It establishes a common set of minimum standards by which customers can compare aggregators (Bray and Group, 2019).

Ofgem's review of energy markets outlined previously (BEIS and Ofgem, 2019) opens a potential route to regulation of TPIs, including digital energy platforms. Citizens Advice have previously called for TPIs to be brought into the scope of sectoral regulation for certain consumer-facing activities and that consumers should be protected to the same level regardless of how they engage with the market. Citizens Advice suggest a combination of activities-based regulation and high-level principles-based rules is a potential approach to regulating TPIs. It is already used by the Financial Conduct Authority (Citizens Advice, 2019).

There is also an issue of conflicts of interest arising from currently licensed parties, for example network companies being allowed to provide contestable energy services to other parties, such as the ESO (see Section 7.2.4 above). The effectiveness of actions to mitigate potential and perceived conflicts of interest are one of the aspects that Ofgem and Government will take into consideration when considering if further changes are needed to the structure and roles of network companies (BEIS, 2017b).

The regulator will need to adapt

Changes in technology, actor participation and business models will mean that the regulator will also need to adapt its operations. There are calls for regulators to move away from static, steady-state regulation and adopt a much more 'agile and risk reflective' approach to keep pace with innovation and disruption.(CEER, 2019; Energy Systems Catapult, 2019c). This would require more flexible methods where, instead of managing processes, regulation incentivises (and penalises) based on outcomes. (CEER, 2019; Sandys et al, 2017; Sandys et al, 2018). This could allow emerging technologies, markets and business models to innovate whilst protecting both the system and consumers.

The regulator will also need to upskill to prepare itself for the transition. When it comes to data, for example, both the Energy Data Taskforce and the Council of European Energy Regulators stressed the importance of regulators keeping pace with digitalisation of the sector, equipping themselves with new skills and capabilities related to information technology, data science and artificial intelligence (CEER, 2019; Energy Systems Catapult, 2019c). Ofgem states it is already coordinating its data-related regulations to promote common working practices not only within the energy sector but across other sectors (Ofgem, 2020d).

Implications:

The regulator, Ofgem, has several important roles to play and for digital energy platforms to emerge it will need to change both what and how it regulates. Ofgem will be receptive to evidence on creating space for innovative business models, including digital energy platforms, as it reforms its sandbox.

Ofgem is currently undertaking a series of far reaching reforms on network access and charging, smart meter rollout, half-hourly settlement, supplier-hub and industry codes and will be seeking evidence on how these interact with smart local energy systems and associated digital platforms.

In terms of how digital energy platforms could be implemented Ofgem is monitoring market developments but is yet to formally regulate. It has a balance to strike between allowing digital energy platforms to emerge and protecting the interests of consumers. Consequently, Ofgem will be receptive to evidence on approaches that work in other sectors or countries particularly agile and risk reflective approaches to regulation.

Ofgem should continue to look to other sectors and countries for lessons to be learned on anticipatory, information- and principles-based regulation.

8 Conclusions

Digital platforms are not a new phenomenon in the energy sector. Platforms such as Active Network Management and Home Energy Management Systems have been active for several years. But compared with other sectors, digital energy platforms are yet to be as disruptive. This can be seen as a positive as it means there is the luxury time to consider the benefits and impacts of such platforms in energy, how their influence may differ from other sectors and what these insights mean for their policy and regulatory environment.

The emergence of digital energy platforms is strongly linked with the trends of digitalisation, decarbonisation, decentralisation and, for some, democratisation of energy. In this review we have shown that digital energy platforms are becoming more prevalent in the energy sector, and that there is a diversity of types emerging. Whilst it is possible to segregate platforms into different types, in reality they are not always so clear cut and platforms perform activities across multiple types. Often the activities of these platforms are dictated more the objectives of the platform, the geography and the actors involved.

As we showed in our previous review on electric storage and electric vehicles, legal definitions can impact, positively or negatively, emerging technologies. Digital energy platforms are emerging in a currently unregulated space. Whilst there is an opportunity for the energy sector look to and learn valuable lessons from other sectors – such as on agile/anticipatory regulation – energy's status as an essential service means there may be specific issues and challenges for it to resolve.

Defining and subsequently regulating digital energy platforms when in the most part they are innovating in energy system niches seems premature.

Increased availability of data is a driver of digitalisation which in turn has been shown to drive the development of digital platforms in other sectors. In energy, such platforms require access to data of sufficient quality including data on time- and space-resolved energy generation and consumption, energy system state (for example network constraints) and weather.

There are numerous energy data barriers caused by how energy data is collected, stored and processed. So, whilst the data might exist, it isn't interoperable (or even sometimes accessible) between actors. This is the rationale behind the Energy Data Taskforce's recommendation to "digitalise the energy sector and evolve its culture to embed the values of 'presumed open'". This will require a paradigm shift in the way data sharing is valued; making energy data accessible and interoperable is expected to be beneficial for stakeholders across the energy sector. Another important aspect of data interoperability is that it can support other types of interoperability, including commercial and consumer interoperability. Provisions must exist for consumers to switch between different commercial offers and technology choice. Without this provision, consumer choice would be restricted as they find themselves locked-into particular platforms.

Our first conclusion is that unless the energy industry fully embraces the recommendations of the Energy Data Taskforce, then Government and regulators will intervene; and either route will affect the emergence of digital energy platforms.

INDUSTRIAL STRATEGY UK Research and Innovation

Platforms can also create value through producing new or improved data, for example about customer energy usage and preferences. This data may have value both within and outside of the energy sector (for example in the health sector). Thus, akin to other digital platforms, energy platforms may seek to monetise data within and outside of the energy sector. This raises issues of data protection, both in terms of protecting the energy system (for example from cyber-attack) and also protecting consumer's data. Whilst these issues are not unique to the energy sector, there may be additional challenges because of low levels of consumer trust in the sector. This low-level of trust could in fact be an opportunity for digital energy platforms to increase transparency and provide better control for consumers over their data.

Our second conclusion is that approaches on protecting energy system and consumer data could affect, positively or negatively, the viability of some digital energy platforms.

Many of the digital energy platforms we have identified are marketplaces, for example through which local energy or flexibility services are traded. So rather than owning physical assets and resources, the value of these energy platforms is in providing connections between those who can offer products or services and those who seek to buy them. We have identified several barriers to such platforms. These include: A lack of a level playing field (e.g. for example, DER cannot currently realise the value of black start services to National Grid); problems with revenue stacking (e.g. only recently has it become possible for assets to participate in both the Capacity Market and balancing services markets); and issues with current regulation (e.g. peer-to-peer energy can only proceed through a licensed energy supplier).

Our third conclusion is that within the myriad proposed changes to policy and regulation of actors, markets and networks that there needs consideration of how these affect incumbent and emergent energy actors, such as digital energy platforms.

The transition to zero-carbon, smart and increasingly local energy systems will see the emergence of new actors and institutions, and changes to the roles of those that exist today. Digital energy platforms are a family of emerging actor and as a consequence, operate largely outside current energy regulation. They also provide a platform for other actors, both existing and new, to participate in the energy system.

In the future consumers could increasingly provide energy system services through digital energy platforms, changing their role from being relatively to passive consumers to active prosumers. They are owners of important energy system data, like smart meter data, and assets, such as distributed energy resources. On the latter point, digital energy platforms create opportunities for an increased role of rapidly growing distributed energy resources, such as solar energy, batteries and electric vehicles in homes and businesses. These resources, currently pretty much invisible to the wider energy system, have the potential to provide multiple energy system services through most of the digital energy platforms we have identified.

For consumers and distributed energy resource owners to engage in digital energy platforms they will need to be convinced that there is value is providing energy system services. Also, and perhaps more importantly, there needs to be trust in the protections that participants are afforded and that the platforms are safeguarding participant data, being transparent and that there are provisions for participants to switch between both different commercial offerings and technology choices.

Our fourth conclusion is that digital energy platforms need to earn the trust of their participants, and that failure to do so will result in them failing and/or being more stringently regulated.

Some consumers may be left behind in the digital energy transformation due to being excluded from participating in digital energy platforms. This could be because they cannot access them or perhaps their services are not valued by the platforms. Thus, they are harmed because they cannot access the benefits of digital energy platforms. In addition, some consumers who are able to engage with digital energy platforms could become vulnerable as a consequence.

Our fifth conclusion is that without consideration of inclusion in their design that digital energy platforms could exacerbate existing fairness and distributional issues and may cause new vulnerabilities to emerge.

The roles of the Electricity System Operator (ESO) and Distribution Network Operators (DNOs) are expected to change as the energy system becomes increasingly decarbonised, decentralised and digitalised. Both currently operate platforms to procure balancing, ancillary and flexibility services, and the demand for such services is likely to increase going forwards. In the future, it is uncertain how the roles of the ESO and DNOs will evolve. For example, DNOs could become Distribution System Operators, taking an increasingly active role in managing their network including procuring flexibility services via digital energy platforms acting as a neutral market facilitator. In this scenario, DNOs ultimately take on some responsibilities currently undertaken by the ESO. Alternatively, the ESO may increasingly reach down into local networks and undertake activities currently in the purview of the DNOs.

Our sixth conclusion is regardless of how the roles of network and system operators evolve, it is critical that there is good communication and transparency between these roles and the platforms used to avoid conflicts or duplication of effort.

To unlock the potential of DEPs, decisions will be required from Government and Ofgem, even if sometimes that decision is to wait and see how things develop.

An important role for Government is to provide vision for the net-zero transition, this might also entail stepping in where barriers and/or market failures have been identified. For example, driving the adoption and setting standards to deliver on the recommendations of the Energy Data Taskforce, outlined previously. There is also an important role for Government in legislating to clarify issues (for example definitions of key actors) or change rules to create space for business model innovation. Government also has a role in changing the remit of existing, and identifying and creating new institutions, to ensure that governance arrangements are fit for purpose in a zero-carbon energy system. There is also an important role for Government to consider policy and regulatory challenges of digital platforms that are cross-border, for example where such platforms have operations in the UK but are based in another country.

Our seventh conclusion is that Government has an important role in setting the vision for the net-zero transition and creating space for digital energy platforms to emerge; the forthcoming energy white paper is an opportunity to start this journey.

The regulator, Ofgem, has several important roles to play and for digital energy platforms to emerge it will need to change both what and how it regulates.

Ofgem is already gathering valuable insight into what platforms are emerging from trials in its regulatory sandbox, including where its purview ends and where it needs to work with others (such as codes bodies) to create space for digital energy platforms. It is also exploring a range of reforms to regulation including the smart meter rollout, supplier hub model, industry code governance, network charging, roles of network and system operators. Whilst these reforms are not driven by the emergence of digital energy platforms, they are all relevant to them and could affect their regulatory environment.

Ofgem is also considering how digital energy platforms could be regulated. Currently they are subject to general consumer protection rules, but not direct sectoral regulation. So far Ofgem has resisted applying formal regulation, such as licences for digital energy platforms and the industry has put in place a voluntary code of conduct for aggregators (who both run and operate through platforms). This could change as the markets and platforms evolve.

Our eighth conclusion is that Ofgem has a balance to strike between allowing digital energy platforms to emerge and protecting the interests of consumers. Ofgem should continue to look to other sectors and countries for lessons to be learned on anticipatory, information- and principles-based regulation.

Our final point is that digital energy platforms require new skillsets to be brought into the energy sector, such as information technology, data science, machine learning and artificial intelligence. This is important for businesses themselves, but also for those setting policy and regulation of the sector. The skills required in smart local energy systems are being explored elsewhere within our EnergyREV programme.

Our final conclusion therefore is that the industry, Government and the regulator will need to upskill to prepare for, and keep pace with, the smart local energy system transition.

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Appendix: Review methodology, results and analysis

A detailed account of the systematic search, crowdsourcing and review methodology can be found in our first Working Paper of this review series (Morris and Hardy, 2019). Below is a brief description of the process, followed by the results of this review.

Literature search

Figure 5 shows the process used to gather literature for this sprint, as well as a breakdown of evidence characteristics for included documents. Four search methods – crowdsourcing, systematic online keyword searches, background knowledge and citation searches – were used to gather a body of evidence consisting of 97 distinct documents. The pieces of evidence were screened for relevance and 49 were included in this review. Evidence was characterized according to factors such as publishing institution and type of publication. Note that, in some cases, more than one institution may be attributed to pieces of evidence.

Database searches

The focus of this review is of policies and regulations which are currently in place in the UK. The most immediately relevant sources were therefore bodies responsible for developing these. We primarily gathered information published on the UK Government website, Ofgem's website and the Devolved Administration websites (Scotland and Wales). Searches were performed using the search engine of these institution.

Since digital energy platforms are an emerging component of the energy system, definitions and terms to describe them are not well-defined. This, combined with limitations in search engine functionalities, made the search strategy difficult.

An iterative search strategy was combined with the authors' background knowledge to gather relevant documents from known sources. Successful search terms – i.e. those that returned results deemed relevant to the review – included:

- Energy flexibility
- Energy platform
- Flexibility platform
- Platform
- Flexibility

Searches using each of these terms were performed on all the above-mentioned institution websites. Documents deemed relevant (considering factors such as the type and date of publication) were downloaded and imported to the EPPI-Centre systematic EPPI- Reviewer software.

Crowdsourcing

A call for evidence detailing both the scope of the entire review and the relevant topics for this sprint was circulated using a combination of professional, public and personal networks. All received documents[31] were imported first into a reference management software (Mendeley) for tracking purposes, and then into EPPI-Reviewer. Inclusion and exclusion criteria were applied to determine the included documents (see Morris and Hardy, 2019 for details).

31 Where links to documents or references were sent.

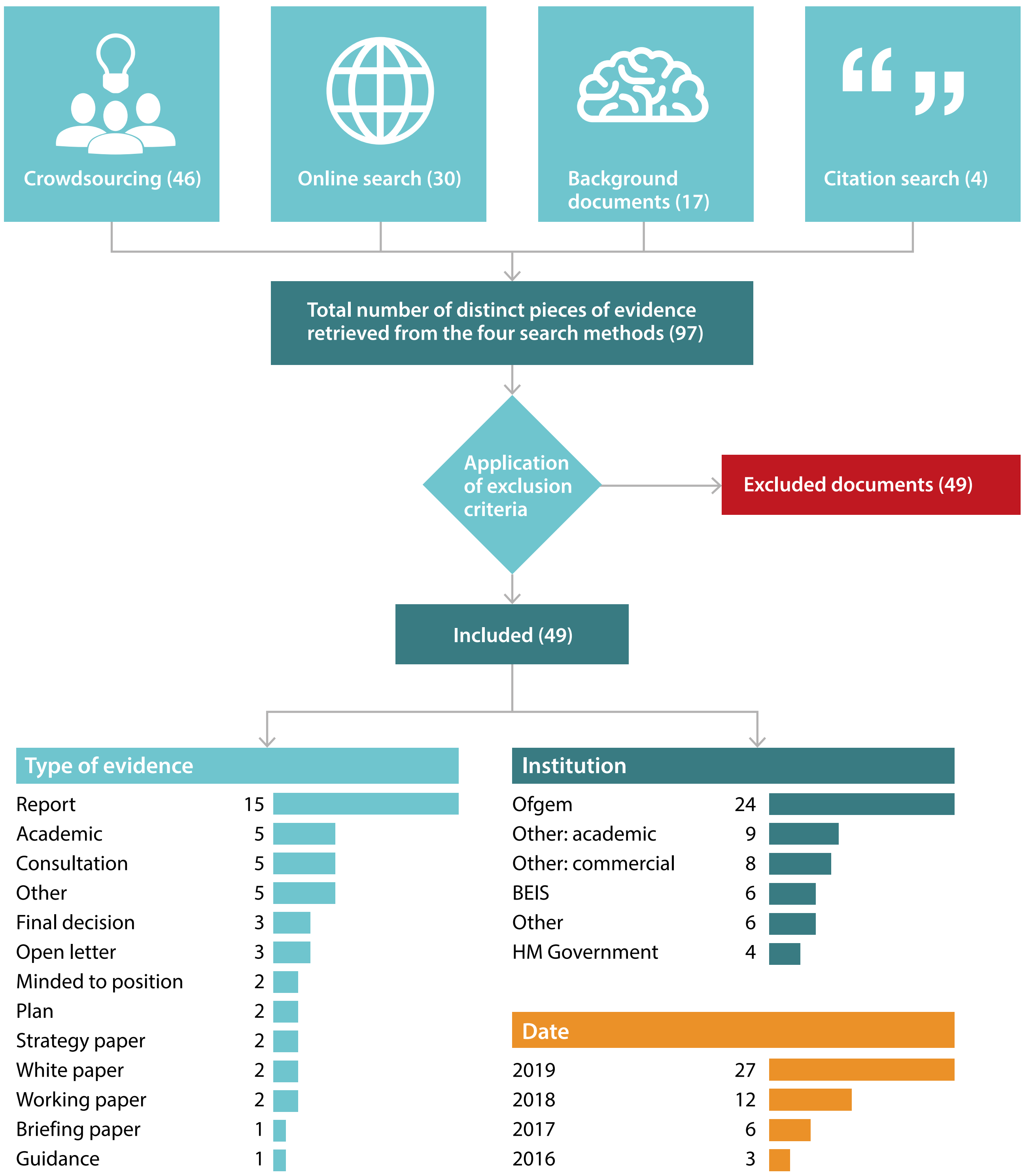

Figure 5: The quick scoping review process and outcomes for Sprint 2: digital energy.

Below is a list of the primary networks we used to gather evidence. The list is not exhaustive, as it evolved throughout the process and the call for evidence was shared further by these networks.

Table 3: Primary networks used to gather evidence

Network	Description
General	
Association of Decentralised Energy	Trade Association for Decentralised Energy organisations
Association of Public Service Excellence (APSE)	Not for profit unincorporated association
BEAMA	UK trade association for manufacturers and providers of energy infrastructure technologies and systems.
British Electrotechnical and Allied Manufacturers' Association (BEAMA)	UK trade association for manufacturers and providers of energy infrastructure technologies and systems.
Centre for Environmental Policy (CEP)	Academic research institute based at Imperial College London
Centre for Research into Energy Demand Solution (CREDS)	UK academic and industry research centre
Community Energy England	Not for profit organisation
Community Energy Scotland	Charity
Community Energy Wales	Not for profit membership organisation
Energy Futures Lab (EFL)	Academic research institute based at Imperial College London
Energy Institute	Society for Energy Professionals
Energy Systems Catapult Energy Revolution Integration Service (ERIS)	Expert guidance and support for selected PFER projects
Energy UK	UK trade association for energy
EnergyREV consortium	PFER Academic Consortium. Policy Contact Group Advisory Group Consortium mailing list
Grantham Institute	Academic climate and environment research institute based at Imperial College London. Channels include Blog Twitter Newsletter Mailing lists (staff, affiliates)
IGov	Established Career Fellowship based at The University of Exeter
Local Enterprise Partnerships (LEPS)	Business-led partnerships between local authorities and local private sector businesses
Personal Networks	Channels include LinkedIn, Twitter, email

Network	Description
General (continued)	
PFER SLES demonstrators and related projects	Including the four funded demonstrators and design projects
Powerswarm	Open network for power system transformation
Project ESO	Oxford-based PFER demonstrator
Project LEO	Oxfordshire PFER demonstrator
ReFLEX Orkney	Orkney PFER demonstrator
RegenSW	Not for profit centre of energy expertise and market
UK Energy Research Centre (UKERC)	Academic research centre based at University College London
UK100	Local government leader network
West Sussex County Council	
Specific to Sprint 2: Digital energy platforms	
EDF Energy	Gas and electricity supplier
Energy Networks Association	Network association
Engie	Energy supplier
New Anglia Energy	Local energy partnership
Octopus Energy	Gas and electricity supplier
Origami	Technology platform
OVO	Gas and electricity supplier
Piclo	Flexibility platform
SSEN	Distribution network operator (north of Scotland and central southern England)
UKPN	DNO
Upside Energy	Technology platform
Verv	Home hub using AI technology, from London-based SME Green Running

Table 4: Cross-tab showing the cross-cutting issues that were coded with digital energy platforms at document and text level.

Code: cross-cutting issue	Documents assigned code	Individual pieces of text assigned code
Assets/ infrastructure	11	10
Behaviours	1	1
Benefits/issues	12	37
Business models	11	33
Consumer protection	15	31
Data	25	57
EU	7	10
Flexibility	26	118
Government incentives	4	5
Industry codes	9	12
Innovation	14	5
Investment	3	2
Local authorities	3	0
Local Energy	16	51
Markets	25	100
Planning	3	1
Roles and responsibilities	25	72
Security of system	6	3
Smart	21	61

Results

Included documents were read and coded – that is, assigned categories/tags – in order to extract themes and cross-sections between them, based on a framework that continues to be developed throughout this review. Table 4 is a cross-tabulation of the cross-cutting issues that came up in this sprint on digital energy platforms, at both document level (i.e. number of documents with a given code) and text level (i.e. the number of individual pieces of text coded with a given code). From the evidence that we reviewed, the main cross-cutting themes that emerged were data, markets and roles and responsibilities. Smart and flexibility were themes that ran throughout the review.

Analysis

Line-by-line coding of the text was developed from an initial framework of activities and technologies across the electricity, heat and transport sectors, and across production, transmission and supply chains.

> 'Coding' in this sense refers to the labelling or categorisation of information within a piece of evidence. It is used so that 'data' – in this case, text – can be organised, examined and analysed in a structured way.

The working codeset – i.e. the categorisation structure – is shown in Table 5, below. The codeset was developed via an inductive process and is neither fixed nor absolute. It is intended to be used throughout the wider review process, and the structure is likely to evolve as other topics are explored.

For this sprint, digital energy platforms fall under the 'activities' code one of the three overarching themes. The other two overarching themes against which literature was coded are the 'energy value chain' and 'cross-cutting issues'. Once all included documents were coded in EPPI-Reviewer, further thematic analysis was conducted using NVivo to identify emerging concepts and themes.

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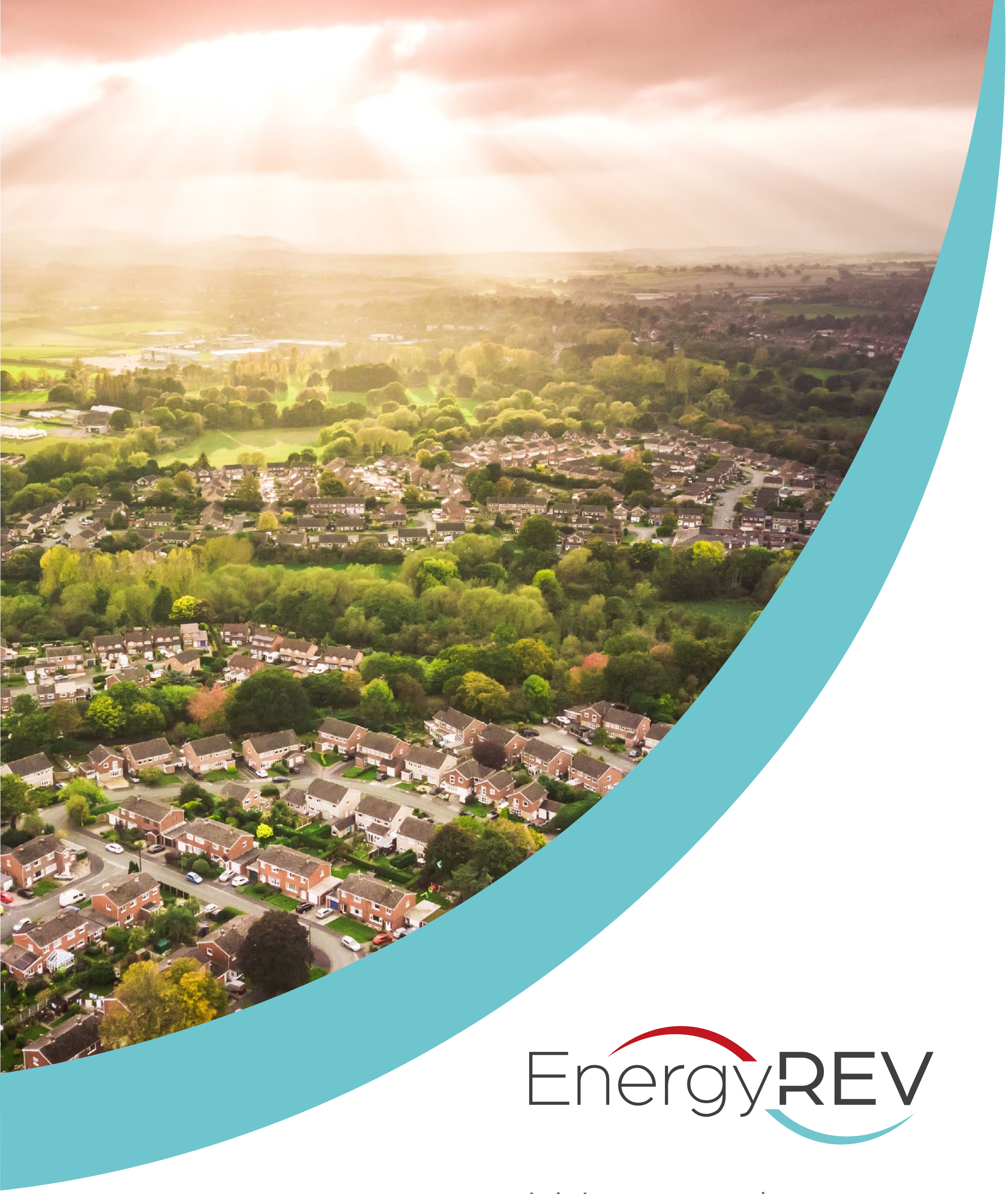
Table 5: Coding structure used for this review.

Activities	Energy value chain	Cross-cutting issues
• **Digital energy platforms**	• Assets/infrastructure	• Energy demand
• **Aggregator**	• Behaviours	• Buildings
• **Customer engagement**	• Benefits/issues	» Homes
• **Grid service platforms**	• Wider benefits	» Non-residential
• **Market integration platforms**	• Emission reductions	• Consumers
• **Peer-to-peer**	• Equity/fairness/justice	» Business consumers
• **Trading & exchange**	• Benefits of SLES	» Domestic consumers
• **VPP/VES**	• Consumer protection	» Energy efficiency
• Electricity	• EU	• Supply
• Heat	• unbundling (EU)	• Energy service provision
• Heat networks	• Flexibility	• Generation
• Heat pumps	• Government incentives	• Licence (generation)
» Domestic	• RO	• Transmission and Distribution
» Large	• FiT	• DNOs
• Hydrogen	• CfD	» Licence (DNO)
• Hydrogen	• Industry codes	• DSOs
• Storage	• Innovation	• TOs
• Definition (storage)	• Investment	• System operator
• Batteries	• Local authorities	• RIIO (price control)
• Transport	• Local Energy	• Network charges
» EV charging infrastructure	• Community energy	• Access rights
	• Markets	• IDNO
	• Ancillary market	
	• Balancing market	
	• Capacity Market	
	• Market competition	
	• Wholesale market	
	» Locational marginal pricing	
	• Planning	
	• Resources	
	• Security of system	
	• Smart	
	• Interoperability	
	• Standards	
	• Security	



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About EnergyREV

EnergyREV was established in 2018 (December) under the UK's Industrial Strategy Challenge Fund Prospering from the Energy Revolution programme. It brings together a team of over 50 people across 22 UK universities to help drive forward research and innovation in Smart Local Energy Systems.

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