Enabling Decentralised Energy Innovation

Analysis and methodology

This report includes the full analysis and methodology behind the Enabling Decentralised Energy Innovation study carried out by Sustainable Energy Futures Ltd for Innovate UK.

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Executive summary

Decentralised energy (DE) is energy based at or near the energy user and has a crucial role to play in the delivery of a decarbonised, smart, flexible, energy future. However, decentralised energy business models face barriers to delivering benefits and value to citizens, consumers, local communities and the wider energy system.

This report, commissioned by Innovate UK, reviews the barriers and potential solutions that will enable decentralised energy to play a full role in decarbonisation, innovation, and delivering positive outcomes for citizens and communities.

Our review of the evidence on decentralised energy business models, barriers, and solutions show that all decentralised energy business models face barriers. These barriers fall into five main themes:

1. **Limitations in realising the value of decentralised energy** - Decentralised energy has significant value to local and national energy systems, as well as wider priorities, but is prevented from discovering and fully realising it.
2. **Market rules and governance** - The current regime for licensing energy suppliers and the self-governance of industry codes and technical standards stifles decentralised energy from realising its potential.
3. **Limitations in innovation support processes** - Innovation processes are not sufficiently flexible or integrated.
4. **Limited attention on the demand side** - Energy efficiency and demand-side approaches have been undervalued in the UK for decades and are inherently local and aligned with decentralised energy resources.
5. **Regulatory uncertainty and lack of multi-level coordination** - There is a national lack of vision and a holistic plan for the future zero-carbon energy system, particularly on the role of decentralised energy.

Together these barriers either prevent or create friction for decentralised energy business models. We have identified a set of priority solutions that could overcome these barriers (summarised in Figure 1). These solutions fall into four main categories: **Reviews** to gather evidence; creating specific and holistic energy system **strategies/visions**; essential **enablers**; and **reforms** to energy system roles, responsibilities, and markets.

Our analysis and discussions in the workshop also revealed that these solutions alone are insufficient. We have also identified cross-cutting issues that pervade decision-making in energy and will affect the outcomes of any measures to enable decentralised energy. These cross-cutting issues are important because they affect both how decisions are taken and cause constraints on solutions. We have identified six cross-cutting issues:

- **A centralised mindset;**
- **A lack of definition and agency for decentralised energy assets and actors;**
- **A lack of cross scale coordination and clear roles;**
- **A lack of risk-based approaches to managing change;**
- **An outdated and uncoordinated approach to resilience;**
- **Limited recognition of the diverse values of decentralised energy.**

In conclusion, one solution stands out from this review. A clear, holistic, and inclusive vision for the future energy system. This vision would set out the principles for future reforms and address the cross-cutting barriers that pervade decision-making in energy. It would accommodate the economic and wider benefits of decentralised energy and the needs, preferences and values of citizens, communities, and consumers. It would clarify and assign the roles and responsibilities of energy system institutions and actors at all scales, ensure data is open and accessible, and allow innovative business models to emerge whilst protecting customers. It would also ensure that all supply and demand-side assets are treated equally and can play a full role in future system operation.

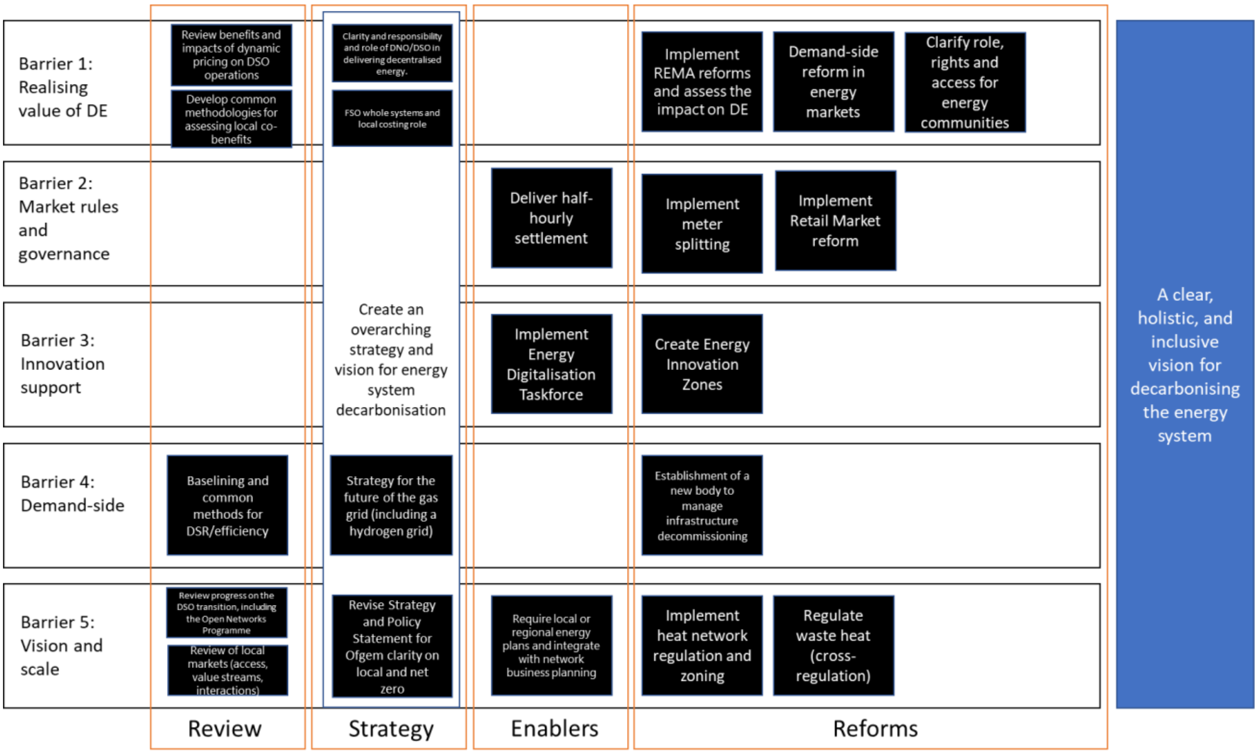

Figure 1: Summary of priority solutions

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Introduction to this report

Decentralised energy (DE) is energy based at or near the energy user and has a central role to play in the delivery of a decarbonised, smart, and flexible energy future. Decentralised energy comprises many different business models and aspirations. Research from PwC estimates that by taking a place-based approach to the energy transition, £108bn of savings on consumer bills could be unlocked for an investment of £58bn, compared to an investment of £159bn for £59bn savings by adopting a purely national strategy (Innovate UK et al., 2022). Decentralised energy, therefore, offers potential savings to the energy transition and substantial opportunities for businesses that can deliver local energy systems. However, decentralised energy business models face barriers to delivering their benefits and value to local communities and customers they serve and the wider energy system.

Innovate UK commissioned this analysis and report in response to emerging evidence from the Prospering from the Energy Revolution (PfER) programme that current governance arrangements do not currently allow distributed energy to play a full role in decarbonisation, innovation or the delivery of positive outcomes for citizens and communities. Existing policy, regulation and governance structures do not recognise the role and value of decentralised energy, particularly at the grid edge and on the demand side. Innovate UK had four objectives for the analysis:

1. Identify possible roles and architecture of a net zero energy system and market with a focus on distributed energy, particularly from a grid edge, citizen perspective.
2. To understand how the current policy, regulation and governance arrangements act as a barrier to distributed, smart energy systems.
3. To assess how governance arrangements could be changed to better enable decentralised energy roles and business models whilst ensuring citizens, customers and consumers are protected.
4. Identify change proposals that are modular, interoperable, scalable and regulated appropriate to the level of risk posed.

Our approach to meeting these objectives is summarised in Figure 2. The detailed methodology can be found in each section.

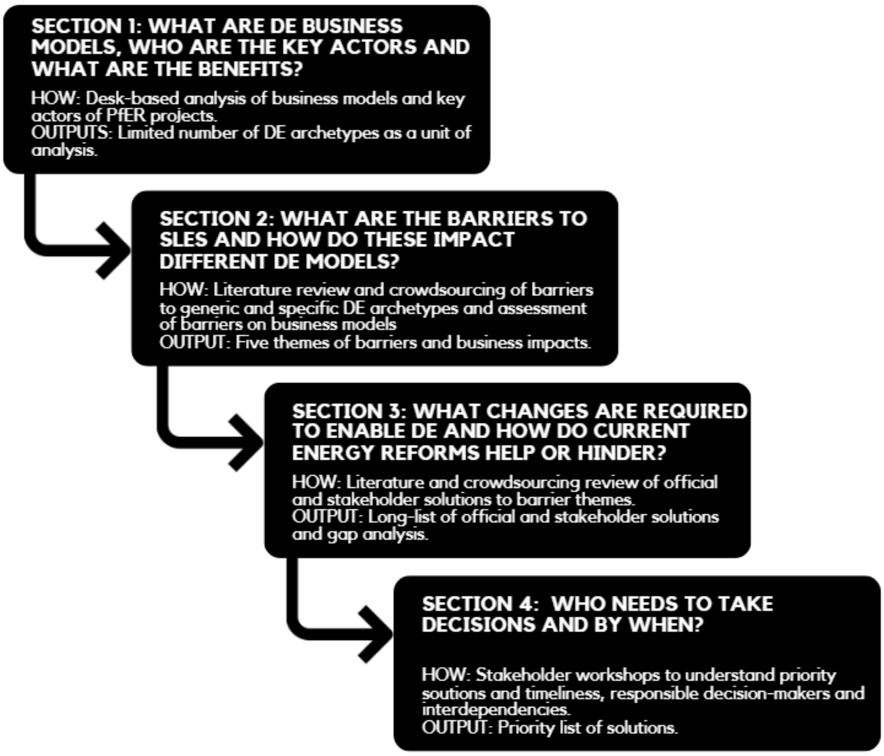

Figure 2: Summary of methodology and outputs of report

The structure of this report follows our methodology.

Section 1, and associated Annexes, describe our analysis of the 14 PfER projects in terms of their objectives, actors and business models. We present seven business model archetypes as units of analysis for the rest of the report.

Section 2, and associated Annexes, summarise our literature review and crowdsourcing exercise of barriers to decentralised energy business models. We present five themes of barriers and multiple sub-barriers that affect decentralised energy business models.

Section 3, and associated Annexes, summarise our literature review and crowdsourcing exercise of solutions to enable decentralised energy. We categorise solutions as official (e.g., government or regulator-led) or wider stakeholder solutions (e.g., proposed by stakeholders who are not decision-makers).

Section 4, and associated Annexes, present the findings and insights of two stakeholder workshops on the priority solutions, timeliness and decision-maker required to enable decentralised energy innovation.

Section 1: What are SLES business models, who are the key actors and what are the benefits?

This section explores the objectives, purpose, actors, and configuration of decentralised energy business models, with a focus on the 14 Prospering from the Energy Revolution (PfER) projects. Our analysis reveals four business model archetype (BMA) clusters, and we describe each of these in detail in terms of the key actors, value, and energy services. We also explore common functions and the customer perspective for each. These four BMAs are supplemented by three additional BMAs derived from the wider literature, and the seven BMAs form units of analysis for subsequent sections of this report.

Methodology

There are several ways in which business models can be characterised, for example, the business model canvas and the business model archetype approach adopted by the Energy Systems Catapult (Energy Systems Catapult, 2022b).

For this work, we wanted to understand the key actors and their relationships and the flow of energy services and money. We applied the methodology developed in the PROSEU project[1] (Hall et al., 2020) to create business model archetypes of 13 PfER demonstrator and detailed design projects. The method captures key institutions and actors, and the flows of energy, payments, flexibility services, and system balancing by creating single-component diagrams showing how each business model works. Each business model archetype was developed by reviewing materials from the PfER projects.

We then undertook a clustering exercise to produce four business model archetype clusters from the 13 PfER projects. These clusters are families of business models that share common traits. The purpose of clustering was to reduce the units of analysis for subsequent analysis of barriers and solutions.

We also analysed the relationship of customers within the four business model archetype clusters. The purpose of this was to understand the relationships between customers and businesses.

Finally, we compared the four business model archetype clusters with other published work on local energy business models. The result of this is that we added three additional business model archetypes to the analysis.

Business model archetypes of the PfER projects

We undertook an analysis of the 13 PfER demonstration and detailed design projects. For each of these projects, we assessed existing literature and materials, and summarised business model functions and energy system relationships to create a business model archetype.

- What is the project doing (its objective)?
- Why is the project doing it (the opportunities and issues it is addressing)?
- Who is involved (key partners and relevant other actors)?
- How is it doing it (a business model archetype and narrative description)?

Demonstrators

Project LEO

What is the project doing?

[1] PROSEU is an EU-funded research project, bringing together eleven project partners from seven European countries. It aims to enable the mainstreaming of the renewable energy Prosumer phenomenon into the European Energy Union. Prosumers are active energy users who both produce and consume energy from renewable sources.

Project LEO is one of the most ambitious, wide-ranging, innovative, and holistic smart grid trials ever conducted in the UK. LEO will improve our understanding of how opportunities can be maximised and unlocked from the transition to a smarter, flexible electricity system and how households, businesses and communities can realise the benefits. The increase in small-scale renewables and low-carbon technologies are creating opportunities for consumers to generate and sell electricity, store electricity using batteries, and even for electric vehicles (EVs) to alleviate demand on the electricity system. To ensure the benefits of this are realised, Distribution Network Operators (DNO) like Scottish and Southern Electricity Networks (SSEN) are becoming Distribution System Operators (DSO) (Low Carbon Hub & Origami Energy, 2021a).

Why is doing it?

Project LEO seeks to create the conditions that replicate the electricity system of the future to better understand these relationships and grow an evidence base that can inform how to manage the transition to a smarter electricity system. It will inform how DSOs function in the future, show how markets can be unlocked and supported, create new investment models for community engagement, and support the development of a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network (Low Carbon Hub & Origami Energy, 2021a).

Who is involved?

- Southern Electric Power Distribution plc (lead)
- EDF Energy
- Nuvve
- Open Utility
- Oxford Brookes University
- Oxford City Council
- Oxfordshire County Council
- The Low Carbon Hub C.I.C.
- University of Oxford

How is it doing it?

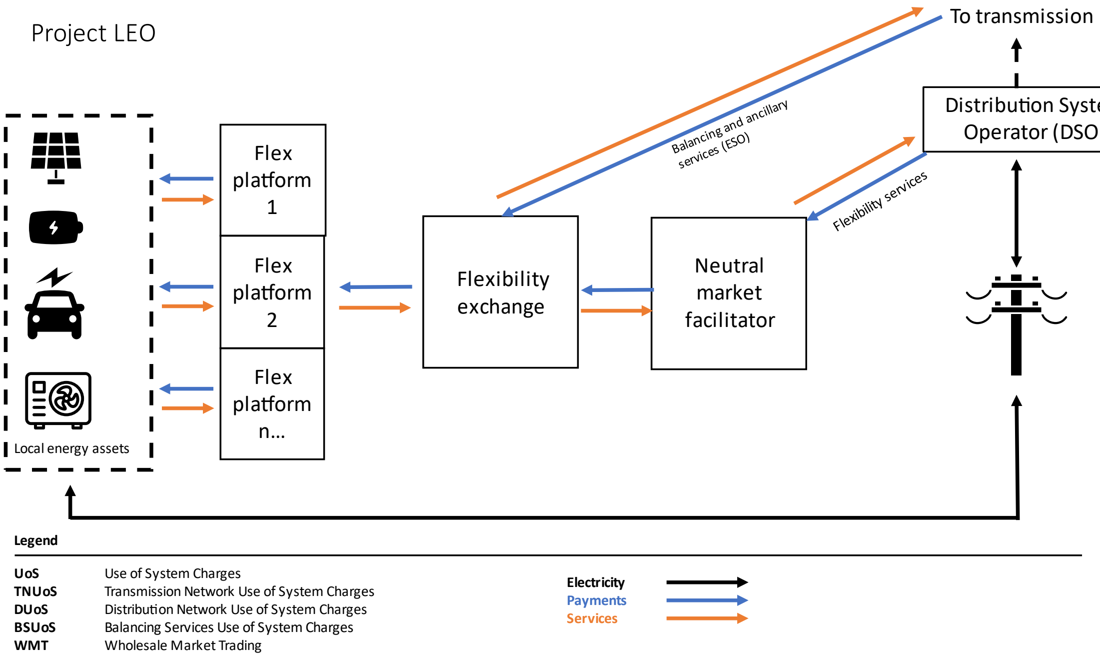

Figure 3: Project LEO business model archetype (Darby and Banks 2020 – p20)

Project LEO has adopted a Local Energy Market structure. In this design, assets within a defined geographical area (Oxfordshire) can participate. These resources can sell their energy or services either locally (e.g., flexibility services to the DSO), or as services on national markets managed by the Electricity System Operator (ESO). Especially for the latter, they may be aggregated. This allows ancillary services to be procured by the ESO to balance supply and demand and to ensure security and quality of supply. Flexibility enables lower variable charges to customers for use of distribution and transmission networks. These opportunities can be 'stacked' to deliver multiple revenue streams or cost reductions (Darby & Banks, 2020a).

The Local Energy Market in LEO operates at two levels:

1. The Neutral Market Facilitation Platform (NMFP) which interacts with another new DSO system, the Whole System Coordinator. The WSC assesses options for mitigating network constraints. These could include contracting for energy and services via the NMFP.
2. The NMFP hosts a Flexibility Exchange Platform, under construction by Piclo. This platform allows flexibility service providers to contract for requested services. Services can be requested either from the DSO or from third parties in P2P arrangements. The service providers in LEO are the Low Carbon Hub, Oxford Behind the Meter (OBM), Nuvve, Origami and EdF.

Energy Superhub Oxford (ESO)

What is the project doing?

Energy Superhub Oxford is showcasing an integrated approach to battery storage, rapid electric vehicle (EV) charging, low carbon heating and smart energy management technologies to cut carbon and improve air quality across the city (UKRI, 2022).

Uniquely, ESO is connecting directly to the national high voltage electricity network, unlocking new energy capacity to support the electrification of heat and transport.

The project will use a 50MW hybrid battery – combining lithium-ion and vanadium flow systems. A machine learning optimisation and trading system will control the battery to provide vital flexibility to National Grid and make the best use of the different asset characteristics.

It will install an EV charging network, enabling the ultra-fast charging of electric cars, taxis, trucks and buses at key locations across the city. Ground source heat pumps will provide low carbon heating to homes and businesses, and smart management technologies will optimise their performance for cost and comfort.

Why is doing it?

The project stated aim is "to eliminate 10,000 tonnes of CO2 emissions a year. That's the equivalent of taking 2,000 cars off the road." (Energy Superhub Oxford, n.d.)

Who is involved?

Partners:

- Pivot Power – part of EDF Renewables
- Habitat Energy
- Invinity Energy Systems
- Kensa Contracting
- Oxford City Council
- University of Oxford

How is it doing it?

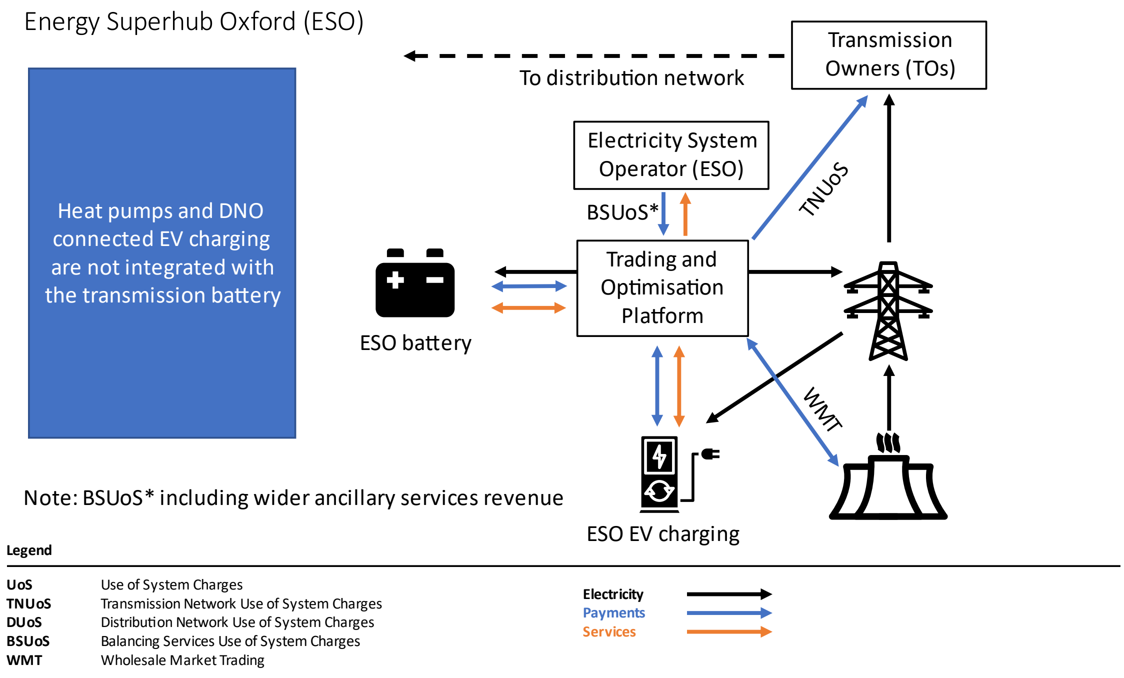

Figure 4: Project ESO business model archetype

The project comprises four main components (Energy Superhub Oxford, n.d.; UKRI, 2022).

1) An electric vehicle (EV) charging hub at Redbridge Park & Ride. The site is connected directly to National Grid high-voltage transmission system, and the battery system alleviating strain on the local distribution network and delivering up to 10MW of power, enough to charge up to 400 cars at once.

2) A transmission connected hybrid battery system comprising a 50MW Wartsila lithium-ion battery and a 2MW Invinity Energy Systems vanadium flow battery.
3) Over 60 domestic heat pumps have been installed in Blackbird Leys, with shared ground arrays, drilled to a depth of 120m and using new “shoebox” heat pumps, which fit discretely in individual properties. Smart controls have been fitted to learn the heat profile of the user and optimise heating to maximise cost and carbon savings.
4) An Optimisation and Trading Engine (OTE) uses machine learning technology to operate and optimise the hybrid battery second-by-second. It is also simulating the potential benefits of charging Oxford City Council’s electrified fleet at optimal times of day to minimise charging and operational costs.

Figure 4 above refers to the transmission connected assets. The heat pump model business model archetype appears separate to the battery and EV station. The heat pump business model appears similar to the GIRONA model (see Figure 8).

ReFLEX Orkney

What is the project doing?

The project is building an integrated energy system (IES) for Orkney – linking local electricity, transport and heat networks into one controllable, overarching system, and digitally connecting the islands’ distributed and variable renewable power resource to flexible energy demand (UKRI, 2022).

The project is demonstrating flexibility using technologies like battery storage, electric vehicles, smart chargers and smart meters.

ReFLEX aims to take away the technical and financial pain of energy transition by making the technology choices very simple for people and by providing services on a pay-as-you-use, lease or rental basis.

Why is doing it?

Orkney has significant renewable energy resources and produces 130% of the electricity it needs through existing installed renewable generation. However, Orkney’s grid is constrained which causes high levels of ‘curtailment’ – where wind turbines are switched off to protect the network from overloading. This limits the economic efficiency of existing turbines, and the ability to install more capacity that will be required as the demand increases to support electric vehicles, and electrified heating systems (Energy Systems Catapult, n.d.).

Energy prices for residents are typically very high partially due to the amount of fuel needed for heating and transport. There is no gas network and therefore homes and businesses rely on either electricity or oil to provide heat. This, in conjunction with Orkney’s older housing stock and the cold local climate, means the area has one of the highest fuel poverty ratings in the UK (63%).

The Orkney’s independent location means it is the ideal location to demonstrate the capabilities of a self-contained smart energy network. The opportunity to harness the excess renewable energy generated that is currently wasted, along with a will to increase the amount of low carbon energy and reduce fuel poverty, forms the main driver for the Reflex demonstration project.

Who is involved?

- European Marine Energy Centre (EMEC) (lead)
- Aquatera
- SMS

- Community Energy Scotland
- Heriot-Watt University
- Orkney Islands Council

How is it doing it?

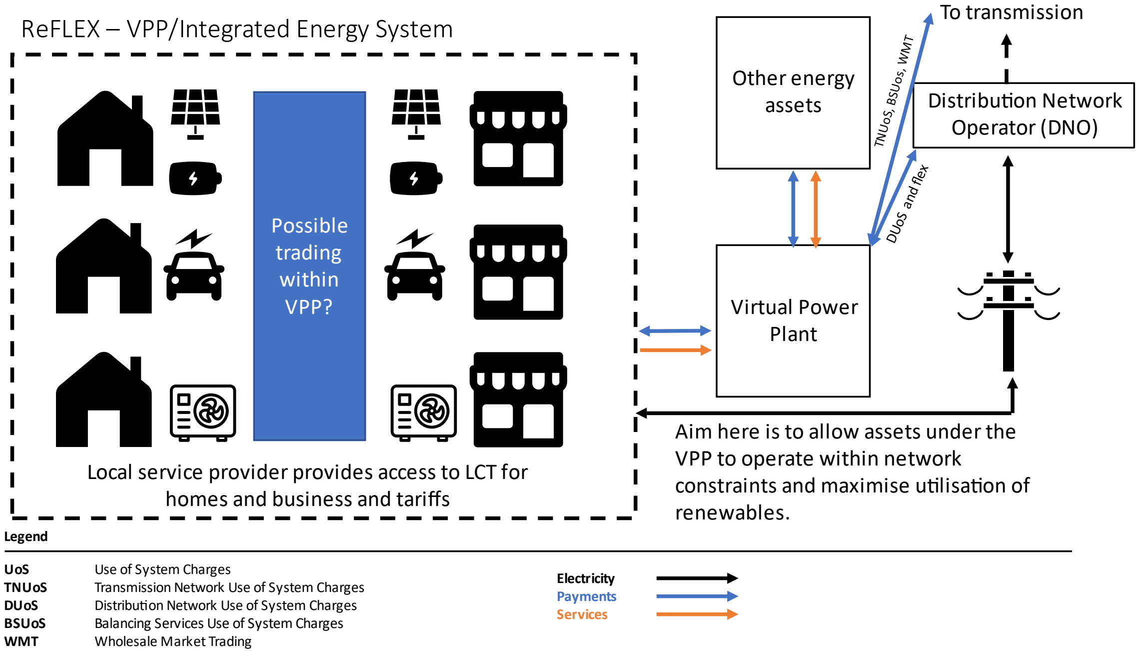

Figure 5: Project ReFLEX business model archetype (Energy Systems Catapult, 2022b)

Aquatera set up a local energy service provider to own and operate EVs, EV charging and electric heating. Around 200 EVs, electric mini-buses and e-bikes and 20 electric heating systems can be managed flexibly (Energy Systems Catapult, 2022b).

SMS developed Flexigrid, which helps match local demand when there is an increase in local generation. Flexigrid generates value for flexible energy assets, through grid services, and reduces impacts of curtailment on local generation assets like wind power.

Orkney Council and its residents get increased access to electric transport and share in the value created by Flexigrid.

Detailed design

Liverpool Multi-Vector Energy Exchange

What is the project doing?

The team is designing a market platform where businesses, universities, homes, landlords and institutions can trade their surplus energy with one another and sell flexibility services to local and national system operators, to reduce energy costs, access new energy revenues, and support their city.

The design comprises two critical layers: a Smart Network Controller to orchestrate energy assets; and a pool-based trading platform which co-optimises and clears bids and offers for energy and flexibility on a half-hourly basis.

Why is doing it?

The Liverpool Energy Xchange is the missing piece of the energy jigsaw. Small-scale producers of cheap and green energy – like rooftop solar – have little incentive to produce more than they need because they get paid so little for it. This means more expensive energy must be bought in, and decarbonisation is slowed down. We are designing a market platform where businesses, universities, homes, landlords and institutions can trade energy with one another – at a price that makes it worthwhile – and offer valuable flexibility services to local and national grid operators (Liverpool Energy Xchange, n.d.).

Who is involved?

- New Resource Partners (lead)
- Decentralised Energy Solutions
- Regent Capital Public
- Smart Power Networks
- SP Energy Networks
- SP Manweb plc
- University of Essex

How is it doing it?

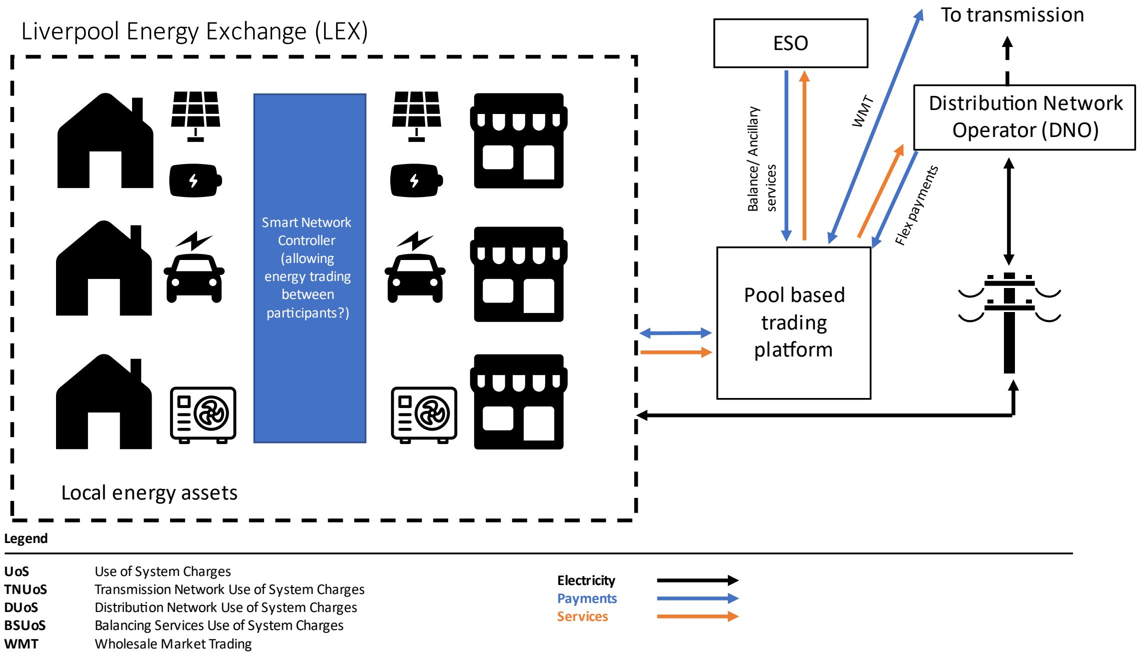

Figure 6: Project LEX business model archetype(Liverpool Energy Xchange, n.d.)

The Liverpool Multi-Vector Energy Exchange (LMEX) aims to create a detailed design for a city-wide, smart local energy system that could facilitate clean energy, electric vehicles, and low-carbon heating and cooling (Liverpool Energy Xchange, n.d.).

The approach has two layers. The first hardware layer is a Smart Network Controller which can communicate with, control and optimise in real-time local energy assets. The second layer is a software-based Flexibility Exchange Platform, through which prosumers can trade peer-to-peer with full transparency, automatic matching, and without third-party intervention.

The stated benefits of the LMEX approach are:

- New flexibility players: all sizes, user-types and technologies able to trade clean, flexible energy services across power, heat and cool, and transport.
- More, cheaper, locally produced energy for lower consumer bills.
- Reduced import from the grid for reduced network losses and avoidance of network reinforcement and associated disruptions.
- More clean energy, leading to improved local air quality, and reduced emissions of greenhouse gases.
- New revenue streams: access for participants to a widening spread of local and national energy market segments, in which new revenues streams are emerging steadily.

Greater Manchester Local Energy Market

What is the project doing?

The Greater Manchester Local Energy Market (GMLEM) aims to change the way the market currently works by developing a platform that increases visibility of energy activity and transactions, suitable for the challenges of the mid-2020s. The project is based on an ambitious whole-system vision for how energy is generated, traded, transported, supplied and used across the city region. It envisions localising energy systems, reducing the distance energy travels to its point of use and optimising consumption. This requires a unique new platform, enabling a local energy market maker to integrate smart technologies across heat, power and transport and link together local demand with supply via local distribution and national transmission (Crook et al., 2022a).

Why is doing it?

Greater Manchester Combined Authority has set a target of becoming Carbon Neutral by 2038.

Geospatial energy planning in the form of local area energy planning is core to the project. It is vital to understand the limitations and opportunities presented by the geographical and socioeconomic conditions of different areas, and how new local renewable generation, heating, mobility resources and infrastructures can best fit. GMLEM is working closely with local communities to draw up these Local Area Energy Plans that will support all the local authorities into the future (UKRI, 2022).

Who is involved?

- Greater Manchester Combined Authority (lead)
- Electricity North West
- Bruntwood
- Hitachi Europe
- Upside Energy (now Kraken Flex, part of Octopus Energy)
- Cadent Gas
- Daikin Airconditioning UK
- Cornwall Insight Group
- Graham Oakes
- Northwards Housing
- Ovo Energy
- Regen SW
- The Society for the Reduction of Carbon

How is it doing it?

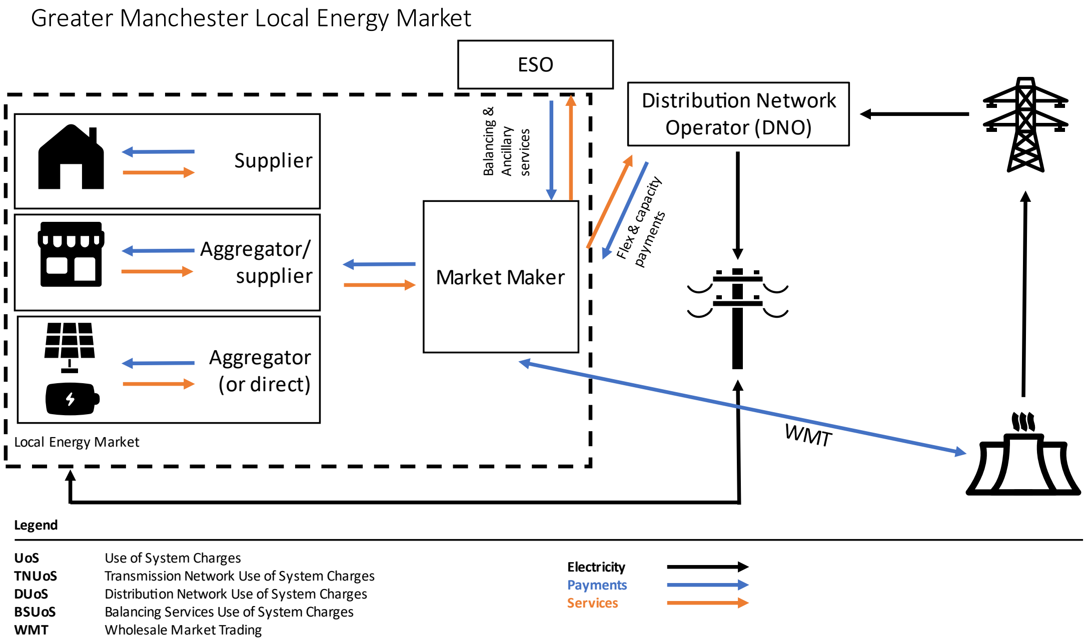

Figure 7: Project GMLEM business model archetype (Energy Systems Catapult, 2022b)

There are four main activities that are facilitated by the Market Maker in the forecasted investment summary out to 2038 (Crook et al., 2022a):

1. Simple energy matching
2. Embedded flexibility
3. Explicit flexibility
4. LEM participation and data sales

The core value of the LEM is in providing visibility of energy system markets and opportunities to LEM participants, and in later phases having a functional role itself in some of those markets. This means the LEM can be a ‘one-stop-shop’ for market participants who might want to sell their generation or demand into more than one market, at the most opportune time. The core functionality that underpins this is the ability to transact at high granularity, at least half-hourly.

It is this granularity that enables participants to mix and match their profiles to customers, using price, location and carbon intensity signals to drive transactions. The better the profiles are matched and reflect the *cost* of using the network (particularly at peak times), the more efficiently the network can be used, lowering peak usage and the requirement to reinforce.

GIRONA

What is the project doing?

In partnership with Causeway Coast and Glens Council, the Girona project is creating a micro-grid, working with around 60 homes in the Greater Coleraine. In the trial, consumers have the chance to install solar panels (if there is no renewable generation at the property already) and a Sonnen SB10 battery to store the energy. The cost is spread out over time and supported by investment from the Girona partners.

The system includes an app allowing customers to monitor and understand their electricity generation and consumption, helping them to profit from unused capacity and to reduce their energy costs. Participants are expected to see an estimated 40% reduction in their current electricity bill.

Why is doing it?

Currently, around 70% of electricity is generated from renewable sources, but 50% is discarded because there is no way to store that electricity and no infrastructure or mechanism in place for it to be used by the grid.

The Project will install a Sonnen battery and where required solar panels to generate and store the energy and use it when required. When all the energy in the battery has been used, the system then reverts back to the mains supply. The Project estimates a saving of around 40% on a current electricity bill.

Who is involved?

- Girona Energy (lead)
- GES Group
- Poweron Technologies (The Electric Storage Co.)

How is it doing it?

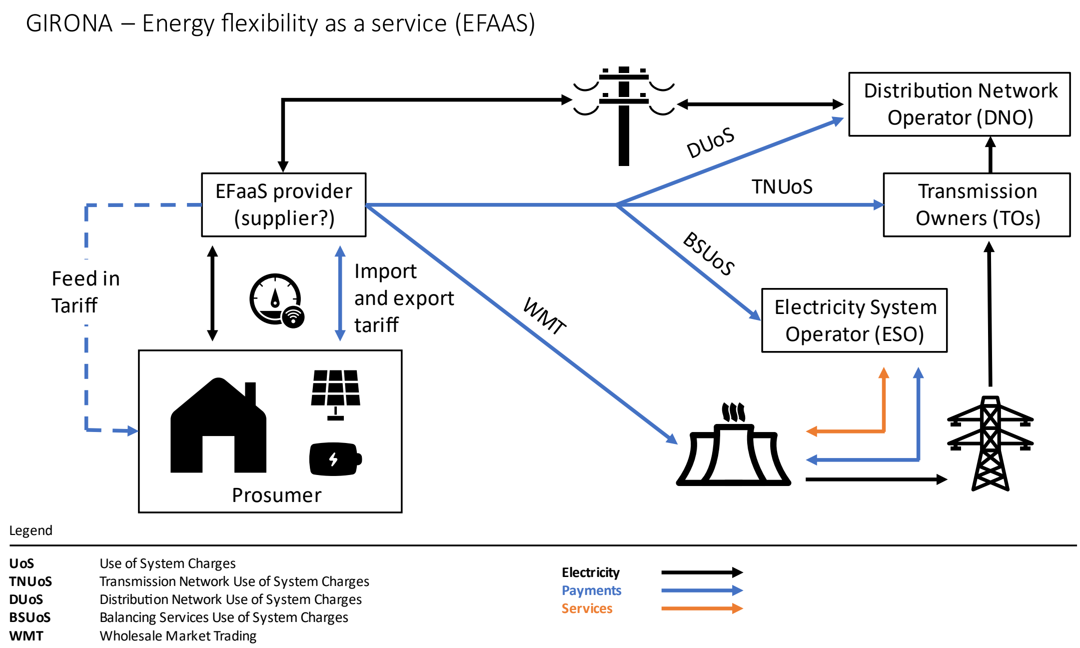

Figure 8: Project GIRONA business model archetype

Project Girona is a detailed design of an energy-flexibility-as-a-service business model via planned installations of batteries and solar panels in up to 100 houses, businesses and community buildings, based in County Antrim, Northern Ireland.

The partnership aims to integrate these solar and battery systems through a renewable energy management platform (PARIS) operated by The Electric Storage Company. The platform uses data analytics to decide whether to use, store, trade, or provide grid service. The sonnen batteries also form a virtual power plant using the sonnenVPP system. This VPP enables coordination of many batteries to provide energy system balancing and grid support services.

Zero Carbon Rugeley

What is the project doing?

Zero Carbon Rugeley is a project to produce an innovative design for a town-wide Smart Local Energy System (SLES) including around 2,300 new homes at the former Rugeley Power Station site. The system will be sustainable and low-carbon, driving the regeneration of the town and its energy infrastructure while offering additional services and value to residents(UKRI, 2022).

Why is doing it?

At the centre of this pioneering project is the Rugeley community; residents, local businesses and commuters who access the area regularly. Crucially, 'User-Centric Design' is embedded in the proposed solutions, using innovative community engagement methodologies to ensure the wants and needs of the community are addressed. Zero Carbon Rugeley will create a 'bespoke Rugeley SLES', not simply an 'SLES for Rugeley', demonstrating how carbon emissions and energy costs can be reduced whilst simultaneously boosting local economic regeneration and social integration (UKRI, 2022).

Who is involved?

- Engie Services (lead) (Equans)
- Cadent Gas
- Chase Community Solar
- Conigital
- Connected Places Catapult
- Keele University
- Opus One Solutions
- Regen SW
- Stoke-On-Trent and North
- Staffordshire Theatre Trust
- Sustainable Housing Action
- Partnership
- West Midlands Combined Authority

How is it doing it?

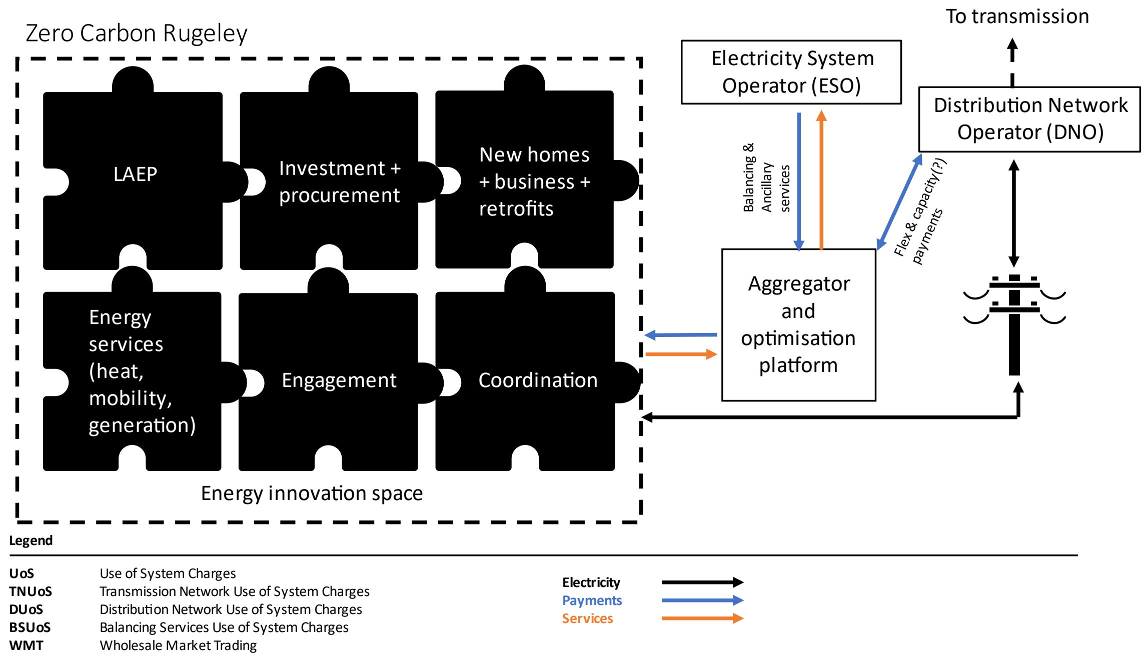

Figure 9: Project ZCR business model archetype (Zero Carbon Rugeley, n.d.)

The Zero Carbon Rugeley SLES project will focus on the design of a local market platform that will

- facilitate the procurement of flexibility services
- allowing customers and energy suppliers to trade
- determine total system value based on a combination of bulk system components, distribution system components, and an evaluation of system conditions

This local market platform will go beyond signposting needs and simply coordinating buyers and sellers. It will include a comprehensive end to end view of the viability of the system and its operation. By placing system and customer needs at the heart of the design of the local market platform will ensure not only economics and technical viability of the market, but also creating the appropriate investment signals, and will remove barriers of entry for local energy participants (Opus One Solutions, 2020a).

West Midlands RESO

What is the project doing?

The RESO design is a partnership approach that brings key decision makers together to enable the integration of new energy technologies into the existing energy, transport and economic infrastructure of the region – including low-carbon vehicles and transport models, energy storage, renewable energy technologies, and energy efficiency.

The project includes a capacity and flexibility trading mechanism which will be readily accessible to both energy users and suppliers – where 'suppliers' include electric vehicles and energy efficiency in buildings.

Why is doing it?

A key focus is encouraging investment in smart local energy systems, through an innovative governance design which allows a combination of strategic investment planning and virtually real-time system optimisation, which uses local price and value signals across electricity, gas, and heat distribution network assets.

The principle of intelligent control to manage local energy flows is already being demonstrated by a real-world system established on the University of Warwick campus, a community of over 30,000 people.

Who is involved?

- West Midlands Combined Authority (lead)
- Coventry City Council
- Enzen
- Western Power Distribution plc
- Cadent Gas
- Camirus
- Electron Global
- Places in Common
- University of Birmingham
- University of Warwick

How is it doing it?

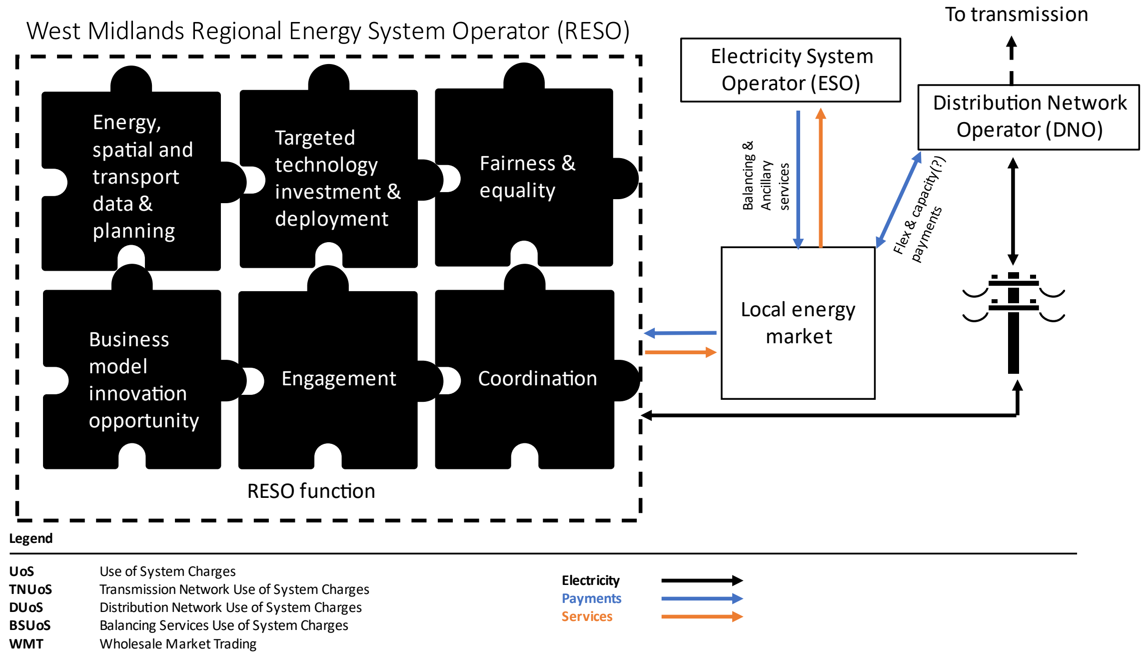

Figure 10: Project West Midlands RESO business model archetype (Energy Systems Catapult, 2022d)

The RESO project developed and explored the hypothesis that giving cities and localities a stronger role within the UK's established model of energy market regulation offered significant potential for releasing additional value, particularly given the need to transition the UK economy to net zero. The conclusions of the project are that this hypothesis is correct, although there are significant cultural, political, practical and regulatory barriers which will need to be overcome to enable the identified value to be realised.

Specifically, the project has (Energy Capital, 2022a):

- Engaged a wide range of relevant stakeholders across the city
- Established the key data gaps that will need to be filled to support any meaningful local institutional model

- Detailed three distinct local markets which will accelerate and reduce the costs of decarbonisation of Coventry
- Developed a range of smart technology pathways and scenarios for decarbonisation of the city, enabling modelling of costs and carbon reductions under varying external policy conditions
- Used the experience of energy cost reductions (under controlled local governance) on the campus of the university of Warwick to inform these pathways
- Developed preliminary organisational and governance models for a local energy systems management structure (RESO), replicable nationally, supported by a cost benefit analysis
- Worked with companion PFER projects towards developing commercial funding models for smart local energy systems, with a view to these being applicable nationally

Peterborough Integrated Renewables Infrastructure (PIRI)

What is the project doing?

Electricity: Creating a local electricity network will balance production and use of energy locally and reduce the strain on the national distribution grid.

Heat: Peterborough has a waste-to-energy plant which generates electricity and produces steam – currently condensed back into water. A next-generation heat network using this wasted energy to heat businesses and homes would remove the need for individual boilers, reducing both cost and carbon emissions and improving local air quality.

Mobility: A low-carbon infrastructure network with widely accessible charging points will allow for the electrification of Peterborough's public transport system and council vehicles. The network will allow energy generated during the night – when demand is lower – to be used to charge vehicles.

Technology to balance demand and supply plays a major role in this scheme. The goal is to meet the fluctuating demands of the city by sharing and recycling energy within a flexible local system.

Why is doing it?

PIRI aims to deliver low-cost and low carbon emission energy for the Peterborough community. Developing an integrated energy system design for electricity, heat and transport will provide benefits to the community and business not just in Peterborough but around the UK. PIRI is working to demonstrate an investment-ready case that can be transferred to other cities (PIRI, n.d.).

Who is involved?

Partners:

- Peterborough City Council (lead)
- Cranfield University
- Element Energy
- Smarter Grid Solutions
- SSE Utilities Solutions
- Sweco UK

How is it doing it?

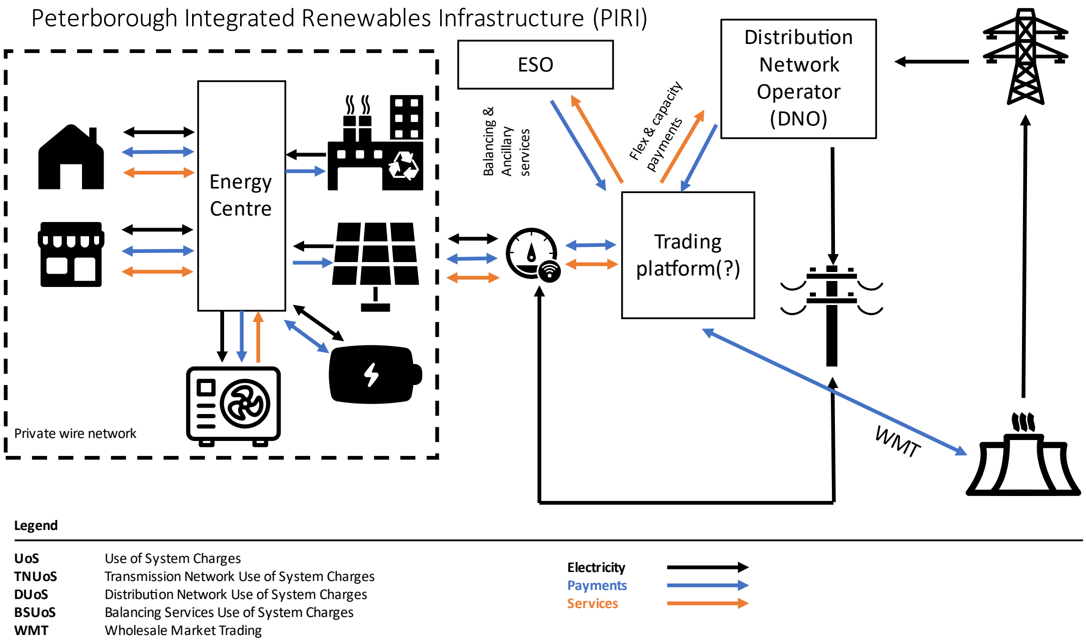

Figure 11: Project PIRI business model archetype (PIRI, 2021)

The PIRI project centres on a whole systems approach to electricity, heat, and mobility (transport), all linked by a smart energy management system. The smart local electricity system will use supply and demand balancing technology to better meet the needs of the city's homes and businesses. The PIRI project would see some of the steam used to generate electricity at the existing Peterborough Energy Recovery Facility (PERF) put through a heat exchanger to derive heat for a heat distribution network. The project will also explore the electrification of buses and council vehicles, as well as providing charge points for public and private use. Energy from waste, solar power and wind will be harnessed to help support the city as it grows (Smarter Grid Solutions, 2022).

Milford Haven: Energy Kingdom

What is the project doing?

The objective of Milford Haven: Energy Kingdom (MH:EK) is to establish seed markets for use of hydrogen around the Milford Haven waterway, by integrating a wide range of major energy facilities, renewable energy generators and energy consumers in the community, using a systems architecture that can be implemented with commercial-ready solutions and which focuses on underlying fundamentals and is therefore robust in the face of regulatory change (Milford Haven: Energy Kingdom, 2022a).

Why is doing it?

Our vision is to create a whole energy system which shines a light on the potential of hydrogen as a renewable energy source as part of an integrated SLES and the future potential and net zero transition pathway for the predominantly hydrocarbon reliant Haven(Milford Haven: Energy Kingdom, 2022a).

Who is involved?

- Pembrokeshire County Council (lead)
- Milford Haven Port Authority
- Offshore Renewable Energy Catapult
- Riversimple Movement

- Wales & West Utilities

How is it doing it?

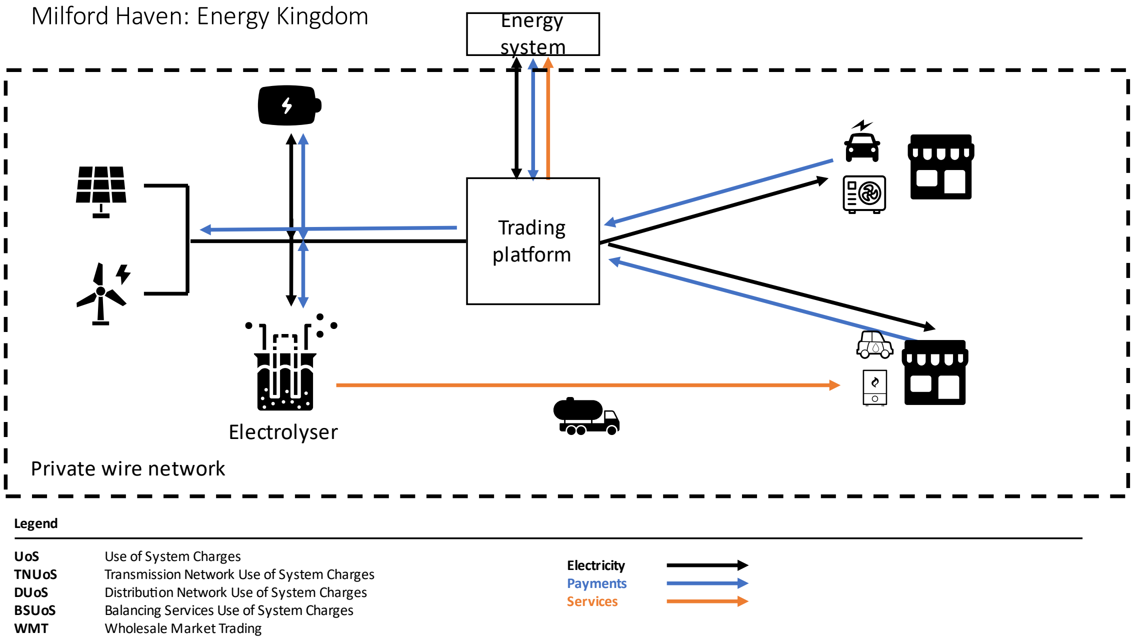

Figure 12: Project MH:EK business model archetype (Milford Haven: Energy Kingdom, 2022a)

The project recommends delivering two propositions(Milford Haven: Energy Kingdom, 2022a):

- Proposition 1: The Milford Haven Marina SLES: Building new Solar and wind assets, and linking them by private wire to Proposition 2. This includes a battery and an electroyser to produce hydrogen. A trading platform will optimise where renewable electricity is used (e.g., consumed in end-user demand, stored in a battery, used the create hydrogen or sold to the National Grid).
- Proposition 2: The Pembrokeshire Food Park SLES includes a new solar park and a new food park (as a demand customer). Hydrogen will moved by tanker from the electrolyser to heating and transport demands.

Project REMeDY

What is the project doing?

The project is developing a new business model for energy systems which are integrated horizontally (working across electricity, heat and mobility) and vertically (connecting generation, distribution, flexibility and supply) (UKRI, 2022).

The model integrates system operation and supply at a local level in a way that puts customers first. Additionally, it works for financiers and is compliant with current regulation. The model provides a blueprint for a new energy system design, enabling the progression from the faltering ‘supplier hub’ model to a highly efficient zero-carbon architecture.

Project REMeDY is based in Southend-on-Sea, Essex. The approach used will produce a contemporary local energy system design to cover Southend

Why is doing it?

The vision for Project REMeDY was to catalyse a Revolution in Energy Market Design by designing a world-leading energy system for Southend (80,800 households). REMeDY aims to integrate distributed electricity, heat and mobility technologies using Artificial Intelligence (AI) and Internet of Things (IoT) controls through an innovative business model that is replicable across urban localities and across the Places for People PLC building stock (190k homes and 112 leisure centres) (Jarvis & Gaundar, 2022a).

Who is involved?

- Southend-on-Sea Borough Council (lead)
- FutureGov
- Imperial College London
- Places for People Group
- SMS
- University of East Anglia
- Vital Energi

How is it doing it?

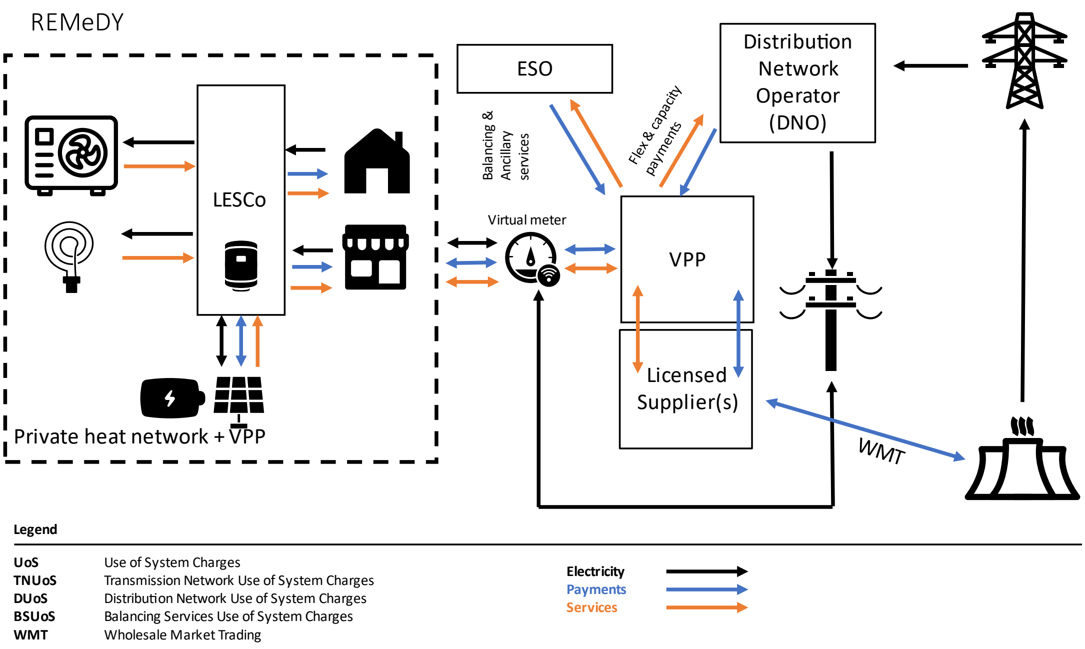

Figure 13: Project REMeDY business model archetype (Jarvis & Gaundar, 2022a)

The final REMeDY smart local energy system is therefore built around a communal heating system, combined with local generation, battery and heat energy storage, and potentially electric vehicle (EV) charging (EnergyUnlocked, 2022a).

Domestic customers would still buy their electricity for lighting, cooking etc from normal electricity suppliers, but would get heat and, possibly, EV charging from the local smart energy system.

REWIRE-NW

What is the project doing?

The project's mission is to create a smart local energy system that is not only optimised in energy terms, but operates at maximum efficiency for the welfare and benefit of all of its stakeholders including the local community.

To achieve this, the project is developing new market arrangements that pave the way for change.

A market system architecture, centred on energy data and enhanced by 5G technology, will operate under a new entity, the Smart Local Energy Company. Together, these elements will drive the energy system towards a lower cost and lower carbon outcome.

REWIRE NW aims to demonstrate the benefits of increasing the role of the public and community sector in energy alongside commercial ownership, redefining the role of community in energy, and designing a system that prioritises local social and economic objectives.

Why is doing it?

To support Warrington in meeting its Climate Objectives and support it through a resilient energy transition, giving them the tools and capacity to undertake this challenge, and derive learnings for replication to similar localities in the UK (REWIRE NW, 2022).

Who is involved?

- Pure Leapfrog (lead)
- Altana Wealth
- Cadent Gas
- Cornwall Insight Group
- Gridserve Sustainable Energy
- Integrated Environmental Solutions
- Qbots Energy
- SP Energy Networks
- Switch2 Energy
- Together Energy
- University of Strathclyde
- Warrington Borough Council

How is it doing it?

We have not presented a BMA diagram for REWIRE-NW as studying the feasibility of a wide range of business models.

Take from scope (REWIRE NW, 2022).

- REWIRE takes a Digitally Driven Approach for least cost whole energy system decarbonisation along a Net- Zero Trajectory
- REWIRE will identify and promote the Regulations and Market Arrangements required to enable this shift
- REWIRE will identify Optimal Investment Pathways across heat, power and transport and;
- REWIRE will develop the Value Propositions and Business Models that shall underpin this new investment

Business models being studied:

- BM #1: Electricity Power Pool
- BM #2: Retrofit Marketplace Platform - A marketplace that gives building owners access to their own building's within the digital twin; linking the twin's recommendations to suppliers and installers of EE measures.
- BM #4: SME Energy Asset Leasing with Smart Tariff (Leasing of flex assets to SMEs via an ESCO model. Batteries, heat pumps, thermal store + Control of flex assets across Q Energy Platform)
- BM #6: Community-BECCS (A community scale Bio-Energy Carbon Capture and Storage technology based on biomass pyrolysis)
- BM #7: SME Smart Green Deal (basically an ESCo that delivers energy efficiency and energy flex to SMEs + help with finance)
- BM #8: Smart Community Energy Supply (A community owned white label energy supply company connecting local generating assets to non-domestic customers via smart tariff and TPI arrangements with supplier)
- BM #9: Community Collaborative EV Charging (Community owned on street residential EV chargers zoned much like parking permits. Zones maximise grid connection through smart fleet charging of residents' vehicles)
- BM #10: SME Fleet Electrification Planning App (Structured planning tool for fleet owners to assess fleet requirements vs real estate potential to facilitate optimal solution discovery for full fleet electrification)

GreenSCIES 2

What is the project doing?

It devised a smart grid integrating heat sources such as the underground system, substations, sewers, supermarkets and data centres, with battery storage and electric vehicle-to-grid points.

After the success of the concept stage, GreenSCIES 2 is now developing detailed designs for technical and business models. In these, heating and cooling energy is exchanged between buildings through a heat network that uses distributed heat pumps and recovers waste heat from data centres. Decentralised energy centres provide solar energy hubs, alongside batteries for energy storage and electric vehicle charging. The hubs use an AI control system to operate on demand and flex with grid requirements, making the most of intermittent renewable energy and helping consumers always get the best tariff.

Why is doing it?

GreenSCIES is a revolutionary smart local energy system that aims to reduce carbon emissions and tackle fuel poverty across the London Borough of Islington. The project will help Islington Council achieve its ambition of being a net zero carbon borough by 2030 (GreenSCIES, n.d.).

Who is involved?

- London South Bank University (lead)
- Building Energy Solutions
- Carbon Data Resources
- Carbon Descent Projects
- Grid Edge
- London Borough of Islington
- Transport for London

- Ubeeqo UK
- Engie Services Holding UK
- Building Low Carbon Solutions
- Cenex
- Consortio
- Cullinan Studio
- E.ON UK
- Hanger19
- Repowering
- Silver Energy Management Solutions
- West Midlands Combined Authority

How is it doing it?

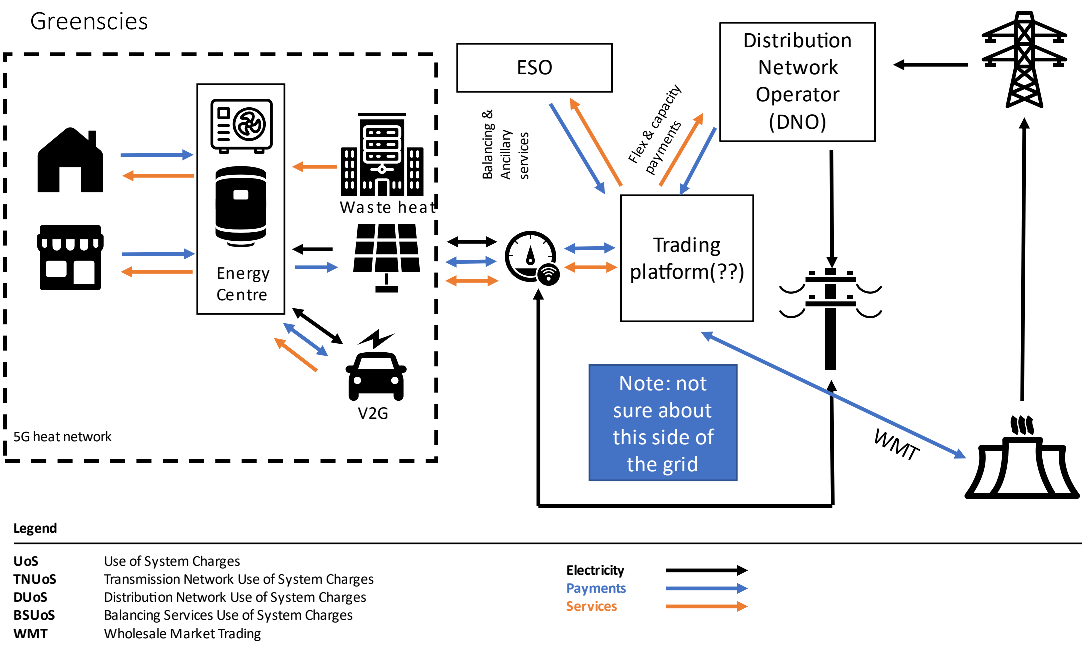

Figure 14: Project GreenScies business model archetype (GreenSCIES, n.d.)

The detailed design will provide an ultra-low 5th generation heat network with distributed low carbon heat pumps to supply heating/cooling using an ambient loop to exchange energy between buildings, enabling recovery of low-grade waste heat from data centres and the London Underground (GreenSCIES, n.d.).

Each of the decentralised energy centres will provide hubs for photovoltaic (PV) electricity generation, electric vehicles and vehicle-to-grid charging/storage alongside large scale batteries. The hubs can then be used for Demand Side Response to flex with the electricity grid requirements/tariffs using a sophisticated artificial intelligence control system. This will be the first large smart energy system in the UK that integrates energy technologies across heat, power and transport, allowing widescale replication.

PfER business model archetype clusters

We identified four distinct archetype clusters from the PfER projects – these are summarised in Table 1. Clustering the business models in such a way allows us to undertake an analysis of barriers and enablers (Sections 2 & 3) with fewer units of analysis. The compromise is that there is less project-specific information and nuance in subsequent analysis.

Table 1: Business model archetype clusters for PfER projects

Business model archetype cluster & *short description*	**Relevant PfER projects**
Virtual Power Plant *Optimising assets behind a virtual meter to achieve energy system objectives.*	ReFLEX Orkney Liverpool Multi-Vector Energy Exchange
Private network *Creating a private electricity or heat network to deliver energy services to users.*	Energy Superhub Oxford (ESO) Peterborough Integrated Renewables Infrastructure (PIRI) Project REMeDY GreenSCIES2 Milford Haven: Energy Kingdom
Flex-enabled business model *Working with local users and assets to address local network constraints and enable more local renewables.*	Local Energy Oxfordshire (LEO) Greater Manchester Local Energy Market GIRONA
SLES marketplace *Creating the conditions for new smart local energy systems to emerge.*	Zero Carbon Rugeley West Midlands RESO Rewire-NW

Common business model functions

Based on Facchinetti (et al.) analysis of local energy management businesses we identify a range of common functions relating to how business models approach customer acquisition, asset procurement, operation, customer interactions and pricing (Facchinetti & Sulzer, 2016). These functions are summarised in Table 2 and our analysis summarises how decentralised energy business models approach these functions.

In addition to these functions, there are also wider and incumbent energy institutions/actors that are relevant and common to most business models and fulfil essential energy system functions. These include:

- Licensed energy suppliers (often responsible for several of the functions above, particularly the delivery of energy services and pricing)
- Distribution Network (System) Operators, DNO (responsible for planning, operation and running flexibility markets (as DSOs) – note this can also include independent DNOs, for example for private wire networks.
- Transmission Network Owners, TOs (responsible for operating the transmission network)
- Electricity System Operator, ESO (responsible for planning transmission network and system operation (balancing and ancillary services)
- Gas distribution and transmission, GDNs and TO (responsible for planning and operating local gas networks and the National Transmission System respectively)

For each of the business model archetypes (BMA), we present a diagram of the key actors and energy, value and service flows. We also include an analysis of the common business model functions. Finally, we present an analysis exploring the BMA from the perspective of a customer.

Table 2: Energy business model functions derived from (Facchinetti & Sulzer, 2016)

Function	Description
Acquisition/loyalty	The acquisition and retention of customers
Procurement of infrastructures	The process and means of purchasing and financing assets
Operation and control of infrastructures	How the relevant assets are operated and controlled
Delivery of energy services	Organisation responsible for delivering agreed energy services to end customers
Pricing	How energy services are priced/billed (and who is responsible for billing) and potentially how energy prices are cleared (e.g., in a trading platform)

Virtual Power Plant archetype

Short description: Optimising assets behind a virtual meter to achieve energy system objectives.

Examples: ReFLEX Orkney, Liverpool Multi-Vector Energy Exchange

Figure 15 below shows the business model archetype.

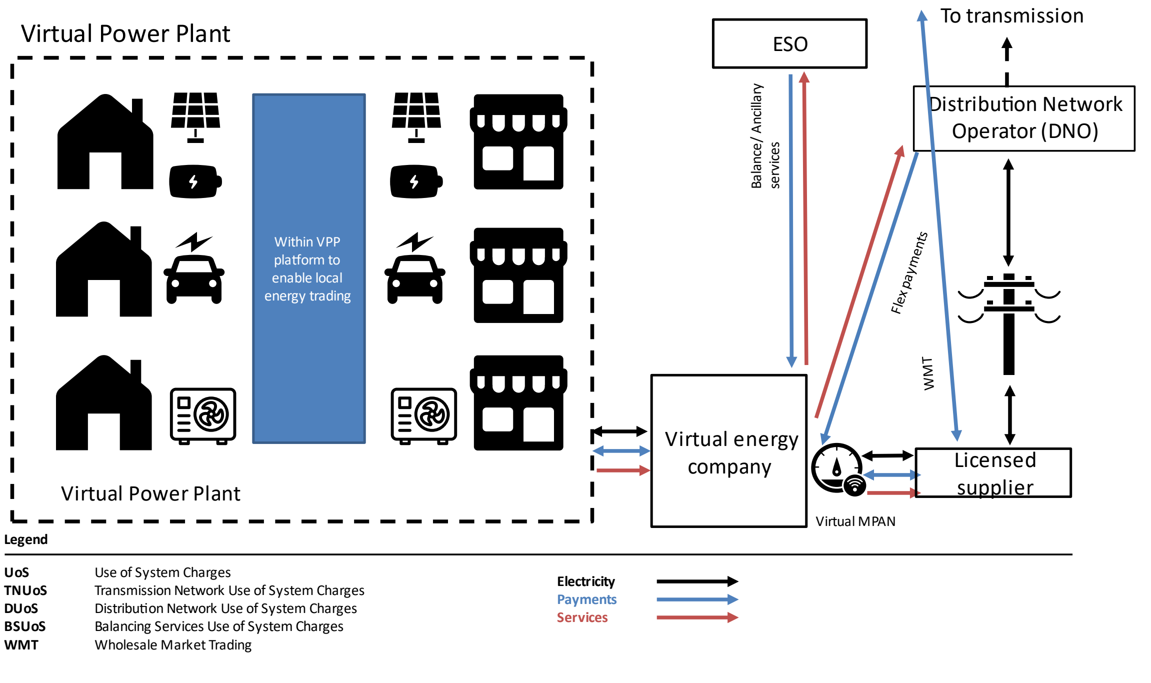

Figure 15: Virtual Power Plant business model archetype

The purpose of a Virtual Power Plant is to create a virtual meter below which all the local energy assets can interact (e.g., trade or share energy, resolve local constraints, maximise self-consumption of local renewables, etc). The wider energy system interfaces with the virtual meter, which will essentially be importing or exporting electricity half-hourly. Depending on objectives, the VPP might also be providing wider energy system services, such as flexibility and balancing and ancillary services locally and nationally.

The objectives of the VPP depend on the actors involved and the issues to be resolved. For example, ReFLEX is seeking to maximise the utilisation of local renewables in a constrained system. In Liverpool Multi-Vector Energy Exchange, the rationale is to allow participants to trade local renewables with one another and incentivise more deployment.

There are common features in the different VPPs. There is some form of optimisation and local trading platform ‘inside’ the VPP. This platform enables assets to trade electricity and moderate demand. There is also an interface with the wider energy system, termed a “virtual energy company (VEC)”, which is responsible for trading electricity with the wider system, most likely through a licensed supplier[2].

The legal status of the VEC depends on the nature of the VPP. It could be a fully licensed supplier, an exempt supplier (see Section 2 for a definition) or could be a form of an aggregator. The latter might be the simplest configuration. The configuration will affect the nature of the relationship between the VEC and its customers. Figure 16 describes a potential customer relationship in more detail.

Functions in VPP (who is doing what)?

Table 3 below outlines which actors are responsible for delivering the functions identified.

Table 3: Functions in VPP business model archetype

Function	**Which actor?**
Acquisition/loyalty	The operator of the VPP (the VEC) is most likely to be responsible for recruiting and retaining customers
Procurement of infrastructures	This depends on the model. Some customers might already have their own assets or choose to purchase and register energy assets for the VPP. Other customers might enter a relationship with the VEC to finance new energy assets. There may be additional assets required to operate the VPP, such as sensors and communication and control systems. Such assets would likely be owned by the VEC.
Operation and control of infrastructures	It is most likely that in such models that assets would be automatically dispatched centrally by the VPP operators (e.g., the VEC). It is possible that price signals might be passed direct to end users and it would up to them to respond, however, this would likely reduce the response compared to auto-dispatch.
Delivery of energy services	The VEC would be responsible for agreeing and delivering VPP specific energy services to end customers. Customers, such as homes and small businesses would also likely have a traditional licensed supplier for wider energy supply. (The licensed supplier could also be the VEC operator).
Pricing	The VEC would be responsible for pricing at the virtual meter (e.g., the price for electricity export or import). Whether they are responsible for billing end customers depends on the nature of the contract. It is possible a licensed supplier could be required for billing end customers.

[2] ‘Analysis here draws upon the PROSEU project which identifies this intermediary with the wider energy system as a ‘virtual energy company (VEC)’ (Hall et al., 2020).

Customer relationship in VPP

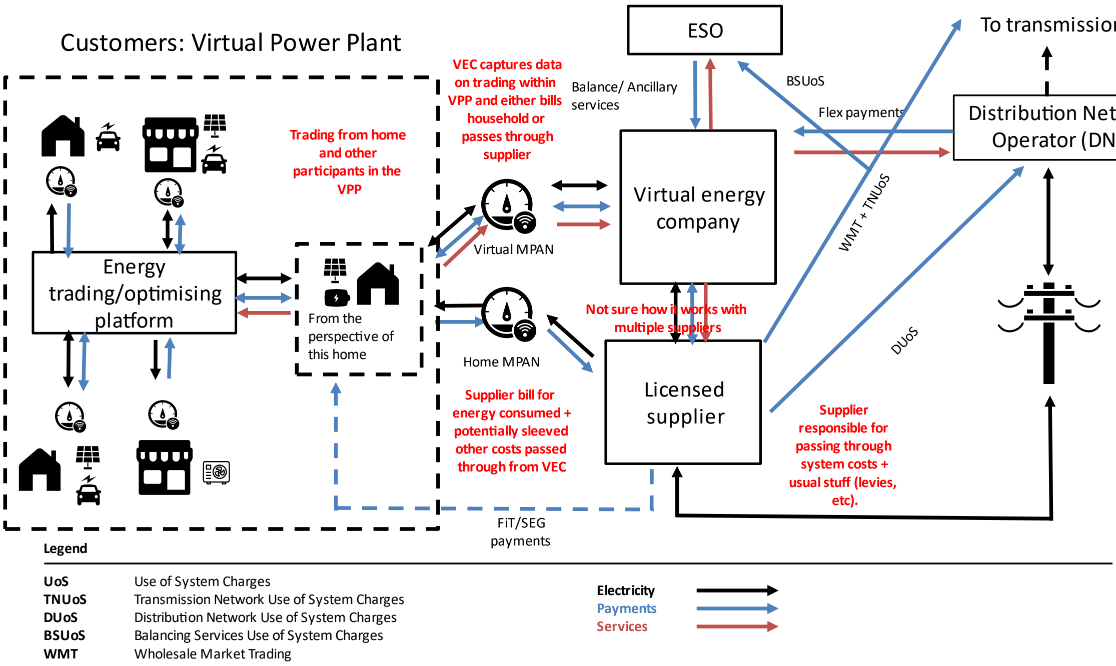

Figure 16: Customer relationships within VPP

Figure 16 above shows how the VPP might work from a domestic customer perspective. The notes below describe the key aspects.

- The customer would need to sign up to the VPP – perhaps through some form of local energy tariff either direct with the VEC or through their usual energy supplier.
- The customer would need to register their assets (for example PV & battery) with the VEC via the trading and optimisation platform. Customers might also need to agree some service level agreements (e.g., under what circumstances and constraints can their assets be used). Likely this would involve some form of automation, so in essence the customer is stipulating prices (min/max) and hard constraints (e.g., I need my car at 50% minimum charge) on automation.
- The VEC would then automatically trigger trades to meet individual and collective objectives (e.g., maximise self-consumption of local renewables/minimise bills).
- Depending on the nature of the relationship of the VPP and the wider energy system, the customer could realistically be billed in one of three ways:
    - Through their supplier via some form of arrangement with the VEC (for example sleeving).
    - Directly from the VEC if for example their energy supplier is the VEC.
    - Directly from the VEC if the arrangements were separate to energy supply, for example, flexibility payments under a different sort of contract.
- The VEC would be responsible for ensuring billing is accurate and for maintaining wider compliance with relevant licenses and codes.

Private network

Short description: Creating a private network to deliver energy services to users

Examples: Energy Superhub Oxford (ESO), Peterborough Integrated Renewables Infrastructure (PIRI), Project REMeDY, GreenSCIES2, Milford Haven: Energy Kingdom

Figure 17 below shows the business model archetype.

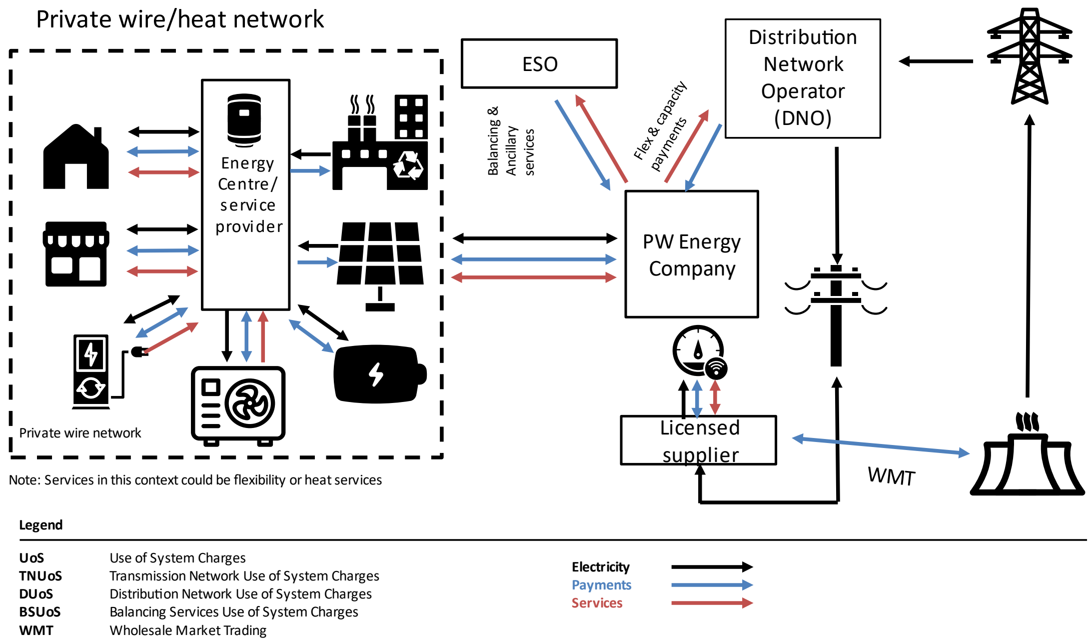

Figure 17: Private wire/heat network business model archetype

There are examples of private networks that deliver either heat or electricity (or both) in the PfER projects (ESO (electricity), PIRI (heat), Remedy (heat), GreenScies (heat), MK:EH (both). Whilst the treatment within regulation might be different, the principles of the business models are similar. Their objective is to build a private energy network to deliver energy services to customers (and possibly the wider energy system). This means that customers of the network will be paying the network operator for both the energy they consume and for the cost of the network via the use of system charges.

For a private wire electricity network, there are similarities with the virtual power plant (VPP) archetype. In both cases, some form of energy company will be required to operate the network, optimise the energy assets and demand, bill customers and interface with the wider energy system. The configuration of that private wire energy company will depend on whether it falls under supply and generation exemptions.

For a private heat network, depending on whether any electricity trading is occurring, then the heat network operator may or may not need similar relationships in place with the wider electricity system. Regardless, the heat network operator will be responsible for operating the network, optimising the energy assets and demand, and billing network customers.

In all examples, and like the VPP, there is a smart platform in the centre of the private network that is optimising the connected assets and customer demand. This might include sources of waste heat, heat assets (like heat pumps), heat networks, heat stores, electricity networks, electricity generation assets (local renewables and behind-the-meter assets in homes), local battery storage and other energy assets, such as EVs. This includes, potentially, trading of energy between users of the network (for example, a home selling its excess PV to other users).

The difference between this example and the VPP is that here the network is private, whereas in VPP it is conducted on the public network. In other words, there is physical delivery of electricity/heat to end customers. This means there will be metering and accurate billing requirements on the network operator.

In both private electricity and heat networks it is likely (where physically possible) there will be a connection to the wider electricity system grid to facilitate the import or export of electricity. Likely this would be through a licensed supplier. For homes and businesses just connected to a heat network, they would have a usual relationship with an electricity supplier for their electricity supply. For those on a private electricity network, this might be the case, or they may be billed for imported electricity via the private wire network operator.

Functions in the private wire/heat network archetype (who is doing what)?

Table 4 below outlines which actors are responsible for delivering the functions identified.

Table 4: Functions in private wire/heat network business model archetype

Function	Which actor?
Acquisition/loyalty	Depending on the nature of the private network, customers may need to be recruited (e.g., to get enough to make a heat network economically viable) or they might come with the network (e.g., if the network is the only source of heat or electricity in a place – for example, a new build housing estate). As such, loyalty might be crucial (because the economics depend on people staying connected) or not so important (because you have created a monopoly). In either case, the private network operator is the key actor.
Procurement of infrastructures	For both heat and electricity networks, the network itself will be procured by the network owner (and likely operator). Other assets might also be present in homes and businesses, such as heat pumps or heat exchange boxes (for het networks) and behind-the-meter assets (such as PV and batteries) in electricity networks. These might be owned by households or businesses or potentially owned (or leased) by the network operator. There may be additional assets required to operate the network, such as sensors and communication and control systems. Such assets would likely be owned by the network operator.
Operation and control of infrastructures	The network operator would be responsible for operating the network. The network operator might also operate assets behind the meter, either because they also own those assets, or they have permission from customers to do so. The former might be the heat exchange unit in homes for heat networks. The latter might be a battery or EV charger in a home. In some cases, homes and businesses might chose to operate their own assets and follow prices.
Delivery of energy services	The network operator would be responsible for agreeing and delivering specific energy services to end customers (heat, power or both). Customers might also operate some assets that deliver some energy services (for example, PV and batteries).
Pricing	The network operator is responsible for pricing and billing for energy services and collecting the use of system charges for its network. For electricity network operators, the billing might be under supplier exemption

Customer relationships in private heat network

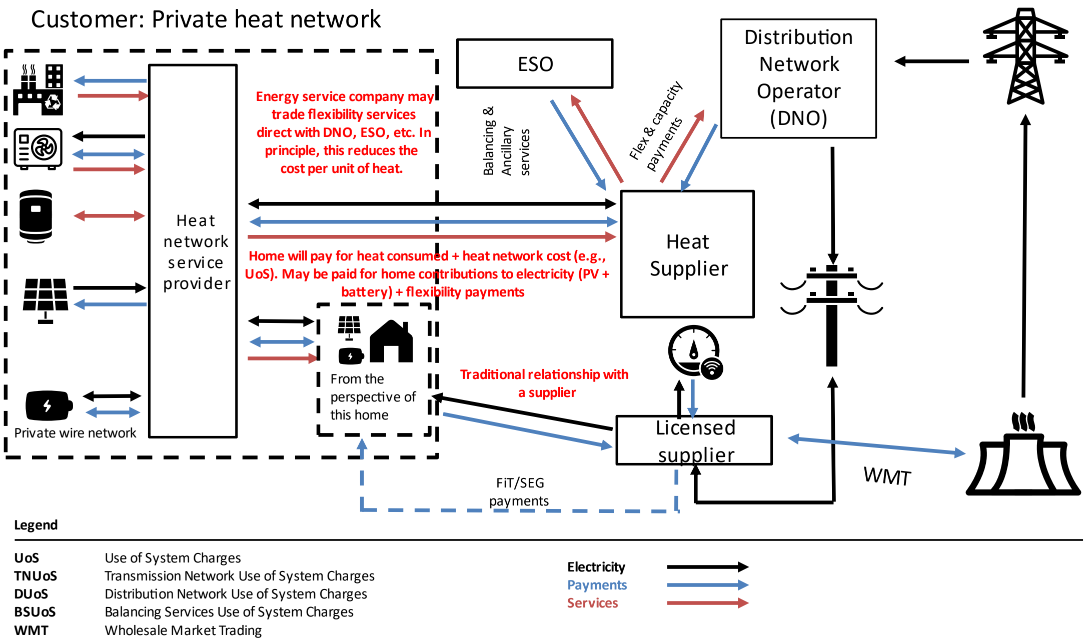

Figure 18: Customer relationships in a private heat network

Figure 18 shows how the private heat network might operate for its customer. The notes below describe the key aspects.

- The customer would need to sign up to be a customer of the private heat network, or it may be the case that they move into a home that is already on the network and automatically become a customer (in that there is no alternative way to heat the house).
- If the customer wants to contribute their assets (in this case PV and a battery) to the heat network, they will need to register their assets (for example PV & battery) with the heat service provider/supplier. Customers might also need to agree some service level agreements (e.g., under what circumstances and constraints can their assets be used). Likely this would involve some form of automation, so in essence the customer is stipulating prices (min/max) and hard constraints (e.g., I need my battery at 50% minimum charge) on automation.
- The heat service provider would operate the heat network. That is sourcing heat from its own and other assets (for example waste heat), storing heat where necessary, supplying heat to customers and billing customers for their heat usage and for network use of system charges (e.g., commodity and fixed cost components of the bill).
- The heat service provider would automatically trigger assets (e.g., buying PV or electricity stored in a battery) to minimise the cost of delivered heat (and for commercial businesses, maximise profit). The heat service provider might sell excess electricity to a supplier or trade flexibility with the ESO or DNO. This might require passing these rewards back to the customer or could be used to reduce the cost of heat overall.
- Whilst the heat service provider will be responsible for billing its customers for heat, they may also have some responsibility for billing its customers for the electricity they provide to the heat network (e.g., local PV or batteries). Depending on the nature of the relationship heat service provider and the wider energy system, the customer could realistically be billed for electricity in one of three ways:

- Through their supplier via some form of arrangement with the heat service provider (for example sleeving).
    - Directly from the heat service provider if the company is also a licensed electricity supplier
    - Directly from the heat service supplier if the arrangements are separate from energy supply, for example, flexibility payments under a different sort of contract.
- Conditionally, the heat service provider could be responsible for ensuring billing is accurate and for maintaining wider compliance with relevant licenses and codes. For heat networks, this now falls under Ofgem's remit, although the exact licensing arrangements are yet to be determined (BEIS, n.d.).

Flex-enabled business models archetype

Short description: Working with local users and assets to address local network constraints and enable more local renewables.

Examples: Local Energy Oxfordshire (LEO), Greater Manchester Local Energy Market, GIRONA

Figure 19 shows the business model archetype.

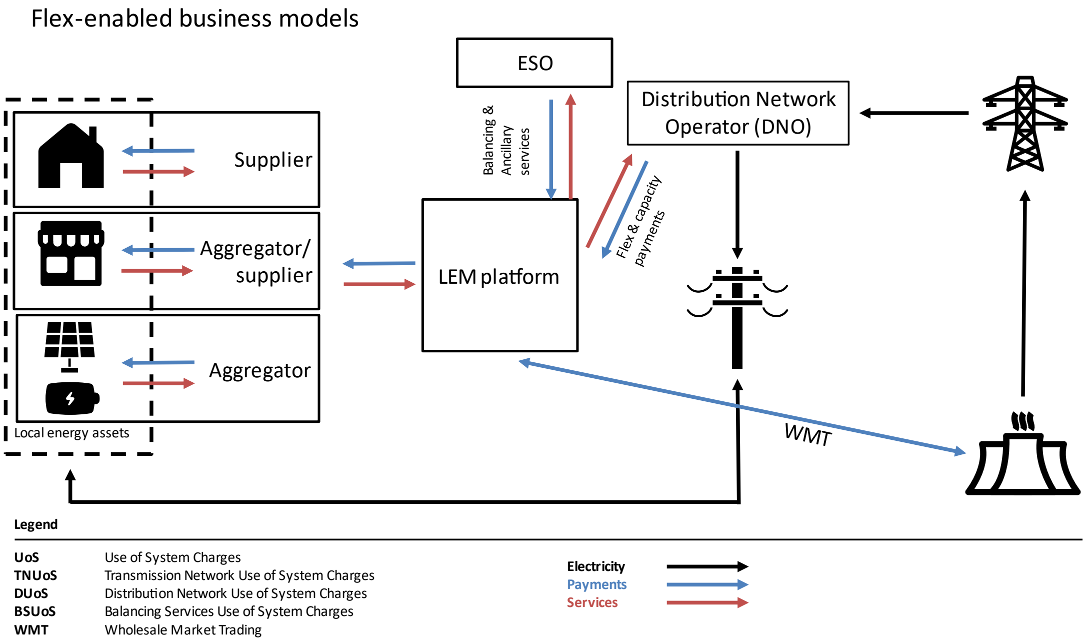

Figure 19: Flex-enabled business models archetype

This family of business model archetypes is focused on unlocking flexibility from a variety of local assets to solve local (and national) energy system issues. Often the driver is local grid constraints acting as a barrier to local renewable electricity generation deployment. Increasing and capturing locally the value of local assets is also a driver.

Ownership of local energy assets is mixed, some are behind the meter in homes or businesses, so are standalone grid-connected assets (for example community energy assets). Consequently, the business models either focus on unlocking multiple different routes to market, or on specific use cases. LEO and Greater Manchester LEM are examples of the former and GIRONA the latter.

LEO is a good example of the archetype, as the Low Carbon Hub (LCH) is attempting to unlock flexibility from all local sources. This means the LCH is playing the role of the Local Energy Market (LEM) Platform.

It works through different intermediaries – energy suppliers for homes and small businesses and aggregators for other assets – or directly with some local assets creating a pool of local flexibility.

At a simple level, the model matches local assets with flexibility opportunities, for example with the local DNO or the ESO. The LEM platform undertakes the contracting and may automatically trigger the assets or do so through an intermediary (like an aggregator). Billing might be direct, or through an intermediary (like an aggregator or a supplier) – which may incur transactional costs.

Functions in the private wire/heat network archetype (who is doing what)?

Table 5 outlines which actors are responsible for delivering the functions identified.

Table 5: Functions in flex-enabled business models archetype

Function	Which actor?
Acquisition/loyalty	This is a key function in the archetype as recruiting a sufficient diversity of assets to participate in multiple flexibility markets is crucial for success. This means that the LEM platform operator could need to work with energy suppliers, aggregators and direct with asset owners. Thus, in part acquisition and retention relies both on the LEM and on the relationships of customers with other third parties (such as aggregators).
Procurement of infrastructures	Most assets will be owned by homes, businesses and other asset owners (for example, community energy groups). There may be additional assets required to operate the LEM or to trigger flexibility from assets (e.g., via an aggregator) such as sensors and communication and control systems. Such assets would likely be owned by the LEM platform or the actor with the direct relationship with the customer (such as an aggregator).
Operation and control of infrastructures	The LEM might be directly responsible for triggering assets to respond to flexibility markets or might send signals through to aggregators or energy suppliers. The LEM platform operator is key to identifying and signing contracts for flexibility, so it is their interest to ensure that flexibility is delivered. This will inform contracting relationships.
Delivery of energy services	The energy services will tend to be those delivered to DSO and ESO markets (and other opportunities). As such either the LEM or, for example, aggregators will be contractually obliged to deliver. Who faces penalties for failed delivery will depend on contracts.
Pricing	The pricing of flexibility services will depend on the nature of the markets entered and the contracts signed. How flexibility providers are billed for the services they provide will depend on whom they have a contract with (e.g. direct with the LEM platform, or via an intermediary, like an aggregator). Likely the LEM platform and intermediaries will charge fees for the services they provide.

Customer relationships in flex-enabled business model archetype

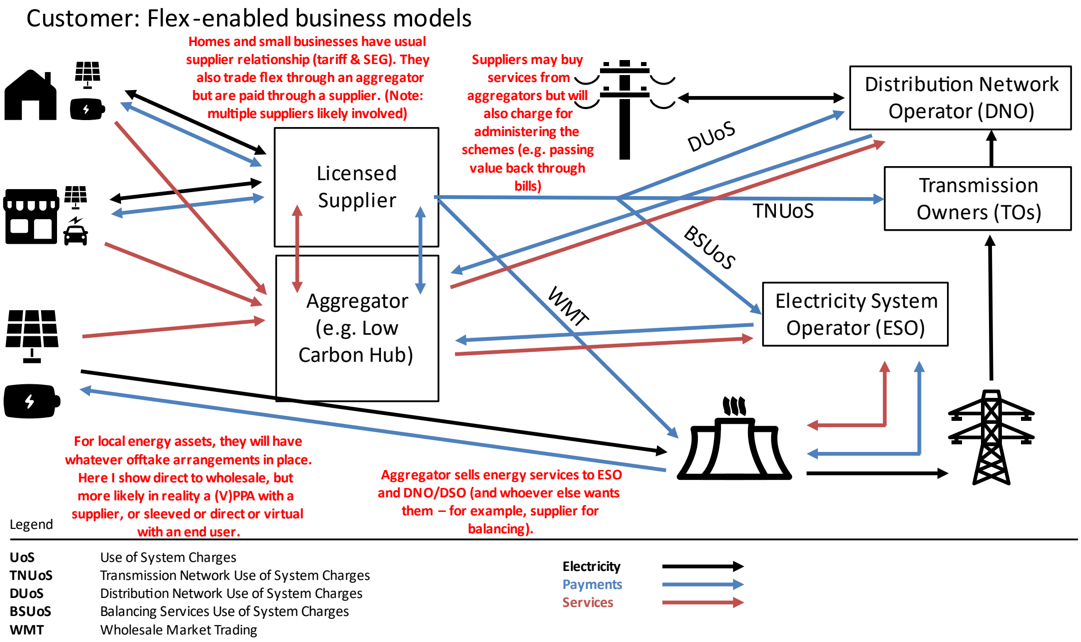

Figure 20: Customer relationships in flex enabled business model archetype

Figure 20 shows how the flex-enabled business models might work from the perspective of a customer. The notes below describe the key aspects.

- For homes and small businesses, they would need to be recruited by the LEM platform – in this case it is shown as an aggregator based on the LEO model. It is likely the contractual relationship would ultimately be through the customer's energy supplier as this how they would be billed (paid) for metered flexibility services. The LEM platform could contract directly with larger assets (such as wind or solar farms or grid connected batteries) in a standard aggregator type arrangement.
- In all cases, some form of service level agreement would be needed, particularly where flexibility is automated. This includes registering their assets with the LEM platform and agreeing the circumstances and price for the use of assets.
- The LEM platform is responsible for finding flexibility opportunities and contracting between assets and flexibility opportunities. As such the LEM platform would be responsible for understanding any complexities, such as exclusivity of certain flexibility products and markets.
- Depending on the nature of the contracts and service level agreements the LEM platform would wither automatically trigger assets or pass the signal through to asset owners or aggregators to do so. It would likely collect the revenue and distribute this through customers directly or through intermediaries (aggregators or suppliers). In both cases some transactions costs would be accrued.
- The LEM platform would also bear the risk of non-delivery of flexibility services. Presumably in some instances could pass these costs through if an asset owner was at fault.

SLES marketplace + optimisation archetype

Short description: Creating the conditions for new smart local energy systems to emerge.

Examples: Zero Carbon Rugeley, West Midlands RESO, Rewire-NW

Figure 21 below shows the business model archetype.

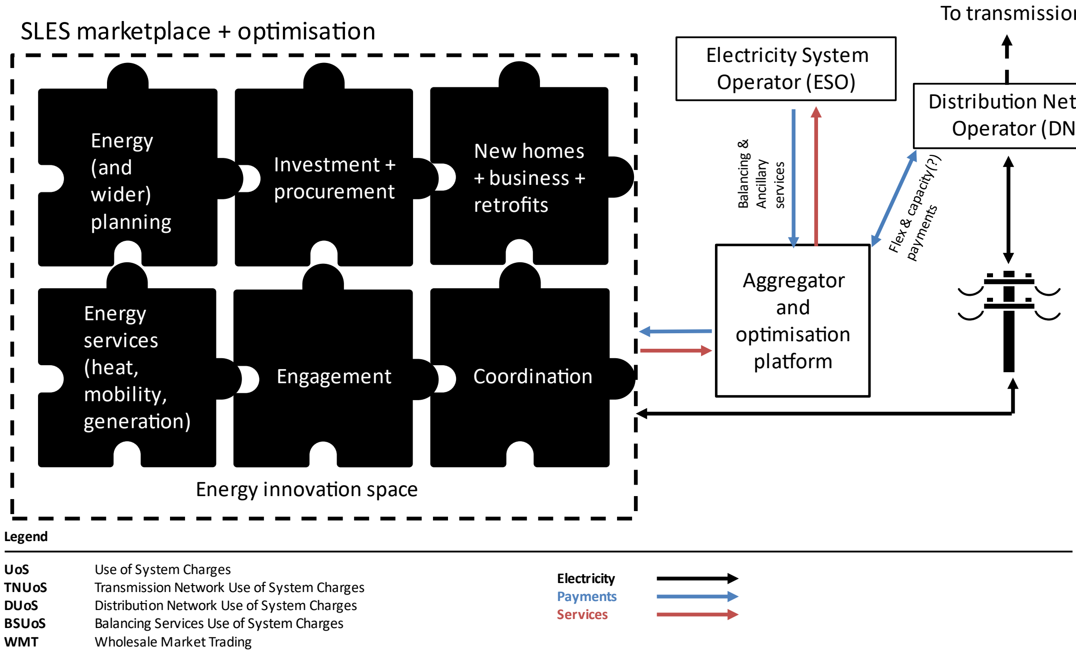

Figure 21: SLES marketplace & optimisation business model archetype

Both Zero Carbon Rugeley and West Midland RESO, in part, are seeking to create the conditions for new smart local energy systems to emerge. Both projects consider energy planning, engagement with local citizens and actors, enabling new energy business models, driving investment and asset coordination. They also feature the introduction of some organisation or platform responsible for optimising the local energy system and maximising value by trading with local and national energy markets.

This business model archetype is harder to describe as there are multiple activities underway and multiple actors involved. It is easier to understand when using a particular customer relationship – see Figure 22 which is based on the GM Local Energy Market.

Functions in the SLES Marketplace (who is doing what)?

Table 6 outlines which actors are responsible for delivering the functions identified.

Table 6: Functions in SLES marketplace business models archetype

Function	Which actor?
Acquisition/loyalty	The marketplace model creates space for energy business model innovation and thus there are potentially multiple businesses created to acquire and retain customers through multiple channels. Whoever is responsible for creating the marketplace likely has an important role in engaging customers and businesses in the vision and benefits of the marketplace.
Procurement of infrastructures	In the majority of marketplaces there are specific functions and roles for investment and procurement. These are often linked to local area energy plans. Who ultimately procures/invests in infrastructure will depend on the activities and assets required within the marketplace.
Operation and control of infrastructures	Again there are multiple potential business models operating (for example, heat-as-a-service in the Greater Manchester LEM).

	A common element is some form of aggregation and optimisation platform that is responsible for optimising assets within the marketplace and also selling services to the wider energy system. The previous three business models give some insights into how this platform could function.
Delivery of energy services	Again, there are multiple potential ways in which energy services are being delivered, and thus multiple energy service providers and models of service.
Pricing	Again, there are multiple potential ways in which energy services are being delivered, and thus multiple ways in which energy is priced.

Customer relationships SLES marketplace +optimisation

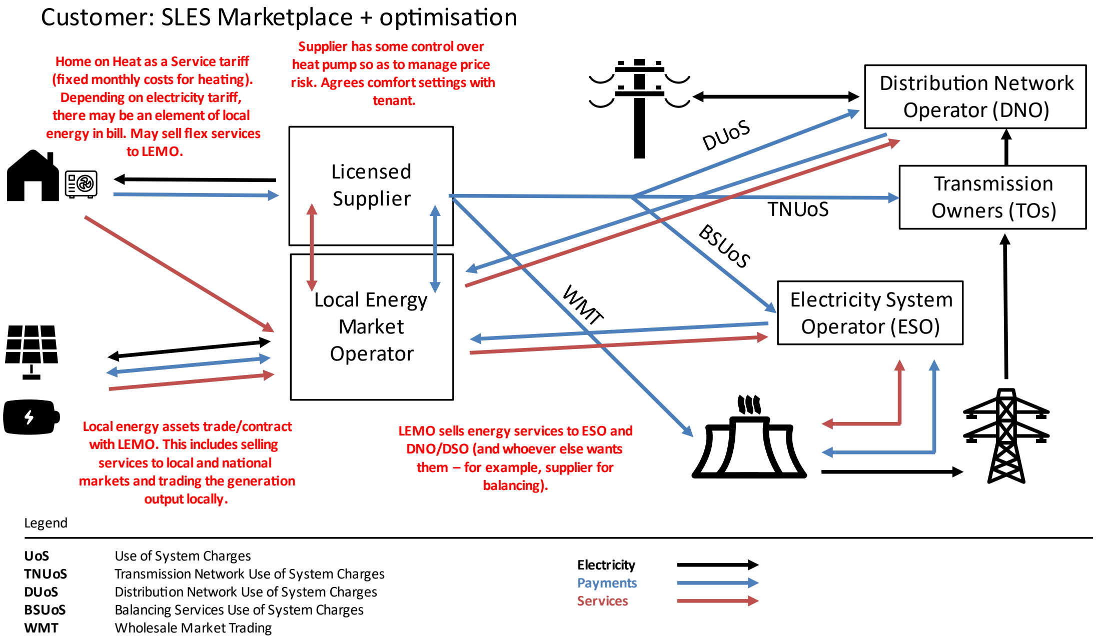

Figure 22: Customer relationships in the SLES Marketplace

Figure 22 shows an example of customer relationships within a potential future decentralised energy business model that has arisen out of a marketplace. It is derived from Greater Manchester LEM, which appears in two archetypes (flex and marketplace) as it has characteristics of both. Focusing on the domestic customer:

- The marketplace has enabled new energy business models to emerge. In this case a Heat-as-a-Service (HaaS) proposition has emerged, operated by an energy supplier.
- Under this model, the customer enters a long-term contract with the energy supplier. This might include the capital costs of a new heating system (and any modifications to the fabric of the house required) and a heating tariff. HaaS tariffs are usually fixed cost per month and are based on an agreed level of heating/comfort with the household.
- The energy supplier and the customer will enter into a service level agreement that will set a level of comfort (e.g. temperature range). It will also include an agreement of the extent to which the energy supplier can automate heating to both minimise the cost of heating (e.g.,

optimising the system to run using cheaper power prices) and also potentially access markets for flexibility. The result of both would be to minimise the price of heating.

- In this case, the local energy market operator would be responsible for coordinating assets to deliver local energy flexibility. This model would be very similar to the flex enabled business models archetype described above.
- In principle, the energy supplier might sell flexibility services direct and either distribute revenue to their customer or use the revenue to keep the cost of HaaS tariff low.

Comparing PfER archetypes with other local energy systems business models

The two previous sections summarised the business model archetypes of the PfER projects and presented four business model archetype clusters. However, these PfER projects are not necessarily representative of the full range of decentralised energy business models operating in the UK. To address this, we undertook a rapid literature review[3] to find additional business models to consider in our analysis. The literature review revealed three additional business model archetypes to include in the barriers and solutions analysis.

Peer-to-peer energy (P2P)

P2P business models use third-party digital platforms to enable prosumers to securely trade energy with each other with minimal involvement from suppliers (Hall et al., 2020). There are myriad of P2P business models outlined in the literature (Schwidtal et al., 2022). Here we have used the UK model developed in the PROSEU project to illustrate the approach (Hall et al., 2020). Figure 23 indicates the energy system relationships and flows for P2P business models.

Several of the PfER projects discuss P2P energy but is still being determined whether any have been successful in demonstrating the model. As such, the PfER projects indicate that P2P is a potential function within decentralised energy business models but there are issues with delivering it today.

[3] Search terms "local energy AND business model" and "decentralised energy AND business model" in Google Scholar.

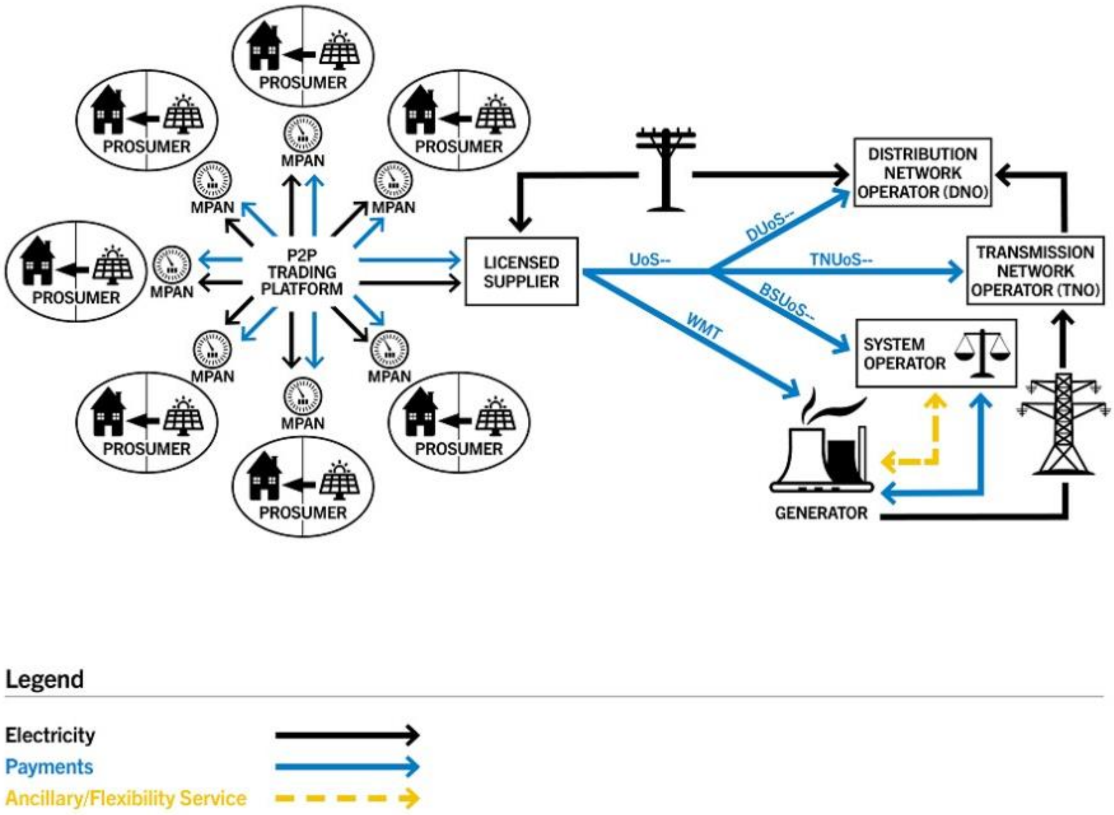

Figure 23: P2P business model archetype (Hall et al., 2020)

Energy Service Company (ESCo)

Energy service business models sell energy services such as: reliable electricity, hot water, and stable room temperatures, rather than selling a specific technology or energy commodity. Consequently, ESCo's shift responsibility for the performance of the building into long-term contracts between the ESCO and the household/business (Hall et al., 2020; Piterou & Coles, 2021; Hall & Roelich, 2016).

Aspects of the ESCo model are present in the PfER projects, for example in projects that are delivering heat networks the Heat-as-a-Service (HaaS) is present. The main reason for including a specific ESCo archetype is that the model often specifically focusses on energy efficiency approaches. Figure 24 demonstrates the energy system relationships and flows for ESCo business models.

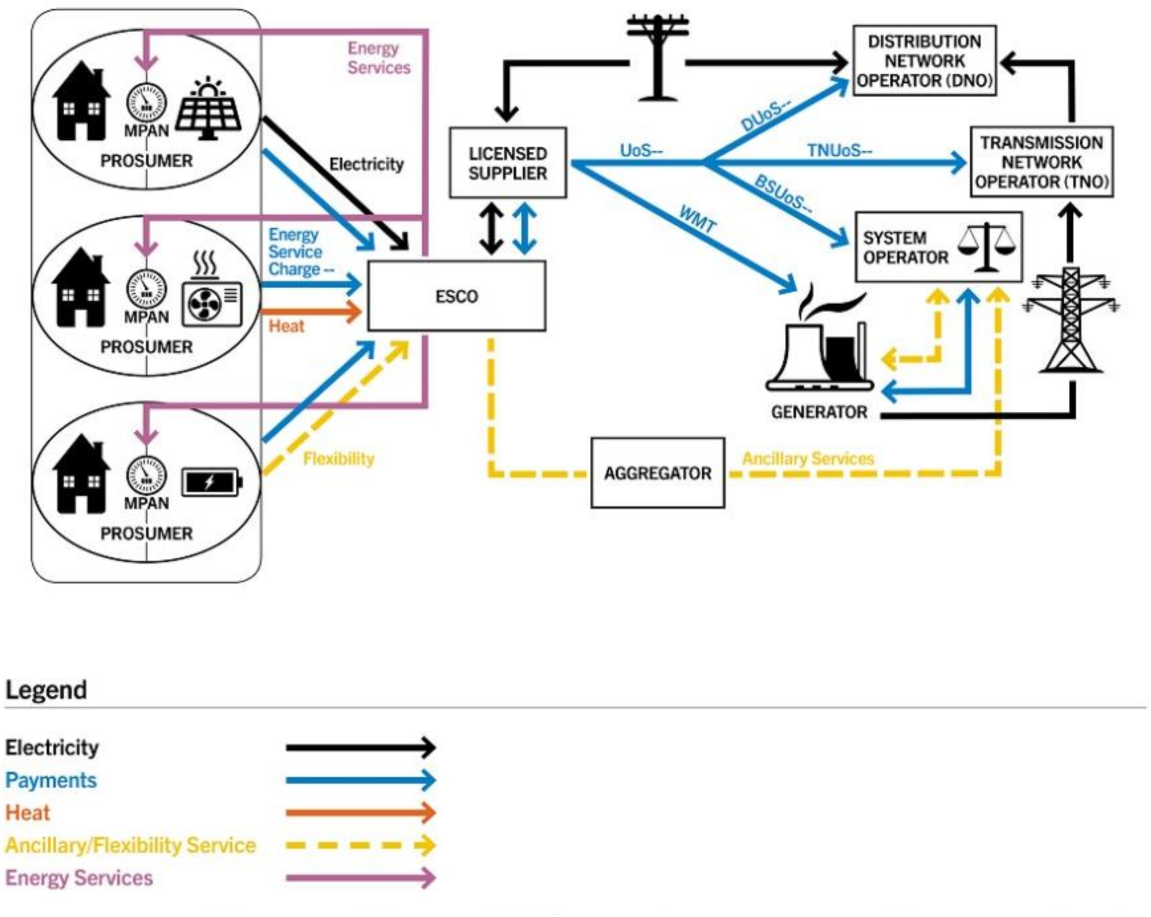

Figure 24: ESCo business model archetype (Hall et al., 2020)

E-mobility service provider

Arguably a sub-business model of ESCo we have included E-Mobility Service Provider because it specifically deals with transport. The emergence of transport electrification across public and private vehicle fleets is an opportunity to link with local energy systems (Hall et al., 2020). Figure 25 summarises the business model archetype.

Elements of this business model appear present in the PfER projects, for example RefLEX Orkney has a electric vehicle lease model and a charging flexibility proposition.

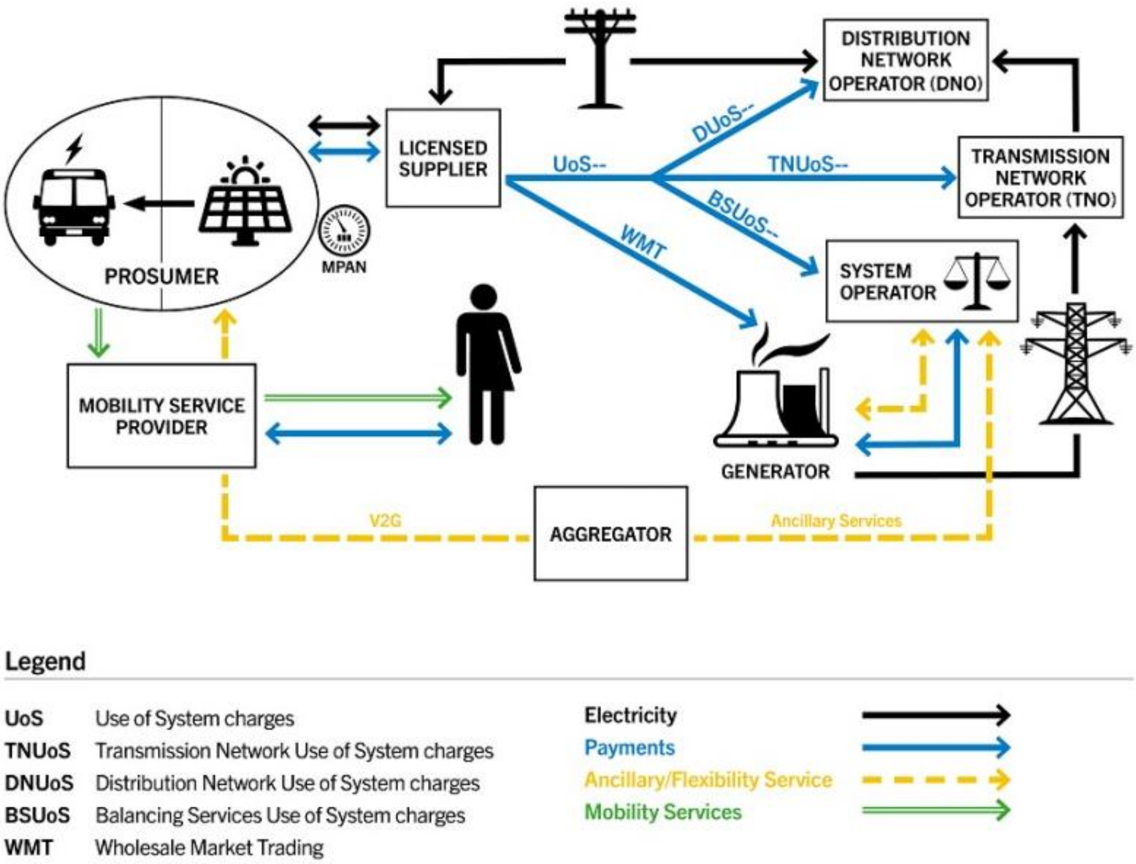

Figure 25: E-Mobility service provider business model archetype (Hall et al., 2020)

Section 2: What are the barriers to Decentralised Energy and how do these impact different DE models?

Significant changes are taking place in the GB energy system. The PfER projects are ending and have generated extensive learning on the viability of various SLES business models. Considerable action is already taking place by the Government, the regulator, and others to develop a smart and more flexible energy system. This includes a shift towards increased network access rights at the distribution level, the development of market-wide half hourly settlement by 2025, commitment to develop a Future Systems Operator (FSO), the ongoing DNO/DSO transition, the work streams identified within the Smart Systems and Flexibility Plan, as well as numerous other consultations and reforms (see Section 3 for the major ones). Nevertheless, considerable barriers for many decentralised energy (DE) business models still exist. This section explores the barriers to emerging DE business models and how they impact different DE business models.

Methodology

Barriers to SLES business models are analysed based on a (rapid) literature review of existing studies. Our analysis focussed on publications from the PFER projects, and associated studies. This includes the analysis produced by Nigel Cornwall on behalf of Innovate UK; "Recognising the Potential Contribution of Smart Local Energy Systems to Net Zero: Lessons from PfER Projects and Recommendations", which drew on extensive qualitative evidence, including expert input from PFER projects and beyond (UKRI, 2021).

This review also incorporates broader studies from academic and policy sources, as well as consultation documents from BEIS and Ofgem. A list of specific and thematic barriers was compiled based on this database of over 40 reports. The list of barriers, their characteristics and their relationship with different business model archetypes was then tested through interviews with PFER projects and with the wider energy innovation community through.

We tested the barriers identified through our literature review through a crowdsourcing exercise. We created an online whiteboard and placed it in the public domain with an invitation to stakeholders to comment on the barriers (this section) and solutions (Section 3). The process generated over 70 comments over the course of a week, which can be viewed here.

The barriers were then mapped against the SLES archetypes identified in section 1, both in terms of frequency of occurrence against each model and type of interaction, to identify shared and business model specific challenges.

Themes of barriers

The barriers identified are structured around five key themes with several sub-topics within these overarching areas of challenge. These are summarised in Table 7.

Table 7: Overview of key barriers by theme

Barrier theme	Sub-barrier
Barrier Theme 1: Limitations in realising value from distributed energy	**1.1 Challenges in revenue stacking and the need for market liquidity**
	1.2 Complex routes to market

	1.3 Local settlement
	1.4 Non-financial value and co-benefits
	1.5 Targeted Charging Review
	1.6 Flexible Connections and principles of access
	1.7 Imbalanced levies between gas and electricity
Theme 2: Market rules and governance	**2.1 Outdated principles and supplier hub**
	2.2 Multiple suppliers
	2.3 Derogations and exemptions
	2.4 Non-energy licensing and regulatory barriers
	2.5 Complex and fragmented industry codes
Theme 3: Limitation in innovation support processes	**3.1 Regulatory sandboxes not sufficient**
	3.2 Inflexibility in innovation funding
	3.3 Data access and sharing
Theme 4: Lack of attention to demand-side measures	**4.1 Challenging to integrate energy efficiency measures into value propositions**
	4.2 Markets skewed towards supply technologies
Theme 5: Lack of coordination within and across scales	**5.1 Policy uncertainty and lack of systemic approach to reform**
	5.2 Governance Gaps at the local and regional level
	5.2.1 No local planning and coordination role
	5.2.2 DSO uncertainties
	5.2.3 Heat network barriers

In addition to these overarching themes there are complex interlinkages between many of the barriers, for example limitations in data visibility and access partly drive difficulties in value stacking across markets, and a focus on the supplier hub model limits opportunities to integrate energy efficiency into value propositions. For many projects it is the combination of multiple barriers which is limiting business model viability and scalability. These complex interlinkages between barriers in recognised in theme 5 which highlights the challenges stemming from a lack of systemic oversight of market and regulatory reforms from Government and Ofgem.

Theme 1: Limitations in realising value from SLES

Problem statement:

Decentralised energy has significant value to local and national energy systems but is prevented from fully realising it.

Distributed energy resources (DER) are an increasingly important part of the energy system. Significant barriers remain to such local energy resources realising their potential energy system value. It is difficult, if not impossible, to trade and settle energy locally in local energy markets, for example, to sell energy from a wind farm to any local customers. DERs are also restricted in their ability to deliver flexibility services locally (because the markets are nascent) and nationally (because there is limited visibility and interoperability between national balancing and ancillary services markets). Recent changes to the residual and forward-looking charges for electricity networks have reduced the business case for existing DER, although they have also reduced the cost of connecting new assets. The cost of electricity is also artificially high compared to gas because of how levies are distributed[4]. These factors have the effect of creating hard barriers and frictions that restrict distributed energy resources from realising their potential value to the wider energy system. In addition, there is a range of co-benefits from local energy that tend to be ignored by decision-makers, despite being important locally.

1.1 Challenges in revenue stacking and the need for market liquidity

Delivering system flexibility is a key potential value stream for most SLES concepts. Matching and despatching energy assets locally has clear value to the wider energy system (Nigel Cornwall & UKRI, 2021). Current flexibility value streams do not enable sufficient retention of value at the local level (termed 'fair value for flexibility' by Low Carbon Hub). The value of flexibility to actors at different locations and times must be signalled and tradeable. Realising sufficient value in matching local generation and demand is challenging under current arrangements, and most business models require the stacking of a range of flexibility revenue streams to achieve viability (Darby & Banks, 2020b; Energy Systems Catapult, 2022c).

Revenue stacking is currently more accessible across revenue streams in different time periods than across multiple revenue streams within the same time period. Whilst there are some operational drivers for this, such as ensuring multiple commitments do not result in an asset being unavailable to deliver frequency response services (ENA & Cornwall Insight, 2020), there is a need to review options to manage these risks and reduce barriers to within-time period stacking.

Revenue values across value streams vary considerably and policymakers should ensure that they have clear oversight of these markets and are acting at the most appropriate level. This may involve prioritising addressing the barriers to the value streams which are most critical to the overall business case for flexibility models. For example, some PFER projects indicated that DNO procured flexibility is often not the highest value revenue stream, while others suggested that capacity market or balancing market revenues may be a relatively minor proportion of overall scheme revenues (Cenex, GreenSCIES & Energy Systems Catapult, 2022a; Energy Systems Catapult, 2022c). Additionally, interactions across markets should be made clear, for example, DSO flexibility markets are largely separated from Active Network Management, yet both address the same underlying issues.

[4] The Government indicated on 8 September 2022 that social and environmental levies will be temporarily removed from bills, https://www.gov.uk/government/speeches/pm-liz-trusss-opening-speech-on-the-energy-policy-debate. However, to date, an enduring commitment to rebalancing levies has not been made.

Additionally, much of the existing market thinking focuses on explicit flexibility, i.e., committed, dispatchable flexibility procured through various flexibility markets. There is much less focus on the embedded flexibility that can be provided by consumers via Time-of-Use tariffs as heating and transport are electrified (Crook et al., 2022b). It is key to effectively aligning incentives around embedded flexibility and this is currently a significant policy gap.

Overall, the central challenge is in ensuring streamlined access to multiple revenue streams and the ability to stack revenues to reduce risks (Low Carbon Hub & Origami Energy, 2021b; Mose et al., 2021a). Additionally, as local energy markets and local flexibility platforms develop there may be a need for some liquidity support to ensure price stability and support investor confidence.

1.2 Complex routes to market

Flexibility markets are largely designed for large portfolios of distributed assets or for large capacity distributed resources. Flexibility marketplace services should be designed to enable a wide range of participation, including distributed assets with low levels of flexibility. This will involve the simplification and standardisation of services and the minimisation of barriers to entry. A trusted, understandable, simple contractual architecture should be developed, and interoperability needs to be addressed at technical, administrative, and commercial levels. There are some limited instances of small-scale assets acting as a portfolio to access flexibility markets; further work to understand how these projects have approached viability would be valuable[5]. Overall, the complex language used around flexibility markets and the energy networks can exclude smaller non-specialist organisations.

There is a need to recognise path dependencies in the development of flexibility and the implications of this for assets of different scales. Under current arrangements value streams from ESO services and energy trading are better developed than those from DNOs. This tends to favour deployment of utility-scale, centralised storage and may result in these technologies dominating early value streams and the exclusion of distributed flexibility (Piclo, Element Energy & Oakes, 2020a, 2020b). This could lead to DNOs spending more than is optimal on traditional network reinforcement. There is currently limited analysis available on the potential local and whole system costs of this approach.

Interactions between existing flexibility markets and emerging Local Energy Markets (LEMs) should be clarified. PFER projects report multiple barriers to LEM operation and a perception of limited regulatory exploration or attention on these business models. Currently the fit between LEMs and the DSO and ESO transition is unclear and impacting on investment confidence. Most LEMs are seeking to integrate all sources of network flexibility into a single marketplace (Opus One Solutions, 2020b).

In relation to storage projects, there have been some improvements in the business case for storage following the definition of electricity storage in the electricity generation license in November 2020. This clarifies that storage is not categorised as a final consumer of electricity and that licence holders are exempted from the payment of final consumption levies. However long-term investment signals for storage remain weak, limiting market growth (EnergyUnlocked, 2022b; Jarvis & Gaundar, 2022b).

1.3 Local settlement

Value stacking adds complexity to business model development and necessitates reconciling and settling transactions at multiple levels and between markets, for example within a local energy market (LEM), between local markets and between a local market and national markets. New processes need to be

[5] Low Carbon Hub identify Kaluza www.kaluza.com/flexibility-platform/, ev.energy https://ev.energy/ and Social Energy's batteries in ESO frequency response services market https://social.energy/, as well as examples of P2P energy allocation markets emerging, e.g. Urban Chain www.urbanchain.co.uk/

established to support these transactions at multiple markets and levels (Energy Systems Catapult, 2019, 2022c; Origami Energy, 2021).

Under current arrangements, generators and consumers participating in a LEM would retain the option of purchasing and selling power into the local and national market. This could undermine the LEM model as during periods of high or low costs the national market may be cheaper. An alternative would be to mandate the use of a single platform in a local area, but this will likely require legislative and/or regulatory change and may present a challenge to the principle of open and competitive markets (Crook et al., 2022b).

To date it is unclear if LEMs will want to pursue local settlement. There are a range of routes to enable local settlement, however the GM LEM project suggests that it would at the very least require changes to several sections of the Balancing and Settlement Code[6] to enable LEM Operators to become regionally limited BSC parties, with several devolved functions of BSC Agents. Alternatively, LEM operators could work with Elexon to become a devolved local settlement body although this would necessitate significant reform to both Elexon's and DNO roles (Crook et al., 2022b; Energy Systems Catapult, 2019).

The GM LEM identifies a third option for local settlement, with the LEM Operator becoming an exchange, to facilitate trading, and a Supplier Volume Allocation Agent (SVAA), to facilitate matching local demand and generation as well as entering the data into wider national settlements. They suggest this enables transparent local power trading and local access to data but does not support the wider functions that LEMs might seek to hold.

Overall, the inability to undertake local trading and settlement has led to many SLES projects to focus on DNO procured flexibility. Whilst this may unlock some forms of local flexibility, they tend to assume passive customers, limit access to wider value (and benefits), and require traded flexibility business models to compete from day one with network reinforcement.

1.4 Non-financial value and co-benefits

The value of flexibility services is often considered only in financial terms and environmental and social benefits are overlooked. There are considerable uncertainties about how to set prices to account for wider systems benefits, or wider community and environmental co-benefits. Further work should evaluate the integration of commercial and social value (Low Carbon Hub & Origami Energy, 2021c; Banks, 2022).

There is also a need to further explore communicating co-benefits to end-users, including improved comfort and control, lower carbon emissions and reduced vulnerability to price volatility (Banks, 2022).

1.5 Targeted Charging Review

Current network charging structures and access rules need to be fully aligned with net zero. While some changes have reduced the costs of connecting decentralised energy, overall the combination of numerous, partial reforms; a shift towards high fixed cost recovery; and ongoing uncertainty about some future changes have undermined the investor case for SLES.

Ofgem is undergoing a process of examining the residual and forward-looking charges for electricity networks. The two reviews are known as "Targeted Charging Review (TCR)" and "Access and Forward-Looking Charges Review (AFLCR) (Ofgem, 2022c, 2019a).

The overarching principle behind the TCR is to spread the costs of maintaining the electricity grid fairly amongst customers. Ofgem's final decision has two major elements (Ofgem, 2019a). First, Ofgem has

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[6] BSC Section A – Parties and Participation, BSC Section C – BSCCo and its Subsidiaries, BSC Section D – BSC Cost Recovery and Participation Charges and BSC Section E – BSC Agents.

changed how residual (fixed) costs of the electricity networks are recovered. The issue is that currently, some residual network costs are levied on consumption, which means some users can avoid paying residual costs if they reduce demand and thus, they are spread unfairly amongst other users. Ofgem's decision means these charges will be fixed costs on bills, such as standing charges.

Second, Ofgem has removed some remaining distortions called 'non-locational Embedded Benefits', because they can increase consumer costs and affect competition. These Embedded Benefits currently favour distributed generation by either avoiding costs that other generators pay or, in some instances, creating additional payments. Ofgem deems these Embedded Benefits to be inefficient payments and charges which benefit certain distributed energy assets, and consequently, they are removing these non-locational benefits. Ofgem state that these benefits distort the competitive market, unnecessarily add costs to energy bills, and do not reward the most efficient generators.

The TCR decision shift to recover network residual costs via fixed charges and reduce benefits for distributed energy assets has reduced opportunities to avoid network charges and depressed the value of local electricity generation and flexibility. This has impacted the business case to invest in storage, on-site generation and demand side response.

Some projects indicated difficulties in engaging with the regulator to discuss impacts on their business model and have challenged Ofgem's assessment that the changes would not fundamentally discourage investment in decarbonisation (Mose et al., 2021a).

It is unclear the extent to which existing and ongoing reforms will meet Ofgem's aim to ensure equal treatment of resources and use of network at different voltage levels. Some PFER projects reported that incentives do not currently act to drive asset connection at the most efficient system wide level (Cenex, GreenSCIES & Energy Systems Catapult, 2022a).

1.6 Flexible Connections and principles of access

Linked to the TCR, Ofgem's Access and Forward-looking Charges review (AFLCR)is an important reform process in the context of the cost of connections and access rights for electricity network users. The objective of Ofgem's AFLCR is *"…to ensure that electricity networks are used efficiently and flexibly, reflecting users' needs and allowing consumers to benefit from new technologies and services while avoiding unnecessary costs on energy bills in general"* (Ofgem, 2022a). The AFLCR reached a decision on two aspects in 2022. These decisions will be implemented for the start of the RIIO-ED2 price control in April 2023.

The first relates to the distribution connection charging boundary. Here, Ofgem has decided to reduce the overall connection change faced by those connecting to the distribution grid. For new demand connections (such as a heat pump or electric vehicle charger), wider network reinforcement costs have been removed altogether. For local electricity generation, the charge for wider distribution network reinforcement (above the voltage level of connection) has been removed.

The second relates to the definition and choice of access rights. Connecting customers currently have limited choice over their access rights to the electricity network (e.g., how much they can import or export, when, and for how long, whether their access can be interrupted, and what happens if it is). Ofgem's decision means that standardised non-firm access options will be available for larger network users. Network operators must also introduce clear curtailment limits and end dates for non-firm access arrangements. Together these decisions reduce the cost of connecting decentralised energy assets to distribution networks and provide clarity of the access rights of assets.

The original AFLCR scope also included a wide-ranging review of distribution use of system charges (DUoS) and a focussed review of transmission network use of system charges (TNUoS). These areas continue to be developed outside of the AFLCR decisions. The DUoS review in ongoing through 2022 (Ofgem, 2022f) and the TNUoS review is likely to conclude in 2024 (Ofgem, 2022a).

Overall, changes to the charging and cost recover framework have progressed as differing timescales, specifically the TCR and the AFLCR have different implementation timelines. This creates uncertainty on their collective impact to business models, impacting on investor confidence. In addition, the outcomes of reforms interact and impact on business models in aggregate. For example, TNUoS charges would change if nodal pricing was introduced as value shifts from TNUoS and the balancing market to wholesale market prices (Cenex, GreenSCIES & Energy Systems Catapult, 2022a).

Wider connection and access issues

Network access is only currently normally offered at a fixed capacity, except in Active Network Management zones (ANM). This blocks any value of time-based connection capacity optimisation (Cenex, GreenSCIES & Energy Systems Catapult, 2022a). Flexible connection agreements with the DNO would benefit SLES that can respond flexibly. There are also potential benefits from shared connections, where a group of sites in a SLES agree not to exceed a certain limit. Capacity trading could also support SLES through reallocating capacity to those that value it most and promoting effective utilisation of the local network. There is a need to trial capacity trading in local areas and integrating the learning in the AFLCR (Crook et al., 2022b).

It is currently very difficult to make changes to connection agreements to accommodate flexibility. The process is long, legalistic and does not enable the DNO decision to be challenged. Business as usual connection processes are highly risk adverse (in favour of the DNO) and impacts are modelled based on extreme worst-case scenario e.g. PV and storage both exporting to maximum.

In ANM zones the application of the 'last in, first out' (LIFO) stack to constraint management can act as a barrier to deployment of small-scale solar and storage as behind the meter DER is treated in aggregate and can be constrained first. Specifically, in generation constrained areas, DNOs appear to have the right to curtail microgeneration at the asset level[7] ultimately preventing self-supply. Consumers are not allowed to satisfy their own demand during these periods from onsite generation, and instead are required to import (expensive) retail electricity from the grid. This impacts on the business case for solar and small-scale storage as curtailment rates may reduce generation significantly, increasing costs for householders and small businesses.

The legal basis for these arrangements should be tested as currently ANM arrangements are developed as a DNO-lead innovation, not prescribed by regulation, and DNOs are cautious of legal challenge if they curtail generators outside of LIFO order.

T1.7 Imbalance of levies on electricity compared to gas

Historically policy costs are recovered via electricity bills. The lack of policy costs on gas has had a very significant impact on the viability of many heat decarbonisation project. This has led to many PfER projects focussing on solar and storage projects where the business case is clearer. Whilst the Government indicated on 8 September 2022 that social and environmental levies will be temporarily removed from household electricity bills, there remains uncertainty about whether this rebalancing of levies will be maintained in the longer-term.

Due to the historic challenges in implementing heat and efficiency-based business models there is a significant need to support further experimentation in this area.

[7] rather than at the boundary meter to prevent export to the grid

Theme 2: Market rules and governance

Problem statement:

The current regime for licensing energy suppliers and the self-governance of industry codes and technical standards stifles decentralised energy from realising its potential.

The current regime for licensing energy suppliers and the self-governance of industry codes and technical standards stifles decentralised energy from realising its potential. To undertake any (at scale) energy generation, supply and network activities, including, in the future, heat networks, a licence is required from Ofgem. These licences are complex, prescriptive, rigid, and were not designed with a highly decentralised energy system in mind. The requirements of licensed activities add significant cost and complexity to energy activities. Consequently, innovative or non-traditional energy activities, such as local energy approaches, struggle to fit in the framework and often cannot deliver the services they aspire to. In many cases, local energy approaches need to work with a licensed supplier, which restricts the customers they can reach and adds transaction costs to their proposition. Whilst there is an exemption regime for generation and supply, the Government is currently reviewing this to reduce distortions. Change to licences and codes is slow, complicated and incremental.

2.1 Outdated principles and the Supplier Hub.

The current GB retail energy market is based around the 'supplier hub', which positions the supplier as the primary intermediary between consumers and the energy system[8] (see Figure 26). Suppliers are the responsible party for a range of social, operational and commercial responsibilities institutionalised through licensing and industry rules. Suppliers then recover these costs through consumer billing, with all customers obliged to access the energy system through a licensed supplier. Suppliers are additionally responsible for a range of agents and service providers that carry out a metering and data gathering services to defined, rigorous standards that are used for settlement and billing purposes. Ofgem have been clear that they consider that the current supplier hub model may not be fit for purpose for energy consumers over the longer term, presenting barriers to through limited access to data, complexity of industry codes and the entrenched role of traditional energy suppliers (Nigel Cornwall & UKRI, 2021b; Ofgem, 2018a).

The supplier hub model is widely accepted as a barrier to the formation of SLES due to complexity and high entry costs for non-traditional and smaller suppliers. The centrality of the traditional supplier within market arrangements often means that innovators must either partner with a supplier or become a supplier to bring new propositions to market. Even with exempt status, the supplier (or the customer directly) must ensure its meters are registered in settlement, which means it needs to establish an arrangement with a competing supplier or existing BSC trading party and that supplier must also be a signatory to DCUSA. Additionally, innovators must become a licensed supplier or partner with one if they wish to participate in industry code governance.

The supplier hub has been under review since the Ofgem's November 2017 Call for Evidence on Future Supply Market Arrangements. Ofgem's response in July 2018 concluded that there were barriers to innovation that prevented beneficial and potentially disruptive propositions to market but there is currently no further timeframe for decisions or implementation.

[8] Outside of exempt, de minimis supply of electricity (and gas).

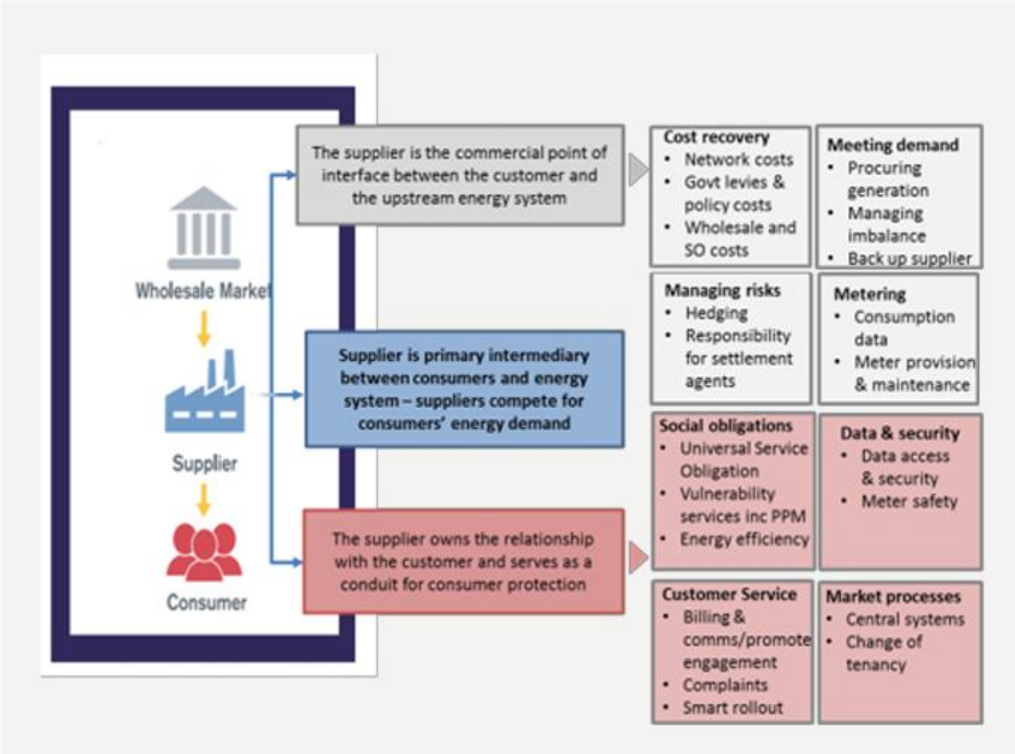

Figure 26: Supply market arrangements (Ofgem, 2018b)

Following the failure of a high number of energy suppliers in 2021/22 Ofgem commissioned Oxera to carry out an independent 'lessons learnt' review of its role in the recent supplier failures in the UK retail energy market (Oxera, 2022). The report suggests that Ofgem's approach to regulating the market 'created the opportunity for suppliers to enter the market and grow to a considerable scale while committing minimal levels of their own equity capital' and concludes that the approach to regulation did not sufficiently balance the trade-offs between accessing the benefits of competition and maintaining financial resilience in the sector. The report notes that Ofgem's emphasis on promoting retail competition was aligned with their duties, and the policy focus of BEIS, but resulted in over-emphasis on maintaining low barriers to supplier entry.

Overall, Ofgem's approach to assessing financial resilience in the sector has been reactive rather than proactive. The report identifies regulatory options that could have mitigated either the risks of failure or the costs of failure, with an emphasis on regulator checks to ensure suppliers are sufficiently financially resilient through stress-testing, audit, and assurances on risk management (including hedging), capitalisation and liquidity. Such changes would have raised barriers to entry and led to a number of players exiting the market and reduced customer switching rates. However, the current energy price crisis has now already reduced switching and resulted in high supplier failure rates, with the costs of failure being largely borne by consumers.

The report identifies the lack of an ex-ante framework for defining and measuring **consumer outcomes** and propose inclusion of the following: quality of service; convenience; availability of choice; delivery of net zero objectives in the economy; value for money; stability and predictability in tariffs; and protection of credit balances. Similarly, the Energy Systems Catapult advocates for adopting a **digitalised, risk-based licensing regime** where licensees provide regular updates to Ofgem across numerous categories, such as number of customers or volume of energy managed as well as providing data on their compliance with licences. This could enable Ofgem to target regulation to specific risk profiles in a data-driven and proportionate way (Johnston, 2022a).

2.2 Multiple suppliers

Input to Ofgem's 2018 call for evidence on 'Future supply market arrangements' indicated that current arrangements based on a single supplier settling system costs on behalf of a consumer is a blocker for business models that rely on transactions from multiple parties occurring at a single meter point. This might include Electric Vehicle (EV) manufacturers wishing to sell energy to car owners, or peer-to-peer trading platforms looking to enable consumers to buy another household's excess solar energy. There are also issues relating to market participants accessing the data held by licensed suppliers. Currently, firms that do not conform to the supplier-hub model cannot easily access the mechanisms that allow them to pass through underlying costs to consumers. This is limiting innovation and the development of new customer propositions.

This also creates a barrier to virtual power plant business models as it is not currently possible to integrate multiple suppliers under a virtual MPAN. This challenge also feeds through to DNO relationships as DNOs do not recognise the netting off of generation/demand under a virtual meter and would only consider this as a net balance if generation and demand was under the same MPAN (e.g., a solar farm and battery at the same site and meter). Multiple suppliers of services to single properties need asset level metering to be accepted universally. Whilst DSO flexibility allows asset level metering, this does not exist across all markets.

BSC modification P379 'Multiple Suppliers through Meter Splitting' was raised to support local energy markets and supply innovation through allowing multiple suppliers to compete for the supply or export of electricity through a single meter without needing to establish an agreement between all of the suppliers involved for every instance (Elexon, 2021c). However, the modification was withdrawn in 2021 following independent analysis indicating that implementation costs would significantly outweigh the benefits. Elexon also found that some of the desired outcomes from P379 would already be delivered through other BSC changes in support of net zero (Elexon, 2021a). These include:

- P375 'Metering behind the Boundary Point' which was implemented on 30 June 2022. This change which will result in the activity of smaller asset owners such as storage, and small scale renewables being visible in Settlement.
- P398 'Increasing access to BSC Data', implemented on 24 June 2021, amended the BSC so that all data is assumed open unless there is a reason otherwise and will not directly impact any market participants. BSC Parties and non-BSC Parties will be able to apply for data under a new process introduced by this Modification.
- P376 'Utilising a Baselining Methodology to set Physical Notifications' (approved P376 with an Implementation Date of 23 February 2023)
- P415 'Facilitating access to wholesale markets for flexibility dispatched by Virtual Lead Parties' (in the assessment procedure)
- Market Wide Half-Hourly Settlement (MHHS)

2.3 Derogations and license exemptions

Existing regimes for derogations and license exemptions are not seen as operating effectively. The Ofgem-BEIS Future Energy Retail Market review[9] and work on supporting retail innovation[10] suggest that those licence conditions which already have explicit derogation provisions may not be the ones preventing specialisation and that other conditions, which currently have no provision for derogations, are more problematic. Specifically, the Universal Services (SLC 22.3) condition and the Payment methods

[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/819624/flexible-responsive-energy-retail-markets-consultation.pdf

[10] https://www.ofgem.gov.uk/publications/supporting-retail-innovation-policy-consultation-ability-provide-derogations-certain-standard-licence-conditions-and-granting-supply-licences-specific-geographic-areas-or-premises-types

(SLC 27.1) condition were identified as barriers to innovation, despite the principles that these conditions are aiming to ensure remaining of central importance (i.e. guaranteed consumer access to a wide choice of energy offers and a wide range of payment methods).

Exemptions: The exemptions regime includes the legislation, powers and policy for granting exemptions from the requirement for a licence for the generation, distribution and supply of electricity. The exemptions regime was introduced to give small scale electricity operators the opportunity to avoid the costs and obligations associated with holding an electricity licence, which were considered to be disproportionate to the scale of these operators' impact on the electricity system. This usually (but not exclusively) includes the costs of the obligations to contribute to administration, balancing, policy and network costs. However, recognising that the Great Britain's energy landscape has changed substantially since the introduction of the exemptions regime[11], in 2020 BEIS initiated a call for evidence to explore how exemptions are currently being used in practice and to inform a wider review. The review focussed on statutory class exemption orders and individual exemptions, across generation, distribution and supply. Class exemptions comprise the majority of licence exempt entities.

There is currently a lack of visibility within Government regarding the types of organisations utilising license exemptions, as a business which considers that it meets the conditions for a class exemption is not required to notify the Government or energy regulator. The review seeks to provide evidence on the use of the exemption regime; whether greater clarity is needed regarding the licence exemptions regime; whether there are opportunities to extend the scope of exemptions (particularly around distribution and supply of electricity); and, implications for ensuring that all market participants, including those who are exempt, pay their fair share of system costs. The Government has committed to publishing this evidence.

Existing PfER projects have indicated that licensing requirements and exemption limits constrain some ESCo SLES models. Market participants are unable to hold supply and distribution licenses if they supply more than 2.5 MW to domestic customers, constraining models that might otherwise seek to supply both heat and electricity to customers as well as operating generation. The nature of these limitations essentially rules out any fully integrated microgrid energy solution that incorporates electricity unless it is on a very small scale (EnergyUnlocked, 2022b). Therefore, a large quantity of the potential revenue generation capacity from the ESCo is reduced.

The removal of domestic power demand from these business models reduces the amount of load and volume under management, ultimately diminishing the amount of flexibility that can be used to reduce prices for end users and assist the DNO in managing in areas of high network constraint. Finally, by removing the electricity supply aspect, the end user experience is also impacted as heat and electricity must be contracted through two separate suppliers (Jarvis & Gaundar, 2022b).

In addition, there are uncertainties regarding the legal status of single entity holding multiple exempt supply undertakings and the extent to which legal structures need to be entirely separate between projects.

2.4 Non-energy licensing and regulatory barriers

In addition to specific energy licensing barriers, the licensing regimes in other sectors can present a barrier to some SLES models. Specifically:

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[11] The current regime has been in place since the Electricity Act 1989, which was followed by the Class (Exemption from the requirement for a licence) Order 2001, last amended in 2007. https://www.gov.uk/government/consultations/exemptions-from-the-requirement-for-an-electricity-licence-call-for-evidence

- Financial Conduct Authority regulations require that business models which wish to finance the installation of domestic assets hold a consumer credit license.
- The landlords resale regulations limit the costs landlords who sell energy to tenants can recoup, undermining the financial case for energy efficiency upgrades.
- Rent control regulations prevent social landlords recovering energy efficiency and flexibility asset investment through rents.

2.5 Complex and fragmented industry codes and governance

Industry codes and the code governance process have been widely criticised as fragmented, reactive and overly complex. Recognising these limitations in current arrangements Ofgem and BEIS consulted[12] on proposed areas of reform for code governance in 2019 and 2021. The consultations focussing on: providing strategic direction; empowered and accountable code management; independent decision-making; and code consolidation and simplification. They identified two options for delivery; 1) a strategic function performed by a 'strategic body' and a separate code manager function; or, 2) an Integrated Rule Making Body (IRMB), where strategic and code manager functions are combined in one organisation.

Some consolidation of relevant industry code provisions is now taking place into the Retail Energy Code. Additionally, in 2022 BEIS and Ofgem responded to consultations setting out their decision to give Ofgem new strategic code functions, including the ability to establish and regulate, via licence, one or more code manager(s). Code administrators and code panels will also be replaced by licensed code managers, who will be responsible for playing an enhanced role in the code change process and delivering the strategic direction set by Ofgem. The detailed design features of this new governance framework are still under development and Ofgem will carry out further consultation on the roles and responsibilities of code managers (BEIS & Ofgem, 2022). These reforms aim to make code governance more accessible and responsive, however change processes are ongoing.

Several recently approved BSC code modifications may support SLES business models through increased access for smaller generators and flexibility providers to the balancing market and ancillary services, and open BSC data helping to identify the best locations to invest and improve business case analysis. The proposed code modifications can enable SLES customers to directly access the wholesale electricity market without transacting through a licensed energy supplier. Nevertheless, modification P379, proposing to allow customers to have multiple suppliers at a time, was withdrawn in 2021, potentially blocking some new business models (Cenex, GreenSCIES & Energy Systems Catapult, 2022a). Additionally, several other proposed modifications are still in the assessment process, creating significant uncertainty for innovators (see Figure 27 and T2.2 multiple suppliers).

SLES innovators have suggested that other code modifications may be required to support emerging business models. For example:

- **Electric vehicles and V2X** – requires the billing of both a charging service and a dispatchable demand response service to be distinguished (Cenex, GreenSCIES & Energy Systems Catapult, 2022a).

[12] Reforming the energy industry codes: consultation document, BEIS, July 2019. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/828302/reformi ng-energy-industry-codes-consultation.pdf and Design and delivery of the energy code reform: consultation, BEIS, July 2021. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1004005/energ y-code-reform-consultation.pdf

- **Export MPANs** - regulation needs to support the existence of separate ownership of import and export MPANs where DERs installed behind the meter are owned by a separate entity (Low Carbon Hub & Origami Energy, 2021c)

BSC	MODIFICATIONS	IMPLEMENTATION DATE
P398 'Increasing access to BSC Data'	All BSC data is now presumed open that can be requested without the needs to be a BSC Party through completing a data request form	24 June 2021
P375 'Metering behind the Boundary Point'	Asset meters will record electricity flows to (or from) assets, including those owned by embedded generators, DSR providers, or owners of EV chargepoints	30 June 2022
P376 'Utilising a Baselining Methodology to set Physical Notifications'	The source of data used in settlement calculations is proposed to be changed	The BSC Panel recommends its approval, currently in the report phase. Planning date - 2022
P415 'Facilitating access to wholesale markets for flexibility dispatched by Virtual Lead Parties'	The arrangements of Virtual Lead Parties (VLP) are proposed to be extended to directly access the wholesale electricity market	In the assessment procedure
Modification P379 'Multiple Suppliers through Meter Splitting'	The assessment has shown that the implementation costs would significantly outweigh the benefits	Withdrawn on 10th March 2021

Table 1: Balancing and Settlement Code (BSC) modifications

Figure 27: BSC Code modifications (Cenex et al., 2022)

Theme 3: Limitations in innovation support processes

Problem statement:

Innovation processes are not sufficiently flexible or integrated

There are several linked problems that slow innovation in decentralised energy business models. The Ofgem regulatory sandbox process, which supports energy business model innovation, is complex, time consuming, limited in scope and often does not create the conditions to test innovations at scale. Additionally, lessons are not easily shared, constraining learning in the sector. Whilst there is funding available for energy innovation funding the landscape is siloed and poorly coordinated. Funding rules can be prescriptive and lack flexibility to change as innovation progresses and the overall process is somewhat risk averse. Ofgem should be resourced sufficiently to coordinate innovation funding and ensure dissemination. Data access and sharing is also an issue for innovation. Access to network and customer data is central to energy business models and access to such data is difficult. Additionally, data from energy assets in increasingly becoming a pay-for service.

3.1 Regulatory sandboxes are not sufficient

Current processes to support experimentation in business models focus on scope to agree regulatory carve outs and derogations with the regulator (Innovation Link and Sandboxes). However, accessing this process is complex and time consuming, and often does not result in sufficient ability to test innovations at scale. Understanding the viability and system impacts of some models requires testing at a large scale (i.e., close to a city-scale) but this exceeds the scope of the normal derogation regime and it's unclear if this would be supported by Ofgem. There is an appetite to test emerging SLES models and post-PFER innovations within defined localities.

There is a lack of transparency in the Sandbox process and lessons are not necessarily shared, constraining learning rates in the sector. Sandboxes have now been established for BSC and DCUSA and learning from all these processes should be pooled and shared with innovators. Proposals for the Retail Energy Code committed to build in sandbox flexibility, but it is, as yet, unclear how this will be structured.

The Sandbox process is also limited in what it can enable (i.e., can't turn off all the licence conditions and is limited to a single supplier licence) and there is no clarity on what happens after a project finishes (e.g., currently, once the derogation finishes, the rules revert to 'normal').

3.2 Inflexibility of innovation funding

There has been considerable funding allocated to energy innovation by a range of agencies, however, may innovators perceive the funding landscape to be siloed with limited coordination. The Government has recently established a Net Zero Innovation Board to "…ensure a co-ordinated and strategic approach to Research, Development & Demonstration (RD&D) funding across these bodies, and to enhance the alignment of the public and private sectors" (HM Government, 2022). The priorities of the board are still to be determined.

Additionally, innovation funding does not provide sufficient flexibility to change, with rigid risk management processes. Structures and reporting are often prescriptive and standardised, resulting in innovators being forced to bear the risks of costs or changes being unapproved. A less linear approach to innovation, which is more suited to consumer engagement or grid edge experimentation, should be adopted. Funding is often based on delivering predetermined outputs which are set at the start of projects. We can learn as much if not more from the things that don't work as from those that do and this should be recognised in the innovation process. Overall, the current innovation landscape is risk adverse and does not does not take a systems innovation approach which seeks to identify where market testing and failure may be justifiable public goods. Schemes still tend to pick winners rather than setting outcome-based challenges.

3.3 Data access and sharing

Current arrangements for data access and sharing are not sufficient. There is a need to establish a robust data ecosystem at a local level that integrates beyond the local boundary (Milford Haven: Energy Kingdom, 2022b). A recurring theme relates to the challenges of accessing timely and granular data from DNOs (metering, constraints, reinforcement) and it is currently not certain the extent to which the DSO transition will address these issues in relation to real-time data exchange, digitalisation of the energy system, increasing transparency and visibility of network operations. Accessible data at lowest voltage levels is likely to be required maximise the benefits of decentralised energy and coordination of real time data flows e.g., a digital spine. However, there is largely an absence of grid monitoring and data and lower voltage levels.

Many of the business model archetypes examined in this report are based on a market maker role which incorporates an independent information platform and energy exchange facility. This will involve timely and granular access to customer data either through customer approval of data sharing, or through changes to the BSC (Crook et al., 2022b). As discussed previously, the GM LEM suggest the simplest route might be for the LEM Operator to become a regionally limited BSC party with several devolved functions of BSC Agents. However, a BSC sandbox may be required to facilitate the sharing of data with the LEM platform. A more complex route could involve the LEM Operator becoming a partner to Elexon for local settlement. However, further research is required to understand what is possible within current data and privacy requirements and customer preferences. Different (opt-in/opt-out) approaches to data sharing may be necessary for different platform users e.g., suppliers/ aggregators, LEM Operator, DNO.

The BSC modification P375 provides the ability to use individual DER meters to verify delivery of flexibility services. However, further work is necessary to enable the use of the data where a physical generation meter, for example, is programmed to send its data to a third-party service. The meter and data are owned by the owner of the DER, but the third-party service operators are reluctant to enable that data to be sent both to the owner and to a flexibility market operator (Low Carbon Hub & Origami Energy, 2021c).

Additionally, many SLES business models involve multiple organisations delivering access to different products or services. A combination of data protection, contract and warrantee terms, grant conditions and financial regulations, mean that the customer journey tends to be complex and involves interacting directly with numerous different organisations. It would make a simpler customer journey if a SLES coordinator could be the only point of contact for customers.

Consumer data protections for energy data should be reviewed to ensure organisation who receive customer energy data (domestic of business) cannot profit from selling access to the data to a third party.

Theme 4: Limited attention on the demand side

Problem statement:

Energy efficiency and demand-side approaches vary across the UK, have been undervalued in England for decades. Such approaches are inherently local and aligned with decentralised energy resources.

There has been a long-term underfunding of energy efficiency by the UK Government and retrofit does not receive the policy recognition, funding or planning it requires (Climate Change Committee, 2022; UK100, 2022a). Whilst significant commitments to energy efficiency and demand side response were made in the 2021 Heat and Buildings Strategy, the Climate Change Committee highlighted a lack of ambition and policy frameworks on energy efficiency in its most recent progress report to Parliament (Climate Change Committee, 2022b).

The Heat and Buildings Strategy emphasised a 'fabric first' approach and provided funding for several local authority delivered programmes, such as the Green Homes Grant: Local Authority Delivery Scheme (LAD), Public Sector Decarbonisation Scheme, Social Housing Decarbonisation Fund. While these schemes have been successfully delivered locally, the short-term and competitively allocated nature of these schemes undermines the long-term planning of area-based retrofit programmes and makes it harder to develop innovative efficiency-based business models.

In addition, whilst the energy price crisis is refocussing many consumers on reducing demand, overall there is a lack of incentives for demand reduction. For example, you can't easily sell negative demand in the wholesale market, even though it carries system benefits. Many markets are also easier to access for fossil fuel generators, such as gas or diesel power plant#, than for demand reduction or energy efficiency products.

4.1 Challenging to integrate energy efficiency measures in value propositions

The lack of a strong signal from Government regarding the role of efficiency in net zero undermines efforts to develop financing routes to large scale retrofit (UK100, 2022b). There is an urgent need for a long-term policy framework for energy efficiency, which recognises the effectiveness of locally coordinated retrofit programmes. The lack of comprehensive policy, particularly in relation to the owner-occupier sector, prevents many business models integrating energy efficiency measures leading to sub-optimal system outcomes. There has been a lack of affordable financing options in the UK, in comparison with other European countries such as Germany and France.

Energy efficiency was not central to many of the PFER projects and those that did seek to integrate efficiency measures found that the licensing regime, which largely precludes long-term consumer contracts, disincentivises business models which integrate energy efficiency, distributed energy generation and demand flexibility into service-based contracts (such as Heat-as-a service models).

Additionally, there needs to be more innovation investment in energy efficiency leading to slow learning and cost reductions. There is a clear demand for a high quality, trusted advice system that takes a whole house approach to decarbonisation across building fabric and other technologies.

4.2 Markets skewed towards supply technologies

It is currently difficult to realise value for demand reduction and in most markets, it is more difficult to access and secure contracts for negative demand than for supply side technologies. As a result high carbon forms of balancing and flexibility are often contracted, as the carbon content of the capacity, balancing and ancillary services markets shows.

Progress is slow. It has taken a long time for flexibility products to reach the balancing market and there is a lack of locational energy efficiency products sold by DNOs as a credible alternative to building new wires. There has also been slow progress on developing new customer offerings that dynamically optimise demand and generation behind-the-meter.

Theme 5: Regulatory uncertainty and lack of multi-level coordination

Problem statement:

There is a national lack of vision and a holistic plan for the future zero-carbon energy system, particularly on the role of decentralised energy.

There is a lack of a holistic statement of policy support for role of SLES in net zero (for example in the Net Zero Strategy). This has fed through into a lack of systemic analysis of risks, benefits and barriers within Government and Ofgem. There is a need to understand and coordinate action on SLES barriers more fully.

Whilst multiple reforms are in progress they are progressing at different rates with unclear interactions. Many reforms have unspecified decision and implementation timescales. This regulatory uncertainty is a major challenge in clarifying the value propositions and financial viability of many projects (Darby & Banks, 2020b).

Local energy systems suffer from a lack of local resources, capabilities, data and powers. Local authorities are seen as important in coordinating local energy and wider spatial planning but lack the formal resources to do so. DNOs are also a key body and lack the incentives to better coordinate.

5.1 Policy uncertainty and lack of systemic approach to reform

As discussed throughout this section, there are a complex and interrelated range of reforms underway to address several the barriers to DER and SLES. Whilst this progress is welcomed, this has created a confusing and complex landscape with the outcomes of many consultations and reforms still awaited. This uncertainty and rapid rate of change impacts on investor confidence and keeping up with reform processes is resource intensive for smaller players.

Some reform processes are slow, increasing uncertainty and the resource requirements to engage. A specific example relates to Ofgem's ongoing review of supplier licensing. Oxera's (2022) review of Ofgem's regulation of the energy supply market identified that Ofgem did identify risks to the sector that could have been addressed with earlier intervention but was slow to design new policies. It particularly identifies the Supplier Licensing Review as an incomplete reform, which was delayed over the period 2016–17, consultation upon in late 2018 and is still ongoing.

Government and Ofgem analysis of future options for reform should provide transparent analysis of both local and whole system impacts. For example, some parts of the industry suggest that zonal or nodal electricity pricing would increase wholesale prices in London, shifting value from the Balancing Mechanism and Transmission Network Use of System (TNUoS) charges to the Wholesale Market. This could drive a need for local balancing services, potentially benefiting SLES (Cenex, GreenSCIES & Energy Systems Catapult, 2022a; Energy Systems Catapult, 2022c) but impacts would be spatially diverse and vary across existing and new DER. Detailed analysis of these multi-scalar dynamics is currently lacking.

5.2 Governance gaps at the local and regional level

5.2.1 No local planning and coordination role

A lack of local coordination, and uncertainty in roles and responsibilities at the local and regional level, are consistently identified as SLES barriers (Hardy & Morris, 2022)(Energy Systems Catapult, 2022a)(Britton & Webb, 2022) Many of the projects, whilst operating commercially, rely on involvement of public sector organisations to provide evidence, coordinate stakeholders, provide anchor demand, generation or sources of flexibility and to manage risks. However, as there is no statutory role for local government in energy system change, innovators need to develop bespoke relationships and processes in each area.

The development, and local authority delivery, of local energy planning is central to many of the business models (EnergyUnlocked, 2022b; Energy Capital, 2022b; Banks, 2022; Crook et al., 2022b). There must be sufficient powers held by a competent body to develop detailed energy plans and begin delivery in a transparent, accountable way. Without this strategic, managed delivery of large numbers of low carbon technology assets, prospects for local energy markets are limited.

The RESO project concluded that giving cities and localities a stronger role within the UK's established model of energy market regulation offered significant potential for releasing additional value. The key elements of a Regional Energy System Operator (RESO) for Coventry include a local data governance capability ('data authority'); whole systems planning and delivery capabilities; consumer and vulnerable citizen protection; and 'security of supply' functionality. Some functions are possible without wholesale energy market or regulatory reform (although statutory powers may be required to ensure necessary data is released to local data authorities) (Energy Capital, 2022b). These are:

- A local energy and climate data governance function
- Local whole systems net zero planning capability
- Integrated neighbourhood decarbonisation support capabilities

Additional city-level functionalities identified by RESO will require regulatory reform. There are also challenges in dealing with misalignments between administrative and physical boundaries of infrastructure networks, local authorities and other sub-regional bodies as a clear regional framework emerges.

5.2.2 The DNO role and DSO uncertainties

In addition to the existing access and data sharing barriers already discussed, there are a range of challenges to DER represented by the existing DNO processes. In general, there is a lack of a whole systems view in DNOs with poor integration between DNO innovation and connections teams. This can lead to projects stalling. In addition, DNOs have almost no visibility of the low voltage network.

The approach to ED2 was viewed by some as too incremental and not going far enough to incentivise rapid change and the valuing of customer needs. The DNO to DSO transition could be a market enabler, redefining how energy networks will operate in the future. However significant uncertainties remain about the emerging DSO role. Each DNO is largely developing its own approach to what a DSO might look like, with varying perspectives on DER coordination, real-time data exchange, digitalisation, transparency of the network and so on (Cenex, GreenSCIES & Energy Systems Catapult, 2022a; Banks, Darby & Grant, 2021). Repeatedly engaging with different DNOs about the DSO transition is currently a significant resourcing requirement for many flexibility innovators.

There should be clarity on the role of DNOs/DSOs in flexibility markets and concerns about conflicts of interest should be addressed.

5.2.3 Heat network barriers

A lack of clarity on the regulatory framework for heat networks has hampered projects for a long time, however, there are now significant developments underway to establish a regulatory framework for heat networks. A detailed review of near and medium-term policy and regulatory changes in relation to heat networks has been provided by the ESC (Energy Systems Catapult, 2018). Ofgem is in the process of being established as the heat network regulator and a licensing regime is under development. Further details of the market framework for heat networks is expected in late 2022. This is likely to include a decision on Heat Network Zoning, following a consultation[13] on new powers and enforcement options for a local zoning approach. The consultation also proposed that new buildings, large public sector, large non-domestic buildings, and communally heated large domestic buildings would be required to connect to a network in a designated zone within a given time period. Once these developments are finalised, they will create a much clearer market and regulatory framework for heat networks, with impacts on SLES projects which include heat networks. Decisions on the implementation of heat network regulation will be key and should ensure that a clear planning role is established, and the ability is established to designate heat network zones with mandated connections. There may also be a need to provide further investment support to support network development in existing housing areas.

Heat networks could play an important for in energy system flexibility, but it is currently unclear if there are sufficient incentives for them to realise this potential role.

How do the barriers affect the business model archetypes?

The effect of the barriers of we have identified on decentralised energy business models will depend on how businesses are configured. To test this, we analysed the seven BMAs we identified in Section 1 against the five themes of barriers. Table 8 below summarises the findings, and the detailed analysis is at this link[14].

For each business model archetype, we assessed whether each barrier a hard-stop (e.g., prohibited the business model), a soft-stop (e.g., the BMA was allowed but issues remained, such as regulatory friction), a green light (e.g., there are no issues with the business model), or not relevant (e.g., doesn't affect the BMA).

As a reminder, the seven BMAs are as follows:

1. Virtual Power Plant
2. Private wire/heat network
3. Flex enabled business model
4. SLES marketplace
5. Peer-to-peer
6. Energy Service Company
7. E-mobility service provider

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[13] https://www.gov.uk/government/consultations/proposals-for-heat-network-zoning

[14] This link will take you to an external view only Google sheet with a more detailed analysis.

Table 8: Summary of analysis of barriers against the seven BMAs

Barrier theme	Sub-barrier	BMA 1	BMA 2	BMA 3	BMA 4	BMA 5	BMA 6	BMA 7
Theme 1: Limitations in realising value from SLES								
	T1.1 Challenges in revenue stacking and need for market liquidity	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T1.2 Ensuring flexibility marketplaces are accessible and standardised	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T1.3 Local settlement and Local Energy Markets (LEMs)	Hard Stop	Soft Stop	Hard Stop	Hard Stop	Hard Stop	Not Relevant	Not Relevant
	T1.4 Non-financial value and co-benefits	Hard Stop	Soft Stop	Hard Stop	Hard Stop	Soft Stop	Soft Stop	Not Relevant
	T1.5 TCR	Soft Stop	Green Light	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T1.6 Flexible Connections and principles of access	Green Light	Green Light	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Not Relevant
	T1.7 Imbalanced levies between gas and electricity	Soft Stop	Soft Stop	Green Light	Soft Stop	Soft Stop	Soft Stop	Soft Stop
Theme 2: Market rules and governance								
	T2.1 Outdated principles and supplier hub	Soft Stop	Soft Stop	Soft Stop	Hard Stop	Hard Stop	Hard Stop	Soft Stop
	T2.2 Multiple suppliers	Soft Stop	Not Relevant	Hard Stop	Soft Stop	Hard Stop	Not Relevant	Hard Stop
	T2.3 Derogations and exemptions	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Not Relevant
	T2.4 Non-energy licensing and regulatory barriers	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Not Relevant	Soft Stop	Soft Stop
	T2.5 Codes and governance	Soft Stop	Green Light	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop

Theme 3: Limitation in innovation support processes								
	T3.1 Regulatory sandboxes not sufficient	Soft Stop	Soft Stop	Soft Stop	Hard Stop	Soft Stop	Soft Stop	Soft Stop
	T3.2 Inflexibility in innovation funding	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T3.3 Data access and sharing	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
Theme 4: Lack of attention to demand side measures								
	T4.1 Challenging to integrate energy efficiency measures into value propositions	Not Relevant	Soft Stop	Not Relevant	Soft Stop	Not Relevant	Hard Stop	Not Relevant
	T4.2 Markets skewed towards supply technologies	Hard Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
Theme 5: Lack of coordination within and across scales								
	T5.1 Policy uncertainty and lack of systemic approach to reform	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T5.2 Governance Gaps at the local and regional level	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Not Relevant	Soft Stop	Not Relevant
	T5.2.1 No local planning and coordination role	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Not Relevant	Soft Stop	Not Relevant
	T5.2.2 DSO uncertainties	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop	Soft Stop
	T5.2.3 Heat network barriers	Not Relevant	Soft Stop	Not Relevant	Soft Stop	Not Relevant	Soft Stop	Not Relevant

Discussion

The analysis demonstrates that all the BMAs are affected by barriers. In the most part the impact is a soft stop / frictional type effect. For example, sub-barrier T1.1 on challenges in revenue stacking affects all the BMAs. This is because all the BMAs can create value in multiple markets, but there are issues with (multiple-)market access, especially for behind the meter assets, such as home batteries.

These soft-stop barriers can range from a very soft stop through to a quite a hard soft stop. For example, barrier T2.1 (supplier hub) can be quite a hard stop for any business model that requires a supplier, especially given suppliers have varying appetites to engage with innovative propositions. Barrier T3.3 (data access and sharing) varies in impact depending on how dependent on data the BMA. For example, some projects could access data, but were now required to pay for it adding cost. Other BMAs might not be able to access data, such as low-voltage network data, that reduces the value or impact of their proposition (i.e., in their ability to relieve local grid constraints).

Several BMAs are affected by hard stops. In Theme 1, barriers T1.3 (local settlement) and T1.4 (value of co-benefits) are problematic for several BMAs. T1.3 causes issues for BMAs where local energy trading and settlement is a (desired) component of the business model. T1.4 is similar as many of the BMAs are predicated on delivering a range of local co-benefits, many of which are not recognised in the relevant regulatory and policy frameworks.

In Theme 2, barriers T2.1 (supplier hub) and T2.2 (multiple suppliers) are issues for several BMAs. T2.1 is a issue for BMAs such as peer-to-peer energy because the single supplier model makes it difficult for multiple peers to trade energy with one another as they may all be with different suppliers. T2.2 is a problem because several of the BMAs would be well suited to multiple supplier models (which is currently not possible) to provide a particular service to end consumers (for example BMA 3 flexibility or BMA 7 mobility services).

Theme 3 has only one hard stop, which is T3.1 (regulatory sandboxes) for BMA 4 (SLES marketplace). This is because the SLES marketplace approach seeks to demonstrate propositions at a town/city scale. This isn't possible in a regulatory sandbox, which grants on licensed party basis (e.g., a single supplier).

Theme 4 has two hard stops, one each in T4.1 (energy efficiency) and T4.2 (supply side bias) for BMA 6 and BMA 1 respectively. BMA 6 is affected by T4.1 because it is a business model established to deliver energy efficiency improvements. T4.2 causes a hard stop for BMA 1 for models where network companies adopt a last in first out (LIFO) rule, which meant that assets that could have contributed to grid flexibility would be prohibited from doing so.

Section 3: What changes are required to enable SLES and how do current energy reforms help or hinder these?

This section explores solutions and builds on the business model archetypes developed in Section 1 and the analysis of barriers and their impacts on the BMAs in Section 2. In this section we present a summary review and analysis of solutions to the five themes of barriers. These solutions are derived from a range of stakeholders, including official stakeholders (such as BEIS and Ofgem) and wider stakeholders. The detailed analysis is at this link[15].

The section is structured as follows. We first examine the official solutions to barriers and briefly summarise key official documents, such as BEIS's Review of Electricity Market Arrangements. We then look at solutions proposed by a range of stakeholders, including the Energy Networks Association, PfER stakeholders and wider stakeholders. We also integrate the findings from a public crowdsourcing exercise. Finally, we reflect on the solution gaps.

Methodology

Our approach to this section was similar to that used in Section 2 (barriers). Solutions to the barriers identified were identified through a rapid literature review of existing studies and official documents.

We categorised solutions by stakeholder as either official (e.g., from the government or Ofgem) or by stakeholders (e.g., industry, PFER projects, other stakeholders). This allowed us to analyse the extent to which official approaches address barriers and to contrast that with solutions stakeholders propose.

We mapped the solutions against the barriers and where solutions (e.g., BEIS's REMA and ENA Open Networks programmes) provide multiple possible solutions we the same solution in each instance.

We also undertook a crowdsourcing exercise to identify gaps in our analysis of barriers and solutions. The exercise was undertaken on an online whiteboard, Mural, and the purpose and invitation was summarised in this article. A summary of the findings from the crowdsourcing exercise is included in this Section.

The detailed analysis is at this link[15]. This Section contains a summary of the key points and observations.

Official solutions

Official solutions are proposals from those who have the power to implement them, for example, government and regulators. In some cases, the solutions are not yet implemented. For example, there might be options being consulted on. Usually, the barrier(s) being addressed are clear.

Key documents

Many of these solutions are proposed in several official documents. Specifically:

- The Net Zero Strategy
- The Review of Electricity Market Arrangements
- The Energy Security Bill

[15] This link is to an external view-only Google Sheet which contains the detailed analysis.

- The consultation on interoperability and cyber security of energy smart appliances and remote load control

Given the key nature of these documents, we summarise their key points below.

HMG Net Zero Strategy

The 2021 Net Zero Strategy describes itself as a long-term plan for a transition to achieve the UK 2050 net zero target (HMG, 2021). It incorporates commitments from the government's "Ten Point Plan for a Green Industrial Revolution"(HMG, 2020). The strategy sets out plans for reducing emissions from each sector of the economy (power, fuel supply, industry, heat and buildings, transport, and natural resources) and where emissions remain, how they will be sequestered. It makes it clear that as a multi-decade plan, some policies will be phased in over the next decade or beyond. The strategy sets out four principles to guide future investments:

1. We will work with the grain of consumer choice: no one will be required to rip out their existing boiler or scrap their current car.
2. We will ensure the biggest polluters pay the most for the transition through fair carbon pricing.
3. We will ensure that the most vulnerable are protected through Government support in the form of energy bill discounts, energy efficiency upgrades, and more.
4. We will work with businesses to continue delivering deep cost reductions in low carbon tech through support for the latest state-of-the-art kit to bring down costs for consumers and deliver benefits for businesses.

BEIS Review of Electricity Market Arrangements

The BEIS REMA programme (BEIS, 2022d) arises from a commitment in the British Energy Security Strategy (HMG, 2022) to undertake a comprehensive review of electricity market design, to ensure that it is fit for maintaining energy security and affordability for consumers as the electricity sector decarbonises. The review focuses on options for zero-carbon electricity supply, wholesale markets, flexibility, capacity adequacy and operability. The options are summarised in Figure 28.

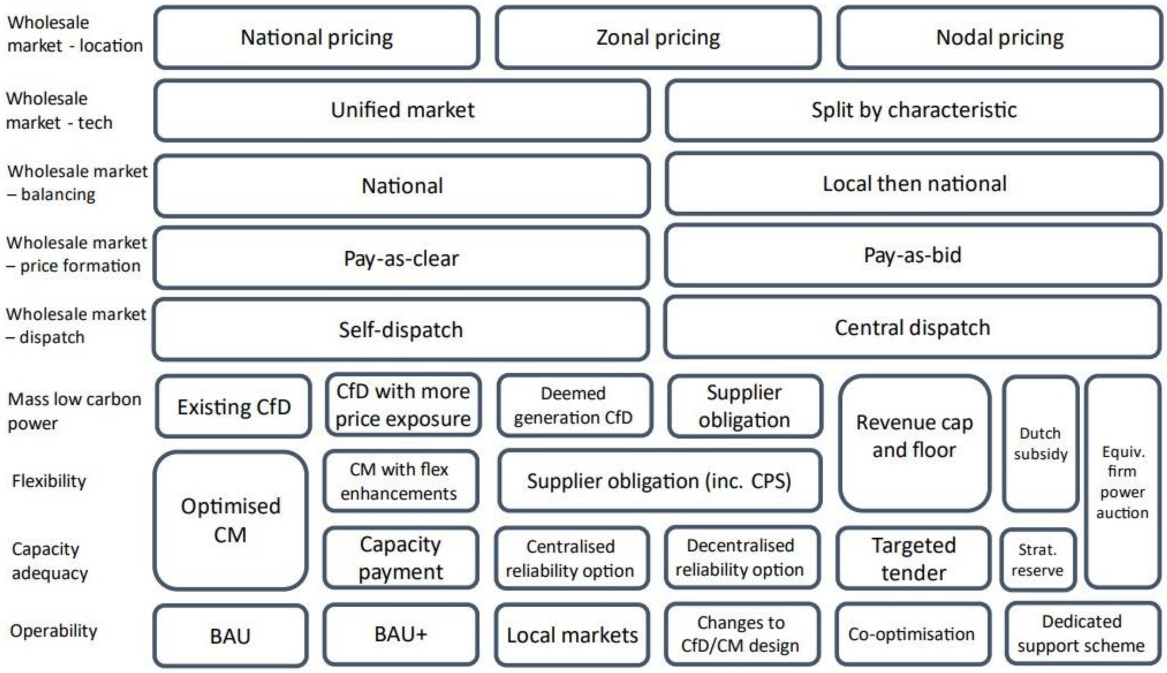

Figure 28: Options within REMA (BEIS, 2022d)

BEIS state in the REMA consultation that the vision for future market arrangement is as follows:

- Deliver a step change in the rate of deployment of low carbon technologies, and reduces our dependence on fossil fuelled generation
- Provide the right signals for flexibility across the system
- Facilitate consumers to take greater control of their electricity use by rewarding them through improved price signals, whilst ensuring fair outcomes
- Optimise assets operating at local, regional, and national levels
- Ensure that the security of the system can be maintained at all times

The Energy Security Bill

The BEIS Energy Security Bill[16] (BEIS, 2022b) builds on the commitments in the Prime Minister's Ten Point Plan (HMG, 2020) and the British Energy Security Strategy (HMG, 2022) to invest in homegrown energy and maintain the diversity and resilience of the UK's energy supply. It contains measures in three areas, of which two (summarised below) are most relevant to this work. The other theme is around the safety, security and resilience of the UK energy system relating mostly to the oil and gas and nuclear industries.

Leveraging private investment in clean technologies and building a homegrown energy system

This includes:

- Measures to accelerate the growth of carbon capture, utilisation and storage (CCUS), Including decisions on CCUS
- A hydrogen heating trial
- Scaling-up heat pump manufacturing
- Establishing a regulatory regime for nuclear fusion.

[16] This is now named the Energy Prices Act 2022 - https://bills.parliament.uk/bills/3341

Reforming the energy system to protect consumers from unfair pricing.

This includes:

- Extending the energy price cap beyond 2023
- Establishing an independent Future System Operator responsible for gas and electricity systems
- Create further competition in the onshore electricity network
- New cyber threat consumer protections for smart appliances
- Reforming the energy industry codes
- Establishing a buy-out mechanism under the Energy Company Obligation scheme for suppliers
- Appointing Ofgem to regulate heat networks and enable heat zoning
- Taking back powers from the EU to amend the Energy Performance of Buildings
- Strengthening the Energy Savings Opportunity Scheme for businesses

BEIS consultation on interoperability and cyber security of energy smart appliances and remote load control

In the BEIS and Ofgem Smart Systems and Flexibility Plan 2021 (BEIS & Ofgem, 2021), they committed to consulting on regulating flexibility service providers and other organisations controlling an electrical load. The consultation on interoperability and cyber security of energy smart appliances and remote load control delivers on this action sets out a range of proposals that will impact appliances and organisations with a role in controlling electricity usage.

BEIS's proposals are in three areas:

Creating the right technical frameworks to unlock the potential of flexibility for domestic and small non-domestic energy consumers – relates to standardising how innovative tariff information is shared (e.g., so that offers are comparable) and ensuring that smart devices can access different tariffs and flexibility services.

Improving the security of the electricity system – developing new cyber security and grid stability standards. These are to ensure that organisations that control substantial electrical load do so in a way that protects the electricity system and manages cyber risks.

Giving consumers the confidence to engage with a smart energy system - BEIS is minded to introducing a proportionate and flexible licensing system for aggregators (and other business models) of smart energy assets to provide assurance and protection to consumers on transparency of offers, interoperability, detriment, redress, vulnerability and flexibility provider of last resort. It is worth noting that this is not obviously linked to any wider retail market reform, such as supplier hub reform. This is important because it is suppliers that have the primary relationship with customers in homes and small businesses.

Analysis of official solutions against the barriers

Table 9 below summarises our analysis of official solutions against the barriers identified in Section 2. The detailed analysis is at this link[15].

Table 9: Barriers and official solutions from decentralised energy

Barrier theme	Sub-barrier	Official solution	Fully/partially/not address
Theme 1: Limitations in realising value from SLES	T1.1 Challenges in revenue stacking and the need for market liquidity	The BEIS Review of Energy Market (REMA) arrangements is consulting on a range of different options for reform of wholesale, zero-carbon generation procurement, balancing and ancillary services and capacity markets (BEIS, 2022d). The implications for this for T1.1 are unclear – options will be narrowed down by December 2022.	Partly, because no decisions are yet taken.
		The HMG Energy Security Bill has several elements relevant to decentralised energy (BEIS, 2022b). The creation of the Future Systems Operator (relevant in how it interacts with DSOs and distributed energy) and the classification of energy storage as a subset of generation (which provides certainty for this asset class).	Partly, because it is relevant to the creation of an FSO, and it classifies storage as a subset of generation.
	T1.2 Complex routes to market	The BEIS REMA programme is consulting on multiple market reforms (BEIS, 2022d). The complexity of future arrangements depends on these reforms.	Partly, because future reforms affect market complexity.
		BEIS have recently consulted on interoperability and cyber security of energy smart appliances and remote load control (BEIS, 2022a). In this consultation, BEIS is seeking to make it easier for consumers to engage with flexibility service providers and to potentially licence such providers to ensure consumers are protected. They are also seeking to ensure interoperability between smart assets and smart tariffs.	Partly, it could reduce consumer complexity and increase trust and participation in the provision of flex services.
	T1.3 Local settlement	The BEIS REMA programme is consulting on multiple market reforms (BEIS, 2022d). One potential reform is to introduce local ancillary service markets, which would provide a greater role for DNOs in managing energy system operability.	Partly, the REMA reforms are at consultation stage.
	T1.4 Non-financial value and co-benefits	N/A	Potential gap
	T1.5 TCR	The Ofgem Targeted Charging Review (TCR) has taken a formal decision which affects the value case for decentralised energy(Ofgem, 2019b). Ofgem has	The TCR decision reduces the business

		changed how residual (fixed) costs of the electricity networks are recovered and removed some embedded benefits.	case for decentralised energy assets.
	T1.6 Network Connections and principles of access	Ofgem's Access and Forward-Looking Charges Review (AFLCR) has taken formal decisions that affect decentralised energy (Ofgem, 2022b). The decisions to reduce the connection costs for new assets and to better define access rights are positive for new assets but could reduce the business case for local flexibility to overcome network constraints.	Partly, because of clarification of access rights. Potentially negative for local flexibility.
	T1.7 Imbalanced levies between gas and electricity	HMG's Net Zero Strategy committed to publishing a call for evidence on the affordability and fairness of energy bills (HMG, 2021). The call has not yet been published, but a temporary removal of green levies from bills was signalled in the cost-of-living package.	Partly, if the consultation goes ahead.
Theme 2: Market rules and governance	T2.1 Outdated principles and supplier hub	Ofgem consulted on supply market reform in 2017 and published its findings in 2018. Whilst Ofgem noted they were convinced of the case for supplier hub reform, there has been no further update since 2018.	Doesn't address the issue because no action has been taken.
	T2.2 Multiple suppliers	The BEIS consultation on interoperability and cyber security of energy smart appliances and remote load control considers introducing a new licence for aggregators and similar business models (BEIS, 2022a). Such licensed parties could feasibly undertake activities akin to those of multiple suppliers. Some BSC modifications in place to improve access the wholesale electricity market without transacting through a licensed energy supplier but meter splitting not pursued.	Partly, because it is a consultation. Meter splitting specifically not pursued.
	T2.3 Derogations and exemptions	BEIS launched a call for evidence in 2020 to explore how exemptions are being used in practice and inform a wider review. There has been no update since the call was closed in 2021 (BEIS, 2020).	No action taken and unclear whether positive for decentralised energy.
		Ofgem published an open letter consulting on derogations from certain standard license conditions (SLC); and, granting supply licenses for specific geographic areas or premise types. No follow-up since the open letter in July 2020 (Ofgem, 2020).	No action taken.

	T2.4 Non-energy licensing and regulatory barriers	No proposed solutions identified	Potential gap
	T2.5 Codes and governance	Some reforms already implemented. The HMG Energy Security Bill proposed to create "a new governance framework for the energy codes that will move the responsibility for code governance to one or more newly created code managers instead"(BEIS, 2022b).	Partly, as the reforms could address issues with codes.
Theme 3: Limitation in innovation support processes	T3.1 Regulatory sandboxes not sufficient	Ofgem indicated they would learn from the regulatory sandbox regarding supplier hub reform in their supply market arrangements (Ofgem, 2018b).	No progress is apparent on this.
	T3.2 Inflexibility in innovation funding	HMG has created a Net Zero Innovation Board (NZIB) to "…ensure a co-ordinated and strategic approach to Research, Development & Demonstration (RD&D) funding across these bodies, and to enhance the alignment of the public and private sectors in support of the Government's wider strategy to achieve our net zero targets by 2050" (HM Government, 2022).	Partly, the NZIB role appears to address some issues but progress is unclear.
	T3.3 Data access and sharing	Ofgem is reviewing data best practice and considering widening participation to others, including codes bodies, heat networks and potentially third-party intermediaries (Ofgem, 2022e).	Partly, DBP could enable data to flow between actors better
		The BEIS consultation on interoperability and cyber security of energy smart appliances and remote load control is proposing standards for sharing smart tariffs, cyber security, device interoperability, etc (BEIS, 2022a).	Partly, standards could assist with data access and sharing.
Theme 4: Lack of attention to demand side measures	T4.1 Challenging to integrate energy efficiency and retrofit measures into value propositions	Three measures in the HMG Energy Security Bill are relevant (BEIS, 2022b): 1) Extending ECO to all suppliers 2) Take back powers from the EU to amend the Energy Performance of Buildings 3) Strengthen the Energy Savings Opportunity Scheme for businesses.	Partly, as these measures affect home and business energy efficiency
	T4.2 Markets skewed towards supply technologies	The BEIS REMA consultation explicitly discusses the extent of competition between technologies with a focus on demand-side technologies (BEIS, 2022d).	Partly, depends on the outcomes of the consultation.
Theme 5: Lack of coordination within and across scales	T5.1 Policy uncertainty and lack of systemic approach to reform	The BEIS REMA consultation, whilst adding to uncertainty in the short-term, could introduce new wholesale market arrangements in the future (BEIS, 2022d).	Partly, it depends on the reforms and if and when decisions are taken.

		The Energy Security Bill is relevant (BEIS, 2022b) and provides a package of measures to deliver the Government's energy priority, however, the status of the bill itself is currently uncertain.	Partly, if the Bill were passed, it would increase certainty on energy policy.
		The BEIS REMA consultation discusses putting decisions into the hands of a dispersed set of actors (BEIS, 2022d).	Partly, BEIS appear cautious on how far decentralisation can go.
		The HMG Net Zero Strategy commits to establishing a Local Net Zero Forum to bring together national and local government senior officials to discuss policy and delivery options on net zero (HMG, 2021).	Partly, it is unclear on the purpose and governance of a Net Zero Forum.
	T5.2 Governance Gaps at the local and regional level	Ofgem's call for input on the future of local energy institutions and governance indicates coordination and planning gaps between national and local energy system (Ofgem, 2022d).	It is a call for input and unclear what the next steps are.
	T5.2.1 No local planning and coordination role	Government is supportive of local area energy planning but has not provided resources or a statutory role for local authorities to undertake planning. Ofgem ED2 guidance suggests that DNO business plans should have regard to local area energy plans but no formalised process. Also see T5.2.	Partly. Guidance available but no formalised role ore resource and capability building support.
		The BEIS REMA programme is consulting on multiple market reforms (BEIS, 2022d). One potential reform is to introduce local ancillary service markets, which would provide a greater role for DNOs in managing energy system operability.	Partly, the REMA reforms are at consultation stage.
	T5.2.2 DSO uncertainties	Ofgem's call for input on the future of local energy institutions and governance explores different governance arrangements including independent DSOs and Regional System Operator roles (Ofgem, 2022d).	It is a call for input and unclear what the next steps are.
	T5.2.3 Heat network barriers	The Energy Security Bill and BEIS heat network zoning proposals contains measures on both heat network regulation and heat network zoning. Together these will better protect heat networks customers and make it easier to deploy new ones (BEIS, 2022b, 2022c). Delays on decisions about hydrogen for heating are also causing uncertainty in local energy planning.	Partly, the ESB measures address heat network consumer protection and zoning issues.

Discussion on official gaps

- Official solutions tend to be national in formulation, and only occasionally consider local or decentralised aspects.
- There are few decisions that individually fully resolve barriers to decentralised energy
- Approaches to address local and national coordination appear to have reservations about going too local.
- There are positive developments in heat network regulation & zoning, code management reform and consumer protection in flexibility services.
- Some decisions have already been taken, such as Ofgem's TCR, which reduces the benefits of decentralised energy.
- There are gaps, or issues, around co-benefits, supplier hub, exemption regime, and local governance issues.
- There is uncertainty over official solutions as many are in the consultation phase or face uncertain futures, like the Energy Security Bill.

Stakeholder solutions

Introduction

In this section, we discuss the solutions arising from wider stakeholders. We describe the types of stakeholders.

Who are the stakeholders

Our review has focused identified three main types of stakeholders:

1. Official industry programmes, specifically the Energy Networks Association Open Network Programme (ENA ONP). We describe the ENA ONP below.
2. Stakeholders associated with the PFER programme, particularly those involved in the demonstration and detailed design projects or commenting on the programme.
3. Wider expert stakeholders, such as Citizens Advice and the Energy Systems Catapult, The Council of European Energy Regulators, UKERC and UK100.

The Energy Networks Association Open Network Programme

The ENA Open Networks programme (ONP) brings together the nine electricity grid operators in the UK and Ireland to work together to standardise customer experiences and align processes to make connecting to the networks as easy as possible and bring record amounts of renewable distributed energy resources, like wind and solar panels, to the local electricity grid (ENA, n.d.). The ONP has been ongoing for the past five years. This current annual work plan has five workstreams (WS):

- WS1A: Flexibility Services: Focus on standardising, simplifying and increasing transparency of flexibility services
- WS1B: Whole Electricity System Planning: Improving data exchange between transmission and distribution, Future Energy Scenarios, and operational planning
- WS2: Customer Connections: Aiming to make customer connections easier and more efficient. Includes an embedded capacity register, work on queue management and implication of AFLCR
- WS3: DSO Transition: Maintain DSO implementation plan against DSO roadmap (NOTE - there are eight DSO functions) + conflicts of interest and unintended consequences risk registers

- WS4: Whole Energy Systems: Created a whole systems CBA tool + whole systems optioneering and LAEP coordination with LAs + monitoring relevant innovation projects.
- WS5: Communications and Stakeholder Engagement

Table 10 below, summarises the solutions that the ENA ONP provides against the five themes of barriers. In all cases, we assess that the barriers are partly resolved by the ENA ONP.

Table 10: An analysis of ENA ONP solutions against the five themes of barriers

Barrier theme	Relevant sub-barriers	ENA ONP solutions
Theme 1: Limitations in realising value from SLES	T1.1, T1.2 and T1.7	ONP seeks to standardise, simplify, and increase the transparency of flexibility. This includes standardising DNO flexibility procurement approaches, analysing barriers to stacking, improving interoperability between the DNOs and ESO and improving the information on Active Network Management (ANM) curtailment.
	T1.4	ONP is examining the whole system benefits and carbon impacts of flexibility, which is a limited subset of non-financial value and co-benefits.
Theme 2: Market rules and governance	N/A	N/A
Theme 3: Limitation in innovation support processes	T3.3	Various aspects of the ONP relate to data sharing, interoperability and transparency, including WS1A (transparency of flexibility decision making); WS1B (data exchange between T&D on planning, forecast and operation); WS4 (sharing T&D data with LAs for LAEP).
Theme 4: Lack of attention to demand-side measures	N/A	N/A
Theme 5: Lack of coordination within and across scales	T5.2.1	Specific activity in WS4 on whole system optioneering for LAs and coordinating ESO and DSO input into LAEPs.
	T52.2	The whole ONP is aimed at creating more certainty in the role of DSOs as well as relationships between DSOs, the ESO and other actors.

Solutions by wider stakeholders and from crowdsourcing by theme

Below, we present the solutions from wider stakeholders and additional solutions derived from crowdsourcing that were included in the workshops described in the next section. We make it clear which solutions are derived from crowdsourcing by including [CROWDSOURCING] before the relevant solution. Note that in all cases, we assessed the solution as partly addressing the issues.

Theme 1: Limitations in realising value from SLES

1.1 Challenges in revenue stacking and the need for market liquidity

Government should review how value (of local matching and dispatching of energy assets) flows to market participants and how reforms could ensure fair access and provide effective incentives

(Crook et al., 2022a; Mose et al., 2021b; Cornwall & UKRI, 2021). Additionally, one stakeholder suggested that given the complexity of reforms, such as REMA, the role of "benefits grandfathering" for flexibility values should also be reviewed for future implications (Cornwall & UKRI, 2021).

The value of flexibility is not being fully reflected in RIIO-ED2 (Cornwall & UKRI, 2021; Citizens Advice, 2022). The checks and balances in the ED2 processes should be reviewed to ensure flexibility is sufficiently incentivised compared with other approaches.

1.2 Complex routes to market

[CROWDSOURCING] Introduce a Local Energy Obligation where some % of revenue must be used for local social/economic benefits. This could be a good way to inform customers about where their energy is coming from and who is benefiting, as well as encourage investment in local schemes.

1.3 Local settlement

The Balancing and Settlement Code should be reformed to better enable Local Energy Markets and local settlement (Crook et al., 2022a).

[CROWDSOURCING] EU Energy Communities are legal entities based on open and voluntary participation, effectively controlled by its members, with the purpose of providing environmental, economic, or social benefits. Provides rights for energy sharing, distribution network ownership, consumer protections, and integration into energy systems & markets.

1.4 Non-financial value and co-benefits

An evidence base and assessment framework for SLES co-benefits needs to be developed to ensure consistent valuation and integration into policy assessments (Cornwall & UKRI, 2021; Hardy & Morris, 2022b). Recent reports such as ‘Accelerating Net Zero Delivery’ have started to fill this gap (Innovate UK et al., 2022).

1.5 Targeted Charging Review

[CROWDSOURCING] We need a much more strategic reform of network charging to open up its value to decentralised flex. Locational Marginal Pricing / Nodal pricing might be one way to do this, but we need to separate the cost of transporting energy from the cost of generating energy so they can be seen and managed separately.

1.6 Flexible Connections and principles of access

Capacity trading in local area should be trialled to test effectiveness in utilising the local network efficiently (Crook et al., 2022a; Cenex, GreenSCIES & Energy Systems Catapult, 2022b).

1.8 Imbalanced levies between electricity and gas

[CROWDSOURCING] Adjust policy cost levies to apply at peak times to help get a stronger price signal as incentive for energy efficiency, and flexibility.

Theme 2: Market rules and governance

2.1 Outdated principles and supplier hub

Risk and innovation could be better managed through the development of a modular, risk-based and digitalised licensing regime (Johnston, 2022b).

[CROWDSOURCING] REMA's proposals for central dispatch could open up roles at the supplier end. Models similar to the California Community Energy Aggregation could then be considered.

[CROWDSOURCING] Single central (public or non-profit) supplier for those on social tariffs, vulnerable, those who don't switch etc - supplemented by multiple competitive alternative offers.

2.2 Multiple energy suppliers

BSC Modification on meter splitting and multiple suppliers (P379) withdrawn 2021 (Elexon, 2021b, 2021d). Various BSC modifications have been delivered, which Elexon determine will deliver some of the outcomes of P379 (specifically P375, P398, P376, P415).

[CROWDSOURCING] The Local Energy Bill is a strategic solution to this (in that it creates a route to local selling and purchase of electricity).

2.3 Derogations and exemptions

The Local Energy Bill has provisions that will allow for the licensing of local electricity suppliers in a geographic area, grant powers to Ofgem to issue these licenses, and allow renewable generators to be local suppliers (UK Parliament, n.d.). The bill could provide an alternative route to license-exempt supply.

2.4 Non-energy licensing and regulatory barriers

Redesigning regulation makes a case for a single essential services consumer regulator & ombudsman and potentially an essential infrastructure regulator (Sandys et al., 2018). This essential services regulator would merge the consumer protection functions of Ofgem, Ofwat and Ofcom.

Reverse the removal of long-term financial support and tax incentives for investment in local energy - specifically the Social investment tax relief (SITR) scheme and the Enterprise Investment Scheme (EIS) (Mose et al., 2021b).

Theme 3: Limitation in innovation support processes

3.1 Regulatory sandboxes not sufficient

Create energy innovation zones to test and explore specific regulatory challenges (Energy Capital, 2022a; Crook et al., 2022a; Cornwall & UKRI, 2021). These energy innovation zones provide a geographically contained area to test new tariffs, network charging regimes or routes to deliver ECO.

Review the energy sandbox regimes and develop a revised framework with greater accessibility, scope and coordination (Cornwall & UKRI, 2021). This review should include an analysis of the Elexon and DCUSA sandboxes and international comparisons.

[CROWDSOURCING] Consider the options for data-driven innovation - allow innovators latitude to do innovative stuff with small groups of consumers, provided all the resultant data is openly available for independent scrutiny. Allow models to scale up progressively unless consumer detriment can be demonstrated.

3.2 Inflexibility of innovation funding

[CROWDSOURCING] Funding is often based on delivering predetermined outputs which are set at the start of projects. We can learn as much if not more from the things that don't work as from those that do and this should be recognised in the innovation process.

3.3 Data access and sharing

[CROWDSOURCING] Enable trusted third parties (innovators) to securely access personal energy data to enable innovative products and services to be developed to solve customer problems and accelerate innovation & competition across the sector.

[CROWDSOURCING] I'd encourage you to have a look at North Sea Transition Authority and particularly the data powers we included in the Energy Act 2016. This approach has enabled innovation on top of NSTA and industry data.

Theme 4: Lack of attention to demand-side measures

4.1 Challenging to integrate energy efficiency measures into value propositions

Introduce comprehensive energy efficiency policy packages across all consumer segments, including owner occupiers (Cornwall & UKRI, 2021; Mose et al., 2021b; Climate Change Committee, 2022a; Ashden, n.d.).

End the reliance on competition-based efficiency programmes at the local level in England and developing long-term, fairly allocated, local government co-ordinated energy efficiency programmes linked to local energy planning (Cornwall & UKRI, 2021; Britton & Webb, 2022b; UK100, 2022c).

[CROWDSOURCING] Place a formal obligation on DNOs/GDNs to invest in energy efficiency, which would allow a more coordinated approach. Ofgem doesn't have powers to impose this. But the government does.

[CROWDSOURCING] Scrap ECO and the supplier led approach and adopt a street-by-street approach for economies of scale. Local government led seems sensible.

[CROWDSOURCING] Where the benefit to the local energy system of both reducing the total energy demand (e.g., insulating at the same time as electrifying heat) and enabling homes and businesses to shift their demand dynamically to local signals of locally generated low carbon and lower priced electricity.

4.2 Markets skewed towards supply technologies

[CROWDSOURCING] An open spot market in which both supply and demand can participate would help here. Note this doesn't extend to the "negawatt" concept though, except as an ancillary service.

Theme 5: Lack of coordination within and across scales

5.1 Policy uncertainty and lack of systemic approach to reform

Create structures to enable dialogue between local innovators and policymakers (Cornwall & UKRI, 2021).

Revise the Strategy and Policy Statement for Ofgem so that it supports decentralised energy and gives Ofgem clear guidance to weight local energy in decisions (Cornwall & UKRI, 2021).

5.2.1 No local planning and coordination role

Create a duty to prepare and implement local energy plans with local or combined authorities identified as the competent, accountable body to implement them and appropriate powers allocated (Crook et al., 2022a; Banks, 2021; Cornwall & UKRI, 2021; Hardy & Morris, 2022b; Energy Capital, 2022a). Any such duty would need to come with the commensurate resources, powers and capabilities to deliver.

[CROWDSOURCING] There needs to be absolute clarity that the DNO and DSO are not participants in DER/flexibility markets. Otherwise, competition will not be allowed to flourish.

Observations across the official and stakeholder solutions

- Most barriers have solutions in progress or proposed by stakeholders.
- Conversely, the fact that there are no complete solutions to the myriad of challenges indicates some gaps and a lack of strategic focus on decentralised energy.
- Stakeholders express support for several of the official solutions underway. These include code reform, supplier hub reform and sandbox reform. In many instances, stakeholders are proposing that such reforms go further or to the extreme of the current plans.
- Stakeholder proposals take several forms, for example:
  - trials (e.g., to test capacity trading)
  - reviews (e.g., reviewing checks and balances of ED2 flexibility)
  - new institutional arrangements (e.g., a modular, risk-based and digitalised supplier licensing regime)
  - new guidance (e.g., a Strategy and Policy Statement for Ofgem that clarifies its roles with respect to decentralised energy)
  - new institutions (e.g., a new essential consumer services regulator)
  - new responsibilities (e.g., a duty to prepare and implement local energy plans with local or combined authorities)
  - innovation areas (e.g., creating energy innovation zones to test and explore specific regulatory challenges)
  - changes to legislation (e.g., the Local Electricity Bill)
- Wider stakeholder solutions appear more consumer-centred than official solutions and to some extent those in the ONP.
- Several crowdsourced solutions pull in learning from other sectors (for example, the North Sea Transition Authority) or geographies (EU and California).
- There is a stakeholder emphasis on the need for a strategic position on the role of distributed energy and the creation of institutional structures to support this e.g., a dialogue process between innovators and gov/regulator, Ofgem SPS, local governance reform, a framework for decentralised energy co-benefits.
- The number of stakeholder proposals indicates significant expertise and experience available to decision-makers in shaping reforms.
- The ENA ONP programme is working on at least three of the barriers. However, there is limited discussion on the programme by wider stakeholders in their proposed solutions. This could indicate a lack of awareness of engagement between wider stakeholders and the ONP.

Solution gaps identified

Our analysis of barriers and solutions to decentralised energy has revealed a range of partial solutions to a range of barriers. We note that this is good news. The analysis has also revealed some areas where there are solution gaps.

Lack of official solutions

- **1.3 Local settlement.** There is no current official programme looking at local settlement. Specific elements of the REMA programme are relevant – for example, local ancillary markets.
- **1.4 Non-financial value and co-benefits.** We could not identify any official programmes exploring this issue.

- **2.1 Outdated principles and supplier hub.** Ofgem has taken no further action since its review of supply market arrangements in 2017/18.
- **2.3 Derogations and exemptions.** BEIS and Ofgem progress on the exemption regimes and geographic supply licences halted in 2020.
- **2.4 Non-energy licensing and regulatory barriers.** We could not identify any official programmes exploring this issue.
- **3.1 Regulatory sandboxes not sufficient.** We are aware that Ofgem is now starting to think about the future of the Innovation Link. However, there is no public notice about this work.
- **4.1 Challenging to integrate energy efficiency measures into value propositions.** The Energy Security Bill contains measures relevant to this. The Bill itself is uncertain, though.
- **5.1 Policy uncertainty and lack of systemic approach to reform.** Whilst several official papers discuss the principles and objectives of reform, there does not appear to be an overarching guiding framework. In addition, many of the reforms themselves are uncertain as they are consultations or need to progress through Parliament.
- **5.2 Governance Gaps at the local and regional level & T5.2.1 No local planning and coordination role.** Whilst several official programmes recognise the governance gap issue, most reference the need for a balance between national and local.

Observations on gaps

There are gaps in official solutions in three areas:

- The first is an overarching and holistic strategy and systematic for reform. Consequently, many of the reforms underway are siloed and specific. There is a lack of attention on the value and benefits of reform, particularly wider co-benefits.
- The second is a lack of attention to the demand and retail side. There are gaps in retail market reform as well as in creating space for business model innovation. There are also gaps in valuing demand-side energy in the same way as the supply side.
- The final gap is local energy, which appears sporadically in policies. It is unclear what the official position on local energy is, particularly its role in the energy transition.

In terms of wider solutions, issues like market complexity and multiple suppliers have been apparent for several years. The fact that initiatives such as REMA, ENA ONP and code reform now underway indicate that the problems are more systematic than isolated – e.g., that the institutional structure needs to change to resolve the issues.

Section 4: Who needs to take decisions and by when?

In this final section, we present the priority solutions to enable decentralised energy innovation. Two participant workshops which prioritised the solutions in Section 3 are a key component of this analysis.

In this section, we first outline a set of important cross-cutting issues that emerged from the solutions and participant discussions in the workshops. Then we explore the priority decisions that emerged from the workshops and the four categories of decisions that they represent. Finally, we reflect on the extent to which the solutions solve the barriers to the business model archetype clusters developed in Section 1.

Methodology

The workshop was conducted online and recorded stakeholder input on an online whiteboard (see the Mural template here). Workshop participants undertook four facilitated activities:

1. Sort the barriers into complexity (to solve) and impact (if solved)
2. Check that you agree with the vision (right-hand side of the board)
3. Choose and order solutions on the timeline (e.g., now, within 5 or 10 years)
4. Comment on interdependencies and other issues

Decisions were taken by consent amongst the group.

Participants were selected to ensure a range of expertise across decentralised energy business, policy, regulation and academia.

Solutions and framework

Cross-cutting themes

Our literature review, analysis and workshops have identified specific barriers and solutions for decentralised energy. We have also observed six important cross-cutting themes that pervade decision making. We summarise these in Table 11.

Table 11: Cross-cutting themes emerging from the analysis

Cross-cutting theme	Description
Centralised mindset	A linear, centralised logic pervades in the energy system. This logic permeates key decisions, such as the REMA programme and retail market reform, skewing them towards centralised and engineering solutions. The impact includes a lack of recognition of the benefits and role of distributed energy and a lack of valuation of demand-side solutions.
A lack of definition and agency of decentralised energy assets and actors	Decentralised energy assets, such as electric vehicles and behind-the-meter assets, such as batteries and heating systems, are not defined (in a legal or regulatory sense) in the same way as conventional assets, such as power stations. Consequently, DE assets, their owners (e.g., households, businesses, and communities) and intermediaries (such as aggregators) lack visibility and agency in the energy system. The impact is that they can be invisible and undervalued in the energy system and not represented in discussions about rules changes.
Coordination, transparency, and clear roles	There is a lack of clarity on the role of decentralised energy and its customers and communities in the current and future energy systems. There is also a lack of attention on how the future energy system will be

	coordinated across scales, including between national, regional, local and individual asset scales. The impact is a lack of clear roles and responsibilities, for example, between DNOs and local actors on energy and spatial planning.
Risk-based approaches to managing change	The overly prescriptive nature of current licensing and innovation processes is a barrier to developing new, customer-centric business models. The impact is a regulatory regime which struggles to accommodate decentralised energy customer propositions. Shifting towards a more risk-based approach to regulation (such as the regimes in food and finance), licensing and innovation would support innovation and provide better consumer outcomes.
Resilience	The definition and approaches to energy systems and climate resilience are not keeping pace with the energy system transition. There is also poor coordination and responsibilities between cross-sector resilience forums such as the UK Regulators Network (UKRN). The impact is a resilience framework unfit for the future. Future energy (and wider cross-sector resilience) should be integrated across scales through local energy and wider spatial planning. Resilience should also be integrated into wider energy decisions, such as the REMA programme.
Recognising the diverse values of decentralised energy	The energy and wider system benefits of decentralised energy are not fully considered in energy systems decisions, particularly those by Ofgem and BEIS. The impact is that decentralised benefits are left off the table in decisions. Decentralised energy can contribute to lower whole system transition and operating costs. It can also deliver additional local benefits, such as health and social benefits. Consequently, it is important that these benefits can be incorporated into decision-making frameworks.

These cross-cutting issues are important because they affect both how decisions are taken (for example mindset or view on value) and constrain decisions (for example the availability of skills and capabilities or limits of system resilience). We discuss these cross-cutting issues further in the discussion section below.

Explaining the framework

During the two workshops, participants prioritised several of the solutions that we identified in Section 3. Participants also proposed new solutions to address barriers, based on their knowledge and experience. We present the prioritised solutions in Figure X.

When we analysed the prioritised solutions, we observed that they fell into four categories. These are:

- **Reviews:** This category is where solutions address a knowledge or evidence gap to inform a future decision. For example, to review the co-benefits of local energy to be able to account for these in future decisions.
- **Strategy/Vision**: These solutions represent public strategies/visions that set a clear direction of travel for the energy sector. These included specific strategies (such as strategy for the future of the gas grid) as well as an overarching strategy/vision for the whole energy sector.
- **Enablers:** These solutions put in place essential enablers that enable infrastructure and actors to deliver decentralised energy innovation, for example, implementation of the full range of recommendations from the Energy Digitalisation Taskforce.

- **Reforms:** These are specific decisions that will reform roles, responsibilities, and markets in the energy system to enable decentralised energy innovation. For example, enabling multiple suppliers at a single meter point.

Priority solutions

Figure 29 summarises the solutions against the five themes of barriers and the four categories of solution types, described above. These are the priority decisions that emerged from the two workshops and therefore do not reflect all the solutions outlined in Section 3.

We provide more details on each solution in terms of categories, barriers addressed, what it enables, key decision makers, timeliness and interdependencies in a series of tables after the figure.

There are important caveats to many of these decisions. We discuss these in a subsequent section.

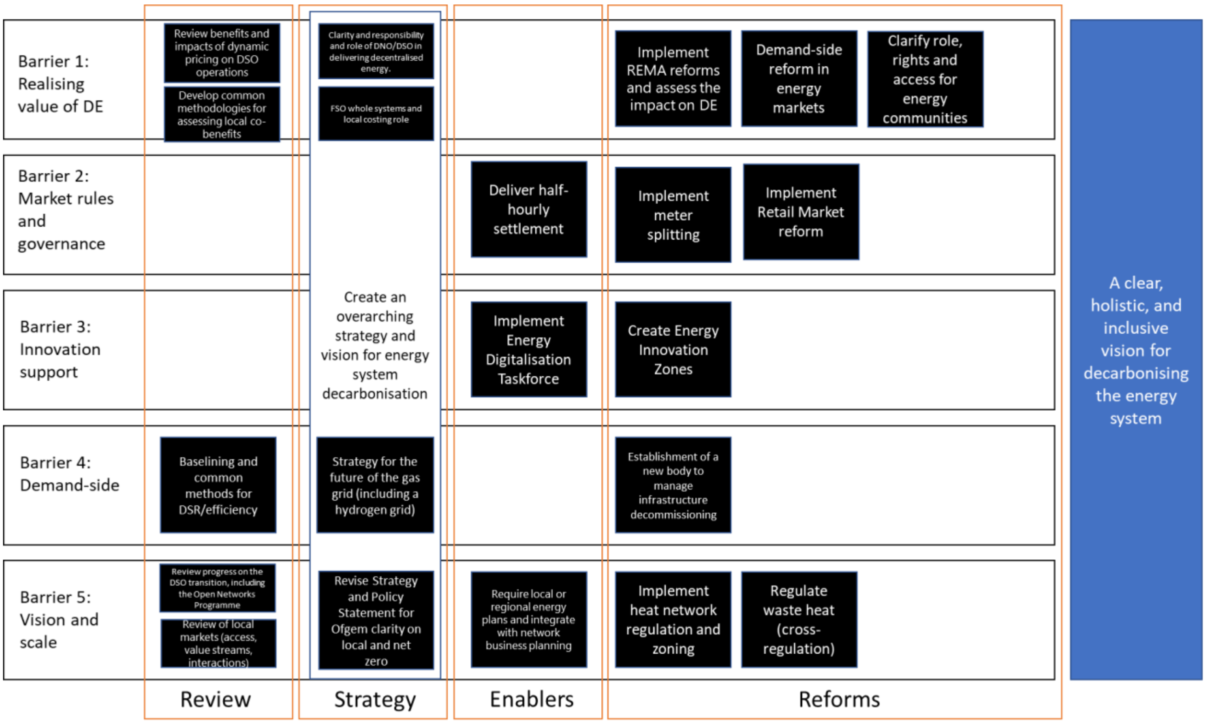

Figure 29: Summary of priority solutions against barriers and solution category

Category: Review solutions

Table 12: Summary of prioritised review solutions, key decision maker, timeliness and interdependencies

Barrier	Prioritised Solution	What does it enable	Decision maker	Timeliness	Interdependencies
1	Analyse and publish the distribution network benefits and costs of dynamic pricing at a large scale to inform network charging reform prior to ED3	Creating a level playing field for distributed assets and services. Enable visibility of system benefits and costs.	Ofgem	Prior to ED3	Action on DE value streams, FSO whole system costing
1	Develop an evidence base and assessment framework for local energy co-benefits to ensure consistent valuation and integration into policy assessments	Consistent valuation of non-energy system benefits	BEIS	Now	Other reforms to unlock local value streams
4	Develop baselining tools and common methodologies so counterfactuals can be created for efficiency and demand-side response business models.	Increases investor and customer confidence. Allows comparability of value propositions.	ENA	Now	Links to other actions to enable value streams, Local energy planning and energy data.
5	Strategy for the future of the gas grid (including a hydrogen grid) and establishment of a new body to manage infrastructure decommissioning	Clarity on key infrastructure	BEIS	Within 5 years	DE value streams, local energy planning, DSO implementation
5	Review progress on the DSO transition, including the ONP programme and progress on a data-driven approach. Ensure the DSO incentive and RIIO ED2 checks and balances are implemented i.e. reopeners and uncertainty mechanisms.	Clarity on progress and challenges in local coordination, data sharing and flexibility markets.	Ofgem	Now	Local energy planning, FSO whole system costings, heat zoning
1	Review how local assets receive revenue from local and national markets and implement local markets across local balancing, flexibility, ancillary services, capacity and ANM. This review should also resolve interactions between markets, making clear rights of different actors to utilise the same asset for various services.	Establishes local value pools	BEIS, Ofgem	Now	REMA, other action to support local value streams. Should build on Smart Systems and Flexibility Plan workstreams

Category: Strategy/Vision solutions

Table 13: Summary of prioritised strategy/vision solutions, key decision maker, timeliness and interdependencies

Barrier	Prioritised Solution	What does it enable	Decision maker	Timeliness	Interdependencies
ALL	Create an overarching strategy and vision for energy system decarbonisation.	Clear vision for energy system transformation and clarity on benefits, roles and responsibilities and structures (markets)	HMG	Now	Everything
1/5	Vision for RIIO-ED3 including role and responsibility	Clarity and responsibility and role of DNO/DSO in delivering decentralised energy innovation.	Ofgem	Prior to ED3	Informed by various reviews on ED2
1	Develop FSO whole system costings role. This include taking a system view of local and whole system costs, managing the FSO/DSO relationship and ensuring visibility and information flows across scales, reviewing changes across the data and interoperability landscape, reform of final physical notification processes to focus on asset data transfer and visibility across scales.	FSO/DSO coordination and role clarity, efficient allocation of costs, data visibility	BEIS/Ofgem/FSO	Now	Links to recommendations on data, market rules and coordination
5	Revised Ofgem Strategy and Policy Statement (SPS), including a clear statement of its support for local energy and its role and benefits in delivering Net Zero.	Clarity on support for distributed energy and policy certainty	BEIS	Now	Link to Ofgem action on local governance of energy system change, LAEP and DSO transition

Category: Enabler solutions

Table 14: Summary of prioritised enabler solutions, key decision maker, timeliness and interdependencies

Barrier	Prioritised Solution	What does it enable	Decision maker	Timeliness	Interdependencies
1	Ensure half-hourly settlement is delivered by 2025	A key enabler of innovative supply arrangements and dynamic ToU tariffs	Ofgem	By 2025 with clear milestones	Other actions to access value streams
3	Implement Energy Digitalisation Taskforce recommendations, particularly on standards and an enabling layer.	Supports innovation and coordination	BEIS, Ofgem, ESO, DNOs	Now	FSO whole system review, DSO implementation, ONP
5	Local Energy Planning: Ensure local/regional energy plans are in place in all areas and integrate with DNO/DSO evolution. Ensure methodology incorporates resilience planning, rather than the current focus on forward capacity planning.	Coordinated local delivery of decarbonised heat, power, transport	BEIS, Ofgem	Within 5 years	DSO transition, heat zoning, methodology for co-benefits

Category: Reform solutions

Table 15: Summary of prioritised reform solutions, key decision maker, timeliness and interdependencies

Barrier	Prioritised Solution	What does it enable	Decision maker	Timeliness	Interdependencies
1	Deliver and extend REMA package of market reforms. The REMA analysis should include specific assessment of the impact of reforms on DE. Analysis and delivery should be connected to other reforms programmes (including the retail market review) to ensure it doesn't result in conflicting or perverse outcomes. Other options e.g., wire by wire network charging should be included in ongoing work	Establishes value pools for local markets	BEIS as lead, multiple other actors involved	Now – delivery over next 2-3 years	Links to strategy and market rules (theme 2 and 5). Setting regulatory and governance frameworks is central to creating revenue mechanisms. Similarly if DE values were clearer then actors

					would take more regulatory risks. Need to address in concert. Key link to recommendation for a holistic reform programme (see theme 5)
1	Clarify the role, responsibilities and access for community energy.	Clarifies the route for local communities to retain value from local energy assets and actions.	BEIS/Ofgem (implementing EU policy, once formed)	Depends on EU policy development	Relates to other aspects of local value, local roles and responsibilities, and local markets.
1	Undertake a fundamental reform programme to reorientate the structures of the energy system to focus on people and the demand-side. This would incorporate strategic direction setting and market and governance reform. It would provide a clear vision and structure for other reforms to flow from	Places people and demand at the centre of the energy system.	BEIS, Ofgem	Now – complete by 2028	Underpins most other action
2	Implement meter splitting (B379)	Enabler of business model innovation, including for progressive tariffs	Ofgem/Elexon	Now	Interacts with retail market reform and consumer protection reform. Would place less emphasis on switching so the consumer protection regime could be more nuanced
1 / 2	Implement retail market reform. Take action on the 2018 Ofgem statement that "there is a strong case for considering fundamental reforms	Enables innovative supplier propositions, potentially more in keeping with wider reforms (such	Ofgem (or BEIS if Ofgem are stalled)	Alongside REMA	REMA and other retail market reforms, such as meter splitting.

	to the supplier hub model, and for evaluating how alternative arrangements might operate in practice".	as dynamic and locational pricing + local energy propositions).			
3	Establish Energy Innovation Zones. Creates safe spaces for local actors and DNOs to innovate and addresses local resourcing challenges.	Support business model scaling and innovation within specified areas.	BEIS, Ofgem, IUK	Now	Links to market rules. Would allow progress to be made in the context of huge complexity and wider reform programme.
5	Implement heat zoning & heat regulation (as per the Energy Security Bill)	Enabler for more structured local energy planning	BEIS then Ofgem	Now	Local energy planning, DSO transition, clarity of sub-national roles and responsibilities
4	Regulate waste heat sources to explicitly incentivise these sources to supply heat to heat networks (e.g. waste water, energy from waste, data centres)	Increased viability of low carbon heat networks	Ofgem, BEIS, Ofwat, Ofcom(?)	Within 5 years	Local energy planning, heat zoning, baselining tools

Discussion

Whilst the workshops and wider analysis have provided a clear framework of prioritised actions to support distributed energy, discussions also focussed on the complex interdependencies between actions and incorporated a number of sources of disagreement. The key areas of consensus, debate and interdependencies are summarised below in relation to the six cross-cutting themes.

Overall stakeholders tended to emphasise barriers in relation to value streams (theme 1) and coordination across scales (theme 5), and, to a lesser extent, market rules and governance theme 2). However, discussions made clear that barriers in relation to innovation (theme 3) and lack of attention on the demand side (theme 4) were seen to largely flow from the other three barrier themes. For example, whilst specific actions were prioritised to improve the innovation landscape, even if there were implemented wider system barrier13s to achieving value or interacting with consumers would persist. Currently, innovators can try to solve specific business model barriers but the scalability of many propositions is limited by the lack of more transformative changes to restructure the energy system to a decarbonised, smart, flexible system.

Centralised mindset

Many stakeholders reported a fundamental lack of recognition of the benefits and role of distributed energy and a lack of valuation of demand-side action. A linear, centralised logic persists in the energy system. Participants proposed that a significant programme of reform is necessary over the next 5 years which reaches beyond the scope of REMA. This large reform programme should be completed by 2028 and would restructure system governance to emphasise security of service rather than the security of supply.

Stakeholders repeatedly highlighted that the responsibilities of consumers in the energy system are currently unclear, as is what people can expect from the energy system. The future expansion of demand side response will require a clear contract and responsibilities between the consumer and the energy system to develop, even if services are managed by third parties. In the absence of a clear understanding of what each actor is responsible for, the system tends to be very risk-averse and misses opportunities to explore wider risk/reward trade-offs.

A lack of definition and agency of decentralised energy assets and actors

Decentralised energy assets, such as electric vehicles and behind-the-meter assets, such as batteries and heating systems, are not defined (in a legal or regulatory sense) in the same way as conventional assets, such as power stations. Consequently, DE assets, their owners (e.g., households, businesses, and communities) and intermediaries (such as aggregators) lack visibility and agency in the energy system. The impact is that they can be invisible and undervalued in the energy system and not represented in discussions about rules changes.

Coordination, transparency and clear roles

Linked to the persistence of a centralised logic in the energy system, stakeholders consistently emphasised the need for a high-level vision on the role of distributed and local energy, more fundamental system reform and coordination across scales. In particular, there is a need for clarity on cross-scale interactions, specifically between the FSO and emerging DSOs and between DSOs and local energy planning.

A perceived lack of policy commitment to distributed energy was framed as critical in shaping the impact of other barriers. Even if supportive market rules and regulations were developed, a lack of coordination and certainty on the role of DE in the future energy system would still impact delivery and outcomes. Whilst market rules and governance processes were identified as important barriers, coordination barriers were prioritised based on clear coordination and regulatory certainty setting the framework for the development of appropriate market rules.

Clarity on local governance roles and responsibilities is required to structure relationships between DSOs and other local actors. There was strong consensus that this should include consistent delivery of local energy planning across the country and clear integration with the with DNO/DSO evolution. Heat Zoning could be an important element of local planning.

Risk-based approaches to managing change

There was considerable emphasis on the overly prescriptive nature of current licensing and innovation processes, with widespread agreement that a shift towards more risk-based approaches would support innovation and provide better consumer outcomes.

Many other sectors, including financial services and food, already operate modular, risk-based licensing systems which enable more light-touch regulation, proportionate to the risk profile of individual participants. The work already completed on licensing reform and the supplier hub should be a springboard to further action in this area. The timing of reforms could also provide an opportunity to integrate the regulation of hydrogen and heat networks as they develop.

Ongoing digitalisation reforms could help to ensure that consumer protection is robust during this transition by creating opportunities for the virtualisation of supply relationships and the maintenance of a single 'supplier' point of contact for consumers. Similarly, reforms to Ofgem's Innovation Link service, Sandboxes and derogations processes should be integrated with licensing reform and adopt the same risk-based principles.

Resilience

Integrated with the emphasis on risk-based management of change, there were numerous calls to incorporate resilience more fully into energy system reforms. This was in relation to creating more coordination between cross-sector resilience forums such as the Energy Emergencies Executive Committee (E3C), UK Regulators Network (UKRN), and National Cyber Security Centre (NCSC). Resilience should also be integrated across scales by explicitly requiring local energy plans to integrate resilience planning.

More systemically, resilience should be emphasised in current reform processes. For example, REMA should go further to analyse what a future energy system could look like through a detailed discussion of levels of individual risk (e.g., individualised VoLLs) and system-level social goods (e.g., having some emergency capacity in case we need it). This would then leads to an informed discussion about cost reflectivity and apportionment.

Recognising the diverse values of DE

Numerous studies have indicated the range of potential energy and non-energy system benefits of more distributed and locally coordinated energy systems (Shakoor, Davies & Strbac, 2017; Tyndall Centre, 2020; Jennings, Fecht & de Matteis, 2019; Aunedi & Green, 2020; Cornwall & UKRI, 2021). Whilst not all workshop participants agreed on how local and whole system benefits of local energy systems should be balanced there was consensus that better processes to understand, accounted for and value benefits across scales and systems should be developed. There currently needs to be more government oversight on the relative value of different distributed energy revenue streams and BEIS should develop an overview of how local market formation should develop. For example, system participants vary in their views on the most important parts of REMA. The government should seek to create a shared understanding of the relative impact of various reforms (local ancillary services markets, LMP etc). Clarity on the FSO's role in accounting for whole system costs would support the Government to take a system view of understanding local and whole system costs. This would enable better management of the FSO/DSO relationship and ensure visibility and information flows across scales.

There is clear local value in optimising network flows, but system value is only part of the story. Distributed energy can deliver import additional value outside of the energy sector, and the PfER projects have demonstrated that some people will pay extra for local energy if it can demonstrate that it also benefits the local area or community. Measuring and valuing co-benefits remains complex and an agreed methodology would help transparency and comparability.

Finally, many barriers to accessing value are often quite small or specific to the business model, but in aggregate these present fundamental barriers to many business models and are a symptom of a need for more structural changes (see **centralised mindset theme**).

Do the solutions enable the BMAs?

In Section 2, we presented an analysis of how the barriers affected the seven decentralised energy business model archetypes (BMAs). We identified that there are hard- and soft stops that affect all the BMAs. However, some barriers cause specific issues and hard stops for BMAs. An example is the supplier hub model which restricts models such as peer-to-peer energy.

We have undertaken a high-level analysis to test whether the prioritised solutions resolve the issues identified in Section 2. We summarise our analysis in Table 16.

Table 16: Summary of the extent to which barriers resolved for BMAs

Barrier theme	RAG status	Comments
Theme 1: Limitations in realising value from SLES	Partly resolved	The prioritised solutions appear potentially resolve several of the issues faced by BMAs. However, the outcomes of programmes such as REMA are unclear. For example, it is still to be determined whether local settlement will be enabled, which is currently a hard stop for BMAs 1, 3, 4 & 5. The specific action on reviewing the value of co-benefits addresses barrier T1.4, which was a hard stop for three BMAs. Clarification of the role and incentives of DSOs for RIIO-ED3 could address barrier T1.6 (connections and access rights).
Theme 2: Market rules and governance	Partly resolved	T2.1 and T2.2 (supplier hub & multiple suppliers) are key barriers to several BMAs. A reform to allow multiple suppliers could resolve T2.2, enabling BMA 3, 5 and 7. Similar to REMA above, the outcome of the reform of retail market arrangements is yet to be determined. Delivering mandatory half-hourly settlement as planned (2025) creates an opportunity for retail market innovation.
Theme 3: Limitation in innovation support processes	Partly resolved	Implementing the Energy Digitalisation Taskforce (EDiT) recommendations fully will remove some barriers to data access and sharing (T3.3). The creation of Energy Innovation Zones could resolve the issues with regulatory sandboxes (T3.1) by enabling place-based innovation.
Theme 4: Lack of attention to demand side measures	Partly resolved	We have assessed this as partly resolved as solutions include baselining demand-side response and energy efficiency data and a focus on demand-side reform in energy markets. Together these could go a long way to resolving both T4.1 and T4.2. There remains a gap in energy efficiency and retrofit measures and viable business models.
Theme 5: Lack of coordination within and across scales	Partly resolved	Several solutions seek to address the challenges in barrier theme 5. A key solution is the development of an overarching vision and strategy for energy decarbonisation that is clear on the role and importance of decentralised energy, which addresses T5.1. Local energy planning is prioritised which partly addresses T5.2.1. Several solutions are orientated towards the role and incentives on DSOs, addressing barrier T5.2.2. There are specific solutions that seek to enable to heat networks (including regulation, waste heat, and Energy Innovation Zones) addressing T5.2.3.

Discussion

The prioritised solutions do appear to tackle several of the hard stops, but some friction (soft stops) will remain. Given that energy is an essential service regulatory friction is to be expected. The issue to date has been that there is more friction for decentralised energy business models, compared to national energy business models, such as energy suppliers.

The extent to which solutions solve issues is dependent on the mindset and direction of the decision. For example, REMA appears to be adopting a centralised mindset, with less emphasis on local energy markets and local settlement.

In part, this is why participants in the workshops focused on a range of reviews to provide an evidence base on decentralised energy approaches. This evidence also includes exploring the roles and responsibilities of institutions, such as Ofgem, DSOs and the FSO. Ultimately, this approach is about ensuring that there is evidence in place to allow DE approaches to be 'chosen'.

Many of the enablers, such as open data and half-hourly settlement, will be good for all business models, not just those relating to decentralised energy.

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