EnergyREV

Building and unlocking flexibility with smart local energy systems (SLES)

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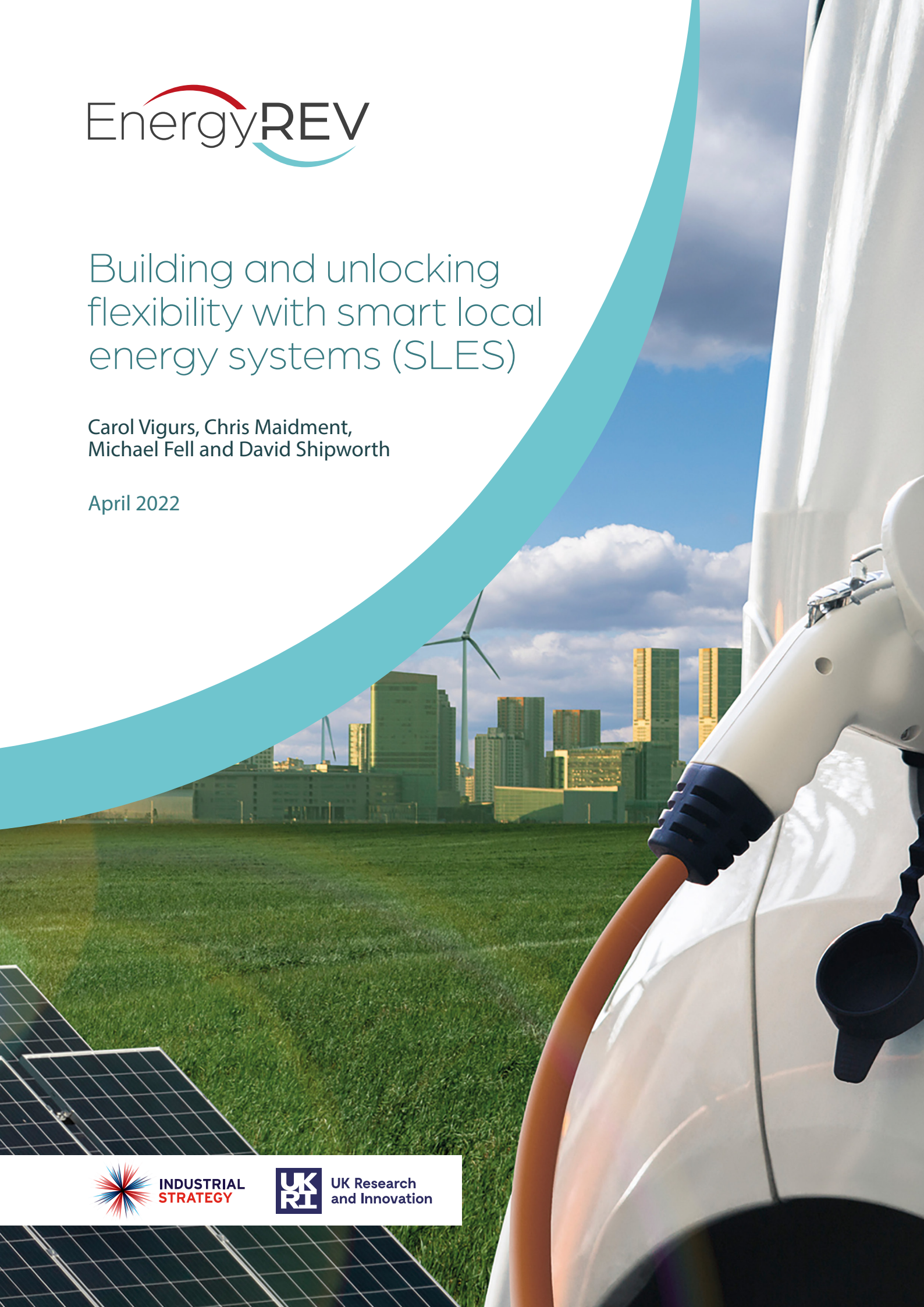

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UK Research and Innovation

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Executive summary

Maximising the economic and environmental benefits of smart local energy systems (SLES) will require changes to our usual patterns of interaction with energy systems. This can be described as flexibility. As we transition to a low carbon energy system, the addition of renewables means less ability to increase and decrease supply centrally to match demand but more opportunity to meet local demands with distributed resources. By coordinating local generation and storage assets either manually or through automated processes, SLES have the potential to balance local supply and demand more efficiently and with fewer carbon emissions, without exceeding the capacity of the network.

In the context of electricity, flexibility means changes from usual patterns of interaction with electricity systems. For example, this might mean using more electricity at a time when renewable generators like photovoltaic panels are putting out lots of power. This systematic review identifies a number of actions that various stakeholders involved in SLES could undertake to increase flexibility in the energy system and make best use of the flexibility that is available. To do this, we first identified the barriers to unlocking and building flexibility capacity in a UK context, focusing primarily on "whole system" socio-technical challenges. These barriers were found to apply at different levels across the system – socio-political, institutional, community, household and individual domains – and were classified into 9 themes:

- The policy making ecosystem
- Knowledge and learning ecosystem
- A system not designed to incorporate flexibility
- Transitional complexity arising from incorporating more energy from renewables (and so creating a need for greater flexibility)
- Realising value from flexibility
- Barriers to new entrants (investors, community interest groups and flexibility service providers)
- Market signal communication
- Managing risk to the consumer
- Values to the consumer and participation

We then searched for evidence of solutions to these UK barriers, supplementing our understanding from the research literature with the views and experiences of experts in the field. The main report describes both the barriers and how they might be addressed in more detail, showing how the recommendations were developed from the evidence. The report also discusses how these barriers and solutions are interconnected; how actions taken by actors in one domain can help to overcome barriers in another domain, suggesting that a multi-sectoral, multi-domain approach is needed to fulfil the potential of SLES to provide and utilise flexibility.

The recommendations for building and unlocking flexibility in the energy system through SLES are summarised over the following pages. To make it easy to refer to the specific recommendations that apply to you, they are arranged by stakeholder. First are those involved in creating the environment necessary for SLES: policy makers, regulators, researchers and funders. Next are those involved in both the groundwork and delivery for SLES: local authorities and Distribution Network Operators (DNOs). Finally we look at the practitioners: providers of SLES, technologies, energy and flexibility services; community groups and data collection agencies. We have also included links to the relevant sections of the main report where the evidence is discussed to help provide more detail and context of when, where, how and why these recommendations apply.

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Summary of recommendations

For further detail and context, please see the relevant sections of the main report by clicking on the arrows below the sets of recommendations.

Recommendations for policy makers/national government

Policy makers should:

- Consider improving investor confidence by developing long term future planning for transition from centralized to decentralized energy to meet the commitments to net zero.
- Create or adapt existing institutions to take a centrally coordinating role in creating guidelines for common standards for electric vehicles (EV) and electric vehicles infrastructure. These should be based on the best available evidence and include input from a diverse range of stakeholders from industry local government and consumers. They should be made available to:
    * Local authorities to guide planning for EV infrastructure
    * Investors in EVs and EV infrastructure
    * Developers of EVs and EV infrastructure
    * Community interest groups

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- Support local authorities with resources to inform their EV uptake forecasting and charging infrastructure planning.
- Support local authorities to deliver incentives to investment in flexibility to ensure they are adapted to local characteristics and needs.
- Minimise investment risk by announcing and consulting on flexibility-related policies and policy adjustments well in advance.
- Consider how less-tested flexibility approaches (e.g. with a high technology- or service-specificity or newer business models) can be incentivised with higher returns.

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Recommendations for regulators

Regulators should:

- Reduce thresholds for participation in capacity and balancing services where possible, to encourage wider and more diverse entrants.
- Provide more active support to potential new participants, including SLES providers, on how to participate in the variety of flexibility services offered.
- Encourage DNOs to engage more with local authorities on EV uptake and infrastructure planning.
- Continue to support collaboration between DNOS, and with the National Grid, working with the Energy Networks Association.
- Continue to work to improve clarity around the regulatory status of local electricity/flexibility trading.
- Ensure that platforms/markets for flexibility are operated by sufficiently neutral parties, or are subject to sufficient regulation to ensure impartiality, especially where the operator may also be operating assets in the market.

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- Amend regulation to encourage innovative markets that reward economic, sustainability and reliability benefits, recognising that customers may also respond to non-financial signals.
- Retain transparency and consistency in regulation to encourage trust and buy-in. As part of this, clearly allocate roles and commitments to all actors and participants to ensure fairness and ongoing support.
- Differentiate price signals to sufficiently incentivise providing flexibility to the network, whether through short term load shifting or long-term investment in storage.

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With regard to consumer protection, regulators should:

- Include a regulatory structure that should evolve in line with recent technologies, systems, markets, and services, balancing the freedom to develop innovative approaches that benefit their participants against the need for them to operate in an effective and fair wider system that protects all consumers.
- Consider the specific regulation change needed to allow customers to take advantage of novel approaches, e.g., amending licensing for local and peer-to-peer energy supply to simplify and speed up the process for switching suppliers.
- Consider how to provide clarity on where responsibilities for consumer protection lie, detailing which stakeholders in emerging markets and services are accountable for which specific provisions.

The changes in regulation needed are discussed in more detail in sections 2 and 4.

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Recommendations for researchers and commissioners of research

Research on policy tools or instruments that support the promotion of flexibility in energy systems should consider the political feasibility and social impacts as well as the technical feasibility of the policy. It should:

- Include diverse stakeholders in setting the research scope and in the co-production of research.
- Proactively seek to include a diverse range of participants beyond the self-selecting already interested, and the most likely early adopters in order to capture the perspectives of groups often underrepresented in research and groups that might be more "on the fence".

Research on consumer acceptability and patterns of use over time should emulate real world market conditions as much as possible. It could:

- Create emulations of price comparisons websites to understand customer decision making priorities, and values. Price comparison websites should include an easy way to calculate prices and costs under different conditions and circumstances, such as those including and excluding EVs and various times of day.

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Recommendations for local authorities

Local authorities should take the lead on introducing investment into flexibility services. They should:

- Reduce electricity costs by reducing power consumption at peak times and avoiding peak network charges. Councils opting for a variable price contract can save by reducing their power consumption at peak times.
- Generate energy within the council's portfolio to create income to offset the council's overall energy spend using batteries to store generated electricity to be used when demand is high.

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- Promote commercial opportunities to supply energy generated at off-peak times to the grid during peak times; weekdays from 4.00pm-7.00pm.
- Participate in the electricity capacity market. Councils should investigate what support their energy supply company or Public Buying Organisation (PBO) can offer as part of their service.
- Consider taking part in variable price contract services directly or through a 'demand side provider', such as an electricity supplier, an aggregator or third-party intermediary who can help councils and others to participate in Demand Side Response (DSR).

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They should also:

- Consult with DNOs to consider making flexibility capabilities a condition in both commercial planning in local area energy plans, and tender processes, for example for EV charging infrastructure.
- Work closely with DNOs to identify priority areas for installation of EV charging infrastructure.
- Audit and seek ways to maximise the flexibility offered by their own assets and estates, where this yields a positive cost/benefit ratio.

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Recommendations for DNOs

DNOs should:

- Increase investment in monitoring the low-voltage network to improve time/space optimal network investment and flexibility planning, and to support other actors in planning their flexibility provision.
- Continue to explore ways to support non-traditional actors (such as community groups) to participate in flexibility programmes and markets, such as through simplifying processes and providing advice, training and resources.
- Consider user-centred design processes with frequent proof-of-concept testing.
- Support the development and testing of electricity/flexibility markets and exchanges to allow a broader range of actors to benefit from providing flexibility, thereby promoting investment in capacity.

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Recommendations for SLES providers

SLES providers and community energy groups could:

- Ensure that there is a diverse range of customers providing flexibility, supported by the local authority and avoid relying on single users wherever possible unless realistic contractual arrangements can be put in place.
- Ensure there are back-up connections to other energy systems. Local energy/flexibility markets should ensure sufficient liquidity through, for example, merging with other local energy markets.

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SLES providers, including providers of energy and flexibility services and relevant technologies, should:

- Consider partnering with a single aggregator/ service provider who is responsible for maximising engagement with flexibility, including through collaboration with other organisations (although note point on regulation to ensure impartiality) .
- Consider how to coordinate with other local electricity/flexibility markets to ensure sufficient liquidity.

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- Consider equity of access for vulnerable groups and individuals and address them by offering:
  * Clear and transparent information on price comparison websites to ensure users understand different price profiles under different circumstances
  * Trials of time-of-use (TOU) tariffs with the option of easily switching back if the customer wishes to
  * Trade-in incentives or "free upgrades" to address rapidly developing technologies and the fear of being left behind with defunct technology after investment
  * Energy micropayment options such as pay-as-you-go solutions or payment platforms for prepaid meters.
- Consider factors that might risk either their customer's privacy or their willingness to participate, including:
  * Fatigue when being asked to share data and consider the privacy implications
  * Consent within households, ensuring that all members retain privacy and data is not used for coercive control
  * Potential beneficial and adverse impacts from sharing data within communities rather than with energy providers.
- Ensure that technologies and processes can be easily understood, trusted and used by:
  * Providing clear feedback via in-home displays to support residents realise their energy goals
  * Using simple, intuitive processes and, where possible, allowing potential users to trial them to build their confidence in using them and incorporate into daily practice.

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- Use smart contracts and technologies, automation in particular, to offer innovative payment options that give consumers more choice and control and encourage consumption patterns that provide flexibility to the network.
- Consider using distributed ledgers to:
  * Enable new flexibility markets and platforms that provide additional accessibility, security, interoperability, and value for customers/ participants. This might include, for example, improving the competitiveness and convenience of EV charging by using blockchain "to discover a near charging station that would bid for the chance of the EVs charging"
  * Improve the interoperability of not just technologies, but also the data they collect or generate, helping ensure that it is accessible to different actors within the system (in the spirit of 'presumed open' that the Energy Data Taskforce recommends).
- Ensure that technologies and processes can be easily understood, trusted and used by:
  * Providing clear feedback via in-home displays to support residents realise their energy goals
  * Using simple, intuitive processes and, where possible, allowing potential users to trial them to build their confidence in using them and incorporate into daily practice.

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- Electricity providers and designers of energy use interfaces should provide reliable and real time feedback on energy use that is useful for the customer to respond to. They could:
    * Use localised displays (e.g., for individual appliances)
    * Make comparisons to similar appliances, or families, or households, to help visualise impacts, rather than just kWh
    * Customise tips based on the user's consumption profile and/or those of similar households
    * Offer the option to customise colours of the data visualisations
    * Offer anthropomorphized elements, such as spoken messages and/or a human-like face.

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Recommendations for SLES providers and data collection agencies

Those involved in SLES data collection should protect SLES users and participants. They should:

- Explore opportunities provided by emerging technologies to make data secure
- Make interfaces easy to understand and use, with clear information on privacy and consent
- Ensure that all parties (e.g. all household members, not just the bill payer) have given consent for data collection and have control over their own environment
- Apply service design principles that aim to make technology products resistant to coercive control
- Consider providing guidance on good practice and fair use with unfamiliar technologies

SLES providers and data collection agencies should look to build trust through communication. For instance, a social media presence and newsletters could help providers:

- Share guidance in the form of customer experience, tips, video demonstration of technologies
- Respond to customer queries and concerns through online questions and answers

SLES providers should also build trust through transparency and fair offers. They could:

- Promote and demonstrate the accuracy of data collection methods such as smart meters, and of billing that would prevent over charging and overestimated bills.
- Offer clear, transparent and predictable unit prices, for example using price comparison websites.

More detailed recommendations on data collection and security are provided in the main report, along with discussion of the evidence and barriers that informed them. Please click the arrow to go to the relevant section.

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Introduction

Distributed energy resources (DERs) are a key part of smart local energy systems (SLES). They include technologies like small renewable generators, storage devices like batteries, and large aggregated electricity loads (virtual power plants for example), that operate at local level. These DERs underpin many of the benefits offered by SLES, such as decarbonisation, economic gains through local ownership, air pollution reduction, and so on. To maximise these benefits, SLES need to ensure they get the most value possible out of their DERs, while minimising negative impacts such as overloading local electricity distribution networks. For many SLES, a central plank of achieving this will be effective use of flexibility.

In the context of electricity, flexibility means changes from usual patterns of interaction with electricity systems (see next section for more). For example, this might mean using more electricity at a time when renewable generators like photovoltaic panels are putting out lots of power. Flexibility can come because of manual or automated action, display a wide variety of characteristics in duration, magnitude, rapidity and reliability, and be sought for a range of different reasons. Whatever the circumstances, if SLES are to perform optimally, the more flexibility they can secure the better.

This report looks at measures a range of SLES stakeholders can take to help maximise the amount of flexibility that SLES can offer. Based on a review of existing evidence, alongside interviews with experts working directly in this area, it shows that action is needed by multiple actors to create the conditions where flexibility is both available in principle and can be unlocked when needed.

The next section sets out some more detailed background about why flexibility is of value in SLES, current ways in which it is incentivised in the UK, and how we approached this review. A short summary of our review and interview approach follows. The main part of the report focuses on our key findings and includes recommendations for stakeholders including national and local government, the regulator, DNOs, and SLES providers.

Flexibility: what and why?

In this report we define flexibility as "responsive change in patterns of interaction with a system to support the operation of that system" (based on Powells/Fell). In the context of electricity systems, this means changes in things like when, where, and how much electricity is used or supplied in response to some kind of signal. There are a few reasons why this is needed. These include:

- Ensuring that supply and demand for electricity are in balance at all times in order to maintain stable operation of the system
- Ensuring that the physical capacity of the system is not exceeded by, for example, sending too much power along cables or through substations
- Optimising factors such as cost or carbon emissions of generation.

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In electricity systems with largely centralised fossil fuel-based generation, most of the flexibility comes from changing the output of generators. As systems decarbonise and decentralise -- as in the case of SLES -- this becomes less achievable, because renewable generation cannot be turned up at will. The challenge of managing physical network constraints also becomes more substantial, as the combination of more supply and demand connected to the distribution network such as photovoltaic panels or EV chargers puts increased pressure on existing infrastructure.

These technical considerations have concrete, practical implications for SLES. For example, in many areas of the country, including parts of the South-West and the Home Counties new generation cannot be connected to the distribution grid without the developer contributing to costly infrastructure upgrades. The result of this is either that new low-carbon generation is not installed – making it harder to meeting net-zero emission targets – or the cost of doing so is inflated, impacting on developer profits and user costs.

The same kinds of limitations apply for primarily demand-side technologies such as EVs. Their penetration is still relatively low, but in areas with higher uptake networks are already approaching capacity and this may soon pose a barrier to new EV acquisitions (OFGEM 2021). The same applies to the potential for electrification of heat, for example through electric heat pumps. Local network constraints that limit new supply and demand technologies pose a significant barrier to their widespread adoption as part of the UK's low carbon transition plans.

Purely supply-side flexibility in a SLES is possible, for example through cutting the output of PV panels. But most of the potential is for either purely demand-side flexibility, or for storage to help provide flexibility in both supply and demand. Demand-side flexibility of individual devices can be thought of as the function of two related things: the characteristics of loads/stores and the nature of their responsiveness to signals:

- Characteristics of loads/stores -- this includes aspects such as:
    * The maximum amount of power it can draw (e.g., a heat pump can use more than a television)
    * How close to this maximum it tends to be in a given period (e.g., a heat pump may operate at close to its maximum demand for most of a cold day, while a television may only be on for a few hours)
    * How interruptible it is (e.g., can it reliably be turned off for a period at any time, like a heat pump on a mild day, or rarely/never, like a piece of medical equipment)
    * How quickly, for how long, and how reliably it can react if exposed to signals.
- Nature of responsiveness to signals – this includes aspects such as:
    * Whether the load/store is exposed to signals (e.g., whether it is part of a flexibility programme of some kind)
    * If it is, whether the signals are more or less direct (e.g., direct control of the technology remotely by a third party, or price signals translated into manual changes by a user)
    * How the load reacts in response to signals (e.g., dependent on algorithms, user decisions, etc.).

Both sides of this equation are important if flexibility is to be delivered. A large home battery cannot provide flexibility from the system if it is not in receipt of signals about the state of the system. Conversely, a smaller load like a dishwasher, even if controlled directly by a system operator, is just too insignificant in size to make a real contribution to flexibility.
For this reason, in this report, we focus on two key dimensions of the SLES flexibility challenge:

- **Building** flexibility capacity – how to ensure the right amount of load/storage with the right characteristics is available to meet the flexibility requirements of the SLES. This means things like driving uptake of EVs, heat pumps, and home batteries.

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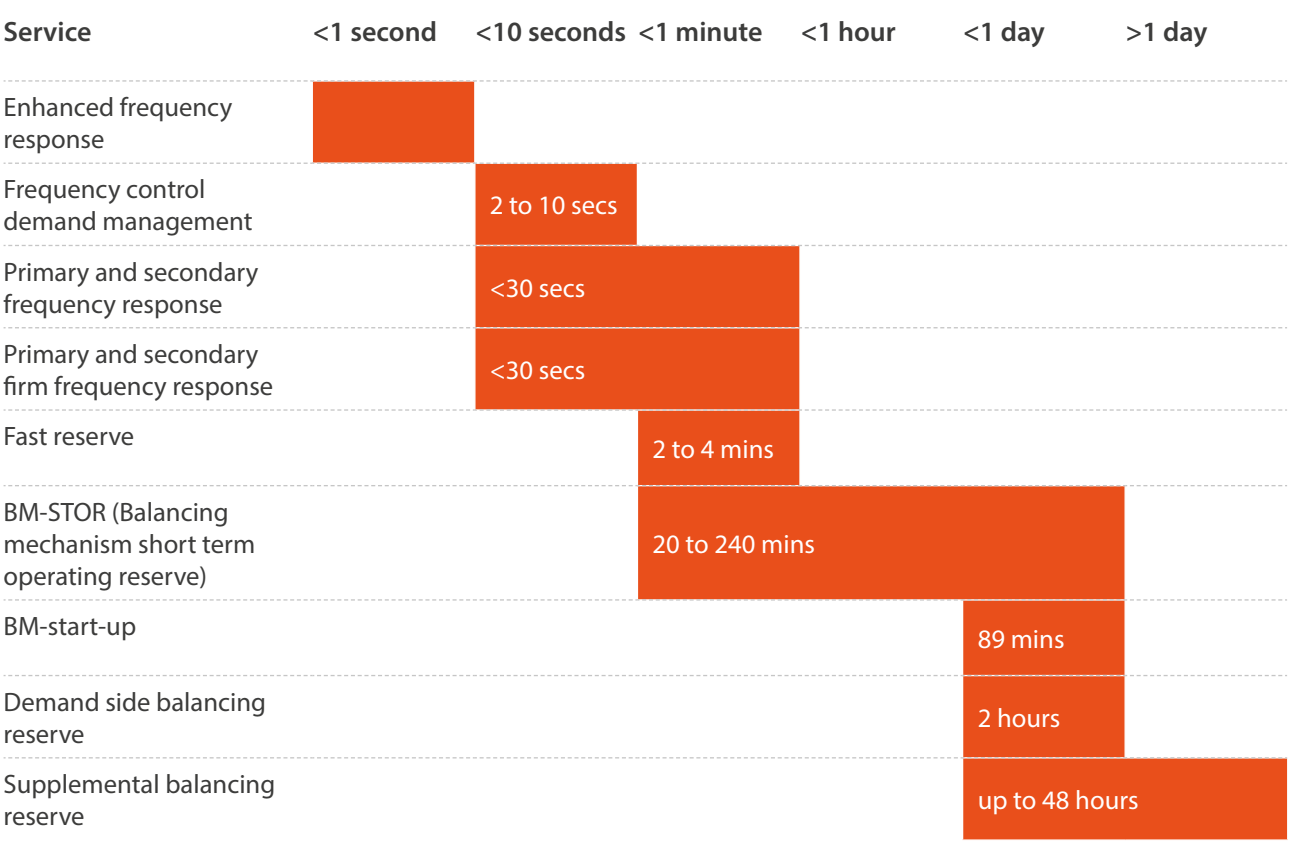
- **Unlocking** flexibility capacity – how to ensure that this load/storage is exposed to, and can respond in appropriate ways to, flexibility-related signals. This means things like enrolling households and organisations in flexibility programmes and ensuring they have the right enabling technology in place to respond to flexibility signals.

A key factor in the extent to which flexibility is built and unlocked is the way in which, and to which ends, it is encouraged. There are already a range of instruments in place to incentivise provision of flexibility in Great Britain. These include the Capacity Market to support system capacity, and a range of balancing services including the Balancing Mechanism, fast reserve, firm frequency response and others. These differ in their functions and the speed/duration of response required (see Table 1 for illustration).

DNOs also procure a range of flexibility services (Anaya & Politt 2021). However, as suggested above and explored further in the remainder of the report, SLES introduce new challenges, non-traditional actors, and opportunities that mean these existing instruments can be inaccessible, hard to access, or just irrelevant for the kinds of flexibility that SLES need to achieve.

Figure 1: Showing a range of grid (ancillary) services with an indication of how quickly a response is required in each case (based on Energy UK Ancillary Services Report 2017).



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Previous work within EnergyREV has already explored a range of ways that SLES could be well-positioned to build and unlock flexibility capacity in ways that go beyond those available to less locally-focused arrangements. They can:

- Integrate local energy/flexibility markets or exchanges, creating greater incentives both to invest in, and deploy, flexibility capacity where is it most needed (Morstyn et al. 2019, Morris et al. 2020)
- Assist local/community organisations to coordinate installation of shared flexible assets such as neighbourhood batteries and encourage participation in the development and operation of flexibility programmes (Devine-Wright, 2019).
- Encourage locally accountable actors such as local authorities and housing associations to invest in flexibility capacity themselves and to ensure that flexibility considerations feature in local area planning processes (González et al. 2020).

To build on this and inform this report, we conducted a review of evidence emerging from EnergyREV, the broader Prospering from the Energy Revolution programme and existing systematic evidence reviews on flexibility. We complemented these with semi-structured interviews and a workshop with ten expert stakeholders whose work relates to flexibility in the context of SLES. These included representatives from industry, community energy, consumer organisations, and academia.

We aim to provide evidence-based recommendations to a range of SLES stakeholders on how they can maximise the flexibility in SLES in ways that are fair and desirable to participants. These recommendations will be relevant to:

- Policymakers
- DNOs
- Local authorities
- SLES providers: those who invest in or implement SLES and relevant services, including private companies and community interest groups

In our review we focused primarily on "whole system" socio-technical challenges. That is, where people and technology interact, and how this is influenced by multiple actors and at multiple scales.

Full details of the method are available in the technical appendix document.

UK barriers and evidence of solutions from systematic reviews

We identified UK barriers to flexibility in 45 studies. Ten themes emerged which we classified as:

- The policy making ecosystem
- Knowledge and learning ecosystem
- A system not designed to incorporate flexibility
- Transitional complexity arising from incorporating more energy from renewables, energy (and so creating a need for greater flexibility)
- Realising value from flexibility
- Barriers to new entrants (investors, community interest groups and flexibility service providers)
- Managing risk to the consumer
- Attitudes and beliefs
- Participation and behaviours

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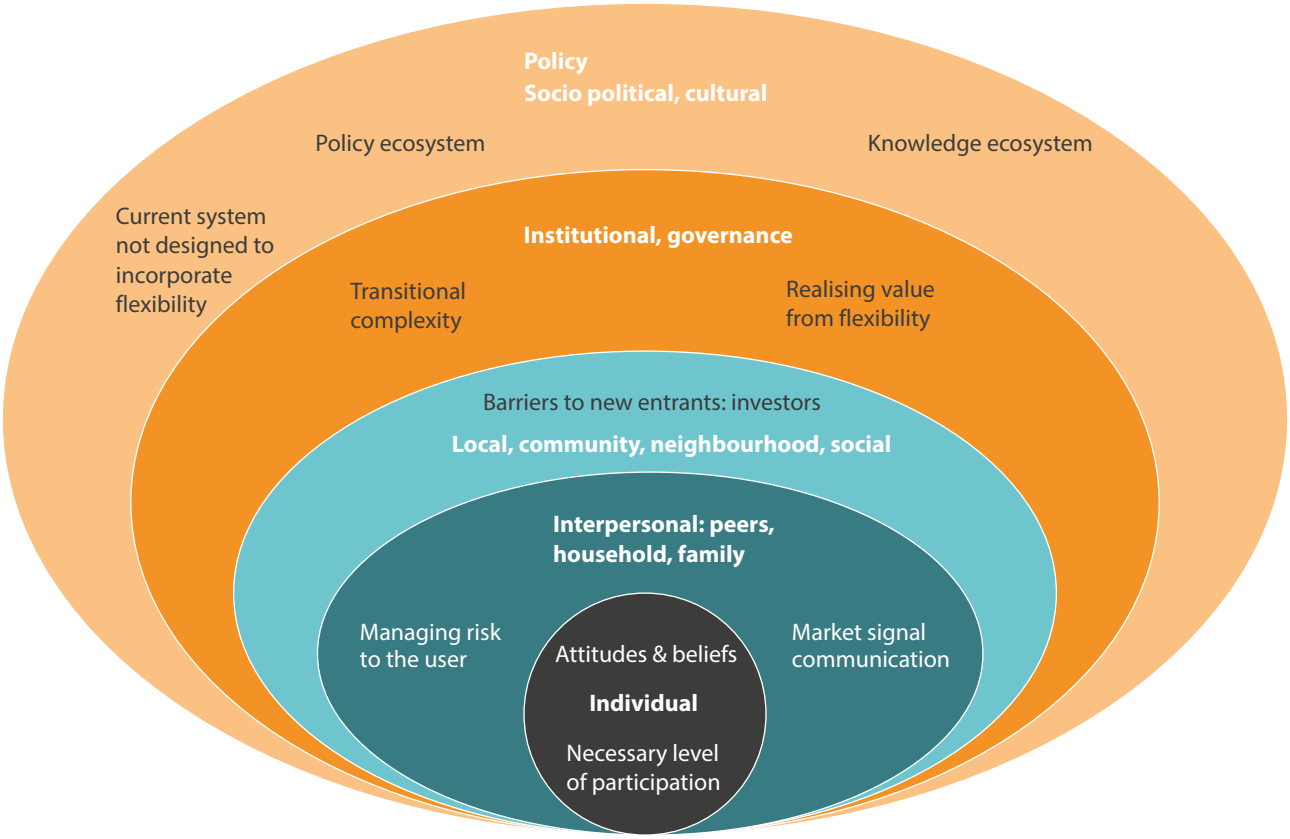
Figure 2 shows these mapped onto a "socio-ecological framework", developed from a model of an understanding of human development (Bronfenbrenner 1977). The framework offers a way of visualising whole systems, and systems within systems, and the domains of activity where flexibility can be situated. It also shows where there may be barriers and blockages to flexibility at which interventions could be targeted. The socioecological framework of flexibility shows the micro domains of individual attitudes and beliefs at the centre and moves outwards to increasingly macro domains such as the policy-making ecosystem of a country.

Barriers and solutions interact with each other; solutions in one domain are likely to unlock and build flexibility in other domains. We consider these interconnections between the barriers and solutions in section 6.

We then searched iteratively for systematic review evidence that directly spoke to these barriers and found 23 systematic reviews.

Figure 2: Socio-ecological model of flexibility.



1. Flexibility in the policy, socio-political, cultural domain

The policy, socio political cultural domain is furthest away from the individual. It is influential, but more difficult for the individual to influence directly. This outer domain can be thought of as creating the conditions for flexibility or the "rules of the game" for other flexibility domains.

Policy making ecosystem

While much of the success of SLES in building and unlocking flexibility will be determined at the local level, national policy that reflects the socio-political and cultural context in which it is made is important in determining the conditions under which this can be achieved. The potential role for flexibility cuts across much of UK energy policy. Specific areas of policy are discussed in many of the following sections. This section focuses on the barriers and solutions in the policy making ecosystem. This was a theme with one of the most connections, second only to the theme "Realising value". In this domain, the policy making ecosystem is occupied by many different actors and stakeholders including those that seek to influence policy such as ministers and civil servants. All interact within the political contexts, problems and recent events that come together to create the policy making "windows of opportunity" for action (Kingdon 1984). Policies that create the conditions for socio-technological change can focus on the supply side or technology-push of technology or services, or on the demand side or demand-pull. Technology-push policies can incentivise socio-technological innovation through publicly funded research and development (see knowledge and learning ecosystems below), reducing the costs of entry and/ or operation.

The demand-pull policies are those policies that aim to support the end user to take up these new technologies and to create and support the development of markets. Policy instruments on this side are related to subsidies, or grants to encourage new purchases, information campaigns and consumer protections and regulations (Nuñez-Jimenez 2019).

Barriers

Several barriers to flexibility that originate in the policy making ecosystem theme were identified from the UK research literature. These studies said that central government and local governments have a leading role in setting common standards to ensure interoperability and growth in the uptake of EVs, and the coordination of charging infrastructure and charge points. Without such coordination there was a risk that the simultaneous development of technologies could duplicate service developments and activities, and lead to declining interoperability.

However, there was a perceived lack of clear, long-term direction-setting that would result in an infrastructure policy framework that recognised the interdependencies between sectors. There remains a need for a long-term plan for the electrification of heat and for EVs as part of a wider commitment to, and vision for, a net zero transition. These issues around creating the conditions for investment and interoperability are raised as actions in recent government policy strategies, such as in the Heat and Buildings Strategy (2021) and the Transitioning to a net zero energy system: smart systems and flexibility plan 2021 (see also evidence for Barriers to new entrants: Investors).

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However, the Munro and Cairney review of energy policy also finds a complex policy system where there are many actors in the public and private sector interacting with each other in different parts of a system which are not subject to direct central government control (Munro & Cairney 2019). Policies then should be able set common standards and expectations without stifling innovation and competition, as it is impossible to know which, in the long run, will prove to be "the best".

Solutions

One solution that emerged to the problem of multiple actors in emerging markets from systematic review evidence was the development of national guidelines and sharing of knowledge of best practice to improve consistency in standards and conventions. This would also balance the impacts of technological-push and demand-side pull policies.

Knowledge and learning ecosystem

The knowledge and learning ecosystem theme concerns the production and distribution of knowledge and learning about flexibility. This knowledge production and distribution spans the private and public sector; it can involve universities, multidisciplinary research centres, community organizations and governments. Types of knowledge creation can range from formal experimental research to action-oriented and experiential learning. It interacts with the policy making ecosystem in that policies can support socio-technical change or technological-push policies by reducing the private cost of research and development (Nemet, 2009) through directly funding research and development, through competitive grants, research centres and funding pilot projects.

Barriers

The UK barriers to flexibility literature identified a gap in knowledge about consumer behaviours under real world conditions and behaviours and preferences over time. Typically, studies were not able to emulate real world conditions on how people make such decisions in a fully operational UK energy market and make choices, such as comparing tariffs from price comparison websites, under different conditions. The impact of this bias may underestimate or overestimate the overall demand for such tariffs (Carmichael 2021). This makes it difficult to know whether the interest shown in trials will translate or scale-up to enough demand to realise effectiveness and value for flexibility services (see also realising value). Ambiguity around the commercial sensitivity and the intellectual property rights of energy data represents a barrier for access to data and information for flexibility service providers and developers (ERIS 2020). Datasets and evidence from trials could be behind paywalls, distributed in many different places and difficult to find. The quality of reporting from such trials was found to be variable, making it difficult to be certain about the cause and effect of interventions and therefore limiting how useful these trials are for informing decision making or service design.

Barriers were identified in the ways that researchers communicated their findings to policy makers on energy policy that supported low carbon targets, and in addressing the increased demand for flexibility services and flexibility markets. One review of energy policies and research communication found differences in the ways that researchers and policy makers conceived of "whole systems thinking" and there was a lack of consideration in the research community of the complexity of policy making, and the diversity of actors involved in making and influencing policy (Munro & Cairney 2019).

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Solutions

Direct evidence of solutions to the barriers of knowledge supply and demand was scarce. The same review on energy policy (Munro & Cairney 2019) suggested that research that considered the "policy mix" necessary for energy transitions and increasing the demand for flexibility should consider the political, social and technical feasibility of policy recommendations. The co-production of research with a diverse range of stakeholders including consumers, engineering, and policy will be more likely anticipate the intended effects and social consequences of interventions.

Current system not designed to incorporate flexibility

There is currently no drive to incorporate flexibility in the UK energy system, according to interviewees and the literature. This is because aggregate demand in GB is falling, so capacity constraints and limits are not an issue, (OFGEM 2017c). Until there is a significant and sustained increase in demand, for instance through widespread EV ownership, then this will not change. If there are the substantial increases in distributed generation envisaged to reach net zero policy targets (von Wirth, Gislason & Seidl 2018), then significant network changes will be required to the current electricity system, designed as it is for centralized generation. The delayed roll out of smart meters and some technical difficulties with those that were adopted, which could have enabled more accurate billing and variable tariffs, further delayed this drive towards flexibility in energy systems.

1.1. Recommendations for policy makers

1.1.1. Policy makers should create or adapt existing institutions to take a centrally coordinating role in creating guidelines for common standards for EVs and EV infrastructure. These should be based on the best available evidence (see also recommendations for researchers below) and include input from a diverse range of stakeholders from industry local government and consumers.

They should be made available to:

- Local authorities to guide planning for EV infrastructure
- Investors in EVs and EV infrastructure
- Developers of EVs and EV infrastructure
- Community interest groups

1.1.2. Policy makers can consider improving investor confidence by developing long term future planning for transition from centralized to decentralized energy to meet the commitments to net zero. Incentives to investment (see recommendations for investors) can be delivered through local authorities adapted to local characteristics and needs.

1.2. Recommendations for researchers and commissioners of research

1.2.1. Research on policy tools or instruments that support the promotion of flexibility in energy systems should consider political feasibility and social impacts, as well as the technical feasibility of the policy. They should:

- Include diverse stakeholders in setting research scope and in the co-production of research
- Proactively seek to include a diverse range of participants beyond the self-selecting already interested, and the most likely early adopters. This should help capture the perspectives of groups often underrepresented in research and groups that might be more "on the fence".

1.2.2. Research on consumer acceptability and patterns of use over time should emulate real world market conditions as much as possible.

- This could be done by creating emulations of price comparison websites to understand customer decision-making priorities, and values. Price comparison websites should include an easy way to calculate prices and costs under different conditions and circumstances, such as those including and excluding EVs and various times of day.

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2. Flexibility in the institutional and governance domain

The institutional and governance flexibility domain consists of the various kinds of local government, and other public bodies and business communities within a national or regional boundary. It also takes in and their structures, devolved powers and regulations and other arrangements for the implementation of flexibility policies and in responding to the conditions for flexibility set at the outer layer.

Barriers

Transitional complexity

Barriers to flexibility in the institutional and governance domain included regulatory complexity for new entrants; the "rules of the game" and costs were too onerous for all but the main incumbents. What was needed in response was a regulatory framework that "could adapt so that new products and services can emerge" (Hall 2020). Current models of supplier-hub, that is of customers contracting with one supplier at a time places limits on local new entrants, limiting a diversity and plurality of market actors, their capacity to realise value and to protect customers from single supplier failures. The lack of data standardisation that could integrate SLES projects with energy networks and enable flexibility through demand-side response creates further costs of operation for new entrants (see also policy ecosystem).

Realising the value of flexibility

Realising the value of flexibility was a common theme in the institutional, business and governance domain, with many connections to other barriers both into, and emanating from, realising value. We connected many of the barriers to realising value to "upstream" barriers, such as barriers in the policy making ecosystems and barriers in the knowledge and learning ecosystem. The barriers to realising value of flexibility were a consequence of, and cause of, barriers to investors as new entrants to a flexibility market. Some of these barriers to realising value emerged from the need for a minimum level of participation before flexibility was effective and had value.

Once the investment has been made in flexibility assets, there may not be enough people signing up to participate in energy markets or to have fully operational markets with a choice of tariffs and services to participate in. There was a risk in overdependence on single providers of flexibility if those providers ceased trading. This may be because:

- Smaller systems become unsustainable in the longer term
- The system, or elements of the system, stop being commercially viable
- Demand or supply provided by lost users means that other supply/demand/service commitments cannot be met (Ball 2020).

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Solutions

The complexity and diversity of demands in providing flexibility services for residential buildings meant that commercial premises could be an important alternative or addition to the residential customer sector. The local authority estate could potentially be a major customer and catalyst for flexibility demand through planning and procurement mechanisms.

A local government association review of local authority energy investment opportunities using current procurement frameworks (LGA 2019) suggested that local authorities are well placed to lead on the implementation with electrification of heat in homes and businesses, commercial partnerships for EV infrastructure and renewable energy generation and storage.

2.1. Recommendations for local authorities

2.1.1. Local authorities should take the lead on introducing investment into flexibility services. They could:

- Reduce electricity costs by reducing power consumption at peak times and avoiding peak network charges. Councils opting for a variable price contract can save by reducing their power consumption at peak times.
- Generate energy within the council's portfolio to create income to offset the council's overall energy spend using batteries to store generated electricity to be used when demand is high.
- Promote commercial opportunities to supply energy generated at off-peak times to the grid during peak times; weekdays from 4.00pm-7.00pm.
- Participate in the electricity capacity market. Councils should investigate what support their energy supply company or PBO can offer as part of their service.
- Take part in variable price contract services directly or through a 'demand side provider' such as an electricity supplier, an aggregator or third-party intermediary, who can help councils and others to participate in DSR.

2.1.2. SLES providers and community energy groups should ensure that there is a diverse range of customers to provide flexibility. They should be supported by the local authority and avoid relying on single users wherever possible unless realistic contractual arrangements can be put in place

2.1.3. SLES providers and community energy groups should ensure there are back-up connections to other energy systems. Local energy/flexibility markets should ensure sufficient liquidity through, for example, merging with other local energy markets.

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3. Flexibility in the local, community, neighbourhood, and social domain

This is the domain where the SLES is physically located: the local, community, neighbourhood and social domain where the local is more visible to the individual and where they may have more influence and be influenced by than at the outer domains.

New entrants and investment

Building and unlocking flexibility capacity requires substantial investment. This may be in the underlying technologies that provide capacity, such as batteries or heat pumps; in the technologies that enable flexibility, such as control and monitoring devices; and more broadly in the development of products and services that help unlock and extract value from flexibility such as aggregation, tariff, and platform development. A proportion of this investment is expected to come from private households, and this is considered in section 5 (attitudes and beliefs in the individual domain). This section considers barriers to investment and involvement in flexibility by businesses and organisations.

Barriers

A core consideration for investors is the value that can be realised from building and unlocking flexibility which underpins return on investment. The harder it is to stack up the value unlocked by providing flexibility for various functions such as capacity, constraint alleviation, and balancing, the poorer the economic case for investment (Morris & Hardy 2019). This especially applies to technologies such as batteries, because providing these kinds of grid services is one of their primary functions (unlike EVs for example, whose primary function is to provide mobility). Maximising ease of access to a range of flexibility incentives and markets, including local ones, is key to unlocking investment.

There was recognition both in the research we reviewed and from our interviewees that opportunities to build and unlock flexibility would be improved with the entry of new service providers and other actors. These might range from technology manufacturers and start-ups to community energy groups and local authorities – all of which will have an important role to play in SLES. However, we identified barriers which hamper the chances of these new entrants getting involved in flexibility provision.

A commonly cited barrier to entry in many sectors is the existence of fixed, upfront costs or hurdles that must be overcome to enter a market. A relevant example of this in the case of flexibility is minimum capacity thresholds, or the minimum magnitude of flexible load that must be offered (interviews, Morris et al 2020). For example, the minimum threshold in the capacity market mechanism (see figure 1) is 1 MW, which is roughly equivalent to the simultaneous power consumption of 2000 UK homes. Given that only a small proportion of these homes' consumption is likely to be flexible, many times this number of homes would need to be enlisted to provide a flexibility offering with any certainty. This scale is beyond the reach of many single SLES, excluding independent SLES operators from this potential source of value. While more local flexibility procurement processes offer lower thresholds (just 10 kW in the case of UKPN (UKPN 2021) the returns obtainable through these routes are insufficient unless they can be stacked up alongside other sources of value as outlined above. This is illustrated by the fact that most flexibility-related mechanisms (e.g. balancing mechanism, short term operating reserve) are still dominated by fossil fuel contracts (Sandys and Pownell 2021).

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There is evidence that the complexity surrounding the area of flexibility provision and procurement processes can act as a barrier to entry for some types of organisations. This ranges from issues such as navigating the arrangement of new grid connections, to understanding exactly what is sought and is being committed to in tendering to provide flexibility services. These can be especially challenging for small organisations with limited capacity to employ specialist advisors and with limited existing experience of engaging with flexibility, for example community energy groups. (Centrica, Regen, interviews).

Another potential barrier to new investment and entrants concerns the length of contract available to flexibility providers. Too short, and it is hard to make a case for investment in costly new assets or control/measurement instrumentation with no guarantee of a long-term revenue stream. Too long, however, and uncertainty around the ability to maintain new flexibility offers can lead to reluctance to commit to such contracts. (Centrica, interviews). If flexibility is to provide a viable alternative to network reinforcement, it must be able to be relied upon to provide services such as capacity in the medium to long term. This does, however, still provide space for intermediaries such as flexibility market or exchange providers to construct flexibility offers that are reliable in the long-term (Anaya & Politt 2021) but made up of shorter contracts which allow new and smaller local actors to participate and unlock value (interviews).

Investment is made more difficult when it is not clear exactly where such investment can bring most value (interviews, ENA ON). At present, the visibility of both DERs and network assets on distribution networks is limited, both to the DNOs themselves and to stakeholders more broadly. While extensive work has already been done to improve this situation, there is still a long way to go in building in visibility to UK's electricity assets and infrastructure.

Solutions

A lot of investment in SLES flexibility capacity is expected to come from private households (see attitudes and beliefs) in the form of EVs, heat pumps, and home batteries. Such investment decisions are determined by a variety of factors, many of which are not directly relevant to flexibility. Local authorities have a key enabling role to play. For example, willingness to invest in EVS is determined in part by provision of charging infrastructure (Morris & Hardy 2019). DNOs will need to work together with local and national government to help anticipate where uptake is likely to be most rapid and prioritise the development of charging infrastructure accordingly. This could involve, for example, offering tenders for firms to invest in such infrastructure, underpinned by evidence on likely demand and with specific flexibility requirements. The involvement of national government is key here to avoid this becoming a self-fulfilling prophecy with some areas falling behind (EVET).

The ENA's Open Networks programme has already taken a range of steps to begin addressing some of the barriers highlighted here. For example, it has produced a standardised flexibility agreement (ENA 2020) for use by all DNOs to simplify engagement and investigated ways that network distribution visibility can be improved. There is a standard flexibility agreement for standardised contracts.

The review revealed evidence of other moves in this direction as well. Policy instruments to attract investment by reducing risk and increasing returns on investment include feed-in premiums in combination with feed in tariffs. These attract investment in areas that can produce in peak hours and incentivizes smart load management. Other policy instruments include production tax credit/relief and property tax and sales tax which directly affects the return of projects and so aims to reduce risk and, hence, reduce cost of debt. Public loans and funds generate financial resources; capital grants and making investment costs tax deductible affect returns and attract further investment.

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PROJECT TraDER, Orkney, UK

The Scottish islands of Orkney have been home to many pioneering energy projects. One of the latest is Project TraDER, which has demonstrated how flexibility platform technology can be used to get the most out of local renewable generation, maximising return on investment. The islands have a lot of wind generation connected to the distribution grid. When there is too much generation to use locally, it has to be curtailed (turned off) because network constraints mean it can't be exported. This means lost income for the generators. The Project TraDER platform allows for coordination with local loads in the form of controllable heaters and batteries, meaning that more of the generation that would otherwise be wasted can be used and paid for. It was also able to provide services to the National Grid, in an example of value stacking. The circumstances on Orkney are quite special, with high existing installed generation, controllable demand, and highly engaged communities. However, this context is one that is expected to grow across the UK as SLES begin to emerge and decarbonisation continues. The project shows how smart approaches can unlock value from flexibility in a locality.

Project TraDER was led by Electron, and also involved CGI, Community Energy Scotland, EDF, Elexon, Energy Systems Catapult and Kaluza, supported by National Grid ESO, and Scottish and Southern Electricity Networks. It was funded by BEIS. For more detail on the project, see Electron, Kaluza, Edie.

3.1. Recommendations for national government

3.1.1. Support local authorities with resources to inform their EV uptake forecasting and charging infrastructure planning (EVET).

3.1.2. Minimise investment risk by announcing and consulting on flexibility-related policies and policy adjustments well in advance.

3.1.3. Consider how less-tested flexibility approaches, for example with a high technology- or service-specificity or newer business models can be incentivised with higher returns.

3.2. Recommendations for regulators

3.2.1. Reduce thresholds for participation in capacity and balancing services where possible to encourage wider and more diverse entrants.

3.2.2. Provide more active support to potential new participants, including SLES providers, on how to participate in the variety of flexibility services offered.

3.2.3. Ofgem – Encourage DNOs to engage more with local authorities on EV uptake and infrastructure planning (EVET)

3.2.4. Ofgem – Continue to support collaboration between DNOS, and with National Grid (working with ENA)

3.2.5. Ofgem – Continue to work to improve clarity around the regulatory status of local electricity/ flexibility trading.

3.2.6. Ensure that platforms/markets for flexibility are operated by sufficiently neutral parties, or subject to sufficient regulation to ensure impartiality, especially where the operator may also be operating assets in the market.

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3.3. Recommendations for DNOs

3.3.1. Increase investment in monitoring the low-voltage network to improve time/space optimal network investment and flexibility planning, and to support other actors in planning their flexibility provision.

3.3.2. Continue to explore ways to support non-traditional actors, such as community groups, to participate in flexibility programmes and markets, such as by simplifying processes and providing advice, training and resources.

3.3.3. Consider user-centred design processes with frequent proof-of-concept testing.

3.3.4. Support the development and testing of electricity/flexibility markets and exchanges to allow a broader range of actors to benefit from providing flexibility, thereby promoting investment in capacity (Centrica).

3.4. Recommendations for local authorities

3.4.1. Consult with DNOs to consider making flexibility capabilities a condition in both commercial planning in local area energy plans, and tender processes for e.g. EV charging infrastructure.

3.4.2. Work closely with DNOs to identify priority areas for installation of EV charging infrastructure.

3.4.3. Audit and seek ways to maximise the flexibility offered by local authority assets and estates, where this yields a positive cost/benefit ratio.

3.5. Recommendations for SLES providers

3.5.1. Consider partnering with a single aggregator/service provider who is responsible for maximising engagement with flexibility, including through collaboration with other organisations (although note the point on regulation to ensure impartiality) (Anaya & Politt 2021).

3.5.2. Consider how to coordinate with other local electricity/flexibility markets to ensure sufficient liquidity.

Social Constraint Managed Zones

A constraint management zone (CMZ) is an area of a distribution network that is at risk of exceeding capacity during periods of high demand or supply of electricity. DNOs can ensure capacity is not exceeded in such areas by procuring flexibility services. By calling on these at times of expected peak demand or supply, they can defer or avoid the cost of physical network upgrades. These services are typically procured through tender processes. As outlined earlier in this section, these may be obscure and inaccessible to actors like community groups with limited experience of flexibility and limited time and resources compared to other commercial entities.

To help improve participation by such groups, the DNO Scottish and Southern Energy Networks trialled a concept termed Social Constraint Managed Zones. In essence, it involved providing much more thoroughgoing support through mechanisms such as identifying suitable groups, offering face-to-face guidance, simplifying contracts, and developing bespoke payments for services. The project was successful in engaging with local groups and instigating a project which is being evaluated for suitability by SSEN. However, there are challenges around the limited level of flexibility which such actors are likely to be able to deliver, and the resource required to provide such enhanced support. The report provides a range of further considerations for how local and community groups can be supported to participate in flexibility provision.

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4. Flexibility in the interpersonal – peers, family, household domain

Flexibility in the interpersonal domain is related to the relationships between people. Barriers at this level are around ensuring fairness of communication between peers, as equal market players in a new flexibility-price marketplace. Protections for the consumer are related to a pull for policy/regulation to protect the consumer from new risks when technology may fail and leave this new type of consumer-producer exposed to unfamiliar risks.

Barriers

Market signal communication

Flexibility in energy systems relies on market signals; differing energy prices that encourage participants to change their energy demand in response to predicted peaks and bottlenecks or real time information about network needs. This may involve delaying use of appliances, switching to alternative energy sources, or using storage to reduce demand. If market signals make flexibility sufficiently attractive, they can encourage investment in more efficient and controllable appliances, in batteries and systems that allow greater flexibility and in distributed energy resources that can supply energy to the network when needed. Evidence was identified of various barriers that concern the pricing signals that incentivise flexible behaviours and participation. These barriers fit into two broad categories: issues around how markets are structured and operate and technical issues regarding the data and its communication.

Concerns that the current retail market is not suitably equipped to deliver the benefits that innovative, flexible technologies and approaches can bring are reflected in calls for the creation of new markets. When consulted, expert stakeholders in the energy system prioritised the need for unbiased, transparent, and accessible retail markets that facilitate low carbon business models, delivering flexibility benefits while maintaining the "social legitimacy" of the system – consumer trust in how it is governed (Hall 2020). A review of UK PFER projects (CES PFER 2020) found access to energy markets to be a recurring issue, while Yue (2020) noted that distributed energy resources could be encouraged, incorporated, and coordinated more easily in innovative market schemes. More specific obstacles highlighted in the current system included the lack of a) available attractive time-of-use tariffs (Boait 2019) and b) marginal nodal pricing that could deliver efficiency and welfare benefits if applied at the distribution level (Savelli 2020). The authors note that this has not been adopted (Great Britain is among several countries to model their electricity market as a single zone) in part because of equity concerns. Flexible consumers are able to exploit volatility and local discrepancies in energy prices to profit at the expense of traditional consumers who prefer fixed prices. It is important to note in this context that fixed price tariffs are not themselves without distributional impacts, so any evaluation of the societal impacts of different pricing structures should evaluate them all against independently assessed socially good outcomes.

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Communication issues were identified as a common barrier when it came to the market signals themselves. A review of UK energy system demonstrators (Flett 2018) found data communication from remote sites was hampered by unreliable mobile networks, while Frame et al (2016) noted a domestic flexibility trial where 37% of customers did not receive the event signals requesting reduced demand. Delays to the national roll out of smart meters were cited as barriers to flexibility schemes and trials as the real time energy data collection and communication they provide is vital for applying time-of-use tariffs and incentives (Regen 2017). Without smart meters, demand side response behaviours and impacts cannot be monitored accurately (Murphy 2014). Even where smart meters are present, many are older versions (SMETS1) that do not guarantee interoperability and so make it hard for customer to switch suppliers easily (Regen 2017). The current plan is for all SMETS1 meters to be upgraded or replaced by the end of 2022. Making data accessible and interoperable is among the key recommendations of the Energy Data Taskforce to ensure that consumers can choose and switch between different commercial offers and technologies (Morris 2020). In their examination of the potential of local energy markets, Centrica (2020) called for improved data sharing by DNOs to facilitate a more dynamic management of the distribution network, specifically "congestion and constraint forecasting; network topology changes; the power-flow relationship between grid-nodes; and customer-to-network mapping".

Managing risks to the consumer/prosumer

As SLES continue to evolve, there are concerns that the flexibility, efficiency and profitability that innovative approaches can bring for various stakeholders could be at the expense of consumers or members of the public. Several barriers to providing flexibility concerned the need to protect participants in SLES. EnergyREV warned of the danger that benefits might be distributed unevenly or unfairly, for instance allowing peer-to-peer energy traders to avoid network costs that are then paid by those unwilling or unable to participate (Fell 2019, 2020).

Where business models aim to serve low risk customers this may be at the expense of vulnerable groups (Morris 2020), who often have fewer opportunities to take part or are more difficult to engage with. Whether this is an energy policy or social welfare issue is unclear (Willis 2019).

Energy consumers and prosumers also take the risk that the value of investing in, or providing, flexibility may be less than they expect due to technical performance levels (Boait 2019), regulatory changes affecting revenue opportunities, or competition between diverse sources of flexibility like home batteries and vehicle to grid (The Energyst, 2020). Specific protections that are called for include protecting customer data from cyber-attack and profiteering (Morris 2020) and providing opportunities to switch or other recourse for unsatisfactory service standards (OFGEM 2017c). Current supply licencing regulation complicates the switching process; providing such options in long term contracts in particular is an ongoing dilemma (CES PFER 2020). While the need for fall back mechanisms to protect customers in innovative systems and services is recognised in changing UK regulation (Hall 2020), there is still ambiguity over where responsibilities lie. For instance, as Fell et al. (2019) ask, who will fund complaints procedures in peer-to-peer trading to match those currently provided by energy suppliers?

A lack of independent regulation and code of conduct may increase risks for consumers. Conversely though, rushing to place restrictions on evolving technologies and systems could hamper the development of innovations like flexibility markets and digital energy platforms that may be beneficial for customers (OFGEM 2019). Regulatory guidance is needed particularly to help DNOs procure and use flexibility and to allow independent local flexibility markets to grow and interact with existing markets (Centrica 2020). Transparency and accountability in new markets is complex but necessary to encourage and regulate the data sharing that is needed to develop effective SLES (CES PFER 2020).

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EnergyREV has produced a review (Vigurs et al 2021) examining these and other privacy issues in SLES which makes various recommendations about what issues should be considered and how they can be addressed. See also Value(s) to the consumer.

4.1. Recommendations for regulators

4.1.1. Amend regulation to encourage innovative markets that reward economic, sustainability and reliability benefits, recognising that customers may also respond to non-financial signals.

4.1.2. Retain transparency and consistency in regulation to encourage trust and buy-in. As part of this, clearly allocate roles and commitments to all actors and participants to ensure fairness and ongoing support.

4.1.3. Differentiate price signals to sufficiently incentivise providing flexibility to the network, whether through short term load shifting or long-term investment in storage.

4.2. Recommendations for energy, technology and service providers

4.2.1. Electricity service providers should employ smart contracts and technologies – automation in particular – to realise innovative payment options that give consumers more choice and control while encouraging consumption patterns that provide flexibility to the network.

4.2.2. Service and technology providers should consider using distributed ledgers to:

- Enable new flexibility markets and platforms that provide additional accessibility, security, interoperability, and value for customers/ participants. This might include, for example, improving the competitiveness and convenience of EV charging by using blockchain "to discover a near charging station that would bid for the chance of the EVs' charging".
- Improve the interoperability of not just technologies, but also the data they collect or generate, helping ensure that it is accessible to different actors within the system (in the spirit of 'presumed open' that the Energy Data Taskforce recommends).

4.2.3. Electricity providers and designers of energy use interfaces should provide reliable and real time feedback on energy use that is useful for the customer to respond to. They could:

- Use localised displays (e.g., for individual appliances)
- Make comparisons to similar appliances, or families, or households, to help visualise impacts (rather than just kWh)
- Customise tips based on the user's consumption profile and/ or similar households
- Customise the colours of data visualisations
- Offer anthropomorphized elements, such as spoken messages and/or a human-like face.

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4.3. Recommendations for SLES, energy and flexibility service providers

4.3.1. Service providers should consider equity of access for vulnerable groups and individuals and address them by offering:

- Clear and transparent information on price comparison websites to ensure users understand different price profiles under different circumstances
- Trials of TOU tariffs with the option of easily switching back if the customer wishes to
- Trade-in incentives or "free upgrades" to address rapidly developing technologies and the fear of being left behind with defunct technology after investment
- Energy micropayment options, such as pay-as-you-go solutions or payment platforms for prepaid meters.

4.3.2. Service providers should consider factors that might risk either their customer's privacy or their willingness to participate, including:

- Fatigue when being asked to share data and consider the privacy implications
- Consent within households, ensuring that all members retain privacy and data is not used for coercive control
- Potential beneficial and adverse impacts from sharing data within communities rather than with energy providers.

4.3.3. SLES providers should ensure that technologies and processes can be easily understood, trusted and used. They should:

- Provide clear feedback via in-home displays to support residents to realise their energy goals
- Use simple, intuitive processes and, where possible, allow potential users to trial them to build their confidence to use them and incorporate them into daily practice.

4.4. Recommendations for regulators and policy makers

4.4.1. Consumer protection providers should include a regulatory structure that evolves in line with recent technologies, systems, markets, and services; balancing the freedom to develop innovative approaches that benefit their participants against the need for them to operate in an effective and fair wider system that protects all consumers.

4.4.2. Consumer protection providers should consider the specific regulation changes needed to allow customers to take advantage of novel approaches, for example amending licensing for local and peer-to-peer energy supply to simplify and speed up the process for switching suppliers.

4.4.3. Consumer protection providers could provide clarity on where responsibilities for consumer protection lies, detailing which stakeholders in emerging markets and services are accountable for which specific provisions.

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5. Flexibility at the individual level: attitudes and beliefs domain

Flexibility at the individual level will be concerned with the beliefs and attitudes that translate into flexibility behaviours. This includes how purchasing decisions are made and to what extent the individual can meet their goals – be that a return on investment or non-monetary values. Barriers at the individual level are also concerned with maintaining expected levels of privacy.

Barriers

Value(s) to the consumer and participation

As mentioned in Barriers to new entrants: Investors, much flexibility investment will be as a result of individual purchasing decisions for electric vehicles, heat pumps and home batteries. However, several barriers to these investments were found in the UK literature when it came to the individual attitudes and beliefs domain. One of the barriers to EV purchases was "range anxiety"; a combination of concerns that a) EVs do not match their petrol driven counterparts for how far they can travel without charge, and b) there are not enough accessible ChargePoint's visible and available on demand. Together these concerns create a perception that EVs have less value than petrol or diesel vehicles when the greater costs of initial outlay are balanced against the long-term savings in running costs.

The change in common practices needed to support flexibility demand a level of engagement which is currently the exception rather than the norm, as can be seen in the level of engagement with energy company switching. The recent contraction of the energy market may well have still further damaged confidence in the benefit to engagement. In any case, to make energy flexibility in the home a widespread practice will require a cultural shift (Regen 2017). Many of the studies on attitudes and beliefs of individuals found that barriers to adopting new practices and services resulted from a low level of trust in energy companies. Sometimes this was related to an experience of being over-promised benefits of switching tariffs, known as "tease and squeeze"(Carmichael et al. 2021), but also to scepticism that there was any real value to be had in participation in flexibility other than to the energy company. From the SLES point of view there was also lack of knowledge from SLES providers on how best to engage and incentivise potential customers to the SLES services that were on offer (PFER CES 2020).

Non-monetary values are also important to the customer and acted as a barrier to participation when these values were not met. These included having control over setting goals, inclusivity and increasing quality of life, as well as affordability, transparency and accuracy. However, they did act as facilitators when offered, increasing the acceptance of smart metering, smart home devices, and demand-side management technologies (Milchram 2018).

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Privacy was also a value to the customer. Risks of privacy breaches within communities, and within households, were a barrier to initial sign up and sustained participation. Programmes that tested comparing energy use between households to increase customer engagement in flexibility behaviours found mixed results. In some cases there was increased engagement but no savings, and such comparisons were negatively received. This was the case whether the community, household or individual set the goal for energy saving, suggesting that other values interact with the desire to make cost savings. Studies in related areas that seek behaviour change found that individuals could feel their autonomy was threatened when behaviours are revealed and set against others for comparisons. This compromised the effectiveness of energy use goal setting and goal comparisons.

Solutions

People's concerns about the value of EVs could be addressed by the pace of technological improvement with growing optimism in reviews that EV ranges, battery life and affordability are increasing rapidly. This will also need to be combined with an increased visibility of charging infrastructure to make the widespread purchasing of electric vehicle fair value to the consumer.

Systematic review evidence showed that addressing barriers to low levels of trust in energy companies was associated with increasing transparency of communications and setting realistic expectations of savings. One way of increasing transparency and directness of communication would be near real time communication between providers and customer, using social media platforms such as Twitter and Facebook. They are increasingly used by companies to interact with, and respond to, their customers.

The review evidence of solutions to barriers to customer engagement found that additional human interactions increase the behaviours necessary for an overall reduction in energy costs and to encourage flexibility behaviours. This could be in the form of visits from energy advocates or counsellors who can demonstrate and provide advice on how to use flexibility devices (Valor 2019).

Reviews of preventing coercive control of home-based smart technologies point to social norms that have yet to catch up with the fast pace of technology and implications for privacy. Several reviews point to the potential abusive uses of technologies that can be used to control by surveillance and environmental controls used remotely over others at home. People who are abused by technology (known as "tech abuse") often do not know they are being abused as the technology is more recent than the social norms around its accepted uses. This can be overcome by setting out the expectations of good practice in the use of unfamiliar technologies so that all parties can be informed on its intended usage. Contractual obligations designed to keep the technology for its intended use should also be set out between all parties.

5.1. Recommendations for SLES providers and data collection agencies

Security of data

5.1.1. SLES data collection should ensure the data is protected by suitable data security, such as by using blockchain technology to ensure privacy, data confidentiality and identity protection.

5.1.2. Data collection interfaces and displays should be adaptable and customisable. They should be easy to understand and use.

5.1.3. Data collection interfaces and displays must include the privacy policy and specify the use given to the different levels of disaggregation of information, express consent and revocable consent.

5.1.4. SLES data collection agencies should ensure they have the consent to collect data from anyone affected by it. People in the household should be able to have equal access or to opt out, even if they are not the bill payer, or the main user.

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5.1.5. SLES data collections agencies should be mindful of the potential for abuse of energy use data as a tool of coercive control and surveillance on members of the same or other households (for example, older relatives living elsewhere) and apply IBM's principles in service design (Nuttall et al 2019) which aim to make technology products resistant to coercive control. These principles are designed to:

- Promote diversity. Ensure a diverse design team to broaden the understanding of user habits.
- Guarantee privacy and choice. Allow users to make informed choices about their privacy settings.
- Combat gaslighting. Make it clear when settings have been changed and when functionality of devices is triggered.
- Strengthen security and data. Ensure that products only collect and share necessary data, limiting the risk that data are used maliciously.
- Make technology more intuitive. Give users greater confidence to use technology by making it simpler to understand; limit the risk of abusers exploiting a victim's lack of technical ability.

5.1.6. SLES service providers can consider providing a good practice, fair-use guide in manuals and handbooks to new technologies. These should provide guidance on behaviours expected from unfamiliar technologies and define and warn against behaviours that can be deliberately or inadvertently controlling, abusive or unwelcome.

5.1.7. SLES providers of technologies that control environments should adhere to the energy use profile and requests of the person at home and affected by the environmental preferences, rather than the person not at home who is not affected by any adjustments to the environment (access to hot water, temperature etc).

Building trust through communication

5.2.1. SLES providers and data collection agencies can consider having a social media presence, such as local Facebook groups, Twitter and local authority newsletters to encourage sharing of customer experience and tips, as well as providing near real time question and answers. Via the use of social media, providers can demonstrate their responsiveness to customer queries and or concerns with "You said, we did". Providers can create video content of demonstrations of technologies, such as smart meters, and provide a platform for peer-to-peer questions and answers.

Building trust through fair offers

5.2.1. SLES providers should promote and demonstrate the transparency and accuracy of data collection methods, such as smart meters, fairness and accuracy of billing, thus eliminating over charging and overestimated bills.

5.2.3. Unit prices from SLES providers should be clear and transparent and comparable with any ranges of variation clearly described and under what circumstance prices may change. Consider using price comparisons websites to enable customers to compare prices with other providers on a common metric and under different conditions.

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6. Interconnectedness of barriers to flexibility in different domains

Many of the barriers identified in the literature talked about the connections to other barriers or could be addressed by solutions found in other domains. Overcoming barriers to flexibility in SLES will therefore need a multisectoral, multi domain approach.

There was a perception in the UK barriers literature that there was a lack of **clear, and consistent national policy** on the drive to encourage SLES, and a lack of coordination in the infrastructure development for EVs and standardisation to ensure **interoperability**. This then is impacting on the complexity in the transition to decarbonising heating and transport and meeting this increased demand, while yet meeting the demand for flexibility to balance against an intermittent supply characteristic of renewable energy. This is combined with the current system not being designed to incorporate flexibility.

The lack of certainty around clear and consistent policy is a **barrier to new entrants**, particularly **investors**. This in turn impacts on, and is impacted by, the capacity to **realise value from flexibility**. Local authorities that are looking to support local investment say that this lack of clear policy and funding also leaves energy transitions vulnerable to changing local priorities.

Knowledge and learning ecosystem are driven both by a demand for (pull) and for research that seeks to influence or recommend policy (push). There is a barrier to the creation and dissemination of **knowledge about flexibility** when it was deemed to be commercially sensitive and restricted or too low powered.

The costs of high powered, reliable effectiveness studies are likely to be funded from central government (such as PFER) and so depend on being a policy priority. Policy complexity and lack of knowledge can put off all but the most determined community organisations who may lack the technical and commercial skills to navigate the **current regulations**, costs of entry and reliable knowledge that is applicable to their context.

There is a need to manage the new or emerging **risks to the consumer** which acts as a pull for policy for regulations and protections, particularly for prosumers, as they occupy an intermediate private / public market position of producers and consumers. Other risks to the consumer include **market failure** (when value is not realised and service providers exit the market), technological obsolescence through non-interoperability over time and inadequate **market mechanisms**, such as lack of timely and accurate market signals to respond to and attractive tariffs and price differentials that make responding worthwhile. These factors impact on **people's attitudes and beliefs** about the potential return on investment when they are thinking about whether it's worth participating in energy markets, or purchasing EVs, heat pumps or solar panels or even considering starting a community energy group. The type and **level of participation** in turn impacts on realising value for investors and the providers, as a low participation rate will render flexibility both non-profitable and ineffective.

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7. Closing remarks

Flexibility is integral to the success and implementation of SLES. It can be seen as an outcome, a commodity to be traded, or as a strategy for achieving objectives on efficiency, affordability, resilience, carbon reduction and economic growth.

This report has presented a range of recommendations that stakeholders at various levels within the UK energy system could carry out to overcome barriers or exploit opportunities to help unlock the flexibility that is already present and build further flexibility capacity in the system. We also note how these recommendations are interconnected. Some individual recommendations would help address a range of barriers while others may facilitate implementing further recommendations or make it more likely that they will have greater impacts.

The topic of flexibility is too broad and multi-faceted to capture fully in detail in one report. Instead, we present these recommendations for each stakeholder to consider and provide links to further reading and resources that are available.

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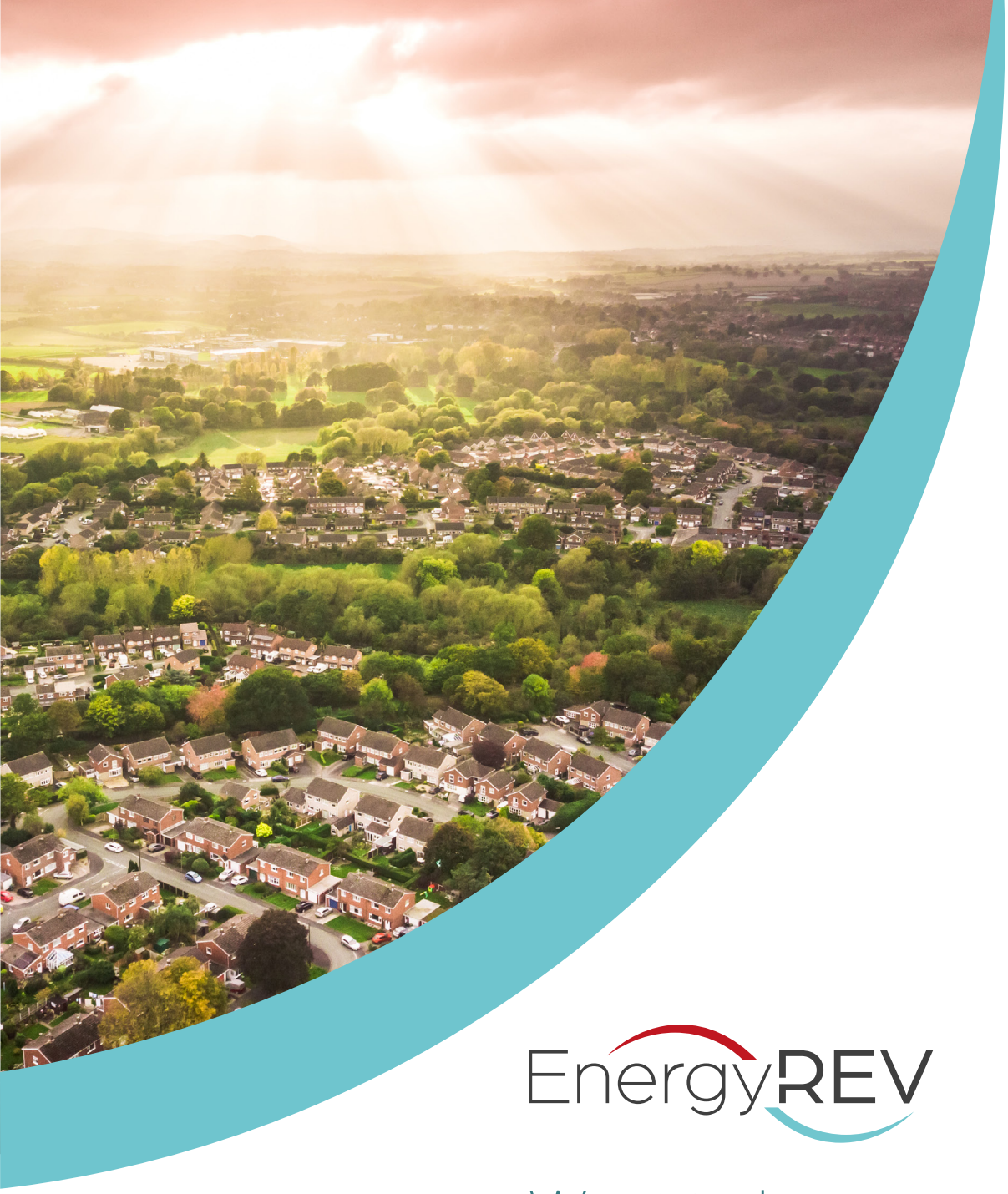

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