Why Smart Local Energy Systems?

Portfolio report on smart local energy systems funded by the Prospering from the Energy Revolution programme

February 2023

Contents

Executive summary

This is one of three reports by ESC evaluating 13 smart local energy system (SLES) projects funded by Innovate UK's Prospering from the Energy Revolution (PfER) challenge. This report seeks to answer the question 'Why SLES?' based on evidence gained from across the evaluation and knowledge of the PfER projects, while the other reports focus on:

- Bills and carbon impact of SLES[1]
- Public awareness and appeal of SLES[2]

This report explores the financial and social benefits of implementing energy systems that are smart, local and integrated, whether SLES can be investable, scalable and replicable, and the barriers that have been encountered in deploying SLES.

Key findings

SLES can facilitate decarbonisation and accelerate uptake of low carbon technologies

By optimising energy flows, SLES can mitigate grid constraints and enable deployment of larger numbers of low carbon energy assets (e.g. solar panels, EVs, heat pumps) on a local network. SLES can also make more efficient use of renewable electricity and avoid the need for curtailment at times of peak generation, by intelligently matching supply with demand. Furthermore, SLES can reduce costs and disruption associated with installation of low carbon infrastructure by combining shared civil engineering and construction requirements between power, heat and transport vectors.

SLES can utilise existing local resources to meet communities' energy needs

SLES can harness the potential of existing resources in a local area, such as waste heat (e.g. from industrial processes, data centres, mine water) or renewable electricity generation (e.g. from hydropower) and integrate them intelligently with new low carbon energy infrastructure (e.g. heat networks or micro-grids) to meet communities' heating and power demands.

SLES can contribute to both local and national delivery of Net Zero

Achieving the UK's national Net Zero target will require decarbonisation of sectors which are inherently local and difficult to address from a national perspective, (e.g. transport and buildings). SLES can provide a joined-up approach to decarbonising local elements, contributing to a national whole-systems approach to achieving Net Zero.

1 https://es.catapult.org.uk/report/bills-and-carbon-impact-of-smart-local-energy-systems
2 https://es.catapult.org.uk/report/public-awareness-and-appeal-of-smart-local-energy-systems

SLES can create a wide range of economic and social benefits
SLES can establish new revenue streams for energy generators, energy system operators, local authorities, businesses and domestic customers, ranging from the sale of electricity and heat to subscription fees for energy services, and payments for providing flexibility services to the grid. SLES can also produce extensive non-financial and social benefits, including reductions in greenhouse gas (GHG) emissions, improvements in public health, warmer homes and the creation of local jobs and training opportunities, among others.

SLES can de-risk investments in energy infrastructure
The PfER projects have demonstrated that SLES can be investable, scalable and replicable, with the development of different business models aimed at repaying initial capital investment and eventually reducing reliance on public subsidies to build energy infrastructure projects. Many of the projects incorporate a diverse range of revenue streams, which may not only help maintain the long-term commercial viability of the system but also allow less profitable elements (e.g. heat networks) to be counterbalanced by higher revenue aspects (e.g. renewable electricity generation and private wire networks).

SLES can improve local energy resilience
By providing greater connectivity between local generators and consumers, energy can flow within a local area, reducing reliance on centralised generation and providing greater resilience to local communities – particularly those in locations with limited connections to the national grid. Reducing the need for grid imports also lessens consumers' exposure to wider energy market volatility and may help users to achieve more stable energy bills.

SLES can reduce energy bills and address fuel poverty
Many of the PfER projects achieved or were forecast to achieve wholesale and network cost savings of up to 25%, which could reduce consumer energy bills by enough to remove households from fuel poverty in some cases. Several of the projects also demonstrated how access to local resources can be shared across entire communities and how energy assets (such as EVs) can be made more readily available to households that would otherwise be unable to afford them.

Regulatory reform is required to unlock the full value of SLES and local flexibility
The current regulatory regime is still based on a centralised energy system with energy suppliers acting as a gateway between consumers and the rest of the energy system. Reform of local energy system policy, governance and licensing requirements is required to allocate proper value to local flexibility and enable new business models that will allow this value to be accessed by the individuals or businesses who provide the flexibility. Improved digital infrastructure and standardisation of connectivity protocols is also required to enable energy assets to participate in smart energy systems.

Introduction

This report sets out the findings of Energy Systems Catapult's (ESC) assessment of investability, scalability and replicability across the portfolio of PfER projects.

What defines a SLES?

A SLES describes an innovative way of delivering energy to system participants in a particular geographical area. They can be **smart by design**, using data to inform locally beneficial configurations of assets and networks to accelerate the Net Zero transition, or **smart by operation**, using automated asset operation and potentially automated trading of energy.

SLES are **local**, defined by a geographical boundary, potentially a local authority or even smaller area. This can provide better outcomes for the community in that area and can provide constructive alignment with local Net Zero plans, i.e. local area energy plans (LAEPs). SLES operate as a **system**; by operating local assets as a system with a more granular approach, there is potential for a more efficient energy system. SLES can take a **multi-vector**[3] **approach**, optimising the whole system locally. **Local users** form a crucial part of considering the system as a whole and can be better integrated at design stage using a SLES approach in contrast to national approaches.

What is ERIS Energy Outcomes Evaluation?
The PfER programme is supporting the development of SLES projects with ESC's Energy Revolution Integration Service (ERIS), bringing learnings from across the programme together to provide recommendations for what is needed to accelerate the development of more local energy systems. ERIS has evaluated the energy outcomes of each project across the PfER programme.

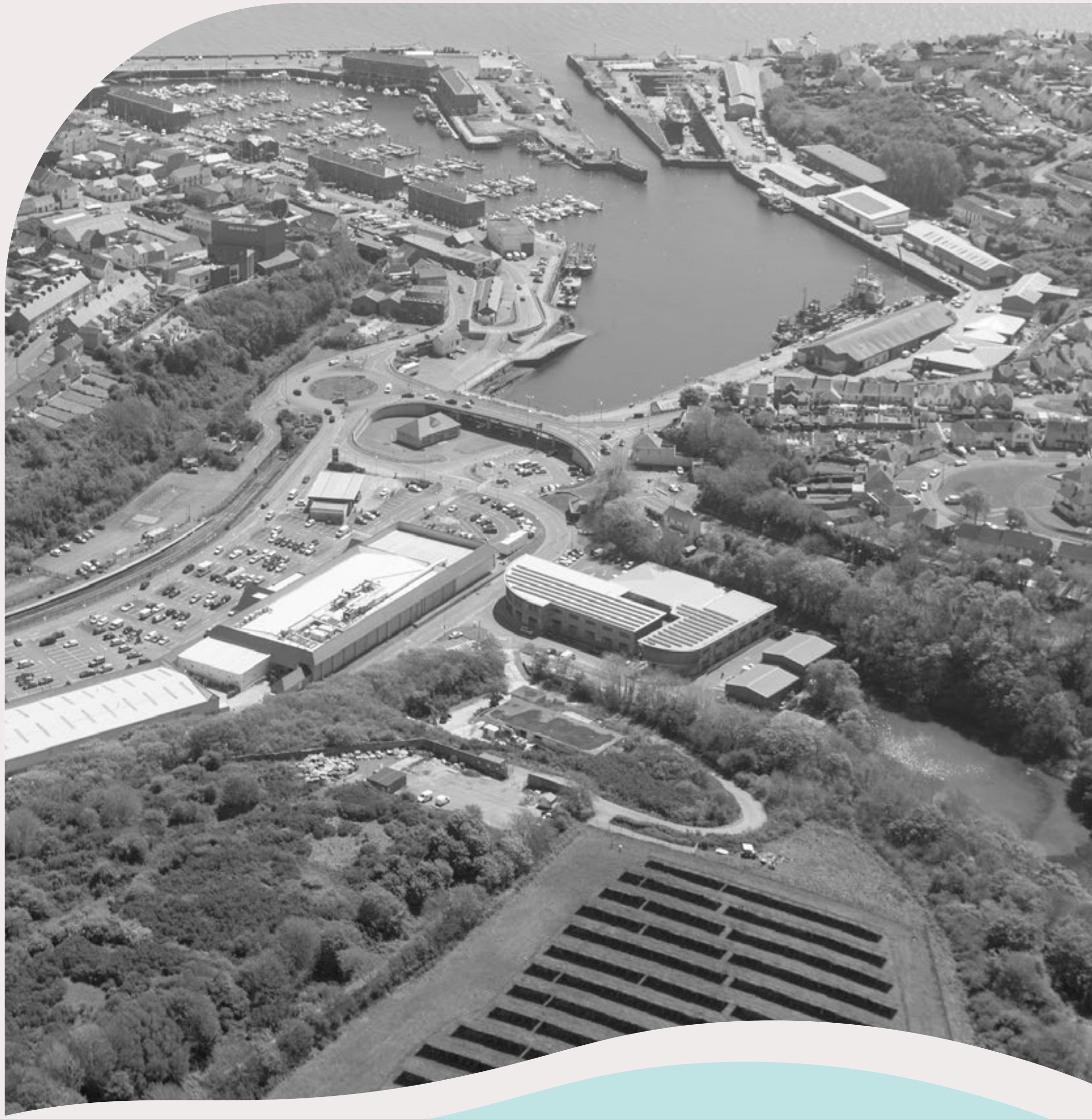
3 Multi-vector here means different carriers of energy to consumers (for example electricity from the grid, gas, hydrogen, heat network, electricity from private wire). A particular use (for example heating) might be supplied by any of these, singly or in combination.

PFER projects and evaluation criteria

The evaluation of energy outcomes was conducted for 10 detailed design and three demonstrator projects funded by the PfER challenge fund (Table 1).

Table 1 PfER project list

Project type	Project name (acronym)
Detailed Design	• Girona **(Girona)** • Greater Manchester Local Energy Market (**GMLEM)** • Green Smart Community Integrated Energy Systems **(GreenSCIES)** • Liverpool Multi-vector Energy Exchange **(LEX)** • Milford Haven: Energy Kingdom **(MHEK)** • Peterborough Integrated Renewables Infrastructure **(PIRI)** • Rewire North West **(Rewire)** • Spearheading a Revolution in Energy Market Design **(REMeDY)** • West Midlands Regional Energy System Operator **(RESO)** • Zero Carbon Rugeley **(ZCR)**
Demonstrator	• Energy Superhub Oxford **(ESO)** • Local Energy Oxfordshire **(LEO)** • Responsive Flexibility Orkney **(ReFLEX)**

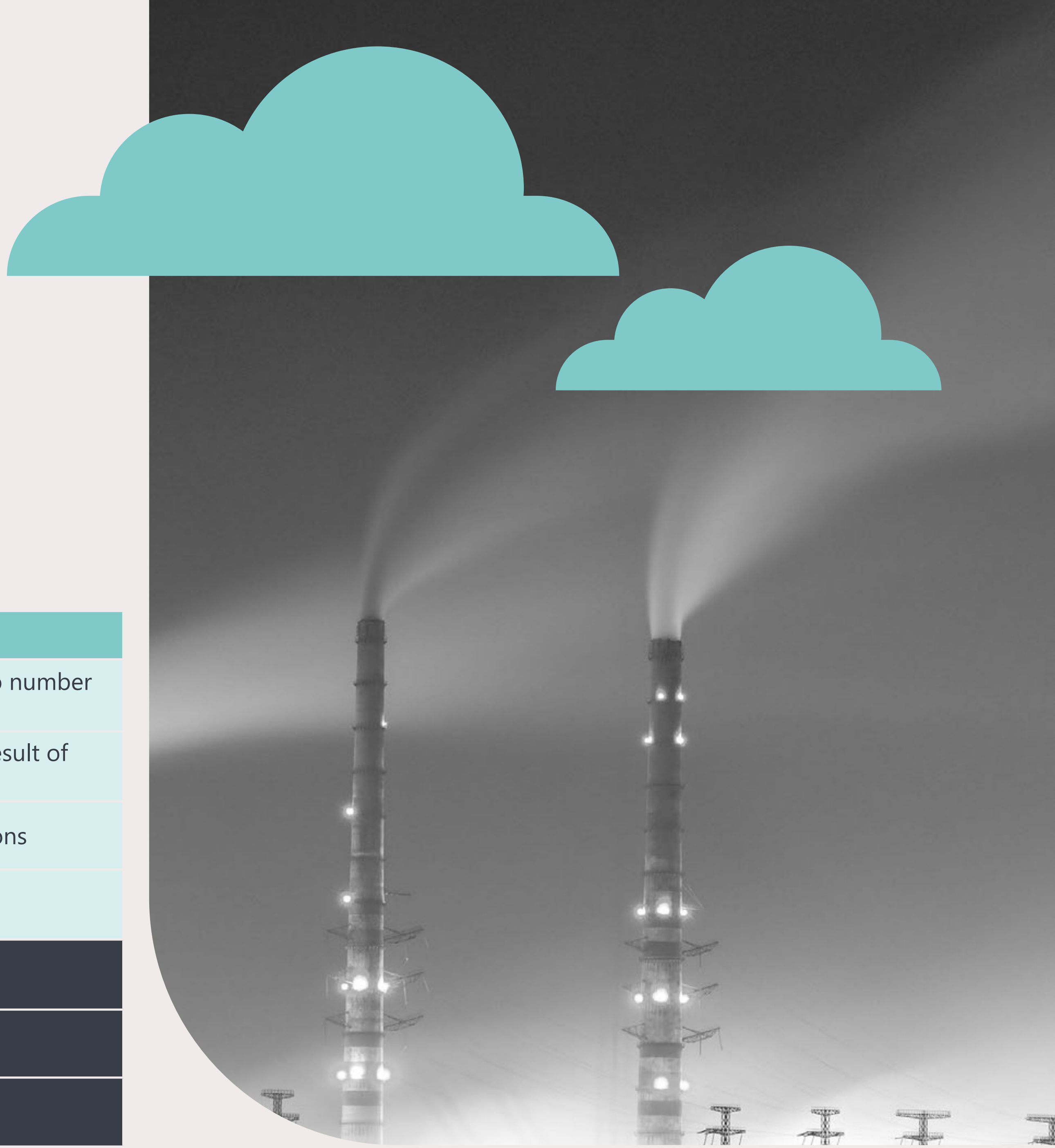


Each of the projects was assessed across a common set of evaluation criteria, agreed with UKRI (Table 2).

The scope of the detailed design projects was to produce a design with evidence to show that it could deliver the PfER objectives, whereas the demonstrator projects' scope was to realise a SLES. Despite these scope differences, energy outcomes were evaluated using a common method for all projects.

Table 2 Evaluation criteria

#	Evaluation Criteria
1	The impact of SLES designs on participants' bills due to number of units purchased or the cost per unit of energy
2	The impact of SLES designs on participants' bills as a result of network usage costs on a bill (forward and recovery)
3	The impact of SLES designs on greenhouse gas emissions
4	The participant acceptance of the SLES designs
5	The investability of the SLES designs
6	The scalability of the SLES designs
7	The replicability of the SLES designs



Why smart, why local, why an energy system?

Why smart?

Smart local energy systems are able to harness data and algorithms to control energy generation, storage and demand assets to optimise local energy usage. This is especially crucial for 'keeping the lights on' in future energy systems, which will see enormous increases in electrical demand and rely on decentralised and intermittent renewable electricity generation.[4] Smart systems will therefore play an essential role in matching demand with a variable energy supply – not only to ensure that electrical devices have power when needed, but also to avoid the need for curtailment of renewable energy generation – and in reducing the need for expensive, grid-scale balancing technologies.

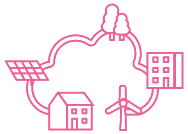
Smart systems may also enable and accelerate the deployment of low carbon technologies, which is often limited by local grid constraints. For example, distribution network operators (DNOs) may currently restrict the number of solar PV panels that can be installed on the roof of a building if the local network is unable to absorb the potential peak power generation safely. Similarly, widespread electrification of heat and transport could quickly overwhelm distribution networks – particularly if many users turn on their heat pumps and charge their electric vehicles simultaneously. Significant and costly network upgrades and reinforcements would be required to accommodate the resulting peaks in energy generation and demand.

Smart systems can smooth out peak loads by temporally shifting demand, through a combination of storage and intelligent control of energy-consuming assets. Curbing peak demand lowers the maximum capacity that the local electricity network needs to be rated for, allowing more electricity-generating and -consuming assets to be installed on the network and reducing the costs of grid reinforcement. These costs would otherwise be passed on to energy users through distribution network charges, so avoiding the need for grid reinforcement not only stimulates energy innovation by allowing more low carbon technologies to be deployed but could also save customers money on their energy bills.

Making energy systems smarter and more data-driven therefore allows the system to be managed more efficiently and cost effectively than the alternative, where users operate their energy assets freely with no optimisation.

Smart systems also have the potential to improve users' experience of interacting with the energy system and to enable an evolution from consumer to prosumer, by providing users with better real-time access to energy usage and market data, more intuitive and intelligent control of their heat and power devices, and greater customisation of energy products and services to meet their wants and needs.

LEX is a city-wide marketplace designed to allow for local trading of energy and flexibility. The project involved development of both a hardware solution for controlling assets connected to the marketplace and a software solution for exchanging flexibility (i.e. the marketplace platform itself). LEX is intended to allow significant growth in both decentralised energy generation and electrical demand in the local area from assets such as EVs and heat pumps, while avoiding the need for network reinforcements by optimising energy usage.



Why smart?

- → Match demand with variable supply of renewable electricity
- → Reduce major peaks in demand and curtailment of peak generation
- → Avoid network reinforcement costs
- → Potentially lower energy bills
- → Improve users' experience of the energy system

4 https://www.nationalgrideso.com/future-energy/future-energy-scenarios

Why local?

Great strides have been made in decarbonising the UK's national electricity supply over the past three decades, with the phasing-out of coal-fired power plants and the introduction of large-scale renewables onto the grid, but challenges remain in decarbonising two of the largest remaining sources of GHG emissions – transport and buildings, which are inherently local in nature. Every city, town and community has its own local characteristics in terms of geography, available resources, building archetypes, transport links, demand profiles and user demographics, as well as different social and economic needs. As such, there is no 'one size fits all' solution for reaching Net Zero, and it is unlikely that a monolithic national energy system will cater to the specific needs of individual communities cost effectively without the assistance of localised elements.

While decentralised energy assets (such as rooftop solar panels and domestic EV chargers) can link into the national grid, inefficiencies and losses associated with long-distance transmission of electricity can be avoided by ensuring that energy generated locally is consumed locally. A smart system of decentralised assets which generate and consume energy locally within a region can improve local resilience and security of energy supply – particularly for communities which have limited connections to the national grid. The buffering effect of local energy systems can also reduce users' exposure to wider energy market volatility, which may help users to avoid spikes in energy prices and ensure greater stability in energy bills in the long term.

A more tailored local approach in alignment with a whole-system context will therefore ensure that low carbon technologies are deployed in the most coordinated and effective way, as well as reducing the risk of stranded assets by ensuring that infrastructure is future-proofed and integrated into a local plan. A local approach may also ensure that energy is used efficiently and not wasted, and that everyone is able to benefit from the clean energy transition.

Local energy systems can unlock the potential of previously unutilised resources in a specific area (e.g. sources of waste heat, hydropower) and allow the ensuing value to be shared within the local community. Such benefits may take the form of low-cost heat or power, or the creation of new revenue streams which can be reinvested to improve amenities in the local area. Other indirect benefits to the community may include cleaner air, better access to sustainable transport and opportunities for training and skilled employment, among others. PwC's 'Accelerating Net Zero Delivery' report suggests that a place-based approach to decarbonisation could create £825 billion in social benefits from £58 billion investment, compared with £444 billion in social benefits from £195 billion investment with a non-place-based approach.[5]

5 https://www.ukri.org/publications/accelerating-net-zero-delivery/

Milford Haven is uniquely placed as an entry point for gas imports to the UK. **MHEK** explored how the associated infrastructure and gas-handling skills in the local population could be repurposed to build a local hydrogen economy, integrating hydrogen for transport and heat into the local energy system.

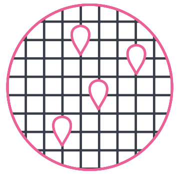
Local authorities (LAs) have powers or influence over roughly a third of emissions in their local areas,[6] including sectors such as public transport, social housing and waste processing. Over 80% of councils have declared a climate emergency, with some setting a target to reach Net Zero by as early as 2030.[7] Smart local energy systems can play an important role in achieving these decarbonisation targets, as well as helping LAs to meet other statutory responsibilities such as tackling fuel poverty (by lowering energy bills and improving the energy efficiency of homes) and improving public health (by making homes more comfortable, reducing air pollution and encouraging active transport).

The council-backed **ZCR** detailed design incorporates changes in street infrastructure to boost walking and cycling in Rugeley. Such changes not only increase levels of exercise, but also create safer streets by prioritising pedestrians and cyclists over vehicles.

6 https://www.theccc.org.uk/wp-content/uploads/2020/12/Local-Authorities-and-the-Sixth-Carbon-Budget.pdf
7 https://data.climateemergency.uk/councils/

Moreover, LAs are uniquely placed to support the delivery of SLES, having an unparalleled knowledge of their local area and residents, and intrinsic relationships with local stakeholders. By taking a local approach, LAs can ensure that SLES meet the needs of local communities and target appropriate measures where they are most urgently needed, for example to prioritise a reduction in energy bills for households in fuel poverty. LAs also hold a significant position of trust with the public (80% trust in LA Trading Standards and consumer groups vs 41% trust in energy suppliers),[5] and so they have a pivotal role to play in fostering local support for Net Zero initiatives and driving successful participation in SLES (in conjunction with appropriate technical support and delivery partners).

Community energy organisations may also be suitable partners for SLES projects, as they are inherently embedded in their local area and may have valuable insights into local energy needs. Community energy organisations are usually wholly or partially owned by the community in which they are based, and so their involvement in SLES can allow communities to have greater input into or even ownership of local energy developments.



Why local?

- Makes use of locally available resources
- Tailors energy system so that it meets local needs
- Avoids transmission inefficiencies and wastage of energy
- Shares benefits of clean energy transition with whole community
- Helps LAs to achieve Net Zero, reduce fuel poverty and meet public health targets
- Harnesses public trust in LAs and community organisations to encourage stakeholder buy-in
- Gives communities more control and ownership over energy developments in their area

Rewire advocates for community/co-operative energy ownership models of bioenergy carbon capture and storage (BECCS) systems to promote a number of local benefits, including:

- Keeping money in the local economy
- Fostering social acceptance for renewable energy
- Keeping the individual investment for renewable energy projects affordable
- Sharing of profits among members
- Reinvestment into the local community

Why a system?

Achieving the UK's national target of Net Zero by 2050 will require wholesale decarbonisation of energy usage across all sectors. While some decarbonisation measures can be installed discretely – particularly energy efficiency measures for buildings – most communal heat and power infrastructure can only be deployed at a system level, as they require collaboration between various delivery partners, regulatory compliance and buy-in from multiple stakeholders.

Installation of communal infrastructure is inherently disruptive and incurs substantial capital costs. Taking a systems approach and coordinating simultaneous installation of different infrastructural elements (e.g. a private wire network with a heat network), rather than installing piecemeal, can have significant cost benefits, by sharing costs for trenching, energy centre construction etc., as well as reducing the total amount of disruption. A systems approach can also ensure that infrastructure is future-proofed and able to connect with additional elements that may be installed later.

Integrating different infrastructure elements together in a wider system can generate value greater than the sum of its parts and facilitate investment in aspects of the system which might have a lower rate of return on their own (e.g. heat networks). Smart local energy systems can therefore allow measures that have greater social impact to be implemented and effectively subsidised by elements of the system which are more profitable. This may be particularly beneficial for LAs who struggle to fund longer-term measures that have a less compelling financial proposition, such as retrofit and energy efficiency, as well as mitigating the risk of private developers cherry-picking only the most lucrative aspects of projects.

While some decarbonisation measures can be installed individually at a household level, such as insulation, heat pumps or EV chargers, there is a large inequality in access to these devices, which remain unaffordable or technically difficult to install for many households. By taking a systems approach, SLES allows individual users to benefit from assets that they would not be able to install themselves, such as local energy generation or public EV charging hubs. Users may also potentially benefit from simpler billing arrangements (i.e. receiving a single bill for heat, electricity and mobility as a service).

GreenSCIES developed an integrated system combining a 5th-generation ambient loop heating/cooling network with renewable electricity generation and EV charging. The business model incorporates a varied and complementary range of revenue streams, including:

- Contracted supply of heating and cooling to customers
- Installation, use and optimisation of EV charge points
- Installation and use of solar PV panels and
- Revenue from vehicle-to-grid services, flexibility services provided to the national grid and electricity market arbitrage

Moreover, joining together many individual, decentralised assets allows SLES participants to contribute towards a whole that is greater than the sum of its parts. For example, by facilitating better connectivity between a larger number of users and devices, energy assets in homes and other buildings can be aggregated to form a 'virtual power plant' (VPP) that can provide larger, more practical volumes of flexibility to local and national grid operators. Enhanced connectivity between individual generators and consumers also improves the inclusivity of the energy system and allows (in theory) anyone to engage and participate in a way that has previously been limited to only large, centralised generators and suppliers.

Following declaration of a climate emergency, some LAs have commissioned local area energy plans (LAEPs) to determine the most effective pathway for reaching Net Zero in their area. LAEPs use a whole-systems approach to provide a fully costed, long-term masterplan for decarbonising heat, power and transport in a given location, using local data and spatial analysis to identify which technologies should be installed in which zones and districts. Smart local energy systems can incorporate into and support the delivery of LAEPs and provide a framework to connect the various infrastructure and assets that are installed via a LAEP, as well as pointing towards high level business models and revenue streams which can facilitate investment in the system.

There are several current challenges and barriers to implementing aspects of SLES projects that, should they be overcome, would accelerate the deployment and improve the benefits of SLES. These are explored in detail in the 'Challenges and opportunities' section of this report.

RESO has explored how a regional energy systems operator can coordinate energy systems, data and infrastructure projects across multiple local authority areas, linking individual LAEPs to form an interconnected region-wide SLES. This design provides the broader oversight of a whole-systems approach while preserving the benefits of local level planning, with a local governance model proposed for managing and collating the relevant data that LAs and energy network operators have access to.

Summary

- Reduces total capital costs and disruption associated with installing individual energy infrastructure elements, by installing co-located elements together simultaneously
- Enables deployment of measures that in combination are financially viable, where individually they are less attractive
- Allows users to benefit from assets that would be difficult or impossible to install themselves
- Improves the inclusivity of the energy system and widens participation
- Supports delivery of LAEPs

Quantitative benefits

A defining reason for 'Why SLES' is that implementation of a SLES will reduce greenhouse gas emissions (carbon) and hence bring the UK closer to its target of achieving Net Zero by 2050. In addition, SLES could save money on all users' energy bills – be they domestic, commercial, public or industrial users.

ESC's quantitative evaluation, as detailed in the 'Bills and Carbon Impact of Smart Local Energy Systems' report https://es.catapult.org.uk/report/bills-and-carbon-impact-of-smart-local-energy-systems, gives an overview of SLES projects' potential impact in 2032 on greenhouse gas emissions and user bills. This assessment found that all of the PfER projects achieved projected greenhouse gas savings, ranging from 2% to 108%. Projected user bill savings also ranged from 0% to 57%.[8]

Across the portfolio, major savings in GHG emissions are achieved where projects facilitate or accelerate transition to electric vehicles and heating technologies. The smart operation of these assets has a much smaller direct effect on GHG emissions reductions. However, when considering the cross-portfolio results, the enabling effect of smart operation should not be neglected. Projects that focus on flexibility and smart operation, while not showing high direct savings, create the potential for greater future technology transfer that will enable greater impact on GHG and bills.

There is wide variation in the effects of the projects on participants' bills. Again, where large energy cost savings are predicted, this is largely due to the switch away from fossil fuels to electricity. While this effect is less pronounced for bills than GHG emissions, the projected price of petrol, diesel and gas in 2032 as compared to electricity across all potential scenarios means that technology switch will yield bill savings on wholesale energy cost.

The chart below shows that SLES can provide large GHG savings, with either low or high energy cost savings. The trend from this sample of 13 projects shows that cost savings on a percentage basis are comparatively difficult to achieve compared to GHG savings.

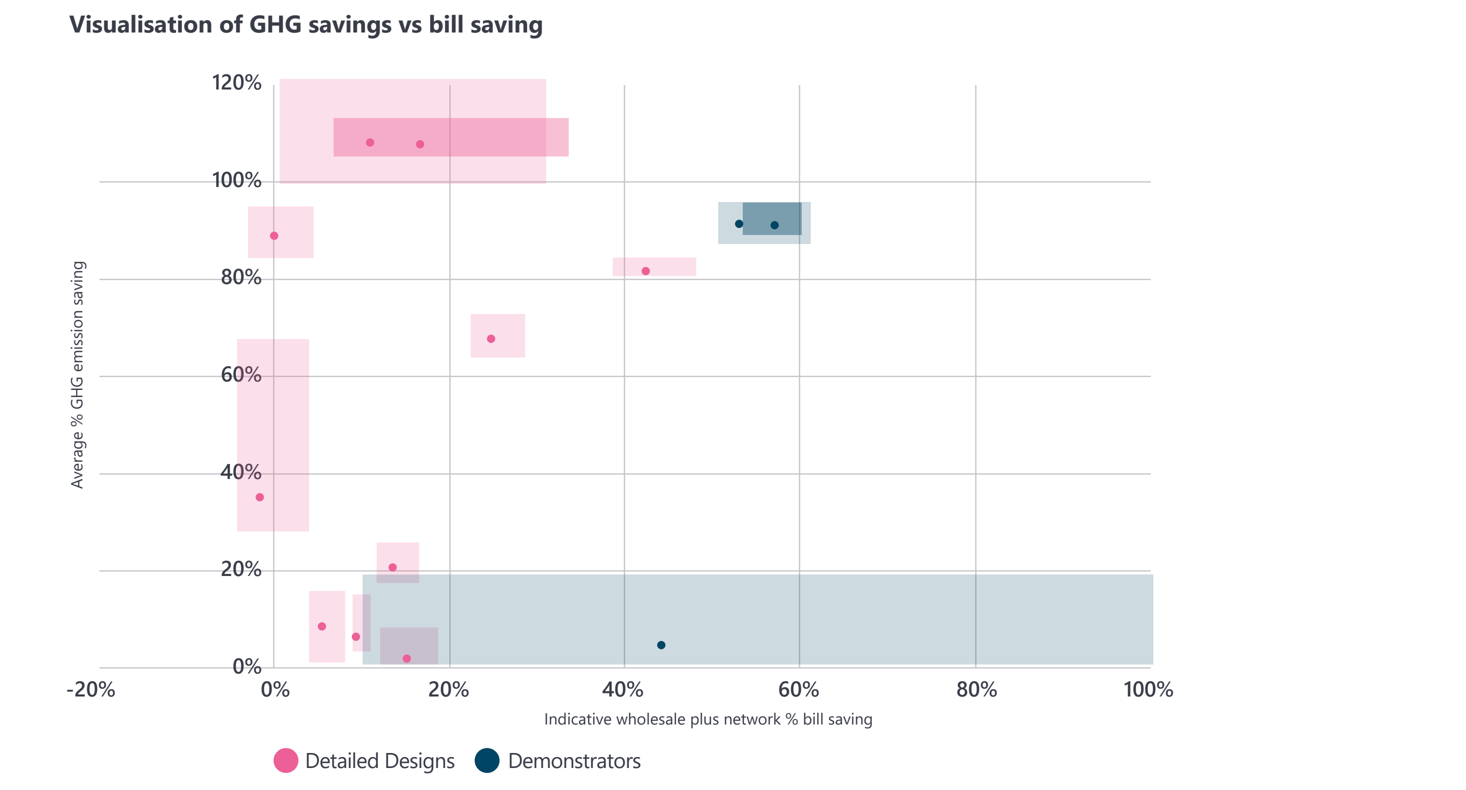


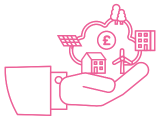
Figure 1 Visualisation of average GHG % reduction vs average bill reduction (energy + network). Each point is a project; shaded rectangles represent ranges of outcomes resulting from Monte Carlo analysis

8 For some projects, a primary aim was to deliver energy at the same cost as it is currently, hence no savings were identified.

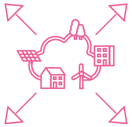
Commercial benefits

Basis for commercial evaluation

Projects were evaluated against a set of criteria that are grouped into three categories:



Investability
Does the SLES offer a compelling and de-risked value proposition?



Scalability
How far can the SLES expand in its location?

Replicability
How easily can the SLES be deployed in other locations?

Investability

Investability is vital for a smart local energy system, as this demonstrates the economic or social benefits that are created for its operators and participants, and whether a return on investment can be achieved in the form of revenues, cost savings (e.g. grid reinforcement costs, healthcare costs) or social value (e.g. cleaner air, warmer homes).

A more investable SLES design may be able to 'pay for itself' and enable LAs to attract external investment to assist with the capital costs of installing infrastructure. This is crucial to allow future SLES to reduce their reliance on public sector government funding. Attracting private finance will, in fact, be a necessity for delivering all of the energy infrastructure needed to reach Net Zero, as the scale of investment required is far beyond the scope of public borrowing or taxpayer funding (£50 billion each year from 2030 to 2050).[9]

The investability criteria used in the evaluation cover a range of characteristics, including revenue diversity, participant pull/uptake, size of total addressable market, unique selling point, IP protection and outstanding risks.

Revenue diversity

A system that relies on a single revenue stream is vulnerable to financial collapse if that source of revenue changes or is withdrawn (i.e. due to changes in regulation or market forces). Investable SLES designs will encompass a diverse range of revenue streams and will therefore be more financially resilient, presenting a less risky investment proposition for LAs, private investors and other stakeholders.

Some revenue streams may be more dynamic or have a higher level of future uncertainty than others. For example, the majority of the PfER SLES designs include at least some provision of ancillary services to the national grid (e.g. balancing mechanism, frequency response or reserve) as a primary or secondary revenue stream. However, ancillary services are currently awarded through a competitive auction process; consequently, bid offers vary significantly from day to day and hour to hour, and the revenue that an individual flexibility provider might be able to capture in the future is difficult to predict, as new flexibility markets may become established to meet rising demand. However, many new parties may also enter these markets and the number of competing offers may increase.

On the other hand, revenue streams that are protected over a relatively long term (e.g. a contract to supply heat to public or commercial buildings over a period of 10 or 20 years) might miss out on possible gains from market fluctuations but guarantee a more consistent revenue stream over a fixed period.

Investable SLES designs may therefore provide an attractive and de-risked rate of return by employing a variety of different sources of revenue, supplementing less certain but potentially more profitable revenue streams (e.g. payments for grid ancillary services) with more stable, fixed revenue streams (e.g. energy supply contracts).

9 https://es.catapult.org.uk/report/enabling-smart-local-energy-systems-finance-and-investment/

Direct revenue streams
Smart local energy systems can encompass a multitude of different direct revenue streams, such as:

- Sale of energy (e.g. heat, cooling, electricity)
- Electricity wholesale arbitrage[10]
- Sale of low carbon fuels (e.g. hydrogen, biogas)
- Sale or leasing of energy assets (e.g. EVs, solar panels, batteries)
- Sale of carbon credits
- Usage fees for private wire networks
- Payments for providing ancillary services to the national grid
- Payments for providing local flexibility services
- EV charge point operation
- Transaction fees for energy trading platforms
- Subscription fees for flexibility and smart EV charging platforms
- Subscription fees for home energy management or smart building management platforms
- Licences for access to platform data streams

These projects achieve good revenue diversity and ensure long-term commercial viability by blending dynamic revenue streams (e.g. flexibility services, arbitrage) with more stable revenue streams (e.g. supplying energy to end users), as well as sales and installation of physical assets (e.g. EVs, solar panels).

ReFLEX delivers a variety of revenue streams from a range of sources and for many different participants in the system, including (among others):

- Sale of wind power which would otherwise have been curtailed (for renewable electricity generators)
- Sale of battery and fuel-cell powered devices to end users (for the energy supply company)
- A commission on peer-to-peer energy trading transactions (for the flexibility platform operator)
- Revenue from ancillary services provided to the national grid (shared between the flexibility platform operator, the energy supply company and local end users participating in the system)

10 Purchasing electricity at times of low demand/high generation when prices are low and storing to sell at a later time when prices are higher.

Indirect revenue streams
Many of the PfER SLES designs enable avoidance of costs, which can be considered an indirect revenue stream.

For example, improved local flexibility or provision of private wire networks can avoid the need for expensive grid reinforcements which would otherwise be recharged to all local users via distribution charges on energy bills. While the construction of private wire networks might not be significantly cheaper than network reinforcements in terms of pure cost, they can be financed by private investment rather than via retail energy bills, which allows the cost of facilities such as EV charging hubs to be passed on more fairly to the customers that use them rather than taking a contribution from all energy users in the area.

REMeDY makes use of SMS's FlexiGrid platform to enable smart charging of EVs and battery storage, optimising energy use and reducing peak demand, thereby saving between £2.6 and £16.1 million in local network reinforcement costs. This in turn reduces costs for energy users, as the avoided reinforcement costs no longer need to be passed on to the consumer.

PIRI and **ESO** both utilise private wire networks to power rapid-charging superhubs for electric vehicles, which would otherwise cause a significant constraint and require upgrades to the capacity of the local electricity distribution network. The capital cost of installing the private wire network is recouped through the sale of solar-generated electricity to EV charging end users (in the case of PIRI) or by levying connection fees to charge point operators (in the case of ESO).

Saving on healthcare costs is another indirect revenue stream which may be particularly important to LAs, who have a statutory responsibility for public health. For example, improving the fabric of buildings through retrofit can make homes warmer and reduce the prevalence of respiratory illnesses caused by cold and damp conditions. SLES designs that support a transition to low carbon transport can help to improve outdoor air quality and reduce the amount of NHS money spent on treating respiratory conditions caused by air pollution, particularly in urban areas, which have higher concentrations of diesel-powered buses, taxis, delivery vans and municipal vehicles.

PIRI and **ESO** enable electrification of local bus and council fleets by providing capacity for rapid charging and, in the case of PIRI, opportunity charging along bus routes. The PIRI project, in particular, sought to prioritise electrification of bus routes that would have the largest health impact for the local community.

An effective SLES design may not only generate revenue within the system itself but also create opportunities for revenue generation outside it, which can in turn provide wider economic or social benefits to the local area.

The community BECCS design proposed by **ReWire** establishes a demand for biochar feedstock, creating a new revenue stream for local suppliers of waste wood or other waste organic materials which can be pyrolysed to produce biochar. This in turn encourages the maintenance of local woodlands or planting of new woodlands, with associated employment opportunities and enhancement of ecosystem services for the local community.

The biochar produced by the pyrolyser can be used as a low environmental impact fertiliser or as a sustainable additive for construction and road-building materials. The BECCS design can therefore indirectly help to decarbonise other industries, as well as generating low carbon heat and power.

Accordingly, SLES have the potential to create not only direct financial value but much wider indirect value. This may be of particular importance to LAs trying to build a business case for deploying a SLES in their area, or for private investors seeking to achieve greater environmental and social impact. However, it is worth noting that quantification of non-financial value is currently limited to the types of value included in The Green Book[11] guidance issued by HM Treasury; other types of non-financial value may be difficult to quantify.

11 https://www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent/the-green-book-2020

Incentives for participants

Value proposition
A compelling value proposition is essential to drive uptake and produce tangible benefits from participation in the SLES or from having a SLES in the local area. The value provided may be financial (e.g. revenues for generators, reduced energy costs for end users) or non-financial (e.g. warmer homes, cleaner air).
Financial benefits for participants may include:

- Revenues for generators, service providers and charge point operators
- Lower energy costs for end users
- Higher self-consumption of zero margin renewable electricity and reduced reliance on grid imports
- Payments for providing flexibility
- Alleviation of local grid constraints (with associated savings in connection charges and reinforcement costs)
- Discounts on energy assets and devices

Non-financial benefits may include:

- Lower greenhouse gas emissions
- Achieving Net Zero targets (especially for LAs, but also contributing towards the overall national Net Zero target)
- Warmer, more comfortable homes
- Improved air quality
- Safer, quieter roads
- Better health and wellbeing
- Lower healthcare costs
- Lower levels of fuel poverty
- Fairer access to local energy resources
- Enhanced access to public transport and low carbon mobility options
- Local job creation and skills development
- Greater community engagement and cohesion

The non-financial benefits created by a SLES may be far wider ranging and potentially greater in social and economic value than the financial benefits generated. PwC's 'Accelerating Net Zero Delivery' report[12] forecasts that a place-specific approach to Net Zero delivery will create £108 billion of energy savings for consumers and £825 billion in wider social benefits. Non-financial and social benefits are therefore a vital consideration for any SLES business model and a significant advantage of deploying SLES instead of individual energy solutions.

LEO found that social and environmental benefits are a strong motivator for early adopters of innovative technologies, and that SMEs tend to consider their contribution to the local community as well as financial concerns when investing in energy efficiency and low carbon technologies. Through their Smart and Fair Neighbourhood trials, LEO has sought to ensure that participation in SLES and access to energy flexibility services are available to everyone rather than just a minority who are able to purchase relatively expensive devices and assets. For example, in one trial at Osney Lock, a car club will provide affordable access to electric vehicles, which will be charged by locally generated renewable electricity.

ZCR proposes a model for carrying out deep fabric retrofit of energy inefficient housing at the same time as installing electrified heat, PV and energy storage solutions, with a payback mechanism that would be affordable to the occupant/homeowner. This would result in homes that are easier and cheaper to power and keep warm, with improved comfort for occupants.

12 https://www.ukri.org/publications/accelerating-net-zero-delivery/

Stakeholder engagement
Strong outreach and engagement with potential customers and participants of the SLES may be time- and resource-intensive, but it is crucial to generate awareness, enthusiasm and trust within the local community, and hence drive uptake of the SLES. In particular, co-creating a SLES with local stakeholders and residents at the design stage may help to ensure that the system meets the needs of users and functions as intended.

ReFLEX has worked closely with the population on Orkney to encourage support for the ReFLEX project and engagement with local energy issues. Methods of outreach include a public experience centre, which acts as a point of contact for members of the ReFLEX scheme as well as an information hub for individuals interested in learning more about the programme. This has resulted in very high uptake of EVs in Orkney, with over 900 members participating in flexibility through smart EV charging.

MHEK carried out extensive public outreach to educate the local community about, and familiarise them with, the idea of utilising hydrogen as a transport fuel and energy vector. Activities included setting up an information hub open to the public and giving talks and demonstrations in schools and at community events. This has resulted in an unusually high level of awareness and enthusiasm for hydrogen in the area.

Scalability

Scalability refers to the ability of a SLES to expand in size in its original location. Expansion is not a necessity for all SLES; some systems will be intentionally designed at a small community or neighbourhood scale, with replicability in mind rather than scaling. However, for some SLES designs – particularly those which incorporate elements of peer-to-peer energy trading or in which individual users are aggregated to provide ancillary services to the grid – a minimum number of users may be required in order to operate the system, and increasing the number of users will improve the system's functionality.

Scaling can potentially be restricted by a number of different factors, including:

- Geographical limitations
- Network constraints
- Local resource availability
- Local addressable market
- Architectural limitations (for software)
- Regulatory barriers

Several of the PfER projects were primarily aimed at designing software-based solutions for local energy and flexibility markets or virtual network management. Such software-based systems are inherently well suited to scaling, as they can accommodate a large and variable number of users and are not limited by geographical constraints. These types of system also tend to be specifically aimed at alleviating network constraints, by matching local supply with local demand and smoothing out peaks, and so are less likely to be restricted in scale by the capacity of the local distribution network.

Installing compatible assets or upgrading existing assets, so that they can communicate with a central trading or flexibility platform, is key for software-based SLES designs. Rapid scaling could therefore be assisted by greater standardisation and harmonisation in energy asset data, APIs and control systems.

Alignment of SLES with local area energy plans (LAEPs) and LAs' regional energy strategies may also help to ensure that any assets installed in a local area are coordinated and ready to participate in any existing or future SLES platforms.

Girona has investigated the possibility of offering 'Energy Flexibility as a Service' on custom micro-grids in Northern Ireland. In this SLES, domestic PV and battery assets can be aggregated and optimised via a trading platform named PARIS (Predictive Analytical Renewables Integration System). PARIS is hosted on the Amazon Web Services (AWS) platform and is therefore capable of processing a very large volume of transactions, which will facilitate scaling. PARIS theoretically allows any PV/battery system to connect in, not just those installed by the SLES operator, so the Girona SLES is not limited in scale by local resource or addressable market availability, and actively facilitates widescale deployment of PV and battery assets across Northern Ireland.

GMLEM comprises a local energy marketplace built on a digital platform called the 'market maker', which allows the system's participants to view local energy supply and demand, and transact with each other directly. While the SLES requires participants to have 'LEM-enabled' energy assets which can transmit their status to the market maker platform, GMLEM forms part of GMCA's overall regional energy strategy and so planned projects are already in place to deploy the necessary assets and create the enabling environment for GMLEM to exist and scale.

Replicability

Replicability refers to the ability of a SLES to be duplicated in other locations. Replicability is an important characteristic that will allow experience and lessons learnt to be shared, which should in turn reduce capital costs, accelerate installations, improve uptake and result in better outcomes for subsequent SLES and their participants.

By nature, SLES are generally tailored to local resources, geography, energy demand profiles and network characteristics. As such, many SLES designs cannot simply be replicated in another location without some level of modifications to reflect local attributes. However, certain aspects of a SLES can potentially be reproduced wholesale (e.g. software-based trading/flexibility platforms, in particular) or interchanged with equivalent components that are available locally (e.g. different sources of heat to supply a heat network). Greater standardisation and interchangeability of components can therefore aid in replicability of SLES (or aspects of a SLES) in different locations.

GreenSCIES developed a methodology for replicating an Islington-based heat, power and transport network in other urban locations across the UK and conducted feasibility studies at three other selected sites. The intention of the feasibility studies was to demonstrate that the core features of the SLES – in particular the 5th-generation heating/cooling network and thermal storage – could be deployed in other locations using locally specific sources of heat/storage (e.g. mine water, industrial waste heat) instead of those used in Islington (e.g. data centres, natural aquifers).

The heat and power modules used in **ReWire's** community BECCS design are completely interoperable with typical heat/power distribution infrastructure and can simply be slotted in as a heat source on an existing or purpose-built heat network or as an electricity generation/storage source on a power network. The compressed air energy storage technology (supplied by Cheesecake Energy) is itself made from ubiquitous and affordable components, such as repurposed end-of-life diesel engines and gravel, which lends itself well to replication in other countries by avoiding the need for complex supply chains. However, the system is compatible with any energy storage technology, so can operate with whatever equipment is locally available.

Business model archetypes

As detailed in ESC's 'Emerging Business Models for Smart Local Energy Systems',[13] SLES can be broadly categorised into five business model archetypes:

- Project marketplace
- Local flexibility market
- Local energy market
- Virtual network manager
- Anchor asset

The evaluation of the PfER SLES projects found that no single business model archetype proved to be significantly more or less investable than the others. Variation in the investability of business models within the same archetype was generally based on the attractiveness of the value proposition to participants and the size of the addressable market. Value propositions which encompassed comprehensive social benefits rather than solely financial benefits tended to score highest on investability, as they provided a more compelling value proposition for participants and communities, which is likely to drive uptake and hence increase the size of the obtainable market, as well as improving the business case for local authority funding and private impact investment.

SLES designs based on virtual connections (i.e. the virtual network manager, local energy market and local flexibility market archetypes) generally scored highly on scalability, being unrestrained by physical limitations. On the other hand, anchor asset based SLES designs tend to be less easy to scale, due to reliance on local resource availability, and benefit less from economies of scale as the number of users increases.

Many of the SLES designs showed good potential for replicating in other locations, with no particular business model archetype standing out as better or worse than the others. Projects which gave greater consideration to the standardisation and interchangeability of the physical hardware and/or software platforms used in the SLES tended to demonstrate strong replicability.

13 https://es.catapult.org.uk/report/business-models-for-smart-local-energy-systems/

Commercial investment case studies

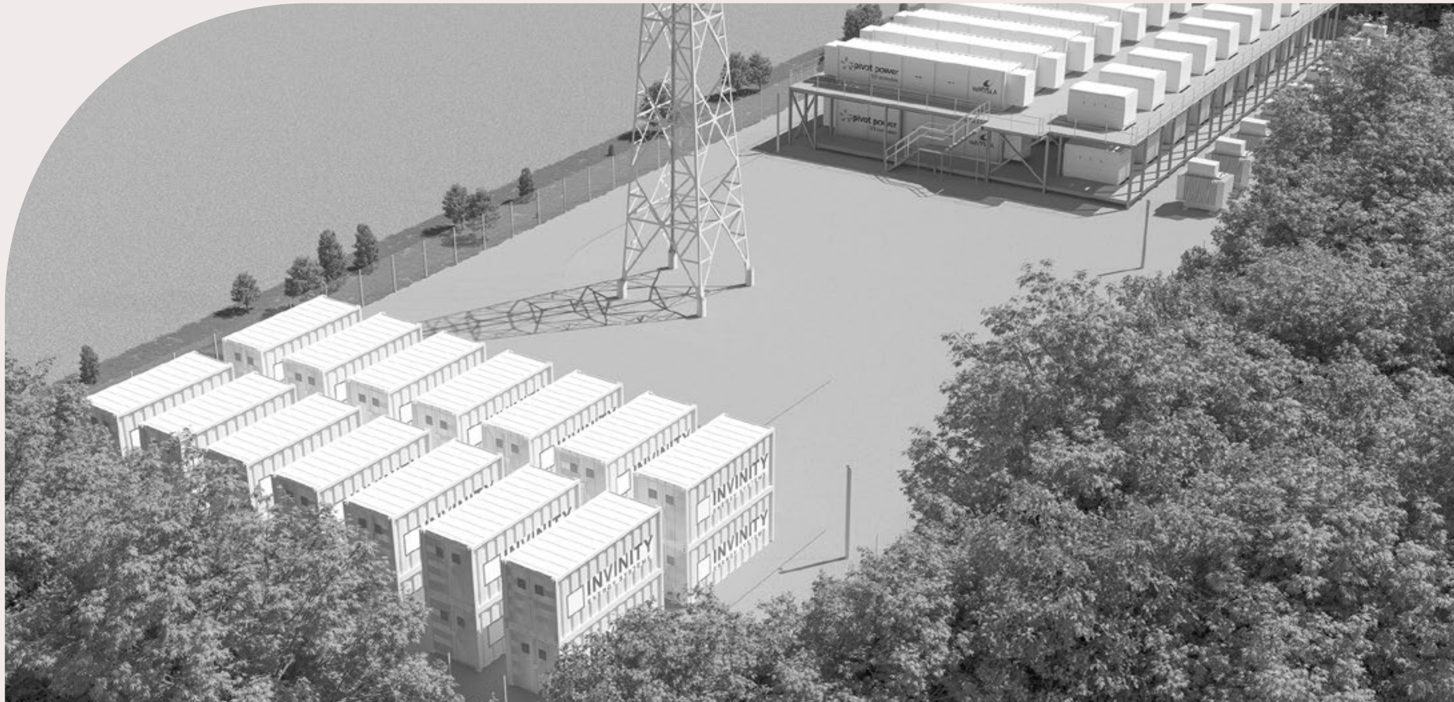
ESC's 'Enabling Smart Local Energy Systems: Finance and Investment'[14] explored in detail the different types of investors that may be interested in collaborating with LAs on SLES opportunities, the roles they can take on within a SLES consortium and the private financing options they can contribute.

The report also summarises several examples of organisations involved in PfER SLES projects that have received significant private investment, such as EDF's acquisition of battery storage and EV charging infrastructure firm Pivot Power (lead partner on ESO).

Since 2018, Low Carbon Hub (a key partner on LEO) has successfully raised over £6 million from over 1,700 private investors for their Community Energy Fund, which is used to support a growing portfolio of community energy projects across Oxfordshire.[15]

In 2020, Legal & General Capital invested in a significant stake of heat pump manufacturer and installer Kensa Group (delivery partner on ESO), to accelerate scaling of ground source heat pump deployments. Since the initial investment, Kensa Group's revenues have doubled, motivating Legal & General to make a further investment of £8 million in June 2022, bringing their total investment to £15.7 million.[16] This investment supported Kensa Group to target a twofold increase in production capacity by 2023 and open the UK's largest ground source heat pump production facility.[17]

Regen's report 'Smart Local Energy Systems: Finance and Investment' notes that project partners have received over £733 million in investment (including private, equity, merger, grant and venture capital funding) since participating in the PfER programme,[18] clearly demonstrating the value and investability of SLES projects.



14 https://es.catapult.org.uk/report/enabling-smart-local-energy-systems-finance-and-investment/
15 https://www.lowcarbonhub.org/invest/
16 https://group.legalandgeneral.com/en/newsroom/press-releases/legal-general-boosts-investment-in-the-kensa-group-to-scale-up-ground-source-heat-pump-deployment
17 https://group.legalandgeneral.com/en/newsroom/press-releases/kensa-and-legal-general-celebrate-a-greener-future-with-official-factory-office-opening
18 https://www.ukri.org/publications/smart-local-energy-systems-finance-and-investment/

User acceptance

To achieve the commercial benefits outlined in the 'Commercial benefits' section above, a SLES must have a sufficiently large customer base and must deliver excellent ongoing customer service that retains those consumers.

ESC surveyed a nationally representative sample of over 3,000 UK consumers to understand the appeal of SLES and the different vectors and services which could be included. The research showed that SLES are appealing to many consumers, with 53% of them welcoming a change from a large-scale and distant energy system to a SLES. More than half of the respondents also reported wanting to get involved in a SLES within the next five years, should one be offered in their local area.

Survey participants were keen to reduce reliance on the national energy network and maximise use of locally generated energy (Table 3). They identified benefits that included reduced energy costs and carbon emissions as well as community benefits.

Five SLES propositions were presented to respondents in ESC's survey, each with a summary of some of the services and technologies that a SLES could include. The propositions were: generating power, using power, home heating, transport services and charging services.

Table 3 Key SLES benefits

Key SLES benefits	% survey respondents
Maximise the use of local renewable energy generation in my community	**70%**
Reduce my community's reliance on national energy networks	**67%**
Create opportunities for people in my community to participate in the energy system	**66%**
Make heat more affordable for vulnerable customers	**66%**
Create a healthy environment for me and my family to live in	**66%**
Enable me to have more control of my energy bills	**66%**
Reduce my carbon emissions to help my local area meet climate targets	**65%**
Reduce my energy bills	**65%**
Share the benefits with my local community	**64%**
Create local jobs within my community	**63%**

Concepts that relate to 'generating power' and 'using power' were the most appealing to survey respondents, with 66% and 59% respectively agreeing that they would welcome these concepts in their local area. The most popular elements of these power-related propositions were being able to store energy when it is widely available, and store energy collected from renewables. These benefits appear to resonate with respondents' concerns in the current economic climate where mentions of power cuts are relatively commonplace in the media.

In addition to understanding the overall appeal of SLES, the demonstrator projects provided an opportunity to investigate how SLES can deliver a best-in-class user experience. An excellent experience is essential to secure ongoing consumer engagement in SLES services and to build positive public perception so that SLES can be replicated in other areas. Demonstrators were evaluated on six user experience metrics representing the customer journey, from first learning about a service to long-term, day-to-day use: awareness, appeal, access, useability, resolution and satisfaction.

Overall, the demonstrators delivered a good service across these metrics, with some even managing **to achieve best-in-class service while trialling innovative technologies and services.**

Awareness levels varied between the SLES projects, with those using 2-way channels of engagement, which invite comment from residents, typically raising greater awareness and appeal of their offering among consumers. The demonstrator projects in particular, which engaged heavily with the local communities, achieved higher appeal for SLES in ESC's survey compared to the rest of the UK.

One-way engagement:

- Website describing trial and updates
- Social media: Twitter, Facebook, LinkedIn
- Newsletter
- Local print and broadcast media
- Community groups

Two-way engagement:

- Community events
- Citizens' jury of local people
- Research activities (e.g. focus groups, surveys, interviews)

MHEK set up an information hub open to the public and gave talks and demonstrations in schools and at community events. This has resulted in an unusually high level of awareness and enthusiasm for hydrogen in the area.

The demonstrator projects were able to deliver their services with low access barriers to consumers by reducing upfront costs and creating consumer-friendly sign-up processes that were easy to navigate.

Girona offered domestic customers free battery storage and solar panels and covered their installation costs, thereby removing any financial barriers to taking part in their SLES.

Most participants of PfER demonstrators also agreed it was easy to use the services once installed and that they delivered the benefits they had expected. However, 39% of PfER project participants in ESC's survey needed technical support with novel technologies. While this might be expected, limiting the need for support by providing adequate upfront information or demonstrations is important to make new technologies easily accessible.

ReFLEX informs people on its website what action it would take should an issue occur, which provides clarity and may alleviate initial worries. For one of its services, it provides a bridging solution, such as a replacement car, for the entire time that the issues with the customer's vehicle are being fixed.

With any ongoing service, resolving issues to the satisfaction of the customer is essential to continuing success. Challenges naturally arose for some demonstrators trialling new technology and services. Where those issues were resolved promptly and to the satisfaction of the customer, participants in ESC's survey reported higher satisfaction with the trial overall. The user acceptance survey found that most PfER project participants (86%) would like to continue participating in the project, signalling their satisfaction with the trial and the benefits received.

ZCR conducted extensive community engagement online, in person at numerous events, and with community ambassadors. Three housing retrofit plans have been created, showing the route to Net Zero as a community engagement tool and support has been given to use the Social Housing Decarbonisation Fund. They gained feedback on businesses' and private consumers' acceptance of topics such as retrofit and smart energy management systems, and they are using these findings in their designs for future SLES.

The importance of user engagement and benefits of local democratisation (who owns what and who benefits), plus a focus on governance, was a theme highlighted during the EnergyREV[19] workshop 'Why SLES – the value case for SLES'. GMLEM addressed the principles of democratisation well, using a citizens' jury[20] to support decision making on how the **GMLEM** should be owned and governed going forward.

19 https://www.eventbrite.co.uk/e/why-sles-the-value-case-for-smart-local-energy-systems-tickets-402327521447
20 https://carbon.coop/portfolio/gmlem-citizens-jury/https://carbon.coop/portfolio/gmlem-citizens-jury/

Addressing energy vulnerability and fuel poverty

Households who are at risk of fuel poverty or are energy vulnerable have a low income, proportionately high energy costs and/or suffer from a health condition exacerbated by the cold. High energy costs can be driven by the amount of energy required to heat the home, for example in poorly insulated properties, or by the price paid for energy, for example if on a prepayment meter or if there is a debt on the account.

National Energy Action estimated that 6.7 million households were in fuel poverty in April 2022. This represented an increase of more than 50% in just 6 months.[21]

Vulnerable households are not all the same; their behaviour, needs and attitudes vary as much as those of other consumers. While they may struggle to afford the cost of energy, research has shown that vulnerable customers do not want to minimise what they spend. Instead, they want to manage how much they spend while getting the heat they want.[22]

Many of the PfER projects achieved a reduction in energy costs, which could have a direct impact on fuel poverty.

- Four projects showed potential to reduce wholesale and network costs by 25%.
- Two projects demonstrated savings of £223 or more per household per year across wholesale and network costs, the amount which BEIS and ONS estimate would remove an average household from fuel poverty[23] in 2020.

SLES present a range of opportunities to address the causes of energy vulnerability while meeting the diversity in consumer needs. For example:

→ Facilitating home retrofit, and particularly insulation, to reduce energy needs

→ Making energy generation and storage available at a local or individual level to reduce energy costs

→ Exploiting low-cost local sources of heat, e.g. waste heat, heat from water sources

→ Reducing the cost to serve customers, and so the cost of energy, through the revenue streams identified in 5.2.1.1 and through centralised operation and maintenance costs as in district heat networks

21 https://www.nea.org.uk/energy-crisis/fuel-poverty-statistics-explainer/
22 'Fuel Poverty in a Smart Energy World', Energy Systems Catapult (https://es.catapult.org.uk/report/fuel-poverty-in-a-smart-energy-world/)
23 BEIS Annual Fuel Poverty Statistics in England, 2020 (2020 data)

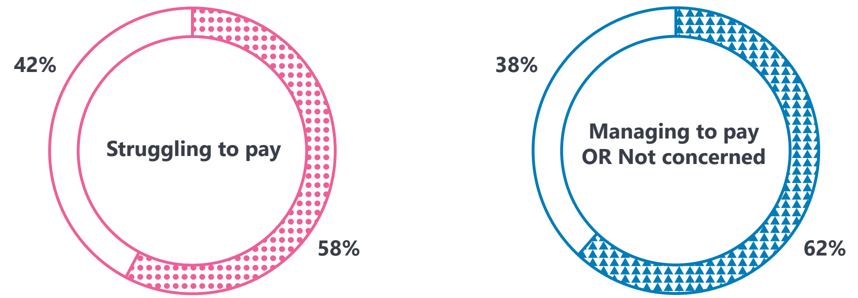
In a nationally representative survey of UK consumers conducted by ESC in October 2022, 16% of people identified as struggling to pay their energy bill. A comparison between those who identify as struggling to pay for energy and other respondents in the survey demonstrates that both groups are seeking similar things from future SLES.

Both groups find the SLES concept similarly appealing and identify the same benefits from SLES, particularly reduced carbon emissions (55%), improved local economic development (53%) and feeling more in control of energy use (53%).

REMeDY conducted surveys and engagement with residents and landlords to inform their design of a SLES for social housing in Southend, and to test resident experiences, they prototyped a future smart energy experience app with different plans and scenarios.

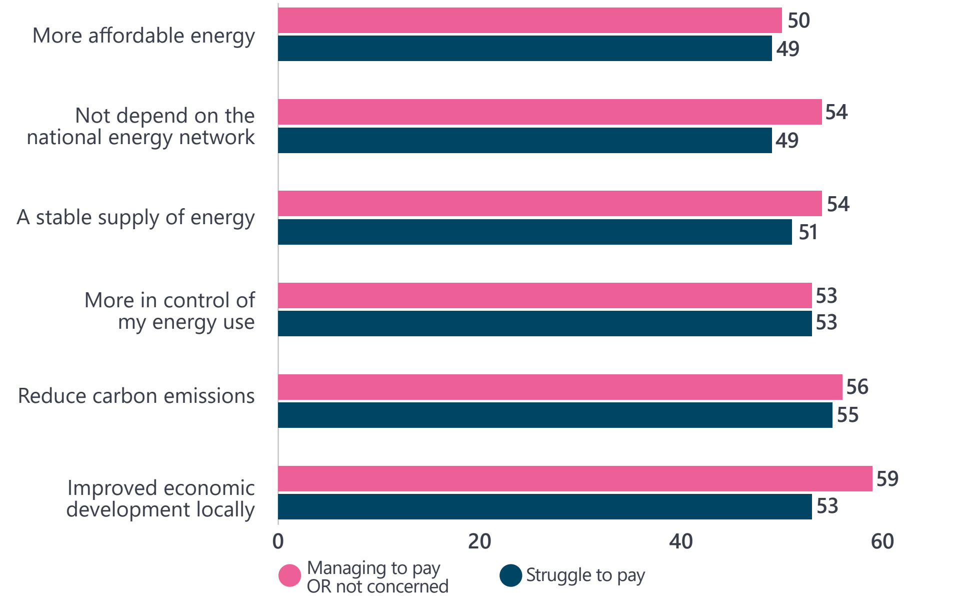
They found that to combat practical concerns and perception of risks, designing services that meet user needs, build community trust and protect – especially low-income vulnerable users – from risk is key to any solution.

% welcoming SLES in their area



Those rating within top 2 boxes on a 5-point scale from strongly object to strongly support Struggling to pay n=472; Managing to pay or Not concerned n=2,537)

% Identifying benefits of a SLES



Those rating within top 2 boxes on a 5-point scale from strongly agree to strongly disagree.Struggling to pay n=472; Managing to pay or Not concerned n=2,537)

LEO's Smart and Fair Neighbourhood Trial included the development of a partnership model enabling residents of flats to benefit from solar panels installed by their landlord or another third party. A new electricity tariff goes further to make flexibility services available to these tenants.

Fuel-poor consumers can face barriers to accessing the very technologies and services that reduce energy needs and energy costs. Below is an exploration of these barriers and the ways in which some PfER projects have addressed them.

Tenancy

Of those struggling to pay in ESC's survey, 57% live in social housing or a privately rented home.

Those who rent their home from a private or social landlord do not normally have the ability to retrofit their home and so reduce their energy needs. They are also unable to install new technologies that might reduce energy costs, be that more efficient heating systems or technology for self-generation and/or storage.

SLES that engage private and social landlords are essential to address fuel poverty.

Payment type

Of those struggling to pay in ESC's survey, 27% have a prepayment meter, compared to 11% of other consumers.

Households who pay for energy on a prepayment meter pay more per unit than other consumers. However, moving off a prepayment meter can be challenging for low-income consumers. It requires the consumer to clear any energy debt and either undergo a credit check or pay a deposit, typically around £150 to £300 depending on their consumption.

There are far fewer energy tariffs available to prepayment customers and there is a risk that future energy services also remain limited or unavailable to this group. Therefore, a prepayment meter could become a barrier to participation in SLES, and other services, limiting access to lower energy prices among those who need them most.

A project led by **Urbantide** as part of the Modernising Energy Data Applications (MEDApps) programme is supporting fuel-poor households through data integration and artificial intelligence. Using smart prepayment meters and other data sources (such as EPC and Experian data), it can help LAs to identify households that are fuel poor or may benefit from energy efficiency programmes.

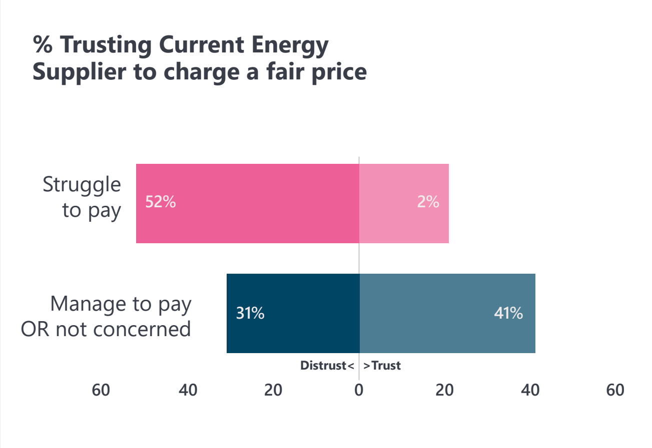
To address energy vulnerability, future energy services will need to deliver for those with prepayment meters and support switching with an energy debt.

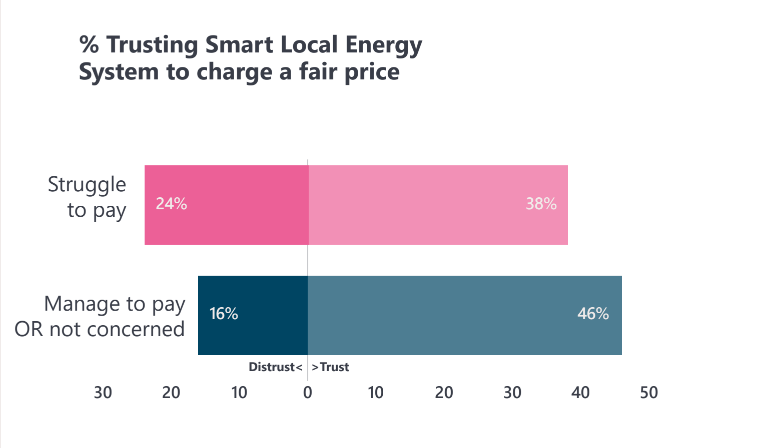
Trust

In ESC's survey, those who are struggling to pay rate their trust of both the energy sector and future SLES propositions lower than other respondents.

Those who are struggling to pay are also less trusting of many sources of energy information tested in the ESC survey. In particular, energy companies and LAs/councils are trusted less by those who struggle to pay.

Building trust among those who struggle to pay for energy will be essential to creating the confidence needed for consumers to move to SLES. Several of the PfER projects demonstrated how the focused engagement of local residents can build awareness and trust in novel SLES services.





Those rating within top 2 boxes (Trust) and bottom 2 box (Distrust) on a 5-point scale from strongly distrust to strongly trust [current energy supplier / Smart Local Energy System]Struggling to pay n=472; Managing to pay or Not concerned n=2,537)

Table 4 Consumer trust

How much do you trust the following to give you impartial information?	Struggling to pay (n=472)	Managing to pay OR Not concerned about paying (n=2,537)
Citizens Advice	71%	77%
Trading Standards	53%	66%
Government websites	38%	53%
Ofgem	31%	43%
Local authorities/councils	28%	42%
Energy suppliers	18%	31%

Energy Superhub Oxford's heat pump partner, Kensa, employed a tenant liaison manager to be on site during drilling and internal works. When first approached, several tenants declined to take part due to concerns about disruption, among other things. The tenant liaison manager talked to tenants and built trust, resulting in the majority of those approached taking part in the trial and providing positive feedback on the installation.

GreenSCIES undertook extensive community engagement through online and in-person co-design workshops in Islington. Residents had their questions and concerns addressed and gave feedback on the scheme. This raised awareness and built trust as potential solutions were discussed with residents.

Levelling up

Successful implementation of SLES can contribute to regional levelling-up aims, particularly "by 2030, pay, employment and productivity will have risen in every area of the UK, with each containing a globally competitive city, and the gap between the top performing and other areas closing".

The PfER projects have all shown that they are commercially viable proposals which have already or would if they progressed increase employment in their areas. Many of the PfER funded projects are in areas which are targeted for levelling up. For example, the West Midlands combined authority (WMCA) levelling-up growth prospectus[24] highlights **RESO** as a project that "identified a net present value of approximately £720 million in savings over 30 years from taking a place-based approach to planning and operating the whole energy system. Additionally, there was a further £34 million of savings per year for its host locality, which in this case was the city of Coventry."

24 https://www.wmca.org.uk/documents/levelling-up/west-midlands-levelling-up-prospectus/

Technology pull-through

Smart local energy systems enable the effective use and pull-through of new technologies, as has been shown by both the detailed designs and the demonstrators, as well as across the 15 projects on Key Technology Components (KTC) and 12 projects on modernising energy data access and applications (MEDA/MEDApps) that the PfER programme has funded.[25]

The application of new technologies has been predominantly demonstrated in the software and control systems utilised in the PfER projects, rather than in new hardware. However, the PfER SLES projects have been able to use existing technologies in smarter and more integrated ways to maximise the benefits of existing and new hardware technologies, such as the **ESO** programme, which demonstrated the use of a novel hybrid vanadium flow/lithium ion battery in flexibility services, and **Girona**, with its behind-the-meter battery storage and solar PV solutions. The **Port Energy System Optimisation** (PESO) KTC project is also exploring large capacity hybrid lithium ion-lead acid batteries at Portsmouth harbour, by integrating them into the port's energy network, and utilising an advanced energy management system that optimises the energy flow and coordinates with the grid.

Other KTC and MEDApps projects, in particular, have shown promising results and great potential for the future.

KTC: Maximising Grid Services from Electric Vehicles (M-GSEV)

The project has developed a solution which allows households to use smart charging to provide flexibility services to the grid, through the existing **ev.energy** platform. This also enables owners to optimise the time when they charge their vehicle, saving them money. The project has a number of partners, including **LEO**, through which they have enrolled 140 assets. As of November 2022, 9,250 EV drivers have downloaded the ev.energy app in the UK, and 1,166 smart-enabled chargers have come online.[26]

KTC: Guru – Intelligent technology for the future of heat

Guru Engage focuses on helping heat networks to fulfil their potential in supporting decarbonisation. During their project, Guru improved outcomes on heat networks, heat pumps and boilers, and carried out a complete redesign of their existing in-home display hardware and user interfaces to include smart heating controls, environmental sensors, language support, flexible payment and household cost projections based on customer and system data.

25 https://www.ukri.org/wp-content/uploads/2022/01/UKRI-250122-SmartLocalEnergySystemsEnergyRevolutionTakesShape.pdf
26 https://www.ev.energy/

Challenges and opportunities

Policy and regulation

As highlighted in Regen's 'Smart Local Energy Systems: Policy and Regulation' report,[27] UK energy policy and regulation is still organised around the incumbent large-scale, centralised energy generation system, with very little allowance made for local-scale energy delivery. While some of the PfER projects have been specifically designed to function in today's regulatory environment, current regulation presents a major barrier for many SLES designs; particularly those incorporating elements of peer-to-peer energy trading, which is currently impossible under today's regulatory regime.

RESO suggested a way of overcoming this problem by delegating regulatory governance of local energy systems to a regional energy system operator, which can react agilely and enact more rapid changes to regulation based on evolving needs of the local energy system. Ofgem has since set out its proposal for energy sector reforms,[28] including an overhaul of energy code governance, which could pave the way for local energy system operators to apply for a code manager licence and enable regulatory powers to be devolved at a local level.

Electricity

Licensing requirements for electricity supply and distribution are currently a significant obstacle for smart local energy systems. Under the 1989 Electricity Act, all energy transactions must go through a licensed energy supplier. However, the process of becoming a licensed supplier is very complex and expensive, reflecting the substantial responsibility and obligations associated with serving a vital public utility.

REMeDY originally aimed to fully integrate heat and power systems, with renewable electricity being supplied by an energy service company (ESCo) over a private wire network to domestic and commercial users. However, due to the aforementioned licensing requirements, the SLES design had to be altered to encompass individual behind-the-meter PV generation, battery storage and EV charging solutions instead of private wire supply. Although this negated the need for the ESCo to obtain a supplier licence, the economic benefits to stakeholders were decreased due to the smaller pool of assets available to participate in flexibility services.

While certain exemptions from the 1989 Electricity Act apply, it may not always be straightforward or possible for a SLES to operate under these exemptions, particularly when seeking to scale the system. For example, Licence Exempt Supply (LES) regulations allow up to 2.5MW to be delivered to domestic consumers without a licence, but only for suppliers who themselves generate the electricity they are supplying.[29] This can be problematic in SLES designs where the generator and the supplier are separate entities.

In the case of **PIRI**, the energy recovery facility (ERF) that is used to generate electricity for the private wire network is owned by Peterborough City Council, but the council is not willing, and does not have the necessary capabilities, to become a supplier to end users. The project partners are therefore exploring the possibility of transferring ownership of the ERF to a special purpose vehicle (SPV) comprising the council and a delivery partner, which would also own the private wire network and supply electricity to customers.

'Third party access' rules, introduced in The Electricity and Gas (Internal Markets) Regulations 2011, are another major hurdle for private wire networks serving residential properties. These rules stipulate that domestic customers have the right to switch their energy supplier and that licence-exempt network operators must provide access to third party suppliers in the event of a switch unless it is not technically feasible to do so. The possibility of customers switching to other suppliers could jeopardise revenues from sale of electricity and undermine returns on investment in private wire networks. However, the threat of third party access could possibly incentivise ESCos to provide excellent customer service and added value to end users in order to discourage switching, thus creating better outcomes for customers.

27 https://www.ukri.org/publications/smart-local-energy-systems-policy-and-regulations/
28 https://www.ofgem.gov.uk/publications/net-zero-britain-developing-energy-system-fit-future
29 https://www.legislation.gov.uk/uksi/2001/3270/schedule/4

DNO-mandated restrictions such as active network management (ANM) may present a further hindrance for SLES. For example, ReFLEX has been prevented from rolling out PV/battery systems on a commercial scale due to ANM restrictions on behind-the-meter assets in Orkney. Individual users are still able to install their own PV/battery systems, which could then be connected into the SMS FlexiGrid platform that **ReFLEX** operates on, but they are currently unable to benefit from the economies of scale that would be associated with the larger asset procurement scheme intended by ReFLEX. Project partners are actively engaging with SSEN to demonstrate that the FlexiGrid system can alleviate network constraints and persuade the DNO to relax the ANM restrictions on larger-scale asset installations.

LEO demonstrated the benefit of bringing DNOs on board with SLES projects to overcome network barriers, facilitate development of end-to-end systems connecting users to DNOs and ensure that local flexibility is appropriately valued.

Heat

Unlike retail electricity supply, heat networks are currently operated under monopolistic arrangements and are not subject to third party access or consumer protection rules. However, this has sometimes resulted in poor outcomes for customers, who are unable to switch their heat supplier in the event of substandard service and are not currently protected by the Ofgem energy price cap. High-profile cases of customers incurring bills of almost £1,000[30]per month could fatally undermine public confidence in heat networks as an efficient and cost-effective means of decarbonising heating.

The Energy Security Bill, which was introduced to Parliament in July 2022, proposes a number of measures to regulate heat networks and provide a framework for heat network zoning in England[31]. Heat network zoning is intended to accelerate the rollout of heat networks, which would benefit SLES designs that include heating. The introduction of consumer protections and price regulation may also improve customer satisfaction and public perception of heat networks, which might help to drive greater uptake of SLES heat networks.

30 https://heattrust.org/news-events/164-heat-trust-sounds-the-alarm-for-half-a-million-families-and-flat-shares-not-protected-by-energy-price-cap

31 https://www.gov.uk/government/publications/energy-security-bill-factsheets/energy-security-bill-factsheet-heat-networks-regulation-and-zoning

Other regulation

As highlighted in Regen's 'Smart Local Energy More innovative SLES designs may face niche regulatory challenges, which could require collaboration with relevant authorities to assist in developing nascent regulatory frameworks.

SLES designs that include hydrogen as an energy vector may be subject to a number of regulatory and planning hurdles. For example, projects will need to ensure compliance with Control of Major Accident Hazards (COMAH) regulations if more than 5 tonnes of hydrogen is to be stored. An absence of specific hydrogen-focused legislation means that it is still regulated alongside natural gas under the Gas Act 1986. Consequently, the responsibility for consenting to hydrogen projects lies with planning authorities, who are not familiar with safety considerations for hydrogen production and distribution. This is currently causing lengthy delays in obtaining consent for hydrogen projects, averaging 20 months.[32]

MHEK actively worked in partnership with Natural Resources Wales to improve the consenting regime for small-scale electrolytic hydrogen production in Wales, simplifying the process to enable more rapid deployment of smaller-scale projects.

32 https://www.burges-salmon.com/consenting-hydrogen-projects

Technical challenges for providing flexibility

Time of use tariffs

Granular time of use tariffs (TOUTs) are a necessity for many smart energy systems – particularly flexibility services – as they allow energy usage and consumption behaviours to be influenced by sending timed pricing signals to end users. However, very few electricity suppliers currently offer TOUTs, and access to these tariffs requires half-hourly smart meters to be installed.

No TOUTs are currently compatible with prepayment meters, which therefore excludes a segment of the domestic market from participating in flexibility and benefiting from lower energy costs at times of high renewable generation.

In order to unlock the full potential of SLES and demand-side response, market-wide half-hourly settlement and greater and more inclusive availability of TOUTs must be supported.

Minimum volumes
A minimum volume of demand or generation (e.g. 1 MW) is usually required to participate in national flexibility markets. Smaller users – particularly domestic users – will not be able to meet this level alone and so will need to be aggregated with other users in order to participate collectively. However, even when pooled together, some communities may not reach the minimum volume required for national flexibility requirements. For example in the case of **ReFLEX**, the combined energy assets on Orkney were not sufficient to be able to participate in the balancing mechanism alone. SMS plc proposed to work around this issue by aggregating users of the FlexiGrid platform on Orkney with other users behind the same grid supply point on the Scottish mainland to meet the minimum required volume.

There is an opportunity for DNOs to establish local flexibility markets and provide more granular half-hourly pricing signals, to encourage higher levels of local flexibility and allow smaller flexibility providers to participate.

Digital standardisation and interoperability
Each different type of asset, and each different brand, may need a custom API written to enable control by smart energy systems and flexibility platforms. Development of new APIs is very time consuming and may limit participation in SLES to only certain types or brands of energy assets. Greater standardisation and harmonisation among manufacturers will be required in order to ensure compatibility and allow wider participation.

Some older assets may also need to be upgraded or replaced so that they can be used for flexibility, which will incur additional costs.

The Energy Digitalisation Taskforce has made recommendations to Government to address these issues, including mandating a minimum level of smart functionality and connectivity in consumer energy devices, and creating a digital spine for the energy system to enable interoperable plug and play options.[33] The PfER programme has also awarded funding for six projects to deliver new open software, hardware and data solutions.[34]

33 https://es.catapult.org.uk/report/delivering-a-digitalised-energy-system/
34 https://www.ukri.org/news/new-open-digital-solutions-to-speed-up-the-energy-revolution/

Conclusions

Opportunities

The scale of low carbon investment required to meet Net Zero by 2050 is not achievable with public borrowing or taxes alone; private finance will also be required to deploy local infrastructure to decarbonise communities. On the other hand, there is a multitude of private funding on offer from institutional investors, but a shortage of investable projects that are readily available to receive it. The scale-up of SLES and establishment of commercially viable business models could provide a channel for investment into local decarbonisation projects and help to accelerate the Net Zero transition.

However, this does not mean that local energy systems need to be purely profit-driven. Smart local energy systems have the potential to create a wide range of both economic and social benefits for local communities, generating wider value which far exceeds their costs. For example, SLES can accelerate uptake of EVs and electrified heating technologies while saving costs on network reinforcement, by using local flexibility to keep peak demand within network capacity.

The PfER projects have demonstrated that SLES can create new revenue streams from locally available resources, allowing energy infrastructure to pay for itself by enabling new business models and combining diverse sources of income across heating, power and transport. This may help to attract external private investment as well as providing a long-term business case for local authority funding. Furthermore, SLES can offer numerous ways of generating social value, from reducing public healthcare costs by improving air quality and the energy efficiency of housing stock, to creating new jobs and opportunities for skills development and training in a local area. SLES can also provide communities with a chance to have greater engagement and ownership of local energy assets, with profits reinvested into local economies – as well as giving energy users better insights and control of their energy consumption.

The PfER projects have also shown that SLES can reduce customers' energy bills and greenhouse gas emissions compared with fossil fuel and individual electrified counterfactual scenarios, as well as tackling fuel poverty, improving local energy security and resilience, and reducing exposure to wholesale energy market volatility.

As such, SLES can help LAs to meet their Net Zero targets and address statutory responsibilities for public health and the energy efficiency of their social housing stock. Local authorities and community groups can play an important role in SLES, due to their intrinsic local position, the trust and relationships they hold with local residents and businesses, and their knowledge of local areas.

There is support for SLES among consumers, who recognise many of the benefits identified above. That this is despite the economic and political context in which consumer research for this programme of work was conducted (with high energy costs, a turbulent political backdrop and rising cost of living) shows the strength of consumer benefit and appeal. The PfER demonstrators further evidence this consumer appeal. All were able to deliver a good user experience such that 86% of participants would like to continue participating in the project. This was achieved by raising awareness via 2-way channels of engagement and delivering appealing, accessible and user-friendly services.

The PfER projects have demonstrated that SLES can have a meaningful impact on fuel poverty, with four projects showing potential to reduce wholesale and network costs by 25%. SLES are also well placed to address many of the barriers that fuel-poor consumers face in accessing the Net Zero technologies and services that could help them. Encouraging service provision for tenants and those who pay for energy through a prepayment meter means that many fuel-poor consumers can access these innovations for the first time. SLES that are delivered by familiar local entities can also elicit greater trust among fuel-poor people and so encourage participation where others, such as current energy suppliers, might not.

SLES can enable cost-effective and efficient cross-vector decarbonisation of power, heating and transport, taking a whole-system approach to ensure that these different sectors are coherently integrated and work seamlessly together rather than conflicting with each other and competing for resources. The PfER projects have demonstrated that SLES can provide a suitable framework for deploying cross-vector energy infrastructure projects and can link them together with investable, scalable and replicable business models, which will ensure their long-term sustainability and de-risk investment. Following on from the PfER programme, project partners have received millions of pounds in further private funding, proving that the concepts developed and trialled in the SLES projects are investable.

Barriers

There remain some barriers to the successful rollout of SLES across the UK, particularly in energy policy and regulation, and in digitalisation of decentralised energy assets.

The UK's current policy and regulatory framework is still based on a centralised energy system, whereas greater devolution of powers is needed to reflect the spread of more decentralised energy assets. Ofgem has proposed favourable reforms to the energy system and suggested the development of local governance models for energy regulation, which will be necessary to enable SLES.

Many SLES designs incorporate heat networks, which currently have low uptake in the UK, partly due to a historic lack of relevant policy and regulation. While proposed policy changes such as the introduction of heat network zoning will improve uptake, the evidence gathered suggests that clearer regulation and better consumer protections would build trust and encourage participation from end users.

Various other enablers for SLES business models, such as TOUTs, development of local flexibility markets and lifting of ANM restrictions, will require cooperation from energy suppliers and DNOs respectively.

Greater standardisation and harmonisation of APIs and controls for energy and flexibility assets is also crucial to allow these devices to be utilised in SLES. Various projects under the PfER programme are looking to develop such solutions for digital transformation, which will begin to unlock the full potential and value of SLES.

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