EnergyREV

Decision Theatre participant briefing

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About this report

This document is a summary of EnergyREV evidence about smart local energy systems (SLES). It was put together by the authors using EnergyREV research insights and outputs, with input from other consortium members.

The briefing material contained in this document was used as the sole input to a series of Decision Theatre workshops run in March 2022 and was sent to attendees in advance of the workshops.

Contents

Introduction

What is, and isn't a SLES?

Current examples of smart local energy systems are diverse projects, designed to satisfy local needs, national goals, and funding objectives, trialling a range of different technologies, and engaging different sorts of stakeholders and end-users. Consequently, it isn't possible to define exactly what a SLES is in terms of the specific technologies, business models, governance structures, operation paradigms, or users. However, we can say that SLES are a particular form of local energy scheme that have the following elements and characteristics (Ford et al, 2021; Wilson et al, 2020):

- Energy system elements are characterised as: multiple vectors, supply and demand, socio-technical, and institutional.
- Local elements such as involving local and community stakeholders, local decision-making, or local asset ownership. Local in such cases can be defined spatially, socially, or by the location of network infrastructure and generation resources.
- Smart elements are characterised as information and communication technologies (ICTs), automation and self-regulation, the ability to learn system dynamics, and smarter decision-making.

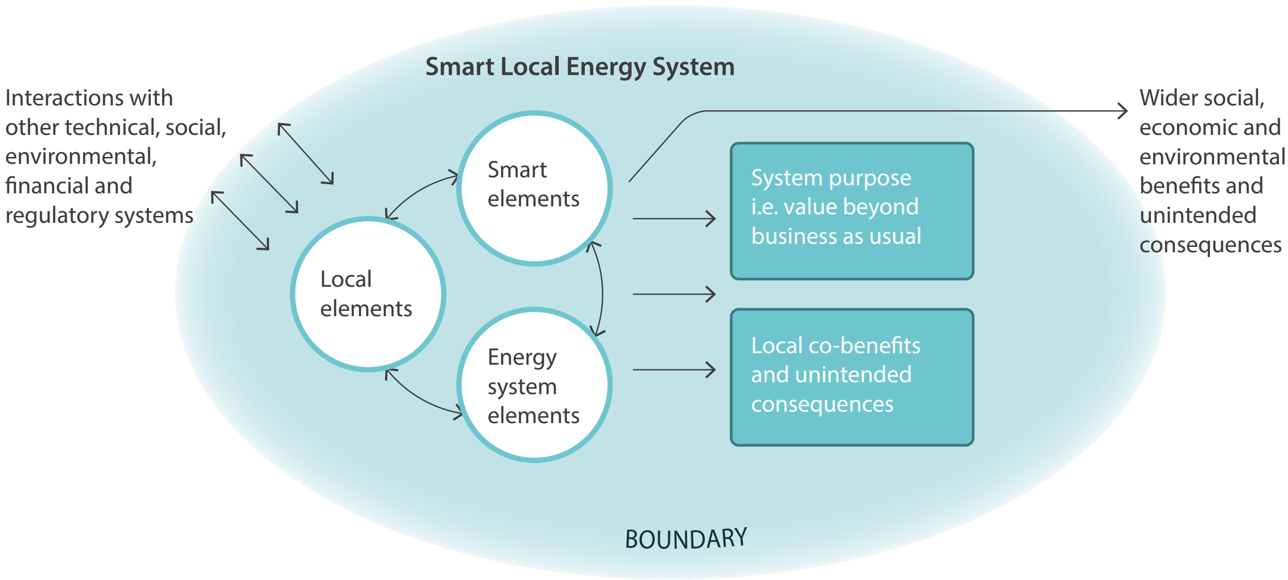


Figure 1: Smart local energy system framework (Ford et al, 2021)

Energy is already (somewhat) local and it will need to be increasingly smart

Energy systems are changing around the world in response to global challenges and to limit climate change. Trends include the increasing prevalence of decentralised renewable generation and the emergence of new low carbon loads such as electric vehicles (EV), heat pumps, and energy storage. There is also a growing emphasis on incorporating digital or 'smart' technologies, enabling more localised system balancing and ancillary services, and engaging the demand side in new ways (Ford et al, 2021).

The decentralised nature of these changes has engaged new types of actors, including community groups and grassroots organisations, local authorities, and local enterprise partnerships working alongside the private sector. These actors have introduced new values to energy system development and operation, such as meeting local social, economic and environmental needs, into what local energy systems could (or should) deliver. As an example, around 75% of local councils have announced a climate emergency and many are formulating local area energy plans[1] covering local electricity, heat and transport provision.

Local conditions influence SLES

These emerging local energy systems are highly place-based. Work by the University of East Anglia has explored the diversity of local energy system (LES) projects across the UK (Wilson et al, 2020; Arvanitopoulos and Wilson, 2021). Local conditions are associated with the development of LES projects, and, to some extent, explain a concentration of LES projects in different areas. These conditions include factors that cause grid constraints, evidence of local strategic investment and planning around low-carbon ambitions, the presence of local knowledge and skills, and issues with the energy efficiency of the local building stock (although LES projects historically have not been specifically associated with areas with high levels of activity to address fuel poverty).

Local conditions not only influence the prevalence of LES projects, but they also bring local opportunities, barriers and goals. For example, homes and offices will need to be retrofitted, with low-carbon heating systems installed, and EV infrastructure nearby. Our EnergyREV report on post-pandemic economic recovery outlines that local approaches could be best to deploy smart local energy systems because of local knowledge, trust, planning, wider economic strategy and scalability (Fell et al, 2020).

Different local contexts and actors could also give rise to different local goals. For example, some regions may suffer from high levels of fuel poverty and aim to address these through local energy system projects. Other areas may have different pressing needs, such as poor air quality. The resulting local energy systems in these areas may well look very different in terms of the technologies deployed, people engaged, or operational structures imposed. To meet these diverse local goals while also delivering a national net-zero energy transition requires joined-up decision making across scales – from individual devices, homes, businesses, through to local and national systems, including energy networks (Vigurs et al, 2021).

SLES are becoming more complex and smarter over time

Over time, these emerging LES projects are becoming increasingly complex, combining energy technologies, vectors, services and behaviours. Work by Heriot-Watt University shows the increasing number of energy vectors in local energy projects rising from mostly single vector projects pre-2015, to projects involving 3 energy vectors in 2020. The emergence of 'smart' is a more recent phenomenon, possibly correlated with the increasing complexity of projects (see Figure 1).

1 Local Area Energy Plans as defined by the Energy System Catapult as 'a process which has the potential to inform, shape and enable key aspects of the transition to a net zero carbon energy system'.

LES projects are also becoming increasingly 'smart' (see Figure 2), and this is an important tool in managing the increasing complexity. At its core, smartness is layered into energy systems by collecting and using more and different forms of data, fusing energy systems with information systems, and allowing the multitude of energy system objectives and local goals to be met in more effective ways. But smart isn't just about how this data is generated, it is about how it is used.

A 'smart' energy system is expected to enable better and more effective use of resources, for example reducing costs or producing larger benefits for individuals, for the system owners and operators, or for the wider world. This could mean energy (and wider) data used to support autonomous management of the local energy system or it could mean semi-autonomous regulation, optimising the system within the bounds of user input or in line with user preferences. The latter brings together people and technology in defining smartness, with users setting parameters, and technology learning and adapting based on revealed preferences (Ford et al, 2021).

Across the databases of (smart) local energy systems compiled by EnergyREV (Arvanitopoulos and Wilson, 2021; Fell et al, 2020; Vigurs et al, 2021; Rae et al, 2021) it's clear that a wide diversity of LES and SLES exist in terms of their objectives, contexts, constraints, technologies, and complexity. However, a common theme is that most of the LES and SLES in the UK are time-bound 'projects', often funded through grant or innovation funding. Some of these evolve over time in the same place, securing new funding and adapting to incorporate new learnings, challenges, or opportunities. Others run for shorter periods of time, do not secure further funding beyond their initial time period, and once this funding has run out there is a risk that the projects also dissolve.

It's important to note that SLES are not stand-alone systems; they are deeply interconnected with wider technology, social, environmental, financial, and regulatory systems. This means it needs to operate within the constraints of these systems, recognising that changes SLES could impact the wider system, and vice versa. A related point is that while SLES are expected to deliver local value in terms of energy system benefits and co-benefits (which may vary according to local context and objectives), there may also be social, economic and environmental impacts beyond its boundary. Understanding how SLES deliver value across a range of areas and for a diversity of stakeholders is critical to knowing whether, how, and for whom it has been successful, and where improvements could be made.

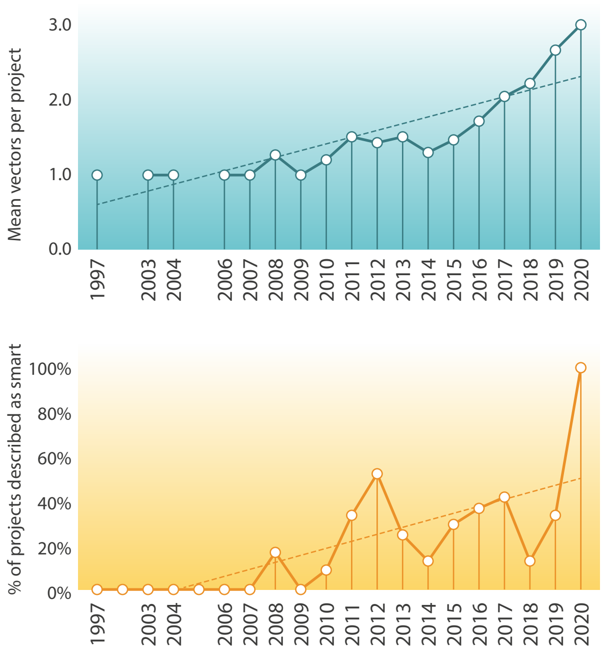


Figure 2: Vectors per project and projects described as smart in UK SLES over time

Provocation 1: Until SLES is properly defined like other forms of energy system, it will remain niche

The value of SLES

Through a systematic review, EnergyREV has revealed a range of economic and non-economic benefits that can be attributed to SLES (EnergyREV work in progress).

These co-benefits range from process-related benefits (e.g. wider participation in decision-making and more accountability), outcome-related benefits (e.g. environmental benefits and wider societal benefits) through to a wider distribution of any benefits (e.g. local ownership models, aligning with community priorities). See Table 1.

Table 1. Potential co-benefits of SLES

	Potential benefits of SLES				
Process related benefits	Inclusion / participation	Addressing inequalities	Public engagement	Transparent / participative decision making	Governance and accountability
Financial / economic benefits	Reduced system costs	Reduced generation costs	Reduced household bills / fuel poverty	Reduced technology costs / payback time	Reduced NHS cost
Financial / economic benefits (continued)	Employment opportunities	New business models	Innovation	Increased (local) revenue	
Educational benefits	Skills development	Energy / sustainability education	Knowledge exchange		
Societal benefits	Improved health and wellbeing	Warmer homes	Social cohesion / acceptance	Community empowerment	Trust
Energy system benefits	Reduced energy demand	Energy security	Grid stabilization	Voltage and frequency control	Better data / grid optimisation
Environmental benefits	Carbon reduction / air quality	Conservation / biodiversity improvement	Increased sustainability	Regeneration / smarter planning	Siting of infrastructure
Distribution of benefits	Distribution of costs & benefits	Distribution of power from monopolies	Local ownership models	Increased social equity	Achieving joint goals

As each SLES scheme will be different in terms of leadership model, technology mix, geographical location and community priorities it is not expected that all of these co-benefits will be desirable to, or achievable by, every SLES. The extent to which different benefits may be unlocked will depend on how SLES are designed and operated, and whether they are accounted for when planning and operating the wider system (Morstyn et al, 2021). Trade-offs will need to be made between the overall SLES design and the range of co-benefits to be sought and SLES are uniquely placed to make these determinations and trade-offs; by the nature of being local, they are already closer to the communities they will serve and can utilise local knowledge and expertise. EnergyREV research has demonstrated that incorporating such social motivators into system design could allow complex human behaviours to be better captured and modelled, leading to better modelling of behaviour-dependent flexible loads (Savelli and Morstyn, 2021).

In addition, many co-benefits are interlinked – with some only achievable if other co-benefits are achieved first (e.g. reduction in air pollution => improved health => reduced NHS cost). Consequently, there are different timescales involved in reaching some of the co-benefits. Factoring in the related pathways to achieving co-benefits early in project development will also ensure that benefits don't become constrained further down the line by limiting factors (e.g. lack of data, lack of public acceptance and take-up) and that identified co-benefits can be sought and used for measuring project success.

SLES also interact and have impacts on wider energy. There is a risk that local benefits may be delivered at the expense of stakeholders outside the local area. EnergyREV colleagues at Imperial College London have developed modelling tools for exploring this issue (Aunedi and Green, 2020). The premise of their models is based on the potential for SLES to change local electricity consumption patterns through a combination of SLES technologies and practices (e.g. demand-side response, local energy storage, self-consumption from rooftop solar PV), and for this local change to have wide-reaching impacts on national networks. The findings indicate that SLES customers with access to demand-side response, solar PV and energy efficiency could see significant bill savings (>40%) compared to non-SLES customers. The work also indicates that SLES can significantly reduce total energy system costs by up to £2.5bn annually.

Provocation 2: SLES could address or widen inequalities

The importance of local system actors in shaping SLES outcomes

EnergyREV research with the PFER SLES projects has highlighted the significant influence the project stakeholders can have in shaping the outcomes of SLES. While all stakeholders recognise the unique social, ecological, political, and infrastructural characteristics of their local areas, the diversity of stakeholders leads to a diversity of views within and across project teams (Devine-Wright, 2022). Locally-embedded stakeholders (like councillors, community energy groups, and academics) give similar weight to local and non-local benefits. Non-local partners (particularly from industry) are more likely to frame success in terms of replicability and scaling up opportunities (Devine-Wright, 2022). This is important because SLES that can harness grassroots support could endure longer and produce greater local co-benefits than company-led investment in local energy schemes (Vigurs et al, 2021).

Harnessing grassroots support and bringing local communities and users along the SLES journey is necessary if these systems are to be adopted and scaled (Devine-Wright, 2022). This implies a need for effective and meaningful engagement with users.

Who are the users?

Compared to traditional energy systems, SLES facilitates the engagement of a more diverse range of users, including consumers, prosumers (those who own distributed energy resources), owners of energy assets (like EVs and heat pumps), as well as indirect users of SLES who gain benefits from implementing energy initiatives in the local region (Gupta and Zahiri, 2021).

These users can be described in different ways, for example, citizens, consumers, prosumers, and market actors. While sometimes used interchangeably, these different ways of framing participants describe differences in roles, responsibilities, and expectations, as well as legal status and regulatory frameworks of protection (Vigurs et al, 2021).

How can users be engaged?

Our research suggests that across the UK there is limited awareness of the meaning for, or the advantages of, new smart technologies (Bray et al, 2022). Engagement is necessary both for the initial uptake of these technologies, and also to equip technology owners with the skills required to make the best use of their equipment.

Without these skills, there could become a widening of the gap between those who are able to engage with SLES and those who can't. This could be through a lack of the appropriate 'smart' skills to be able to choose between different tariffs, technologies and the optimisation of their equipment; or the lack of IT skills to engage with online energy trading platforms.

User engagement can happen through a multitude of ways, including informing (media or social media), communicating (events, workshops, presentations), involving (direct interaction, e.g. consultation, training, drop-in sessions), empowering (allowing users to take more control over their energy), and technical means (online dashboards and apps, gamification) (Gupta and Zahiri, 2020).

Engagement channels need to cover people-to-people as well as people-to-technology interactions (Gupta and Zahiri, 2021). 'Smart local energy engagement tools' are enabling smart tools that enhance user engagement and allow users to better manage, control and observe energy, encouraging users to become active participants.

Engagement challenges

Conducting widespread engagement with users over time is not always easy. Engagement for SLES projects, particularly those in the PFER programme, commencing in late 2019/early 2020 were affected by a variety of forces. The Covid-19 pandemic has had extreme and direct impacts on in-person engagement, for example, the removal or delay of local shows, workshops, high street shop premises and door to door discussions. Brexit has had an indirect impact, causing delays to some of the technologies to be used in projects with a knock-on impact on the engagement of adopters.

There is currently evidence of limited longitudinal engagement to capture the user journey as SLES projects develop over time, which may be due to project time scales, limited budget, and expertise. But this can be stimulated by making use of local actors in specific roles, like community energy groups as intermediaries, local authorities as policymakers, and academic institutions as independent evaluators (Gupta and Zahiri, 2020).

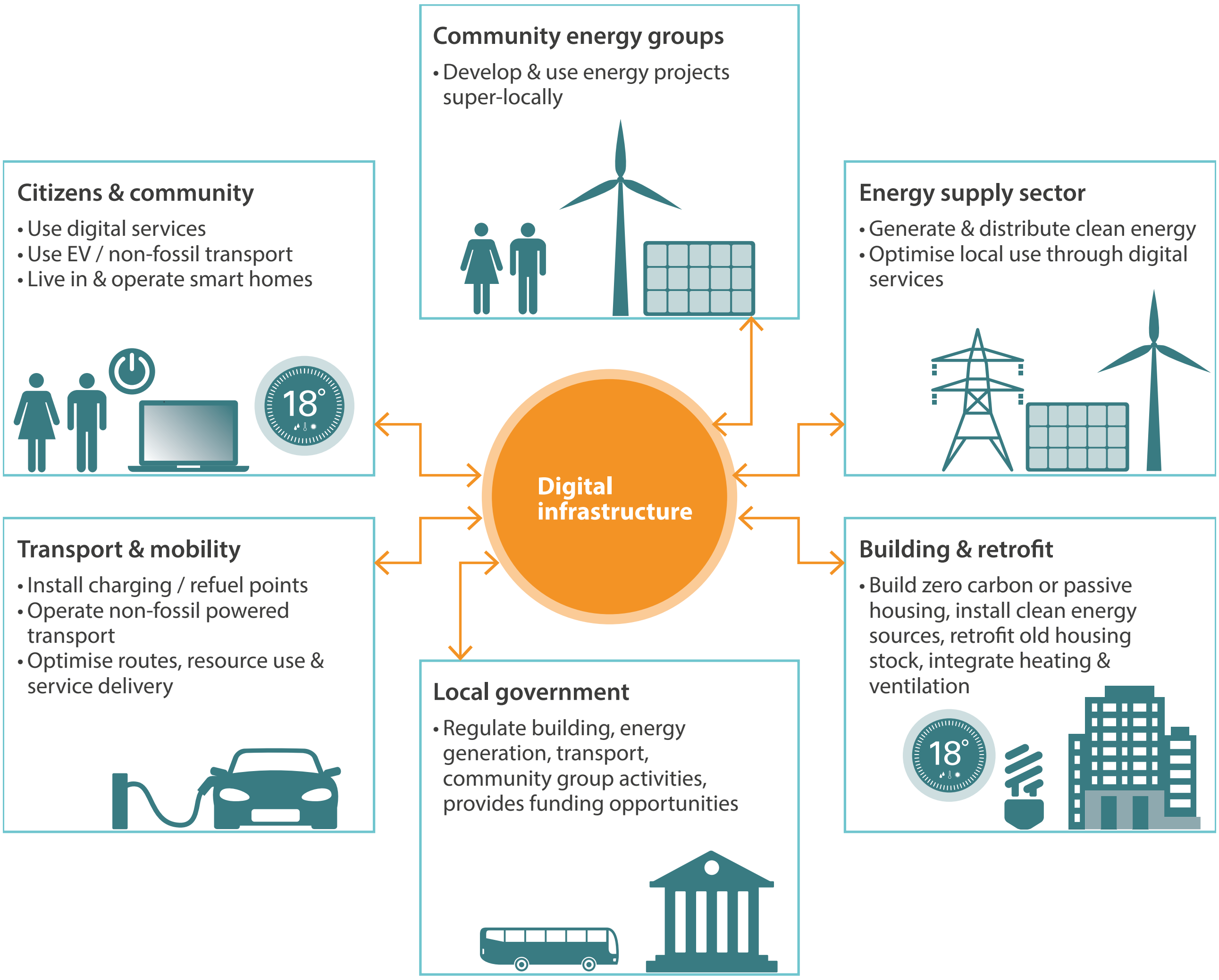
Provocation 3: Without user engagement, SLES will fail

Skills and SLES

The changing energy system requires new skill-sets and novel combinations of existing skill-sets, along with a workforce receptive to upskilling to enhance what they already know, or to retrain. Skills will need to be spread across all parts of the country as these emerging technologies are locally located – homes need to be retrofitted, and generation from renewables and EV charging infrastructure needs to be available in all places.

The EnergyREV team at the University of Bristol has completed three case studies to examine where skills are needed if we are to scale up these new and innovative approaches (Chitchyan and Bird, 2021, 2021b, 2021c, 2021d). We outline some key findings below.

Figure 3: A simplified overview of a smart local energy system as a System of Systems



Skills for whole system integration and sub-system development

Smart local energy systems are complex and comprise many interlinked sub-systems. We frame this as a 'system of systems' (SoS) with key connecting components such as policy, local government facilitation, physical and virtual infrastructure such as buildings, roads and telecommunications and, at the core of it all, the people that design, install, maintain and use all of the components.

Key to enabling SLES is how the components from different sectors can interact and be optimised in relation to each other. These require high-level skills which can be grouped into overarching generic skill 'types', such as managerial, policy and regulation, engineering and trades skills. There are also essential soft skills that help to bring all this together, facilitating collaboration and enabling effective communication at all levels, from engaging citizens to facilitating SME upskilling and brokering cross-system integration.

Elements of these generic skills are needed within the subsystems that comprise a SLES, and there are additional requirements for specific new sectoral skills. These are summarised in Figure 3 below.

There are also some common skill-sets across these subsystems, including a need for increasing knowledge about how the energy system works and how the different elements are relevant and interdependent; communication skills to make sure that no-one is left out and citizens are fully engaged and able to participate; engagement with local policy and planning; development of new business models; software and data management; changing procurement approaches and rules; and construction skills for the supporting infrastructure.

A wider skill-set is required to navigate and integrate the multiple elements that make up a local energy system,for example software engineers need to understand how the energy system works, citizens need to have the knowledge to make informed choices and be comfortable with using the technologies, electricians need to connect and use smart devices in their daily work.

Research shows that there is currently a marked mis-distribution of skills availability across the UK, which could prove a barrier to some regions actively engaging in, or reaping the benefits of, SLES (Bray et al, 2022). Rural areas in particular are associated with skills shortages in specialist skills such as engineering, combined with an inability to retain skilled workers. This presents challenges, not only for supporting the development of SLES across different regions, but in the ability to scale up their deployment at the pace and scale required to transition to a net-zero energy system.

Provocation 4: SLES is more likely to happen in places where the skills already exist

Upscaling SLES

Emerging SLES are typically projects and are currently concentrated in particular places where local conditions are met. These local conditions include available skills and resources, supportive policymakers, and local conditions such as poorly insulated buildings and constrained local electricity grids (Arvanitopoulos and Wilson, 2021). Upscaling[2] is required in order to enable SLES to be widely replicated and deliver on their benefits.

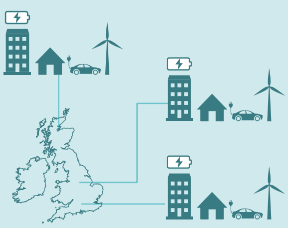
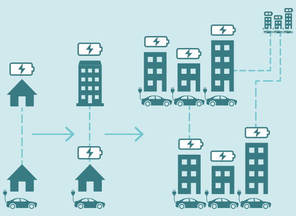
Demonstrating scalability is often cited as a key outcome of many local energy pilot and demonstration projects. However, there is currently no widely accepted definition of upscaling in the context of local energy projects (Rae et al, 2020).

A SLES product, project or innovation can be deemed to be scalable when it is adjudged to have exhibited desirable characteristics, delivered desirable benefits to stakeholders or otherwise demonstrated suitability for wider adoption. These include the following factors:

- commercial or financial viability (e.g. return on investment, cost savings)
- the delivery of local benefits (e.g. job creation, energy security, more affordable energy)
- technical performance (e.g. efficiency, overcoming electricity network constraints)
- environmental performance (e.g. local emissions reduction, carbon savings, use of renewable energy).

Upscaling can occur in a number of ways and through a number of different processes. A framework that illustrates this is shown below:

Figure 4: Framework of SLES upscaling

Growth	Replication	Accumulation	…Transformation
 Where an existing project of initiative is expanded to include more participants	 Where a project concept is replicated in another location	 Multiple projects are linked, physically or organisationally (often via intermediaries)	Transformation doesn't refer to geographical or physical scaling, but to the contribution of project(s) in shaping best practice, policy and industry focus This sees the associated innovation become the norm

2 Upscaling is the process by which a product, project or innovation becomes more widely adopted and eventually becomes business as usual.

It is important to note that forms of upscaling should also be considered in terms of timescales, with 'transformation' as the long-term end goal i.e. the widespread deployment of successful SLES as part of a more sustainable energy model. So, whilst upscaling in the short term may involve the expansion or replication of a specific project, that forms a small part of the wider effort to achieve such a transformation.

What drives upscaling in SLES?

EnergyREV research has identified a number of traits and characteristics which lend themselves to scalability when it comes to local energy projects:

1. A project team that has relevant and transferable knowledge, skills and experience.
2. Alignment of proposals with current policy drivers and funder priorities.
3. Committed (preferably influential) project partners.
4. Identifiably scalable project elements or concepts with clear links to future opportunities.
5. Knowledge of the successes (and limitations) of related previous/existing projects.
6. An element of local momentum. This includes, but is not limited to:
   * Established, trusted skills networks and partnerships.
   * Knowledge and awareness of funding opportunities and processes.
   * Successful track record of similar/relevant project delivery, which lends credibility to subsequent projects/proposals.

There are a number of ways to promote or facilitate the upscaling of SLES in future, which fall into two main categories.

The first can be thought of as 'scalability by design', where the demonstration and achievement of upscaling is a key outcome of a project from the outset. This is commonly used in larger scale, multi-organisation projects and provides project teams or funders a degree of control of the upscaling process by allowing them to prioritise certain aspects e.g. technical, economic, environmental performance etc, thereby minimising the risk of non-scalable projects and outcomes.

The second method of promoting upscaling involves a less structured, more reactive approach. It places priority on the successful delivery of local solutions and outcomes in each SLES, with upscaling opportunities being identified afterwards, based on project success. This approach is observable in locations with an established track record in local energy and better reflects the site-/context-specific nature of SLES than the aforementioned 'cookie-cutter' approach. However, since it involves a less cohesive, strategic approach, it does afford less control over scalability-related outcomes.

Box 2: Example of scalability – Plug & Play Digital Infrastructure for Scalable, Flexible, and Replicable SLES

The smart aspect of local energy systems comprise both the data and the digital infrastructure that allows SLES to operate safely, efficiently and in real-time. For a smart local energy system (SLES) to be truly 'smart', it must be capable of managing complex interactions between data, users, and the physical devices which make up the network, while also meeting the key criteria of flexibility, scalability, and reusability.

These emerging smart energy systems can be considered as having multiple layers – physical, control, service and market – operating at different scales, from a single device or home through the national grid (see Figure 5). Our work has shown that it is crucial that flexibility, scalability and replicability are built into these SLES to avoid extensive, time-consuming and costly re-engineering.

In practice, this means aiming for plug and play smart systems where new devices, analytics and algorithms can be easily integrated and configured within the SLES. The underpinning characteristics of this plug and play system are:

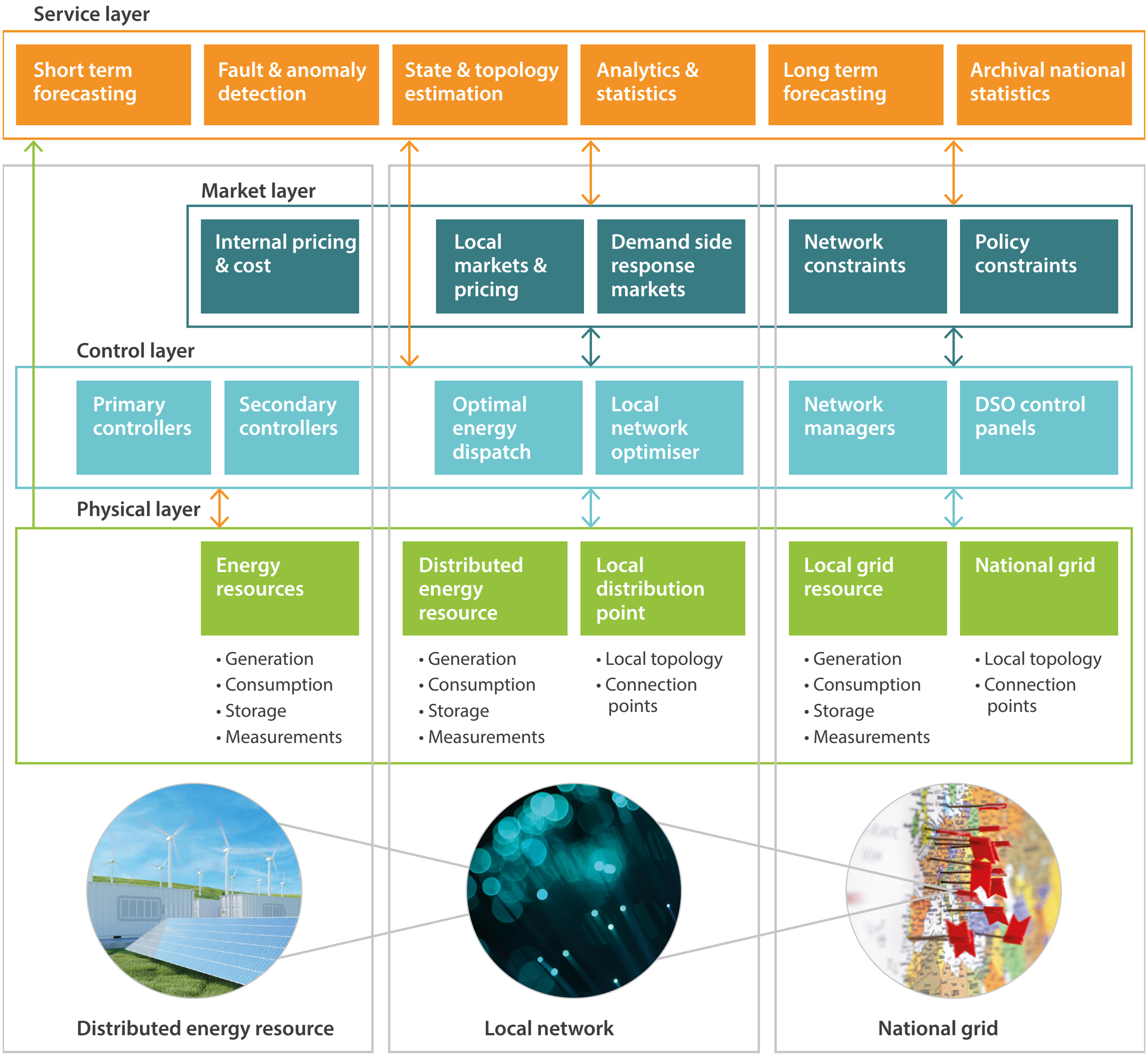
- Flexibility – SLES can expect throughout their lifecycles to be required to deal with expanding and changing use-cases, the connection of new devices and device types (and disconnection of old devices), and the inclusion of traditionally separate energy vectors into the functioning of the system.
- Replicability & Scalability- SLES have to be capable of adapting to increases in both energy delivery devices, and in loads, including new types of both. SLES solutions should be deployable to solve similar problems in different areas.

There are existing, mature, technologies like multi-agent systems (MAS) that can allow for plug and play capabilities to be added to existing systems. EnergyREV researchers used the ADEPT (ADvanced multi-Energy management & optimisation time-shifting PlaTform) demonstrator to prove that MAS can be used to build flexibility into intelligent power management systems[3] (Morris and McArthur, 2021). This case study showed that the use of MAS to allow inter-unit energy trading brought down the costs of balancing the individual smart local energy systems by 10%-15%, while also increasing their income by between 15%-25%.

Provocation 5: A lack of scalability in SLES design is limiting its potential

3 ADEPT is an industrial microgrid, and includes a wind turbine, a PV system, and battery storage, that serves a mixture of industrial and residential loads.

Figure 5: Abstraction layers and their components in digitised energy systems: DER, Local network and National Grid scales (Verba et al, 2021)



Success factors for SLES

Data Security	Data Connectivity	Technical	Transport
• Security • Privacy • Trust	• Digital technology enablers • ICT Infrastructure • ICT Management • ICT Accessibility	• Renewable fraction • Reliability, resilience • Flexibility, scalability • Efficiency • Maturity • Lifespan • Grid accessibility • Innovation	• Transportation Management • EV infrastructure
Techno-economic	**Economic-Market**	**Governance/ Socio-political**	**People**
• Benefits-to-Cost Ratio • Costs (capital, installation and O&M) • Rate of return • LCOE (levelised cost of energy) • Payback period	• Regulations • Compensation structures • Affordable or competitive cost • Investable • Job creation	• Transparency • Socio-economic impact • Integrated Management • Political and regulatory alignment	• Education & Gender equality • ICT Skills • Engaging/participation • Acceptance • User friendliness/ control • Inclusion/ Empowerment • Consumer protection
Living	**Environment**		
• Housing • Equity • Culture or behaviour • Livelihood • Convenience	• Water • Land • Air pollution • Noise pollution • Waste energy potential		

Figure 6: Success factors of SLES (Francis et al, 2020)

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Given the diversity of SLES objectives and outcomes, there is no clear consensus on what a 'successful' SLES is. Rather than constraining 'success' to economic impacts or carbon abatement measures, EnergyREV has developed a multi-criteria approach, which is well suited to analysing the performance of such complex systems and understanding the trade-offs between different outcomes and corresponding key performance indicators (KPIs) – see Figure 6 (Francis et al, 2020). These KPIs build on many of the co-benefits discussed above and cover wider technical aspects.

They also align broadly with the wider UN Sustainable Development Goals. Rather than evaluating a project as being 'successful' or 'unsuccessful', tracking this diversity of KPIs over time can help monitor the performance of the SLES and the realisation of potential benefits over time.

By planning for co-benefits in the initial phases of SLES development each SLES community can identify which co-benefits they are aiming for and incorporate these into project KPIs and outcomes. Indeed the success of any SLES should be measurable against these wider co-benefits achieved, not just on financial targets and reduction in carbon which are the usual metrics applied to low-carbon energy schemes.

Case study – ReFLEX Orkney

This case study on ReFLEX, one of the PFER demonstration projects, brings together a number of the themes we have discussed in the briefing materials.

ReFLEX Orkney is one of the three full-scale demonstration projects in the PFER programme. It aims to develop an innovative AI-based 'integrated energy system' to balance supply and demand across transport, heat, and power. It will do this by monitoring generation, grid constraints and demand, and using battery storage, electric vehicles, heating systems and hydrogen to link electricity, transport and heat networks.

As an island community in the North Sea, Orkney has some unique characteristics which make a SLES suitable. It has met more than 100% of its electricity demand from renewable energy since 2013, and the Orkney Islands Council, a project partner, is a unitary authority which simplifies planning processes. Its geography also means that Orkney faces some challenges, including network constraints (which limit revenue from energy generation), expensive energy and transport costs, and high levels of fuel poverty (63%).

Objectives

ReFLEX has therefore set objectives that will achieve technical, environmental, economic, and social benefits, including:

1. Maximising the use of its renewable energy generation and reducing dependence on more carbon-intensive electricity imports from the UK grid;
2. Improving affordability and reduce levels of fuel poverty.

Success factors

Success of these objectives will be measured according to the following metrics:

Partners and engagement

The project involves a wide range of stakeholders. Led by a private company (European Marine Energy Centre), it also includes local and national businesses, the local authority, and an academic institution.

Engagement is a core part of the project, with dedicated customer engagement officers with specialisms in different key elements such as EVs and decarbonisation for local businesses. Regular 'drop-in' sessions are conducted at locations around Orkney to help the community find out more about their services, and the website provides signposting for householders to source grants and loans for domestic energy efficiency improvements.

Skills

It could be argued that the project participants started from a high technical knowledge base, due to their previous participation in the Orkney Renewable Forum and the history of collaboration. But the project also has objectives relating to skills and jobs, with aims to almost triple the number of students studying energy in Orkney and double local jobs relating to sustainable energy by 2030.

Business model

Orkney is operating on an Energy-as-a-Service business model across all vectors. An exclusive Orkney tariff will be tailored to the needs of the ReFLEX's innovative integrated energy system, which will use advanced software to balance demand and supply.

Scalability

Scalability has been a consideration since the beginning of ReFLEX, and its achievements have already earned it international recognition as a renewable energy pioneer. While some aspects of the project are distinct to the unique geographical context of Orkney, it aims to export the integrated energy system model and associated energy supply framework to other areas across the UK and internationally. It also expects to increase the amount of exported energy ten-fold by 2030.

Figure 7: Success factors for ReFLEX

Criterion	Now	2027–2030
Renewable generation of electricity	120%	400%
Total energy demand (MW)	250	200
Electricity demand (MW)	25	100
Electricity storage & commoditisation capacity (MW)	2	100
Energy export (MW)	20	200
Decarbonised energy use	10%	50%
Planned installed capacity (MW)	60	400
Households in fuel poverty (approximate)	60%	20%
Jobs related to sustainable energy	300	600
Students studying energy in Orkney	35	100

What are the barriers to SLES?

Our work in EnergyREV has uncovered a number of barriers to SLES. In this section, we present themes of barriers at a high level. We have deliberately avoided details here because these barriers and their solutions are a key focus of the decision theatre workshop and we don't want to bias your discussions.

National and devolved government and regulation

- UK energy policy is largely centralised and relatively siloed (Morris et al, 2022)
- A long term and strategic vision for decarbonisation is lacking – policy has been somewhat stop-start (Morris et al, 2022)
- Energy regulation is prescriptive and does not promote innovation (Morris and Hardy, 2020)

Local government

- Three-quarters of UK local authorities (LAs) have declared a climate emergency but lack the statutory mandate and powers to deliver (Tingey and Webb, 2020)
- LAs also lack the resources (e.g. finance) and capabilities (e.g. skills) (Tingey and Webb, 2020)

Provocation 6: Local government does not have the powers, resources and capabilities to deliver SLES at scale

Energy (and wider) markets and trading

- SLES cannot currently be rewarded for the range of benefits it can provide to the energy system, particularly in terms of balancing, capacity and flexibility services (Morris and Hardy, 2020)
- Current market arrangements, for example limited locational pricing, limit options to realise value from local energy trading (such as via peer-to-peer trading or local energy markets) (Savelli and Morstyn, 2021)
- The co-benefits of SLES, beyond traditional energy benefits (such as health, welfare, education and environmental) blur the boundaries between energy and other services and are not always valued or accounted for in traditional decision making processes (Morris and Hardy, 2020)

Smart elements of local energy systems

- The roll-out of smart metering is behind schedule and may not be enough to fill in existing data gaps, such as near real-time energy usage (Morris and Hardy, 2020).
- Data protection and privacy is harder in small, geographic SLES than in national energy systems – there is a risk to trust if mistakes are made (Maidment et al, 2020).
- A lack of flexibility, scalability and replicability are built into SLES is causing extensive, time-consuming and costly re-engineering (Morris and McArthur, 2021).

Engagement

- There is a need to establish a culture, and provide a supportive infrastructure, in which social learning about what forms of engagement 'work' or don't work, in what contexts, can more easily be shared between projects (Gupta and Zahiri, 2021)
- Some households may be excluded from participating in SLES either due to initial outlay cost of technologies or housing tenure (e.g. the inability or unfeasibility of adapting rented properties) (Hall et all, 2021)

Business model innovation

- Energy, as an essential service, is heavily regulated and prescriptive and this stifles business model innovation, including with SLES (Morris and Hardy, 2020).
- A lack of long term energy strategy on key SLES activities like energy efficiency and clean heat creates uncertainties that hold back businesses investing in training, skills, capabilities, and partnerships (Morris et al, 2022).

Provocation 7: Many SLES business models are ruled out by current regulations

Scalability

- Many SLES projects are unique and are not designed with scalability or replicability in mind (Rae et al, 2020)
- We don't learn from mistakes – project reporting has been found to prioritise positive outcomes at the expense of negative ones and can even be abandoned altogether if a project ends prematurely or is not successful (Rae et al, 2020)

Skills

- New skills are required and new combinations of existing skillsets, and the availability of such skills varies regionally (Chitchyan and Bird, 2021, 2021b, 2021c, 2021d)
- There is a time lag of skills development (Chitchyan and Bird, 2021, 2021b, 2021c, 2021d)

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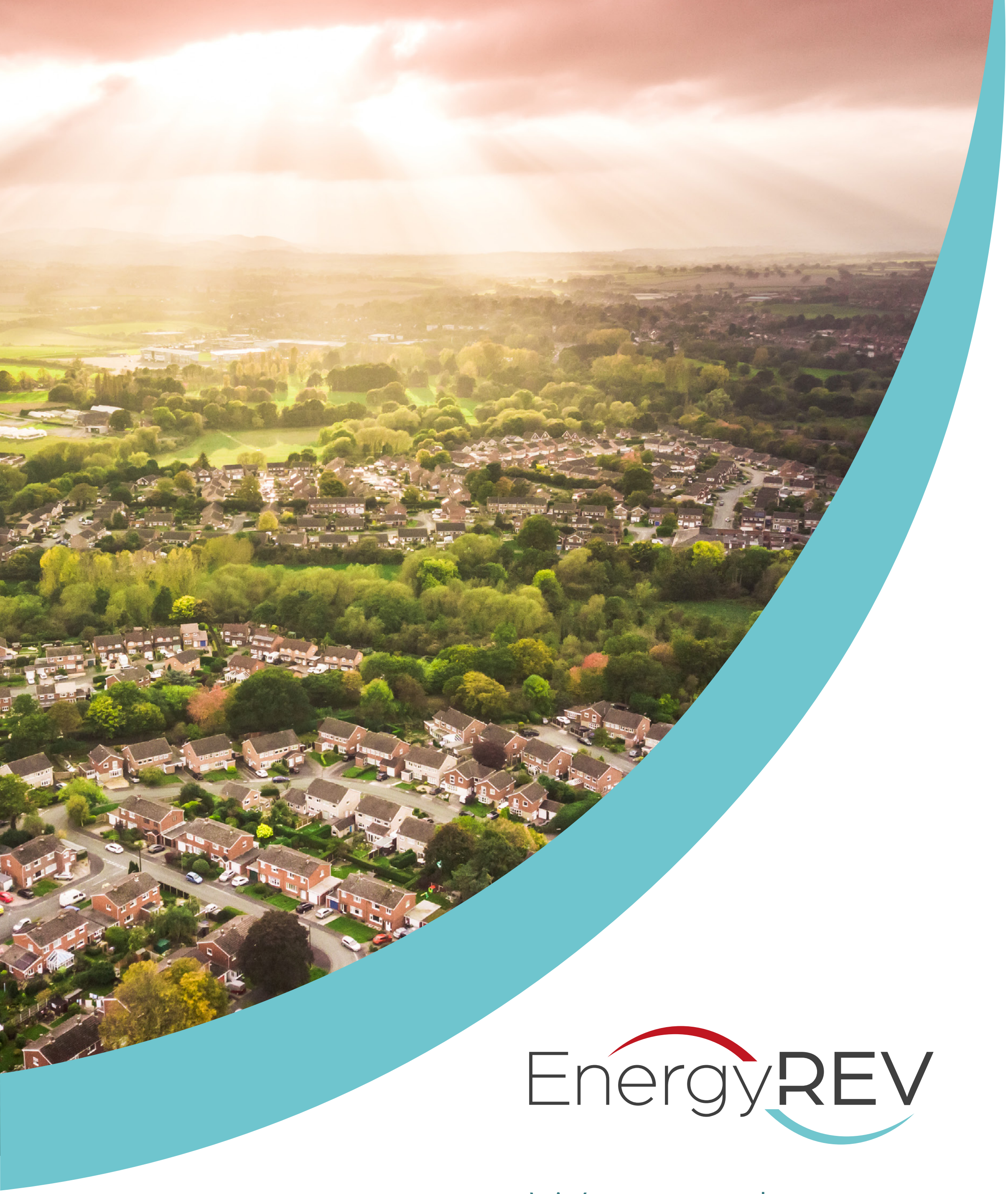

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