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Meta-study of smart and local energy system demonstrators in the UK: technologies, leadership and user engagement

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Abstract. Smart local energy systems (SLES) can intelligently and locally link energy supply, storage and use, and power, heating and transport in ways that dramatically improve efficiency. This paper undertakes a meta-study of the technologies deployed, leadership and extent of user engagement achieved in SLES initiatives undertaken in the UK from 2009-2018. An extensive review of literature revealed 122 SLES projects that have received some form of funding, deploy multiple vectors (heating, power or transport) and have an element of ‘smartness’ to them that includes innovative use of data, digitalisation or innovative energy management systems. Meta-data analysis reveals that more than 50% of the SLES projects were undertaken in Scotland and Southern England where grid constraints are prevalent. Nearly 30% of the projects were led by district network operators (DNOs) or energy suppliers and 27% were led by private sectors, while only 19% of SLES were undertaken in collaboration with community energy groups, local authorities and/or universities. Less than 50% of SLES projects had some form of user engagement through public events and workshops. Learning from this meta-study can inform the next generation of SLES projects that have been funded under the £102 million Prospering from the energy revolution programme.

1. Introduction

The UK Government has recently committed to a net-zero emission target by 2050 [1] to limit future temperature rise to 1.5°C and address the growing concern of climate emergency [2, 3]. To meet this statutory obligation, significant effort and innovation is required to decarbonise the UK energy system [4]. Decentralised energy systems offer a wealth of advantages for consumers, taking energy supplies away from major utilities and into the remit of local authorities for lower carbon emissions with greater flexibility [5]. Such localised energy systems focus on area or place based systems of energy provision, while also helping to achieve the UN Sustainable Development Goal 7 (SDG 7) on affordable and clean energy. The aim of UN SDG 7 is to ensure access to affordable, reliable, sustainable and modern energy for everyone that cares for the climate [6].

Over the last 10 years, energy systems have not only become decarbonised and decentralised (local or community energy), but have also developed in a smart way by becoming more digitised [4]. Such systems are being termed as Smart Local Energy Systems (SLES). Although there is no standardised definition of SLES, the UK Government cosiders SLES as energy initiatives at local scale that have elements of energy demand and supply, are integrated across demand side reduction and demand side response (DSR), include innovative use of data or digitalisation, and may involve local trading of energy and system balancing. The UK Government’s Clean Growth Strategy [1] states that SLES will deliver cleaner, cheaper, energy services for more prosperous and resilient communities, and benefit the national energy system as a whole. However there is limited research on the actual outcomes of SLES initiatives undertaken in the UK.

This paper undertakes a meta-study of the technologies deployed, leadership and the extent of user engagement achieved in the SLES initiatives undertaken in the UK over the last 10 years, so as to explore possible reasons why certain areas in the UK have seen a growth in SLES initiatives.

2. Methodology

This paper uses a meta-study (cross-project) approach to assess energy technologies deployed in SLES initiatives in the UK in the last 10 years, as well as examining the leadership of the projects and engagement of users in these initiatives (demonstrators). The time period considered was the last ten years (2009 to 2018) to cover major funding programmes on local and smart energy. These included the *Low Carbon Communities Challenge* (LCCC) and *Localised Energy Systems* funded by the UK Government, *Network Innovation Allowance* (NIA) funded by regulators, *Energy and Communities* programme by UK Research Councils and *Horizon 2020* funded by EU.

The methodological approach combined systematic examination of academic (journal publications) and grey literature (project reports), followed by statistical analysis of the meta-data gathered. Drawing upon the study by Devine-Wright [7] key criteria were established to characterise the meta-data of each SLES initiative. As shown in Table 1, these criteria include participating actors, positioning of individuals, goals set, energy technologies and scalability and replicability.

Table 1. Criteria to select SLES in this study

	SLES
Participating actors	Institutions including DNO, energy suppliers, universities and private sector working individually or in partnership.
Positioning of individuals	Active consumers or prosumers of energy technologies, products or services that aim to maximize personal utility and choice
Spatial focus	Networks of organizations spanning local and non-local areas
Goals	political, economic, social, environmental and technological dimensions are included in the energy chain alongside delivering energy services tailored to the local areas with the great opportunity of smart local energy systems, using the latest digital and data-based solutions
Technologies	Have elements of both demand and supply. Local balancing of supply and demand, across multiple domains - heating, electricity and transport. Element of 'smart'. Grid balancing and management
Scalability and replicability	The boundary can vary from a single street or estate up to a county or region. Accounting for local priorities to meet local needs. Wider value-based needs include addressing a local desire to reduce global environmental impacts.

Additional criteria were identified based on the UK Energy Research Centre's (UKERC's) report on UK energy system demonstrators [8] that described SLES in terms of lead actors, project start year, funder, geographical location, energy vectors, and engagement methods. Figure 1 presents the overall approach of the meta-study, starting from an extensive review of literature to identifying variables, conducting data analysis and drawing lessons for achieving SDGs.

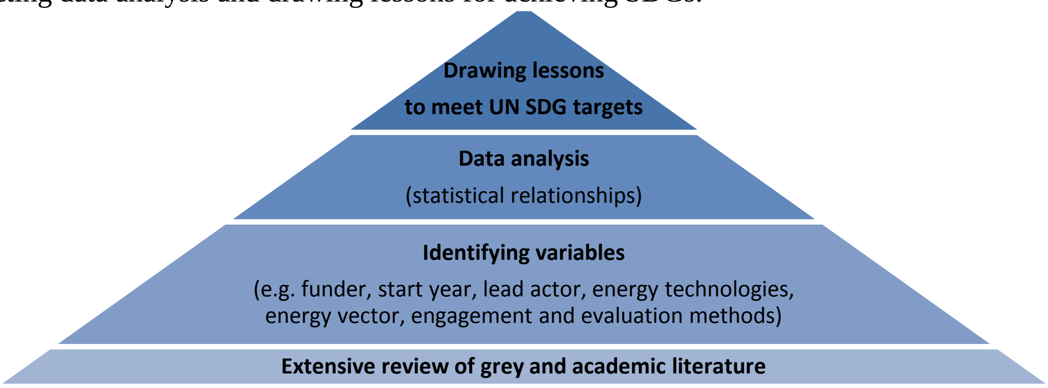

Figure 1. Approach in Meta-study in identifying SLES initiatives; technologies, leadership and engagement

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3. Findings

In total, about 122 SLES initiatives (also called as demonstrators or projects) were identified that have received some form of funding, deploy multiple vectors (heating, power or transport) and have an element of 'smartness' to them that includes innovative use of data, digitalisation or innovative energy management systems.

3.1. Lead actor, start year and Funder

It was realised that lead actors of SLES included DNOs/energy suppliers, private sectors, community groups, universities/academic institutions and local authorities. Significant numbers of SLES demonstrators were led by DNOs/energy suppliers that covered more than one-third of SLES, while private sector led and partnership based SLES initiatives accounted for 27% and 19% of demonstrators respectively (Figure 2a). Despite having a strong element of public engagement that is necessary to increase the uptake of smart local energy, community energy groups, Universities and local authorities, led a small number of SLES in comparison to DNOs and private sectors.

It was also found that more than 64% of SLES were started in or after 2015, which also saw a surge in the involvement of private sector and a decline in the involvement of community energy groups (grassroots initiatives). This was despite the fact that in 2014, the UK government published the first ever Community Energy Strategy, which presented a decentralized vision of energy transitions in which communities would play a leading role. Although SLES were carried out at local scale, a key focus of the projects were on the elements of smart rather than locality.

The main Funders of SLES included the national government, regulators such as Ofgem, and research and innovation Funders such as Innovate UK and EPSRC, as well as EU (Figure 2b). It was found that 28% of identified SLES were funded by regulators including Ofgem, while around 25% were funded by national governments (England, Scotland), 18% by UKRI and 15% by EU. Although DNOs led a number of SLES, a very small number of SLES initiatives were funded by them.

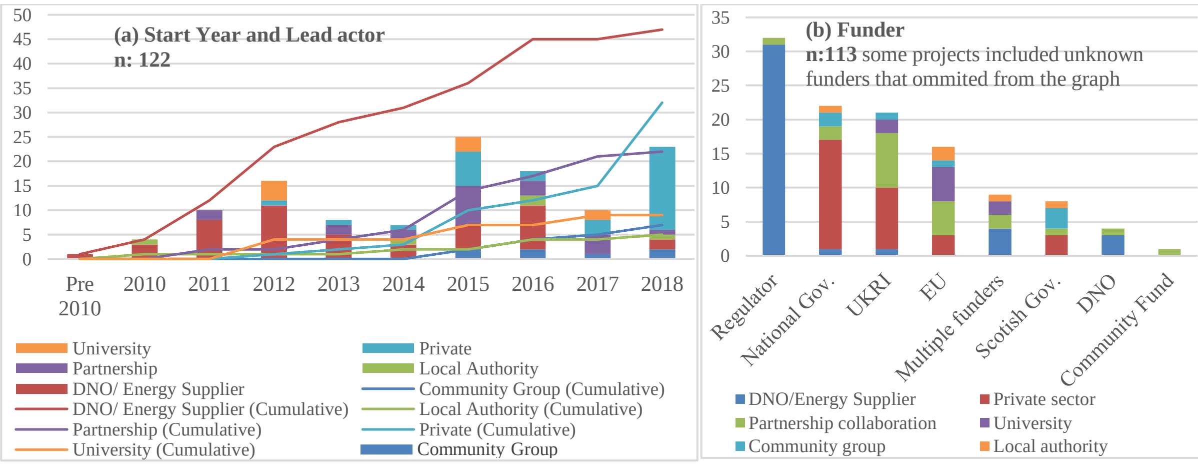

Figure 2. Lead actor and start year (a) and Funder (b) of SLES

3.2. Energy technology and energy vector

Each SLES demonstrator included at least two energy vectors (power, heat or transport), though a large number of SLES (over 110) focussed on power (95%), followed by heat (54%) transport (25%) (Figure 3a). Electric vehicle related technologies (charging) were not included in most SLES initiatives.

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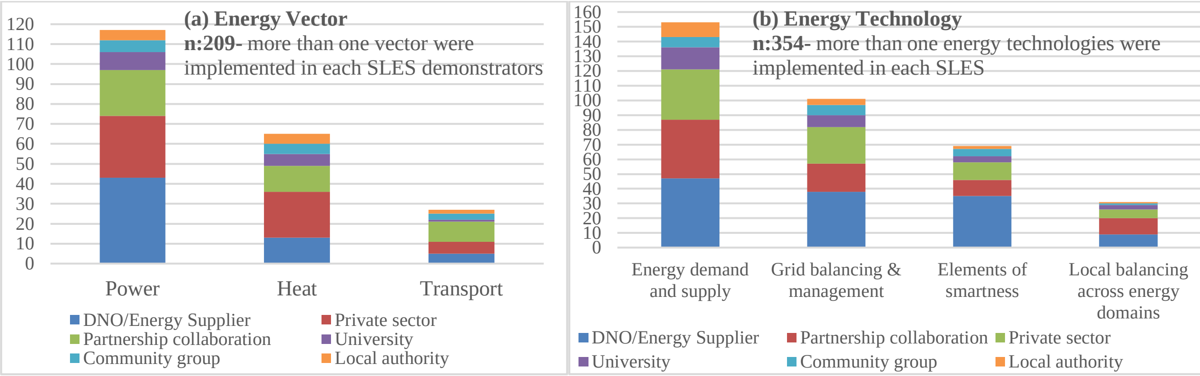

Figure 3. Energy vector (a) and energy technology (b) in SLES

A range of energy technologies were implemented across 122 SLES initiatives (Figure 3b) – these included: elements of energy demand and supply, grid balancing and management, elements of smartness and local balancing of energy. Each SLES project used at least two types of such technologies. About 43% of SLES had elements of energy demand and supply, followed by grid balancing and management (29%), and elements of smartness (20%). Local balancing across multiple energy domains was adopted in 9% of SLES (Figure 3b).

3.3. Geographical characteristics

Give the area-based nature of SLES initiatives, their geographic location was closely examined. The location of SLES projects were categorised under different regions in the UK, as shown in Figure 4 below. The locations of a few number of SLES were unknown and these were omitted from the location analyses. It was observed that about 35% of SLES projects were carried out in South-East and South-West of England, while 22% were carried out in Scotland and 10% in North-East of England. This is likely to be since Scotland and South England are areas of grid constraints which have also seen the most increase in renewable energy and SLE projects were designed to achieve grid balancing and local energy management.

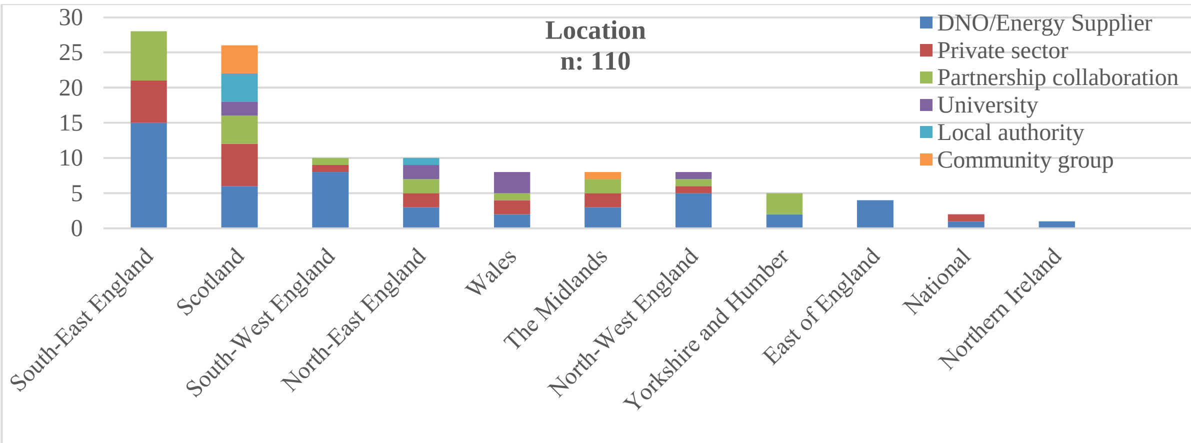

Figure 4. Spread of SLES across different geographic locations in UK

3.4. User Engagement

User participation in smart local energy systems is imperative for their successful deployment. This is why extent of user engagement across the 122 SLES initiates was investigated to explore how users were engaged with while considering their needs such as local jobs, improving energy efficiency and reducing energy costs. Users of SLES consisted of *stakeholders* who were involved in the initiatives *direct energy users* of energy services such as households with rooftop solar, heat pumps, batteries;

local business owners; residents participating in peer-to-peer energy markets, consumers, prosumers who produce and use local energy, as well as *indirect users* who benefitted from SLES, for example through improved air quality.

It was found that only half of the 122 SLES projects deployed some kind of engagement activities to involve users. The extent of engagement varied, depending upon project aims and allocated budget. About 25 different engagement methods were identified. The most popular user engagement methods were events, meetings and trainings that covered 41% of the overall engagement activities. Websites, local media, poster, flyers and leaflets formed 22% of engagement activities. Interestingly open days and exhibitions were not found to be popular possibly due to resource implications. Although a combination of engagement methods were used, most of the methods were one-offs with little longitudinal engagement.

4. Discussion

This meta-data study helped to characterise SLES initiatives in the UK in terms of start year, lead actor, energy technologies, geographical location and user engagement. It is evident that majority of SLES were either led by, or had involvement of DNOs given that most SLES projects focussed on grid balancing and local energy management. Despite the high levels of innovation involved in these projects, only a fifth of the initiatives were either led by, or had involvement of Universities who could have conducted independent and impartial evaluation of the outcomes and impacts of SLES initiatives.

It was found that majority of SLES demonstrators were located in Scotland and the Northeast England, as well as Southeast and Southwest of England. One of the reasons for the surge in SLES initiatives in Scotland especially in island areas, was to overcome grid constraints and manage demand peak using smart grids [9]. A study of the Renewable Energy Planning Database [9] and Scottish and Southern Electricity Network energy generation mapping [10] revealed high grid constraints in South-West England (Cornwall, Devon and Somerset) with low levels of electricity generation (Figure 5).

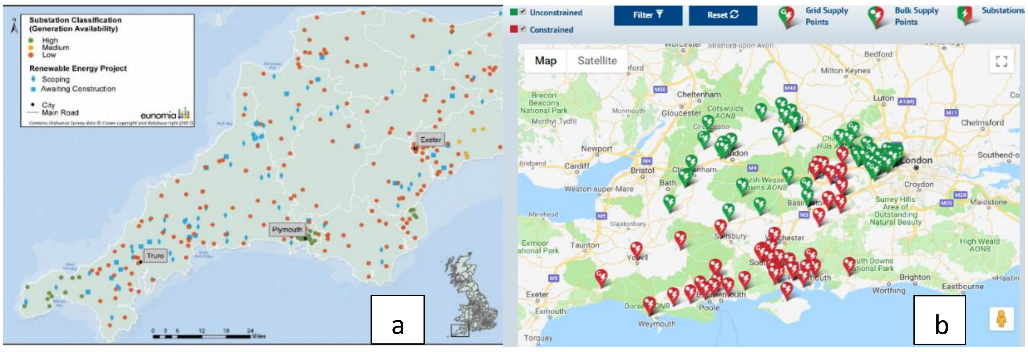

Figure 5: Grid constraint in (a) Devon, Cornwall and South Somerset [9] and (b) South of England [10]

Furthermore, Scotland, South of England and South-West England were found to have a high concentration of community energy groups, as shown in the Community Energy Strategy 2014 [11] and Community Energy Hub online map [12]. Majority of renewable energy and energy related projects were undertaken in these regions as shown in Figure 6b below. For example, community energy projects undertaken in South-West England used electricity sub-station metering data for stimulating community-led behavioural change initiatives to reduce local power demand and shift peak load [13]. The prevalence of SLES initiatives in Scotland also matched with high levels of local authorities' engagement with the energy system [14] (Figure 6c). This implied that areas which had seen a growth in SLES initiatives tend to have grid constraints (technological) and active community energy groups (people) as well as local authorities who engage actively with the energy system (policy).

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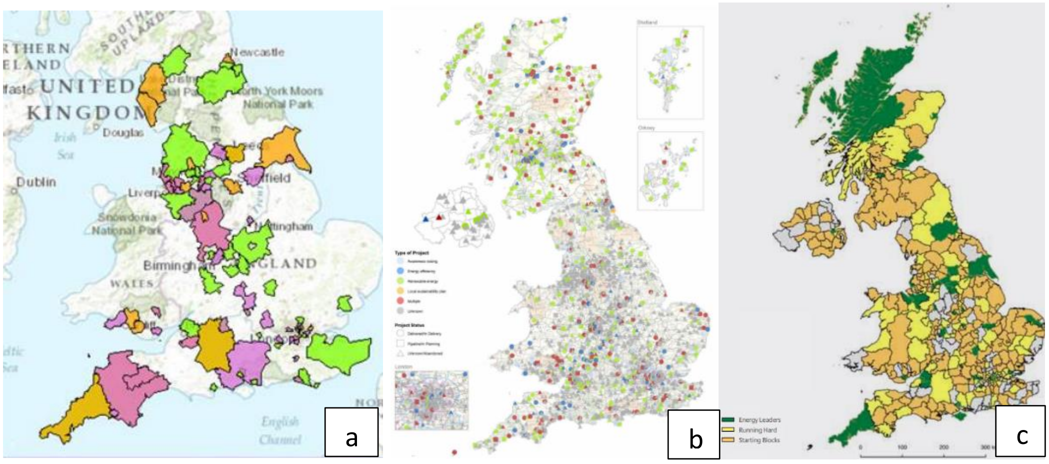

Figure 6: Spatial distribution of (a) renewable energy technologies and energy plans [15] (b) local/community energy actions [16] and (c) local authorities' engagement with energy system [14]

The meta-study also revealed that only half of the SLES projects had some kind of engagement with users. Although SLES initiatives were carried out at local scale, a key focus of the projects were on the elements of smart rather than locality and user engagements. Most of the engagement methods were implemented as snapshot (one-off) to encourage participants to participate in the SLES project. Public events, advisory meetings and training were found to be the most commons methods of user engagement. However none of the initiatives tracked the 'user journey' over time (before, during and after the SLES project). Such longitudinal engagement with users is necessary not only for considering users requirements in demand side response and grid balancing, but also to ensure user acceptance of SLES initiatives for their scalability and replicability [17]. The reasons for the lack of longitudinal user engagement were due to project time-scales, limited budget and expertise of the project team.

5. Conclusion

This paper has carried out a meta-study of 122 SLES demonstrators in the UK from 2009 to 2018. These SLES initiatives have received some form of funding, deploy multiple vectors (heating, power or transport) and have an element of 'smartness' to them that includes innovative use of data, digitalisation or innovative energy management systems. The SLES initiatives were characterised in terms of their leadership, location, types of energy technologies deployed, energy vectors and the extent of user engagement. This helped to explain why certain SLES projects were carried out in specific location, led by a specific actor and happened in specific period of time.

Despite the fact that the UK government published the first ever *Community Energy Strategy* in 2014 that presented a decentralised vision of energy transition in which communities would play a primary role in engaging users, it was found that only 20% of the 122 SLES initiatives were undertaken in partnership with community energy groups (civil society). In these 20% of SLES initiatives, although user engagements activities were undertaken, they were largely one-off, with absence of longitudinal evaluation to capture 'user journey' over time, despite the need to understand how users begin to engage with SLES and how these initiatives engage with users, and how that engagement develops over time.

Such insights can inform the next generation of SLES initiatives in the UK that have been funded under the £102 million *Prospering from the energy revolution* (PFER) programme as part of UK's Industrial Strategy Challenge Fund. In future SLES initiatives, it is also vital that that user engagement is paid more attention to, not only for the wider acceptance and roll-out of SLES initiatives, but also to achieve SDG 7 on providing affordable and clean energy for all and SDG 13 goal on Climate Action [6].

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