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Smart power to the people: Business models for engaging domestic energy users in smart local energy systems in Britain

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ABSTRACT

Smart Local Energy Systems (SLES) are proposed as a method of decarbonising energy systems that uses demand management by energy users to integrate intermittent renewables. SLES therefore require the increasingly active participation of energy users in the operation of energy systems. We spoke to operators and developers of existing local energy systems in Britain today, to understand their business models, and how they interact with users. We find that users are seen as critical to the effective operation of local energy systems. Operators support users to play this role, either through providing advice, or through minimising the amount of adapting to new technologies and techniques users are required to do. Often these users are physically connected to the local energy system, and cannot easily switch to a different system.

As widespread deployment of SLES will require the participation of domestic users who currently can easily switch suppliers, better user engagement is a key challenge for SLES. We ran two workshops with local energy system stakeholders to develop business models to address this challenge. We present two outline business models designed to provide increased consumer protection and support to SLES users. We draw on the literature on smart energy users to analyse existing systems and our outline novel business models, discussing the conceptualisation of users that underpins them, their governance and potential conflicts of interest, and who they create value for. We end with suggestions for policy to maximise the potential of these business models to provide socially equitable access to SLES.

1. Introduction

Smart Local Energy Systems (SLES) are proposed as a key component of an affordable and secure decarbonised energy system [1,2]. While definitions of SLES vary [3], they generally involve ideas about balancing energy generation and use at regional or local scales; integrating heat, power, transport and storage to make the most efficient use of all available decentralised energy resources; and the use of digital technologies to enable this process. SLES are a significant change both from the large-scale centralised structures, and from the separation of the heat, power and mobility energy vectors, characteristic of the mainstream British energy system.[1]

This paper looks at the relationship between domestic energy users and SLES. A critical change envisioned in SLES is in the role of domestic

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[1] As none of the interviewees and workshop participants was based in Northern Ireland, and as Northern Irish energy governance is slightly different to that of the rest of the United Kingdom, this paper will refer exclusively to the energy system in Britain (England, Scotland and Wales) rather than the UK as a whole.

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energy users.[2] Whereas previously users were conceptualised as passive consumers,[3] SLES are generally seen as needing the increasingly active participation of energy users in the operation and governance of energy systems [3–5]. While this active user engagement offers some new opportunities to receive income as 'prosumers' [6], it also risks imposing new costs and burdens on users [7,8]. Users perceive this risk and are understandably wary of adopting smart energy technologies and contracts [9].

The focus of this paper arose out of research that sought to complement studies of grant-funded demonstrators and pilot projects [3,4,10–15] with an exploration of local energy systems that are currently operational in Britain as an ongoing concern, i.e. that are *not* grant-funded demonstrators or pilot projects. These were systems where multiple energy activities were operated together within a defined regional or local geographical area. To avoid definitional confusion over what counts as 'smart' in this context, we simply call all these existing systems 'local energy systems'.[4] We use the term 'Smart Local Energy System' to refer to a broader range of potential future local energy systems envisaged in the SLES literature.

We sought to explore, first, their *current* business models; and secondly, what *new* business models their operators and developers felt were needed to take the next steps towards creating SLES across Britain. We focussed on new business models, rather than new technologies or new policies because, firstly, literature on business models for SLES remains scarce. Secondly, we were interested in exploring actions that could make an expansion of SLES economically viable in the short term. The objective was to explore actions that did not require a lead-in time for policy change or regulation, and that lay within the power of local energy businesses (and other energy actors beyond central government) to take.

Therefore, we collected data on 29 systems via interviews, and ran two workshops with operators and developers of local energy systems, in order to better understand their business models (see Methods). While we found that existing systems are highly diverse, (for more detail see [16]), we also noted an important similarity regarding the user relationships: almost all of the systems were integral to a physical estate of some kind (housing development, industrial or commercial estate, university campus). In the terminology of Briggs (see below section 2 and [11]) these were "physically connected" systems. Therefore the energy users (residents, businesses whose premises were located on the estate, etc.) were 'tied' to the local energy system as their energy supplier. Unlike most energy users in Britain, they were not free to switch energy suppliers – unless they were prepared to move to another home or premises in an area beyond the local energy system.

Following this research exploring the business models of existing local energy systems, we conducted two workshops with local energy stakeholders, aimed at developing novel business models that would support the expansion of SLES in the UK. In both workshops, rather than explore the expansion of existing physically connected [11] local energy systems, participants focussed on devising business models to engage 'mainstream' domestic energy users. In a significant departure from understanding SLES user relationships as dominated by digital technologies, both models include face-to-face support for users as a key activity, to address perceived weaknesses of existing approaches to user engagement.

Our research had thus taken us from a broad exploration of the business models of existing local energy systems, to the specific issue of how domestic energy users could engage with future SLES. We therefore decided to focus this paper on the engagement of domestic energy users with SLES. In particular, we seek to answer these two questions:

1. What are the main characteristics of domestic energy users of local energy systems?
2. What business models could support domestic energy users' engagement in SLES?

The paper is structured as follows. Section 2 situates this paper in relation to other research on SLES business models in general, and on the position of domestic energy users in SLES in particular, exploring different meanings of and approaches to user 'engagement'. Then in Section 3 we describe the research methods we employed and the analytical framework that underpinned our work. In Section 4, Results, we present, firstly, our findings about local energy system domestic users in Britain today; and secondly, the business models developed in stakeholder workshops to address some of the challenges of engaging users. In Section 5 we discuss these results, exploring how the new business models approach user engagement and impact on users' power, and what kind of value they create. Finally, in Section 6, the Conclusion, we present a summary of key points, followed by a discussion of limitations of our research and suggestions for further study.

2. Context: SLES business models and domestic energy users

There is an extensive research literature on SLES, covering topics from the technical possibilities and requirements of systems (e.g. [17–19]) to the more socio-technical aspects, such as their purpose, development, organisation and governance (e.g. [3,11,20–26]). Our focus on users within SLES business models places this paper firmly within the socio-technical domain of the literature. In this section, we situate the paper in more detail within the literatures on, firstly, business models for SLES; secondly, domestic users' relationship with SLES; and thirdly, engaging users in SLES. Finally, we explain the paper's contributions both in connecting these three areas of the literature and in adding novel insights from our research. As noted in the Introduction, there is no one settled and precise definition of the term 'smart local energy system', and so we have looked at any research on local energy systems, whether under the name of 'SLES' or another term, e.g. 'smart grids' [27] or 'energy communities' [28].

2.1. Business models for SLES

When examining other research into SLES business models, three clear themes emerge. Firstly, SLES are expected to create multi-dimensional value, beyond the economic value which is the focus of the conventional Business Model Canvas (BMC) [6,27,29]. Studies suggest that this extra value takes the form of safety (system reliability), ecological value or "environmental protection" in the form of facilitating greater use of renewables [30], and social value e.g. in the form of lower cost heat supply to mitigate fuel poverty [27]. Consequently, an analytical approach that builds on the BMC to incorporate extra value dimensions is required.

Secondly, diverse business models are identified, with studies proposing five emerging models for SLES [11], eight archetypes for "energy communities" [28], seven "prosumer business models" [6], nine business model archetypes for "local supply" [31], or six types of activity and three types of revenue stream for "virtual power plants" [30]. Hence, the concept of 'smart local energy system' does not indicate a single way of organising energy provision, but can encompass many different business models.

This diversity is also related to the complexity of energy systems, and how different components are connected to form a system, as shown in Table 1 (adapted from [11]). These different types of connection have

[2] Throughout this paper we will use the term 'energy users' rather than 'consumers' or 'customers', except when quoting others. This is in order to use as simple and accurate a term as possible: SLES may have various customers including other energy companies, and technically energy is used not consumed.

[3] With conceptions of "active" consumerism restricted to switching between different energy providers [32].

[4] More detail is available in [16]

Table 1
A summary of Briggs' typology of SLES internal connections.

Connection type	Explanation	Examples
Digital	Data on energy in a local area made available to third parties.	Asset register, project marketplace
Commercial	Removing complexity to facilitate energy trading. May involve aggregating smaller scale providers.	Local energy market, aggregators.
Virtual	System components managed virtually to match demand and generation in a local area.	Virtual power plant, local energy market
Physical	Physical connection and control of energy system components.	Anchor asset: EV charging fed by storage, heat network fed by solar.

Source: [11] p7.

implications for business models: for example, a model based on a "physical system" may incur considerable operating and maintenance costs, but also allow the operator considerable direct control over components; conversely, a model based on a "commercial" or "virtual" system may require less physical maintenance, but present more complex challenges of coordinating the activities of many different actors.

Thirdly, the literature provides little insight into user relationships. However, an important point that is made is that business models that involve users being flexible with their energy use "reach deeper into their lives" than existing energy retail business models. While this is an opportunity to engage users, it is suggested that many users may prefer to "delegate the management and optimisation to a third party" [6], thus minimising active engagement.

These issues of SLES user relationships and value propositions are taken up in the wider literature on SLES (beyond that focussed explicitly on business models), which we now explore.

2.2. SLES energy users: role and difficulties

The 'engagement' of users in an energy system can mean several things, from (at a minimal level) being given information about a system, to expressing views (for or against!) about a system in some public forum, to becoming involved in its management and governance [32,33]. For any energy system, a fundamental way that actors can 'engage' is in becoming a user of the energy provided by the system. This engagement might require the user simply to undertake to pay for the quantity of energy they use. However, one of the features often associated with 'smartness' in energy systems is that users' management of their energy appliances is seen as critical in determining the technical and commercial functioning of the system [17]. Previous patterns of energy demand, particularly for domestic users, were largely taken as given, with generation and distribution organised to accommodate them. In contrast, SLES concepts [3,10,34] expect domestic users to provide 'flexibility' or 'demand-side response' to intermittency of supply from renewable generation, with benefits to the whole energy system. Such flexibility services might include, for example, matching their household's energy use to the availability of local supply, or avoiding energy use during peak demand times. Therefore, the question of how domestic user energy management will be assured, and how users can meet the demands placed upon them, is important for the creation and operation of SLES business models.

Users' capacity to fulfil the role that SLES assigns them should not be taken for granted. In terms of the social impact of SLES on domestic energy users, it is important to realise that the capacity to be flexible in order to meet wider system requirements is not equally distributed among the population. Different actors are regarded as having different amounts of "flexibility capital" [8], depending on factors such as the physical characteristics of the building they live in or the local energy network [35], their ability to afford technologies such as electric vehicles (EVs)s [8,21], the health and care needs of their household [7], or their housing tenure and whether they control the energy infrastructure of their housing [35].

This issue of uneven capacity of domestic users to benefit from being a SLES customer is sometimes missed in the literature on smart local energy. One major literature review of over 100 studies of local energy market business models notes that, while 'prosumers' are by far the most prominent actors identified, there was virtually no mention of any particular skills or capabilities prosumers would need in order to participate in local energy markets [36].

Other studies do, however, highlight challenges around users. The "engagement and recruitment of users/consumers" is considered one of the "key barriers" to upscaling SLES projects [37]. Another study notes that the successful decarbonisation of heat depends on "millions of decision-makers" [22]. And, while suggested policy measures for heat pump deployment focus on pricing, finance and regulation, a toolkit for promoting heat pumps also features "communication" and "eliminating fear" – although in this case with as much emphasis on changing the views and practices of installers as changing those of users [38].

Beyond "fear", other specific barriers to "the engagement and recruitment of users" are identified in the literature on SLES and the energy transition. A recent review of the literature on energy flexibility [13] identifies the following potential risks to domestic users in a transition to a smarter energy system: not being included because SLES focus on 'low risk', often wealthier, groups; lower than expected performance or financial benefits from smart technologies, and lack of understanding about how best to operate these technologies; lack of consumer protection and redress services; and users being abused through exploitation of their data or even of external system operators overriding user home energy settings. These risks raise issues of power relations between users and system operators, and also (again) issues of uneven capacity of users to engage with SLES, and of unequal distribution of costs and benefits from SLES. Another recent study found that a wide range of energy system stakeholders felt that addressing issues of power and fairness would be essential if households were to be persuaded to participate in SLES [39].

These various barriers and inequalities can certainly be seen as risks that SLES pose to domestic users, or as contributing to potential "injustices of SLES" [21]. However, they also present clear risks for the development and operation of SLES [39]. Without users who understand how to operate their energy technology, and how end-user behaviour fits into the wider system, SLES are likely to function inefficiently. Clearly, without users who are willing to participate, SLES may not function at all. Yet according to the consumer affairs body Citizens Advice, many people feel that equipping their homes for the energy transition is "too complicated" and that "things go wrong too often" [40]. Most people have low confidence in smart energy services and contracts, and are concerned about data privacy [9]. Energy users' trust is further undermined by "chaotic" information provision, and a lack of the basic consumer protections found in many other industries [40].

2.3. Overcoming barriers to SLES user engagement

How, then, can these difficulties be overcome and users be successfully and equitably engaged? Two reviews of the extensive SLES literature shed light on how developers and researchers address this question. Throndsen [5] analyses the ways that SLES users are conceptualised in theory and practice, categorising them into three approaches to engaging users: economic, technological, and sociological. A more recent review [4] directly addresses the issues of power relations and inequalities between users, and between users and system operators, highlighted in the previous section.

2.3.1. Economic incentives, technological solutions, and sociological critique

Throndsen finds that the economic approach can be found in research about the economic viability of SLES business models, which often evaluates strategies for the pricing of user flexibility, the potential revenue streams they might generate and the users that might be engaged [41,42].

The technological approach seeks to remove the burden of domestic energy management by letting automation do the work. 'Smartness' is often interpreted in this technological sense, although not necessarily as removing *all* need for users to actively manage their energy system [3,43]. Another variant on this approach is to have another organisation, rather than a piece of hardware or software, take the workload off users. Rather than seeking to fine tune their energy usage, users may value "simplicity" of experience and be prepared to "delegate" control to others [6].

In contrast, Throndsen contends that the sociological approach often takes the form of a critique of the economic and technological approaches. It is exemplified by the work of Strengers [44], who coins the term "Resource Man" to describe the kind of user that domestic smart energy technology appears to be designed for: one who, like an energy company in miniature, "is interested in his own energy data, understands it […], responds rationally to price signals and makes informed decisions". Strengers [44] suggests that, instead of expecting "consumers" to adapt those lives to better fit the designs of industry, the smart technology industry might have to adapt to the "messy" reality of most people's domestic lives (where decisions are made about cooking, washing, etc., rather than 'energy management' per se). Focusing on energy use flexibility and SLES in particular, this messy reality can constrain different households' capacity to e.g. shift their energy use to a different time of day [7].

2.3.2. Rationalities of user engagement: participation and power

Alternatively, approaches to user engagement can be analysed through the lens of the power relations between system operators and users. Based on theories of citizen participation, user engagement in SLES pilot projects can vary between "citizen power", "consumerism", "tokenism" and "non engagement" [4]. While noting that the state-led nature of the pilot projects precludes true "citizen power" - where local citizens have full control of the management of SLES - the literature nevertheless identifies some "diluted forms" of citizen power where projects include local community bodies as official partners. "Tokenism" refers to projects where local residents are given information and SLES are promoted to them, but they have no formal control – rather the emphasis is on "helping people feel they have ownership" rather than actually giving them a "literal" ownership stake. The category of "consumerism" is closest to the economic approach identified by Throndsen, where engagement focuses on "marketing" SLES based on the self-interest of potential users "who are assumed to be apathetic with regard to system-wide or community benefits". Finally, "non-engagement" is a strategy where "engagement with users or community groups [is] actively avoided" because they are thought to lack the knowledge and interest to contribute to SLES projects.

It can be seen that the concept of 'consumerism' outlined by Soutar et al. [4] has some overlap with Throndsen's 'economic' approach, both being based on financial incentives to individual users. Again 'non-engagement' has echoes of Throndsen's technological approach to users where "disruption" is to be minimised. However, Soutar et al. [4] highlight the unequal power relations in situations where "control is held entirely in the hands of project partners as SLES 'experts'". We will return to the categories proposed in both these reviews in our Discussion (Section 5), in particular in relation to governance arrangements for the new business models outlined in the Results (Section 4).

2.4. Contribution of this paper

This paper contributes to the literatures on SLES business models, and on domestic energy users in SLES, by bringing these strands of research together for the first time. In answer to our first research question about current domestic energy users of SLES, we provide new empirical data on users in local energy systems in Britain today, noting that they are mostly physically, rather than virtually, connected [11]. In answer to our second research question on how to support new domestic users engaging with SLES, and driven by the focus and concerns of participants in our stakeholder workshops, we then outline two novel business models for intermediary organisations delivering support services to domestic energy users. These support services address three of the challenges noted in the literature, namely: lack of domestic energy user understanding, lack of consumer protection, and risks of technology underperformance. They are also novel in their focus on the provision of personalised, face-to-face and ongoing support to households joining SLES, going beyond conventional energy advice services.

We then bring the literature on SLES business models and user engagement to bear on the new business models we outline. Specifically, we draw on the literature on the varied approaches to, and meanings of, user 'engagement' to analyse how these are reflected in the new business models, and the power relations between the different actors involved. And we draw on the literature on SLES business models and the position of users within them to analyse what kind of value the models might create, for which actors. We also explore the implications of this analysis for the business models' funding, and for their capacity to expand the reach of SLES and impact on the energy transition. In so doing, we contribute to the literatures on local energy business models or 'archetypes', and on approaches to user engagement and power relations in smart energy systems.

3. Methods

Our research was conducted across four inter-linked stages. We first developed an analytical framework to structure the research. We then conducted interviews with the operators of existing SLES. Following analysis of the interview data, we used an online survey to propose several topics for workshops on overcoming challenges to the expansion of SLES. On the basis of responses to the survey, we organised two workshops, one on heat and the other on demand and flexibility. These stages are set out in more detail below, and represented diagrammatically in Fig. 2.

3.1. Analytical framework

In our research, we used the concept of a 'business model' to break down the operations and structure of the different local energy systems into a set of "critical components" [45], i.e. fundamental elements that every system needs to have in some form or other. While there are diverse conceptualisations of what a business model is in the academic literature [45], the Business Model Canvas (BMC) [29] is a well-established tool for analysing business models, and is increasingly used to analyse smart or local energy systems [27,28,30,46]. It outlines the fundamental elements of a generic business: providing something of value ("value proposition") to particular customers ("customer segments", "channels" and "customer relationships") by using resources ("key activities" and "key resources") – including those supplied by other organisations ("key partnerships") – in a financially viable way ("cost structure" and "revenue streams") [29].

However, the BMC is focussed on the conventional economic aspects of business models. As we noted in Section 2, SLES are expected to create multi-dimensional value, and the development of SLES is motivated by their potential contribution to the broader energy transition [3]. Therefore, we wanted to examine the environmental and social aspects of SLES, as well as the economic. To do this we chose the Triple-Layered Business Model Canvas (TL-BMC) [47]. The TL-BMC builds on the strengths of the original BMC, but adds layers of analysis that track the environmental and social impacts of each element of the business model alongside its economic aspects. It thus combines a wide-ranging approach to sustainability analysis with clarity of basic structure (the

BMC layout) which would facilitate communication with industry stakeholders in interviews and workshops.

The original TL-BMC includes 27 distinct topic areas comprising three analytical layers (economic, environmental and social) each with nine topic areas. It is presented as a framework that could be used for a generic business supplying products to a retail customer. While it has been used for research into SLES previously [43], we made several adaptations to produce a novel and condensed framework that fitted better both with the characteristics of GB local energy systems and the practicalities of our data collection methods.

To produce an interview schedule for our semi-structured interviews, we reduced the number of topic areas from 27 to 11, by identifying topic areas from different layers that overlapped each other. For example, questions on the number and type of customers served by the system could be used for the economic and social analysis; questions about the energy technologies employed in the system for the economic and environmental analysis. We also added topic areas about the use of smart technologies and methods of operation, and about the geographical scale of the system, to reflect our focus on SLES. The relationship between the original TL-BMC layers and topic areas, and the topic areas in our interview schedule, is shown in Fig. 1. The full interview schedule is reproduced in Appendix 4.

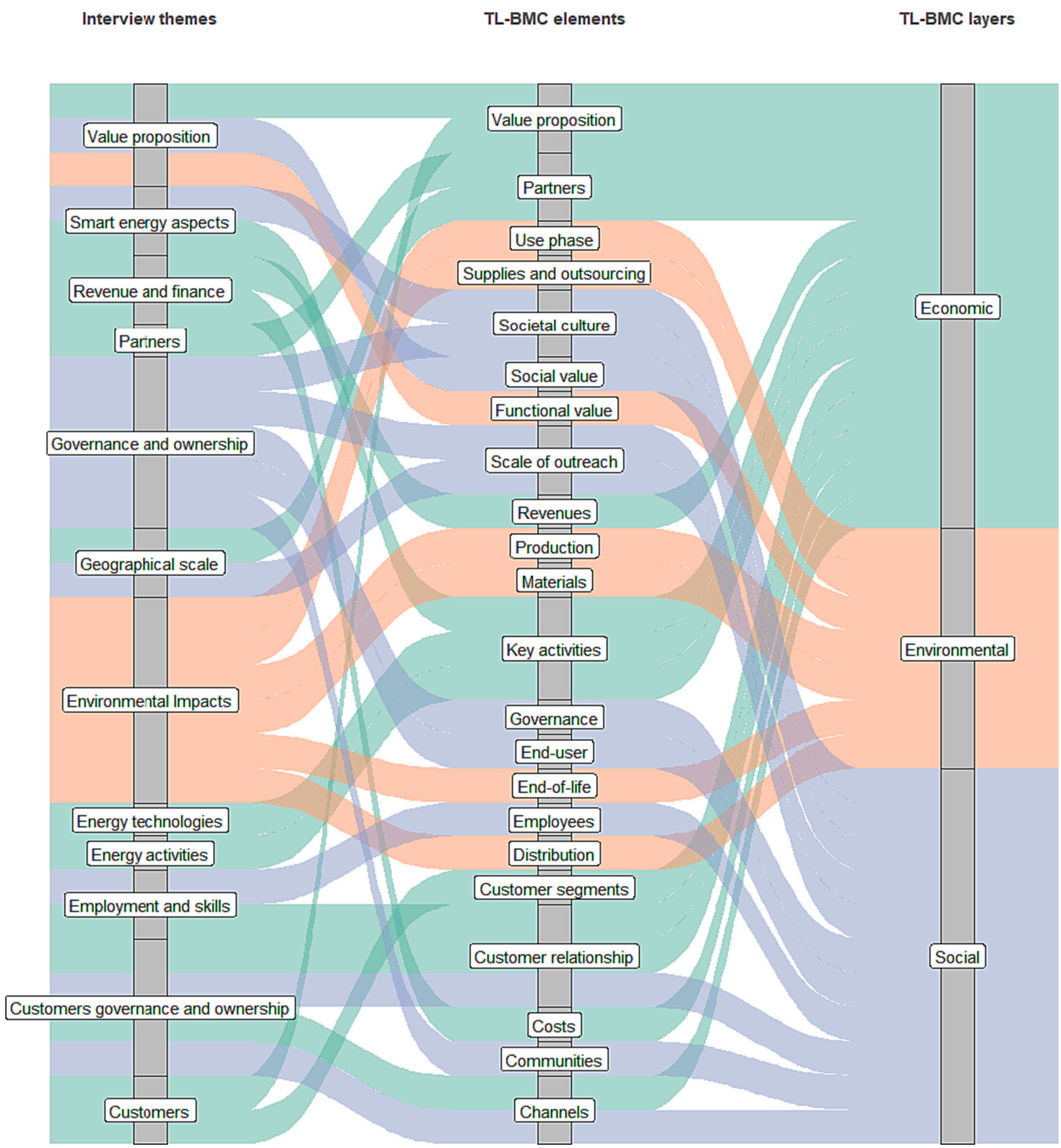

Fig. 1. Relationship of simplified Triple-Layered Business Model Canvas (TL-BMC) in our interview schedule to original TL-BMC.

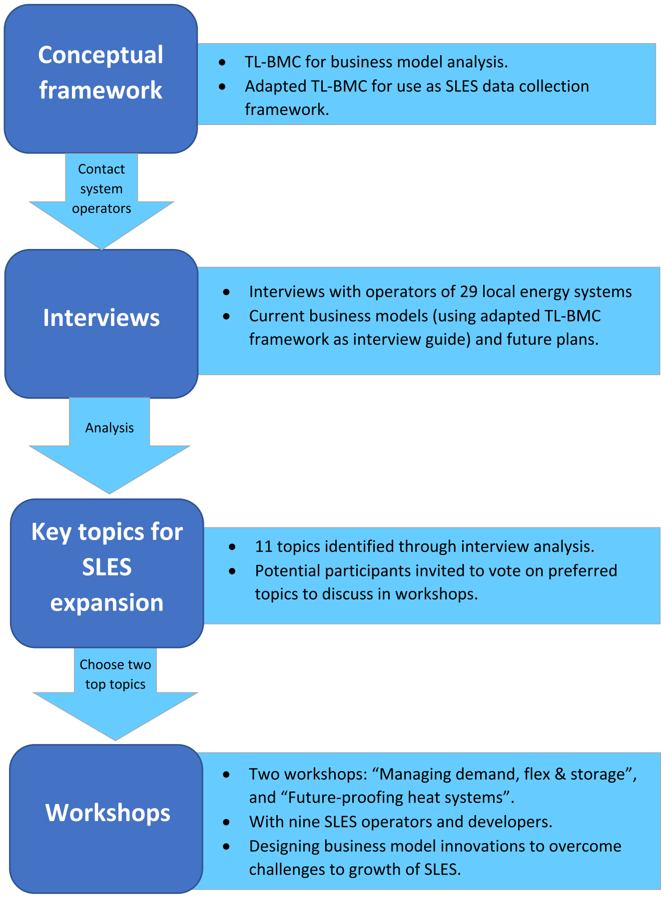

Fig. 2. Research Process Flowchart. Acronyms: TL-BMC – Triple-Layered Business Model Canvas; SLES - Smart Local Energy Systems.

To produce a framework for the future business models we hoped to design in workshops, we simplified the TL-BMC further. We produced a business model outline framework with just six topic areas – resources, activities, value, users and revenue, geographical scale, and ownership and decision-making. The workshop facilitators then prompted for economic, environmental and social issues within this framework. The framework was featured in a Mural Board which provided the overall structure for the workshop – a blank Mural Board is reproduced in Appendix 3.

3.2. Data collection - interviews

Our data collection strategy was driven by our analytical framework and the state of knowledge of local energy systems in Great Britain. Firstly, the analytical framework called for data on many aspects of a business model, in a clearly structured way. Secondly, part of the task of the research was to explore the range of systems that existed, as there was not a well-defined "smart local energy system" sector, nor were there comprehensive lists available of every energy system that might fall within our remit. Therefore, we needed a data collection method that would enable the systematic comparison of an unknown range of energy systems. We felt that a semi-structured interview schedule provided the right balance of structure and flexibility to ensure comparability of data across potentially diverse responses.

The interview schedule was based on our adapted Triple-Layered Business Model Canvas and comprised of a mixture of questions. Some were tightly structured, with a range of predefined answer options (e.g. technologies used in the system). Free-comment sections were used to ensure that we captured the diversity of local energy system configurations, including possibilities that we had not anticipated in our predefined answers, and to capture qualitative insights about value propositions or aspirations for the future. The initial draft of the interview schedule was shortened and refined with input from the UK Research & Innovation (UKRI); researchers from IPSOS Mori working with the Prospering from the Energy Revolution (PFER) SLES

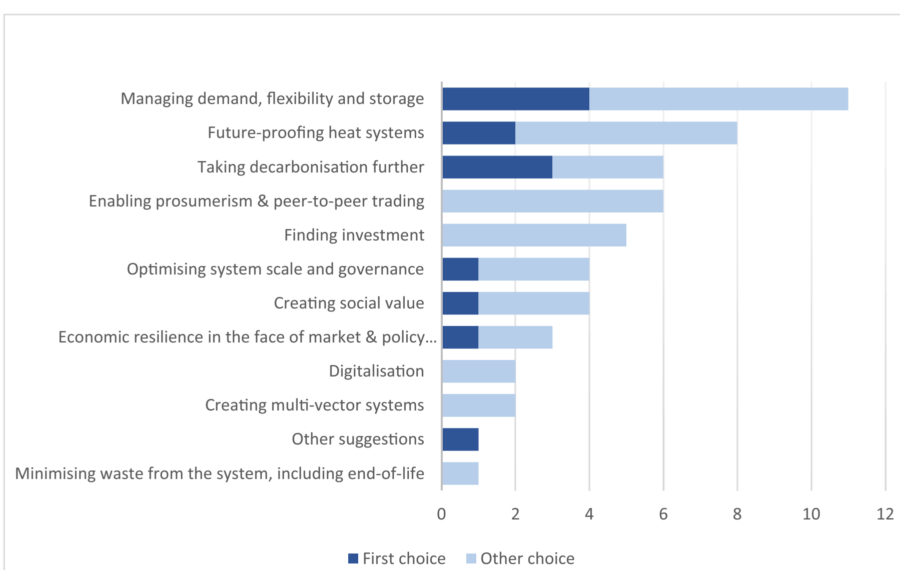

Fig. 3. Challenges for the future of Smart Local Energy Systems (SLES) which workshop participants voted on.
Note: stakeholders were invited to list up to five of the topics below, in order of preference, to be the focus of a workshop. Short explanations of each topic were also provided: these can be seen in Appendix 2.

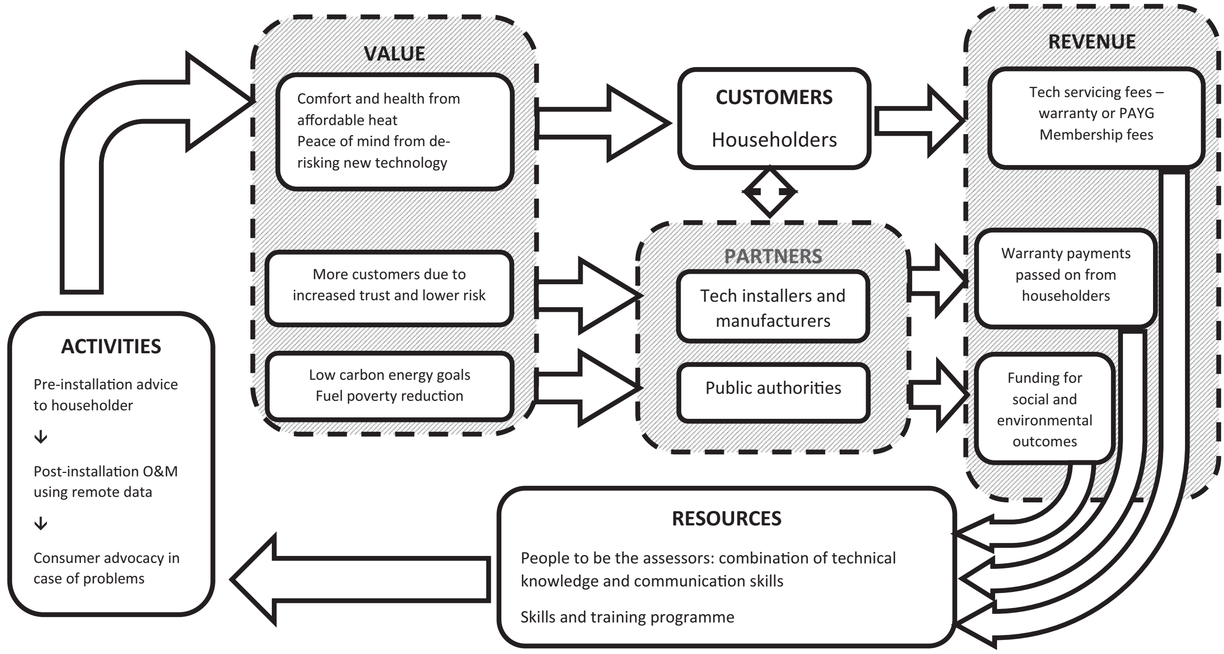

Fig. 4. Outline business model: Local Heat Advisory Service.
Note: O&M means Operations & Maintenance.

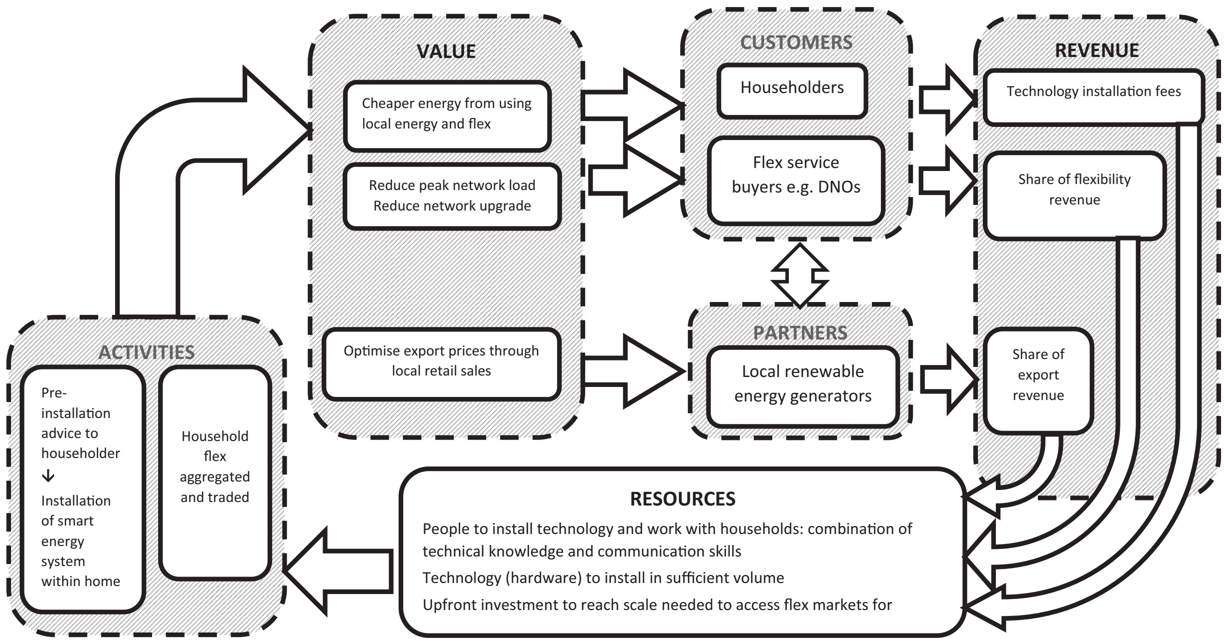

Fig. 5. Outline business model: Household Smart Energy Integrator.

demonstrator projects; and the lead engineer for a PFER SLES Design Demonstrator project (Zero Carbon Rugeley). The full interview schedule is reproduced in Appendix 4.

Interviews were conducted between February and September 2021. Researchers contacted potential participants via several different approaches: the EnergyREV website and mailing list; UKRI's Knowledge Transfer Network; newsletters of the Association for Decentralised Energy, and Local Energy Scotland; and through directly contacting potential operators of local energy systems, based on web searches and contacts in the energy sector. Organisations that were interviewed are listed in Appendix 1 (see Section 3.4 regarding data confidentiality also).

We designed the interview schedule so that it could also be used as an online questionnaire, should system operators prefer to provide data in that format rather than in interview. However, the great majority of participants (23 out of 29) chose to be interviewed using video call platforms such as Zoom and MS Teams. In these interviews, the researchers completed the online questions on behalf of the interviewee participating in the study; the researchers shared their screen so that the participant could see the responses that were entered. In addition, one in person interview was conducted, in which the researcher noted down responses on a printed copy of the interview schedule, and later input the responses into the online questionnaire.

3.3. Data collection - workshops

After investigating current local energy system business models in interviews, we wanted to explore how innovative business models might help overcome challenges to the future of SLES. We felt that this exploration was best done in collaboration with local energy system operators and stakeholders, in workshops. Analysis of interview data identified eleven topics relevant to growing the number, scale or scope of SLES in the UK. We used a short online survey to obtain the views of potential participants on which of these topics should be the subject of a workshop (see Fig. 3). We asked people to select up to five topics they would be interested in discussing in a two-hour online workshop.

We then scheduled two workshops on the two most popular topics. As seen from Fig. 3, "Managing demand, flexibility and storage" was the most popular, and became the topic of one workshop. We set "Future-proofing heat systems" as the topic for the other workshop, despite it having fewer first choice votes than "Taking decarbonisation further", for three reasons: it was clearly popular, several people voted for both these topics; and heat is a key challenge for further decarbonisation.

The workshops were held online using Zoom, with Mural Boards as a visual guide to the structure of the workshop, and for participants to write down their ideas. (A blank Mural Board is reproduced in Appendix 3.) In the workshops, participants were first asked to individually provide potential innovations that might help overcome the challenge. These innovations were then discussed in terms of how significant an impact they would have on SLES development and how feasible they were to implement in the next two to three years. A single innovation was then selected to focus on in the second half of the workshop. In that second half, participants built up a business model around this innovation using the simplified six-topic-area business model framework described above. The facilitators acted as scribes, noting down points and comments from participants in the appropriate part of the framework on the Mural Board, and also noting any key issues that were raised but not resolved during the workshop.

While we are not able to provide names of workshop participants for confidentiality reasons, some further details of the workshop participants are given in Table 2 below.

3.4. Data analysis

Data collected during the interviews, or through self-completion of an online questionnaire, was downloaded into Excel and analysed both quantitatively and qualitatively. Simple quantitative analysis was used to describe the range of systems covered by the interviews, e.g. numbers of technologies employed, numbers and types of customers served, range of organisational forms, and more. Qualitative analysis was used to identify common themes in interviewee responses, e.g. around how they engaged with customers, or about their plans for the future. With their consent, participating organisations were listed by name in [16], although specific data were not linked with individual participants without further consent.

Data from the workshops comprised Mural Boards and notes made by the facilitators. We used the simplified business model framework to construct the Mural Boards and conduct an initial analysis of the novel business models (presented in Section 4). We then revisited the SLES literature to analyse the workshop data in greater depth, as presented in Section 5.

Table 2
Workshop participants.

Sector	Size/type	Energy specialism(s)	Seniority of participant and years in energy sector	Workshop number	
				1	2
Public	Local authority	Local Authority	Manager 18 years	X	
Private	Public sector and micro enterprise	Heat	Project Manager and Director 14 years	X	
Private	Micro enterprise	Heat, smart systems	Director 38 years	X	X
Private	Large enterprise	Heat networks	Mid level 8 years	X	X
Private	Large enterprise	Heat networks	Junior 2 years	X	X
Private	Medium enterprise	Heat	Department lead 2 years	X	X
Private	Micro enterprise	Smart systems	Director 24 years	X	X
Private	Micro enterprise	Smart systems, storage	Director 2 years energy (previously 33 years tech sector)		X
Third	Micro enterprise	Solar, storage, smart systems	Director 12 years		X

4. Results

In this section, we present data from the interviews and workshops. We begin with the interviews. While the interviews covered many topics (see [16] for more information), here we only focus on the interview data relevant to our first research question, showing how domestic energy users are engaged in current local energy system business models. We then present the business model innovations developed by industry stakeholders in our workshops, which provide potential answers to our second research question: how domestic users can be encouraged and supported to engage more actively in SLES in the future.

4.1. Local energy systems and domestic energy users in Britain today

The local energy systems covered in our interviews were highly heterogenous, varying considerably in size, energy sources and use of smart technologies (for more details see [16]).

However, we also noted some similarities, such that existing systems are generally run by organisations whose primary business is not energy, but who manage an energy system to provide services to a physical estate of some kind. Examples included local authorities running heat networks in social housing or in commercial centres, an industrial estate supplying tenants with solar power, universities running multi-vector energy systems for their campuses, and housing cooperatives running renewable power systems.

In these systems' business models, because the system is an integral part of a physical estate, the energy users on that estate have little choice but to buy their energy from the local system – or move out. Using the terminology of Briggs [11], the energy users were 'tied' to using the system. This dependence on the physical system significantly affected the operator-user relationship and engagement. Users may have primarily chosen a place to live, with the energy supply being just one element (and quite possibly a minor one) in their decision-making. This is a significant difference to the situation of most domestic energy users in Britain, who can choose to buy energy from many different suppliers, and can change supplier while remaining in the same home.

Engagement was therefore less about attracting and retaining users (as customers), and more about problem-solving in the context of a long-term relationship. In some cases, operators organised open days or events to encourage residential customers in housing developments to learn about the system and discuss any issues. In other cases, the system was wholly or partly owned and managed by residents themselves, for example in the case of a housing cooperative that owned a biomass heating system and contracted with two separate energy cooperatives for provision of solar and hydroelectric power.

Not all systems operated this user relationship. Notably, Energy Local is a social enterprise that has founded several virtually connected local energy systems around Britain, with the first and best known in Bethesda in North Wales [48]. In these systems, users are free to opt out at any time [49]. However, while our data is not a representative survey, such virtually-connected systems are in the minority at present.

Our interviewees explained that the type of user relationship is important. This is because user operation of heat and power generation technologies in their buildings was regarded as important, both to the performance of the system overall and to the users' experience.

Secondly, users' reactions to new technologies varied widely. One system operator noted that user adoption of new technology "can go wrong… but sometimes is excellent!" (interviewee #3). Less positively, another interviewee told of a trial of air-source heat pumps, where users never became comfortable with the new technology. Therefore, because user behaviour was important to system operation, system operators took steps to manage it. We found that where users had to learn new ways of using energy – for example, switching from individual gas boilers to networked heat, heat pumps or heat recovery systems – then some system operators dedicated staff time and information days to helping users manage. Conversely, some system operators tried to design the system to minimise the learning required of users: in the words of one, the user experience was intended to be "seamless" [interviewee #24]. This latter approach fits well into the 'technological' or 'non-engagement' approaches to users identified in the SLES literature [4,5].

Thirdly, new types of energy tariffs were challenging to users. Some systems in our sample used 'time of use' tariffs that charge a different price for energy at different times. User understanding of how these tariffs are structured is important for maximising cost reductions from them. The tariff may fix peak and off-peak price periods in advance, for example always relatively expensive at evening peak times, always relatively cheap in the middle of the night. Alternatively, the prices may be variable, for example prices may be lower when local renewables are producing power, in order to encourage local use of that power. In the latter case, users may need to consult online information on local generation levels before turning on appliances. Yet in all cases, even where tariffs used relatively simple 'time bands', system operators reported that at least some users needed support to understand and use the tariffs efficiently.

Finally, there were a small number of systems where the users played a greater role in system governance. In the cases we studied, these were all cooperatives (of various types), and they often placed a strong emphasis on creating environmental value (e.g. through maximising the use of renewable energy) and responsiveness to the user experience. We will return to this theme of engaging users in system governance in the Discussion section.

4.2. Business models to support SLES expansion

As the previous section has explained, the majority of existing local energy systems supply only 'tied' users. Engaging domestic energy users who are not tied into a physically-connected system is therefore a major challenge for future SLES. In this section, we present findings from our two workshops, each of which developed a business model to help overcome this challenge. A key novelty of these business models is their emphasis on face-to-face support for domestic energy users.

4.2.1. Local Heat Advisory Service

The low carbon heat workshop participants felt that a lack of consumer confidence in low carbon heat technologies (such as heat pumps) was the key challenge for future SLES.[5] To overcome this challenge, a Local Heat Advisory Service offering expert advice and support was proposed (see Fig. 4 for a diagrammatic outline of the business model for this Service).

Two features of the activities involved in this business model stand out in relation to SLES: (1) the provision of face-to-face support for users (alongside the use of information and communication technologies (ICT) for monitoring and feedback, which commonly characterises smart energy business models); and (2) the emphasis on independent support extending beyond initial user advice into 'aftercare' also. Beyond the specific value proposition it offers customers and other heat systems actors, one workshop participant suggested that it could create value for the wider energy transition too. This wider value could be to transform the public image of heat pumps in the same way achieved for double-glazing in the UK in previous decades: from a product seen as expensive, of uncertain performance and promoted by pushy salespeople, to a standard energy efficiency feature of a good quality home. Note that while heat pumps would not necessarily be the appropriate technology for every home, participants believed that they would play a major role in the decarbonisation of domestic heat.

4.2.1.1. Value proposition. The heart of this business model was the creation of value for domestic customers in the form of better support and consumer protection when switching from fossil fuel heating to a low carbon heat system. Such support was seen as enabling them to "get the right sort of heat system" for them, and ensure that it was running correctly and that they knew how to get the best performance out of it – bringing both thermal comfort and cost savings. Value would also be created for other heat system actors: for system operators or energy suppliers in the form of better data on actual use of heat technologies, and in the form of increased take up of low carbon heat because of increased customer confidence generated by the Advisory Service.

4.2.1.2. Key activities. The critical element is that the Local Heat Advisory Service would provide support both before and after installation. Such support might include advice prior to installing a new system, as well as post-installation inspections of the system in operation, help in remedying any problems, and holding suppliers and installers accountable for any defects in their service. Initial advice could cover: suitable technologies for the household, likely costs, what is involved in installing and operating different sorts of system, etc. Follow up visits could ensure that householders understand how to use the new technology, and that it is working correctly. The cost of repeated home visits could be reduced by using smart technologies and remote data monitoring. For example, if the Advisory Service had access to heat pump performance data and temperature sensors in homes, advisers could focus on visiting homes where there appeared to be an anomaly, rather than visiting all homes.

4.2.1.3. Key resources. While there were some technological resources specific to this business model, including IT connectivity for participating households to enable remote monitoring of their heat system, the most important resource was felt to be the people who would interact with customers. Their ability to provide a face-to-face service, explaining the technologies to customers and building a relationship with them, would be critical.

4.2.1.4. Revenues and costs. One key difficulty was establishing the revenue stream that would pay for the Advisory Service. Vulnerable customers most in need of the Service might often also be those least able to afford it. Suggestions included an Advisory Service paid for by the installer for the first few years as part of a warranty offered to customers, similar to that currently offered by gas boiler installers; customers could then pay for advice if needed after the initial period. There was also a suggestion that public funding, perhaps from local authorities, might provide some revenue to enable the Advisory Service to serve users who could not afford to pay for it.

[5] Other business model innovations – notably several linked to making better local use of waste heat (e.g. from industrial processes) – were discussed but felt not to be so feasible in the short term.

4.2.2. Ownership and scale

Independence from technology installers was regarded as essential for the Advisory Service to play its advocacy role and to gain consumers' trust. If revenues were high enough, it might be attractive to a commercial owner; alternatively, a not-for-profit model might work better. These organisations might be community energy groups, or perhaps local authority led. The precise institutional set up might vary from one locality to another, depending on the scale of population to be covered and the existence (or not) of local groups and companies that could provide the service. More generally, while some aspects of the Advisory Service were regarded as essentially local – the face-to-face customer relationship and the knowledge of local heat options – others should be part of a national scheme, e.g. accreditations for proper installation of technologies. This latter part of the Advisory Service could be modelled on the work of FENSA (the double glazing standards body), which maintains a nationally-recognised system of quality accreditations applied by a network of locally-based inspectors and assessors.

4.2.3. Household Smart Energy Integrator

In the second workshop focusing on demand-side response and grid edge flexibility in the electricity system, participants proposed several innovations and activities that they felt would facilitate the development of SLES. These included smart charging of EVs aligned to local renewable generation, and the use of heat pumps as flexibility assets via heat batteries and variable tariffs. While these all represented attempts to enable grid-connected households to participate in local energy markets via smart technology, there was a lack of consensus as to which was the key next step. Therefore, these activities were combined into a single business model focussed on integrating smart energy technologies at household level as the building block of larger SLES (see Fig. 5). While the technologies discussed were all electric, the key features of the model could be used for non-electric technologies, e.g. water-based thermal storage. As with the first workshop, the key novelty of this business model is the focus on face-to-face support for households throughout the process of adopting new low carbon domestic energy technologies.

4.2.3.1. Value proposition. These activities would create value for the key customers, householders, by enabling them to save money on energy bills through maximising the use of "locally available cheaper energy". It was suggested that there might be a social dimension to this value in that customers currently on prepayment meters might gain the most (in comparison with their current tariffs). It was also felt that smart controls would give householders valuable data and the power to better understand their energy use and expenditure. Participants also saw value for other energy system actors: renewable electricity generators connected to the distribution network could maximise their energy export revenues, and distribution network operators could benefit from time-sensitive tariffs lowering peak demand on their networks.

4.2.3.2. Key activities. This business model would first involve advising households on which smart energy technologies were suitable for them, taking into account household circumstances, and the condition of the building. The next step would be to install multiple horizontally-integrated energy technologies in homes all at the same time, to maximise the benefits from smart operation. On installation, customers are signed up to an aggregator service (see ownership below) in order to allow them to participate in flexibility markets. Households with existing smart energy technology could also join the aggregator. The aggregator service was seen as an essential step for households to benefit from flexibility revenue in the short term, as British flexibility markets currently have minimum capacity requirements that preclude individual households participating directly.[6] A post-installation follow-up visit and ongoing monitoring of system data were also specified to help householders learn how to get the best performance from their new technology, and address any issues with the installation.

4.2.3.3. Key resources. This business model was considered to rely on technological, financial and human resources. Participants thought that the relevant technologies were largely developed and ready for commercial operation; but not necessarily widely available yet. An increase in the production of hardware was essential for the widespread success of this business model. Institutional finance from investors seeking higher environmental or social returns would be needed to enable rapid scale up of the model. Pension funds and ESG funds[7] were mentioned as possible sources. Regarding the people who would do the work, as with the Local Heat Advisory Service business model, the key missing piece of the jigsaw was locally-based organisations to engage consumers and explain "in plain English" the system benefits and how to work it.

4.2.3.4. Users, customers and revenues. Revenue for the business model operator was seen as coming from flexibility markets (and, presumably, from technology installation fees). While householders would be the key users of the service, whether they would pay for it might depend on whether they were owner-occupiers or tenants. In the latter case, landlords might be the customers. In both cases, there is a question of how the revenues are split between operator and customer; and for landlords, of how much of the revenue is passed on to the tenant. It was suggested that social landlords might wish to retain part of the revenues for other purposes, e.g. for a hardship fund for tenants.

4.2.3.5. Ownership. Related to questions of revenue sharing is the ownership of the business and what kind of organisation would operate it. Participants suggested that a commercial aggregator would seek to capture as much of the value as possible, whereas a different ownership structure - termed a "social enterprise model" - would be more open to sharing value ("the spoils") more evenly between participants. Transparency in the allocation of revenues and profits was felt to enhance trust and consumer take-up. It was assumed that ownership of the in-home energy technologies would stay with the owner of the home, although in the case of rented accommodation, or multiple-occupation buildings with multiple private owners, arrangements might be more complicated.

4.2.3.6. Scale of operation. Workshop participants felt that the aggregation of multiple households' flexibility in electricity demand would need to be at regional or even national level, in order to meet the minimum capacity requirements of flexibility markets. However, the business model contained some activities that necessarily operated at smaller scales, from integration of technologies at household level to integration of multiple households' energy consumption with renewable generation at 'community' or local scale.

5. Discussion: users and value in the new business models

Following on from the exposition of our data on system operator experiences of user engagement, and of the two innovative business models developed in our workshops, we now explore aspects of these

[6] One exception is the Demand Flexibility Service introduced by the UK National Grid in the winter of 2022–23. This initiative allowed individual households to be paid (via an energy supplier as intermediary) for reducing their electricity demand during "demand flexibility events"..

[7] Funds that make their investment decisions based on 'environmental, social and governance' criteria, in addition to financial criteria.

new business models in relation to wider themes in the SLES and energy transition literature. Specifically, we discuss: the approach to user engagement that underpins the two innovative business models; the power relations between users and other actors in SLES; and what kind of value those business models create, and for whom.

5.1. Approach to user engagement

The approach to user engagement in the novel business models presented in this paper mixes elements of the economic, technological and sociological approaches discussed in the literature. There is an *economic* element, in that users are envisaged as being able to manage their home energy technologies to save money (or earn it through flexibility tariffs). There is a *technological* element, in that the characteristics of the technologies involved are important. It is envisaged that users may need to adjust daily routines to adapt to how the SLES works, e.g. using energy at specific times of day, or learning the slower pace at which heat pumps warm a home. We also find elements of *sociological* approaches evident, as it is envisaged that the simple supply of the technology, or one-off provision of advice and information, will not be sufficient for all users to competently balance their needs with the characteristics of the technology. Instead, an ongoing customer relationship, including in-person home visits if necessary, will need to be available.

This extensive and personalised support contrasts with approaches that design energy systems for a kind of average or "meta-user" [5], and shows an awareness of human variety and the "messy reality" [44] within which energy is actually used. It also suggests an awareness that the 'smartness' in a SLES can be located in the human user as well as in the technology. While in Britain, 'smart' is most often associated with technology, user decision-making is recognised as integral by some [3], and some SLES projects in other countries explicitly focus on users' collective behaviour rather than on technology, e.g. Kityakushu SLES in Japan [43].

A personalised approach to user support also contrasts with the typical approach to customer support of energy utilities in the UK, where methods such as online billing and call centres are used to mediate the relationship between supplier and user. A shift to a more personal energy service approach of the type described in this paper would increase labour costs. Recovering these costs may entail trade-offs between the economic, social and environmental dimensions of value, and raises the question of how the costs and benefits of a transition to SLES are distributed (see Section 5.3 below).

In terms of the "rationalities of user engagement" [4] underpinning these business models, the new models predominantly take a "consumerist" approach. They do not trust that the "tokenistic" provision of information will be sufficient to win support for SLES. In their emphasis on consumer protection, they acknowledge that reluctance to embrace SLES and new domestic energy technologies is not (or not only) the result of users' lack of information, but also reflects real risks of technologies being mis-sold or badly installed. In contrast to the "technological" or "non-engagement" narratives that we heard from some of the operators of existing local energy systems (Section 4.1), the premise of the new business models is that technology cannot create a seamless transition to a SLES that householders hardly have to engage with. Instead, the new business models focus on, and create value for, the individual user or household, as a purchaser of goods and services. However, there is also a political element of "citizen power", in that the new business models explicitly acknowledge potential conflicts between the interests of users, technology providers, and the organisation operating the business model. In the next subsection we explore questions of these power relations further.

5.2. User power and business model governance

The potential for conflict between the interests of technology users, on the one hand, and technology manufacturers and installers, on the other hand, raises the question of the relationship between the technology manufacturers and installers, and the organisation that operates the business model (the 'BM Operator'). To the extent that the BM Operator is relying on warranties provided by installers and manufacturers for its customer leads and revenues, then it must maintain a good ongoing relationship with those manufacturers and installers. Yet part of the value proposition for users is what workshop participants called the "peace of mind" provided by knowing that the BM Operator will help them if the technology or the installation is at fault. Playing this consumer protection role might involve holding those same manufacturers and installers to account.

It was for this reason that workshop participants felt that the BM Operator would have to be owned independently of any manufacturers or installers, because otherwise users would not trust the Operator to play its consumer protection role. However, independent ownership in itself does not necessarily eliminate the issue of dependency on installers for warranty revenues. One way to tackle this issue would be to have a diversity of revenue streams, e.g. public funding, or direct payments from users as well as warranties. This diversification could also help increase the financial resilience of the business model, by spreading the risk of any one income stream drying up.

Another way to increase the BM Operator's accountability to users rather than to installers would be for the users to own all, or part of, the Operator. The precise institutional form that the BM Operator would take was left undefined in our workshops, but participants expressed interest in what they termed a social enterprise model, which could incorporate an element of user ownership. Such ownership would add a "citizen power" element to the role of users in the business model [4]. As noted in our Results section, some existing SLES are owned by their users, often as some form of cooperative. Companies owned directly by large groups of people – whether as cooperatives or some other legal form – are a small but established part of Great Britain's renewable energy sector [50,51], and a much larger part of some other countries' renewable generation e.g. Germany or Denmark [52–54]. Taking on ownership places yet more responsibility on the shoulders of users, but also gives them more power to monitor company activities. This may increase user confidence and engagement in SLES [39]. It also gives them power over the distribution of profits, potentially enabling them to create more social value, e.g. in the form of grants to insulate inefficient homes or subsidise the bills of fuel poor households.

5.3. Triple-layered value creation

We have noted in the Results section how the workshop participants saw both business models as creating economic value for domestic energy users, in the form of more affordable energy. The Household Smart Energy Integrator was also intended to create value for: (1) energy network companies, captured and monetised by the Integrator in the form of revenue in exchange for providing demand flexibility to network companies; and (2) for local renewable energy generators, captured and monetised in the form of a share of local energy sales revenue (see Fig. 5). Both business models also indirectly created value in the form of jobs for the people who would advise and support domestic energy users.

In addition to economic value, our analytical framework (TL-BMC) asks what social and environmental value is created by business models. Some of the economic value created could have social aspects, e.g. if it helps alleviate fuel poverty. Another possibility is that these models might help people feel part of the "energy revolution" [10]. Some studies find that many people are keen to 'do something' to tackle climate change, and that the collective action aspect of being part of a SLES can be rewarding [26,55]. Our interviews identified SLES where users were co-owners who valued their system contributions to the energy transition. As noted earlier, people may feel excluded from SLES because the system is perceived as "too complicated" or risky [9,40];

these business models could help simplify and de-risk participation in SLES. However, some of the reasons why people may lack "flexibility capital" [8] – such as household health and care needs, or capacity in the local energy network – are beyond the capacity of these new business models to change.

Turning to the environmental dimension, facilitating the decarbonisation of energy generation (the 'Production' element in the TL-BMC), whether heat or power, is the main environmental value created by both models. As SLES are intended to use 'smart' matching of demand and generation to lessen the need for network reinforcement and additional power generation capacity, they might create further environmental value in the form of avoided material consumption. However, material use and 'end of life' disposal, including the fate of obsolete high carbon technology such as gas boilers, were not raised as priorities by the research participants.

Consideration of value creation also raises the questions of who captures the value (both monetary and non-monetary), and who pays for it. This includes value capture in terms of ownership and profit distribution (as we discussed in the previous sub-section), but also in terms of how the delivery of services is funded, and how far it is linked to user ability to pay. The business models include personalised and face-to-face support as a critical element in making smart low carbon energy work for the most vulnerable domestic energy users, thereby going some way towards addressing the "injustices of SLES" noted in the Context section earlier in this paper, and creating maximum social and environmental value. However, such support requires considerable staff time, and is therefore costly. Revenue from end users may not be sufficient to maintain such support. Further, participants in the heat workshop felt that those energy users who might benefit most from support, who were least confident and least informed about low carbon heating, might also be those least able to pay for it. The same concerns would seem to apply equally to the Household Smart Energy Integrator: customers on prepayment meters, who were suggested as particular beneficiaries from new tariffs and technologies provided through the Integrator, are more likely to be on low incomes than other households [56] and therefore least likely to be able to invest in new technology or pay for the Integrator support service themselves.

Therefore, creating maximum social value through widening access to domestic low carbon energy technologies might require external funding. One candidate for the provider of this funding would be a local authority, for whom the Advisory Service could create environmental and social value through helping them meet decarbonisation and fuel poverty reduction goals. There would be a case for the Advisory Service to be supported from the budgets of multiple departments, e.g. housing, environment, and economy, perhaps supplemented by public health funding as several 'warm homes' programmes have been in the past [57]. Local authorities face general resourcing constraints that will limit the number of households whose support could be funded in this way in the near future [58,59]. However, centrally-funded but locally-implemented home energy advisory schemes - such as Home Energy Scotland, Energy Efficient Scotland or the Green Homes Grant (Local Authority Delivery) scheme - offer a foundation that could be built on and developed, if public funding were to be available.

6. Conclusions

In this paper, we have considered the business models of existing and potential SLES in Britain, with special reference to the role of domestic energy users. This analytical focus emerged from the research process and the concerns of stakeholders. First examining local energy systems in operation today, we find that most of their domestic users are 'tied' to a system, which is physically integral to their home, such as heat networks or micro-grids. We note that user behaviour is integral to the smooth functioning of a SLES, and that accordingly system operators either invest time in working with users, or design their system to minimise the need for users to actively adapt their behaviour.

Moving on to the challenge of expanding SLES to recruit domestic users currently choosing their retail gas and electricity supplier through the GB market, we outline two business models developed in workshops with industry stakeholders. One, the Local Heat Advisory Service, aims at increasing user confidence in adopting low carbon heating technologies. Notably, this business model is not a SLES in itself, but is envisaged as an essential 'building block' of a future SLES. The other, a Household Smart Energy Integrator, ambitiously aims both to facilitate the installation of integrated smart energy technologies in homes and to maximise the user financial benefit through a flexibility aggregator service, earning revenue from network companies and local renewable energy generators.

There are challenges to putting either of these business models into practice. There may also be limits as to how far implementing either of them can contribute to the development of SLES in the UK, create more multi-dimensional value and address potential SLES injustices. Firstly, the organisation that would run the business model would have to strike a balance between maintaining a relationship with technology installers and network companies, and acting as a 'champion' of energy users, including in disputes with installers or networks. Users taking a stake in the ownership of the business model operator might facilitate this balance. Secondly, while the models promise to increase user confidence and de-risk participation in SLES to some extent, they cannot overcome all the obstacles to user participation identified in the literature on domestic energy flexibility. Thirdly, the question of whether the models will generate sufficient revenue for economic sustainability is under-explored in the outlines developed in our workshops. It seems likely that the models would rely on some level of public funding – at least if they are to serve those people most likely to be excluded from SLES.

There is also the question of what role the business models outlined in this paper might play in the further development of SLES. One of the fundamental premises of arguments for more localised energy systems – of localised and place-based approaches to any issue – is that different local contexts need different solutions. Therefore, the outline business models presented in this paper should be seen as just that: outlines, to be fleshed out and altered to fit local conditions. We expect them to be a starting point for practitioners, rather than finished investable propositions. We know that at least one of the workshop participants was hoping to be involved in creating something similar to the Local Heat Advisory Service in their locality in the near future; we hope that this paper inspires further developments in other localities also. We also see this paper as contributing to the literature on SLES in the tradition of earlier papers presenting "archetypes" or models of local energy [6,28,30,31].

The emphasis on the availability of ongoing face-to-face support and consumer protection is a key novelty of the business models we outline. In this respect they share some similarities with the business model of Energy Local's Energy Clubs, that we referred to in Section 4.1. These systems generally involve a local community renewable energy generation company, providing not only renewable energy, but also a local human presence for customers to contact. While Energy Clubs do not currently involve the full integration of multiple energy vectors envisaged by many SLES concepts, further research into their practices of user engagement and support might shed further light into how users can be supported in the energy transition.

Research on domestic energy users could also be usefully complemented by work on how to engage other kinds of energy user, and indeed on other aspects of business models beyond user recruitment and user relationship. In particular, the wider environmental impacts of SLES merit further study, notably end-of-life waste issues associated with SLES components, and the older technology that they might replace.

In terms of theoretical lenses, as a SLES is a combination of many elements, both human and non-human, an assemblage or actor-network theory approach might prove fruitful. Questions could include examining how and why different actors and technologies come together to form a SLES; what the obstacles to assembling and maintaining a SLES are, perhaps in different local contexts; and identifying 'weak links' in the chain of actors and actions needed to develop SLES, and ways to strengthen these links. In the present paper, we have pointed to one such link – domestic user engagement – as highlighted by our research participants; future studies might find others.

In recent years Britain has seen a great deal of activity trialling and developing smart and local energy business models and bringing them to market: from the many pilot projects [10,11,14] to recent initiatives such as National Grid's Demand Flexibility Service or the range of time of use tariffs offered by Octopus Energy. Yet, we believe that the emphasis on face-to-face support for energy users - that continues *after* they have had new technology installed and/or joined a SLES - sets the two models outlined in this paper apart from many of the approaches taken to users both in the wider smart energy literature and in recent practice. Given the substantial issues related to users' mistrust, and the potential injustices resulting from uneven access to smart energy that are described in the literature, such support may be critical for enabling equitable uptake of SLES (and its attendant benefits).

However, while the operation of these business models is potentially viable without public policy support – in keeping with our intention to look at approaches for expanding SLES that did not depend on government – their reach in the short term would be limited to the 'able to pay' customer segment. Public funding for providing support to households who would struggle to pay for their services would greatly increase these business models' contribution to a just energy transition.

CRediT authorship contribution statement

Tim Braunholtz-Speight: Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Maria Sharmina:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft, Writing – review & editing. **Dimitrios Pappas:** Conceptualization, Data curation, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Janette Webb:** Conceptualization, Supervision, Writing – original draft, Writing – review & editing. **Fabián Fuentes-González:** Writing – original draft, Writing – review & editing. **Matthew Hannon:** Methodology, Writing – original draft, Writing – review & editing.

Declaration of competing interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Data availability

The authors do not have permission to share data.

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Appendix A. Supplementary data

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