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Clear support for an unclear concept? Public attitudes towards local energy systems in the United Kingdom

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A R T I C L E I N F O

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A B S T R A C T

Decentralisation offers one route to energy system decarbonisation, and local energy systems (LES) provide focal points for decentralisation. LES involve the integration of different generation, storage, and demand-side technologies across heat, power, and transport systems, within defined localities. Public support is necessary for LES deployment at pace and scale, but while past research has examined public attitudes towards individual technologies, few studies have investigated perceptions of systemic shifts towards LES. This paper presents findings from a nationally representative UK survey ($n = 3034$) on LES. We compare two ways of exploring perceptions of decentralised energy: as a broad systemic shift, and as the cumulative deployment of multiple LES innovations. Results show high levels of public support for a systemic shift towards decentralisation, but more moderate levels of support for specific LES innovations. Regression analysis highlight the role of personal characteristics, climate concern, political beliefs, and engagement with technologies in influencing support for LES. Support is more predictable for decentralisation, whose meaning is clear in principle while containing ambiguities in practice. Support for LES innovations is less predictable and is explained by the diversity with which households interpret the multiple propositions afforded by LES innovations. For LES to benefit from majority public support for a systemic shift, policy and industry actors need to better understand the diverse set of perceptions and values that LES hold for the public and seek broader and deeper engagement with the public around specific LES innovations, as well as around systemic change more broadly.

1. Introduction

Mitigating climate change requires the widespread and rapid transformation of energy systems [1]. There are no simple, quick technological fixes. Rather, it will require the adoption and integration of a suite of generation, storage and demand-side technologies, as well as novel trading arrangements, across heat, power, and transport. This implies the development of a *system* of technologies, organisational arrangements and behaviours [2,3] to decarbonise energy while managing supply and demand across scales [4].

It is in this context that local energy systems (LES) hold promise. While there is no universal definition of LES [5], they are broadly characterised by tailored, place-based interventions involving combinations of power and heat generation, distribution, storage, consumption, and transport solutions to address challenges in local energy systems [6,7]. The role of local energy was highlighted in both the UK Government's 2017 Industrial Strategy [8] and the 2021 Net Zero Strategy [9] as offering an important route towards energy system decarbonisation.

While there is a growing body of studies focusing on how the public relates to specific components of LES, e.g., local and domestic renewable energy technologies (e.g. [10]), smart home technologies (e.g. [11]), and tariffs (e.g. [12]), little is known about public attitudes and levels of support towards LES as a whole. Studying LES provides opportunities to

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understand how the public relate to locally situated *assemblages* of energy technologies and trading arrangements, rather than to specific components.

As with individual low carbon initiatives (e.g. deploying onshore wind), the speed and shape of LES developments will be determined in part by the scale and depth of household and community participation in accepting, adopting, and hosting new technologies and by extension, the nature and extent of community engagement on the part of actors involved in developing new LES. LES' emphasis on systems may however require a deeper level of user and community engagement than might be required for single innovations. LES may imply, for example, the adoption of *multiple* complementary domestic technologies (e.g. heat pumps and batteries), support for complementary community and domestic technologies (e.g. community batteries and EV charging infrastructure), provision of access to data for managing local grid constraints, and participation in local grid management (e.g. via peer-to-peer trading platforms) [13]. For LES to be accepted and find legitimacy among local communities and the wider public, a better understanding of public attitudes to the myriad developments envisaged to be part of LES will be critical.

This paper seeks to address this research gap. We argue that developing a deeper understanding of public support for LES will requires an dual emphasis on the broad principless of decentralisation and as the implications of adopting multiple innovations.

Based on a large-scale survey of UK households, this research uses regression analysis to examine the factors influencing support for LES. Section 2 proceeds by introducing the concept of LES, summarises the literature on support and acceptance of sustainable energy systems and components, and presents our three research questions. Section 3 outlines the approach and methodology, and results are presented in Section 4. Section 5 concludes the paper by summarising our findings, discusses their implications for research and policy, and highlights some limitations of the study.

2. Literature review

2.1. The emerging focus on local energy systems

The interplay between regulatory pressures, national decarbonisation policies, and cost reductions in small and medium-scale renewable technologies is driving a shift towards the decentralisation of energy systems in many economies [14]. Indeed, decentralisation may itself be regarded as a policy objective, helping to reduce the costs of the energy transition, enhance local grid resilience, and drive innovation [15].

Localisation of energy systems in the United Kingdom can best be considered as an emergent outcome of decarbonisation policy, rather than resulting from explicit decentralisation policy. While policy rhetoric has long been supportive of a shift to smaller scale and more local systems, policy developments have typically focused on large scale technologies and associated infrastructures, such as nuclear and offshore wind [16]. More recently however, decentralisation has been the focus of increasing policy attention as a necessary component of decarbonisation. For example, the UK's 2017 Industrial Strategy [8] highlighted ‘smart local energy systems’ as a key ‘challenge area’; by 2019, government policy rhetoric around ‘community energy’ was being replaced with ‘local energy’ [6]; and in 2021, the UK's first Net Zero Strategy [9] highlighted the contribution of local energy systems for decarbonisation. Policy attention on local energy is also increasingly being echoed within industry, regulatory and academic communities (e.g. [17–19]). Up to 2021, 147 local energy system funded projects “implementing integrated or ‘systems’ type solutions across supply, distribution and demand” were recorded in the UK [20].

Interest in LES builds on the foundations of research and practice across a range of energy system concepts, including smart grids, community energy and smart cities. LES are frequently understood as place-specific management of energy assets and infrastructures towards system-wide objectives. As such, a key aspect of LES is that they are stimulated, funded (at least in part) and shaped by national government rather than solely by local or private entities [19].

It is important to emphasise that although decentralisation may imply a relative shift away from a centralised system, it is likely that some form of centralised system will always exist. In other words, decentralisation (at least in UK policy terms) does not refer to the development of *isolated* local systems, but instead represents a set of solutions that can help overcome challenges emerging from the decarbonisation of centralised systems, such as network constraints.

2.2. The meaning of local energy systems

Within UK policy and industry circles, local energy systems are characterised by the deployment of multiple innovations, the interactions of which can potentially provide benefits to both local and national energy systems. Ford et al highlighted seven such areas of potential value including efficient provision of energy services, enhanced ecosystem benefits, maximising local sufficiency and independence, enabling flexibility, improving resilience, supporting social justice and equity, and meeting fundamental local needs [21].

However, the concept of local energy systems is neither widespread nor unambiguous. The LES projects developed in the UK to date [21] represent discrete, time-limited experiments rather than providing evidence of a widespread phenomenon [22]. Similarly, while some of the technologies incorporated within LES projects may be relatively well established (e.g., rooftop solar PV), many of the innovations around system integration within LES experiments (e.g., community and domestic battery storage, or peer-to-peer trading) are not [22].

The conceptual breadth of LES is such that they also represent ambiguous propositions with a diversity of potential outcomes, even among industry actors. Drawing on expert interviews, Ford et al. explored the ambiguity of the parallel concept of *smart* local energy systems (SLES)[1] [23], and noted diverse ideas about: the potential purpose of SLES (e.g., in embodying more effective, efficient, environmentally sustainable and just energy systems), the nature of emerging SLES regimes (e.g., in terms of operation, digitalisation, users and institutions), as well as how SLES boundaries should be defined (e.g., by geography, resources, infrastructures, social constructs, or scales of localness). In the context of this ambiguity, developing an understanding of public perceptions of LES is critical.

Here, we draw on commonalities across the various conceptualisations to define local energy systems (LES) as the integration and management of energy generation, storage and demand technologies and associated business models to help maximise sustainable energy within local energy networks.

2.3. Support for local energy systems and their components

A large body of research has sought to understand the role of factors influencing public support and adoption of a range of innovations which might ultimately play a role in future LES, including community-scale renewables, domestic energy (including smart) technologies, and novel electricity tariffs. Since LES can include innovations within households as well as within localities, three key areas of research are relevant here: the literature analysing public support for energy technologies, research focusing on adoption of innovations within the domestic sphere, and research focusing on attitudes towards system change more broadly.

Research on predictors for community renewables has largely focused on wind energy, with largely unequivocal findings relating to

[1] We regard the ‘*smart* local energy systems’ discussed elsewhere as synonymous with the ‘local energy systems’ discussed here.

age, gender, education and income [23]. For example, opposition towards wind projects has been found to be more common among older age groups, although younger age groups have also been identified as opponents [24,25]. Having a higher income has been related to both non-acceptance [24] and acceptance [23]. Support for wind has been found to be higher for those with higher levels of education in some, but not all studies [24,25]. Gender has not been found as a key determinant of support or opposition, although again there have been contradictory findings [23,25].

Non-personal factors have also been associated with support for wind, including: place attachment of people within communities and community trust in the planning processes [26]; the nature of the development in question, such as the visual impact of turbines [27] and the presence of community benefits [28]; community trust in developers [29]; and scope for community participation [30].

The uptake of domestic solar PV has also been related to several factors - both fixed and modifiable - with varying levels of significance relating to education, gender, ethnicity, location, income, age, employment status, environmental awareness, and peer effects (e.g. [31]). Statistically significant relationships have been found between willingness to adopt ground source heat pumps and interest in the environment, engineering and technology; climate awareness; youth; higher incomes; and higher levels of education [32].

Prospective adopters of smart home technologies have been found to be motivated by a desire for enhanced energy efficiency, potential financial savings, and enhanced quality of life [33]. Meanwhile, potential adopters have been found to be discouraged by multiple concerns, including perceptions of distrust, unreliability, cost, security concerns, technology anxiety, loss of control, apathy, and negative perceptions of technology [34].

Analysing uptake of low carbon electricity tariffs, Gerpott and Mahmudova [35] highlighted attitudes towards environmental protection, peer endorsement, and price sensitivity as key determinants. The role of environmental concern is echoed in a study by Diaz-Rainey and Tzavara [36], although the effect is lower according to Ozaki [12], who highlights the overriding effects of social norms, inconvenience related to switching, uncertainty about quality, and lack of information. Relatedly, Reis et al. [37] identified energy literacy, age and home ownership as key personal factors affecting willingness to adopt time-differentiated energy tariffs.

Beyond the studies focused on single technologies are some that have sought to understand public attitudes to new energy *systems*, comprising new assemblages of technologies, infrastructures, and socio-politics. For example, Braunreiter et al. used deliberative workshops to identify the existence of distinct clusters of people varying in their expectations about the future energy system [38]. Through a combination of workshops and a large-scale survey, Demski et al. [39] highlighted the role of values in underpinning preferences for whole energy system transitions.

At a more granular level, Rogers et al. [40] explored a single community's views of a proposed project in the UK. This highlighted support for local renewable energy generation and expectations of associated benefits, but low levels of desire for personal involvement. Focusing on smart cities, Georgiadis et al. [41] explored how Greek and Cypriot citizens view the concept of smart cities, revealing varying levels of understanding of the concept between populations, as well as reservations about the viability of the smart cities.

Of particular relevance to our study is a pair of nationally representative, industry-led surveys examining public awareness and support for SLES in 2021 and 2022 [42,43]. The authors reported low - and decreasing - levels of awareness and knowledge of SLES over two waves of data collection, underlining the immaturity of the concept. The majority of their sample supported SLES, with higher levels of support among those who had a better understanding of the concept of SLES and who found the concept easy to understand. However, the outputs of this research were largely descriptive, did not include explanatory analysis, and focused primarily on attitudes to broad value propositions rather than systemic combinations of LES innovations.

Developing a better understanding of the factors that might influence support for (and opposition towards) new LES developments is critical. LES can be conceptualised in two contrasting ways: as a broad set of shifts in the structure and organisation of energy systems; and as the localised diffusion of specific low carbon innovations and associated behaviours. For innovations to become integrated within new local energy systems, the assumption is that households and communities will not only support LES in principle, but become much more 'engaged', not only as adopters of novel technologies, but in ways that support system integration. While complementary then, these perspectives reflect LES from different perspectives, can be expected to hold resonance with the public in different ways, and require further analysis. Specifically, this research addresses the following questions:

1. What degree of public support exists for systemic change towards decentralised energy?
2. How does public support vary depending on whether LES are conceptualised as a systemic shift towards decentralisation versus the cumulative local deployment of innovations?

In answering both questions we also draw out implications of these methods and findings for research, policy and practice.

3. Methodology

3.1. Background

This research was undertaken as part of the 2018 UK government funded programme, 'Prospering from the Energy Revolution' (PFER) [44]. Conceived in response to one of several challenge areas identified in the Government's 2017 Industrial Strategy [8], the programme represented a component of the UK's decarbonisation strategy, amounting to £102 m of government funding over four years to design and demonstrate – and ultimately provide necessary learning to scale up - local energy systems across the UK [45]. Central to the PFER programme was the focus on integration to help manage local supply and demand to overcome flexibility challenges [45]. For this call in particular, the expectation was that projects should focus on a named UK location, "at least the size of a town" [46,47].

The PFER programme sought to design and demonstrate new SLES by way of collaborative projects led by private sector actors, with involvement from the public sector and research community. Previous research has highlighted how public engagement in the programme is constrained by narrow consumerist conceptualisations of 'users', as well as by project factors including place contexts, technological emphases, and the nature of project partnerships [19]. Integrated into PFER was the interdisciplinary EnergyREV[2] academic consortium, within which this research was carried out; as part of EnergyREV, the current study was designed to explore public understandings and support for LES.

3.2. National survey

A national survey was conducted online over two weeks in April 2021. Compared to alternative approaches such as interviews or focus groups, surveys are useful for characterising and quantifying variation within a population [48], an important attribute given the focus on upscaling LES across the UK energy system. Quantitative surveys are valuable for identifying the prevalence of attitudes among representative samples and examining the strength of relationships between multiple variables [49]. The online setting for the survey was appropriate given restrictions associated with the COVID-19 pandemic across the UK.

[2] www.energyrev.org.uk.

The survey was structured around themes of decarbonisation, decentralisation, digitalisation and democratisation (i.e., the ‘4 Ds’), trends underpinning the development of LES [50]. The survey was designed in parallel with a similar national ‘SLES user acceptance survey’ undertaken in early 2021 by Energy Systems Catapult (ESC), a UK R&D agency focused on energy system decarbonisation [42,43]. Our survey comprised of 56 mostly Likert-scale questions and took participants an average of 17 min to complete. Ahead of the questions, participants were provided a brief overview of the current energy system in terms of key technologies and infrastructures, and a description of the kinds of changes that local energy systems might bring (Appendix G).

A market research firm was commissioned to undertake large-scale sampling of the UK adult population from their panel of participants. Participants were remunerated between £3–5.[3] The targeted sample was nationally representative across socio-economic, demographic and geographical dimensions (Appendix A). Prior to analysis and following Yan [51], responses with consistent patterns (e.g. 1,2,3,4,3,2,1 or 1,1,1,1,1) were rejected, as were surveys completed in under 6 min. In total, around 10 % of the original responses were rejected due to concerns around data quality to give a final dataset of 3034 responses.

3.3. Independent variables

A range of independent variables were identified from the literature as significant factors influencing support and/or adoption of LES components, or else were hypothesised as potentially important factors by the authors (Appendix B). Socio-demographic, socio-economic factors included participants' age, gender, educational attainment, household income, employment status, political affiliation, tenure and geography.

Attachment to place was measured through six 5-point Likert-type questions (Appendix B) relating to levels of agreement with statements including “I would regret having to move to another place” and “This is my favourite place to live”. Principal components analysis (PCA) using direct oblimin rotation confirmed a single factor solution explaining 74 % of variance. A Cronbach's Alpha score of 0.93 indicated high internal consistency for the single factor solution and supported retaining all items in a single factor construct.

Concern about climate change was measured through three questions (Appendix B). PCA with direct oblimin rotation confirmed a single factor solution explaining 82 % of the variance, interpretable as concern and collective responsibility for addressing climate change. A Cronbach's Alpha score of 0.89 indicated high internal consistency for the single factor solution.

Technophilia (attraction to new technologies) was measured using agreement to the Likert-scale question: “I'm the kind of person who looks forward to new technology and gets excited to try them out”, again measured on a Likert-scale.

Responses to three questions measuring adoption of key innovations (renewables, EVs and heat pumps) were combined into a single linear variable named “Tech Adoption” for which a Cronbach's alpha of 0.72 indicated high internal consistency. Three additional questions relating to adoption of green tariffs, and relationships with suppliers were included separately.

Finally, we measured attitudes to digitalisation and democratisation, two key trends in energy system change which are both related to the ongoing development of LES.

3.4. Dependent variables

We explored support for LES as expressed by two dependent variables. The first assessed public support for a systemic shift towards decentralisation using the question “to what extent would you support or oppose a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system?”, with Likert-scale response options (strongly support to strongly oppose, and don't know). Since scale and proximity are central to LES, we use this as our first proxy for support for LES.

The second dependent variable captured public support for LES by way of support for a suite of innovations and associated propositions of particular relevance to local energy systems. People were asked which of eight innovations they “would like to see more of in their area in the next ten years”. Options covered a range of electricity, heat and transport propositions being tested within the PFER LES projects [52] and included “Electric vehicle leasing programs”, “Electric heating systems like heat pumps”, “In-home batteries to store electricity”, “More neighbourhood-scale batteries to store electricity”, “Smart technologies like smart meters”, “Variable pricing programs during the day and night”, “Opportunities to buy and sell electricity” and “Opportunities for electric cars to help with the local energy network”. PCA (direct oblimin rotation) confirmed a single factor solution to these 8 variables explaining 36 % of variance. Reliability analysis indicated high internal consistency (Cronbach's Alpha score of 0.77).

Both dependent variables relate to LES but emphasise different aspects of the concept. The first references decentralised energy explicitly as a shift to more local energy systems. Information provided to respondents emphasised what LES might mean in terms of local generation, grid balancing and governance (Appendix G). This question focused on the principle of decentralisation rather than the detail around its implementation. In contrast, the second dependent variable focused on attitudes towards specific LES innovations relating to power, heat and transport. Some focused on technological shifts (e.g. electric heating systems like heat pumps), but others emphasised new ways of interacting with energy (e.g. opportunities to buy and sell electricity; using EVs to help with the local network). While the individual questions did not reference LES as such, information provided to participants (Appendix G) made a direct link between specific innovations and implications for the decarbonisation, integration and control of local energy systems. In this way, high levels of support for LES-relevant innovations is a useful proxy for support for the concept of LES, not least in the way they refer to the specific rather than the abstract.

Cross tabulation and Chi Square analysis reveal that the two dependent variables were moderately associated with one another (Pearson's r of 0.392), with those supporting decentralisation most likely to support a higher number of innovations (Appendix C). These two variables therefore capture attitudes to LES as a broad phenomenon and as the result of the adoption of multiple innovations.

3.5. Hierarchical regression

Hierarchical logistical regression was used to explore the role of multiple independent variables on the two dependent variables. Following Devine-Wright and Wiersma [53], independent variables were entered into the regression analysis in four blocks, each representing a specific dimension of interest. Blocks were ordered according to a combination of assumed explanatory power as indicated in the literature, and from more static to more dynamic variables [54].

4. Results

4.1. Levels of support for energy system decentralisation

Fig. 1 illustrates majority public support for a shift to decentralised (smaller scale and more local) energy systems (66 % either strongly support or support). This is slightly higher than responses to a similarly

[3] The precise value of the incentive was not disclosed by the provider.

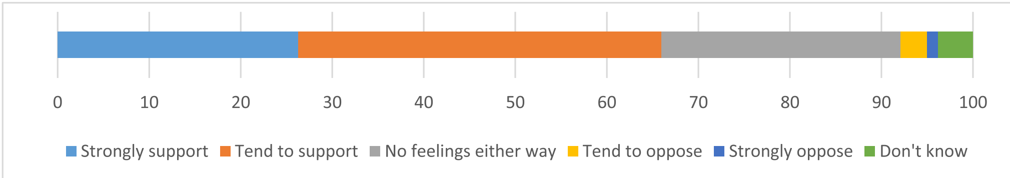

Fig. 1. Support and opposition for "a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system?".

worded survey[4] undertaken by ESC [42]. Of note here is the relatively large proportion of people indicating 'no feelings either way' (26.1 %), which together with 'don't know' responses (3.8 %) indicates a degree of ambivalence, uncertainty and/or apathy to the concept of decentralisation.

When asked about preferences for specific energy system scales expressed in terms of proximity, number and size of assets, participants again indicated a clear preference (47 %) for local energy systems (Fig. 2). However, when given the option, a considerable proportion of people favoured options in which centralised energy systems still play a role, either in combination with local energy (28 %) or on their own (10 %). As with the previous question focused on decentralisation, some (15 %) expressed uncertainty and/or ambivalence about a preferred scale.

While there is clear public support for a relative shift to decentralised and more local energy, some degree of large-scale and distant energy systems evidently holds merit for some people. As is the case with levels of support, this may indicate ambivalence or apathy around preferred energy system scales, but it may also suggest a recognition of the benefits of local within national energy systems.

4.2. Explaining public support for energy system decentralisation

Following Field [55], bivariate correlations and multicollinearity analyses were carried out as an initial step to identify potentially problematic covariation among independent variables (Appendix D). Climate concern correlated strongly with decarbonisation (0.681) so the latter was removed from subsequent analysis. Support for decentralisation correlated slightly less strongly with support for a) democratisation (0.614) and b) digitalisation (0.495), and support for digitalisation also correlated with democratisation (0.516). However, since VIF scores were relatively low, support for digitalisation and democratisation were both retained in subsequent multivariate analyses.

Table 1 summarises the results of hierarchical regression with support for decentralisation as the dependent variable. Block 1 comprised personal characteristics, including socio-demographics, socioeconomic variables, political beliefs and technology attitudes. Block 2 is defined by geographical context and relationship to the environment. Block 3 includes variables relating to current engagement with the energy system including adoption of technologies and green tariffs, supplier switching behaviour, and level of satisfaction with current suppliers. Block 4 captures support for increasingly digitalised and democratised energy systems.

The final model explains almost 48 % of the variance in support for decentralised energy systems. In order of significance and strength, support for democratisation, climate concern, support for digitalisation, Green party affiliation, education, satisfaction with one's supplier, frequent supplier switching and having a green tariff are all positively related to support.

There are several shifts across the four models worth noting. There is a marked increase in explanatory power between Models 1 and 2 following the addition of climate concern, while age, gender and education lose significance, suggesting that climate concern mediates the effect of personal characteristics. There is another jump between Models 3 and 4 following the addition of support for digitalisation and for democratisation. Support for digitalisation appears to mediate the explanatory power of enthusiasm for technologies. Finally, place attachment is initially important but is not significant in the final model.

Taking key variables in turn, climate concern is a key factor, suggesting that decentralisation is seen as an effective pathway for mitigating climate change. Support for democratisation, defined in the survey as support for "more local control of energy systems in the UK" suggests an alignment between social and technical aspects of decentralisation. Support for digitalisation (here, "a change to using digital or `smart` technologies in energy systems") is also influential, perhaps indicating a recognition of the role of technologies in decentralisation. Association with the Green Party is a significant variable throughout (although the effect is mediated slightly in successive models) reflecting the alignment of interventionist and collective action with the process of decentralisation. The importance of green tariff adoption might be explained by its alignment to the sustainable values associated with small-scale, low carbon generation. The reason for the appearance of switching behaviour and consumer satisfaction in the model is less obvious; our assumption here is that engaged consumers are engaged *in part* through their expression of demand for tariffs involving local suppliers or environmental attributes.

Finally, isolated interactions between key sociodemographic variables and specific blocks were explored also explored (Appendix E). In-depth examination of mediation/moderation interactions is beyond the scope of this paper but could form a valuable aspect of follow-up research.

4.3. Levels of support for LES innovations in local areas

Fig. 3 illustrates levels of support for specific innovations related to LES. When asked which innovations they would like to see more of in their local area in ten years' time, electric heating systems like heat pumps were most popular (40 %) among participants,[5] followed by domestic batteries (39 %) and smart (meter) technologies (37 %). The two least popular options were opportunities to buy and sell electricity (23 %), and opportunities for EVs to help with local networks (26 %).

Table 2 illustrates levels of support for future deployment of different numbers of innovations in local areas. Three main groups of participants can be identified that are characterised by varying levels of support for local deployment of LES innovations. First, 17 % indicated that they would not like to see any of these innovations deployed in their local areas. A second group (54 % of total) indicated support for a few (i.e., 1–3) innovations. Finally, a third group (29 % of total) indicated support for multiple (i.e., 4–8 innovations).

[4] Energy Systems Catapult's two surveys included the word 'smart': "To what extent would you support or oppose, a change from a large-scale and distant energy system to a smart local energy system?" 54 % and 58 % of respondents indicated support ('Strongly support' or 'Tend to support') in surveys carried out in 2021 and 2022 respectively.

[5] This is higher than UK Government datafrom the following winter, which suggested that only 17 % of people were 'likely to install' (air source) heat pumps the next time they needed to change heating systems [78]. The disparity between the two figures can be explained by the relative immediacy and the more active nature of BEIS' question.

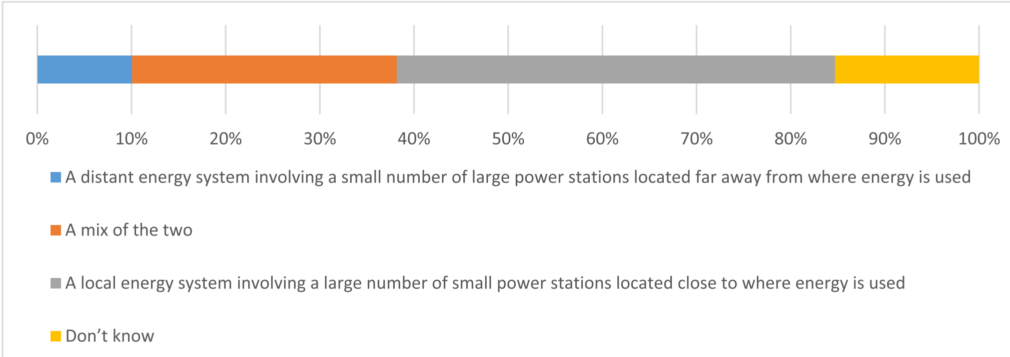

Fig. 2. Public preferences for different scales of energy systems.

Table 1
Hierarchical regression analyses of support for decentralisation ("Do you support or oppose a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system?")[a]

Block	Independent variable	Model 1 (Adjusted $r^2 = 0.117$)	Model 2 (Adjusted $r^2 = 0.308$)	Model 3 (Adjusted $r^2 = 0.318$)	Model 4 (Adjusted $r^2 = 0.480$)
Block 1	Age	0.073***	−0.008	0.002	0.020
	Gender	−0.071***	−0.024	−0.027	−0.005
	Education	0.082***	0.042*	0.038*	0.042**
	Income	−0.037*	−0.039*	−0.045*	−0.026
	Conservative	0.012	0.024	0.016	0.006
	Labour	0.129***	0.075***	0.070***	0.024
	Green	0.108***	0.069***	0.068***	0.047**
	HomeOwner	−0.012	−0.004	−0.029	−0.018
	Private Renter	−0.006	0.005	0.004	−0.006
	Social Renter	0.023	0.024	0.011	−0.002
	TechEnthusiasm	0.291***	0.155***	0.148***	0.012
Block 2	Urban		−0.012	−0.014	−0.015
	PlaceAttachment		0.069***	0.054**	−0.003
	ClimateConcern		0.444***	0.432***	0.244***
Block 3	TechAdoption			0.029	0.006
	GreenTariff			0.046**	0.040*
	Switching			0.045**	0.042*
	Satisfaction			0.065***	0.039**
Block 4	DigitalSupport				0.162***
	DemocSupport				0.402***

[a]Values provided are standardised regression coefficients; *** = significant at $p < .001$; ** = significant at $p < .01$; * = significant at $p < .05$.

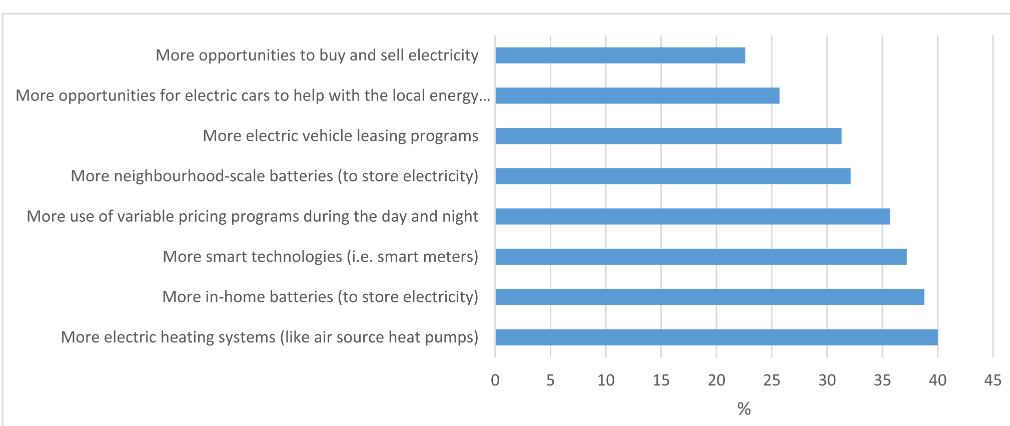

Fig. 3. Levels of support for individual LES innovations.

4.4. *Explaining public support for future deployment of LES innovations*

Table 3 presents results from a second round of regression analysis, this time with support for the future deployment of LES in local areas (as defined by stated intentions to adopt specific LES innovations) as the dependent variable. This model includes all variables used in the previous round of analysis, with support for decentralisation included as an additional independent variable. As with the previous round of regression analysis, isolated interactions between key sociodemographic variables and specific blocks were also explored (Appendix F), but are not

Table 2
Levels of support for future deployment of multiple LES innovations.

Number of innovations	Number supportive	% supportive
0	515	17.0
1	761	25.1
2	485	16.0
3	383	12.6
4	251	8.3
5	222	7.3
6	118	3.9
7	100	3.3
8	199	6.6

discussed in depth here.

In this analysis, the final model explains 28 % of total variance and includes (in order of significance and strength) support for digitalisation, climate concern, support for democratisation and decentralisation, enthusiasm for technologies, age, education, association with the Labour party (negative association), switching frequency, and association with the Conservative party (negative association). Technology adoption is statistically significant but is negatively related to support.

The explanatory power of this model is weaker than the previous model focusing on support for decentralisation, suggesting that patterns of support for decentralisation are less heterogeneous than for specific LES-relevant innovations. Our assumption here is that the broad phenomenon of decentralisation (specifically defined in our survey as "a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system") is relatively easy to understand. In contrast, framing LES as the aggregate of multiple innovations foregrounds multiple propositions for cost, comfort and convenience, which can be interpreted in different ways and appeal to different values across the population.

The largest jumps in explanatory power come between Models 1 and 2 due to the insertion of Climate Concern, with another jump between Models 3 and 4 upon insertion of support for digitalisation, democratisation and decentralisation. Across the models, some personal characteristics (e.g. age, education, and technology enthusiasm) are retained as persistently important factors shaping support for LES. In other cases, the findings suggest mediating relations. For example, adding climate concern leads to Green Party voting becoming non-significant in Model 2.

Support for digitalisation, decentralisation and democratisation are all important factors underpinng support for LES innovations. In other words, support for a change to digital/smart technologies in local areas, support for localisation of systems, and support for more localisation of control – all quite general propositions - are aligned with support for LES in more specific terms. Climate concern is important in determining support for LES innovations, indicating that the public regard the innovation options as plausible options for mitigating climate change. Enthusiasm for technologies is, as would be expected, aligned with support for more novel energy technologies.

One surprise is that technology adoption is negatively associated with support. There are two possible explanations. First, the dependent variable used here measures support for innovations and associated *system* or *collective* benefits (e.g., "in-home batteries to store electricity", "opportunities for electric cars to help with the local energy network"), whereas early adopters of technologies may be more driven by individualistic rather than collective motives. Individualistic motives may be financial (e.g. potential for cost savings), but they may also be related to technophilia and a related desire to 'prove' a concept [56]. This further echoes findings from work by Sloot et al. [57] which found that financial motives of involvement in community energy are viewed as substantially more important than communal motives. A second explanation is that the local benefits described (e.g., storing electricity, local trading, managing local networks) are not mature enough for people – even those who get excited about technologies – for people to be able to express support.

The appearance of age and education as significant predictors of innovation-focused support echoes the role of these factors in explaining uptake of specific technologies such as PV, as discussed in Section 2.3. It has been shown that older people, as well as those with higher levels of education have a better understanding of how specific innovations might work [32].

In comparison with the previous set of models focusing on decentralisation, the initial role of Green Party association in Model 1 here is mediated by climate concern. While Green voters' environmental values align with climate concern and responsibility, they do not explain support for local energy innovation.

Finally, place attachment emerges from the analyses in contrasting ways. It is a significant predictor of support for decentralised energy in Models 2 and 3, but not the final Model 4. Future research is required to assess whether the 4D variables mediate between place attachment and decentralised energy support. Moreover, the non-significance of place attachment in the innovation-focused dependent variable may be explained in several ways. First, only a quarter of innovations referred to

Table 3
Hierarchical regression analyses of support for future deployment of LES innovations[a].

Block	Independent variable	Model 1 (Adjusted $r^2 = 0.094$)	Model 2 (Adjusted $r^2 = 0.188$)	Model 3 (Adjusted $r^2 = 0.196$)	Model 4 (Adjusted $r^2 = 0.283$)
Block 1	Age	0.179***	0.123***	0.95***	0.106***
	Gender	−0.005	0.027	0.028	0.039
	Education	0.110***	0.079***	0.081***	0.080***
	Income	−0.006	−0.008	−0.011	−0.043
	Conservative	−0.045	−0.030	−0.028	−0.029*
	Labour	0.015	−0.021	−0.019	−0.049*
	Green	0.055**	0.025	0.026	0.008
	Home Owner	0.009	0.016	−0.007	0.015
	Private Renter	0.029	0.035	0.023	0.019
	Social Renter	0.059	0.057	0.055	0.043
	TechEnthusiasm	0.276***	0.192***	0.199***	0.085***
Block 2	Urban		−0.016	−0.002	−0.001
	PlaceAttachment		−0.013	0.006	−0.029
	ClimateConcern		0.328***	0.320***	0.153***
Block 3	TechAdoption			−0.100***	−0.115***
	GreenTariff			0.016	0.008
	Switching			0.047*	0.040*
	Satisfaction			0.013	−0.013
Block 4	DigitalSupport				0.205***
	DemocSupport				0.147***
	DecentSupport				0.116***

[a] Values provided are standardised regression coefficients; *** = significant at $p < .001$; ** = significant at $p < .01$; * = significant at $p < .05$.

geographical aspects (e.g., neighbourhood-scale batteries, and EVs helping the local energy network). Second, it may be that these propositions are disconnected from the questions about place that we asked (Appendix B). And third, it may be that the propositions are too immature for the public to make judgements about the impact they will have on local places. These are important issues for future research to elaborate.

5. Discussion and conclusions

This study examines levels of public support for, and the factors influencing support for, new local energy systems. While LES represent active fronts for policy and industry actors working on decentralisation, their development depend on the diffusion of combinations of technologies within communities and households, many of which are not widely understood by the public. Our focus on support for system change as well as for individual technologies represents a timely contribution given the burgeoning interest among academic, policy and practitioners on the former, while also complementing the growing literature on the latter.

First, we provide evidence of high levels of public support for a shift to more decentralised energy systems in the UK, echoing the high levels of support for climate change mitigation and for key renewable energy technologies such as onshore wind documented elsewhere [58]. However, we also highlight divergence in opinions around the most appropriate scale of energy systems. While this may reflect a degree of ambivalence or apathy among some parts of the public, it likely also signals support for a hybrid system in which local and centralised energy systems coexist. Given that decentralisation can be interpreted in a number of ways (e.g. comprising new technologies, ownership models and modes of governance), those seeking to develop new LES will need to engage the public around the meaning of the developments.

In doing so, there is an opportunity to open up discussions about the relationship between new LES, and existing centralised systems. For example, ongoing electrification of heat and transport within localities are unlikely to replace centralised transmission infrastructure, but rather, require it be upgraded. Meanwhile, overcoming distribution network constraints with LES could help support further integration of large-scale electricity generation assets, such as offshore wind. Rather than presenting LES as a simple departure from centralised systems then, there is an opportunity to engage people around the implications of LES developments for local as well as national energy systems.

Second, we find reasonably high levels of public support for some specific LES innovations, including heat pumps. Given that heat represents a pressing challenge area for energy system decarbonisation in the UK, this is encouraging, and provides a foundation for more in-depth analysis of the technology-specific factors influencing heat pump adoption rates, such as cost, perceived disruption, available levels of support and supply [32]. More generally, higher levels of support can be found for more familiar technological innovations, with lower levels of support for less mature (and thus less familiar) innovations in novel tariffs and trading arrangements. More attention is needed from policymakers and practitioners to communicate the meaning and implications of LES innovations to the public, particularly those that may be less familiar.

Third, we highlight the role of multiple factors in explaining support for multiple framings of LES. These include age, climate concern, support for digitalisation, and enthusiasm for technologies. Several additional factors appear as more or less important when considering LES as a process of decentralisation, versus a process of innovation adoption. These factors suggests a limit to the growth of LES (as currently envisaged) as the most viable route to decarbonisation: if LES and decentralisation more generally are only supported by segments of society, their potential to reduce carbon emissions and balance local grids will be constrained. Moreover, there is a risk that the private and public and benefits of LES accrue only to a subsection of society, exacerbating existing inequalities. To maximise the environmental and societal impact of LES, policy and practice must work to engage a wider swath of society than is currently the case [59]. Indeed, future LES programmes may provide opportunities to help identify and address issues being faced by householders, as well as help address wider system issues [60].

Finally, we have highlighted a difference in the explanatory power of regression models focusing on decentralisation versus specific LES innovations. These two framings of LES are different but complementary as they represent more conceptual or more concrete interpretations of what LES are. While principles of decentralisation may be relatively clear to people, we argue that the actual meaning of the concept is relatively clear, even if it potentially encompasses multiple shifts relating to the geography, decision-making, ownership, and control of energy systems. In contrast, the novel technologies that LES are envisaged to contain represent a diversity of propositions to households, which are interpreted in different ways by different groups of people. This includes diverse perceptions about the impact of new innovations on household cost, comfort and convenience, but also about the implications for households of becoming more integrated with new local energy systems. While research and policy frequently implicates households as active participants in the future energy system (e.g. [61]), our research highlights a diversity of interests and motivations among the public for becoming engaged. For LES to develop further, policy and industry actors will need to understand the diverse set of perceptions that LES innovations hold for people. This may mean finding ways to develop LES *in concert with* households and communities rather than simply developing LES *for* people to better align system and householder values.

5.1. Limitations and further research

We acknowledge some limitations to the study. First and foremost, we acknowledge that our data represent a snapshot in time of public attitudes towards LES, constituent technologies and associated propositions. Since 2021, ongoing macroeconomic and geopolitical events (notably the war in Ukraine and the cost-of-living crisis) are likely to have affected public discourse around energy, particularly security and cost dimensions. BEIS (the former UK Government Department for Business, Energy and Industrial Strategy) [62] reported a steady increase in both public concern for climate change and awareness of net zero throughout 2022; and public exposure to novel technologies (e.g., heat pumps) and behaviours (e.g., reducing and managing demand) has certainly increased since then. This does not diminish the value of our findings. Rather, the snapshot presented here provides an important baseline upon which future research can build. For example, future research could examine the extent to which LES are understood as supporting energy security, affordability and decarbonisation objectives.

Second, our analysis demonstrates a potential limitation in the use of large-scale surveys in examining public perceptions of emerging technological developments, in particularly when such developments are multifaceted and lacking in a clear conceptualisation. Future work on perceptions of LES could employ fine-grained deliberative methods to further explore the multiplicity of meanings and values attached to these developments.

And third, our focus has been on understanding attitudes towards system change in the UK. However, the shift to smart local energy systems (and their synonyms) is not confined to the UK, and there is a clear opportunity to use similar methods, drawing on established methodologies, literatures, and theoretical frameworks as we do here - to examine the factors influencing support – and opposition towards LES developments within other geographical contexts. Recently published analysis [63] that combined our dataset with a companion 2022 dataset from Canada [64] provides an example of such important comparative opportunities.

5.2. Concluding remarks

For many industry and policy actors, LES hold great potential in helping to meet decarbonisation goals by optimising energy flows in local networks. While the long-term future of LES policy in the UK may be unclear, decarbonisation and energy security agendas both provide supportive policy environments for decarbonising heat and transport, maximising renewable generation, overcoming local grid constraints, reducing and managing energy demand, and reducing local communities' reliance on imported fuels. These are all objectives consistent with LES. As these policy objectives are not unique to the UK, the potential of LES in meeting these goals will be of interest more widely.

For LES to play a role in the future, policymakers and practitioners will have to play closer attention to public perceptions and attitudes towards the process of decentralisation, and towards the many innovations around which LES are expected to form. LES represent profound shifts in the structure and organisation of energy systems but importantly, they imply new modes and levels of public engagement with technologies and novel trading arrangements, many of which are still in their infancy. In this context, this research provides a valuable set of insights around how LES appeal to different parts of society, and in turn how policymakers and industry could better engage people in and around LES developments in order to deliver on stringent climate change mitigation objectives.

CRediT authorship contribution statement

Iain Soutar: Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Patrick Devine-Wright:** Writing – review & editing, Supervision, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Hannah Devine-Wright:** Writing – review & editing, Methodology. **Chad Walker:** Writing – review & editing, Methodology, Investigation, Data curation. **Charlie Wilson:** Writing – review & editing, Methodology, Funding acquisition, Formal analysis, Conceptualization. **Rajat Gupta:** Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Jillian Anable:** Methodology, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A. Descriptive statistics of the sample

Variable	Number and proportion in dataset
Socio-economic group I (*n* = 3034)	AB – 874:(28.8 %) C1/C2: 1298 (42.8 %) DE: 785 (25.9 %) Not stated: 77 (2.5 %)
Age (over 18; n = 3034)	18–24: 152 (5.0 %); 25–34: 554 (18.3 %); 35–44: 440 (14.5 %); 45–54: 669 (22.1 %); 55–64: 553 (18.2 %) 65–74: 539 (17.8 %) 75+: 127 (4.2 %)
Age groups (n = 3034)	18–34 years: 706 (23.3 %) 35–54 years: 1109 (36.6 %) 55 + years: 1219 (40.2 %)
Gender (*n* = 3034)	Male: 1516 (50 %) Female: 1511 (49.8 %) In another way: 7 (0.2 %)
Nation (n = 3034)	England: 2545 (83.9 %); Scotland: 239 (7.9 %); Wales: 150 (4.9 %); Northern Ireland: 100 (3.3 %)
Region of England (*n* = 2545)	North East: 125 (4.1 %); North West: 325 (10.7 %); Yorkshire And The Humber: 251 (8.3 %); East Midlands: 200 (6.6 %); West Midlands: 276 (9.1 %); East: 251 (8.3 %); London: 375 (12.4 %); South East: 467 (15.4 %); South West: 275 (9.1 %)
Home status (n = 3034)	Sole owner (either with or without a mortgage): 839 (27.7 %); Own it with someone else (either with or without a mortgage): 1026 (33.8 %);

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(*continued*)

Variable	Number and proportion in dataset
	In social housing: 376 (12.4 %); In privately rented accommodation: 506 (16.7 %) Sole owner in a shared ownership scheme: 10 (0.3 %) In parents' home: 186 (6.1 %) In my friend's/relative's/partner's home: 43 (1.4 %) Own with someone else in a shared ownership scheme: 10 (0.3 %) No - other situation: 38 (1.3 %)
Area living in (n = 3034)	Urban City Centre: 489 (16.1 %); Urban Non-City Centre: 516 (17.0 %) Suburban: 1384 (45.6 %) Rural: 624 (20.6 %) Remote: 15 (0.5 %) Other: 6 (0.2 %)
Occupation type (n = 3034)	Senior managerial/professional: 191 (6.3 %); Intermediate managerial, administrative or professional: 466 (15.4 %) Supervisor; clerical; junior managerial, administrative or professional: 531 (17.5 %) Manual worker (with industry qualifications): 471 (15.5 %) Manual worker (with no qualifications): 292 (9.6 %) Unemployed: 298 (9.8 %) Retired: 695 (22.9 %) Student: 26 (0.9 %) Prefer not to say: 64 (2.1 %)
Education (n = 3034)	No formal schooling: 25 (0.8 %) Primary school: 37 (1.2 %) Secondary school (e.g. O-Level, GCSE): 840 (27.7 %) Sixth form/College (e.g. A-Level, NVQ): 919 (30.3 %) Higher education (e.g. Bachelor's Degree): 892 (29.4 %) Post-graduate (e.g. Masters, Doctorate): 321 (10.6 %)
Household income (*n* = 2793) (remainder did not know or want to share)	£0–5000: 88 (3.15 %) £5001 - £10,000: 166 (5.94 %) £10,001 - £15,000: 302 (10.8 %) £15,001 - £20,000: 304 (10.9 %) £20,001 - £30,000: 601 (21.5 %) £30,001 - £50,000: 671 (24.0 %) £50,001 - £75,000: 362 (12.96 %) £75,001 - £100,000: 190 (6.8 %) Over £100,000: 109 (3.9 %)
Political affiliation (*n* = 3034)	Conservative: 990 (32.6 %) Labour: 776 (25.6 %) Liberal Democrat: 181 (6.0 %) Scottish National Party or Plaid Cymru: 109 (3.6 %) Green: 126 (4.2 %) DUP: 13 (0.4 %) Brexit Party: 10 (0.3 %) UKIP: 9 (0.3 %) Reform UK: 8 (0.3 %) SDLP: 4 (0.1 %) Alliance: 3 (0.1 %) Ulster Unionist Party: 3 (0.1 %) Independent: 2 (0.1 %) All others: 16 (0.53 %) I do not associate with any party: 681 (22.4 %)

Appendix B. Definition of variables

	Variable	Definition (categories/range)[1]	Source
Socio-demographics	Age	Age (1 = 18–24, 2 = 25–34, 3 = 35–44, 4 = 45–54, 5 = 55–64, 6 = 65–74, 7 > 75)	[32,37,65]
	Gender	Male (yes = 1, no = 0)	[66]
	Education	Highest level of education (1 = No formal schooling, 2 = Primary school, 3 = Secondary school (e.g. O = Level, GCSE), 4 = Sixth form/college (e.g. A = level, NVQ), 5 = Higher Education (e.g. Bachelor's Degree), 6 = post-graduate (e.g. Masters, Doctorate))	[32,65,67–70]
	Income	Household income (1 < £5000, 2 = £5001–£10,000, 3 = £10,001–£15,000, 4 = £15,001–£20,000, 5 = £20,001–£30,000, 6 = £30,001–£50,000, 7 = £50,001–£75,000, 8 = £75,001–£100,000, 9 > £100,000)	[32,65,71–73]
	Retired	Retired (yes = 1, no = 0)	–
	Unemployed	Unemployed (yes = 1, no = 0)	–
	Home owner	Own home (yes = 1, no = 0)	
	Private rented	Private renter (yes = 1, no = 0)	[37,74,75]
	Social renter	Social housing tenant (yes = 1, no = 0)	
Political affiliation	Conservative	Affiliated with Conservative Party (yes = 1, no = 0)	
	Labour	Affiliated with Labour Party (yes = 1, no = 0)	[73,76]
	Green	Affiliated with Green Party (yes = 1, no = 0)	
Residential context	Rural	Rural area (yes = 1, no = 0)	[73]

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(*continued*)

	Variable	Definition (categories/range)[1]	Source
	Suburban	Suburban area (yes = 1, no = 0)	
	Urban	Urban area (yes = 1, no = 0)	
Local attachment	PlaceAttachment	Factor constructed from sum of 6 place attachment variables (1–25, in which higher numbers = more place-attachment): "I would regret having to move to another place", "This is my favourite place to live", "This place is a part of me", "This place says a lot about who I am", "This place is the best place for what I like to do" and "No other place can compare to this place".	[77]
Environmentalism	ClimateConcern	Factor constructed from sum of 3 climate concern and responsibility variables (1–13, in which higher values = more concern/responsibility): "I am concerned about climate change", "Individuals have a responsibility to tackle climate change" and "Government and authorities have responsibility to tackle climate change"	[35,36]
Technophilia	TechEnthusiasm	Level of excitement about new technology (1–5, in which higher numbers = more excited)	[32]
Current engagement with the energy system	TechAdoption	Number of domestic energy technologies owned (0–3)	[76]
	GreenTariff	Has green tariff (yes = 1, no = 0)	
	Switching	Frequency of supplier switching (1 = never, 2 = rarely, 3-often)	[35]
	Satisfaction	Level of satisfaction with current energy supplier (1–5, in which higher values = more satisfaction)	–
Support for energy system trends	DecarbSupport	Level of support/opposition to "reducing greenhouse gas emissions from electricity, heating, and transport in the UK?" (1–5, in which higher values = more support)	–
	DecentSupport	Level of support/opposition to "a change from a mostly large-scale and distant energy system to a smaller scale and more local energy system?" (1–5, in which higher values = more support)	–
	DigitSupport	Level of support/opposition to "a change to using digital or `smart` technologies in energy systems?" (1–5, in which higher values = more support)	–
	DemocSupport	Level of support/opposition to "more local control of energy systems in the UK" (1–5, in which higher values = more support)	–
Overall LES support	InnovationSupport	Number of LES innovations supported (0–8)	–

[1] Unless otherwise stated, responses reflect the characteristics of survey participants rather than of householders more generally.

Appendix C. Cross tabulation analysis comparing 1) Support for decentralisation and 2) Support for LES innovations. Shaded cells represent higher than average levels of support for innovations across five subpopulations indicating varying levels of support for decentralisation

Table C1

			InnovationSupport									
			0	1	2	3	4	5	6	7	8	Total
DecentSupport	1	Count	10	22	2	0	1	0	1	0	1	37
		% within DecentSupport	27.0%	59.5%	5.4%	0.0%	2.7%	0.0%	2.7%	0.0%	2.7%	100.0%
	2	Count	25	38	11	8	2	2	1	0	2	89
		% within DecentSupport	28.1%	42.7%	12.4%	9.0%	2.2%	2.2%	1.1%	0.0%	2.2%	100.0%
	3	Count	220	295	118	70	38	22	8	8	13	792
		% within DecentSupport	27.8%	37.2%	14.9%	8.8%	4.8%	2.8%	1.0%	1.0%	1.6%	100.0%
	4	Count	161	256	245	186	117	94	58	30	56	1203
		% within DecentSupport	13.4%	21.3%	20.4%	15.5%	9.7%	7.8%	4.8%	2.5%	4.7%	100.0%
	5	Count	76	91	93	114	91	99	49	62	123	798
		% within DecentSupport	9.5%	11.4%	11.7%	14.3%	11.4%	12.4%	6.1%	7.8%	15.4%	100.0%
Total		Count	492	702	469	378	249	217	117	100	195	2919
		% within DecentSupport	16.9%	24.0%	16.1%	12.9%	8.5%	7.4%	4.0%	3.4%	6.7%	100.0%

Appendix D. Correlation matrix

Supplementary data to this article can be found online at https://doi.org/10.1016/j.erss.2024.103658.

Appendix E. Isolated regression analyses of variable blocks explaining support for decentralisation

	Independent variable	Model 1 (Adjusted r^2 = 0.018; SE = 0.873	Model 2 (Adjusted r^2 = 0.118; SE = 0.827	Model 3 (Adjusted r^2 = 0.281; SE = 0.748	Model 4 (Adjusted r^2 = 0.061; SE = 0.850	Model 5 (Adjusted r^2 = 0.117; SE = 0.828
Block 1	Age	−0.054**	0.062**	−0.075***	−0.040	0.039*
	Gender	−0.036	−0.070***	−0.002	−0.043*	−0.016
	Education	0.115***	0.088***	0.053**	0.100***	0.072***
	Income	−0.030	−0.047*	−0.041*	−0.045*	−0.020
Block 2	Conservative		0.023			
	Labour		0.133***			
	Green		0.107***			
	HomeOwner		−0.008			
	Private Renter		0.002			
	Social Renter		0.024			
	TechEnthusiasm		0.286***			
Block 3	Urban			0.000		

(*continued on next page*)

(*continued*)

	Independent variable	Model 1 (Adjusted r^2 = 0.018; SE = 0.873	Model 2 (Adjusted r^2 = 0.118; SE = 0.827	Model 3 (Adjusted r^2 = 0.281; SE = 0.748	Model 4 (Adjusted r^2 = 0.061; SE = 0.850	Model 5 (Adjusted r^2 = 0.117; SE = 0.828
	PlaceAttachment			0.097***		
	ClimateConcern			0.490***		
Block 4	TechAdoption				0.053*	
	GreenTariff				0.122***	
	Switching				0.044*	
	Satisfaction				0.120***	
Block 5	DigitalSupport					0.249***
	DemocSupport					0.486***

Appendix F. Isolated regression analyses of variable blocks explaining support for LES innovations

	Independent variable	Model 1 (Adjusted r^2 = 0.017; SE = 2.31	Model 2 (Adjusted r^2 = 0.092; SE = 2.22	Model 3 (Adjusted r^2 = 0.148; SE = 2.15	Model 4 (Adjusted r^2 = 0.031; SE = 2.30	Model 5 (Adjusted r^2 = 0.246; SE = 2.03
Block 1	Age	0.058**	0.158***	0.042*	0.032	0.130***
	Gender	0.033	−0.003	0.057**	0.036	0.036*
	Education	0.125***	0.108***	0.078***	0.120***	0.090***
	Income	0.008	0.000	−0.001	−0.002	−0.010
Block 2	Conservative		−0.030			
	Labour		0.015			
	Green		0.044*			
	HomeOwner		0.023			
	Private Renter		0.047			
	Social Renter		0.067*			
	TechEnthusiasm		0.278***			
Block 3	Urban			−0.004		
	PlaceAttachment			0.023		
	ClimateConcern			0.362***		
Block 4	TechAdoption				−0.077***	
	GreenTariff				0.087***	
	Switching				0.041*	
	Satisfaction				0.051**	
Block 5	DigitalSupport					0.254***
	DemocSupport					0.156***
	DecentSupport					0.174***

Appendix G. Information on key concepts provided to survey participants

G.1. Local energy

Throughout the survey, you will see the words 'Local' and 'local area'. Please take these words to mean whatever best fits your own understanding of 'local' and 'local area'. This might be the city, town, or village that you live in.

Currently, the UK has an energy system where electricity is generated in large power stations located far away from where most people live. The national grid delivers this electricity to where it is used. The gas that we use to heat buildings comes partly from the North Sea and partly from other countries in Europe and the Middle East. Finally, the petrol and diesel that we use to fuel our vehicles is often imported from other, distant countries.

Local Energy would involve a change to this system. Electricity and heat would mostly be generated using renewable energy (i.e. solar or wind) in the same city, town or village that you live in, Cars would be powered by locally generated electricity, and their electric batteries would be used in ways that make the local grid work best, for example storing electricity when renewable energy is abundant (e.g. on a sunny day), and releasing it into the local grid when it is scarce (e.g. when dark at night). Energy would be managed by local organisations, for example electricity would be sold to you by local people and businesses.

G.2. The 'four Ds' of new local energy systems

We can describe the potential changes in Local Energy systems as the 'Four Ds' –Decarbonised, Decentralised, Digitalized, and Democratised. The questions below deal with each of these themes separately.

G.3. The first D of local energy is DECARBONISATION

This means reducing greenhouse gas emissions from electricity, heat, and transport. The UK government has set legal targets for reducing emissions that contribute to global warming. To meet these targets, they propose the following:

(1) To increase the use of renewable energy sources (i.e. wind, solar, hydro) to generate electricity.
(2) To reduce the use of natural gas for heating buildings and for industry.
(3) To stop the use of petrol and diesel for transport and instead switch to electric vehicles or other "green fuels' (e.g. hydrogen).

Local Energy systems will use renewable energy much more than our current system. This means that they will need to use new technologies to manage energy sources that are variable – sometimes plentiful and sometimes scarce.

One way to do this is to use **large household or neighbourhood-scale batteries**. Batteries can help to store electricity when renewable energy is abundant (like a sunny day) and share it locally when there is less available (like at night). This would also help to level the 'highs' (lots of people using electricity) and 'lows' (fewer people using electricity) of electricity usage, which means less reliance on large, non-local, and often polluting backup power stations in the UK.

Another way that Local Energy systems reduce emissions would be to have **heat pumps** installed in houses or buildings. Heat pumps replace gas boilers by using local renewable energy to move warmer underground or outside air into your home.

A third way that Local Energy systems reduce emissions would be to introduce more **electric vehicles** to replace petrol or diesel vehicles. Local Energy systems will not produce electric vehicles, but may introduce ways to make them easier to use or to own. This includes leasing programs, or car clubs The batteries in electric vehicles may also serve as a way to store and share local renewable energy when not in use.

G.4. *The second D of local energy is DECENTRALISATION*

Currently, in the UK we get our electricity mostly from large, distant power stations that use coal, nuclear or natural gas. We often heat our homes via national gas networks, and we power our vehicles using petrol and diesel from around the world. Local Energy systems would make the energy system closer to where we live, using locally available renewable energy to generate electricity or heat and to power vehicles for transport.

G.5. *The third D of local energy is DIGITALIZATION*

Digitalization means using 'smart' technologies in energy systems. You can think of 'smart' technologies as those like your smartphone or computer – they are connected to the internet and are able to send and receive information with other people and groups from around the world.

Examples of digital energy technologies include smart meters and smart thermostats. They can help to monitor use of electricity or heat; to predict patterns of use based on past behaviour; to control when appliances come on or off during the day; and to control appliances remotely.

Digital technology can help energy supply and use to be more balanced, especially in a local system that uses a lot of renewable energy.

For example, it may help by turning on your washing machine earlier (or later) to help with energy system balance and emissions.

It may also let you know about Time of Use Tariffs – different tariffs for electricity use throughout the day. If the supply was predicted to be low, tariffs would be high. If supply was high, prices would be low or even negative (i.e. you would be paid for using energy).

G.6. *The fourth D in local energy is DEMOCRATISATION*

What we mean by this is the potential for more local control over energy systems. Right now, most of the UK energy system is owned by a small number of large companies that are not based in people's local areas and most of the system is managed at the national level. Local Energy systems allow for more participation and control by local councils, local businesses and local community groups over how these systems work.

Local Energy systems could allow local people to generate and store your own electricity (like through rooftop solar panels + a storage battery) and then buy and sell this energy with other people in your local area.

Local Energy systems could also promote the use of batteries in electric cars to help the local grid network. It would do this by offering car owners financial incentives to charge their car at a certain time of day when energy was plentiful or to release electricity from their car battery into the grid when energy was scarce.

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