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Inclusive innovation in just transitions: The case of smart local energy systems in the UK

Adrian Smith [a,*], Gerardo A. Torres Contreras [a], Marie-Claire Brisbois [a], Max Lacey-Barnacle [a], Benjamin K. Sovacool [a,b,c]

[a] Science Policy Research Unit, University of Sussex, Brighton BN1 9QE, UK
[b] Center for Energy Technologies, Department of Business Development and Technology, Aarhus University, Birk Centerpark 15, Herning, DK 7400 Denmark
[c] Department of Earth and Environment, Boston University, 725 Commonwealth Avenue, Boston, MA 02215, USA

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ABSTRACT

Inclusive innovation addresses the challenges and aspirations of poor and marginalised groups in society. Attention towards these groups is also important for social justice in sustainable transitions. How can research insights from inclusive innovation contribute to just transitions? In this paper, based on original mixed methods data, analysis built around levels of inclusion is applied empirically to the case of smart local energy systems in the UK. Despite innovators acknowledging inclusiveness as significant for their decarbonised, decentralised and digitalised transition goals, inclusion operates currently at low levels owing to the prevalence of a liberal-individualist approach to justice in the electricity regime. Noting efforts (and constraints) in higher-level inclusion in some demonstration projects, we discuss whether and how social-collectivist approaches to justice open up more transformative possibilities. The case illustrates how analysis of relations between justice and inclusion can invite more transformational innovation policies.

1. Introduction

In recent years, an emerging and important research-policy interface has developed 'just transitions' as a broad framework for bringing social justice into sustainability governance (Wang and Lo 2021). Just transitions strive for greater social inclusion in transition agendas and processes, with a more equitable distribution of benefits, and a focus on marginalised and deprived areas, communities and groups (Upham et al., 2022). Given the centrality of (transformative) innovation for transition governance (Schot and Steinmueller, 2018), so it is reasonable to ask if strategies for inclusive innovation might help in the practical realisation of just transition goals? To our knowledge, insights from research into inclusive innovation have not yet been brought into just transitions analysis.

Inclusive innovation research analyses the processes for improving social inclusion in innovation, its consequences for the kinds of innovation that develop, and the possibilities and challenges for improving the conditions for inclusive innovation (Arocena and Sutz, 2003; Chataway et al., 2014). Originating in international development settings (Arocena and Sutz, 2003; Chataway et al., 2014; Heeks et al., 2014; Pansera and Owen, 2017), inclusive innovation is no less relevant for addressing exclusions and entrenched injustices in wealthier societies also (Jiménez, 2019; Smith et al., 2017). Indeed, calls for 'just transitions' in sustainability makes salient

* Corresponding author.
E-mail address: a.g.smith@sussex.ac.uk (A. Smith).

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inclusive innovation across societies as well as within them (McCauley and Heffron, 2018; Sovacool et al., 2022b; Wang and Lo, 2021).

The aim in this paper is to use empirical analysis, based on extensive original data for Smart Local Energy Systems (SLES) in the UK, to test a justice-based framework for inclusive innovation. SLES are envisaged by developers as an important niche component in plans for a transition from historic centralised, fossil-fuelled electricity systems towards a decarbonised, decentralised and digitalised systems. This includes innovations in energy technologies or practices such as smart meters, in-home visualizations, household solar photovoltaic panels, battery storage including electric vehicles, and digital platforms for managing and trading more flexible energy demand and generation between 'prosumers' (Hyysalo, 2021; Knox et al., 2022; Sovacool et al., 2022a). Our framework analyses how different levels of inclusive innovation in SLES demonstrations are related to underlying struggles for social justice in the electricity regime (Heeks et al., 2014; Levidow and Papaioannou, 2018).

The paper asks: (1) How is inclusive innovation conceived and practiced in SLES in the UK? (2) Why are some levels of inclusion more prevalent compared to other possibilities? and (3) What are the implications for just transitions? The next Section introduces the context for our empirical study and the analytical framework. Section three explains our research methods. Section four provides the results, which are discussed in section five. Section six draws some conclusions.

2. Analytical framework and context for analysing inclusive innovation in smart local energy systems

Our analysis begins with an established heuristic for identifying different levels of social inclusion in innovation activity, which we adapt for the transformations sought in SLES. Explaining the levels of inclusion in the SLES transition requires theoretical insights that link different approaches to inclusive innovation with struggles between contending notions of social justice. However, before elaborating this analytical framework it is helpful to provide some context for the empirical study and establish why inclusion has become a salient issue in this case.

2.1. Smart local energy systems in context

Fossil-free electricity is expected to become the dominant vector for sustainable energy services in the UK, extending beyond conventional use in power and lighting and moving into charging electric vehicles, cooking and keeping homes warm by replacing gas-heating with electric heat-pumps (HM Government, 2020). The electricity system must reconfigure dramatically in order to meet these demanding new activities much more efficiently (Iskandarova et al., 2022, 2021).

Conventional regime approaches would need large investments to strengthen local grids and provide back-up electrical power for balancing supply with demand. Proponents argue SLES can reduce these investments by smoothing and shaving peak loads through active demand management using digital controls that simultaneously maximise local consumption of decentralised generation and storage (Energy Digitalisation Taskforce, 2022). The Committee on Climate Change estimate innovations in SLES cutting decarbonisation costs by £3-8 billion per year by 2030 and reaching £16 billion annually by 2050 (Strbac et al., 2015). The Energy Revolution Research Centre estimate annual savings from local demand flexibility, PV generation and battery storage alone at between £1.1 billion and £2.5 billion (Aunedi et al., 2022).

A key attraction to SLES is that it integrates a variety of disruptive innovations (and entrepreneurs) into digitalised electricity regimes. Examples of the disruptive innovations include (Energy Digitalisation Taskforce, 2022; Van Summeren et al., 2020): automated battery storage and dispatch (including grid-connected electric vehicles); real-time monitoring of electricity-demanding devices and their control through the internet of things; better forecasts for on-site generation from renewables and local storage levels; real-time monitoring of electricity flow states across networks; dynamic electricity pricing that incorporates new sources of value and cost recovery through innovative tariffs; big data analytics for improving electricity management by correlating it with other factors, such as the weather or patterns of household occupancy; digital platforms for aggregating and trading household demand flexibility with network operators; and platforms enabling peer-to-peer electricity sharing or trades between households with small-scale generation and storage.

Digitalisation can conceivably permit the automated control of when, how and where devices demand electricity and are billed for, whilst maintaining service levels to households in terms of lighting, warmth, power and mobility (Marie et al., 2021; Rommetveit et al., 2021). Indeed, participating households could sell their individual flexibility and on-site generation and storage as services to SLES operators. Incentivised in this way, households monetise a share in the value that SLES generate for the energy system overall (Hiteva and Foxon, 2021). Flexibility becomes a capital asset for households with the right capabilities, as does their generating capacity and storage (Angel, 2021; Powells and Fell, 2019). All this relies upon sufficient data being shared responsibly across the system to enable transactions. The roll out of smart meters and open data sharing is foundational. Complete installation of smart meters across the UK's 28 million homes is anticipated by 2025 (the 10 millionth was installed 1st February 2021).

Developments in this niche space focus upon building the technical and business case for local generation and storage, new grid management controls, and techniques for reducing and shifting demand into periods when there is plentiful local supply from renewables. Through combinations of the techniques above, developing across a network of demonstration projects, SLES innovators experiment with incentivising households to trade flexibility, generation and storage through dynamic tariffs that rise and fall with peaks and troughs in demand on the local system. Diverse organisations pursue their interests in the SLES niche space: energy suppliers, regional electricity network operators, new entrant energy service businesses (particularly platform and data businesses), electricity generators, storage- and demand-management technology providers, regulators, policy-makers, industry bodies, local authorities, community energy organisations, consumer associations, universities, and research funders.

Different governance arrangements promote niche activity: research programmes, policy fora, innovation hubs, system catapults,

regulatory sandpits, living labs, and other devices bring actors together to explore possibilities, negotiate partnerships and mobilise investment. Practically, the ensuing demonstrations involve trials of new technologies, pilot novel energy services and business models, test user and customer experiences, develop and deploy datasets, agree protocols for opening up data, market new platforms for trading flexibility and aggregation, build knowledge bases for industry learning and regulatory deliberation, inform consultations on policy frameworks, and instigate local energy planning and community engagement.

None of this activity is geographically, socially or economically even. It takes place in a mix of locations, amongst lead developers and networks of early adopters. Experimentation is driven by competitive bids for public funds and private investment. For example, regional electricity network operators have access to Innovation Funds for piloting smart electricity activities in different localities. The most significant and coordinated catalyst for niche activity is the Prospering from the Energy Revolution (PFER) programme, which since May 2018 has invested £102 million public money (matched with £100 million private finance) in three large SLES demonstrations and studies of smaller activities elsewhere.

The articulation of different actor capabilities and interests is a key challenge. Effective frameworks and strategies are needed to coordinate deliberations, facilitate social learning, build alignments and mobilise power for transformation (Brisbois, 2020). Curiously, whilst significant technical and organisational changes are anticipated by SLES, developers imagine future energy services operating within the existing regime of highly commodified services, marketed to individual household consumers, and where neoliberal capitalist accumulation endures (Angel, 2021; HM Government, 2020; Strengers, 2014).

Implicated in all this are 28 million UK households - a tiny fraction of whom participate in demonstration projects (Iskandarova et al., 2022). However, UK households are currently unaccustomed to 'prosumer' roles like being active producers and responsive consumers of valuable new energy services. Only five percent surveyed were aware of the expectations being placed upon them by SLES developers (Energy Systems Catapult, 2021; see also Roberts et al., 2020).

It is within this context that questions of social justice become prominent. A growing body of energy research identifies critically important injustices in energy transitions in society and whose resolution must be part of just transition agendas (Calver and Simcock, 2021; Jenkins et al., 2018, 2017; Lacey-Barnacle, 2020; Milchram et al., 2018; Sovacool et al., 2017; Wang and Lo, 2021). Two recent reviews of SLES research (Knox et al., 2022; Powells and Fell, 2019) identify challenges for social justice in developments like those described above:

- Difficulties for some households to attain the assets, capabilities and circumstances necessary for effective SLES participation;
- The scope for enabling consumer agency and service accountability within the automated controls set by system developers;
- Protection of consumer and citizen rights under data extraction and automated transactions; and
- Unfairness in the relative distribution between system-level operators and households of the benefits and risks in SLES.

Cataloguing such injustices whether in terms of recognition, procedural or distributional justice is an important contribution of research for just transitions. In addition, however, research must help develop strategies for supporting fairer niche developments and just transition processes. Here inclusive innovation research becomes relevant: how households marginalised and excluded on grounds of poverty and other vulnerabilities can be brought centrally into developments in order to make sure systems innovations work for them as well as others.[1]

Indeed, the UK's statutory consumer rights organisation, Citizens Advice, argue SLES must present a "future energy market that is inclusive by design, facilitates innovation, and is fair and accessible to all" (Citizens Advice, 2020, p. 2; Crisp and Kruja, 2019). The Energy Systems Catapult (a public body promoting digitalisation) advocates "inclusion by design" (Chard et al., 2021). The Connected Places Catapult (another digitalisation public body) recognises inclusive innovation as a significant issue (Metro Dynamics and Lee, 2022). And policy and industry fora endorse 'smart and fair' electricity systems (Roberts et al., 2020; SSE, 2020). Helping these aspirations is the fact that widescale household participation is essential to the conception, functioning and value of SLES. Households have to become active components and perform suitably for the system to work. However, such an instrumental approach to inclusion – seen in terms of system function – risks narrowing the conception and practice of social justice in this energy transition. As we will see, calls for inclusive innovation risk dividing households between those that can be supported into becoming smart local consumers from those households who cannot or will not, and who will be left behind on social tariffs and minimum energy service protections. In both instances, households are essentialised into entities that need inclusion doing to them, rather than being recognised as diverse subjects with different positions towards inclusion in SLES and rights to justice in the transition.

The current energy crisis heightens further the stakes for social inclusion (Sovacool et al., 2023). SLES are presented as increasing energy resilience and autonomy for local communities through reduced dependency upon international fossil fuel markets. But with over six million households falling into fuel poverty already in the UK and fears that as many more will follow, so expedient measures for alleviating immediate hardship becomes their priority. Future SLES benefits are distant from desperate day-to-day realities. In response to rising household debts, some energy suppliers have taken to forcibly switching tens of thousands of households over to costlier pre-payment metering; effectively forcing them to self-disconnect when they cannot top up the meter. In some cases, this has been as simple as switching smart meters over to prepayment mode remotely, and in others has involved forced entries to change the

[1] It is important to note Just Transitions research also looks at the workplace and questions of those losing livelihoods in carbon intensive industries and equitable employment prospects in new sustainability sectors.

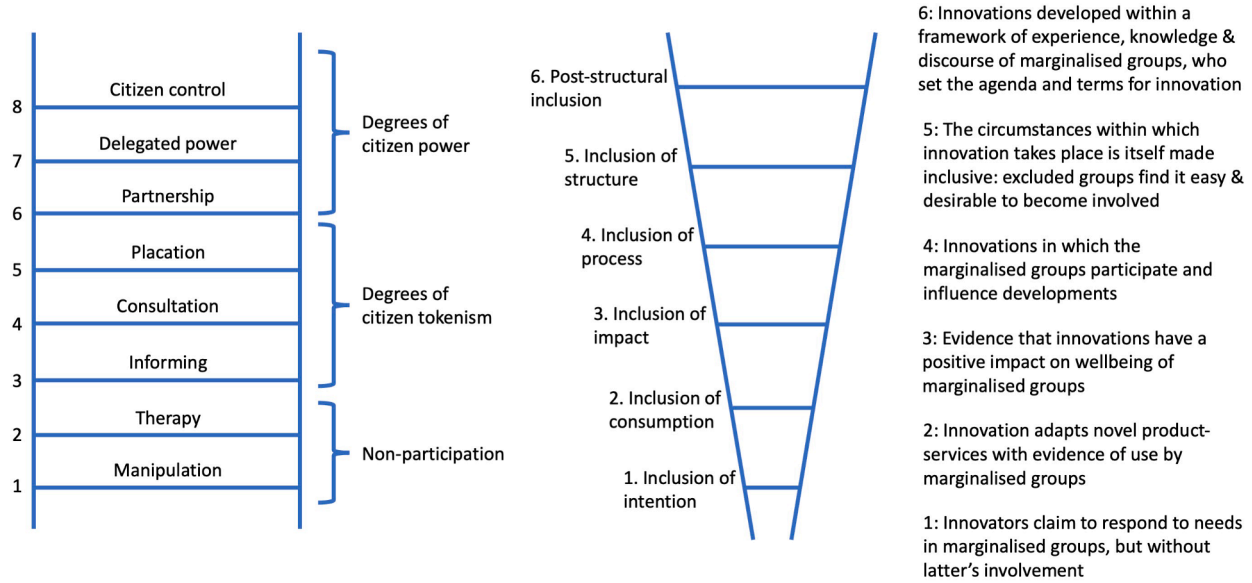

Fig. 1. Arnstein's ladder of citizen participation and the ladder of inclusive innovation (adapted from Heeks et al., 2014).

meter. Some warrants have incorrectly included vulnerable households supposedly protected from such measures (Citizens Advice, 2023).[2] How this metering scandal will influence long-term public trust the digitalisation of electricity is uncertain. Any perceptions of unfairly disciplining poorer households through metering illustrates the significance of getting inclusion right in a meaningful as well as instrumental way and securing legitimacy for SLES as a reasonable answer to a major social problem (Marie et al., 2021).

2.2. An analytical framework for inclusive innovation

Inclusive innovation researches "the extent to which innovation processes address the challenges and concerns of poor and marginalized communities and the extent to which these communities benefit from the resulting innovations, either through direct uptake or because the innovations contribute to including them in systems, markets, or benefit streams from which they were previously excluded." (Hoffecker, 2021, p. 5). A recent review of the inclusive innovation research literature found it tended to be largely descriptive or prescriptive without much analytical depth (Heeks et al., 2014; see also Bryden et al., 2017). Seeking to add depth, Heeks et al argue Arnstein's classic ladder of citizen participation can be adapted to inclusive innovation analysis (Arnstein, 1969; Heeks et al., 2014).[3] It is this heuristic that we use in our study. However, whilst the ladder is promising for distinguishing different levels of inclusion evident in SLES innovation, it does not in itself provide an explanation for any patterns it helps identify. We subsequently turn to Levidow and Papaioannou's discussion of social justice issues in inclusive innovation for such explanation (Levidow and Papaioannou, 2018). Understanding how struggles for justice in regime and niche settings open different inclusion possibilities, offers a helpful development for analysis.

The ladder of inclusive innovation is presented in Fig. 1 alongside Arnstein's ladder of citizen participation. The lowest level of inclusion on the ladder is *Intention*. Here it is sufficient for innovation to be called inclusive if innovators claim they address the needs or wants of a marginalised group. Inclusion of *Consumption* is a slightly stronger criteria, for which evidence of use of innovation by marginalised groups is required. Stronger still is evidence that the innovation has beneficial outcomes for those groups; which Heeks et al call inclusion of *Impact*. Inclusion of *Process* holds that hitherto excluded groups are involved in the development of the innovation (involvement that might range, after Arnstein, from being informed and consulted to actively collaborating or even controlling the process).

Heeks et al. (2014: 178) describe how "each level accepts the inclusion of the levels below, but pushes the extent of inclusion further" (Heeks et al., 2014). At their best, lower levels can be genuinely demanding of innovators and beneficial towards marginalised groups. At their worst, the lowest levels can be tokenistic. Attention has to turn towards the circumstances in which innovation is taking place. To what extent is the niche space of SLES demonstrations, for example, empowered to transform regime structures in ways that make it easier for fuel poor households, say, to participate in innovation in meaningful and rewarding ways? Reforms to

[2] After weeks of complaints, the market regulator Ofgem ordered suppliers to remove incorrectly fitted meters on 21st February 2023 and has ordered an investigation.

[3] A recent paper uses Arnstein's ladder to analyse the different rationales for public engagement used by SLES developers in the UK. The research objective is different to the innovation focus here but there is common ground and their results appear consistent with those reported here (Soutar et al., 2022).

regime structures that enable fuller inclusion are consequently called inclusion of *Structure*. Finally, Heeks et al suggest that inclusive innovation is at its highest level when it takes place within a frame of knowledge and discourse established by marginalised groups themselves, who are able to set the terms for innovation agendas, processes and outcomes: something they call *Post-Structural* inclusion (see also Fressoli et al., 2014). These heights of inclusive innovation are analogous to the empowered citizens at the summit of Arnstein's ladder and might, in the case of SLES, involve energy poverty activists and social justice organisations influencing the agenda and priorities for SLES developments through new forms of energy citizenship.

Levidow and Papaioannou (2018) argue that what is deemed a reasonable level of inclusion in innovation depends upon the prevailing conception of social justice in a regime. Dominant concepts of justice set the basis and justifications for who to include, how to include them, and why. Struggles by citizen energy activists for higher level inclusive innovation might, for example, be motivated by conceptions of social justice that are very different to the ideas of fairness that inform the public engagement activities of SLES developers. Critical researchers argue that on balance industrial responses to energy justice tend to make techno-managerial concessions involving relatively minor reforms in electricity regimes. These reforms appear reasonably conceived under the assumptions and norms prevalent in the regime, but hardly seem right to those with more radical ambitions for energy justice (Bouzarovski, 2022; Szulecki and Overland, 2020).

Theories of social justice differ if one sees it arising in questions of mutual advantage, of reciprocity, or in impartiality of treatment (Wolff, 2006). Each approaches fairness of distribution, reasonableness of procedure and equality of recognition differently (dimensions of justice common in energy justice research). For our purposes, we follow Levidow and Papaioannou in illustrating this difference in an ideal-typical contrast between 'liberal-individualist' and 'social-collectivist' approaches to social justice. Each conceives social justice very differently.

> "The liberal-individualist camp emphasizes the need to more fairly distribute costs and benefits of innovation to individuals. Towards those aims, it advocates more high-tech investment, skills training, cheaper products and/or more favourable external conditions which will help lower income people to gain greater access to innovation. By contrast, the social-collectivist camp advocates more equal relations of innovative production, seeking different conditions for distributing societal goods – or redefining them, for example, through commons and public goods."
>
> (Levidow and Papaioannou, 2018: 211)

In the UK, the passing of the Electricity Act 1989 and the subsequent wholesale privatisation of the electricity industry in 1990 has meant that the electricity regime has typically operated within the confines of a neoliberal political economy over the past 30 years. This is supported by a liberal welfare state whose institutions accommodate a liberal-individualist conception of justice (Esping-Anderen, 1990; Lockwood et al., 2017). Recent changes to the UK energy system, such as the creation of a publicly owned Future System Operator, the need for a £69 Billion Energy Bill Support Scheme to counter the steep rise in the cost of energy for households (National Audit Office, 2023) and the 2018 launch of Ofgem's Redress scheme, which redistributes large payments from energy company fines into funds for innovative energy projects, challenges the withdrawal of the state from electricity markets. However, problems persist in the form of weak protections for consumers in a largely privatised energy system. Under pressure to become fairer, the UK electricity regime is likely to see inclusiveness in its innovative activity in liberal-individualist terms (Bouzarovski, 2022). This is exemplified by various different Energy Pol. interventions, such as the Smart Meter Rollout and the Energy Company Obligation targeting individual households in their respective activities, rather than taking neighbourhood, building or community-scale approaches.

> "A liberal-individualist camp attributes social exclusion and inequity to 'impacts' – for example, of obsolete inefficient technologies, or of a skills deficit for more efficient technology, or of unfavourable conditions, as if the latter were merely contingent."
>
> (Levidow and Papaioannou, 2018: 222)

Reasons for inclusion rest upon ensuring SLES innovations do not unduly harm poorer and marginalised households. Inclusion centres predominantly in ensuring conditions for access to innovations individually through markets. Any prevalence of a liberal-individualist approach in the electricity regime is therefore likely to result in lower rung inclusion (Fig. 1), and middle rung activity conceived in terms of consulting marginalised groups, enabling them to participate where possible, and if not, then compensating them. Less consideration would be given to challenging and even changing regimes so that they are more equitable and generally inclusive by default.

However, one must not overly essentialise the electricity regime nor rush to all-encompassing hypotheses. There are differences between regime actors and dynamic processes between them that open the regime up to reassessed assumptions and norms, including different conceptualisations of social justice. Decarbonisation, decentralisation and digitalisation require higher-levels of planning, public subsidy and coordination that invite debates about the purpose and ownership of new electricity systems. Research and advocacy groups like Common Wealth, for example, push for the public ownership of energy systems and digital infrastructures.[4] They argue that as well as sharing benefits collectively and equitably, such arrangements permit more democratic inclusion in key decisions in the development. Whilst the electricity regime was never monolithic, its future rules of operation appear susceptible to challenge. The question is how these uncertainties open space for social justice to manifest differently in developments like SLES.

In their framework, Levidow and Papaioannou deal with this difference and contestation by contrasting liberal-individualism with

[4] See https://www.common-wealth.co.uk/ (last accessed 21st February 2023)

a social-collectivist conception of social justice. Social-collectivist justice commits to changing the conditions for distributing SLES benefits and exploring the organisational and institutional changes necessary for higher-level inclusion to be common, i.e., to remove the structural causes of injustices and build structural bases for inclusion.

> "Looking beyond an 'impact' model, a social-collectivist camp highlights collective capacities and struggles to transform the constitutive conditions which perpetuate socio-economic inequity."
>
> (Levidow and Papaioannou, 2018: 222)

Such approaches would envisage SLES niches quite differently. Rather than seeing digitalisation as enrolling more households into more sophisticated electricity markets, as might be the case under liberal-individualism, the social-collectivist approach might wish to see greater local autonomy through shared provision of energy services. Community energy groups emphasise the public good and commons-based features of electricity when prototyping cooperative ownership in SLES initiatives (see later). Forms of inclusion thereby open beyond the invitation of individuals to access technologies as customers,[5] and consider instead how excluded groups become part of a new collective that has equitable and controlling ownership in SLES.[6]

In sum, turns to inclusive innovation can pitch innovators into profound questions about whose innovation agendas count, why processes take the forms they do, how the relative standing of different knowledgeable actors is structured and organised, the forms of innovation to be attempted, and who benefits ultimately (Rammelt and Gupta, 2021). Linking levels of inclusive innovation to different conceptions of social justice provides a framework useful for researching these challenges. Whilst analysis must explain the patterns of inclusion achieved and its consequences, the framework also points usefully to absent levels (and more inclusive possibilities) whose explanation might be found in struggles for social justice.

3. Research methods

SLES present a 'strategic case' (Flyvbjerg, 2006; Yin, 1984) for analysing inclusive innovation: the demonstrations constituting this niche space exhibit complex sociotechnical configurations (Ryghaug and Skjølsvold, 2021), in a context of an unsettled regime under pressure to transform, and against a landscape in which justice issues are increasingly prominent. Case study methodology is appropriate given the dynamic setting and considerable experimentation involved in SLES. Our methods were extensive document analysis, semi-structured expert interviews (N=24), household interviews (N=24), and site visits (N=4). Our analytical framework anticipates inclusion operating across different levels influenced by contrasting approaches to social justice. Given this complexity, we selected demonstrations with different kinds of inclusive innovation activity and analysed their relation to SLES development strategies more generally.

Specific demonstrations select and configure SLES techniques differently. They involve partnerships between public, private and (sometimes) civil society organisations. Most receive public funds; some are industry-led with additional investment-finance, whilst others include community-based projects. Industry databases[7] of demonstrations and demonstration webpages and reports were used to gauge the variety of initiatives in the UK. We sampled a cross-section of nine demonstrations for desk-based investigation based on what we could learn initially about their approach to inclusion (Annex A). We included all three flagships under the government's Prospering from the Energy Revolution programme. We complemented the studies with analysis of SLES policy and strategy documents from diverse organisations (Annex B). Some documents addressed inclusion specifically (where we noted the approaches recommended and justifications given). Other documents explain SLES strategies more broadly (which we analysed for approaches to inclusion). We attended industry events (mostly online due to the COVID-19 pandemic) and observed discussions.

In-depth, semi-structured interviews with twenty-four experts (throughout 2021) provided additional information. Snowball sampling identified prominent experts from public, private and civil society organisations (Annex C). Interviews lasted one hour and covered the context for SLES strategies generally before moving to inclusion issues specifically. All interviews were transcribed and analysed manually with the ladder of inclusive innovation informing the identification, interrelation and interpretation of themes (see Fig. 1). Whenever we identified SLES demonstration activity approximating to one or more levels, we studied the explanations given for the basis of that activity, its operation and any issues or consequences arising. Throughout we sought evidence for the underlying approaches to social justice and noted absent levels of inclusion. The aim was to improve our understanding of the technicalities of SLES and form an overview of inclusion strategies.

We coupled our expert interviews with community site visits and household interviews. Four different neighbourhoods of Brighton & Hove in England were visited (see Fig. 2), each with significant household solar uptake: Hangleton and Knoll, Coldean, Bevendean, and Whitehawk. Within these four neighbourhoods, we passed out leaflets to approximately 150 homes inviting interviews over August and September 2021. Twenty-four household interviews were completed. We sought a mix of demographic types (old, young, male, female), housing types (homeowners, private renters, those in social/council housing), and solar adopters and non-adopters (Annex D). We asked a semi-structured set of questions including patterns of solar energy adoption, thoughts about inclusion and exclusion, experiences with digitalisation, and suggestions for improved support in adopting PV. PV is a common technological

[5] The excluded may not wish to become involved in the complex and demanding minutiae of the innovation anyway nor welcome the terms of the invitation to participate (Cooke and Kothari, 2001).

[6] Research into direct participatory experiments amongst previously unorganised individuals finds the experience can motivate the development and design of such collectives (Kelty, 2019).

[7] The Smarter Networks Portal (https://smarter.energynetworks.org/)

a. Hangleton & Knoll

b. Coldean

Fig. 2. Sampling strategy for community interviews and neighbourhood site visits in the United Kingdom, 2021
Source: Authors.

c. Bevendean

d. Whitehawk

Fig. 2. (*continued*).

component in SLES demonstrations and we used household experiences to validate and challenge the observations identified through our other methods.

4. Results: inclusive innovation in smart local energy systems

We found inclusion operates mostly at lower-levels in SLES demonstrations, with limited activity at higher-levels indicating further inclusive possibilities (and consistent with other research into participatory engagement in SLES projects (Soutar et al., 2022)). Our results are summarised in Table 1 and elaborated for each level in the following sub-sections.

Table 1
levels of inclusive innovation in SLES demonstrations in the UK.

Level of inclusion	Summary of evidence in UK smart local energy systems
1: Inclusion of intention Innovators claim to respond to needs in marginalised groups, but without latter's involvement.	Tools being developed that monitor smart products and services for their 'fairness' and the capabilities and assets required for households to benefit: permitting assessments of who can access, and who is excluded. Digital divides compound inequalities in fuel poverty and energy injustices. Research highlights new vulnerabilities and exclusions in relation to assumptions and practices in emerging SLES.
2: Inclusion of consumption Innovation adapts novel product-services with evidence of use by marginalised groups.	Studies suggest little uptake of smart electricity products beyond an asset-owning, confident, and technologically-inclined set of customers. Innovation trials involving poorer and marginalised groups identify a variety of obstacles to adoption and, in donating equipment to these households, provide access in artificial ways in order to test the likelihood of them becoming an economically rational prosumer in smart markets. There is less evidence for designing and developing smart services with the needs of excluded groups as the point of departure.
3: Inclusion of impact Evidence that innovations have a positive impact on wellbeing of marginalised groups.	Inclusion of impact typically is framed as not further excluding disadvantaged groups and ensuring that those who already suffer poor energy services can access basic products suitable for them. Inclusion is still conceived in converting users into rational, consenting customers in smart markets. Market-based segmentations and the tailoring of products and services risk creating low value groups of (regulated) provision rather than pathways with equitably shared SLES benefits.
4: Inclusion of process Innovations in which the marginalised groups participate and influence developments.	Demonstrations that include poorer and marginalised customers mostly bring them into the process as testers in trials designed by others, and rarely as co-decision makers, nor with innovation constituted around discovering their particular energy-demanding needs, situations, and aspirations. Exceptions that are more inclusive by design, such as community generation, storage and flexibility projects in social housing, remain isolated and rarely inform strategic policy.
5: Inclusion of structure The circumstances within which innovation takes place is itself made inclusive: excluded groups find it easy and desirable to become involved.	Some community energy projects propose more democratic structures of ownership and governance of SLES, thereby making services more inclusive. Demonstrating such alternatives requires accumulated resources, skills and assets held only by relatively established groups. Even these have to compete within an electricity marketplace designed for larger utilities, with whom community groups often have either to partner or emulate. SLES policy and strategy does not address structural impediments or support for higher levels of inclusion.
6: Post-structural inclusion Innovations developed within a framework of experience, knowledge and discourse of marginalised groups, who set the agenda and terms for innovation.	Limited evidence that alternative frameworks, assumptions and collectives are informing innovation, nor that innovation is seen as a valuable way of anticipating and exploring inclusive energy systems (e.g., energy infrastructure conceived as a commons, public ownership, municipalization or co-operative governance, and their potential in aligning all user interests with system interests). Rather, inclusiveness is treated instrumentally, with engineers and economists building SLES according to their frameworks, and seeking to make these designs compelling to customers. Systems are not designed sociologically, around the inputs, knowledge and aspirations of participants, and thereby more inclusive in conception. Strategies do not deliberate with new emerging collective actors, such as energy citizens, that might arise in SLES and who might shift the frame for innovation.

4.1. Inclusion of intent

SLES demonstrations recruit already willing and able volunteers. Exclusions soon become apparent and some understanding of inclusion arises. SLES developers see exclusions in terms of difficulties accessing technical assets and capabilities and dealing meaningfully with the language and concepts in SLES, both due to inhibiting household circumstances. As an interviewee working on energy digitalisation strategy puts it,

> "The thing everyone worries about is you go to really dynamic price signals that drive the right behaviour on the system, but only if you are rich enough to buy an EV and buy a battery and have solar panels and weather the storm of the prices. If you can't buy any of that kit, you end up basically just having to pay whatever anyone tells you at any time." (EXPINT_2)

Demonstrations acknowledge that households unable to invest in demand flexibility, storage or small-scale generation, and ill-adapted to real-time tariffs, risk becoming penalised by SLES for otherwise legitimate energy demands basic to modern life. Those living in the private rented sector, for example, lack the tenancy security and incentive to invest in renewable energy generation, or battery storage and heat-pumps. Households living in buildings with multiple occupancy have limited agency over communal energy service infrastructures; whilst earning income from the grid balancing services of an electric vehicle battery is hard without a private driveway with charging point. Pre-payment meter users, typically in private-rented accommodation or households with poor financial

ratings, are not a focus for SLES even though they already pay the highest rates for energy and could benefit considerably. Poorer households are acutely aware of their energy costs, but without the means to invest, so SLES demonstrations focus instead on households with wealth and more secure contracts.

Household surveys find many unfamiliar with complex billing arrangements, and with migrants and other vulnerable groups particularly exposed to confusing offers and charges (Bouzarovski et al., 2022). The fuel poor exceeded three million households in 2019 (in England), and National Energy Action[8] anticipate it surpassing 6 million (in UK) as the energy crisis bites deeper. Households already unable to pay for adequate energy services can struggle to access basic energy efficiency measures (Department for Business Energy & Industrial Strategy, 2021). The capital to invest in flexibility, generation and storage capabilities is neither a priority nor practical for such households, even if SLES might provide affordable, resilient energy in the long-term. In our household interviews, Coldean_12 said "I am guessing we couldn't afford it [new technologies like solar or smart meters] … Groups like me can't afford it, I have enough trouble paying rent or getting food." Bevendean_09 stated "it's difficult because the housing crisis at the moment is crap for people similar to my age. We were very, very, lucky, we were very lucky indeed in the situation that we were in. For people around my age, it's very, very, difficult."

Digital exclusion is another barrier to SLES inclusion. Thirteen percent of adults in the UK do not use the internet (Ofcom, 2020). As Hove_13 explained "there're so many factors that are constantly changing with so many different types of gadgets and white goods. It's difficult to keep up with." Whitehawk_01 noted that "'I'm not even on the internet, or anything like that […] because I can't afford it'" implying they had even less funds to purchase smart energy equipment. Even when supported into accessing smart technologies, households need the requisite skills, confidence and trust in suppliers to make informed decisions about new energy service contracts and requirements. Around 1 in 6 adults in England have very poor literacy skills,[9] and nearly a third of people in national surveys[10] say they struggle with everyday maths. People rely upon friends, neighbours and family for help understanding conventional energy bills. Complex social and economic factors cause such poverty and inequality in the UK. As an interviewee at an energy charity put it, "a lot of the factors that now affect whether you can meaningfully engage in these [smart energy] offers and take advantage of them are dependent on factors that are outside the energy market … if you want to get a smart-energy system to operate in a more fair situation, you need to work on a lot of those broader contextual issues" (EXPINT_14).

Automation might alleviate the significance of active household capabilities in SLES. But even wealthier households need to trust SLES operators enough to provide informed consent and have confidence in the accountability of automated controls (Marie et al., 2021; Rommetveit et al., 2021). A review of surveys into public trust in energy suppliers in 2015 found it to be as low as thirty-two percent and rarely above fifty percent (Citizens Advice, 2015). Excessive profiteering and poor service were the main reasons attributed. A recent study of customer perceptions of SLES found an openness towards decentralised systems provided benefits, responsibilities and reassurances were clearly specified (Energy Systems Catapult, 2021).

Inclusion of intent acknowledges these issues and commits to addressing exclusion. Statements are made for SLES to become 'inclusive by design' but generally, "people on the more vulnerable end of the spectrum don't get involved in this. It is not of interest, it is not a priority, it is too expensive, it is not really targeted at them" (EXPINT_2). In many cases, however, intent does not lead into higher level inclusion efforts. Instead, the approach is to acknowledge inclusion as an issue but leave it for later or to suggest an (unspecified) future basic electricity service provision for those unable to participate in SLES. Such protections imply regulatory reforms for which there is little evidence. Government policy for SLES does not mention social inclusion (Department for Business Energy and Industrial Strategy and Ofgem, 2021). This situation risks entrenching energy inequalities.

4.2. *Inclusion of consumption*

For SLES to work, a large proportion of households need to be participating in order for generation, storage and flexible demand to balance across the local system. A high degree of inclusion of consumption is important. *Smart and Fair*, a project led by the Centre for Sustainable Energy and funded by two electricity network operators[11], developed a method for mapping 'smart readiness' amongst households: 'who is keeping up' and 'who is left behind' (Roberts et al., 2020). Stakeholder workshops gathered insights from industry bodies, consumer associations, policy makers, and academics about smart energy and social inclusion. These workshops informed the smart readiness mapping methods used by *Smart and Fair*, meaning the project represents a sector-generated and sector-oriented assessment. It reveals how progressing inclusion beyond intent is mainly considered in consumer terms.

Smart readiness is conceived in terms of technology adoption curves. Strategy for inclusive innovation rests in moving more households onto those curves. The hope is that social learning will improve smart technologies and services in ways that bring down costs, remove barriers for later adopters, and heighten household incentives to invest. The goal is to equip households with the assets, capabilities and incentives to participate (Roberts et al., 2020) – an approach evident in inclusive demonstrations (Chard et al., 2021; Crisp and Kruja, 2019). Nevertheless, *Smart and Fair* concludes policy intervention is needed to reshape the adoption curve:

[8] https://www.nea.org.uk/energy-crisis/fuel-poverty-statistics-explainer/ (accessed 14 September 2022)
[9] https://literacytrust.org.uk/parents-and-families/adult-literacy/ (accessed 12/1/2022)
[10] https://www.nationalnumeracy.org.uk/news/new-research-nnd21 (accessed 12/1/2022)
[11] Scottish and Southern Electricity Networks and Western Power Distribution.

> "[T]his reasoning also leads to a clear conclusion that 'fairness' will not reliably emerge from the market without deliberate and purposeful action by policy-makers and regulators to secure it from beyond those organisations trying to deliver smart energy offers." (Roberts *et al.*, 2020: 9-10).

The households we interviewed tended to agree. Whitehawk_18 stated that:

> "You need to make it easy for people to participate. I own a solar system, and I don't know where the council got the funding from, why the council did it, or why installations across this area are patchy, some solar is privately owned, some is council owned, and some have nothing. I don't know how it was decided who got it, who didn't. It doesn't seem fair, and what's worse is I don't even know how it works … we weren't given any information about solar. No knowledge, no manual, no information, it was just 'let's get this job done, thank you very much', period"

Hangleton and Knoll_24 added that "I haven't bothered [to adopt new energy systems] … The amount we spend on electricity though is too low to justify it, we only spend £30 a month on our electricity bill, a few hundred pounds a year." They noted it would only be cost effective to adopt if major policy incentives were implemented.

4.3. Inclusion of impact

Smart and Fair finds around half the households in England cannot participate in smart electricity services even if they wished to do so (Roberts et al., 2020). This estimate of 'smart-readiness' is based upon data that approximates to the capabilities households need to become SLES customers: financial position; suitability of dwelling and local grid; energy use and technologies; digital readiness; and personal and social circumstances. Whether smart-ready households actually consent and join SLES will depend upon how system-level benefits (accruing largely to operators) become shared with them.

SLES developers conceive household benefits in terms of financial savings. Economically rational behaviour is assumed amongst individualised households responding optimally to price signals, and seeking out in competitive markets the most efficient and suitable service providers. A civil servant working in smart Energy Pol. explained, "making sure that consumers can use their consumer data to get better propositions and deals" (EXPINT_16). Entrepreneurial 'aggregators' are developing innovative business models in which the outlay, inconvenience and technicalities of contracts for maximising local consumption and optimising flexibility are organised by them across multiple households in exchange for a share of the total savings. Other business innovations involve peer-to-peer electricity trading between households over automated control platforms and similar market-based mechanisms in which electricity generation, storage and demand is financialised in complex combinations. Households must be capable of conforming to this flexible, market-based activity in order to be impacted beneficially - thereby becoming "domestic resources" for the SLES operators (EXPINT_7).

Significantly, focus groups and surveys of households participating in demonstrations find the experience prompts questions about the inclusiveness of SLES. For example, a hundred households in the Cornwall Local Energy Market demonstration were donated solar, battery and digital technologies by a utility company, in which the latter was testing its techniques for running them as a Virtual Power Plant. Participation led households to want to know more about future social, economic and environmental potential of SLES. As well as impacts for them, household feedback revealed interest in questions of ownership, community benefit, local energy and flexibility as a public good, and concerns for excluded households (Bray and Woodman, 2020; Melville et al., 2017). One household suggested:

> "The people who can least afford to pay are probably paying the very most. If this could be used for some social good, then we'd be even more delighted. If everyone could pay the amount we're paying, even in fuel poverty, those who are on the universal credit, for example, could have an energy bill of 50-60p a day, that would be a huge result wouldn't it, for everybody, I would have thought." (Bray and Woodman, 2020, p. 46)

Another household proposed,

> "A cooperative would be better so that money just gets ploughed back into it so that we see the benefits that can be spread out for other people rather than it just going into one person's pocket." (Bray and Woodman, 2020, p. 53)

And a third argued,

> "Like a community project or something like that to benefit people, or perhaps say supplying cheaper or free electric to a school or something like that. So, that it could be something built back in that goes back into the community." (Bray and Woodman, 2020, p. 53)

Our household interviews revealed similar concerns for social inclusion (Sovacool et al., 2022a). Even when SLES demonstrations take a liberal-individualistic approach to inclusion, participating households can nevertheless conceive possibilities through more social-collectivist approaches.

4.4. Inclusion of process

Inclusion of process is pragmatic in SLES. Recruitment to demonstrations typically target households indicating interest, time and the adaptability needed to fit and conform with developer objectives, and who can quickly acquire the capabilities needed by the organisations orchestrating the trials. Inclusion of marginalised and disadvantaged households is rarely the defining aim. An inclusive energy design consultant attributes this to the way innovation is conceived,

> "The early adoption curve and stuff is quite interesting when you start to think about demographics, and you start to question it. I would argue that the adoption curve depends on what offers are coming into the market. Like I said, the centre of gravity seems to be towards people that are tech savvy, but also want new tech. Because the offers that we've currently got in the energy market, the innovative ones, tend to be centred around tech and devices. Of course, those people are the early adopters." (EXPINT_12)

SLES developers argue the risks for vulnerable groups in experiments are greater compared to wealthier participants. The view of this researcher working on a large demonstration is typical:

> "In terms of running trials and in terms of being at this early demonstration stage, I don't think it's always the best idea to target the vulnerable groups because it's quite important for people that are on low incomes and they're groups vulnerable to having their power supply discontinued, to maintain those things … So, in a way, the groups that you should be working with at this experimental stage are the ones that can afford to take the risk, if you know what I mean, who are higher income and less vulnerable." (EXPINT_19).

The innovation involved is deemed to be too risky and complex for more inclusive processes. However, the inclusive design consultant disagrees:

> "If the type of offers that were on the table, that were innovative, were more of around pre-payment meter tariffs or pay as you go energy, then the early adopters might then become more low income or vulnerable households. Because they're the ones that are interested in that space … We have people using pre-payment meters that, for some of them, literally have to go to a shop to put money on a meter. The amount of money that is on a meter at any one time, they have no idea how long it's going to last because how would you know? There is no way you could know how much a shower costs you, how much your heating costs you because one day it might be cold outside, one day it might be warm. For me, in terms very much commercially minded, there's a great opportunity there to better serve that market. You only have to do something a little way better than having to go to the shop or not knowing how much your money is going to last … Much to my dismay, we don't see the centre of gravity focused on why are people's needs not being met" (EXPINT_12)

There are 4.5 million households using pre-payment meters. Good participatory design processes, if done meaningfully, could expand SLES inclusion in ways embraced by marginalised groups and that need not leave them vulnerable to risks (Raman and French, 2022). Demonstration challenges can be anticipated and monitored if one actively listens to participant needs and remains responsive to their positions. However, most SLES demonstrations are not set up in this way. For developers, participatory design seems to risk for them a reduction in control over the purpose and focus of the demonstration.

Instead, SLES demonstrations seek reliable volunteer households that can adopt the technology, operate it reliably, and participate informatively according to the developer's templates. Typically, the aims are technical and managerial: testing the engineering performance of devices; learning about system installation, integration and performance in the home and on the network; validating and developing business model concepts; receiving consumer feed-back. Behaviours are monitored and experience surveyed in order to gain intelligence for future marketing.

Trust will become a significant element in the process of expanding participation (Citizens Advice, 2019). As the Chief Executive of one energy charity explained, "Actually to get people to participate beyond the innovators and the early adopters, to get the people beyond that, they need to feel that it's a trustworthy, safe place to join in because as opposed to the early adopters who will take a bit of risk and they just want to get the kudos for being out of the blocks fast, the early majority will want to know that a lot of people have already tried it out, but also no one has really got burnt by doing that" (EXPINT_14). Household Hove_07 spoke about how:

> "Energy companies aren't the best obviously, I've had first-hand experience of that, to respond to having things like energy meters installed. There's a level of trust about people coming in your house and then the type of information it feeds to householders. So, I think there're a lot of these barriers that need to be overcome."

SLES demonstrations have been partnering with community energy groups because they value the trusted outreach skills the latter bring to including households. The senior innovation manager at an electricity network operator argued, "The community-led was the most effective by a long shot in terms of getting people interested and engaged in the topic" (EXPINT_9). A technician at a community energy group reflected, "Actually, a lot of the problems that other trials have had with automated DSR [demand side response], we just haven't had them at all really … There is a strand running through it which is like, 'Because we share your values and we trust you, as an organisation, we're not worried about you doing things like turning things on and off automatically'" (EXP_INT15). However, even community energy recruitment can tend to focus on smart-ready households because partners and parameters in demonstrations projects restrict higher forms of inclusion.

Some exceptional demonstrations have used community champions to recruit households into projects based in social housing or in poorer neighbourhoods. Low Carbon Hub (a community energy group) describe their involvement in a large demonstration, "We are working across a spectrum of very highly motivated and experienced community groups that includes a community and customers

where most householders are tenants and there are high levels of multiple deprivation" (Hammond and Middleton, 2021: 10). However, even for community energy groups, inclusion of process can prove demanding. As a SLES researcher working with community groups explains, "They've generally tried to identify an energy group, a low carbon group or a sustainability group that's already embedded in those communities. They're linking to those pre-existing groups in each of these communities" (EXPINT19). The prospect of the SLES demonstration becoming more inclusive depends upon success recruiting beyond those embedded groups and their constituencies. The technical director at a different community energy group attributes more diverse recruitment difficulties to the narrowness of the approach to innovation being taken and the lack of attention to favourable structural changes:

> "I think the system as a whole isn't really starting from the point of how can we make sure that everyone's basic energy needs are met. It assumes that everyone will be able to pay for the energy that they need and then there is a marketplace for choosing different providers … what we're trying to do is make the opportunities that are being created broadly by the transition to low carbon technologies and digital technologies more accessible, more inclusive … That's our starting point basically for all the innovation work that we do, is how can this help more people participate in and benefit from the transition" (EXPINT_8).

4.5. Inclusion of structure

The experience of community energy groups in SLES demonstrations is instructive because these groups often aspire to higher levels of inclusiveness compared to the other partners involved. Differences over purposes and expectations can create tensions that are rarely open to equal negotiation because the electricity regime itself excludes more transformative possibilities. Community energy groups nevertheless enter pragmatically into SLES partnerships because these afford them opportunities to learn about technical possibilities, even if the demonstration itself is far from their ideal. Local relationships, knowledge and skills can be developed further, and ideas for ideas for higher-level inclusivity in SLES can still be developed and advocated with experience built up in demonstrations.

Pooling household demand-side responsiveness into larger-scale community flexibility, for example, might enable members to bargain collectively for a greater share in SLES benefits. A few community demonstrations already match collective demand to periods when local generation and storage is high, thereby enhancing local energy autonomy. However, these demonstrations require community participants to switch their household energy contract to a partnering electricity supplier. This is because market regulations require local generators to sell into a wholesale market, and it is only the licenced supplier (typically a multinational firm) who can contract with households. As the community energy technical director explains, "in terms of the perception of the project, it then is less clear whether this is a community initiative or whether it's a big six utility initiative" (EXPINT 8). Market and regulatory institutions mean community organisers have to adapt what looked like an inclusive process into a less clear-cut consumption arrangement.

Regime structures constrain experiments beyond compliant, market-based and commodity-driven designs in SLES. Similarly, decision-making structures for infrastructure planning and provision can block innovative SLES demonstrations seeking greater local ownership. More deeply still, the idea that electricity is a commodity best provided commercially has become so hard-wired into energy cultures that arguments for other bases for its provision are excluded from regime discourse. More radical propositions are absent in proposals, or conveyed in market-friendly terms for relevance to the funders of demonstrations. The right to energy services in non-commodity form, for example, had until recently fallen so far away from mainstream energy discourse as to not warrant exploration in any single SLES demonstration.

The system into which communities and households are being included remains framed in terms of offers to markets in which established energy actors retain structural privileges and remain central gate-keepers. As such, inclusion in SLES entangles households further into complex dependency upon the electricity regime at a point where community energy groups hope to demonstrate innovations for delivering greater local autonomy. This contradiction in SLES presents dilemmas for community energy groups. Even the strongest community-based processes find value is determined ultimately in terms of services sold to regime operators. This lack of inclusion of structure in the SLES niche space means experimentation with alternative SLES frameworks involving say, more democratic ownership or participatory governance is difficult.

4.6. Post-structural inclusion

Despite structural impediments, a handful of community energy initiatives are developing proof-of-concept activities in which alternative, more collectively-conceived models for inclusion are put forwards and elaborated. These make use of agendas and discourse for energy that is marginalised in the regime but which offers an approach to social inclusion closer to social-collectivist approaches. Community energy projects are proposed, for example, in which technologies like batteries are owned and governed collectively by neighbour associations (e.g., the CommUNITY project, Annex A). Others consider arrangements in which use rights to renewable generating assets are held in common, or local energy clubs that seek to manage demand collectively in order to maximise

consumption from local renewable generation. The potential for energy data cooperatives to give more members voice in SLES governance is another area where there has been some activity (Open Data Manchester and Carbon Co-op, 2021). Free software and open hardware methods are also being deployed to develop open platforms for exchanging electricity.

Aspirations for post-structural inclusion anticipate demonstrations working beyond the regime's adoption model by bringing social-collectivist approaches into the organisation, ownership and governance of new systems. Innovation is not only technical and managerial but experiments with more democratic forms of governance and ownership also. These are marginal projects, but their significance rests in reconceiving the technical affordances of digitalising energy in terms of commons-based approaches, public goods and basic rights rather than private commodities to be traded. Even though such ideas might have a degree of public popularity[12], and whose experiments might justify support, they remain a distant prospect in SLES without structural changes and democratic representation in key market, regulatory and innovation policy decision-making processes.

5. Discussion

We have considered SLES developments in depth and at length. The practical details matter for inclusive innovation; as does the relative standing of different approaches to social justice. In this section, our discussion considers the usefulness of an inclusive innovation framework for just transitions research. But first, to return offering answers to our research questions.

Inclusive innovation in SLES is conceived largely within liberal-individualist approaches to justice, which incentivises households in acquiring individually the assets and capabilities that enable them to join technology adoption curves. SLES demonstrations develop knowledge and arrangements for marketing smart products and services to different customers, who are expected to fit and conform to a particular kind of flexible and smart energy user. The consequential task for niche development is to find appropriate techniques for ensuring enough households can join SLES markets and help them become effective customers. Fairness is conceived in helping households to participate productively in the marketplace, which expands through suppliers competing for customers.

Low-levels of inclusive innovation inform these developments. Households that are too asset poor, too unreliable or living in challenging circumstances are unwelcome, at least initially. Regulated basic services and social tariffs are evoked as an alternative for those excluded, but the details remain scarce (and such reforms are beyond the agency of innovators). Thus regime norms that already exclude and marginalise some households are conserved and reproduced within the so-called disruptive innovations in SLES (and more generally, see also Smith and Fressoli, 2021). Community energy and civil society groups try to open space for social-collectivist experiments but this kind of inclusive innovation attracts less material interest than prevailing liberal-individualist approaches.

These answers relate only to the SLES case. One might hypothesise that transitions in which liberal-individualist notions of justice will display similar tendencies, but only comparative research can find out. Moreover, we believe this particular application of inclusive innovation analysis raises three points of merit for further just transitions research, which we discuss here.

1 Multiple levels of inclusion can co-exist in transitions, and whilst there is no simple 'ladder', overall patterns are nevertheless shaped by dominant approaches to social justice.
2 The types of innovation emphasised expands as higher-level inclusivity is promoted and, at the same time, innovation becomes more overtly political because these higher levels are associated with social-collectivist demands for social justice.
3 New collective actors that develop through inclusive innovation can bring alternative conceptions of social justice into the emerging transition – which policies for just transitions should actively accommodate.

5.1. Interrelating the multiple levels of inclusion

This study found the ladder of inclusive innovation to be a useful heuristic for looking more deeply and critically at social inclusion in SLES. The marginalisation and absence of some levels of inclusion soon became apparent. In helping lift attention towards overlooked levels, so the ladder casts existing levels of inclusion in a different light. Innovations seeking laudable inclusions of intent and consumption appear constrained and even diminished when related to higher-level aspirations for structural change and post-structural re-framings of purpose. Conversely, experiments in post-structural inclusion can appear utopian in the absence of processes for building agency for supporting structural changes. Lower-level inclusion is thereby cast as the more pragmatic strategy.

Our analysis found inclusive innovation operating across multiple levels simultaneously and in relation to one another. At the level of inclusion of process, for example, we found inclusion predicated upon households eventually fitting and conforming to the ideal smart customer template; which reduced more expansive community flexibility alternatives down to instruments for selling demand responsiveness into existing markets, rather than a new institution for sharing local energy resources collectively. As a result, an inclusive innovation process falls away from structural and post-structural possibility, and slips back down into inclusion of consumption. However, whilst some levels certainly predominate, they do not eclipse higher-level alternatives entirely.

If the ladder heuristic is to be developed further, then it needs to do so dynamically, relationally and sensitive to underlying

[12] A petition launched by Fuel Poverty Action in February 2022 for minimum level energy services free to all in the UK (and funded by charges on higher consumption) attracted 400,000 signatures. It has since been proposed as a measure to address the energy crisis. A poll of British adults found 75 percent supported the right to free energy for basic energy needs. See: https://www.fuelpovertyaction.org.uk/press-release/press-release-75-support-the-right-to-free-energy-to-meet-basic-needs/ (accessed 26/07/2022)

complexities (see also Soutar et al., 2022). Levels interact sometimes coherently, sometimes in contradiction, and always in relation to the complex and varied causes of social exclusion. Indeed, learning from research into ecologies of participation, there could be a case for not imposing the ladder heuristic into a complex milieu (Chilvers et al., 2018; see also Quetzal and McCallum, 2006). Used reflexively, the ladder provides a language and sensitivity towards absent relations of inclusion; but forcing initiatives onto a series of steps and expecting a progressive lead from one into others is misleading.

More useful in the analysis has been to relate the different levels to the relative standing of different concepts of social justice. Attempts in social-collectivist justice in SLES demonstrations are ultimately shaped (and hobbled) by the more powerfully instituted liberal-individualism that currently prevails in the electricity regime. Whether and how different conceptions of justice render varied approaches to inclusive innovation more appropriate or better than others are matters for debate and contestation (Dobson, 1998; Wolff, 2006). But it would be in keeping with the normative aims of just transitions if conceptions of justice and their material manifestations were included explicitly in demonstrations and were subject to open and democratic deliberation. Higher-level inclusive innovations will remain marginal in the absence of concerted pressure for social-collectivist justice. Transformative innovation might be progressed more effectively if antagonistic approaches to justice are recognised and supported more pluralistically.

5.2. Expanding the diversity of innovation

Differences in inclusion in this case had a material impact on the kinds of innovation developed. Lower-level inclusion presumes direct household participation as consumers benefitting from lower-cost carbon-free energy services within a largely unchanged institutional regime. In contrast, feasibility studies for data co-operatives and community flexibility seek to include member-households collectively in a different kind of SLES. Innovation extends from designing an accessible kind of technology to orchestrating experiments with different ownership and governance models for energy systems. Inclusion conceived social-collectively situates novel socio-technical experiments (like community-scale battery storage and data management) within accompanying institutional innovations (Hess, 2016; Melville et al., 2017; Radcliffe and Williams, 2022).

This finding chimes with niche studies that explain how distinct purposes alter the conception of the niche and kinds of innovation promoted (Haarstad et al., 2022; Smith and Raven, 2012). When niche purpose opens up to institutionally transformative goals (compared to strategically managing the diffusion of a novel sociotechnical configuration) so experimental designs change, the knowledge production prioritised and disseminated shifts, intermediaries orchestrate activities differently, and the politics of expanding niche development is conceived and mobilised differently (Smith et al., 2016). The analysis of SLES suggests that allowing space for different approaches to social justice will diversify niche purposes and thus the transformative directions inclusive innovation can take (Feola, 2020; Newell and Simms, 2021).

Such diversity can be of instrumental benefit to those less inclined to exploring different social justice arguments. If liberal-individualist attempts to help households along adoption curves begin to stall amidst indifferent and apathetic consumers, for example, or the social licence for automation loses legitimacy amongst suspicious households, then other ideas and lessons for inclusive SLES remain available. But they only become available if their generative social-collectivist commitments to justice are recognised more symmetrically and given material support to develop. Experimentation and debate across liberal-individualist and social-collectivist approaches to inclusion will, arguably, enrich the diversity that gives niches their transformative potential.

5.3. Cultivating new collective actors

As well as including existing actors excluded from innovation, it is important to notice the formation of new collective actors through inclusive innovation. Higher-level inclusive innovations amongst community energy groups are trying to transform households into energy citizens. Surveys of households included in more conventional SLES demonstrations indicate openness towards these kinds of collective approaches. In pursuing them, the data cooperative, the community flexibility trust, and the neighbourhood electricity exchange emerge as new collective actors seeking a different kind of SLES.

This finding will be familiar to ethnographic research into citizen participation (Kelty, 2019; Melville et al., 2017; Pateman, 1970; Smith and Prieto Martín, 2020). Studies find participants forging new collectives through the experience of participating together, often in ways unanticipated by those orchestrating the participation exercise. The new collectives bring new interests, agendas and ideas into niche developments (Kelty, 2019; Seyfang and Smith, 2007; Smith et al., 2017).

In the SLES case, cultivating new kinds of collective actor is neither an explicit goal for demonstrations nor for smart energy. Of course, it can be argued that turning households into smart energy consumers means cultivating a new collective actor. But this is really about aggregating behaviour change more than recognising and cultivating an autonomous collective actor. Failure to do so widely enough will lead to poor implementation of the market-configured SLES (Ransan-Cooper et al., 2020; Strengers, 2014): either due to 'indifferent consumers' failing to adopt (Goulden et al., 2018), or because circumstances exclude too many households (Powells and Fell, 2019). Demonstrations tend to essentialise households into utility-maximising actors for inclusion in SLES markets. Overlooked is the possibility that different collective subjectivities can arise through inclusion in demonstrations, with households acting as autonomous, knowledgeable and capable subjects with diverse interests and aspirations in a different kind of SLES. Public opinion surveys in the UK reveal, for example, a consistent majority in favour of restoring public ownership in energy, but there are no serious

and detailed programmes proposing social-collectivist reforms amongst the major political parties contending for government.[13] Broader-based economic justice organisations like We Own It and Common Wealth are turning their campaigning towards the inequities of the energy crisis (Mckinley et al., 2020; Trades Union Congress, 2022). These collective actors might yet force structural changes favourable to social-collective approaches in future SLES developments.

Other collective actors are emerging in relation to just transitions more broadly that may eventually enter influentially into the SLES niche space. Currently, for example, no demonstration seriously considers ecological issues in digitalisation, such as mining materials for batteries and devices, and the social conflicts and inequities for communities in mining and processing regions, nor the accelerating upgrades, maintenance demands and electronic waste involved in smart systems and digital infrastructures (International Energy Agency, 2021; Lee et al., 2020; Marín and Goya, 2021; Pohl et al., 2021). Collective actors in the Right to Repair movement and anti-extractivism might generate social pressures that could eventually intrude into SLES.[14] SLES demonstrations may eventually need to anticipate practices for remanufacture, repair and extended durability that are absent currently. Of course, anticipating the eventual influence of future collective actors is speculative. But it nevertheless underscores how struggles for social justice can draw in collective subjects whose dynamic formations bring new pressures into just transition pathways.

6. Conclusions

We began by this paper asking how inclusive innovation research can help in the practical realisation of just transitions for sustainability. A ladder heuristic provided a helpful starting point for analysis. Whilst most inclusive innovation activity in SLES demonstrations operate at lower-levels (inclusion of intent and consumption), the ladder draws attention to activity and absences at higher-levels (procedural, structural and post-structural inclusion). Higher-level inclusion opens space for reframing transitions by widening who gets to be included, how they are included, and why. Higher-level possibilities widen the focus from participation in technical projects and towards experiments in more inclusive ownership and governance arrangements that anticipate economic and political change.

The prevalence of liberal-individualist conceptions in SLES justice currently and the way it eclipses social-collectivist conceptions in the niche space, attenuates the transformative power of inclusive innovation. However, the SLES case indicates that making inclusive innovation more transformational is more complex and challenging than ascending a simple ladder heuristic. Different kinds of inclusion co-exist across different demonstrations, and in some instances are interdependent upon one another. These complicated relations are given extra dynamism whenever inclusion helps cultivate new collective actors, who bring additional demands based in their experiences with the transition. In the SLES case, inclusion understandably focuses upon bringing existing actors into innovation activities. Social learning might be expanded fruitfully by becoming attentive to new and emerging collective actors also.

Finally, perhaps the aim we started with in this paper actually needs to be reversed? We wished to explore how inclusive innovation research might contribute to just transitions agendas. Ultimately, however, it is differences in normative commitments to social justice that help drive inclusive innovation into higher and transformative forms. Just transitions are an opportunity to critically challenge and progressively reshape whose innovations have influence in sustainable transition agendas.

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

The authors do not have permission to share data.

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[13] The Labour Party committed in September 2022 to establish a publicly-owned national electricity generation corporation.

[14] Implicated in this are a host of socio-ecological relationships with non-human actors, which raises questions of ecological justice, the rights of nature and how different species and ecologies can be included in (transformative) innovation.

Annex A

Annex A
Example SLES demonstration projects.

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
Local Energy Market	1. Centrica (lead); 2. Western Power Distribution; 3. National Grid ESO; 4. N-SIDE; 5. Imperial College; 6. University of Exeter	Cornwall	A local energy marketplace tool was developed and tested that allowed network operators to buy flexibility services (including frequency management) from households and small businesses. The latter were given smart meters, solar PV and batteries in order to sell flexibility into the market, and the tool helped aggregate these offers into a valuable service useful to network operators. A hundred households were recruited, and whose demand and local generation were operated by Centrica as a Virtual Power Plant.	Recruiting households who were already interested in energy issues and had the motivation to participate. Those without PV or batteries were given the technologies as part of the trial. However, the trial focused on proving the technicalities of VPP from a provider viewpoint. Householder surveys provided information of awareness, motivations and views towards flexibility, experience using the smart technologies, and impact of the trial on energy behaviours. More open questions revealed interest amongst households in community benefits and possibilities for other kinds of household to benefit.	Trial recruits were self-selecting and no explicit attempt was made to recruit marginalised or disadvantaged households. Majority of households were higher income. Even amongst those participating, inclusion is framed and serves developer concerns and the trial is designed on that basis.	Level 2: Inclusion of Consumption. Participants benefitted from savings in energy bills and optimised use of own rewables and battery.	Liberal-individualist
Project LEO	1.Southern Electric Power Distribution (lead); 2. EDF Energy; 3. Nuvve; 4. Open Utility; 5. Oxford Brookes University; 6. Oxford City Council; 7. Oxfordshire County Council 8. The Low Carbon Hub; 9. The University of Oxford	Oxfordshire	Project LEO aims to understand how new technologies and services, particularly at the 'edge' of the network - closest to the point where people are using energy - can benefit local people, communities and energy systems. Project LEO comprises three main elements: 1. Testing new market and flexibility models - Exploring products and services resulting from energy generation, storage and use across households,	Project LEO is based on the hypothesis that the community renewables path, with a decentralised, local energy approach, focused on balancing energy use, will be the most desirable pathway to accelarating the transition to a zero carbon energy because of the following reasons: 1) It minimises the need to massively strengthen the network infrastructure 2) Offers the potential for a more diverse range of solutions 3) It is more likely to	Both Low Carbon Hub and Project LEO highlight that those in fuel poverty, who could potentially gain the most from energy efficiency and flexibility, lack the means to access them: money, building ownership, grant filling requirements, etc. Since they are not included in these schemes, they end up up paying the most for energy.	Level 2 and 4: Inclusion of Consumption and Process. Project Leo is seeking to adapt novel energy services (flexibility) with evidence of use by marginalised groups (through the Rose Hill project)	Liberal-individualist and social-collectivist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
			businesses and communities. 2. Advancing the capabilities of networks to manage smart, renewable and storage technologies - Understanding how electricity networks needs to change to make them ready for a SLES system. 3. Facilitating local participation in the energy system - Making sure that individuals, households and organisations are part of the energy transition.	result in improved energy equity. Project LEO is trying to implement the following principles for 'ethical trial delivery': 1) Clarity of scope; 2) Collaborative design: 3) Inclusive Participation; 4) Do no harm; 5) Rewarding Experience; 6) Informed Consent; 7) Respect; 8) Continuous Improvement			
Energy Superhub Oxford (ESO)	1. Pivot Power (EDF Renewables); 2. Habitat Energy; 3. Invinity Energy Systems; 4. Kensa Contracting; 5. Oxford City Council; 6. University of Oxford	Oxfordshire	Energy Superhub Oxford (ESO) provides a blueprint for towns and cities globally to accelerate net zero, reducing emissions and improving public health by accelerating a switch to electric vehicles and decarbonising heat in homes and buildings. ESO aims at combining a number of technologies and integrates these to deliver more efficient and cheaper energy solutions. The key innovations include: 1. Electric Vehicle Charging - Plans to install 38 charge points, including a combination of Ultra-rapid DC chargers and Fast AC Chargers catering for a range of vehicles. 2. Battery Energy Storage - ESO will install a transmission - connected battery at National Grid's Cowley Station.	Nothing much on inclusion/equity on the webpage. Certain spaces for inclusion in each technology in the following bullet points: 1) Electic Vehicle Supercharging: This technology will electrify 37 council vehicles including tipper trucks and refuse collection vehicles. It will also assess the opportunities for phased migration of the public bus fleet to zero emissions. 2) With the ground source heat pumps, it is estimated that consumers will benefit from clean, renewable heat savings of up to 25% compated to standard ground source heating system. It is also mentioned that they will use the Octopus Energy's Agile tariff, providing 48 half-hourly price points each day.	Some of the features of Energy Superhub Oxford are aimed at individual houhseholds who own a car. At the same time, only two electric taxies were offered for cab drivers under the "Tr-B4-U-Buy" scheme. On the other hand, the project will provide 300 participating households with a ground source heat pump. However, there is no mention of the economic standing of these households.	Level 1: Inclusion of Intention. Energy Superhub Oxford claims to respond to the needs of marginalised groups, but there is no evidence of the involvement of these groups.	Liberal-individualist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
			The battery consists of 50 MW of lithium-ion and 2MW of vanadium flow. 3. Ground Source Heating - 60 domestic heat pumpts will work with shared ground arrays, drilled to a depth of 120 meters and will use new shoebox heat pumps, which can be discretely installed in individual properties. 4. Optimisation and Trading Engine - This technology will use machine learning to estimate demand for power acrosss the EV network. It will also gather real-time energy data from the energy markets and use this to trade energy to and from the battery.				
ReFLEX Orkney	1. European Marine Energy Centre (EMEC) (lead); 2. Aquatera; 3. SMS; 4. Community Energy Scotland; 5. Herriot-Watt University; 6. Orkney Islands Council	Orkney Islands	The ReFLEX project aims to build an Integrated Energy System (IES) to coordinate and combine multiple energy assets across electricity, transport and heat. To integrate separate elements of the system, the Flexigrid will act as the control platform that will automate decision making within the system.The project tries to emphasise the potential benefits of flexibility using technologies like battery storage, electric vehicles, smart chargers and smart meters. The ReFLEX project aims to offer these technologies to local households and businesses through leases and other financing.	As in the case of Oxford Energy Superhub, there is not much information on inclusion and equity dimensions. However, there are some elements that can be deduced from the ReFLEX documents and technologies: 1) In terms of heating, they aim to provide access to affordable low-carbon energy services. They do this by showing the range of grants/ loans available for landlords. 2) ReFLEX is not offering a funded domestic solar and battery solution to homeowners and the private rental market. However, they offer information on grid connection processes and free	ReFLEX Orkney is aiming for homeowners and for those individuals/ communities that are able to drive. In this way, ReFLEX might be excluding some of the most vulnerable households.	Level 1, 2 and 4: Inclusion of Intention, Consumption and Process. ReFLX Orkney claims to respond to the needs of marginalised groups, but there is no evidence of the involvement of these groups.	Liberal-individualist and social-collectivist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
				loan interests. 3) ReFLEX offered a one year 100% renewable tariff. However, the fixed rate is coming to an end in a context of the energy crisis. 4) ReFLEX is investing in a car club to provide affordable and low-carbon transport around Oarkney. This scheme was created in collaboration with Co Wheels Car Club. 5) ReFLEX can install smart chargers and help Orkney residents apply for grants to cover some of the cost. However, as of 2022, Energy Savings Trust is not accepting any new applications for grants.			
CommUNITY	1. Repowering; 2. Électricité de France; 3.UCL Energy Institute	London	Lambeth Community Solar is a Community Benefit Society, which is a type of co-op. Repowering's model ensures that financial returns are locked into Lambeth and delivered back to the community, thereby delivering a socially responsible energy project. The model aims to provide more than low-carbon energy, and tries to deliver a programme incorporating social, financial and educational opportunities. More specifically, CommUNITY aims to demonstrate a way of residents in a block of flats being able to buy benefit directly from a rooftop solar installation on a block of flats.	In the CommUNITY+ project residents are given a portion of the energy generated by the solar panels on the rooftop of the building where they live and stored in a community-owned battery in the building. The local community can share or sell their unused solar energy to their local community. This is also known as peer-to-peer exchange.	There are two potential limitations to inclusion: 1) The fact that Repowering was working with an existing big six supplier affected the residents' perception of the project, as the requirement was that participants would be customers of EDF. 2) By using an opt-in model, Repowering might be excluding those households that do not have time nor interest in participating.	Level 2 and 4: Inclusion of Consumption and Process. This is an innovation in which the marginalised groups participate and influence developments (through peer-to-peer trading).	Social-collectivist
	1. Scottish and Southern Energy	Hampshire	Explored with local community-based	Inclusion is all about cultivating the	Local organisations need to be able to	Level 1: Inclusion of Intention.	Liberal-individualist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
Social Constraint Management Zone	Networks (lead); 2. National Energy Action		organisations (interested in energy advice and sustainability) methods to identify and sell flexibility services to the Distribution Network Operator in Constraint Management Zones. Community groups, residents associations, local authorities, local businesses bidding for flexibility contracts where network capacity is reaching a limit, using an adapted process identifying and procuring industrial flexibility in other CMZs. Two trial areas were provided with seed funding and technical support. Lessons were: improved transparency; technical support; manage expectations on project financing; improve project matchmaking process.	ability to offer and bid flexibility services. Local organisations are provided with information and seed funding to develop a proposal that met DNO criteria. Promising proposals were invited to tender using industry procurement systems. Participants needed time to learn how to fit in. Stakeholder engagement focused on matching partners to develop projects. Inclusion set by the network operator, including how flexibility is commoditised and rewarded. Unclear if any projects ultimately traded flexibility.	convene and aggregate enough flexibility from households and community organisations. Need the skills and capacity to meet and follow the technical, tendering and procurement criteria of the distribution network operator.	Information and engagement activities provided, but community organisation had to meet inflexible project criteria of network operator. Little attempt to change processes.	
Energy Community Aggregator Service	1. Carbon Coop; 2. Regen; 3. Megni Open Energy Monitor	Manchester	A feasibility study analysing community-based aggregation using the UK smart metering system, commodity hardware, common open standards and open-source software. Follow-up work looks at trading and sharing flexibility benefits amongst households via membership of an intermediary energy cooperative. The co-op will aggregate the portfolio of domestic distributed energy assets and agree with members how to optimize and	Co-op members are owner occupiers and already invested in sustainable energy practices. They can participate in a demonstration of an aggregation service and share in the benefits. The community aggregation service also helps the community organisation explore future economic models for its sustainable energy activities.	Households need to be able to join the co-op and have the necessary energy assets.	Level 2 and 5: Inclusion of Consumption and Structure. Co-op members benefit with reduced bills associated with the flexibility service they provide to the community energy aggregator. Conceiving aggregation benefits as a collective organization arrangement under common ownership of members challenges prevailing market structures.	Social-collectivist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
			distribute benefits (and risks). The demonstration produced knowledge regarding load shifting, economic models, technical organisation and open software/ hardware approaches consistent with co-operative ethos.				
Smart and Fair?	1. Centre for Sustainable Energy; 2. Scottish and Southern Energy; 3. Western Power Networks	National	Not a demonstration project per se, but rather a methodology co-developed with the energy industry to measure the inclusivity of smart energy products and services. A Capability Lens framework appraises the circumstances, skills, technologies, finance, social capital, and digital readiness needed to access different kinds of smart energy. Smart Offer Profiles tune these to different smart energy products and services, and data about household characteristics is used to build up a Consumer Classification Model that estimates how many homes can access those services in principle. Data is patchy and work is in progress, but the effort of developing these measures has already advanced dialogue about social inclusion in SLES.	This is a diagnostic tool and tool for dialogue with developers of smart energy products and services. Poor and marginalised households are not included directly, rather as much data about them as can be gathered is included in the appraisal. Smart and Fair has been adapted by some SLES demonstrations, such as Project LEO, to help them develop the design of community outreach initiatives.	The Smart and Fair methodology assumes inclusion will arise through policies that assist the market-based movement of more households along technology adoption curves. It is recognized that earlier adopter groups will not be as inclusive as later adopting groups. Those excluded by adopting an adoption curve approach will be targeted with statutory minimum service standards.	Level 1: inclusion of Intention. Smart and Fair generates information and awareness about exclusions from SLES, and intends to inform developer deliberations about how to be more inclusive.	Liberal-individualist
Energy Local Clubs	1. Energy Local; 2. Partner energy supplier, such as Octopus	Communities in Wales, South-West and North-West England, and London.	Each Energy Local Club is a cooperative constituted by households equipped with the software and demand flexibility	Each cooperative makes use of the tools, system and model know-how developed by the Energy Local community energy enterprise. Members	Membership requires a household to have the assets and capabilities to offer flexibility and participate in smart electricity.	Level 4: Inclusion of Process. In forming a consumer co-operative households have a degree of bargaining power	Social-collectivist

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Annex A (*continued*)

Project	Stakeholder	Location	Description	Approach to inclusion	Potential exclusions	Ladder of inclusion	Justice
			to maximise the use of local renewable electricity generation. They agree a 'match' tariff with local generators, to pay for electricity when their demand matches local generation; and they are charged at higher market rates at times when demand is in excess. A participating supplier (e.g. Octopus Energy) bills them for this differentiated electricity consumption. The cooperative commits to matching demand to generation as much as possible (e.g. 'turning their washing machine on when they know the local Hydro scheme is working at full pelt') thereby keeping as much revenue in the local economy as possible.	get cheaper electricity when consumption is 'matched' and local generators get a price better than wholesale market rates. Cooperative members decide how the Club is run and negotiate match tariffs with suppliers and local generators – something made feasible by the collective approach.		by pooling flexibility and offering local generators better-than-wholesale prices. However, whilst ownership of flexibility is shared, the model remains dependent on licensed electricity suppliers.	

Annex B

Annex B
SLES documents analysed.

Author	Title	Date
Association for Decentralised Energy	Let's Talk About Flex: Unlocking Domestic Energy Flexibility	2020
Carbon Co-Op/Regen	Local Flexibility Markets: What Are They and How Can Community Energy Organisations Get Involved?	2020
Centre for Sustainable Energy	Smart and Fair? Exploring Social Justice in the Future Energy System	2020
Centrica	Cornwall Local Energy Market	2019
Citizens Advice	Future for All: Making a Future Retail Energy Market Work for Everyone	2019
Citizens Advice	Clear and In Control: Energy Consumers' Views on Data Sharing and Smart Devices	2019
Department for Business, Energy and Industrial Strategy	Digitalising Our Energy System for Net Zero: Strategy and Action Plan	2021
Department for Business, Energy and Industrial Strategy	Transitioning to Net Zero: Smart Systems and Flexibility Plan	2021
EDF Energy	Powering Flexibility	2021
Energy Digitalisation Taskforce	Delivering a Digitalised Energy System	2022
Energy Networks Association	Electricity Network Innovation Strategy	2020
EnergyREV	Skills for Smart Local Energy Systems	2022
EnergyREV	Building and unlocking flexibility with smart local energy systems	2022
EnergyREV	Incorporating novel renewable energy cooperatives to scale-up smart local energy systems for UK's net zero future	2022

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Annex B (*continued*)

Author	Title	Date
Energy Systems Catapult	Fuel Poverty in a Smart Energy World	2021
Energy Systems Catapult	How can innovation deliver a smart energy system that works for low income and vulnerable consumers?	2021
Energy Systems Catapult	Home Truths Panel Survey: Evaluating Common Themes in Smart Local Energy Systems	2019
Green Alliance	A Manifesto for Community Energy	2019
HM Government	Powering Our Net Zero Future	2020
UKRI Industrial Strategy	Prospering from the Future Energy Revolution	2019
National Energy Action	Maximising the smart meter rollout for prepayment customers	2021
National Energy Action	Critical Factors for the Adoption of Smart Homes for Energy Efficiency: Implications for Consumers and Providers	2022
Ofgem	Vulnerable Consumers in the Energy Market	2019
Ofgem	Energy Regulation Sandbox: An Introduction for Innovators	2020
Ofgem	Consumer Protection Report	2021
OVO Energy	Flexibility First: How the UK's Network Companies Can Facilitate Clean, Affordable Energy for All	2018
Parliamentary Office of Science & Technology	Energy Sector Digitalisation	2021
Project LEO	Developing an Ethical Framework for Local Energy Approaches	2020
Regen	Power to Participate: A specification for community energy to participate in a flexible energy system	2019
SSE Enterprise	Connectivity and the Digital Future of Energy	2021
UK Power Networks	Flexibility Roadmap	2018
Western Power Distribution	New Innovation Projects: Communities and the Smart Energy Revolution	2020

Annex C

Annex C
in-depth interviewees.

Code	Interviewee	Organisation description	Actor type	Date of interview	Duration
EXPINT_1	Founder	Regional community energy co-operative	Community energy	16/02/2021	62:00
EXPINT_2	Leading national digitalisation strategy	Energy data and digitalisation public body	Energy digitalisation	23/02/2021	60:00
EXPINT_3	Technical advisor	Energy advice and advocacy	Household energy	24/02/2021	58:00
EXPINT_4	Researcher	National community energy association	Community energy	05/03/2021	61:00
EXPINT_5	Energy affairs	Statutory consumer affairs organisation	Consumer rights	08/03/2021	60:00
EXPINT_6	Flexibility markets specialist	Member organisation specialising in distributed energy	Energy industry association	09/03/2021	62:00
EXPINT_7	New markets specialist	National energy regulator	Regulator	10/03/2021	59:00
EXPINT_8	Technical Director	Community energy organisation working in smart energy projects	Community energy	26/03/2021	43:59
EXPINT_9	Head of future networks	Distribution Network Operator	Distribution Network Operator	02/04/2021	60:01
EXPINT_10	Technical Director	Sustainable energy consultancy specialising in digitalisation	Energy consultancy	06/05/2021	59:00
EXPINT_11	Head of innovation	Energy data and digital services company	Energy digitalisation	18/06/2021	41:00
EXPINT_12	Social inclusion specialist	Energy data and digitalisation public body	Energy digitalisation	24/06/2021	1:07:51
EXPINT_13	Smart trials coordinator	Community engagement services	Energy consultancy	08/07/2021	28:05
EXPINT_14	Director	National sustainable energy charity	Advocacy organisation	14/07/2021	1:07:52
EXPINT_15	Engineer	Community energy organisation working in smart energy projects	Community energy	15/07/2021	1:02:25
EXPINT_16	Smart energy specialist	Smart energy department at in energy ministry	Government department	20/07/2021	36:31
EXPINT_17	Head of innovation	Association of distribution network operators	Energy industry association	29/07/2021	56:56
EXPINT_18	Programme director	Digital inclusion charity	Consumer rights organisation	19/11/2021	43:20
EXPINT_19	Researcher	Energy research centre participating in SLES demonstration project	Academic	7/11/2021	56:37
EXPINT_20	Head of social impact	Community energy hub	Community energy	4/3/2022	58:00
MLB01	Project manager	Regional public body promoting local energy systems	Energy digitalisation	14/04/2021	58:21
MLB02	Sustainable energy officer	Local authority running inclusive solar PV programme	Local authority	26/04/2021	1:04:21
MLB03	Project manager	Regional public body promoting local energy systems	Energy digitalisation	09/06/2021	57:34
MLB04	Housing officer	Local authority running smart energy programme for social housing	Local authority	29/06/2021	58:43

Annex D

Annex D

Summary of household interviews completed for this study (N=24).

Respondent No.	Demographic details	Housing/Tenure type
Whitehawk_01	Female	Council Housing
Whitehawk_02	Female, children at home	Council Housing
Coldean_03	Female	Homeowner
Coldean_04	Male	Homeowner
Coldean_05	Male, elderly/retired	Homeowner
Hove_06	Female	Homeowner
Hove_07	Female	Homeowner
Hove_08	Male	Homeowner
Bevendean_09	Male	Homeowner
Bevendean_10	Female	Homeowner
Coldean_11	Male, young, single	Renting in PRS / from landlord
Coldean_12	Male, young, single	N/A
Whitehawk_13	Male, elderly, widower	N/A
Whitehawk_14	Female, elderly/retired, married but no children at home	Council Housing
Bevendean_15	Female, elderly/retired, married but no children at home	Council Housing
Whitehawk_16	Male, middle age, children at home	N/A
Hangleton&Knoll_17	Female, elderly/retired, married but no children at home	Homeowner
Whitehawk_18	Male, middle age, children at home	Council Housing
Bevendean_19	Female, young, single	N/A
Coldean_20	Female, middle age, children at home	Homeowner
Hangleton&Knoll_21	Male, middle age, children at home	Homeowner
Hangleton&Knoll_22	Male, elderly/retired, children left home	Homeowner
Hangleton&Knoll_23	Male, elderly/retired, children left home	Homeowner
Hangleton&Knoll_24	Male, elderly/retired, remarried widower	N/A

Source: Authors.

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