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Spaces, forms, and levels engagement: Using the Powercube to explore social inclusion in digital energy and mobility systems

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ABSTRACT

Energy and mobility transitions are often coupled with digital innovations to meet decarbonisation goals. Enthusiasm for digitalisation arises from the belief that such technologies can democratize energy and mobility supply and use, empower homeowners and communities, maximise efficiencies, and generally improve quality of life. However, realising these benefits depends upon effective inclusion, strong governance, and clear conceptions of shared responsibilities and accountability. These features can be limited in practice. This study examines social inclusion in digital energy and mobility systems through a power lens, and based on extensive, original, mixed-methods data across three comparative case studies: smart and local energy systems in Brighton (UK); smart meter-enabled energy communities in Trento (Italy); and digitalisation of urban mobility systems in Bergen (Norway). Through Gaventa's "Powercube" approach, a combined analytical and co-productive tool, the study interrogates claims of equity, justice, and improved social outcomes. It examines the state of, and potential for, inclusion in digitalised energy systems. Methodologically, the paper presents insights into the Powercube method – currently underexplored in energy and mobility transition scholarship – by analysing its strengths and weaknesses in studying these contexts. Empirically, the paper discusses the potential of digitalisation to increase energy and mobility system inclusion, and what this means for energy and social outcomes. Findings highlight that, pursued in their current forms, digitalisation of energy and mobility systems is exacerbating existing inequalities, entrenching exclusive decision practices, and creating new closed off spaces as public energy data is moved into private ownership.

1. Introduction

National energy and transportation plans increasingly integrate digital technologies to meet decarbonisation goals (Rozite and Kamiya, 2022). Digital energy and mobility systems are interconnected and automated systems enabled through digital technologies. They include smart meters, ICT-integrated transportation and electricity demand services, automated building management, home energy management systems, smart homes and more. Digitalisation has fundamentally transformed innovation (Nambisan et al., 2019) and such systems are anticipated to enable flexibility, allow optimisation of intermittent renewable energy resources and integrate new decentralised generation and storage resources (Adams et al., 2021; Rommetveit et al., 2021). By disrupting incumbent systems, digital technologies have potential to "break path-dependent behavior and escape lock-ins," (Bohnsack et al., 2021), and specifically in energy and transport systems, digitalisation

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can integrate new energy owners and decision-makers through the shift from consumers to 'prosumers', and enable increased comfort and liveability in an open and inclusive manner (Fell, 2020; Knox et al., 2022; Sareen et al., 2023; Smith et al., 2023).

Enthusiasm, and even hype, about the potential of digitalisation comes from many quarters. Aronoff et al.'s (2019) book examining the potential of an American Green New Deal shows how it presents a utopian vision of a radically just and inclusive society where energy systems are fully and transparently digitised. Italian energy experts assume energy digitalisation will produce an 'automated virtuous pattern of consumption and production' (Gantioler et al., 2023). A UK Power Networks (2021:12) Strategy and Action Plan on Energy Digitalisation states that "…data and digitalisation will be fundamental to help and encourage consumers to participate and prosper from the transition to net zero by enabling more tailored services, including for those who are low income or vulnerable". The Norwegian National Transport Plan (Norwegian Ministry of Transport, 2021:55) envisions that transport sector digitalisation will "make every day travel easier, increase competitiveness for businesses, provide more value for money […]and help reduce greenhouse gas emissions and negative environmental impact from the sector". The potential to provide benefits to energy users is a common anticipated feature of energy digitalisation by governments and authorities. Indeed, developers recognise that high user participation rates are critical to the success of new systems (Roberts et al., 2020; Smith et al., 2023).

However, these positive outcomes are not assured. As emerging evidence indicates, digitalisation can be pursued in a manner that reproduces or exacerbates unequal patterns of resource distribution, elite-level decision-making, and power relations (Fell, 2020; Furszyfer Del Rio et al., 2023; Knox et al., 2022; Sareen et al., 2023; Smith et al., 2023). Other academic communities recognise these issues in, for example, smart cities (e.g. Malek et al., 2021; Wiig, 2016), and there is caution that digitalisation needs to be pursued carefully to ensure data safeguards (e.g. European Commission, 2022). This tension between possible positive and negative outcomes of energy digitalisation reflects broader societal tensions over who is included in shaping and benefiting from discussions about new technology and democracy (Stirling, 2014).

Inclusion represents both a process and an outcome in that it involves ongoing, meaningful engagement in decision-making and its associated benefits and responsibilities (Nwachi, 2021; Quick and Feldman, 2011). This is more specific than general energy participation which, depending on the academic field, can be conceptualised as constituting broad engagements with physical or holistic energy systems including, and beyond formal decision processes (e.g., Chilvers et al., 2018; Ryghaug et al., 2018), or more limited public input into programs or policies (e.g., Quick and Feldman, 2011). Regardless of disciplinary differences, there are increasing questions about the extent to which digital energy systems are actually inclusive and provide advantages that move beyond the narrower economic benefits that are characteristic of systems where citizens are conceptualised as simply 'consumers' (Heeks et al., 2014; Smith et al., 2023; Soutar et al., 2022).

The key questions that define inclusion concern who makes energy decisions, how, and who benefits. These are also questions of political and social power. As energy digitalisation progresses, and opportunities for, and claims of, inclusion become more prominent, theories on power offer helpful ideas and frameworks. This paper contributes, mainly methodologically but also empirically, by using Gaventa's (2006) "Powercube" approach to interrogate claims of inclusion and benefits in energy and mobility digital pathways. The Powercube approach provides a method for introducing complex questions of power in energy digitalisation into workshops held with various stakeholders involved in digitalisation initiatives. Exploring power with participants enabled the development of research findings. In the process, empirical settings were an opportunity to build research participant capacities to secure greater levels of inclusion in energy digitalisation, and move beyond perspectives that limit inclusion to the narrow consumer form only. We provide new insights into the Powercube method – currently underexplored in energy and mobility transition scholarship – by analysing its strengths and weaknesses in examining energy digitalisation. We also develop policy-relevant insights for ongoing transitions to smart local energy systems (SLES), smart meter enabled community energy, and urban mobility transitions.

The next section provides insights on energy system digitalisation, inclusion and power. We then outline methods, empirical context, and the technological focus for our three cases: smart and local energy systems (SLES) in Brighton (UK); smart meter-enabled energy communities in Trento (Italy); and, digitalisation of urban mobility systems in Bergen (Norway). We describe how the Powercube approach was adopted and adapted in each. The results section describes outcomes for each case and analyses prospects for inclusion across the Powercube vectors and digital technology applications. We then discuss our co-produced findings about power in the context of rhetoric regarding the potential of digitalisation to increase energy system inclusion, what this means for energy and social outcomes, and the utility of the Powercube in studying digitalisation and transition processes. We conclude with thoughts for research and policy.

2. Background and context

This section introduces issues that shape possibilities for inclusion in energy digitalisation, defines inclusion, and presents the Powercube framework. As digitalisation creates possibilities for different forms of inclusion in energy systems, and as social inequalities widen, there is both an opportunity and a need to revise the centralised logics that characterise traditional energy systems (Brisbois, 2020a). Until recently, citizens have largely participated in energy system decision-making as voters who indirectly shape energy system policy and regulation, and as consumers whose preferences are considered. Digitalisation, and concurrent trends toward decentralised energy resources, hold potential to shift roles from participation as consumers in the outcomes of energy systems, to deeper inclusion as decision-makers that shape energy systems (Brisbois, 2022, 2020a; Sareen and Haarstad, 2021; Smith et al., 2023).

2.1. The potential of digitalized energy systems

Emerging digitalised systems have the potential to deliver energy equity and benefits to the local community by engaging actors in new ways through the local provision of energy systems and services (Ford et al., 2021; Ryghaug et al., 2018). However, digital energy systems are not inherently just and inclusive. As with any other technology, their use and outcomes are shaped by the ways that they are designed, and by social interpretations of that technology (Geels, 2011). Research into inclusion in these systems has – so far – focused on the experiences of individuals. For example, Angel (2023) found that most participants in a UK Demand Side Response trial were male. Participants in renewable energy communities also tend to be white, male, and upper middle-class (Creamer et al., 2018; Łapniewska, 2019). Consistent with trends concerning the gendered burdens of innovation identified by Cowan (1983), working-class women will likely bear the additional labour of manually orchestrating digitalised energy activities (Johnson, 2020). There is already evidence that digital technologies can increase conflict within households over different energy activities, preferences, and values (Sovacool et al., 2020).

Energy digitalisation does have empirical or prospective system-wide benefits that can make systems more efficient, and there is broad consensus that future renewable energy systems need to be digitalised (Torriti, 2024). Provided that pricing schemes are designed appropriately, this should eventually lead to lower costs for all consumers (Khan et al., 2023). However, there is increasing evidence that the benefits of digitally-enabled energy flexibility are more likely to accrue to the already privileged, often at the expense of those less well off, as these households are better able to access the technology and resources that enable demand flexibility (Powells and Fell, 2019).

For example, time-of-use pricing schemes are more likely to benefit those who are in a position to shift demand, who have greater appetite for the risk involved in adopting new practices and technologies, and who have digital competencies – all conditions which those at greatest risk of energy poverty struggle to meet (Calver and Simcock, 2021). Emerging forms of prosumership, local electricity systems, and smart, local energy systems tend to benefit system operators and incumbents more than community energy groups, new entrants, or householders themselves (Iskandarova et al., 2022; Smith et al., 2023). Digitalisation of public transport provision may also create inequalities, for example between those who can take advantage of cheaper tickets in digitalised transportation ticketing and those who cannot (Durand et al., 2023). There are further potential equity issues around participant composition and household roles (Wågström and Michael, 2023).

2.2. Defining inclusion in energy systems

Broader questions of inclusion in digital energy systems, characterised as the ways that energy decisions are made, responsibility is assigned, and actions taken, remain under explored. Inclusion represents a specific form of deep and ongoing engagement that differs from general participation in energy systems and decisions. In practice, more inclusive practices are those that integrate different forms of knowledge and ways of knowing, co-produce both decision processes and outcomes, and represent sustained and ongoing interaction (Quick and Feldman, 2011). Inclusivity can thus be either a precursor to, or an outcome of, participation as it both creates the conditions that facilitate wider engagement, and it can be used to go deeper than more general participation (Nwachi, 2021).

Different fields have developed different frameworks and approaches to navigate between general ‘participation’, and deeper inclusion, although not always making the specific distinction between the two. Research on inclusive innovation describes a “ladder of inclusion”, building from Arnstein’s (1969) classic ‘ladder of participation’, with levels ranging from simply designing an innovation with the intention to benefit others, to inclusion in design, to participant control over design (Heeks et al., 2014). The ‘wheel of participation’ from resource governance and planning research identifies four overlapping types of participation including top-down communication and three other types that describe increasing levels of inclusion of affected and relevant actors (Reed et al., 2018).

More wide-ranging theories on participation in energy systems from sociotechnical studies (STS) provide less guidance on the degree to which practices are inclusive but are useful for mapping activities that extend beyond engagement in traditional decision-making structures (e.g., Chilvers et al., 2018). This is very helpful in the current context where there are calls for greater inclusion in an expanding range of energy activities than has previously been common (e.g., in electricity generation, local distribution). This broadening engagement with energy systems is conceptualised as ‘energy citizenship’, and the focus on inclusion in decision-making in energy systems represents an emerging focus on ‘energy democracy’ (Ryghaug et al., 2018).

Empirically, deep inclusion in energy systems tends to be limited by the top-down logics that dominate energy system decision-making. For example, examining smart, local energy systems (SLES) in the UK, Smith et al., 2023, find that SLES initiatives are pre-defined by private and policy actors, and conceptualise inclusion in terms of being included in the decentralised hosting of energy resources, and in financial benefits, but without any decision-making power or responsibility. This reflects a broader lack of discursive consistency over what “smart” systems represent with conflicting perspectives over who should own and control them (Wolsink, 2024).

However, benefits related to addressing societal wealth and power inequality are lost when possibilities for citizen inclusion as owners and decision-makers in community energy are limited (Devine-Wright, 2019). In Norway, the consequences of limited inclusion were revealed when actors who perceived themselves as excluded from mobility planning organised politically around deepening urban-rural divides (Remme et al., 2022).

While high levels of inclusion are normatively desirable, there are also strong instrumental arguments to broaden inclusion in decision-making around digitalised energy systems. Knox et al. (2022) argue that access to information and participation is key for fair digitalisation, as this can reduce tensions in communities and increase the perceived level of legitimacy. Including citizens as active decision-makers in digitalised, distributed energy systems is also necessary to ensure buy-in and compliance, and the integration of necessary local knowledge (Brisbois, 2020a). It is thus necessary to allow those affected by those systems to influence them (Soutar et al., 2022; Soutar and Mitchell, 2018).

2.3. Understanding inclusion through the Powercube framework

Inclusion is shaped by relationships of power and, in examining inclusion in digital energy systems, it is helpful to use a perspective that reveals where decisions are made, by whom, and who receives resulting benefits. These types of queries can be usefully examined using the concept of power as a lens to help explain who is included and how, in the framing and definition of technological choices, and their impacts. Power is a wider concept than inclusion. Its definition is contested and varies with interpretation and intent, but is often defined as the ability of one actor to make another do something that they would not otherwise do (Weber, 2009). While this definition implies coercion, other theorists (e.g. Ahrendt; Parsons) have expanded ideas about power to encompass the ability to collectively and consensually shape actions, decisions and outcomes to represent broader sets of interests and incorporate diverse values and views. These perspectives make clear that the exercise of power is always relational, rather than an entity or object that can be possessed and used with equal impact in all situations (Haugaard, 2002).

Lukes’ (2005) three dimensions of power are one possible framework for examining how power can be used to dominate others. Gaventa’s Powercube approach (2006) integrates Lukes’ (2005) domination-focused views on power with consideration of the different ways that non-powerful actors can be empowered to counter forms of coercion and address their interests. The Powercube thus provides a useful framework for examining restrictions on, and possibilities for, inclusion across different sites, scales and forms of power (Fig. 1). Sites where power operates include closed spaces where elites, or those disproportionately

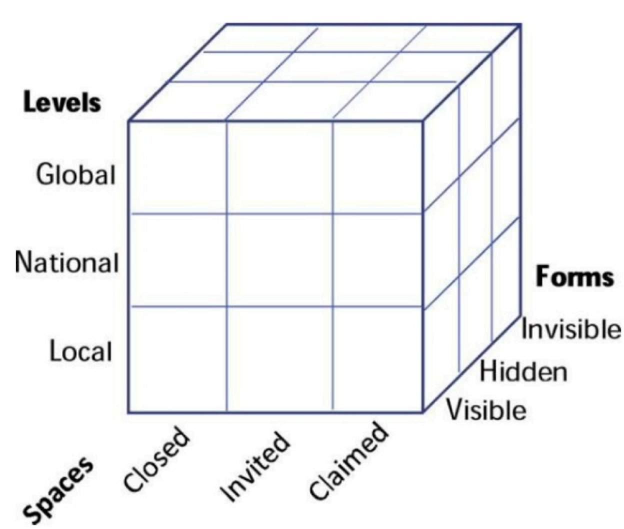

Fig. 1. The Powercube (Gaventa, 2006).

able to shape decisions and outcomes, make decisions behind closed doors, invited spaces where elites invite other actors to shape or give input on decisions, and claimed spaces where less powerful actors create or claim space outside of elite control. Scales are the local, national or global levels where different decisions and actions are taken. Forms of power can be visible, hidden or invisible. Visible power includes easily identified resources or capacities like financial resources or technical abilities. Hidden power relates to the ability to control the structures that shape decisions and includes abilities to frame problems and shape what is up for decision, and to decide who is included in decision-making. Invisible power is the ability to shape the ideas, values and norms of others, through the media and convincing narratives (Lukes, 2005).

By focusing on the sites and scales where actions and decisions are made, it is possible to analyse who is making choices relevant to digitalised energy systems, the types of decisions made, and the potential for broader inclusion in these. Examining different forms of power can offer insight into which actors are best able to participate in decisions due to their resources, capacities, structural position, and the ideas or narratives they can mobilise. Table 1 offers some more concrete examples of how different forms of power can shape inclusion.

Beyond its use as an analytical framework, the Powercube was designed as a co-productive tool, useful for helping participants better understand the relationships of domination affecting them, identify sites of agency, and target efforts for change, by looking for possibilities for movement, mobilisation and change (Gaventa, 2019). Initially developed for use with coal miners facing a declining industry in Appalachia in the USA (Gaventa, 1980), the Powercube has been used in very different contexts to co-produce knowledge with actors seeking emancipation in, for example, local villages in Tanzania (Rabé and Kamanzi, 2012), and the UK in the wake of the 2007 global economic crisis and a significant change in government (Hunjan and Keophilavong, 2010). However, its application in energy transition contexts, beyond its original use in Appalachia, is limited (Sovacool and Brisbois, 2019).

3. Case study descriptions, technology foci and research design

Our study makes use of qualitative case studies in three European mid-sized cities: Brighton (UK), Trento (Italy), and Bergen (Norway). The cities represent paradigmatic cases in our in-depth investigation of a defined phenomenon. Cases were selected to a) capture a diversity of energy digitalisation contexts; b) ensure examination of a range of policy mixes and institutions; and c) examine sites with ambitious digitalisation targets and energy policies, and where innovative projects are underway and relevant institutional structures are developing but not yet entrenched. Each examined inclusion in the context of a different digital energy innovation: smart and local energy systems (SLES) in Brighton; smart meter-enabled energy communities in Trento; and, digital mobility services in Bergen.

Data collected using different methods were used to inform Powercube workshop design in each case, and to triangulate workshop findings, where possible. This contextual data collection allowed the tailoring of approaches to each case and the exploitation of a broad range of information. Details on methods are summarised in Table 2 for each case, and are discussed in detail in case-specific sections. Initial data collection was not explicitly framed around the Powercube but focused on the broader themes of inclusion in digital energy systems that define our research questions. Data collection guides for all three cases are included in Appendix A. Researchers in Norway also used surveys to collect background data and these guides are included in Appendix B. These guides are not identical across cases as each team combined data collection for the Powercube workshops and analysis with questions on other digital energy inclusion-related research (e.g., Smith et al., 2023; Sovacool et al., 2022 for the Brighton case, others noted below). This pre-workshop data collection provided insight into how inclusion is, or is not, being operationalised, developed contextual information that was used to set workshop participant lists, shaped the local framing and focus of Powercube activities, and allowed the research team to triangulate claims made during Powercube workshops.

A Powercube approach was then adapted to local contexts to co-productively explore forms of power, levels and spaces relevant to inclusion. Background data collection revealed varying perceptions of our research themes across cases. In Italy, researchers decided that explicit use of the word “power” would deter participation in the Powercube workshop. Therefore, the Powercube approach was explicitly used for data collection in Brighton and Bergen; in Trento it was not used explicitly but instead the underlying concepts were used to frame the workshop in order to facilitate participant engagement. All data from all cases were analysed using the Powercube. Variation resulting from these differences in data collection are discussed in more detail below.

Table 1
Aspects of different power forms relevant for inclusion.

Dimensions	Aspects related to inclusion
Power	
Visible	- Visible differences in the technical, financial, human, etc. capacities and resources held by different actors that shape whether they are able to participate in taking actions and making decisions
Hidden	- Who is, and is not, making decisions about what the problem is, and what possible options for action are? - Who is included in making decisions about who makes decisions in the future, at what level, and in which spaces? - Who has the knowledge and networks to be able to participate on an equal footing in making relevant actions and decisions?
Invisible	- Who is able to shape worldviews, perspective, values, opinions and ideas?
Spaces	
Closed	- Decisions are made behind closed doors by elite actors (e.g., a government decision)
Invited	- Decisions are made by elite actors who invite select others to provide input into decisions (e.g., a government decision which is opened for consultation)
Claimed	- Non-elite actors find ways to have their voices heard in decisions (e.g., climate protestors forcing consideration of other choices), or create new spaces where they can make their own decisions (e.g., within a renewable energy cooperative)
Levels	
Global	- International or translocal levels including formal bodies (e.g. the UN, IPCC) and informal arenas (e.g., social media)
National	- State or country level
Local	- Formal and informal local institutions and arenas

3.1. Case study – Brighton

3.1.1. Case description

Brighton & Hove is a city on the South coast of England (275,000

Table 2
Data collection methods by case study.

Case study	Data collection method
UK	• Desk-based research of SLES projects (2021) • Observations at SLES industry events (2021) • Semi-structured expert and citizen interviews focused on inclusion in SLES (2021) • Powercube workshop with local stakeholders (November 2022)
Italy	• Semi-structured expert and citizen interviews focused on inclusion and justice related to smart meters and community energy (2021) • Non-explicit Powercube workshop with local stakeholders (October 2022)
Norway	• Desk-based review of urban transport policy documents and media reports (2021) • Semi-structured expert focus groups focused on inclusion in digital transport systems (2021) • Surveys with local car and public transportation users (2021) • Powercube workshop with local stakeholders (October 2022)

inhabitants), with two universities and an economic sector focused on providing services.[1] The city and surrounding regions are home to several local and community energy associations, and various local energy advice and support bodies. Across local and national scales, SLES are portrayed as systems expected to deliver benefits related to reducing carbon emissions, improving ecosystems, equity dimensions and the efficient provision of energy through smart and local components (Ford et al., 2021). SLES, thus, present a good opportunity for analysing inclusion, power relations and energy governance. This is because these technologies raise questions related to how different actors can be engaged, at what scale, and under what conditions.

3.1.2. Technology focus

SLES is a term widely used in the UK that shares commonalities with concepts such as smart energy systems, clean energy communities, and renewable energy communities, among others (Walker et al., 2021). Smart systems and local smart grids are used to describe the same dynamics. SLES are energy systems with digitalised and local components, incorporating various technologies (e.g. smart meters and appliances, solar panels, batteries), business models (e.g. corporations, co-operatives), and forms of governance (e.g. top-down, multi-level) to facilitate localised energy system operation by new actors that engage users in new ways (Ford et al., 2021). They differ from citizen-led energy initiatives in that they are often state-initiated through partnerships between private, public and research organisations (Soutar et al., 2022). SLES usually bridge technologies (e.g. smart meters, heat pumps or electric vehicles) and sectors (e.g. mobility and energy) with a focus on local applications that brings infrastructure closer to spaces where people live and work. This may include local forms of system management, operation, governance, ownership of the energy system and the geographical boundaries around the system (Soutar et al., 2022; Walker et al., 2021). Finally, there is a focus on citizen participation and engagement in the context of climate and environmental challenges (Soutar et al., 2022). This offers the opportunity to consolidate new relations between actors who have the ability and willingness to contribute to and benefit from local energy systems (Banks and Darby, 2021).

3.1.3. Data collection

Data collection in Brighton and Hove took place in 2021 and 2022 and focused on identifying potential social exclusions and inclusions resulting from SLES development in the South East of England. The research team drew upon three methods to develop the Powercube workshop: desk-based research on SLES pilot projects across the UK, observations at industry SLES events, and semi-structured interviews with energy experts.

Nine SLES demonstrations from the UK were analysed for inclusion. These included three government Prospering from the Energy Revolution flagship projects, six projects led by community organisations (but including corporate actors), and studies from diverse organisations on SLES policy and strategy. Observations were also made at industry events concerning SLES. Twenty-four semi-structured interviews following snowball sampling techniques were conducted with energy sector experts, and 24 with community participants. Community interviews focused specifically on inclusion in digitalised solar with participants recruited through direct leafletting of residential neighbourhoods in Brighton. Interviews were transcribed and returned to interviewees for review.

A one-day Powercube workshop was held in Brighton in November 2022 on "Smart – and Inclusive – Local Energy" systems with nine attendees from local councils, charities, and energy providers. The workshop participant list was informed by interview materials. Two key questions guided the workshop: 1) what are the main social inclusion issues in SLES and; 2) How and where to promote inclusive energy systems in the South East of England? Workshop participants used a "power twister"[2] activity where they mapped issues of inclusion and exclusion onto the Powercube framework and reflected on their ability to influence the energy sector. Researchers took notes to document conversations and these notes became a key data source. Conversations were not recorded to support more open dialogue.

3.2. Case study – Trento

3.2.1. Case description

The province of Trento is an autonomous regional authority in Italy, located in the northeastern part of the country, containing part of the central as well as southern Alps. It has a population of 542,050, with 118,052 in the capital city of Trento. The province of Trento is committed to adopting alternative models for local energy governance, aligning with its broader digitalisation and clean energy transition targets (Prov. Autonoma di Trento, 2021a, 2021b). At local and provincial governance levels, energy communities are explored as a promising alternative to central energy system governance. In this decentralised model, citizens are expected to play active roles in energy production, consumption, and management.

Social inclusion in energy communities is recognized as a key aspect to ensure accessibility of energy, affordability of prices and fair distribution of benefits regardless of citizens' socio-economic status (Sareen et al., 2023). Power dynamics influence the governance arrangements of energy communities and the degree of participation by citizens. The power relations common in incumbent energy systems can marginalize citizens in the developments of energy communities (Brisbois, 2020b).

3.2.2. Technology focus

The deployment of the second generation of smart energy meters is described as an enabling factor for energy communities (Lowitzsch et al., 2020). Italy is currently in the process of replacing the first generation of Smart Electricity Meters (SEM 1.0) with the second generation (SEM 2.0). The replacement process started in 2017 and is ongoing. SEM 2.0 are electronic devices that record electricity consumption and production data and communicate it to the consumer and supplier. SEM 2.0 records electricity data near real-time and reports it more frequently than SEM 1.0 (every 15 min versus three times a day). SEM 2.0 enables bi-directional communication between consumers and producers. These additional features support new functionalities for consumers for greater clarity of electricity use, and for electricity suppliers for better infrastructure monitoring (European Commission: Directorate-General for Energy et al., 2020), which can ultimately reduce electricity consumptions, GHG emissions and electricity costs (Hmielowski et al., 2019; Sareen and Haarstad, 2021).

SEM 2.0 can make local energy systems more efficient through improved coordination between supply and demand, supporting new models of self-consumption, distribution, and production of energy, especially from renewable sources. By balancing energy supply and demand, and by handling dynamic energy prices, SEMs 2.0 are considered valuable tools for operating energy communities. Besides the technical benefits for efficient energy management, the impact of SEM 2.0 on social participation and inclusion within energy communities is unclear (Hmielowski et al., 2019). Energy communities are still in the process of formal definition in Italy, and as such, the question of governance is central to their establishment and operation. SEM 2.0 could be a tool to support management of energy systems within energy communities.

[1] https://www.nomisweb.co.uk/sources/census_2021/report?compare=E06000043.

[2] http://www.Powercube.net/wp-content/uploads/2010/01/PowerPack_web_version.pdf.

3.2.3. Data collection

Forty expert and citizen interviews provided data on inclusion that informed the Powercube workshop, recruited as key informants and through snowball sampling (guides available in Appendix A, full findings reported in Gantioler et al., 2023). As noted, interviews indicated a strong cultural sensitivity around the term 'power'. Participants were thus presented with empirical examples of the Powercube levels and briefed on digitalisation, energy and the governance of energy communities without explicit use of the word 'power', and joined facilitated small and large group discussions.

The 20 workshop participants included local public authorities, energy utilities and businesses, universities and research centres, and a local energy community. The workshop was designed to help participants identify ways to ensure inclusive, just processes and outcomes in the creation and development of digitally-enabled energy communities. Discussion was structured to reveal information about spaces, levels and forms of power through reflection on narratives of *energy as a commodity* and of *energy as a common good*, identified as relevant in the interviews (see Wågsæther et al., 2022; Remme et al., 2022; Sareen et al., 2021). This contrasted perspectives of users as consumers or prosumers and users as citizens with decision-making roles. Participants also examined the Powercube dimensions through discussion of strategic and operational issues *vis a vis* energy communities, the former related to the definition, planning and development of energy communities, and the latter related to operational and management aspects of energy communities.

Data was collected via a dedicated note taker to enable open discussion. This included participant observation data. The workshop did not fully represent the governance of the energy system in the Trentino region due to the absence of environmental movements and other civil society representatives but still offered valuable observational data and investigation of local power dynamics.

3.3. Case study – Bergen

3.3.1. Case description

The city of Bergen, population 290,000, located on the Norwegian West coast, has in recent years developed a strong policy focus on "green" mobility transitions (Bergen Municipality, 2023). Bergen aims to have fossil fuel free transport by 2030, and zero growth in personal transport, with a 20 % reduction from 2013 levels by 2030 (Byvekstavtalen Bergen, 2019; Ministry of Transport, 2021). Local and regional decision-makers have moved away from car-centric planning in the form of stricter parking regulations and rush-hour fees, a focus on active and collective transport (i.e. light rail), and innovations in mobility like micro-mobility, car-sharing, and mobility hubs (Bergen Municipality, 2020; Sareen et al., 2021). This has generated significant contestation. For example, the toll-road schemes led to local political turmoil and resulted in the formation and subsequent local electoral success of the populist People's Action No to More Road Toll Party in the 2019 local elections (Wanvik and Haarstad, 2021). The oft-contested nature of urban mobility governance makes it an ideal case for analysing social inclusions, governance processes and power dynamics in the context of sustainable urban development.

3.3.2. Technology focus

Digital technologies are important both in governance of mobility and in the development of new forms of mobility. Digitalisation allows local governments access to vast amounts of data and algorithmic platforms in decision-making processes over urban mobility (Rosol and Blue, 2022). Moreover, digitalisation enables digitalised forms of mobility like shared mobility (e.g. car-, bike-, and ride-sharing, ride-hailing), autonomous cars/buses, and micro-mobility (e.g. bicycles, e-bikes, electric scooters, electric skateboards, etc.), and can potentially contribute to the sustainable development of cities. Such digitalisation of mobility implies not merely a shift to new forms of transport, but a transition from ownership models (i.e. car ownership) to shared models and automated mobility forms which have implications for the roles of users (Axsen and Sovacool, 2019). Therefore, digitalisation in mobility has implications for inclusion, in the sense that it may reproduce the inequalities and exclusions of digital technologies. This has been called a new "multimodal divide", understood as the "reproduction of low mode options [i.e. retaining very limited variety in transport modes] in the guise of supposed improvements through smart mobility" (Groth, 2019:66).

3.3.3. Data collection

Data collection in Bergen took place throughout 2021 and 2022. Data from 24 experts, recruited as key informants and through snowball sampling, were collected in a focus group setting (see Appendix A). Relevant urban transport policy documents were consulted, while also tracking mainstream media reports on the theme and making field observations as transport users. Citizen perspectives, collected in the other two cases through interviews, were collected using a survey ($n = 162$) distributed in person in urban transportation locations (i.e. a parking lot and in public transit stations) that posed different questions to car users and to transport users (schedules in Appendix B). These data and methods are also reported in Wågsæther et al. (2022), Remme et al. (2022), and Sareen et al. (2021).

These data informed a Powercube workshop on 'transition in urban transport' in October 2022. This focused on knowledge co-production about urban mobility transitions in Bergen. The 16 workshop participants were stakeholders in the urban mobility context including city planners, policymakers, representatives from local interest groups and foundations, students, politicians, private sector actors, and employees of the regional public transport operator. Participants worked in predefined groups on tasks based on the Powercube framework. Participants were given a brief introduction to the levels, spaces, and forms of power in the framework and tasks were designed to inspire identification of power dynamics within the different categories and to reflect (perhaps banal) ways in which power plays out in everyday situations in relation to local mobility governance processes.

3.4. Thematic analysis and cross-case synthesis

3.4.1. Thematic analysis

In all three cases, relevant content from background data collection and full workshop records were thematically analysed by each country team. Data on inclusion in the empirical contexts (SLES in Brighton, SEM-enabled energy communities in Trento, smart mobility in Bergen) was iteratively coded under broad deductive headings corresponding to the three faces of the Powercube (forms, spaces, levels), and their elements (e.g., visible, hidden, invisible forms of power). The specific themes presented in the results were developed inductively within the Powercube framing. Notes on the experience of using the Powercube, and the experience of knowledge co-production with workshop participants, were also thematically analysed, again working to categorise emergent themes according to the Powercube dimensions.

The goal of analysis across the three cases was to use a Powercube framing to develop wider insights about the depth and nature of inclusion in innovative cases of energy digitalisation. While the cases vary significantly across technology type, political system, actor composition, and engagement patterns, our focus is on inclusion as the dependent variable. To develop insights, thematic results were analysed and compared to identify key common themes and points of contrast. Country teams first developed partially analysed data, in raw format but organised according to the Powercube dimensions. Synthesised findings were developed by one member of the research team and then circulated to all three country teams for testing. Results were refined and recirculated three times to support accurate representation of findings.

4. Results: spaces, forms, and levels of engagement

This section is organised to first highlight findings related to inclusion as revealed through Powercube analysis, and second to review insights into our use of the Powercube as a participatory research method. Results related to inclusion are organised around the spaces where power is exercised as this was the dimension with the greatest explanatory value for the dynamics observed. Forms of power and the levels at which they are exercised are highlighted.

4.1. Closed spaces

Across cases, it was clear that the exercise of power in closed spaces limits the inclusiveness of energy digitalisation. This manifested thematically in elite decision-making behind closed doors, incumbent control over information and infrastructure, and the impact of digitalisation on moving personal information into closed spaces – all issues of hidden power that manifest largely at national levels.

Hidden power exercised as decision-making behind closed doors at the national level was the most prevalent barrier to inclusion in energy digitalisation, emerging across all three cases. In Brighton, workshop and some interview participants repeatedly emphasised their frustration with restrictive regulations and market models that disincentivise participation of households beyond as traditional consumers. Interviews and documents revealed that the SLES trials that were authorised by the regulator, Ofgem, were all designed and strictly controlled by incumbent industries, without wider access to key decisions about operations, ownership, or how any economic benefits would be shared. Addressing entrenched inequalities in cities like Brighton, a prerequisite for meaningful social inclusion, was similarly off the decision-making agenda (although workshop participants recognized this as centrally important).

Workshop and interview participants in Trento expressed similar frustrations, noting that the regulations that determine if, where and how energy communities can exist are dictated by national regulation that is decided in closed spaces by policy makers and energy incumbents. In both Brighton and Trento, participants raised concerns that information about the grid conditions that define what opportunities are technically possible is created and controlled by incumbent grid operators who operate at a national level.

Participants in Bergen likewise noted that local mobility policies depend on national targets and policy guidelines, and that key decisions in the mobility sector (on, for example, large-scale transport projects) are usually made through parliamentary and bureaucratic processes where elected officials make decisions based on 'expert opinion' and governmental reports. This differs from land use decisions where more invited participation is institutionalised. Focus group and workshop participants also noted that digitalisation enabled a new set of globalised mobility technologies and practices that were developed and enacted in closed international and national spaces that transcend local control. E-scooters, Foodora and similar gig economy mobility-based services, and the (attempted) arrival of Uber were interventions enabled by a market-based national government orientation and were not subject to local inclusive or democratic approval processes.

Across Bergen, Brighton and Trento, themes of invisible power expressed as dominant discourses that legitimised or created closed spaces were also apparent. Participants in Bergen identified their lack of agency in the face of trends in urban policy (i.e. smart city as a global discourse)[3] and technological innovation. In particular, they highlighted EU influence on agenda-setting and budget allocation for local mobility innovation projects. These top-down mechanisms were perceived to restrict potential legitimate mobility futures. Additionally, the emergence of gig economy interventions was framed as inevitable and outside the control of decision-makers. In Brighton, participants highlighted that national SLES decision-making is guided using engineering and economic logics that leave little room for thinking of communities and citizens beyond as consumers, let alone including them meaningfully or considering collective good. In Trento, the view of the energy system as naturally top-down and centrally controlled was identified as a barrier to the inclusion of grassroots energy communities in the energy system. Dominant discourses identified in interviews and workshops stressed prosumerism and economic benefits rather than community engagement and social cohesion, limiting inclusion and active participation by community members.

Data across all three cases also revealed concerns that energy digitalisation creates new forms of hidden power by enabling the capture and control of personal data. In Brighton, this manifested as concern that the installation of smart meters, a requirement for SLES participation, would allow national retailers to control usage and disconnect customers without warning – something that did happen during the energy crisis in Winter 2023.[4] In Trento, interview and workshop participants expressed concern over the fact that private companies at the regional, national, or even international level now control access to personal energy data, also through smart metering. Given the focus on transport rather than in-home energy use in the Bergen case, explicit concerns of privacy were not articulated, which perhaps signifies a difference in perception across sectors, where participants may consider transport data as treated in aggregate and external to the home.

4.2. Invited spaces

Power issues arising in invited spaces were linked to controlled participation, and capacities to participate. Invited spaces of inclusion controlled by national and regional interests, especially belonging to energy utilities, were consistently perceived as limited, and as having little effect on larger decisions. For example, documents and focus group data reveal that Bergen municipality uses apps to source citizen inputs on misplaced e-scooters, or to identify the need for road maintenance. While these make good use of digital technologies to connect citizens to the local bureaucracy, the inputs they allow for are highly structured and limited in scope, evidence of hidden power in limiting access to spaces of key decision-making. In Brighton, inclusion in SLES is perceived by non-industry interviewees and workshop participants as highly structured and assumes the form of inclusion as consumers with roles pre-defined by elites in closed spaces. This represents hidden power, but also invisible power as it exploits broad societal logics that normalise treating citizens as passive consumers rather than decision-making agents. However, actors who are invited to relevant spaces also noted that they are empowered to try to shift these logics. In Trento, workshop participants perceived that incumbent actors use visible power to control the energy system, and hidden power to create defined invited spaces that constrain the radical potential of digitally-enabled energy communities. Invisible power in Trento is also perceived to be used to perpetuate a narrative of low trust in the capacity of citizens as meaningful energy system actors.

Limitations in capacities to participate in invited spaces restricted inclusion in these examples of energy digitalisation. In Trento, workshop participants identified visible power issues related to the need for energy and digital literacy to enable inclusion. There is also hidden power at work as much of the existing capacity and knowledge of the energy system sits with incumbent actors. Interviews made clear that energy communities are therefore dependent upon these actors to function, particularly when the primary entity involved is the local authority. In Brighton, there were visible power issues related to capacity and

[3] Here we refer to Joss et al. (2019) and the concept of policy mobility (see Wathne and Haarstad (2020) and base our claim on workshop observations).

[4] https://uk.news.yahoo.com/smart-meter-cut-off-prepayment-meter-switch-by-stealth-warn-campaigners-142534893.html.

knowledge limitations on participation in SLES for both citizens and city councils. This included the digital literacy to navigate SLES, but also the financial capacity that allows access to digitally-enabled technologies and, thus, the ability to be included in energy systems in a role beyond that of a consumer. The same dependence on incumbent actors to facilitate access to, and use of, the grid that was identified in Trento was also present.

In Bergen, the introduction of digital mobility-involved services rapidly and fundamentally changed the city's mobility sector. Despite jurisdictional responsibility to address these impacts, without the power, information, or time to develop a coordinating role, local bureaucrats made clear that they have struggled to understand the nature of these changes and their implications. They have therefore been unable to properly regulate digitalised mobility innovations. For example, local authorities initially struggled to regulate e-scooter companies after their abrupt appearance in Bergen in 2019, gradually putting digital systems of regulation into place with e-gating, capped numbers, and spatial incentives, and disincentives in the city centre and suburban localities.

4.3. Claimed spaces

Spaces were claimed across the three cases as citizens both resisted decisions made in closed spaces, and tried to carve out new spaces of experimentation and innovation. In Brighton, the workshop revealed that individual actors claimed space largely by exercising visible and hidden power in the form of energy and digital literacy, and personal wealth, to set up smart systems behind the meter. One participant was able to use his capacities and position as a retired engineer to contact the regional grid company and secure information on grid loading possibilities in order to enable the development of a new smart system. However, this claimed space was only possible because of visible and hidden power related to his knowledge of grid functionality, and prior interpersonal connections.

In Trento, similar efforts were made to claim space for and by energy communities, and to cultivate new skills and experiences. However, workshop participants highlighted that these efforts were subverted by more powerful actors using hidden power to create additional restricted invited spaces that limit and control the extent of citizen autonomy with respect to digitalised energy innovations. This happened through an emphasis on technological and economic knowledge held by 'experts', making it difficult for non-expert communities to be viewed as legitimate participants. In particular, in Trento, the local energy supplier and local government are the main energy community actors. However, these actors are also key players in the existing energy system and their actions therefore tend to support maintaining the status quo.

In Bergen, data from documents, and the focus group and workshop reflected that space was claimed using visible power through bottom-up protest movements that disrupted decision-making processes by shaping public opinion through various media and digital media platforms. Protests over road tolls and over the extension of Bergen's light rail past its heritage harbourfront, were mobilised on digital platforms (i.e. Facebook). This shaping of public opinion represents hidden power resting upon the perceived legitimacy of citizen voices as members of a broader public. The ability of citizens to use these platforms to mobilise protests has had a significant impact on mobility policies. For example, the rise of a new party focused solely on road toll reduction changed the discourse on this policy measure, and made it more difficult for policy makers to fund public transport using road tolls. These political dynamics continue to evolve in complex ways, most recently in the aftermath of local elections in late 2023 in relation to contention over light rail expansion.

4.4. Co-production through the Powercube process

The Powercube helped to co-produce reflexivity in both participants and researchers by facilitating examination of the forms of power, spaces, and levels that different actors can access. In the case of Brighton, the Powercube was useful in revealing where blockages to more progressive SLES logics, policies and regulations lie and thus where future political pressure should be applied. Through the "power twister" activity, participants were better able to identify the capacities they need (e.g. resourcing for councils to build energy and digital literacy), targets for change (e.g. barriers to information on grid loading), and the capacities that they do have that could be better mobilised (e.g. access to spaces that appear 'closed' but where reflection revealed there are opportunities for input). For example, representatives of citizen's associations self-identified their strong public legitimacy and ability to use invited spaces in national conversations on energy poverty to push for more robust inclusion policies for future SLES developments.

Deeper issues of the hidden power that reinforces itself through closed spaces were also identified. Participants noted that the discourse of energy security perpetuated by national actors does not allow a broader conversation of what "energy security" means and identified the need for a more inclusive conversation around a plurality of (energy) securities. This includes whether a 100 % reliable top-down energy supply for all citizens precludes broader citizen inclusion, and is necessary at all for people to be energy secure.

In Trento, the Powercube was not used explicitly. Sensitivity to using power as an explicit and direct topic of conversation from the outset is in itself a reflection of hidden discursive power. The dimensions were instead explored through structured conversations that revealed relevant information. Despite non-explicit use of the Powercube, researchers were able to reflect on the powers, spaces, and levels to which they have access. For example, the power dynamics within the discussions in the working groups were clearly observable, mirroring those in wider energy infrastructure digitalization contexts. Those with access to closed spaces and who define invited spaces were more likely to engage with narratives of energy as a commodity, while community actors preferred energy as common good narratives. This indicates that future energy communities and the impact of energy infrastructure digitalization is likely to reflect energy as commodity narratives.

In Bergen, the Powercube was used to structure the workshop, and participants were also encouraged to use it in their discussions and workshop tasks. It provided participants with the tools to broaden their perspectives on the various issues of mobility by thinking through the levels, spaces and forms of power, and to more directly engage with power as a concept by thinking across their experiences (e.g. daily mobility practices, political struggles in local mobility cases). This opened up the discussion and enabled them to expand their perspectives and to critically reflect upon the rhetoric and focal points of the local mobility debate. For example, some policymaker participants expressed that the Powercube helped them to look beyond frustrations in their everyday bureaucratic encounters, to see institutional mechanisms and potential conflicts through a new perspective where power dynamics became more apparent.

5. Discussion: reflecting on inclusion and co-production through the Powercube framework

These three cases reveal insight into a) the limited extent to which digitalisation is currently fulfilling its supposed promise in creating more open, inclusive and equal societies, and b) the utility and limits of the Powercube approach in addressing power-linked issues of inclusion, and empowering participants.

5.1. Digitalisation and inclusion

Energy digitalisation has the potential to expand inclusion in the energy system. However, application of the Powercube to examples of innovative energy digitalisation in three European midsized cities revealed that many of the power dynamics directly discussed by participants or observed focused on domination in ways that did not expand broad inclusion. Across the three cases it is evident that digitalisation is largely reproducing existing marginalising, closed and unequal patterns of exclusion and resource distribution, decision-making and power. These are the patterns that characterise modern capitalist economies where energy is conceptualised as a commodity and individuals as consumers. Opportunities for greater inclusion in digitalised energy innovations is strongly limited by the institutional structures, logics and power relationships that characterise energy configurations of existing electricity and mobility systems. The experiences and perceptions recorded in our data reflect a tension in understandings of *who* will own and control digitalised systems. While many people are interested in contributing to energy system decisions and control through expanded energy citizenship, incumbent energy system actors often reproduce centralised and top-down ownership and control models (Iskandarova et al., 2022; Torriti, 2024; Wolsink, 2024).

In both Trento and Brighton, digitalised energy models that open up possibilities for reshaping who controls and benefits from energy systems are tightly restricted by incumbent actors through the exercise of hidden power inherent in existing structures (e.g. through decision-making in closed spaces), and invisible power over competing ideas and discourses (e.g. focusing on the all-encompassing power of the consumer rather than potential collective citizen agency). In this way, potential opportunities for change and restructuring of decision-making dynamics toward greater empowerment of local communities, civil society, and other emerging actors are lost. In Bergen, possibilities for wider local and public control over mobility services were likewise controlled by decision-making in closed spaces by those with hidden power.

These dynamics of elite control and the limiting of citizen inclusion in decision-making are not new and have been thoroughly discussed in energy and mobility contexts (e.g. Avelino et al., 2016; Smink et al., 2015; Stirling, 2014), and with respect to political economy more broadly (Fuchs, 2007; Newell, 2019). What is notable is the extent to which the reproduction of power, inequality and control observed in our cases contrasts with the narratives of inclusion used by proponents of digitalisation (see Smith et al., 2023), and even those of proponents seeking to radically restructure economic and social relationships (e.g. Aronoff et al., 2019).

Far from reducing inequality and opening up energy systems, our cases provide evidence that digitalisation, as currently enacted, is exacerbating the enclosure of decision spaces by moving control over digitalised energy and mobility data into the hands of private actors who tend to operate in pursuit of private profit rather than with public interest at the fore.

The cases also demonstrate that increased inclusion is hampered by a lack of capacity on the part of both citizens and local authorities. This includes financial resources to purchase key required infrastructure (e.g. solar panels, energy community shares, smart), digital and energy literacy, as well as access to key technical information and data, and the basic time and human resources to understand issues and intervene in or take advantage of new opportunities. These limitations are consistent with findings on inclusion in smart grids in Sweden (Tarasova and Rohracher, 2023).

In short, for those living in or close to poverty who are often targeted by "smart" interventions, it is unrealistic to expect them to be able to participate unless their basic needs are first met (Durand et al., 2023; Powells and Fell, 2019). This points to the need to address fundamental issues of societal inequality *prior* to roll out of digitalised energy services, instead of assuming that digitalisation will correct these imbalances without careful pre-design. This is equally important when supporting more bottom-up digitalised energy movements. There is evidence that bottom-up digital energy initiatives also often reproduce existing inequalities and dynamics (Gantioler et al., 2023). The key point here is not that digitally enabled solutions should not be pursued, but rather that their considerable potential is fundamentally predicated upon addressing underlying drivers of inequality.

We also identified ways in which invisible power in the form of dominant discourses functions to limit opportunities for broader forms of inclusion. Discourses of centralised energy systems, the fallibility of citizens as energy actors, engineering as the appropriate dominant logic for energy system organisation, and the "smart city" as a positive ideal manifested differently across cases but had the common effect of limiting the agency of local actors.

Competing bottom-up discourses were also apparent and reflected shifting from concepts of "consumers" to that of "citizens" (Gantioler et al., 2023) in Trento and Brighton, and to the legitimacy of bottom-up control in Bergen. These discourses are consistent with wider social movements and calls for increased energy citizenship and energy democracy (e.g., Burke and Stephens, 2017). The identified competing discourses have been subject to different power dynamics across cases. In Trento, existing elites co-opted spaces claimed by community actors that explored more radical discourses of energy as common good by creating bounded invited spaces consistent with energy as commodity framings (Gantioler et al., 2023). In Brighton, no response from elites has yet emerged as prior elite decisions on regulations and policies have pre-set the terms for citizen inclusion, minimising space for contestation. This is consistent with dynamics of control over agenda setting by powerful actors (Lukes, 2005).

However, results from the Powercube activity made evident that there are nascent discourses questioning current energy security framings and the positioning of energy as commodity, and that action in claimed spaces at local to national levels can create significant change. These discourses provide insight into how different resources can be mobilised to shift entrenched power structures. In Bergen, citizens were successful in shifting decision-making through more disruptive claims on decision spaces. In Trento, municipalities and representatives of local energy communities challenged the commoditization discourses on energy promoted by regional authorities and local energy suppliers at municipal events. In Brighton, community energy groups used their technical knowledge and networks to construct collective energy visions with local authorities, would-be energy citizens, and relevant energy system actors. Following empirical work for this study, the results of this long-term mobilisation by many similar UK actors manifested in an incoming government proposal for a Local Power Plan intended to support SLES and local energy development.[5] This is consistent with research on social movements indicating the long durée of many struggles for greater inclusion of citizens (Gillan and Edwards, 2020).

In all cases, the durability of these shifts remain contingent on power dynamics that continue to change, coupled with incumbent political structures, logics and processes, and shaped by evolving forms of countervailing power. This points to the power of discourses to limit, but also to liberate, depending on how they are mobilised and by whom.

5.2. Using the Powercube approach

The Powercube proved useful as both a methodological and analytical tool in improving understanding of how issues of inclusion are playing out for both researchers and participants. Structured workshops allowed the co-production of findings by identifying empirical manifestations of theoretical concepts (e.g. the lack of access to specific closed decision spaces as an example of hidden power). This approach also allowed participants the space and structure to identify that they actually do have some power in the form of knowledge and legitimacy that they can mobilise through different spaces and at different levels (e.g. claiming space behind the meter, where some actors are invited to provide input to higher level decision fora, through protest). In the process, participants were able to develop awareness of where decisions are being made, what spaces need to be opened, and which discourses

[5] https://labour.org.uk/change/make-britain-a-clean-energy-superpower/.

need to be actively challenged.

Co-production takes significant investment and time on the part of both researchers and participants, and must be shaped to different contexts (Chambers et al., 2021; Reed et al., 2018). Further, co-production can produce “considerable conceptual, epistemic and practical challenges that require careful moderation” (Rau et al., 2018:270). In our study, these challenges manifested early on in the research design phase. In Trento, explicit discussion of the concept “power” was not considered appropriate during the three hours available for the workshop. As noted, this in itself reflects invisible power rendering certain topics of conversation off limits. In order to facilitate deep engagement in the topic, workshop organisers made the decision to raise the Powercube dimensions through proxy concepts. This made it possible to use the Powercube as an analytical tool, but also meant that there were less obvious empowerment outcomes than seen in Brighton and Bergen because there was no explicit focus on how power can be claimed.

Sensitivity around the concept of power in empirical settings is a common research problem (de Geus et al., 2023). While the Powercube approach proved flexible enough to allow exploration of power across different contexts, it did mean that some of the emancipatory potential of the method was lost in Trento. Ultimately, decisions about trade-offs between explicit use of power and more subtle approaches must be made by local research teams. There is value in using an explicit approach to power, evidenced here and also by others (e.g. de Geus et al., 2023), but researchers must also make sure concepts are approachable enough to get participants into the room. However, one unforeseen consequence of the non-explicit use of power in Trento was that power dynamics within Powercube levels became more visible because discussion was not structured around positioning oneself and others relative to the Powercube. This additionally highlights the value of observing power operating within levels.

The co-production approach also, perhaps usefully, creates additional responsibility on the part of researchers to maintain meaningful engagement with participant communities. This is because co-productive processes can create relationships of obligation and responsibility between researchers and participants (Marshall et al., 2018). Co-production can also lead to more legitimate research that has greater societal visibility among actors outside of academia (D’Este and Robinson-García, 2023).

For example, in the case of Brighton, the workshop inspired a community-led exploration of funding to better integrate academic knowledge into the decision-making of community energy actors. It also led to the creation of a comic[6] as a novel knowledge translation tool. In Bergen, relationships strengthened by co-production are used to share data and studies between practitioners and academics. In Trento, a network between researchers and other actors working on digitalised energy communities i.e., public utilities, authorities, and grassroots initiatives, produced a document with the results of the co-produced contents of the workshop. These types of activities help create stronger connections between academic, practice and policy communities and bridges the gaps between academic theory building and societal impact.

Making use of a co-productive approach also bears risks. Where the Powercube is used in settings that are not well integrated with formal decision processes, participants can be left with no concrete or immediate options to take action and further develop claimed spaces. This, at least in the short term, can exacerbate feelings of powerlessness – something expressed by participants in Trento. However, the long-term benefits of increased awareness of power dynamics can outweigh these risks, especially when participants are introduced to empowering examples and opportunities by the research team (as the Brighton team attempted with their comic).

A further limitation of the Powercube is the risk that only more obvious or visible aspects of power are revealed because participants and even facilitators may be less aware of, or comfortable discussing, less visible or even invisible power dynamics. In science and technology studies, this can also reflect the “captives of controversy” effect where researchers themselves reproduce the asymmetrical power relations of social conflict when they try to treat each “side” equally (Pels, 1996; Scott et al., 1990). If participants are not aware of how power operates, this can create a bias toward revealing power “over” and feelings of disempowerment (Gaventa, 1980).

While revealing and empowering through power “to” and power “with” is one purpose of the Powercube approach, it can be helpful to supplement Powercube approaches with other data collection or analytical methods to uncover deeper narratives and values. For example, in the case of Trento where discussion of power itself was difficult, the team used narrative analysis to make visible hidden values and identify latent value conflicts that can result in inaction and disempowerment (Gantioler et al., 2023). Other techniques that reveal how actors interpret their positions such as frame analysis (Goffman, 1974), may also be useful. Limitations in the knowledge of participants on, for example, how decisions are made, who the relevant actors, or the nature of relationships between actors can be addressed by carrying out additional actor-network analysis.

Our experiences also made clear that it would have been helpful to spend more time with participants, ideally through two or more workshops across several months or years. This would have enabled the generation and evaluation of strategies for working with power to advance issues of inclusion. Research on application of the Powercube is consistent with the perspectives of our participants in emphasising the commitment of participants in working with ideas of power to share their newfound knowledge to empower others and work toward organisational goals (Hunjan and Keophilavong, 2010). To this end, Powercube workshops could be usefully embedded in professional trainings or even into policy processes for designing and planning for inclusive digitalisation.

6. Conclusions

We used a Powercube approach to examine three cases of inclusion of diverse social actors in energy and mobility digitalisation in Brighton (UK), Bergen (Norway), and Trento (Italy). This approach produced conceptual and methodological insights, and practical impacts. Conceptually, the Powercube was useful in revealing where broad structural barriers exist, and foregrounding their importance. Significantly, we found that contrary to popular messaging, digitalisation of energy and energy-related services is exacerbating existing inequalities, entrenching exclusive decision practices, and creating new closed off spaces as public energy data is moved into private ownership. There is thus a need for policy and practice communities to address broader issues of inclusion and inequality before, or in the process of, implementing technical innovations.

Addressing inclusion issues will often mean limiting the power of incumbents to control digitalisation processes and outcomes. Failing to explicitly address these issues means that they will likely be reproduced and entrenched in resultant outcomes. In this study, despite co-creating an invited space for diverse participants to voice concerns and deliberate collectively and critically, the agency of participants was limited. This limitation relates to our own limited role and influence within formal planning and implementation processes, where research-based evidence most often has indirect impact on policy design.

The co-productive Powercube approach revealed spaces for change, and helped participants identify relationships of power and personal and collective agency at different levels and in different spaces. It also revealed – and perhaps amplified – frustration on the part of participants as the limitations on their ability to claim space and create more inclusive digital energy systems were thoroughly explored. For some

[6] Open access copies of the comic can be downloaded here: https://www.sussex.ac.uk/webteam/gateway/file.php?name=sles-comic-digital.pdf&site=18.

participants keen to see specific changes enacted quickly, the value of spaces such as the one we created can be limited. This points to the importance of more structural inclusion of actors and perspectives in deliberative discussion as inputs to overarching policies and measures.

It is also important to note that the frustration with closed, elite decision making expressed by participants across our cases reflects broader societal frustration with what are seen as locked-in elite decision making that consistently favours the interests of those already privileged (e.g. Mehleb et al., 2021). Tools facilitating reflection of how citizens can engage for change, such as the Powercube, are thus necessary to help address these building frustrations. Our application of this approach across three energy-related contexts highlights its broad utility and reveals similarities in urban-scale trends in how power dynamics play out across sectors that are being digitalised and decarbonised. Whether this extends to sectors – like manufacturing and construction – where such interventions are likely to become more common in the near future is a timely research question, and one where our insights from more public-facing sectors may be useful.

Current energy systems and regulations across our three case studies allow limited scope for radical change. However, evidence on worsening inequality, and on the need to rapidly transition energy systems to address climate change, means that radical change is indeed necessary. Digitalisation, despite the problems we have identified, has a role to play in addressing these challenges. There is thus an ongoing need to find ways for both researchers and citizens alike to claim space for more just and inclusive energy innovation.

CRediT authorship contribution statement

Marie Claire Brisbois: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Gerardo A. Torres Contreras:** Investigation, Methodology, Writing – original draft, Writing – review & editing. **Morten Ryen Loe:** Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Jessica Balest:** Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Adrian Smith:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Siddharth Sareen:** Conceptualization, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Håvard Haarstad:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Chiara Pellegrini:** Investigation, Writing – original draft, Writing – review & editing. **Federico Voltolini:** Investigation, Writing – original draft, Writing – review & editing. **Silvia Tomasi:** Conceptualization, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Sonia Gantioler:** Conceptualization, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Benjamin Sovacool:** Funding acquisition, Writing – original draft, Writing – review & editing.

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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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.respol.2025.105323.

Data availability

The data that has been used is confidential.

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