Buildings & Cities

Social implications of energy infrastructure digitalisation and decarbonisation

SPECIAL COLLECTION: DATA POLITICS IN THE BUILT ENVIRONMENT

RESEARCH

]u[ubiquity press

SIDDHARTH SAREEN
ADRIAN SMITH
SONJA GANTIOLER
JESSICA BALEST
MARIE CLAIRE BRISBOIS
SILVIA TOMASI
BENJAMIN SOVACOOL
GERARDO A. TORRES CONTRERAS
NIVES DELLAVALLE
HÅVARD HAARSTAD

*Author affiliations can be found in the back matter of this article

ABSTRACT

Digitalisation provides opportunities to decarbonise energy and, simultaneously, address social exclusion and inequality—but it is unclear whether and how these opportunities are realised. Three case studies investigate whether ongoing energy infrastructure digitalisation processes are accommodating commoning or enclosure, using a continuum of commoning versus enclosure practices to examine this question. Multi-sited fieldwork throughout the period 2021–22 is used to compare sectoral transitions in three European mid-sized cities: mobility in Bergen (NO), solar generation in Brighton & Hove (UK) and smart electric meters in Trento (IT). Semi-structured and narrative expert interviews (*N* = 66), a mix of structured (*N* = 134) and semi-structured (*N* = 49) citizen interviews, citizen focus groups (*N* = 17), seminars (*N* = 2), participatory workshops (*N* = 4), and extended participant observation reveal multiple and contradictory processes of commoning and enclosure. Decarbonisation and digitalisation are proceeding unevenly, with tendencies of enclosure and missed opportunities to achieve commoning of energy infrastructure for public benefit. Opportunities are identified to enable commoning pathways in ongoing twin transitions.

POLICY RELEVANCE

The digitalisation of energy infrastructure is a significant transition because it holds the key to rapid electrification of multiple sectors and thus wider societal decarbonisation. Yet the way it takes place must embody justice and social inclusion in order to advance just transitions while developing new infrastructures. European cities constitute some of the most advanced arenas globally where such changes are simultaneously unfolding

CORRESPONDING AUTHOR:
Siddharth Sareen
Department of Media and Social Sciences, University of Stavanger, Stavanger, NO
siddharth.sareen@uis.no

KEYWORDS:
cities; commoning; data politics; enclosure; energy; inclusion; infrastructure; social impact; social justice; smart energy; twin transition

TO CITE THIS ARTICLE:
Sareen, S., Smith, A., Gantioler, S., Balest, J., Brisbois, M. C., Tomasi, S., Sovacool, B., Torres Contreras, G. A., Dellavalle, N., & Haarstad, H. (2023). Social implications of energy infrastructure digitalisation and decarbonisation. *Buildings and Cities*, 4(1), pp. 612–628. DOI: https://doi.org/10.5334/bc.292

and being contested. This comparative multi-methods qualitative study offers insights into the challenges of enclosure—and opportunities for commoning—during transitions in urban transport in Bergen (NO); household solar photovoltaics in Brighton & Hove (UK); and smart meters in Trento (IT). This analysis provides policymakers and practitioners with a novel understanding of the social implications of energy infrastructure digitalisation. This can inform praxis for just transitions that transcend these specific contexts.

DOI: 10.5334/bc.292

1. INTRODUCTION

Increasingly, there is consensus that low-carbon-sourced electrification of multiple sectors, through their digitalisation and real-time coordination, is key for decarbonisation—a linkage termed the 'twin transition' (Fouquet & Hippe 2022). Digitalisation can be understood as the application of digital and connected technologies to broader organisational and socio-economic processes (Bukht & Heeks 2017), through real-time data flows and the decisions they enable. Proponents of 'just transitions' suggest that transitions can simultaneously address such multiple forms of exclusion while improving environmental sustainability and climate resilience (McCauley & Heffron 2018).

However, there is a clear risk that transition processes may be exclusionary and disempowering. The literatures on both digitalisation and decarbonisation in cities suggest that rapid technological development can disrupt public and democratic control mechanisms and have potentially undesirable implications for justice (Leszczynski 2020; Webster & Zhang 2021). Scholars have cautioned and shown that extractive data infrastructures can lead to enclosure of public goods (Sadowski 2019; Rommetveit *et al.* 2021).

The aim of this paper is to assess forms of commoning and enclosure in twin transitions in ongoing processes of energy infrastructure digitalisation. Ostrom's (1990) work on common pool resources has highlighted the potential effectiveness of common forms of organisation. Commoning can be contrasted to processes of enclosure, tending towards individualised organisation and distribution of benefits (Nikolaeva *et al.* 2019; Sevilla-Buitrago 2022). It can be understood as the organisation of society's resources in ways that emphasise user rights, collective management and distribution of ownership. Commoning represents interventions that aid inclusive transitions to low carbon energy infrastructure by creating common goods and services, and enlarging the urban commons (Nikolaeva *et al.* 2019).

Enclosure cordons off these benefits from broader publics for narrower private benefit, often at the cost of specific marginalised user groups. It represents digitalisation that increases commodification and inaccessibility of urban spaces. Zuboff (2019) posits that dystopian surveillance capitalism extracts behavioural surplus from users and holds them subservient to data-hungry (hence, energy-intensive) corporate infrastructuring. This can be applied to urban space, services, and flows of energy and information. Do energy infrastructure digitalisation efforts advance goals of commoning to create widely shared benefits, or of enclosure to privatise and individualise benefits to elites?

Many scholars have advanced this line of work. Moss *et al.* (2021) address commoning related to urban digitalisation, while Smith & Prieto Martin (2020) examine commons-based digital technologies for urban governance. Yet scholarship on commoning has predominantly focused on rural resource extractive contexts of marginality (*e.g.* McKay 2023; Cumming *et al.* 2020), far less on rapidly digitalising cities and forms of marginalisation in an urban context affected by a changing climate (Moss *et al.* 2021; Smith & Prieto Martin 2020).

Using the commoning–enclosure continuum, we seek to critically examine ongoing decarbonisation processes of energy infrastructure digitalisation for how they organise and distribute access and benefits across three distinct technologies and deployment in three specific cities: electric mobility in Bergen (NO), household solar photovoltaic (PV) in Brighton & Hove (UK) and smart meters in Trento (IT).

This is novel for its focus on urban digital innovation in relation to commoning and enclosure and the structured comparison of energy system digitalisation in three European cities. The consideration of the conceptual framing as a continuum indicates the difficulty to identify a trend as solely commoning or enclosure. Continuum thinking avoids pinning strong labels on trends that can be ambiguous and contingent, especially when underpinned by analysis that is mindful of the complex societal contexts in which transitions are rapidly unfolding.

The analysis is based on multi-sited fieldwork undertaken during the period 2021–22 in three sectors and three mid-sized cities, looking at energy infrastructure digitalisation in three sectors. The processes of commoning and enclosure were explored through broadly comparable fieldwork techniques featuring semi-structured expert interviews, citizen engagement through structured and semi-structured interviews, participatory workshops, and extended participant observation. To ensure analytical commensurability across case studies, the lenses of agency, power and accountability structure the analysis. These lenses are operationalised to characterise responses to digitalisation, whether resulting into commoning or enclosure. Agency relates to who has the ability to respond or act, power to who has the ability to decide how to respond, and accountability to who is held to account in responses to the twin transitions.

The paper is structured as follows. Section 2 elaborates on ideas of commoning and enclosure, and links these to analytical structuring questions that characterise responses to digitalisation. Section 3 outlines the methodology, empirical strategy and case study background with a tabular overview. Section 4 reports the empirical analysis in narrative form and identifies processes of commoning and enclosure. Section 5 concludes by discussing the implications for future commoning pathways during digitalisation.

2. COMMONING AND ENCLOSURE IN ENERGY INFRASTRUCTURE DIGITALISATION

Energy social science has made it abundantly clear that energy infrastructure digitalisation concerns more than simply technological innovation. It also involves deeply sociopolitical questions about emergent data infrastructures, flows and implications of related decision-making (Sadowski 2019). Energy infrastructure digitalisation implies changes in critical societal infrastructures, including data infrastructures and scope for new forms of control whose regulation is not fully embodied in existing institutional structures (Rommetveit *et al.* 2021). This creates conditions for opportunism and scope for confusion as to the attribution of responsibility for effects of emergent innovation (Zuboff 2019). The way energy infrastructure digitalisation becomes organised, owned and accessed is, arguably, key to which outcomes it produces, especially considering its role attributed to decarbonisation.

These terms can be conceptualised as conflicting processes of commoning and enclosure, to highlight the way energy infrastructure digitalisation efforts for decarbonisation create common benefits, or privatise and individualise benefits. Ostrom's (1990) work on common forms of resource governance has provided insights into core features of social arrangements underpinning commoning, and to some extent mainstreamed the concept. A key point of her work was that people are able to self-organise commons in ways that preserve ecological balance and equality of access, in contrast to the idea that private ownership is the only way to get people to manage resources fairly and effectively. However, this literature has more recently shifted attention towards the more dynamic and interstitial struggles for commoning in the midst of liberalisation and privatisation. Here commoning has less to do with 'traditional' and pre-capitalist social forms and more to do with finding spaces for collective organisation and ownership (McKay 2023), not mediated by purely transactional relations, and is also concerned with mobilising resistance against enclosure (Sevilla-Buitrago 2022). To Gibson-Graham *et al.* (2016: 195), commoning is a relational process of 'negotiating access, use, benefit, care, and responsibility'. In other words, there has been a shift from focus on 'the commons' as an actual domain with particular legal and organisational characteristics towards 'commoning' as a countervailing process and relationship in a continuous struggle with processes of enclosure. One can assess policies and interventions for whether they draw societal development towards commoning or enclosure.

In energy infrastructure digitalisation, there are ongoing contests between commoning and enclosure in multiple domains, including knowledge and information, decision-making processes, access to space, and ownership over infrastructure itself (De Angelis & Harvie 2014). Should energy infrastructure be governed in common, owned by state institutions that purport to represent the public interest, or marketed by private actors? Who owns and should access information generated through digitalisation processes, based on what grounds? To what extent should public interests and collective decision-making shape governance processes? Processes of digitalisation may be driven by energy service providers or private software platforms, which are typically unaccountable, hard to regulate and fundamentally undemocratic (Graham 2020). Or, they may be driven by peer-to-peer production, resting upon the participation of equal partners engaged in the production of common resources, and not organised according to hierarchical methods of command and control (De Angelis & Harvie 2014). Between these contrasting models there are, in most real-life cases, hybrids, overlaps and contention. This is especially true in relation to data politics in digitalisation, as access to, control over and collection protocols for data flows in novel infrastructure are typically poorly regulated compared with emergent enablements of innovation (Zuboff 2019; Zook 2017), and this poses exploitation risks especially for the most vulnerable (DellaValle *et al.* 2021). In extreme cases, patterns of digitalisation can only further entrench the scope and power of incumbent technology firms, erode privacy, or lead to increases in household conflict and social control (Iskandarova *et al.* 2022). This is of particular interest given the focus of the special issue to which this article contributes: data politics in the built environment.

To examine the practical struggle between commoning and enclosure, how the ideal forms are shaped and struggled over, the concepts of agency, power and accountability are operationalised in the case studies (*e.g.* Ahlborg 2017; Sareen & Haarstad 2020). Agency is central to longstanding social science debates (Sovacool *et al.* 2018), wherein economic perspectives consider agency as the capacity of individuals to decide and enact changes, while structural perspectives regard agency as a process entangled in social structures (Giddens 1979, 1984). Mindful of this legacy yet inclined to keep analytical treatment simple, 'agency' is operationalised here in terms of who responds (*i.e.* enacts changes) to enable digitalisation for decarbonisation. For example, entity X responding to data Y in a decisive and autonomous way has high agency, whereas entity B reacting to data C unwillingly is an instance of low agency. This aids empirical specification.

Power is intimately related to agency. Scholars of sociotechnical transitions recognise the importance of democratic decision-making, but also its difficulty, given power imbalances (Smith & Stirling 2010). The capacity to enact change is often asymmetrically distributed in terms of various forms of capital, and consequently, power (van Veelen & van der Horst 2018). 'Power' is operationalised here in terms of who decides how to respond to enable digitalisation. It is acknowledged that humans cannot act independently of their context (Hoff & Stiglitz 2016), and face complex motivational and cognitive structures to act collectively to address societal dilemmas without clearly defined authority (Ostrom 2010). Powerful actors are better positioned to freely make choices and thus 'decide how to respond', whereas those with less access to resources, technologies, knowledge, information and educational privilege are unable to express their agency without structural empowerment mechanisms that shift power relations (DellaValle & Czako 2022). Accordingly, 'accountability' is operationalised here through a focus on who is held to account in these responses and how, which concerns *answerability* as well as *enforceability* (Patterson *et al.* 2017). This relates to who ought to be responsible as well as to what mechanisms are necessary to ensure accountability.

These questions related to agency, power and accountability structure the empirical analysis of actors' responses that enable digitalisation in Section 4. Section 5 identifies processes of commoning and enclosure, as well as commoning pathways.

3. METHODOLOGY AND CASE BACKGROUND: AGENCY, POWER AND ACCOUNTABILITY

The analytical framework discussed above structures our analysis of distinct processes across multi-sited fieldwork efforts in the cities of Bergen, Brighton & Hove and Trento. In each city, after completing approximately 25 expert interviews and various forms of citizen engagement, stakeholder workshops were held. Stakeholders from the relevant sector were invited to a half-day gathering of 14–21 people who represented a range of interests to discuss power dynamics related to digitalisation in their sector. This primary data collection, summarised below, fed into numerous case-specific outputs of the Responsive Organising for Low Emission Societies (ROLES) project, and is selectively used here towards this first synthesis article across the case studies.

For mobility in Bergen, 25 expert interviews were conducted with various urban transport and spatial planners, transport operators and regulators, and representatives of civil society and interest group organisations active in public debates on transport. A total of 134 structured, multi-sited layperson interviews were on urban transport practices, focused on aspects of social inclusion, and three focus groups involving 17 interested laypersons. Additionally, there were two seminars (one public and the other limited to municipal planners for transport), one public workshop with role-play on urban transport, and one workshop in October 2022. These methods were supplemented by participant observation which included tracking media reports, following Facebook discussions on a group dedicated to urban development in Bergen, and observing and engaging in everyday urban mobility and in related events and debates.

For household and neighbourhood solar energy in Brighton & Hove, a mixture of methods was employed, aimed at generating evidence for different aspects of the uneven and multi-scalar twin transition. A total of 24 semi-structured interviews were held with households in four different urban neighbourhoods, each with mixed-residency housing, to understand their experiences with solar PV and related views on social inclusion. In parallel, 24 longer in-depth interviews were conducted with a variety of national stakeholders involved in 'smart local energy system' (SLES) demonstration programmes as the principal vehicle for the twin transition in the UK. These interviews explored social inclusion issues and strategies for digitalisation. A workshop was organised in Brighton & Hove in November 2022 with participants interested in energy justice questions, where local authorities, community energy organisations, and fuel poverty advisors mapped issues of inclusion and exclusion in energy systems and brainstormed about where, how and who could develop inclusive SLES.

For smart electric meters in Trento (which is implementing the smart city concept through European projects such as Stardust), the Madonna Bianca neighbourhood was selected for citizen interviews. Its ongoing innovative energy retrofit interventions and particular socio-economic characteristics directed this choice. The neighbourhood comprises a range of contrasting resident zones, from densely inhabited social housing to wealthy detached family houses. Here, 25 citizen interviews were conducted during summer 2021. In addition, 17 local and national experts across public and private sectors and civil society were interviewed on topics spanning climate and energy policy, smart electric meter policy and implementation, digitalisation, data governance and energy use, housing conditions, vulnerability and marginalised groups, energy justice, and energy poverty. Finally, stakeholders in Trento's twin transition participated in a half-day workshop in October 2022.

Table 1 features a cross-case summary overview analytically structured in terms of the questions corresponding to agency, power and accountability presented in Section 2. These short case backgrounds define and bound the scope of the content featured subsequently. This bounding draws on the surface level of our empirical case studies, and serves as background information on which the analysis in Section 4 builds in directions relevant for commoning pathways.

	PAST: PRE-DIGITALISATION	PRESENT: DIGITALISING FOR DECARBONISATION
Agency: who responds?	• For mobility in **Bergen**, this concerned supply-side actors who managed aggregate issues of supply-side management to steer the urban mobility sector in terms of routing, rolling stock, fuelling needs and multimodality • For solar energy in **Brighton & Hove**, this concerned distribution operators, private households and businesses that wished to take advantage of subsidised installations, the local council installing panels across some of its social housing stock and supporting bulk-purchase schemes for homeowners, and two local energy cooperatives coordinating larger scale installations on partner buildings for members, all feeding the electric grid • For smart electric meters in **Trento** in their first generation (1G) in the early 2000s, this concerned wholesale electricity market actors, including regulators, larger consumers and distribution utilities, who traded electricity on spot and future markets to secure competitive tariffs	• For mobility in **Bergen**, this concerns a widening set of actors who use electric vehicles such as e-buses, the expanding electric light rail, e-cars, e-bikes and e-scooters, and associated digital infrastructure for ticketing and parking • Digitalisation in **Brighton & Hove** has consisted of the national rollout of smart meters. A proposal to a national funding programme for 'smart local energy system' (SLES) trials around the city port and neighbouring residencies fell at the last hurdle. Photovoltaic (PV) rollout proceeds largely as for pre-digitalisation. The city council, network operator and community energy groups are keen on smarter demand management and local consumption. Households with smart meters can access flexibility tariffs offered by a national commercial utility • For smart electric meters in **Trento**, this concerns households receiving second generation (2G) smart electric meters, with widening applications for demand response, info apps and smart home energy devices. Meter replacement in homes aims to provide new and big data connected with user interfaces for better energy consumption information
Power: who decides how to respond?	• For mobility in **Bergen**, this concerned supply-side actors including the city council, regional transport operator Skyss, and the national highways authority determining traffic flows in and out of and within the city • For solar energy in **Brighton & Hove**, this concerned the national ministry managing the energy portfolio, and solar developers and electric utilities operating in the municipality • For 1G in **Trento**, this concerned the regulator and wholesale electricity market actors, as electricity was centrally managed as a technical sector	• For mobility in **Bergen**, this also concerns new companies leasing e-scooters, selling e-bikes and e-cars, and competing in public procurement processes for e-buses, as well as national and municipal actors devising mechanisms to promote electric vehicles and regulate movement of modes in the city • For solar energy in **Brighton & Hove**, this also concerns household solar self-consumers and prosumers, and ones keen to participate in SLES yet blocked by barriers, *e.g.* tenancy • For 2G in **Trento**, this also concerns those using electricity monitoring apps and in-home displays, dynamic tariffs and those flummoxed by changes as users of digitalising home electricity systems
Accountability: who is held to account in responses?	• For mobility in **Bergen**, this concerned users and providers of transport, the former for working within the centrally steered system, and the latter for abiding by service obligations based on terms of public tenders • For solar energy in **Brighton & Hove**, this concerned primarily small-scale solar actors blocked from installing plants, but also large actors governed by stringent rules on electricity service provision with fixed tariff structures • For 1G in **Trento**, this concerned primarily households as takers of conditions put in place by central regulators and executed by electric distribution utilities	• For mobility in **Bergen**, this concerns a wide swathe of increasingly differentiated transport users who increasingly organise in social movements related to heavily politicised urban transport sector debates, as well as the formal decision-makers • For solar energy in **Brighton & Hove**, this concerns installers, developers and regulators as well as households who interact through new regulations for solar energy prosumerism • For 2G in **Trento**, this concerns new data infrastructures shaping electricity use, pricing and electricity management practices in unevenly understood and shaped ways across actors

Table 1: Agency, power and accountability dynamics in energy infrastructure digitalisation and decarbonisation for three case studies.

4. AGENCY, POWER AND ACCOUNTABILITY

4.1 COMMONING

4.1.1 Who responds?

4.1.1.1 Bergen

In terms of agency towards commoning or enclosure, this varied enormously within Bergen's transport sector for different modes. With e-scooter rollout, there was ample public pushback that led to legislation to digitally regulate the use of public space through new micromobility infrastructure provision. During the period 2020–22, the municipality governed the emergent mode by demarcating parking spaces, providing residents an app to report misparked e-scooters, tendering the right to ply a limited number of e-scooters to operators through a competitive process with standards, and contracting out development of a digital regulatory tool to implement spatial delimitation of e-scooter operation across districts. A push towards commoning was evident in these attempts to make e-scooters meet residents' micromobility needs across suburbs.

With cars, digitalisation enabled toll stations, reduced city centre parking and aided car-sharing. Digitally enabled, heavily politicised toll roads fed into public transport funding while penalising car users, tending towards commoning mobility while penalising suburban car reliance for city trips. The growth of car-sharing with city-wide digital card access for members supported municipal goals on car-sharing and reduced urban public space devoted to cars, an important move towards spatial commoning.

4.1.1.2 Brighton & Hove

In this case, the expansion of solar energy relied upon innovative responses by households and businesses with the capital to purchase and install PV technology, which either had large financial assets they could leverage to purchase systems themselves, or were able to benefit from electricity sold into the distribution network at rates guaranteed by public policy (feed-in tariffs) and regulations permitting connections to the local network. City council housing budget investments supported installations for adoption in some social housing locations, and a national scheme helped homeowners finance some of the PV systems (although complaints did arise over the cost of breakdowns, invertor failures, poor warranties and costly energy storage devices to couple with the solar systems). Overall, Brighton reached 13 MW installed urban PV capacity by 2020. Two notable community energy organisations emerged and enabled larger installations based on members' investments, with generated income serving to expand cooperative installations. These community-based initiatives are the closest approximation to commoning, but they mark a commons-based approach that is contained and constrained within the national rules of a dominant wider market for trading solar electricity.

4.1.1.3 Trento

Here moving to smart electric meters freed residents' time away from manual readings and improved users' access to electricity consumption information. Based on increased decentralisation since the 1990s, regional distribution utilities have diversified an actor landscape formerly dominated by the public utility ENEL, and blackouts have become rarer. By 2017, distribution utilities began upgrading to second generation (2G) meters. Legislation for 2G meters mandated free choice on the electricity market and access to electricity consumption information for users, commoning key elements of electricity distribution. The national Regulatory Authority for Energy, Networks and Environment (ARERA) supported this thrust by requiring information provision of rollout plans through websites, toll-free numbers, leaflets, local newspapers and events. This development, however, offers a limited basis for shared energy management by energy communities, a future sectoral commoning possibility that remained distant. As stated in an expert interview, more granular electricity consumption data 'is not necessarily of immediate concern to many vulnerable groups, living in poverty'.

4.1.2 Who decides how to respond?

4.1.2.1 Bergen

In terms of who decided how to respond, with e-scooters in Bergen, authority shifted from their emergence to the development of legislation. Initially, a private company capitalised on the advent of these digitally enabled gadgets and acted aggressively, exploiting a legal loophole to defy the municipal vision and win in court, to continue plying e-scooters without effective regulation. Slower legislative processes took a year and the municipality was then able to devise its own regulations, drawing amply on digital tools to regulate the use of public space for micromobility. For the Light Rail, the city council and municipality largely led decision-making, while managing contestation across interest groups. This set back focus on digital innovation for multimodal integration, including ticketing, but initiatives such as mobility hubs did emerge, and the existing phases of the Light Rail proved highly successful, opening up room for manoeuvre for municipal authorities. This expansion of a mass transit solution is a key win for commoning. The procurement of a fleet of over 100 e-buses in 2021 was also significant for an electric multimodal system.

4.1.2.2 Brighton & Hove

As with many other cities, limited energy planning and policy authority locally in Brighton & Hove relied on keeping abreast of information and reporting from demonstration projects elsewhere on things such as: packages of PV, battery storage and flexible tariffs for participating households; digital platforms for aggregating and trading demand flexibility in energy markets; price incentives and marketing packages that offer discounts for demand timed to maximise consumption of local generation capacity; marketing that enables electric vehicles connected to charging stations to offer their batteries as a distributed balancing storage service across the local grid; in-house demand/generation displays and peer-to-peer coordination and trades; and greater control over demands from different household practices (*e.g.* laundering, heating, cooking) through internet controls. Household respondents in particular cautioned against adoption patterns for solar energy that seemed to exclude students and those renting property, those with low incomes, or those with emotional connections to their lofts (*e.g.* widows or widowers) who did not want the emotional trauma of sorting through and cleaning out their attics so installations could occur. The energy industry and government anticipated greater local consumption of local renewable electricity generation through better, digitalised data and controls for energy flexibility. Greater flexibility in the home and wider decentralised prosumption effectively enrols and integrates a wider range of agents into the electricity system. Thus, SLES designs will work best when there is sufficiently high inclusion of households and local generators for dynamic load-shifting and peak-shaving. It is anticipated that this will arise through market incentives towards individual, economically rational household consumers of commodified energy services. This dominant institutional frame leaves limited space for experimentation and consolidation of more commons-based approaches.

4.1.2.3 Trento

With 2G meters increasingly in place, there is now an emerging basis for decentralised initiatives such as energy communities where smart meters can play enabling roles. National government decisions, in line with ARERA which regulates implementation, have been influenced by European agreements such as the Clean Energy Package, enabling safeguards and cross-learning. Highly educated and wealthier households were generally better equipped to use available information to improve their practices already with first-generation (1G) meters and more readily drew the benefits of reducing electricity consumption. As an expert interviewee reflected:

> In the future the smart electricity meter may achieve its aim [to trigger energy savings], but I don't think the interaction part will be given to users for free. [...] Precisely those that may need it most will be excluded.

This shows a move towards commoning, but with twin transition benefits potentially biased towards socio-economically better-off households early on.

4.1.3 Who is held to account in responses?

4.1.3.1 Bergen

The city's transport twin transition debates featured a heavy focus on spatial politics. The municipality held car users to account as those occupying most space in the dense city centre, and e-scooter operators for running roughshod over limited pedestrian spaces with existing use. The Light Rail expansion likewise held to account national visions of transport futures that remained car centric in funding large highway projects, instead driving investment to a public transport mode that offered attractive options for residents. The car-sharing collective *Bildeleringen* as a digitally enabled car-sharing collective promoted an alternative of reduced car use while providing options for occasional car usage with limited public space allocation in recognition of the needs imposed due to existing car-centric infrastructure. Commoning thus worked to different extents for each transport mode, and in tension with wider spatial planning politics for the urban transport system as a whole.

4.1.3.2 Brighton & Hove

On the margins in Brighton & Hove, there was evidence of aspirations for more commons-based approaches to SLES, including integration of PV through energy digitalisation. Inspiration was drawn from community energy groups in other locations that coordinated demand flexibility across household members to maximise local consumption of energy from community-owned and -shared generation and storage of PV and other renewable electricity. Groups were developing feasibility studies for business models that sell 'community flexibility' services to electricity system operators in smart energy markets. One larger energy cooperative had looked into the feasibility of using data-cooperative models to govern and retain the value of member energy data. Another community group developed a community-owned battery in a social housing apartment block that would store electricity from the cooperatively owned PV on the roof during periods when generation exceeded local demand. Surplus in the batteries was then shared back amongst participating residents; however, this attempt at commoning electricity was constrained by costly market licences for trading in electricity and thus faced structural barriers. Thus, commoning pathways were being identified at the sub-urban scale but without clear institutional support and feasibility, or prospects of scaling without changes to private, market-dominated governance at higher policy levels.

4.1.3.3 Trento

For smart electric meters, ARERA had the formal responsibility to specify how users were informed about 2G smart meter rollouts and to govern user involvement in the process. It had mandated the provision of increasingly granular data to give users an improved basis for decision-making on electricity use and to help distribution utilities offer customised (and thus potentially more need-recognising) services to users. In addition, experts emphasised increased opportunities of easier switching between energy providers, building on flexible tariff systems. This national thrust offered indirect support to commoning by aiming to ensure user-centric offerings in a complex hybrid electricity market.

4.2 ENCLOSURE

4.2.1 Who responds?

4.2.1.1 Bergen

The twin transition cases presented several instances of advancing enclosure even as they showed some elements of commoning discussed above. For the Light Rail, recognition of success with the first two phases helped the city council back a third phase, but debates raged on its routing. More technical concerns of multimodal integration, in both apps and ticketing systems, remained marginal in public debates, despite their importance for holistic transport transitions. A failure to ensure proactive integration could lead to missed opportunities to combine bus/bicycle/e-bike/e-scooter usage with the Light Rail, or embrace peripheral park-and-rides to limit car trips into the city centre. This failure would facilitate enclosure of transport futures by electric cars, using cleaner energy sources but perpetuating the use of urban space by individually owned vehicles. Indeed, the national highways authority continued developing car-centric infrastructure into Bergen, encouraging increased future car use and frustrating urban efforts to move away from car dependence in infrastructure development. This indicates the limits of digital infrastructure in shaping the urban transport sector political economy.

4.2.1.2 Brighton & Hove

In the UK, the enclosure of electricity and capture of its regulation by the private sector has been extensive since the 1990s. The phase-out of feed-in tariffs in the UK after April 2019 made small-scale community solar projects less viable, including in Brighton & Hove. But cost declines in PV have nevertheless enabled continued PV installations, such as city council installations in social housing and community energy organisation investment in larger scale shared installations. While these remain viable, they must compete and operate within a form of digitalisation that encloses and commodifies demand flexibility and local generation, limiting PV growth at small scales with local beneficiaries, itself a form of enclosure of agency. This atrophied agency for solar in the UK sits in stark contrast to how other leading European countries promote and finance solar and renewable energy (Iskandarova *et al*. 2021).

4.2.1.3 Trento

The introduction of smart meters has provided users with more information, but it is also a digital and distant form of information that puts more control into the hands of distribution utilities. Interviewees stated that the lack of in-person interactions reduced personal connection with energy distribution utilities, making electricity more taken for granted but simultaneously a more liberalised sector. A household interviewee quipped:

> I have a meter because by law I have to have a meter, but I don't trust that any company provides me with the actual consumption.

This distancing marks a form of technical enclosure of possibilities for engagement due to digital infrastructure and automated data flows, with higher acceptance of default options and lower potential for energy citizenship. Digitalisation shifted meter reading authority to the remote distribution utility, making smart meter locations of little interest for households, except during power shortages for those with a 3 kW price-capped electricity supply on the 'safe electricity market'. Default options included three time slots with differentiated tariffs during parts of weekdays and full weekends to shift residential consumption to low industrial demand periods. Despite the ambition to empower users through information-sharing, in practice electricity markets prioritised supply-demand balancing for system efficiencies. Smart meter designs (and the design process) required additional tools for useful interfaces co-produced with users to recognise specific needs and provide relevant and intuitive information. Without such proactive engagement which requires enhanced digital literacy and awareness of energy rights among users, the digitalised electric grid became a site of supplier-led information or feedback enclosure (Andrejevic 2007), benefitting only some.

4.2.2 Who decides how to respond?

4.2.2.1 Bergen

National authorities played a heavy role in determining effects of digitalisation for cars. Attractive subsidy packages for e-cars led to a rapid rollout, clashing with urban priorities to shift away from car-centric planning, as e-car charging infrastructure took up new space. Yet municipal authorities exercised strategic digital control over public space to limit parking and penalise fossil fuelled cars in the city centre through tolls. The heavy promotion of car use and dependence by national authorities backed by well-organised lobby groups and embodied mobility practices embedded in car-centric infrastructures nonetheless marks a major form of spatial enclosure.

4.2.2.2 Brighton & Hove

As in the UK more broadly, energy policy and regulation for the twin transition were heavily centralised in the national energy ministry and energy market regulator. Regional network operators, national utility companies, local authorities and energy customers worked within the national framework (which included programmes for rolling out smart meters, promoting digitalisation in demand-side management and developing smarter energy systems). Here, SLES were a key component. National demonstration programmes combined public and private funds to competitively select partnerships to test and trial different energy digitalisation initiatives in a limited number of locations. Proposals for a large SLES demonstration around the port (at Shoreham-by-Sea) a little to the west of Brighton & Hove got to the final selection stage before falling at the final hurdle, and thus opportunities to experiment with digitalisation suffered a setback. Developers elsewhere recognised their activities should be 'inclusive by design', however in practice they operated through a digitalisation strategy that left the basic economic model for the electricity system broadly unchanged: regulated markets operated by private enterprises selling energy commodities to individual households who behave as utility-maximising individuals. Actors see demand flexibility as a capital asset. This assemblage constitutes a form of capitalist enclosure through state–corporate cooperation that excludes communities.

4.2.2.3 Trento

Electricity distribution remained centrally governed, from pre-digitalisation throughout digitalisation. As a private sector supplier-led initiative, smart meter rollout was initially shaped for supply-side efficiency rather than user empowerment. Mandates for user involvement were ineffective in shaping smart meter design for empowerment, with more influential sectoral actors driving developments towards their objectives. An expert interviewee described digitalisation as a central piece for the efficiency of the energy system and new business models: 'the more autonomous and less dependent on human action the better'. This marks enclosure of decision-making power.

4.2.3 Who is held to account in responses?

4.2.3.1 Bergen

Coming to enclosure and accountability, protesters against car tolls in the city centre held municipal planners to account against marginalising suburban residents in digital gatekeeping, with active debates and decisions. Digital e-scooter regulation learned from this, as the municipality contracted a company—Nivel Regulator—to develop a tool regulating how players spread their e-scooters in suburbs. During the study period, however, e-scooter rollout marked the enclosure of public space by private operators which regulations then evolved to control (for a detailed account, see Sareen *et al.* 2021).

4.2.3.2 Brighton & Hove

Broader notions of social inclusion in the twin transition for solar PV were noticeably absent, given the UK's centralised governance system of SLES development, and the politics of austerity that led to the rollback of numerous government support programmes, including the national feed-in tariff. This led to an enclosure of SLES benefits away from households unable to invest in requisite energy and digital technologies and capabilities, or in circumstances inappropriate for techno-economic integration into the emerging dominant SLES model. It also excluded households that were indifferent, disengaged or with more pressing priorities when struggling to access and afford basic services during an energy crisis as the cost of living crisis ran deeper. Distant energy system operators and those able to invest in prosumption locally drew off the benefits.

4.2.3.3 Trento

The outcome of formal requirements and strategies for smart electric meters rested largely on the set-up of intermediate devices, indirectly favouring households with higher disposable incomes for strategic investments. Civil society organisations and interest groups promoted concerns of energy poverty alleviation, but using 2G smart meters towards this goal in a practical sense remained without visible champions of change. ARERA can only provide procedural principles, giving distribution utilities discretionary room to adapt them to their regional contexts, and utilities in turn provide an implementation plan for smart meters. In practice, a distinct lacuna remained on who was responsible to ensure transparent information-sharing and effective user engagement in line with national legislative mandates.

5. COMMONING PATHWAYS FOR URBAN TWIN TRANSITIONS

What commoning and enclosure dynamics occur as cities digitalise energy infrastructure? This study has shown that they traverse a wide range in different sectors and circumstances, yet with some notable similarities. Both enclosure and commoning tendencies were found to occur.

Some brief implications are offered for future commoning pathways during twin transitions based on each case. The Bergen case shows that for urban transport, twin transitions can play out in diverse ways across different modes simultaneously, and that commoning requires thinking about multimodal integration when digitalising and electrifying a historically car-centric transport system. The Brighton & Hove case shows that the ways that digitalisation reframes and impacts the specific pathways for solar technology rollout in cities is contingent upon SLES as a larger ecosystem that requires comprehensive changes in non-technical parts of the sociotechnical system (such as legislation and bureaucracy) for widespread use in urban neighbourhoods. Without this, rooftop solar benefits are subject to enclosure by well-off households or beneficiaries of limited subsidy schemes. Concerns were also raised about solar energy waste streams, especially electronic waste, and warranties. The Trento case shows that smart electric meters in themselves change very little despite experience from previous rollouts. Thus, this infrastructural intervention needs to be co-produced with electricity users (increasing their energy literacy and the comprehensibility of the information given by smart meters) and informed by a wider understanding of flexible energy systems and their role in advancing equity to lead towards commoning of digitalised energy systems.

5.1 MOBILITY

The case study in Bergen shows that agency in mobility-related twin transitions (who responds) involves participation from unforeseen actors in societal debates on car-centric versus public transport-oriented urban planning and investment, where commoning outcomes are at stake. Strikingly, much agency rests at the national level, from where major investment decisions are directed (*e.g.* on highway infrastructure feeding traffic into the city) and co-shaped (*e.g.* through federal investment in urban transport being contingent on no growth in absolute car numbers within city limits) (see also Remme *et al.* 2022). When it comes to power (who decides how to respond), there is active negotiation and contestation between commoning and enclosure, varying across modes. With the Light Rail, societal engagement has ensured detailed analysis of options for expansion, with increasing recognition of its desirability as a transport mode for commoning urban mobility. With e-scooters and car tolls, public debate has often taken on aggressive overtones (Wanvik & Haarstad 2021), meaning formal authority alone does not suffice to push decisions through; rather, public legitimation of official stances is necessary. This raises questions of accountability (who is held to account in responses), and here the answer is complex. The e-scooter case in particular shows that regulatory lag during rapid digitalisation-enabled innovation can limit the ability of public authorities such as the municipality to control public space (*e.g.* Sareen *et al.* 2021). Yet, the emergence of new modes and forms of multimodality leads to evolving regulations such as e-gating of urban neighbourhoods, embodying digitalisation deeper into the ontology of everyday transport choices and experiences. Accountability can then be exercised in novel ways to create commoning pathways, such as through smartphone apps to report wrongly parked e-scooters once regulations have been developed. Yet those less keen on or unable to use such devices to modulate their relationship with transport become ever more systematically excluded, a form of digital enclosure. Thus, several tendencies of commoning and enclosure interplay, without a definitive orientation to the urban transport twin transition.

5.2 SOLAR TECHNOLOGY

Bottom-up attempts to configure the digitalisation of PV (and other technologies) into a commons-based SLES in Brighton & Hove were compromised by an electricity regime that serves to enclose control and benefits for energy companies and away from users. SLES and PV digitalisation demonstrations do not extend to experiments with new ownership models or governance arrangements for reconceiving electricity as a digitalised commons to coordinate real-time demand flexibility with shared local generation (Smith *et al.* 2023). Instead, community energy groups can become outreach partners with industry demonstrations. These arrangements offer only limited possibilities to engage with households (including those in disadvantaged communities) and afford little scope to explore community-based commoning during digitalisation. For instance, the electricity market regime makes a grassroots innovation scheme for energy flexibility by a community energy organisation reliant upon established private utility companies (*e.g.* buying the flexibility or licensing trades in electricity), enclosing control with the latter. Community members and residents are consequently required to contract with these coordinating utilities (the same for local energy groups wishing to maximise local consumption of local generation) with the result that commons-aspiring schemes turn into community-based extraction. Consequently, marginalised users exhibit 'non-engagement' in SLES (Soutar *et al.* 2022). More generally, surveys show public trust in energy utilities in the UK never exceeds 50% of households (Citizens Advice 2015), with another survey finding only 5% of households were aware of the roles and possibilities that digitalisation and SLES strategies anticipate for them (ESC 2021). Despite this, the case study shows that measures purportedly for inclusive innovation in SLES demonstrations persist in turning households into willing smart energy customers (with hopes that unspecified social tariffs will cushion those unable or unwilling to comply). An enclosure model prevails in what are profoundly complex and penetrating sociotechnical changes being proposed in energy systems.

5.3 SMART ENERGY INFRASTRUCTURE

The balance of agency, power and accountability relations in Trento is stacked against residents in the digitalisation of energy infrastructures through 2G smart electric meter rollout. This perpetuates the enclosure of smart grid functions and benefits by influential political and economic actors such as incumbent electricity distribution utilities. Organisations such as research institutes lobby for more inclusive designs of twin transition processes and technologies, *e.g.* to alleviate energy poverty and increase energy literacy. Yet a lack of definition of which actor is accountable to create an effective tool, relevant for residents and able to enhance social inclusion, holds back commoning in the 2G rollout. The case study reveals implications for socially inclusive pathways in the twin transition. First, rather than energy access, the 2G rollout poses challenges related to the effective use of digital technologies by demographic groups such as the elderly, who are vulnerable to the adverse effects of fluxes in dynamic tariffs. Second, despite legal mandates for public involvement in the 2G design and rollout, nothing prevents utilities from treating this symbolically with impunity, reducing it to mere information provision about new technological infrastructures. This perpetuates stereotypes of residents as disinterested in design and decision-making processes in twin transitions, while excluding them from the outset and thus rendering the devices less relevant to their energy practices (see also Gillespie 2014). Third, workshop discussions identified the scope for a commoning pathway through transparent voting mechanisms within energy communities to balance power dynamics and ensure collaborative democratic processes, a structural emphasis extendable to wider energy systems governance. Finally, the lack of attention to redistributive possibilities within twin transitions to support vulnerable groups, by using digital infrastructure such as 2G meters to disseminate information and knowledge to boost effective individual decision-making for cost reduction and load optimisation, represents a form of digital enclosure due to lacking (co-designed) user-centric communication channels.

Some cross-cutting aspects from the case studies can inform thinking about commoning pathways for digitalising energy infrastructure more broadly in urban twin transitions beyond these case studies. Fieldwork with households in Brighton & Hove revealed that interviewees identify with numerous inequities in existing PV arrangements (Sovacool *et al.* 2022). Inequalities in ownership in housing skew PV uptake towards wealthier, privately owned households, or social housing tenants fortunate to be selected for panels under publicly administered schemes. Participants spoke about key household decisions in PV adoption and use being gendered, and only being available to those with the money, skills and technical education required. Nearly all respondents were concerned that SLES would exacerbate exclusions such as those evident in PV. These trends are remarkably similar to those identified in Trento related to 2G smart meter rollout. Another similarity is cognisance of the need to move towards collective solutions. Despite PV rollout being organised largely as an individualised and market-based experience in Brighton & Hove, households were interested in community-oriented approaches and benefits, as is also the case more widely in the UK with participants in SLES demonstrations (Bray & Woodman 2020). This is reminiscent of the embrace of the Light Rail as a collective transport solution towards commoning in Bergen along tracts formerly dominated by a preference for cars. These views and experiences suggest a basis for building up more commons-oriented approaches where resources and opportunities for digitalisation open to experiments in different kinds of ownership and use rights.

Ownership and influence at key decision-making loci (*e.g.* of the electric grid, or of transport networks) were often seen as vital power issues that inhibited aspiration for commoning the twin transition. However, several participants valued agency in holding incumbents to greater account, from transport users to solar prosumers to smart grid enthusiasts keen to counter energy poverty.

DOI: 10.5334/bc.292

To different extents, digitalisation was seen as a form of enclosure extending the scope of service providers to exclude and discipline some users (*e.g.* poorer or less tech-savvy households) and worth challenging. Holding enclosures and exclusions to account was thus a way to undermine a liberal-individualised rollout of digitalisation and thereby to enhance the legitimacy of alternative, commons-oriented approaches, thus creating commoning pathways. A cross-cutting key challenge was to normalise commoning pathways across local actors and institutions and to bring them to bear on decision-making at higher levels of governance than the local (*e.g.* the national).

To a limited extent users do respond linearly to price signals, communities to self-organisation possibilities, and regulators to technological developments. But there are far greater barriers to enabling commoning pathways during urban twin transitions. Research on commoning pathways argues that authoritative institutions must promote contexts for collective action by users rather than shifting responsibilities to them (Lennon *et al.* 2020; Rommetveit *et al.* 2021). Without local commoning, digitalisation may fail to shift energy infrastructure away from its current unjust configurations (DellaValle *et al.* 2021), perpetuating a top-down tendency to accumulate and concentrate wealth in a few pockets of privilege through remote cybernetic control, while raising troubling prospects for data justice and accountability as new data flows emerge and their control is institutionalised through emergent forms of digitalised enclosure.

There is a clear need for researchers, policymakers and practitioners to identify, enable and institutionalise commoning processes in infrastructures that increasingly deliver essential services such as energy, transport and data. These three case studies offer a basis to build upon for this massive challenge.

ACKNOWLEDGEMENTS

The authors are grateful to the respondents who spared their time to share their views, to the funders who supported this research project, and to their colleagues who contributed along the way. The views expressed in this paper are purely those of the authors and may not, under any circumstances, be regarded as an official position of the European Commission.

AUTHOR AFFILIATIONS

Siddharth Sareen orcid.org/0000-0002-0826-7311
Department of Media and Social Sciences, University of Stavanger, Stavanger, NO;
Department of Geography and Centre for Climate and Energy Transformation, University of Bergen, Bergen, NO

Adrian Smith orcid.org/0000-0001-8027-712X
Science Policy Research Unit, University of Sussex, Falmer, Brighton, UK

Sonja Gantioler orcid.org/0000-0003-3597-6460
Institute for Renewable Energy, Eurac Research, Bolzano, IT

Jessica Balest orcid.org/0000-0002-5319-3075
Institute for Renewable Energy, Eurac Research, Bolzano, IT

Marie Claire Brisbois orcid.org/0000-0001-6600-7297
Science Policy Research Unit, University of Sussex, Falmer, Brighton, UK

Silvia Tomasi orcid.org/0000-0002-5815-1544
Institute for Renewable Energy, Eurac Research, Bolzano, IT

Benjamin Sovacool orcid.org/0000-0002-4794-9403
Science Policy Research Unit, University of Sussex, Falmer, Brighton, UK;
Global Sustainability Institute, Boston University, Boston, MA, US

Gerardo A. Torres Contreras orcid.org/0000-0003-2520-7924
Science Policy Research Unit, University of Sussex, Falmer, Brighton, UK

Nives DellaValle orcid.org/0000-0001-8241-4677
European Commission, Joint Research Centre, Ispra, IT

Håvard Haarstad orcid.org/0000-0002-2791-9282
Department of Geography and Centre for Climate and Energy Transformation, University of Bergen, Bergen, NO

AUTHOR CONTRIBUTIONS

SS led the conceptualisation, methodology, writing of the original draft as well as review and editing, and funding acquisition and project administration, with contributions from the co-authors. All authors contributed to data collection and analysis.

COMPETING INTERESTS

The authors have no competing interests to declare.

DATA AVAILABILITY

The data are available from the authors upon reasonable request and in anonymised form.

ETHICAL APPROVAL

The study was carried out as part of the Responsive Organising for Low Emission Societies (ROLES) project and in compliance with national ethics guidelines in Norway, the UK and Italy.

FUNDING

This research was supported by funding from the Joint Programming Initiative (JPI) Climate, via the SOLSTICE call, through the Research Council of Norway (grant number 321421), the UK's Economic and Social Research Council (ESRC) (grant number ES/VO1403X/1) and the Italian Ministry for University and Research (grant number SOLSTICE19_00007) for the project entitled Responsive Organising for Low Emission Societies (ROLES).

REFERENCES

Ahlborg, H. (2017). Towards a conceptualization of power in energy transitions. *Environmental Innovation and Societal Transitions*, 25, 122–141. DOI: https://doi.org/10.1016/j.eist.2017.01.004

Andrejevic, M. (2007). Surveillance in the digital enclosure. *Communication Review*, 10(4), 295–317. DOI: https://doi.org/10.1080/10714420701715365

Bray, R., & **Woodman, B.** (2020). *Cornwall local energy market—Householder survey report*. University of Exeter. http://hdl.handle.net/10871/120972

Bukht, R., & **Heeks, R.** (2017). *Defining, conceptualising and measuring the digital economy* (Development Informatics Working Paper Series Vol. 68). University of Manchester. DOI: https://doi.org/10.2139/ssrn.3431732

Citizens Advice. (2015). *Trust in the energy sector and billing*. Citizens Advice. https://www.citizensadvice.org.uk/global/migrated_documents/corporate/attachment-2---summary-of-energy-trust-polling.pdf

Cumming, G. S., Epstein, G., Anderies, J. M., Apetrei, C. I., Baggio, J., Bodin, Ö., … & **Weible, C. M.** (2020). Advancing understanding of natural resource governance: A post-Ostrom research agenda. *Current Opinion in Environmental Sustainability*, 44, 26–34. DOI: https://doi.org/10.1016/j.cosust.2020.02.005

De Angelis, M., & **Harvie, D.** (2014). The commons. In M. Parker, G. Cheney, V. Fournier & C. Land (Eds.), *The Routledge companion to alternative organizations* (pp. 280–294). Routledge.

DellaValle, N., & **Czako, V.** (2022). Empowering energy citizenship among the energy poor. *Energy Research & Social Science*, 89, 102654. DOI: https://doi.org/10.1016/j.erss.2022.102654

DellaValle, N., Gantioler, S., & **Tomasi, S.** (2021). Can behaviorally informed urban living labs foster the energy transition in cities? *Frontiers in Sustainable Cities*, 3: 573174. DOI: https://doi.org/10.3389/frsc.2021.573174

ESC. (2021). *SLES user acceptance survey 2021*. Energy Systems Catapult (ESC). https://es.catapult.org.uk/report/user-acceptance-of-smart-local-energy-systems-key-insights-on-public-opinion/

Fouquet, R., & **Hippe, R.** (2022). Twin transitions of decarbonisation and digitalisation: A historical perspective on energy and information in European economies. *Energy Research & Social Science*, 91, 102736. DOI: https://doi.org/10.1016/j.erss.2022.102736

Gibson-Graham, J. K., Cameron, J., & **Healy, S.** (2016). Commoning as a postcapitalist politics. In A. Amin & P. Howell (Eds.), *Releasing the commons: Rethinking the futures of the commons* (pp. 192–212). Routledge. DOI: https://doi.org/10.4324/9781315673172-12

Giddens, A. (1979). *Central problems in social theory: Action, structure, and contradiction in social analysis* (Vol. 241). University of California Press. DOI: https://doi.org/10.1007/978-1-349-16161-4

Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. University of California Press.

Gillespie, T. (2014). The relevance of algorithms. In T. Gillespie, P. Boczkowski & K. Foot (Eds.), *Media technologies: Essays on communication, materiality, and society* (pp. 167–194). MIT Press. DOI: https://doi.org/10.7551/mitpress/9780262525374.003.0009

Graham, M. (2020). Regulate, replicate, and resist–the conjunctural geographies of platform urbanism. *Urban Geography*, 41(3), 453–457. DOI: https://doi.org/10.1080/02723638.2020.1717028

Hoff, K., & **Stiglitz, J. E.** (2016). Striving for balance in economics: Towards a theory of the social determination of behavior. *Journal of Economic Behavior & Organization*, 126, 25–57. DOI: https://doi.org/10.1016/j.jebo.2016.01.005

Iskandarova, M., Dembek, A., Fraaije, M., Matthews, W., Stasik, A., Wittmayer, J. M., & **Sovacool, B. K.** (2021). Who finances renewable energy in Europe? Examining temporality, authority and contestation in solar and wind subsidies in Poland, the Netherlands and the United Kingdom. *Energy Strategy Reviews*, 38, 100730. DOI: https://doi.org/10.1016/j.esr.2021.100730

Iskandarova, M., Vernay, A. L., Musiolik, J., Müller, L., & **Sovacool, B. K.** (2022). Tangled transitions: Exploring the emergence of local electricity exchange in France, Switzerland and Great Britain. *Technological Forecasting and Social Change*, 180, 121677. DOI: https://doi.org/10.1016/j.techfore.2022.121677

Lennon, B., Dunphy, N., Gaffney, C., Revez, A., Mullally, G., & **O'Connor, P.** (2020). Citizen or consumer? Reconsidering energy citizenship. *Journal of Environmental Policy & Planning*, 22(2), 184–197. DOI: https://doi.org/10.1080/1523908X.2019.1680277

Leszczynski, A. (2020). Glitchy vignettes of platform urbanism. *Environment and Planning D: Society and Space*, 38(2), 189–208. DOI: https://doi.org/10.1177/0263775819878721

McCauley, D., & **Heffron, R.** (2018). Just transition: Integrating climate, energy and environmental justice. *Energy Policy*, 119, 1–7. DOI: https://doi.org/10.1016/j.enpol.2018.04.014

McKay, S. (2023). Common-pool resources and democracy. *Critical Review of International Social and Political Philosophy*, 1–24. DOI: https://doi.org/10.1080/13698230.2023.2185382

Moss, T., Voigt, F., & **Becker, S.** (2021). Digital urban nature: probing a void in the smart city discourse. *City*, 25(3–4), 255–276. DOI: https://doi.org/10.1080/13604813.2021.1935513

Nikolaeva, A., Adey, P., Cresswell, T., Lee, J. Y., Nóvoa, A., & **Temenos, C.** (2019). Commoning mobility: Towards a new politics of mobility transitions. *Transactions of the Institute of British Geographers*, 44(2), 346–360. DOI: https://doi.org/10.1111/tran.12287

Ostrom, E. (1990). *Governing the commons: The evolution of institutions for collective action*. Cambridge University Press. DOI: https://doi.org/10.1017/CBO9780511807763

Ostrom, E. (2010). Polycentric systems for coping with collective action and global environmental change. *Global Environmental Change*, 20(4), 550–557. DOI: https://doi.org/10.1016/j.gloenvcha.2010.07.004

Patterson, J., Schulz, K., Vervoort, J., Van Der Hel, S., Widerberg, O., Adler, C., ... & **Barau, A.** (2017). Exploring the governance and politics of transformations towards sustainability. *Environmental Innovation and Societal Transitions*, 24, 1–16. DOI: https://doi.org/10.1016/j.eist.2016.09.001

Remme, D., Sareen, S., & **Haarstad, H.** (2022). Who benefits from sustainable mobility transitions? Social inclusion, populist resistance and elite capture in Bergen, Norway. *Journal of Transport Geography*, 105, 103475. DOI: https://doi.org/10.1016/j.jtrangeo.2022.103475

Rommetveit, K., Ballo, I. F., & **Sareen, S.** (2021). Extracting users: Regimes of engagement in Norwegian smart electricity transition. *Science, Technology, & Human Values*. DOI: https://doi.org/10.1177/01622439211052867

Sadowski, J. (2019). When data is capital: Datafication, accumulation, and extraction. *Big Data & Society*, 6(1). DOI: https://doi.org/10.1177/2053951718820549

Sareen, S., & **Haarstad, H.** (2020). Legitimacy and accountability in the governance of sustainable energy transitions. *Global Transitions*, 2, 47–50. DOI: https://doi.org/10.1016/j.glt.2020.02.001

Sareen, S., Remme, D., & **Haarstad, H.** (2021). E-scooter regulation: The micro-politics of market-making for micro-mobility in Bergen. *Environmental Innovation and Societal Transitions*, 40, 461–473. DOI: https://doi.org/10.1016/j.eist.2021.10.009

Sevilla-Buitrago, A. (2022). *Against the commons. A radical history of urban planning*. University of Minnesota Press.

Smith, A., Contreras, G. A. T., Brisbois, M. C., Lacey-Barnacle, M., & **Sovacool, B. K.** (2023). Inclusive innovation in just transitions: The case of smart local energy systems in the UK. *Environmental Innovation and Societal Transitions*, 47, 100719. DOI: https://doi.org/10.1016/j.eist.2023.100719

Smith, A., & **Prieto Martín, P.** (2020). Going beyond the smart city? Implementing technopolitical platforms for urban democracy in Madrid and Barcelona. *Journal of Urban Technology*, 28(1–2), 311–330. DOI: https://doi.org/10.1080/10630732.2020.1786337

Smith, A., & **Stirling, A.** (2010). The politics of social–ecological resilience and sustainable socio-technical transitions. *Ecology and Society*, 15(1). https://www.jstor.org/stable/26268112. DOI: https://doi.org/10.5751/ES-03218-150111

Soutar, I., Devine-Wright, P., Rohse, M., Walker, C., Gooding, L., Devine-Wright, H., & **Kay, I.** (2022). Constructing practices of engagement with users and communities: Comparing emergent state-led smart local energy systems. *Energy Policy*, 171, 113279. DOI: https://doi.org/10.1016/j.enpol.2022.113279

Sovacool, B. K., Axsen, J., & **Sorrell, S.** (2018). Promoting novelty, rigor, and style in energy social science: Towards codes of practice for appropriate methods and research design. *Energy Research & Social Science*, 45, 12–42. DOI: https://doi.org/10.1016/j.erss.2018.07.007

Sovacool, B. K., Lacey, M., Smith, A. & **Claire, M.** (2022). Towards improved solar energy justice: Exploring the complex inequities of household adoption of photovoltaic panels. *Energy Policy*, 164, 112868. DOI: https://doi.org/10.1016/j.enpol.2022.112868

Van Veelen, B., & **Van der Horst, D.** (2018). What is energy democracy? Connecting social science energy research and political theory. *Energy Research & Social Science*, 46, 19–28. DOI: https://doi.org/10.1016/j.erss.2018.06.010

Wanvik, T. I., & **Haarstad, H.** (2021). Populism, instability, and rupture in sustainability transformations. *Annals of the American Association of Geographers*, 111(7), 2096–2111. DOI: https://doi.org/10.1080/24694452.2020.1866486

Webster, N. A., & **Zhang, Q.** (2021). Centering social-technical relations in studying platform urbanism: Intersectionality for just futures in European cities. *Urban Transformations*, 3(1), 1–7. DOI: https://doi.org/10.1186/s42854-021-00027-z

Zook, M. (2017). Crowd-sourcing the smart city: Using big geosocial media metrics in urban governance. *Big Data & Society*, 4(1). DOI: https://doi.org/10.1177/2053951717694384

Zuboff, S. (2019). *The age of surveillance capitalism: The fight for a human future at the new frontier of power*. Hachette.

TO CITE THIS ARTICLE:
Sareen, S., Smith, A., Gantioler, S., Balest, J., Brisbois, M. C., Tomasi, S., Sovacool, B., Torres Contreras, G. A., Dellavalle, N., & Haarstad, H. (2023). Social implications of energy infrastructure digitalisation and decarbonisation. *Buildings and Cities*, 4(1), pp. 612–628. DOI: https://doi.org/10.5334/bc.292

Submitted: 01 February 2023
Accepted: 30 July 2023
Published: 18 August 2023