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Digitalisation and social inclusion in multi-scalar smart energy transitions

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ABSTRACT

Activity generated around smart energy transitions risks undermining a basic spatial planning principle: create better places for inhabitants. The possibilities unleashed by digitalisation have enigmatic force. Stepping back from this techno-centrism, this article asks: where are the people in these visions? How can energy sector digitalisation become people-centric and inclusive? It employs a multi-scalar approach to examine social inclusion in case studies of two smart energy transitions: electricity sector digitalisation in Lisbon, and mobility sector digitalisation in Bergen. This reveals how planning and implementing sustainability transitions can exacerbate existing inequalities, but equally offers opportunities to enable inclusive smart energy transitions.

1. Digitalisation and socially inclusive energy transitions

The hive of activity generated around smart energy transitions, i.e. transitions to smart energy systems (see also [1]), runs the risk of forgetting basic planning principles: create better places for those who inhabit them [2,3]. A core aspect of smart energy transitions is digitalisation, which unleashes untold possibilities for future energy systems and energy practices. Digitalisation can enable real-time cross-sectoral coordination for desirable changes such as rapid decarbonisation. Weber and Schaper-Rinkel [4] point out that digitalisation is about “the instantaneous interconnection of activities in different sectors, and thus about trans- and intersectoral innovation dynamics.” This paper employs a “differentiation between “digitisation”: conversion of data from analogue to digital form; and “digitalisation”: application of digitisation to organisational and social processes (including economic activity)” [5, p.12], focusing on processes linked to digitalisation. These emergent processes captivate spatial planners, motivate a lobby of industrial entrepreneurs innovating new technologies, and become a go-to for administrators and politicians who are in positions where they need to demonstrate progress [6]. A tangible, sleek new digital technology conveys a sense of the future through its association with utopian and dystopian visions that are deeply imprinted in our social imaginaries of likely urban evolution [7]. Digitalisation entails risks of data extraction, social exclusion and systemic instability, and thus must be critically evaluated in terms of benefits and risks [8]. This paper assesses whether digitalisation, as a process at the core of smart energy transitions, is people-centric and inclusive.

The article extends an emerging debate on inclusion in digitalisation. Sadowski [9] critiques the datafication of society as mainly driven by data extraction, while Cardullo and Kitchin [10, p.813] lament low emphasis on “the right to the city, entitlements, community, participation, commons, and ideals beyond the market” in smart initiatives. The innovators, planners and public–private collaborators of digitalisation efforts rarely prioritise inclusion in consequential decisions [11,12]. They are often planners without training in digital innovation ecosystems; or engineers whose point of entry into digitalisation was their technical ability and training; or analysts and marketers who understand niche development and excel at implementing new technologies [13]. Traditionally, these roles were more separated, because the private sector required authoritative approval to roll out technological solutions, or was called upon to design technologies to address specific public needs. The way has been paved for the acceleration of technological innovation by the steady erosion of the public sector through first incipient (through public–private partnerships on risky activities that constructed cities as objects for investors, see [14]) then increasingly dominant neoliberal forces [15]. For digitalisation in smart energy transitions, we have entered a situation where innovation leads whereas public regulation lags [7], and municipal authorities arguably find themselves taking on the role of facilitators of rapid technological rollout unfettered by pro-citizen regulation, a state role that Mazzucato [16] has influentially addressed in Europe by pushing for a more pro-active entrepreneurial state that directs innovation towards public benefit. More bottom-up modes of citizen-centric and citizen-driven innovation are also proliferating (see e.g. [17]).

At such a juncture, mechanisms to ensure that public accountability is built into the rollout of digital energy transition technologies gain

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renewed importance [1,18]. The reconstitution of the urban fabric presents numerous opportunities for actors to leverage privileged positions [19]. Even without malintent, such actors' interests may not necessarily align with what is good for residents in the city or the wider region [20,23,31,32], although smart city scholars are underway with identifying ways to move towards virtuous big data usage that creates public benefits in practice [24,25]. A basic understanding of the public good implies that cities and regions must be inclusive spaces, where residents can be assured of their safety and feel free to express themselves in ways that are respectful of others [26]. This combines both aspects of citizenship: civic rights and obligations. Extending this basic principle to smart energy transitions, one can state that such forms of development must be accessible to and generate benefits for everyone. An inclusive orientation in regulation may include, for instance, reducing outsized benefits to incumbent actors–or to heavily incentivised recent entrants–who may be unduly privileged due to historically inequitable structures [27]. Yet whether inclusive regulation is politically feasible merits empirical enquiry, as it may be blocked by powerful, self-interested stakeholders.

This article therefore empirically examines whether smart energy transition initiatives actually deliver social inclusion, and identifies ways to enable this. Hughes et al. [28] argue that digitalisation promotes narrow metrics of change, on whose basis decision-makers may fail to address concrete local needs. The electrification of mobility is a notable example: whereas a rational smart energy transition objective would be to simultaneously reduce individual automobile use and enable modal shifts to public transport with low-carbon sources [29], leading transport electrification transitions reveal significant dilemmas about social inclusion and elitism in allocating subsidies and public space [30]. Such examples increasingly intertwine with people's lives across sectors, as digitalisation transforms everyday acts into domains of hybrid governance (through what [31, p.273] refers to as "smart urban infrastructures"). This hybridisation motivates the present investigation of whether and how smart energy transitions are inclusive or not, using two prima facie successful digitalisation case studies.

The next section combines conceptual insights on digitising energy systems from multiple sectors with a common analytical concern with socio-spatial inclusion, i.e., inclusion concerning societal and built infrastructural interactions. Section three presents a multi-scalar approach and draws on insights from the scholarship on intersecting inequalities [32]. Section four applies this approach to two smart energy transition cases: smart electricity transitions in Lisbon, Portugal and smart mobility transitions in Bergen, Norway. This section uses primary and secondary data to analyse the societal impact of digitalisation [33]. Section five discusses how digitalisation can co-produce knowledge with vulnerable residents for socio-spatially inclusive smart energy transitions. Section six concludes that a multi-scalar approach can help enable inclusive smart energy transitions, by bringing granular processes and impacts of digitalisation into view across scales from the national to the neighbourhood.

2. Cross-sectoral coordination and vulnerable users

As advanced digital technologies penetrate most spheres of human activity, their omnipresence drives significant changes in social organisation [34]. Increasingly pervasive automation encounters the institutional continuity of analogue modes of social organisation in particular sectors [35,36]. This gives rise to what Safransky [21, p.200] terms 'algorithmic violence', defined as a "repetitive and standardized form of violence that contributes to the racialization of space and spatialization of poverty" due to inequitably distributed socio-spatial impacts. This dynamic of extraction and seamless continuity of historically unjust patterns through new data infrastructures drives specific socio-spatial trajectories as cities and regions update sectoral operations, increasingly by digitalising them, not necessarily in the direction of low-carbon transitions but rather towards surveillance capitalism. The failed attempt of Sidewalk Labs in Toronto (where the information technology giant Alphabet tried to build data infrastructures into the fabric of an urban neighbourhood to maximise systematic data extraction potential) is a cautionary tale, whereas Barcelona Digital City (which took a broader, socially-engaged approach to digitalisation to align outcomes with expressed needs from a wider public) marks an instance of a city avoiding narrow techno-centrism [22]. Thus, smart energy transitions may embed historically unjust patterns in new, extractive data infrastructures.

Coincident with an unprecedented merging of sectors, digitalisation raises complex regulatory challenges. The electrification of transport, for example, requires coordination between traditionally separate transport and electricity authorities, to balance supply and demand. These sectors have rarely cooperated to such an extent [37]; electrification of railway systems constitutes a historical example, albeit one that took place with less multi-modality and partly at higher spatial scales. With more electric vehicles increasing electric demand, grid management and transport charging infrastructure embody unprecedented complexity [30]. This can only be resolved by digitising electric meters and chargers, and deploying charging standards for vehicles.

Such developments have made recognition of people's needs in transitions governance of great importance [38]. This recognition is notable in European Commission policies and funding mechanisms, including a prominent Horizon 2020 call focused on energy citizenship, defined as "civic engagement, active participation and interaction with institutional or corporate actors" in the energy sector.[1] However, as noted in [10], citizenship can be constructed as a vehicle to proliferate neoliberal tendencies over public interest. Engagement must negotiate interests between competing actors and a state apparatus that cannot always track forums where negotiation occurs. For instance, citizens who drive electric cars determine when significant demand is placed on the electric grid and play roles in deciding when to prosume–i.e., to return electricity to the grid–from car batteries for remuneration. Transport authorities liaise with electric utilities to provide charging infrastructure, which requires coordination with land use planners to avoid disrupting residents' lives, while serving electric car users. There is thus a need to balance incentives and returns to supply-side implementers of digitalisation with ensuring a positive impact on the needs of energy end-users whom it is intended to serve.

A parallel can be drawn to solar energy prosuming, where households are also producers of electricity they can stream to the grid from rooftop solar modules. Prosumers can help or hinder grid management based on the regulations that penalise or reward distributed energy generation [39]. Such emerging socio-technical challenges make cross-sectoral coordination key to socio-spatial thinking across scales, by directing attention to the allocation of benefits and burdens across actors and spaces of vulnerability [40]. Vulnerability is understood after Sovacool [41, p.4] as "not only shaped by exposure and the extent of human capabilities [but] … also shaped by social relations and the reproduction of ethnicity, class, caste, gender and heritage", a conception that opens up for both vulnerable users and vulnerable areas as exposed to risk, in keeping with the focus on socio-spatial inclusion. Co-producing knowledge for cross-sectoral coordination becomes essential to inclusive digitalisation of energy systems, as it enables analysis of problems whose varied societal impacts may adversely impact marginalised residents. For instance, energy poor households are especially vulnerable to fluctuations in electricity tariffs, as electricity bills constitute a higher share of their budget, and as their electricity use patterns tend to be relatively inflexible [42].

Differentiated societal impacts of digitalisation are identified (albeit not specific to energy systems) in vast literatures on social protection

[1] For details, see the call: https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/lc-sc3-cc-1–2018-2019–2020

and environmental justice, with focus areas on values such as affirmative action [43], participatory planning [44] and management of power dynamics [45]. Scholars have shown that vulnerable users are rarely informed about or explicitly considered within urban agendas to digitise; poorly positioned to provide inputs about their preferences within urban planning processes; and thus discriminated against in business-as-usual evolution, e.g., digitalisation [46]. Such exclusion of impacted stakeholders is especially stark at the global scale, for instance with the adverse effects of extraction for energy infrastructure (e.g. rare-earth metals like lithium for batteries) felt by vulnerable groups largely based in Global South contexts to drive decarbonisation efforts in Global North settings [47]. While this paper limits its scope to the urban and related scales for coherence, a multi-scalar approach must be mindful of the cosmopolitan justice implications of such global scale trends.

At the urban scale, the logic of urban planners and service providers who position electric vehicle charging infrastructure undergirds continued prioritisation of urban space for automobiles. While electric cars pollute less than fossil fuel cars, they nonetheless exemplify an automobile-centred city rather than one geared toward public and non-motorised transport solutions [48]. Following the logic of Safransky [21], digitalisation and urban sustainability debates–such as autonomous car-sharing and mobility-as-a-service–can lock-in the use of public space by elite urban dwellers who have electric cars, which remain beyond the economic reach of most and compete with other uses of public space at present, e.g. for bicycle and bus lanes. This can depoliticise the issue of how space long prioritised for car users could be opened up to serve mobility needs of wider, disadvantaged population groups who rely on public transport [49].

Research on intersecting inequalities emphasises the link between vulnerable groups being multiply marginalised through exclusion and coercion, e.g. in a classic book by Harvey [50]; the lack of access to timely, adequate information leading to sub-optimal choices [43, see also 51]; and low degrees of freedom limiting human capabilities [52]. Public policy addresses these problems through support schemes, safeguards, and capability enhancement measures [53]. Digitalisation can support such measures: it can improve people's access to support schemes, raise awareness of safeguards available to them, and help authorities identify and attend to vulnerable users (cf. [54]) using granular, crowd-sourced metrics. Yet, the institutional continuity of analogue workflows [35,36] fails to position administrative authorities in different sectors to respond through their newly expanded digitised tools [55]. Institutional inertia entails the risk of underutilised potential, abuse and cooptation of digital tools [21].

The next section presents a multi-scalar approach to assess digitalisation in terms of its impact on socio-spatial inclusion, and to identify ways to enable inclusion. It explains case selection, presents case backgrounds and provides an overview of study methods and materials.

3. Methodology, case selection and methods: Assessing digitalisation for socio-spatial inclusion

This article adopts a multi-scalar approach – i.e., one that addresses and cuts across multiple spatial scales – to identify the needs of vulnerable users to harness digital technologies that can aid in participatory mapping of urban environments from hitherto marginalised perspectives. The analysis places these users at the centre of spatial planning and asks in what ways digitalisation enhances socio-spatial inclusion, i.e., inclusion across various social and spatial characteristics of urban population sub-groups, similar to [56]. Due to data limitations, social inclusion is emphasised, whereas spatial aspects are noted in a more general sense at and across multiple scales. What forms of cross-sectoral coordination of smart energy transitions benefit socio-spatially peripheralised residents?

This multi-scalar approach draws on intersecting inequalities scholarship [32,57] to assess digitalisation in two key services where rapid digitalisation is underway: electricity generation and mobility [58]. This empirical focus identifies concerns related to the effects of digitalisation on marginalised energy service users at multiple scales, e.g. the household, neighbourhood and city. It probes whether digitalisation in smart energy transitions generates wider benefits, or conversely diminishes public space and services.

The two cases are used to examine intersecting inequalities across increasingly interconnected, essential sectors. One concerns smart electricity transitions in Lisbon: a combination of multi-scalar solar energy rollout and digitised electric grids equipped with smart electric meters for real-time automated management of two-way flow of renewable energy between grids and users. The other case concerns smart mobility transitions to electric vehicles in Bergen, which has a fully digitised electric grid: these transitions are determined by policies on how to fuel and manage public transportation and private vehicle use, and intertwined with clashing social imaginaries on the use of public space. Each city is a front-runner for its respective case. Moreover, both European cases take place in democratic contexts with progressive energy policies that prioritise socially inclusive digitalisation and a just transition through ambitious visions, notably the European Green Deal. The cases thus hold potential for transferable lessons with social legitimacy. They are moreover applicable to relatively understudied medium-sized cities such as Bergen and Lisbon. This can generate insights transferable to many cities with comparable sizes and hence institutional structures and local capacity, e.g. budgetary scope, expertise, and decision-making power. A further advantage of these case choices is the author's sustained in-depth engagement and considerable empirical experience in both contexts since 2017.

The multi-scalar approach addresses these intersecting inequalities in each case in specific ways:

1. Smart electricity transitions in Lisbon: Are vulnerable users able to derive benefits from renewable energy uptake due to the digitalisation of electricity?
   - The case study examines benefits through reduced electricity expenses by prosuming and monitoring solar energy flows to the grid.
2. Smart mobility transitions in Bergen: Are vulnerable users able to derive benefits from mobility services due to the digitalisation of mobility?
   - The case study examines benefits in terms of lower transport energy demand, generation of and access to data to secure better service delivery.

By asking questions directed by sectoral relevance and a grasp of how digitalisation can ameliorate or exacerbate the intersecting inequalities that vulnerable users experience (cf. [59]) at multiple scales, the study foregrounds the implications of digitalisation for social inclusion. It illustrates the need for socio-spatial analysis to understand the societal impact of smart energy transitions. Importantly, the analysis identifies digital monitoring technologies that vulnerable users can use to capture data on intersecting inequalities for claim-making to the government for greater socio-spatial inclusion (cf. [60]). Table 1 shows the broad categories of vulnerable users of digitalisation in each case; how the author engaged with them and others to relay the concerns of vulnerable users; and how planners can increase their inclusion in digitalisation. The empowerment strategies indicated draw on findings presented and discussed in later sections.

This article draws on data from two projects: one on multi-scalar solar energy transitions in Portugal, and the other on urban actors in energy transitions with a focus on Bergen. In Lisbon, empirical material is drawn from five months of fieldwork conducted during 2017–2019. This includes 80 interviews with energy sector experts and engaged citizens, participant observation, time in a rural community and site visits to smart grids, and a questionnaire with 47 respondents from a solar energy cooperative (for details, see [61]). The article uses data relevant to smart electricity transitions, with a focus on grid

Table 1
Vulnerable users, engagement and empowerment strategies per case.

Digitalisation case and city	Vulnerable users	Mode of engagement	Empowerment strategies
Smart electricity transitions in Lisbon	Energy-poor households for various socio-spatial factors	Participant observation (site visits to smart grids, five months in Lisbon), interviews with holders of relevant expertise	Schemes to identify and alleviate energy poverty using digitised grids and solar energy
	Users unable to have solar power on their rooftop	Solar energy cooperative member survey and interviews; field visits to solar plants; part of two national energy transition events	Favourable solar techno-economic frameworks; laws to enable small community solar energy schemes
	Users with inflexible electricity needs/use	Expert interviews with regulators, journalists, urban and national energy agencies, part of two local meetings on energy flexibility and poverty	More accessible energy efficiency support schemes; lower fees in fixed grid charges
Smart mobility transitions in Bergen	Users who must rely on public transport and micro-mobility	Survey with 113 public transport users; participatory seminar with urban planners; public co-creation workshop	Multi-modal mobility hubs; improved public ticketing tools; more equitable service delivery
	Users with low access to public transport	Survey with 49 car users; closed workshop with urban planners on car-free zones; 20 expert interviews with various sectoral stakeholders	Avoiding toll charges on poor users; incentives other than for electric car users
	Users with an interest in better transport options	Focus group discussions publicised and incentivised with 17 transport users in 3 groups; expert interviews with car sharing operators	Participatory planning modes; responsiveness to feedback; more information flow
	Users with restrictions (e.g. blind, wheelchair)	Observation of e-scooters on streets at all times of day; scanning of media coverage and heated public debate	Penalties on e-scooter operators and users for illegal parking

digitalisation alongside solar energy rollout, and field observation of smart grid infrastructure. In Bergen, empirical material is drawn from participant observation of smart mobility transitions during 2017–2020, alongside media reports and fieldwork by a four-person team from August 2020 to March 2021. It includes three focus group discussions with 17 transport users in Bergen, two surveys on public transport use (113 respondents) and car usage (49 respondents), three events (a public seminar with experts, a closed workshop with municipal employees, and a co-creation workshop online) and 20 expert interviews with mobility sector stakeholders.

The case studies illustrate the argument regarding socio-spatially inclusive digitalisation. Lisbon has branded itself as a solar city and a leader in smart electricity transitions and included these as prominent features in its successful bid for the European Green Capital 2020. The city councillor for energy and environment is quoted on its energy observatory website:[2] "Only when well-informed may citizens be sufficiently motivated to participate, and only with accessible data will we be able to understand the positive impact that individual behaviors may cause on the city". Moreover, its incumbent electricity distribution grid company Energias de Portugal (EDP) is rapidly digitising its electric grid for system efficiencies and promoting smart grids and homes to citizens, making this a timely case study. Bergen has among the world's highest penetration rate of electric cars per capita, and over half of all cars sold in Norway and Bergen's Vestland county in 2020 are electric [62]. Since January 2019, this transition combines a fully digitised electric grid with smart electric meters in 97% of Norwegian households [63]. The transition takes place alongside ambitious efforts to expand public and non-motorised transport infrastructure and a 'zero growth objective' of no increase in car numbers in Bergen's urban growth agreement [64].

4. Two case studies on smart energy transitions and social inclusion

4.1. Smart electricity transitions in Lisbon

In the late 2000 s, Portugal began to attract solar developers. With Europe's highest solar irradiation rates, it briefly featured the world's largest solar plant in 2008, and during the early 2010s small-scale solar plants were incentivised and installed rapidly. Starting in 2007, smart electric meters followed a similar initial timeline, with a pilot project of over 30,000 households in the Evora municipality. The effects of economic recession slowed the rollout until 2015, but both technologies diffused during 2016–2021. By 2019, the National Energy and Climate Plan 2030 envisaged strong roles for solar energy, low-carbon electricity, and a smart electric grid [65]. It envisaged alleviating energy poverty, and was complemented by a Roadmap for Carbon Neutrality 2050.[3] The capital's 'Lisbon Solar City' strategy backed such ambitions. It committed to install 8 Mega Watts (MW) of rooftop solar capacity by 2021, a two MW solar plant to power a tram line, 20 electric buses and 50 waste management vehicles,[4] and targeted 103 MW of solar capacity by 2030.[5] A top municipal representative (interviewed 21.8.2018) stated that "it is about leading by example with the capital, installing four MW on municipal buildings. The rest will come […] for electric [bus fleet] charging."

These commitments were complemented with activities such as a solar festival, hosting major international conferences on solar energy and the role of cities, and providing workshops on community energy. These platforms engaged diverse actors, from municipal agencies to solar developers, researchers and media agencies. A representative from the municipal energy agency Lisboa E-Nova (interviewed 21.8.2018) stated these outreach activities "offer a tool for people to estimate self-consumption, provide building level mapping of installed solar rooftop capacity, and to develop a knowledge resource." This quote underscores the twin nature of the transition as digitalisation and decarbonisation, rolling out data infrastructures alongside renewable energy capacity. Its sustainability plans won Lisbon the European Green Capital 2020 award. Meanwhile, EDP's smart meter rollout accelerated in the late 2010s. A solar energy researcher (interviewed 6.3.2019) explained that "EDP has decided their 'main investment' or next opportunity is energy community and electric vehicle integration. The 'uber of energy' is a question mark, everyone is scrambling to be ready. EDP plans to hire 50

[2] Website accessed on 25.02.2021: https://observatorios-lisboa.pt/en/
[3] Website accessed on 25.02.2021: https://descarbonizar2050.apambiente.pt/en/roadmap/
[4] Website accessed on 25.02.2021: https://observador.pt/2020/10/14/camara-de-lisboa-anula-novamente-concurso-*para*-central-fotovoltaica-em-carnide/
[5] Website accessed on 25.02.2021: https://energy-cities.eu/lisbon-a-solar-city/

people in the next four years for a 'Smart Hub' to integrate smart grids with renewables." By January 2021, the incumbent had installed nationwide 3.2 million smart electric meters, anticipated completing all six million meter installations by 2024, and changed its name to E-Redes or 'e-grid' [66], a significant symbolic shift indicating digitalisation as a core company value.

This enhanced the infrastructure for small-scale actors to participate in digitised solar prosuming, selling locally produced power to the electric grid, and enabling significant supply-side efficiencies for EDP [67]. Yet legislative barriers remained, limiting households with solar modules to a self-consumption regime. Another solar energy researcher (interviewed 6.3.2019) stated that "The benefit from aggregation is not favouring communities, but retailers at the sub-distributor level. … There is a need for fungible models for community solar energy. Automation is clearly part of the way forward, time-of-use is too much of a demand for ordinary people." This regime made investing in rooftop PV realistic only for house owners with high daytime consumption who could afford to invest in batteries for energy flexibility, while low feed-in tariffs made prosuming unattractive for small actors. Of 47 respondents from Lisbon's solar energy cooperative Coopérnico, 16 (34%) reported unsatisfied energy needs (i.e., needs that were not met due to physical access constraints or affordability concerns); most were frustrated by high taxes and fees in electricity bills; and 20 (43%) mentioned a socio-economic motivation for membership. Nordholm and Sareen [68, p.8] capture a Coopérnico member's frustration thus: "The state needed to get money. So basically, over the next 20 years, citizens are paying for that need." This shows recognition of government failure in ensuring people-centric digitalisation, despite increasing ambitions of low-carbon transition.

While the rollout of distributed solar PV languished, large-scale solar PV plants proliferated remote from urban electricity demand centres, increasing the need for transmission grids [69]. The government responded to such concerns in January 2020, with legislative changes to permit community energy by using digitalisation for multiple actors to consume and prosume electricity from a single solar plant. These changes were instituted from the capital's urban environment of climate ambition. They opened up options for tenant households through virtual solar consumption from solar plants feeding into the grid elsewhere. Moreover, building residents with shared rooftops could now consume shares of a co-owned solar plant with a range of neighbours. As an interested citizen (interviewed 25.7.2019) who contacted the author after reading about this research in a Portuguese magazine said: "Energy is like a currency so if my brother lives in a house with a roof why can he not transfer it to me? … I live in a block of apartments and with the old legislation we could only have power that corresponds to the meter that we have for the building that serves the elevators. Now this will change dramatically and we will be able to have production and distribute it to all apartments." These changes due to a smart energy transition thus have clear potential to benefit vulnerable groups.

National policies introduced solar auctions, which in 2019–2020 allocated 2,000 MW in large solar plants at competitive tariffs, setting two world records. Additionally, power purchase agreements cropped up around Lisbon due to its industrial demand and strong grid infrastructure. Portugal's solar energy rollout became part of a multi-scalar smart energy transition based on increasing low-carbon electric capacity and shifting energy uses to electric form alongside rapid grid digitalisation by EDP, which had strategically waited to accelerate this investment until renewal of its long-term distribution grid licenses [70]. Early shifts were evident in transportation, with 15 electric buses on popular city routes in 2019, and 350 more planned for the wider region in 2021.[6]

Yet the inequitable allocation of benefits from digitalisation frustrated users. An early adopter of rooftop solar and electric vehicles (interviewed 29.7.2019) pointed out how laws favour incumbent companies over citizens: "A big bottleneck in the development of solar is how much protection there is over the electricity companies. The regulations protect EDP. For instance with electric cars, the payment model we use is absurd. There are two entities we have to make contracts with, the energy supplier and the owners of the charging station, who cannot sell energy directly so they always have to add middlemen, which adds expenses and bottlenecks. So if people want to install solar panels, the self-consumption system gives peanuts if they prosume. Or you have to invest in batteries which are still expensive. So it does not take off despite large roof space." This suggests that the early stages of digitalisation have concentrated benefits to the incumbent, and that pro-citizen regulations like the legislative changes of 2020 are essential for more equitable distribution of benefits.

Thus, benefits were initially limited to large solar developers and incumbents, and early adopters who were typically affluent urban dwellers investing in rooftop solar modules with incentives [68]. A European Green Capital 2020 representative (interviewed 31.7.2019) said that "We [municipal agency] do not have access to updated data on solar PV installations in Portugal which comes from the Directorate General for Energy and Geology who are struggling with digitalisation of their services, to be very polite." So far, despite competitively low costs, benefits of integrating solar energy on the digitised grid have not been accessible to ordinary users, especially those in energy poverty with inadequate access to energy services [71]. Large solar developers leased land in regional hinterlands, eyeing strategic locations close to limited electric grid capacity [69]. For wider adoption of smart electric meters and solar modules to benefit prosumers, regulations and economic models must implement the new community energy legislation in spirit, namely by enabling greater participation of and cooperation among citizens in energy systems in systematic and scalable ways. During the 2010s, mainly EDP experienced efficiency gains from digitalisation.

Table 2 presents an overview of opportunities for and barriers to social inclusion during digitalisation in the electric grid and solar rollout in Lisbon.

4.2. *Smart mobility transitions in Bergen*

The second case study illustrates how the smart mobility transition in Bergen has provided limited benefits to vulnerable users, as digitalisation has concentrated benefits to privileged users. During the late 2010s, Norwegian urban mobility policies became firmly wedded to

Table 2
Opportunities for and barriers to social inclusion during digitalisation in Lisbon.

Opportunities for social inclusion	Barriers to social inclusion
Solar rollout within Lisbon integrated with electrification and decarbonisation of transport	Supply-side and intermediary control of electric grid infrastructure and excessive fee capture
Outreach and awareness-raising activities to build capacity among vulnerable users	Dearth of techno-economic models to include lower-income households in solar prosuming
New legislation that enables community energy schemes to include a wider base of users	Lack of targeted inclusion of energy poor households based on socio-spatial patterns

[6] Websites accessed on 25.02.2021: https://jornaleconomico.sapo.pt/en/news/rails-presents-first-electric-bus-with-Portuguese-technology-557459 and https://www.sustainable-bus.com/news/new-contract-in-lisbon-portugal-for-arriva-group/

decarbonisation plans [72]. Norway relies on hydropower generation for over 95 percent of grid electricity, with much of the rest sourced through wind power and gas. This makes other sectors key for decarbonisation, notably transportation which contributes a large share of carbon emissions. Transport is vital and complex in Norway and Bergen's challenging mountainous, coastal geographies and sprawl.

Mobility transitions policy has emphasised shifts to public and non-motorised modes of transport [64] to reduce energy demand and build a thriving, convivial urban centre. As a municipal representative (interviewed 22.10.2020) explained, "the shift from ownership to access is really important … Maybe the biggest potential of sharing is when it comes to transport," citing the International Transport Forum [73] simulation of Lisbon that shows 3% of current cars would satisfy demand through sharing and a backbone of high capacity public transport. This push has been complemented by extensive incentives to phase-out fossil fuel cars with electric vehicle adoption, notably cars but also electric bicycles [30], expansion of the electric light rail, and the adoption of 102 electric buses since December 2020.[7] Complementary efforts include car-free areas in central and by 2022 also suburban Bergen, the reduction of city centre car parking, and the electrification of ferries where Western Norway's coast leads the world. Full electric grid digitalisation by 2019 has enabled rapid transport electrification. Yet a planner from the nearby municipality of Østeroy (interviewed 29.10.2020) highlighted the difference between Bergen and wider Vestland county: "We have a densification focus but are struggling with the past … We need enough people for public transport to work. Not everyone is used to taking the bus." He pointed out that Osterøy aims to reduce transport emissions by 80% by 2030, but the goal lacks local political support from developers and commuters. This suggests that sociopolitical legitimation is a greater challenge than technical solutions, thus addressing social inclusion is key.

Some smart mobility transition policies in Bergen have been controversial. The main example is the establishment of a political party named 'People's campaign against toll charges' (FNB) in Stavanger's municipal elections in 2014, spreading to other municipalities and gaining national party status in 2018. In Bergen's 2019 elections, FNB garnered over a quarter of all votes [74]. Its main manifesto item is the rollback of road tolls–especially high on fossil fuel cars–as a way to finance infrastructure. A representative (interviewed 27.10.2020) argued that "the city council today is only for the people who live in the city centre – they get it all, while people in the outer suburbs get nothing and have to pay for everything." This claim highlights the marginalisation of suburban dwellers who are penalised for driving into city centres while tolls finance public and non-motorised transport infrastructure. This has been heavily contested in public debates and in expert interviews, where the portrayal of suburban car owners as vulnerable is seen as over-emphasised and an opportunistic form of populist politics. Critics point out that less frequented roads in regions are also financed through taxpayer funds, and argue for congestion charges as a vital component of mobility transitions to ensure greater use of urban public transportation and densely populated public space freed from cars. While this debate is not directly about digitalisation (for details, see [75]), its political contentiousness limits the scope for innovative transport solutions.

Nonetheless, representatives from the Agency for Planning and Building Services (interviewed 22.10.2020) argued that "the municipal plan aims to increase public transport services with a special focus on the opportunity to walk", which they viewed as consistent with a policy push dating back to the 1980s that has already made the city centre far more accessible and socially inclusive. This suggests a long-running planning emphasis on social inclusion, despite which digitalisation efforts have faced critique due to socio-spatial splintering among residents. Thus, concerns of digitalisation must be understood within a complex historical terrain of energy and transport infrastructural plans.

A complement to this debate is the equity aspect of subsidising luxurious electric cars. A focus group participant (21.8.2020) pointed out negative regional effects of the increasing need for electricity, stating: "there is no energy production that is completely unproblematic. So it's better to invest in electric bicycles than an electric car." During 2021, higher electricity tariffs after a cold dry winter in Norway have raised concerns of when electric car charging loads are placed on the grid, as these especially impact lower income households with temporally inflexible electricity needs for cooking, heating, lighting and other essential services such as laundry (also see [76]). Those in favour argue that initial incentives accelerated electric car adoption and the rollout of charging infrastructure to enable usage well beyond the suburbs and on regional and national routes [29,72], also advancing electric mobility on the global scale. A representative of the Agency for Urban Environment (interviewed 29.9.2020) emphasised the need for socio-spatial targeting: "in the past, there has not been much basis for where to locate infrastructure, a bit arbitrary and based on emergent processes, with the risk that more resourceful people get their way. It is not data-driven, but that is changing now. There are no guidelines, but people are working on this for choice of locations." She pointed out that mapping suitable areas is a priority for car-free zone development in the suburbs as well.

These transport debates feature interesting sub-themes: electric vehicle adopters are learning how to match evolving mobility technologies with transport needs, including e.g. smart charging and flexible electricity tariffs. Focus group discussions highlighted the feasibility and cost effectiveness of electric vehicles, but also flagged elitism and the need for robust public transport services that do not penalise users with time wastage on commutes, uncertain connections, and user-unfriendly smartphone application interfaces for routing by the operator Skyss. A focus group participant (20.8.2020) who commutes from the island of Askøy which is part of Bergen explained that "At least for me who has children, I have to get home at some point. So then I have to put in half an hour of slack to make sure I get on the bus or boat. So it is half an hour or three quarters extra you save by driving, and then the thought [of using public transport] is a bit gone." Another female participant added "On public transport it is young people with children. Many of those who drive are one and one in a car and over 50 because they can afford to take that cost. But they actually have perhaps the most [flexible] time." Yet another focus group participant explained that "today I was going to take a city bike to work, and there were two bikes in the rack right outside where I live. But they were not registered on the app. It said zero on the app. Two bicycles were standing in front of me. It was frustrating. So I had to go all the way to the next one to get a city bike." These observations highlight the many gaps left by digitalisation to enable a smooth, user-friendly and time-efficient multi-modal trip for marginalised public transport users, to compete with car use for convenience and desirability.

Another controversy erupted during 2020, with the dumping of 500 electric scooters in public spaces in Bergen by a company called Ryde. Ryde's bypassing of a municipal permission process proved controversial. The municipality took Ryde to court but lost–an instance of regulation lacking innovation–with the upshot that multiple competitors had to wait for approval while Ryde as of early 2021 was the sole operator. However, the municipality did gain legal recognition of arguments that enabled it to charge rent from electric scooter companies for the use of public space and to demand that companies share some data about user behaviour with the municipality via a platform under development, to eventually enable better coordination of micro-mobility with public transport. Media forums featured debates on whether private actors should use public space for commercial leasing. Many saw the electric

[7] Website accessed on 25.02.2021: https://bussmagasinet.no/na-kommer-elbussene-til-bergen/

scooters as a convenient, enjoyable mobility solution, whereas critics pointed out the danger posed to vulnerable groups such as blind people and wheelchair users,[8] and the inconvenience to pedestrians and emergency vehicles due to electric scooters scattered carelessly. A municipal planner (interviewed 22.10.2020) estimated that "Currently, 60% trips with electric scooters are replacing walking trips, not a great idea. But it would be good to make it work so that people park a private car and then use them–integrated with car sharing maybe."

The contentious nature of these debates meant that attention to some aspects of digitalisation remained relatively subdued. These aspects indicate a cleavage between city centre and suburban mobility users. People's enthusiasm for the electric scooters risks reduced ridership and revenue for the public electric bicycle scheme. The latter has been publicly funded and expanded to include charging and bicycle docking stations well beyond the city centre. As a representative of 'Bryggens Venner' ('Friends of Bryggen', an interest group for a popular heritage site in the city centre, interviewed 9.10.2020) explained, "I like the electric scooters. We need control of it, yes. But Bergen has to deal with it, we need mobility in Bergen. How do you get young people to the center? I think [the municipality] is afraid of scooters because they are afraid for their own project–the city bike." This illustrates government schemes and regulations lagging behind private innovation on digitalisation, and its recognition by transport users. A Bergen planner at a September 2020 public seminar indicated plans to advance socio-spatial inclusion by tracking electric scooter provision in suburbs and making demands on companies to provide coverage at par with the city centre. In late October 2020, the municipality invited electric scooter companies into a pilot project.[9] As interviewed planners explained, this could enable licensing of urban areas to micro-mobility providers with conditions that incentivise availability in low density neighbourhoods and charge operators in dense areas, to guard against congestion of pavements with the electric scooters.

Finally, two small-scale surveys (implemented on-site in person at Bergen's major transport hubs as well as with an online response option due to restrictive pandemic circumstances) made clear that public transport users commonly (105/113) factor climate concerns into transport choice. Over half of fossil fuel car users among respondents (15/25) reported using public transport 3–7 days per week, which indicates some active prioritisation of public transport. The car user survey revealed that a relatively large proportion (39/49) actually supported financing public transport through tolls, which suggests that this debate is more blown up in media than in public perception. Hence, smart mobility transitions are a heavily debated subject, centred on whose definition of justice matters regarding the impact of digitalisation on socio-spatial inclusion, yet with broad consensus on decarbonisation.

Table 3 presents an overview of opportunities for and barriers to social inclusion during digitalisation of transport in Bergen.

Table 3
Opportunities for and barriers to social inclusion during digitalisation in Bergen.

Opportunities for social inclusion	Barriers to social inclusion
Ambitious policy targets to electrify transport and a robust existing low-carbon electric grid	Slow progress on solutions to advance digitised multi-modal transport in low-density areas
A fully digitalised electric grid with options for households to contribute to grid flexibility	Inadequate integration of multi-modal solutions in digitised transport access systems (apps)
Electrification of multiple modes of transport at regional, urban and neighbourhood scales	Reproduction of individualised transport modes in digitised form rather than collective ones

5. Co-producing knowledge for smart energy transitions

The two smart energy transition case studies bring to light emerging initiatives for multi-scalar consideration of potential benefits from digitalisation, particularly to identify and involve vulnerable users, and better understand and address their needs. Such emphases merit greater attention in smart energy transition debates. Projects of smart urbanism have been promoted by powerful, well-financed actors who stand to profit from data infrastructures, as data scholars and critical urban geographers have argued [7,36,77], while working to identify publicly beneficial ways forward [24,25]. How governments can stymie the neoliberal takeover of cities through digitalisation, and ensure people-centric and inclusive digitalisation of multi-sectoral services, is a pressing concern.

In both cases above, digitalisation has been driven by purposeful actors who can act influentially and rapidly [78]. Actors range from an incumbent electricity company rolling out smart meters, to a technology entrant like an electric scooter company embedding data infrastructures into public space. These actions inflect the use of contested public space, repurpose it, and reconstitute socio-materiality to shape users' experiences [79]. The impulses that drive digitalisation are not primarily geared to address vulnerable users' needs during decarbonisation (see Table 1 in section 3). Rather, they maximise data extraction (electric scooter use, real-time electricity use) and profit generating activities (micro-mobility revenue, electricity bills) for the companies. Social inclusion and handling of vulnerability tends to be addressed through ex post regulation rather than built into data infrastructures and logics of spatial targeting up-front. This risks addressing symptoms rather than the underlying structures being rolled out as sectors are reconstituted and integrated through digitalisation, consequently locking in vulnerability and data extractive practices that benefit supply-side actors rather than being placed systematically at the service of improved public services.

Following [2,3], if the purpose of planning is to create better places for those who inhabit them, and to therefore bring about and maintain inclusive spaces where residents feel safe and free to access essential services, then the cases offer opportunities for digitalisation to assist in accomplishing these aims, indicatively presented below.

Smart electricity transitions in Lisbon can enhance the practical benefits of smart energy transitions among ordinary households, of whom an estimated 15–23% are energy poor [71] and thus vulnerable to electricity price fluctuations without necessarily being able to benefit from solar energy or smart meter rollouts unless people-centric legislation governs digitalisation. They can make issues such as the building of energy efficienct residential units–customarily regarded as a matter of technical expertise [80]–a topic of user rights, especially given that low energy efficiency spatially overlaps with lower income neighbourhoods [71]. Rather than something being measured occasionally by specialists, building energy can be the subject of user engagement, with residents moving from being passive recipients of information or cost bearers of energy retrofitting [81] to visualising how building energy impacts their everyday lives. This can include and extend well beyond rooftop solar generation and community solar plant ownership. Efforts by the municipality's energy agency Lisboa e-Nova through the Sharing Cities project indicate a range of ways to enable social housing residents to avail of retrofit schemes [82]. Mapping tools can direct strategic rollout of urban solar plants close to energy use [83]. These approaches to enhancing public engagement with and demanding tangible benefits from smart energy transitions are emerging across Europe. In Barcelona, for instance, the Alliance against Energy Poverty uses participatory energy monitoring through digitalisation to map electricity disconnection events to identify vulnerable users [84]. In Bucharest, households

[8] One notable example, of many, is this statement by the Norwegian Association of the Blind, accessed 10.3.2021: https://www.blindeforbundet.no/om-blindeforbundet/nyhetsarkivet/el-sparkesykler-til-besvaer

[9] Website accessed on 10.3.2021: https://www.bergen.kommune.no/hvaskjer/bymiljo/inviterer-til-pilotprosjekt-for-utleie-av-elsparkesykler

that pay for faulty grid heating crowd-source a map of grid failure to visualise their lack of access to home heating, bringing pressure to bear on the utility and politicians [85]. As the European Union moves to demonstrate 100 positive energy districts where buildings produce more energy than they consume, such democratic digital proxy metrics can serve to validate and verify claims as well as identify areas where energy efficiency lags most [86].

Smart electric meter displays only provide simple consumption data of limited use to electricity users [87]; electricity suppliers like EDP offer add-on applications that show users their digitised energy behaviour. Regulators could make these mandatory where smart meters are installed, to equip users with real-time digitised energy behaviour data free-of-charge [20]. Disaggregated data on building energy efficiency solutions for diverse user needs can be routinised into energy retrofitting schemes using digitised databases on electricity use (see [88]).

Smart mobility transitions in Bergen can explicitly link ambitious transport decarbonisation efforts to mobility justice [89] and socio-spatial targeting of (transport) energy poverty [90]. Such an agenda can range from enlarged public spaces for walking and bicycling as in Oslo [91] to co-benefits such as local air quality improvements [92]. Existing projects employ a lending model, such as a monitoring back-pack participants carry to monitor individual exposure to variable air quality, e.g. during commutes [93]. Other projects mobilise users to map urban pollution using a distributed sensor network [94]. Such user-generated databases, targeted to vulnerable groups (e.g. high-traffic areas, valley neigbourhoods where smog settles), can provide users a basis to make claims to urban planners to address problems like neigh-bourhood smog and congestion [95].

Transport operators have long used in-house data to plan frequency and routing, analysing actual usage of services and adjusting delivery. With digitalisation and machine learning, this supply end is increasingly automated, while the range of offerings has complexified [96]. This complexity places additional demands on transport users, who face a plethora of options from multiple operators (e.g., Skyss, Ryde and the city bicycles). Competition drives down user prices, but vulnerable users may find it hard to select optimal options as they download numerous applications to navigate digitised urban mobility [43]. Such digital-isation unlocks new options but also constitutes *hidden burdening* of users (see [97] for a nuanced spatial analysis of energy vulnerability more generally). It distracts attention from the failure to use digitalisation to drive suburban car users towards public transport in congested city centres through better connectivity and inter-operability [48]. A linked opportunity is for users to access and anonymously aggregate their digitised travel data to support demands for improvements at town hall meetings. Moreover, municipalities can incentivise electric scooter companies to expand services to suburbs where automobility dominates and use data-driven targeting of users' micro-mobility needs to address last-mile gaps, enabling virtuous modal shifting to electric buses.

Thus, digitalisation offers ways to empower users, including vulnerable ones, and to visualise their needs for better identification and resolution [54,98]. Case analysis reveals lacunae in regulation, lack of policies, and piecemeal implementation, but also identifies scope for concrete advances to ensure inclusive essential services. Within and across sectors like electricity, energy generation and mobility, address-ing vulnerabilities of end-users in socio-spatially sensitive ways should be a core concern embedded into data infrastructures being rolled out as sectors digitalise. Regulatory frameworks are poorly adapted to the affordances of digitalisation and must be updated to avoid a zeroing out of its benefits by supply-side actors to their own benefit over end-users. An explicitly citizen-centric focus as the core premise of such regulatory updates can help ensure that digital solutions move beyond the current limited focus on users as consumers, to a fuller appreciation of users as a differentiated set of individuals whose needs and priorities must be taken into account using data infrastructures, and addressed to minimise vulnerabilities like energy poverty.

6. Multi-scalar thinking for socially inclusive digitalisation

Two cases cannot provide comprehensive recommendations for planners beyond Lisbon and Bergen. Recommendations differ by local context and require deep knowledge of socio-technical particularities, including sectoral political economy and effective rollout modes for digitalisation [99]. The contribution here is to highlight many under-utilised opportunities, and to show that even in two prominent cases in progressive policy contexts, digitalisation has adversely impacted vulnerable users. People live in relative deprivation in cities in relatively affluent Europe [40]. This is avoidable and incumbent upon government to address, as digitalisation drives definitive changes to essential ser-vices across increasingly integrated sectors during the 2020s.

The multi-scalar approach assesses digitalisation and identifies ways to adjust its implementation in any sector by focusing on what smart energy transitions can achieve for the most vulnerable users socio-spatially, i.e., in societal and built infrastructural interactions, at mul-tiple scales. In concert with implementing actors and regulators, plan-ners must champion *citizen-centric* digital solutions that draw on vulnerable users and their digital data, to better understand and resolve the problems they face. Regulators must guard against uncritically enabling data extraction that serves supply-side interests [20] at the expense–rather than at the service–of citizens [7,9]. By opening up op-tions for users to crowd-source data on their own behaviours and needs, digitalisation can enable responsive systems and responsible innovation [100].

To the questions addressed in each case, one can add related issues for future research on socio-spatially inclusive digitalisation. During smart electricity transitions, are vulnerable users able to use digital technologies to monitor and adjust their energy behaviour and access related support schemes to enhance savings? During smart mobility transitions, are vulnerable users able to draw on digitised data as a basis to make claims for improved public mobility services?

As a way to assess digitalisation, the multi-scalar approach is generative in three respects. First, it acknowledges that digitalisation is often piloted in and steered from urban centres, and focuses empirically on the 'actually existing' smart city [36]. Urban transport, for instance, has long been digitised on the supply end; yet extending digitised tools such as ticketing and other smartphone applications to transport users represents a sectoral reconstitution [96], enabling individualised usage tracking and preference customisation as well as digitised multi-modality (e.g. unlocking city bicycles and e-scooters using smart-phones with a bus ticket). Since the repercussions of digitalisation transcend urban centres, analyses of socio-spatial inclusion must attend to how socio-spatially peripheralised vulnerable users experience smart energy transitions.

Second, the multi-scalar approach recognises that digitalisation concerns data infrastructures. This insight, well-established in science and technology studies and the subject of current interest [7,9,21], must be acted upon by planners and practitioners. Empirical study of expanding automation focuses attention on the societal embedment of digitalisation and its effects on sectoral user groups. Such assessment politicises the impact of particular modalities of digitalisation, and can open up public deliberation on desirable automation pathways [18], in terms of their impact on sectoral performance and public service de-livery. A linked, key point is that analyses of digitalisation often stand to gain penetrative power by employing mixed methods, even in relatively simple form. Future research on data infrastructures in energy transi-tions would thus do well to employ such designs (also see [101]), notably by combining ethnographic techniques with user surveys at lower scales.

Finally, multi-scalar analysis is a relational approach that enables boundary crossing. The multiple scales at play in this article lie mainly at the urban, neighbourhood and household scale, e.g. rooftop solar plants and community energy initiatives in Lisbon, and car-free zoning and electric scooter debates in Bergen. They occasionally extend to the national scale on key target-setting and decision-making, e.g. smart electric meter policies and community energy legislation in Portugal, and electric car subsidies and emission reduction targets in Norway. These scales manifest in drawing out dilemmas of socio-spatial inclusion and showing how, despite progressive intentions and claims, it proves difficult to achieve in practice for diverse vulnerable users (also see [56]). One could further bring in the global scale for a fuller analysis of how digitalisation impacts extractive zones elsewhere (e.g. see [47]).

By contrast, without a focus on multiple scales, it would be possible to conclude that the case cities performed relatively well on socio-spatial inclusion in digitising transport and energy sectors. After all, Bergen is one of the front-runners in electric vehicle adoption and Lisbon is the founder of Solar Cities. A multi-scalar approach, by directing attention to more granular aspects, lends itself to analysis of multiple sectors that are increasingly integrated through digitalisation. This mode of approaching digitalisation recognises that socio-technical assemblages are in flux [102], moving out of a period of relative stability into one where emergent digital technologies are disrupting old ways of living in society [7,60]. Such an approach can bridge fields of scholarship like historical institutionalism and political economy on the one hand, and socio-technical innovation studies, urban geography and regional studies on the other. It can enable research insights to engage with practice in reflexive ways that have real-world application and are simultaneously informed by the critical rigour of the academy. Such knowledge co-production and public discourse are critical components to steer smart energy transitions towards socio-spatially inclusive outcomes.

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.

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