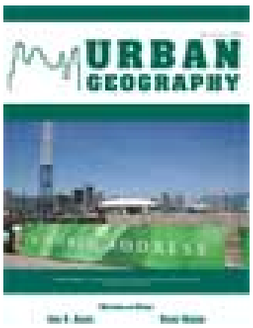

Urban Geography

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/rurb20

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To cite this article: Tomas Moe Skjølsvold, Ida Marie Henriksen & Marianne Ryghaug (2022): Beyond the car: how electric vehicles may enable new forms of material politics at the intersection of the smart grid and smart city, Urban Geography, DOI: 10.1080/02723638.2022.2044692

To link to this article: https://doi.org/10.1080/02723638.2022.2044692

Published online: 19 Apr 2022.

URBAN GEOGRAPHY
https://doi.org/10.1080/02723638.2022.2044692

Routledge
Taylor & Francis Group

RESEARCH ARTICLE

Beyond the car: how electric vehicles may enable new forms of material politics at the intersection of the smart grid and smart city

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ABSTRACT

When large shares of electric vehicles are adopted, local electricity grids face new challenges associated with managing peak loads emerging from charging. Smart charging has been proposed as a way of addressing this challenge. To date, experiences of such combinations of technology mainly stem from pilot and demonstration projects, often organized as part of the research, innovation, and development initiatives. The paper explores local efforts to implement such technologies in four urban residential communities in Norway, where the technologies are needed for local electricity grids to keep up with the rapid uptake of electric vehicles. The authors study how the influx of electric vehicles enables new forms of material politics and new forms of engagement with the electricity grid. Their findings illustrate how the influx of EVs and the related response in urban residential communities often transforms very local democratic processes and actors into key sites and intermediaries of energy transitions. Through such processes, decisions are made about how to develop both the grid and the community through the mobilization of "smart" technologies. A further finding is that the influx of EVs might function as a conduit for the development of what the authors call electricity grid sensitivity.

ARTICLE HISTORY
Received 29 January 2021
Accepted 4 February 2022

KEYWORDS
Electricity grid sensitivity; material politics; smart charging; smart grid; urban residential communities

Introduction

Calls for deep sustainability transitions have given rise to academic literature containing analyses of systemic change across different levels (e.g. Geels, 2002; Geels et al., 2017). An important strand of this literature is concerned either with the roles of intermediaries (e.g. Kivimaa et al., 2019) or the related idea of middle actors (Parag & Janda, 2014) in advancing such systemic change. These concepts point towards the importance of actors that can mediate information, interests, and insights between systems, sectors, actors, or levels. As noted by Moss (2009), intermediaries serve a key purpose when the challenge at hand relates to advancing collective action. This suggests that

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intermediation is not only a neutral act but that it might also be a form of politics (e.g. Moss, 2009) that both open and close trajectories to different future socio-technical arrangements. In this paper, we link intermediation to the concept of material politics (e.g. Marres, 2011; Martiskainen et al., 2018) in order to explore how new combinations of social and technical arrangements that emerge in urban contexts alongside transport electrification might enable new forms micropolitics that are central to transition processes.

Empirically, our focus is on the broad socio-technical implications of transport electrification, as we zoom in on the practices and political aspects of electricity grid development in urban residential communities. As others have illustrated (e.g. Canzler et al., 2017; Rommetveit et al., 2021), smart technologies may reconfigure socio-technical relationships and enable new forms of action, in our case spanning urban transportation systems, ICT, and electricity grids. Such changes are arguably generative for broader social transformations (Sareen & Haarstad, 2021), involving the governance of local communities and the ways that various actors participate in transformative processes (Adams et al., 2021). Empirically, we focus on urban residential communities in Norway, which have the highest market penetration of electrical vehicles (EVs) worldwide (Skjølsvold & Ryghaug, 2019).

Previous research has shown how using EVs might actualize and open up a space for other new technologies, such as solar PV or vehicle-to-grid (Ryghaug et al., 2018; Sovacool et al., 2018; Winther et al., 2018), and that these technologies can enable new actualizations and forms of local engagement with the electricity grid (Skjølsvold et al., 2020). In the early phase of the Norwegian EV transition, many EV owners used ordinary electricity wall sockets in shared garages when charging their vehicles. The result was increased fire hazards and often a lack of local power capacity. Therefore, many elected community boards in urban residential communities simply banned EV charging in shared spaces. Such incidences made the headlines in local newspapers, which carried reports of the conflicts between EV owners and elected boards of urban residential communities. The situation signaled the emergence of a new form of local political battleground as part of the energy transition, where the interests of early adopters of EVs were pitted against shared local interests such as safety and local capacity, especially during peak load hours.

Beyond addressing a local power capacity problem, this paper provides a narrative of "smart" at the intersection of the city and the electricity grid, which differs from the rational, planned, and fully integrated visions of global cities or electricity grids often promoted through "smart" concepts (e.g. Ballo, 2015; Lanzeni, 2016) that often have been studied through structured pilot projects in recent years (e.g. Niesten & Alkemade, 2016; Smale et al., 2017). In visions of how such projects should unfold, well-structured and tidy ICT infrastructures typically provided by big technology companies tend to be portrayed as the "bloodstream" of networked cities (e.g. Marvin et al., 2015). Instead, our account provides a patchwork approach to "smart" that emerges from concrete and place-bound urban issues related to the electricity grid and its new links to the transport system through a layer of ICT in very localized ways. Through the emergence of such issues, a range of actors becomes sensitized to the electricity grid in new ways, which opens up new forms of materially enabled politics, enacted by intermediary groups such as housing boards.

More specifically, we study processes of smart-charging implementation in which housing boards have played a key role. We highlight how such processes become imbued by collective values and have been made part of local participatory processes and legal matters. This allows us to see how the governance of smart charging infrastructures becomes stabilized, how the establishment of charging systems is translated into a matter of concern, and what form of democratic organization might be enabled. We answer these questions by building on a "minimal definition" and understanding of democracy "as a category in the making" and that is not meant to be "operationalized in criteria that could discriminate what is democratic and what is not" (Laurent, 2017, p. 15). Such an understanding of democracy points us in the direction of the sites where (smart) charging infrastructures and democratic orders are co-produced, and where political processes for expressing and reconciling conflicts of interests happen. Accordingly, such sites are the foci of this paper.

The materiality of EVs and smart charging: towards new politics of urban electricity grid sensitivity

Much has been written about the introduction of EVs in Norway and elsewhere, but typically with a "car-centric" gaze. Scholars have focused on vehicle choices (e.g. Klöckner, 2014), driving practices (Ryghaug & Toftaker, 2014), cultural aspects of electromobility (Anfinsen et al., 2019), and policies and incentives for EV adoption (Bjerkan et al., 2016; Ingeborgrud & Ryghaug, 2019). However, large-scale EV adoption is likely to affect the socio-technical fabric beyond the car and impact energy systems, ICT systems, buildings, and urban developments. Beyond an interest in the discrete elements of this development, such as the roll-out of charging infrastructure (e.g. Figenbaum, 2017; Henriksen et al., 2021; Skjølsvold & Ryghaug, 2019) and using EVs in vehicle-to-grid schemes (e.g. Sovacool et al., 2018; Sovacool & Hirsh, 2009), attention to the broader socio-technical and urban implications of EV uptake is lacking in the literature.

Our analysis of how smart-charging implementation processes unfold in a set of different urban residential communities is inspired by literature within science and technology studies (STS) and geography that emphasizes the role of material elements in producing new public and political issues (e.g. Latour, 2005; Marres, 2007; Ryghaug et al., 2018). This literature considers publics and issues to be emergent rather than static, and it highlights the centrality of things in constituting public issues, often within mundane and domestic settings. Within the same literature, we are particularly interested in the idea of material politics and material participation (Marres, 2012, 2013; Marres & Lezaun, 2011), which highlights the political potential of technologies. Objects may both enact a political reality and intervene in the world, e.g. by "enrolling actors such as local communities, governmental organizations and environmental researchers" (Marres, 2013, p. 427). Within critical literature on urban governance, the implementation of "smart" has often been seen as a material means to realize the "latest wave of neoliberal economic development shaping urban trajectories in line with the strategies of urban governmental and business elites" (Bulkeley et al., 2016, p. 1171).

However, as Martiskainen (2017) has pointed out, one should be careful about confusing the idea of material politics with a priori assumptions about the social and political

potential of certain objects. Technological objects can acquire a range of political capabilities as they become part of relational configurations. In our case, we are particularly interested in how working to implement smart charging might enable new forms of politics on behalf of intermediary actors, through what Bulkeley et al. (2016) call the actualization of issues. This means studying how work to implement smart charging might allow for the formulation of new forms of community, including ideas about equity and justice. This does not mean that smart charging is just, but rather that in the context of certain configurations of actors it might enable the production of such issues, around which new forms of politics could be organized, and actors enrolled as participants.

Many studies of material participation and material politics have focused on how technologies can render the mundane and domestic political. Marres (2010) highlights how, as the Mayor of London, Boris Johnson, mobilized phone chargers in campaigns to encourage energy saving, thereby co-producing material publics consisting of humans and phone chargers, which together enacted a form of green politics. Similarly, Ryghaug et al. (2018) argue that electric vehicles and smart energy technologies are potential conduits for translating abstract understandings of climate change and the role of the energy system into concrete domestic and political issues. Zooming out from a focus on the domestic, there are also studies that look at projects of grassroots innovation and neighborhood energy projects through the lens of material politics. For example, energy cafés have been described as material and discursive spaces that can bring together diverse voices and create fertile political ground for communal engagement with the issue of energy poverty (Martiskainen et al., 2018). The dynamics of material participation and politics have been particularly visible in technology experiments and demonstration projects (e.g. Marres, 2012; Throndsen & Ryghaug, 2015), in which technologies have entered into new relations, and in which the emergent qualities of potential politics remain open but are often propagated in the spirit of neoliberalism (Rommetveit et al., 2021).

Our study differs from previous studies of material participation and politics in that we do not study how technologies are mobilized either in what Chilvers et al. (2018) call "dominant forms of participation" such as deliberative processes orchestrated by external actors, or through pilot and demonstration projects. Rather, we study how material publics and their politics become actualized through the proliferation of electric vehicles, and the way that these vehicles have become part of localized everyday life, the practice of managing urban residential communities, and part of broader ideas about urban connectedness and urban form. Hence, the material politics studied here are what Marres (2011) calls multivalent, in that we show how devices and technologies serve to frame action in multiple registers, bringing together diverse voices. This diversity entails the production of new responsibilities on behalf of intermediaries, as well as the production and eventual resolution of controversies.

Research context: electric vehicles and urban residential communities in Norway

Norway has become a key market for EVs, in both absolute and relative terms, and EVs currently dominate sales statistics relating to new vehicles in the country (Norsk

elbilforening, 2021). The introduction of EVs in Norway has taken place within a distinct material and social context, where historically the energy supply has been very stable and based on close to 100% hydropower. This has resulted in an energy culture in which Norwegians generally expect full electricity coverage at a relatively low cost (Aune, 2007; Aune et al., 2016). Hence, while there have been controversial energy projects in Norway (e.g. Aas et al., 2014; Saglie et al., 2020), the electricity grid has seldom been an object of mundane political concern. Some local exemptions exist, e.g. on certain Norwegian islands and some local distribution grids, e.g. where grid connections to the mainland are weak. There, the grid has become an object of concern, leading to a form of electricity *grid sensitivity*. In such cases, local communities and citizens have formulated political agendas and practical strategies to engage with the grid as a matter of concern (Skjølsvold et al., 2020). One of our interests in the following analysis is to address the question of whether the influx of EVs in urban residential communities might enable similar forms of grid sensitivity also on the mainland, hence signaling the emergence of the electricity grid both as a mainstream object of concern, e.g. while conducting mundane tasks such as charging an EV, and as an object actualizing political issues.

The widespread transport electrification in Norway should be understood in relation to other characteristics of Norwegian society. Over 81.8% of all Norwegians own their own homes, most of which are detached, semi-detached, or terraced houses or apartment blocks (Statistics Norway, 2021). This accounts for why 88% of all private owners of EVs mainly charge their vehicles at home, rather than depending on public charging infrastructure (Ingeborgrud & Ryghaug, 2019). It is also important to note that roughly 12,4% of the Norwegian population live in what in Norway are called community association housing (*borettslag*), either as a "co-owner" or as a "shareholder" (Statistics Norway, 2021). In this paper, we study community association housing as a housing type. Within this form of housing arrangement, actual buildings are collectively owned, maintained, and governed at a local level. Such housing, which often is situated in and around urban areas, emerged in post-war social democratic Norway as a form of social welfare arrangement that was intended to ensure a certain standard of living for the inhabitants.

While the market for ownership of apartments in community association housing has been liberalized and is today almost equivalent to homeownership, the difference is primarily that maintenance responsibilities for facilities such as garages, parking lots, playgrounds, and other shared spaces are collectively shared by local residents. Management and maintenance of the shared spaces are typically carried out by democratically elected housing boards. When making large decisions on investments, a democratic majority – sometimes a qualified (two-thirds) majority – is required. Decisions are typically made during a general assembly of all local residents. Hence, such democratically elected boards have an important intermediary function, such as when interpreting and implementing policy, e.g. with respect to energy efficiency upgrades (Hauge et al., 2013). As intermediaries, the boards differ from the types of intermediaries that have typically been studied in the past, such as cluster organizations, efficiency agencies, and project development companies (Mignon & Kanda, 2018), or others that operate at the systemic level (van Lente et al., 2003), as they link local neighborhood interests or citizens' interests with policy interests, as well as the interests of innovators and technology developers.

The operation of housing boards is key to understanding many contemporary Norwegian local discussions about the implementation of EV charging infrastructure. In single-unit dwellings, individuals make investment decisions, whereas in collective housing settlements and in building blocks the implementation of charging infrastructure is subject to more collective forms of decision-making. Garages and parking spaces are predominantly scarce and valuable resources, as well as part of the shared community space, which means that expenses related to development or maintenance of these infrastructures are typically also shared. Therefore, we find that actors, who in the past were not engaged or interested in energy issues, suddenly become central decision-makers regarding the implementation of new, complex energy infrastructures.

Until recently, one easy solution for elected housing boards facing decisions on how to deal with the implementation of EV charging was simply to refuse to implement charging facilities. This created local battles between EV owners and elected boards, which were echoed in Parliament and in public debate, when politicians realized that in an unexpected way, community board decisions had become barriers to the further advancement of electromobility. Following debates in 2016–2017, a new law was passed in January 2018, under which urban residential communities, such as those discussed in this paper, became subject to an Amendment to the Ownership Act (*eierskapseksjonsloven*), often simply referred to in Norway as § 25 of LOV-2018.06-22-74 (Lovdata, 2018).[1] This made it difficult for elected boards to slow down the rollout of EV charging infrastructure. The law requires boards to facilitate EV charging unless there are "reasonable objections". The condition, which allows for continued refusal, has caused some concern among large interest organizations representing urban residential communities. Currently, a new Ownership Act is being prepared, one does not see the boards as potential obstacles but rather targets the democratic process of such urban communities by explicitly stating that a majority vote is not needed to implement charging. When passed, charging should become an individual right. Monica Mæland recently stated the following when she was Minister of Local Government:

> The strong growth in the number of electric cars and increased demand for charging is the reason why the Government will give co-owners in communal housing statutory right to charging. The right should apply even where there is no majority vote to invest in charging points during the general assembly. (Hattrem, 2019)

Hence, in principle, the Act removes the need for a democratic majority vote, on the grounds that a continued growth of EVs is central to fulfilling national climate ambitions. Thus, local smart charging infrastructure is heavily promoted, in part because it is envisioned that the infrastructure will be able both to help solve potential congestion problems in the electricity grid locally and to optimize the charging patterns of urban EV fleets to avoid or shift peak loads and assure available grid capacity for all. Nonetheless, through this Act, housing boards are given formal responsibility for standardizing and harmonizing charging solutions locally.

Background

When studying smart grids and smart cities, scholars have often focused on demonstration projects, experiments, or test beds to explore the politics of smart houses

(Pallesen & Jenle, 2018; Skjølsvold et al., 2017; Strengers, 2013). In this paper we move out of the pilot and demonstration context, to explore the implementation of smart charging in ordinary urban residential communities that strive to cope with the increasing demand for EV charging and associated peak loads. Our interest in collective and smart EV charging emerged from a discovery of a large underground garage consisting of four distinct sections. The sections were used by four different building blocks (Figure 1), organized for four urban residential communities, each of which had its own elected management board. We were puzzled by the fact that within the same garage, EV charging was organized in several different ways, indicating strong links between social action and technical configuration.

Urban residential community A consisted of 54 apartments, B consisted of 53, while C and D both had 49 apartments. Community A had installed a smart charging system with load control, grouping all EV parking close to the exit to reduce infrastructure costs and fire risk. Community D had made charging an individual responsibility, the only rule being that EV owners could not install systems demanding more than 16 amperes. Community B had a similar arrangement, but with a 10-ampere restriction at the time when interviews were held.

To us, the garage and its different forms of the social organization represented a blind spot in social scientific analysis of EV implementation and smart grids. This led us to study EV charging in urban residential communities as an empirical-analytical case to further our understanding of different modes of orchestrating material and social elements within and around urban residential communities in several regards, namely with respect to citizen involvement in decision-making, the mobilization of external competence, the role of incumbent actors, and technologies. The situation also sparked our interest in the mobilization of EV charging technologies to actualize new forms of micropolitics, the production of new forms of electricity grid sensitivity, and the transformation of local social relations and urban form. Additionally, we were interested in how housing cooperative board members, board managers, and electrical engineers worked as intermediary actors who not only sought to implement technologies, but also contributed to institutionalizing ideals of equity, fair access to energy, and inclusive participation in the reconfiguration of the energy system.

Figure 1. Floor plan of the garages for cases a, b and c (see Table 1). Permission from the architects has been grantedy.

We used a qualitative mixed-methods approach to understand how different actors involved in the work to implement smart charging in the urban residential communities made sense of EV charging, and how different actors and technologies co-produced new forms of electricity grid sensitivity and micropolitics in urban energy transitions involving EV charging infrastructure. Our analysis is based on studies of the EV charging implementation process in five urban residential communities in one of Norway's largest cities, Trondheim, a municipality with 205,332 inhabitants. The municipality is a center of higher education in Central Norway and has a high population of students. A total of 20% of the inhabitants live in residential communities, such as those studied here. At the start of 2020, there were 9,850 EVs registered in the municipality. The municipality financially supports EV charging infrastructure installments, and in 2018 and 2019 about 90 different residential communities were granted such support. The provision of such financial support is common in all big cities in Norway in order to facilitate the implementation of charging infrastructure.

To acquire in-depth knowledge of the implementation process, we conducted 15 in-depth interviews with 16 participants between May and August, 2018. The interviews lasted on average about one hour, were recorded and later transcribed in Norwegian. We also conducted participant observation in two general assembly meetings in which debating and voting on the implementation of different forms of EV charging infrastructure were on the agenda. Our interview data, together with the socio-spatial context of the four housing cases, are presented in more detail in Table 1.

Urban residential areas 1, 2 and 3 include shared garages. Urban residential area 4 is the largest in Norway and consists of 1,113 sections (apartments and terraced houses). Residential area 5 is a newly built residential area, where immediately after construction there was a need to decide on whether or not to install smart charging infrastructure. Almost all apartment owners living in the middle and outer zone of Trondheim Municipality are guaranteed a parking space either in their building or on the street. Our

Table 1. Description of interview data by case.

Urban residential area	1	2	3	4[a]	5[a]
Number of sections (i.e. apartments or terraced houses)	54	49	53	1113	65
Informants and their employment/ position	1 board leader 1 electrician 1 technical adviser from the housing association	1 board leader 1 electrician	1 board leader	1 board leader 1 CEO 1 technical management 1 electrical engineer 5 residents	1 board representative 1 resident
Direct distance from city center[b]	2.7 km Middle zone	2.7 km Middle zone	2.7 km Middle zone	4.3 km Middle zone	3.2 km Middle zone
Public transport	Five different bus routes to the city center	Five different bus routes to the city center	Five different bus routes to the city center	One dedicated bus route departing 6 timed during rush hour	Hub for public transport
Parking lots (norm), per m^2 living space	0.8 parking lots per 70 m^2	0.8 parking lots per 70 m^2	0.8 parking lots per 70 m^2	0.8 parking lots per 70 m^2	0.8 parking lots per 70 m^2

[a]Observations of board meetings.

[b]Trondheim Municipality has four regulatory zones: The outer zone requires 1.2 parking lots per living unit, the middle zone 0.8 parking lots, the inner zone 0.5 parking lots, and the city center 0 parking lots (Trondheim kommune, 2012). All cases were located in the middle regulatory zone, requiring 0.8 parking lots per 70 m^2 of living space.

selection of cases was guided by a form of inductive curiosity, as the phenomenon emerged through another study that initially focuses on car sharing. At the same time, the local newspaper was including reports of controversy about the EV charging within what would become our fourth case, where 765 charging points were being installed.

The material political dynamics of shared EV charging

In urban residential communities, including those studied in this paper, decisions about infrastructural investments such as smart charging are enacted within a context of relatively well-defined democratic rules. While such communities are typically governed by an elected board, the board is accountable either to a general assembly or to a general meeting of residents. Each section owner has one vote. In the cases we studied, collective decisions on investments in smart charging required a majority vote of at least two-thirds to be accepted. However, as already mentioned, the organization of (smart) charging infrastructure implementation differs substantially between urban residential communities, as do the technological solutions that ultimately are chosen. In other words, depending on the relations that EVs and the vision of smart charging become part of, EVs and smart charging constitute a set of quite different issues concerning participation in energy transitions, the value of local urban space, and ensuring fair access to electricity. In some instances, these issues sensitize local actors to regard the electricity grid as a political object. This form of sensitization goes beyond the long-standing interest in making electricity use material, tangible, and visible, e.g. through feedback technologies such as described in previous studies (e.g. Burgess & Nye, 2008; Wallenborn et al., 2011). What we describe here is rather a process of collective sensitization to the electricity grid as a political object than sensitization to electricity as a commodity. This, collective grid sensitization may serve as an enabler for new types of energy discussions, in which awareness of the limitation of the grid and the links to electromobility feeds into broader discussions about how to distribute electricity fairly, how to distribute the costs of infrastructural upgrades, and how to include different actors in those decisions in a fair and democratically sound way.

Citizens and elected management boards co-producing electricity grid sensitivity

In Norway, the elected management boards of urban residential areas tend to be comprised of individuals with a wide range of social backgrounds and competences. The boards' mandate is regulated by the Housing Cooperatives Act of 2003 (Ministry of Local Government and Regional Development, 2013). Housing cooperatives and co-ownership housing are quite similar forms of housing, with the main difference being that the boards of housing cooperatives have a wider mandate than have the boards of co-ownership housing. As an example, housing cooperative boards can rearrange rights to use parking spaces because the spaces are not owned individually. This happened among those living in urban residential community 1 (Table 1). However, in both types of housing organizations, the board has a percentage of total annual income that it can use to upgrade housing infrastructure without the need for a vote

to be taken in a general assembly meeting. In most cases, investing in smart charging infrastructures would not be an investment that would breach the limit set on the percentage. Investing in smart charging infrastructure also tends to emerge through the actions and interpretation of inhabitants, and in the interaction between inhabitants, management boards, and external actors.

At the time of our study, the community 4 had installed 55 EV charging points. However, the adoption of EVs increased rapidly, and there was a strong pressure from residents to increase the capacity and have more chargers installed. About 60 tenants in the community were on a waiting list for acquiring an EV charging point. After a lengthy dialogue with a local electrical engineer, as well as the electricity provider and grid operator, the board decided to install infrastructure for 765 charging points with a centralized load management system intended to minimize local peak loads. The system could set thresholds for how much electricity could be used to charge an EV during different times of the day.

The board was convinced that introducing smart EV charging with load control would ensure fair access to electricity and fair charging. Therefore, they decided to work to anchor their decision among residents through voting on it at a general assembly meeting. This illustrates how the board's sensitization to the grid had raised the need to produce a legitimate form of local grid governance through smart charging.

In our observation of the general assembly meeting in residential area 4, discussions about the EV infrastructure dominated. Many residents came well-prepared, as they had received an agenda and documentation well ahead of the meeting. The documents were also handed out by the board members to attendees at the entrance so that they could be read at the venue. Prior to the meeting, a resident had put forward a competing charging solution without any infrastructure requirements, and this was included in the documents. The room was filled with lively small talk before the meeting started with a 30-minute presentation on the EV charging solution proposed by the local network company. Much of the presentation centered on how the "state of the grid" depended on the ways that the residents lived their lives and used electricity. A key aspect was illustrating that the local grid was too weak to handle the new demand for EV charging. Additionally, trends within electricity provision, expected future developments, as well as potential consequences for the urban residential communities resulting from different choices (installing shared smart charging vs. not installing them) were presented by the provider of the EV charging infrastructure. Thereafter, the board opened for questions and comments from the residents. The discussion was dominated by EV owners, but considerable time was also spent on the alternative proposal (i.e. a charging solution without any infrastructure requirements) that had been put forward by one resident. Alternative proposals are a common feature of such meetings and illustrate that as the meetings become sites where energy transitions are enacted, those transitions become subject to more agonistic forms of deliberation (see, e.g. Burke, 2018, for a related discussion). One interviewee vented his feelings in an interview as follows:

> I have been part of the board for a long time, and there is a group of people who always come up with counterproposals. They are also very concerned about finances. First, we come up with a proposal that we think is good. Then comes the counterproposal, typically completely insane. In many cases we should put forward a proposal with the opposite of what we want,

> then we would spend much less time arguing. (Interview 5, elected bord leader, residential area 4)

Thus, disagreement is integral to the democratic process of meetings between residents on the one hand, and representatives of network companies and providers EV charging infrastructure on the other hand. Prior to the meeting we observed there clearly had been a mobilization of residents in favor of the proposed solution. As one of our interviewees noted: "There were many who showed up, especially because of the [charging] case. So, there is a lot of interest […] I thought everyone would come here to vote 'no,' but it turns out that they came to vote 'yes'" (interview 8). The informant was prepared to battle verbally for the EV charging infrastructure because he was of the opinion that it was difficult to convince people to make new investments.

In effect, the general assembly meeting became what Martiskainen et al. (2018) have called a material and discursive space of diverse voices, which enabled a new form of engagement with the social and material aspects of the grid. Consequently, we see how the meeting space, the presence of the diverse voices and forms of competences, and the materiality of EVs and the grid itself became part of an ecology through which awareness, new knowledge, and new practices could be constructed and constitute new forms of political engagement through material objects. The influx of EVs into the studied urban residential community generated a new form of material politics, for which sensitization to aspects of the electricity grid on behalf of a range of actors was key.

Recent literature has noted that as energy transitions become more pervasive and accelerate to encompass broader aspects of societies, new types of intermediary actors are needed, among other reasons to increase the uptake of technology, to manage controversies and tensions, and to engage users and create new markets (Kivimaa et al., 2020). In our case, the elected community board took on such a role, illustrating how the processes of making such infrastructure developments change once they have moved outside the demonstration and pilot settings that characterize much smart energy technology. As the discussions about smart charging unfolded, they spilled over into discussions about equity and fairness, but also about broader visions of the future role of the urban residential community and the energy system. This illustrates a potential for collective material politics beyond the domestic sphere in which such technologies as smart charging are employed.

The above-described way of organizing highly structured dialogue-based general meetings was representative of all but one of the urban residential communities that we studied. The board in residential area 4 had carefully framed the issue that should be voted on: residents could vote against smart charging or choose between two different, but relatively similar charging solutions. Visions of charging infrastructure and its relationship to grid capacity problems were presented during meetings, and grid requirements and grid operators' needs were presented to enroll residents in the dissection of investing in smart charging infrastructure. This form of public actualization of the smart grid had some unforeseen consequences.

Our exception, residential area 1 (Table 1), represented a much more technocratic approach. The board members and the manager of the board had strong feelings about the grid and the need to implement smart charging, but unlike the other

boards, they did not feel the need to anchor their decision among the residents. This was partly due to a lack of belief that the residents would understand the need for such a new technology. Therefore, the board of residential area 1 assumed the residents' "knowledge and interest [were] deficient," an interpretation of public agency that is quit commonly found among smart grid implementers (e.g. Skjølsvold & Lindkvist, 2015), but perhaps more surprising in our context. The manager of that board said:

> We asked around a little bit, and after that we decided that we did not need a general assembly resolution. We will do this [invest in smart charging infrastructure] within the sum that the board can spend without a general assembly meeting and what the board can do with the building. When it comes to the building structure nothing happens, just some wires […] [The residents were] not manipulated, but we decided it that way. I think this is so important, you must keep up with the future. We have made an offer and will have it organized, because you cannot have anarchy out there. (Interview 2, board manager, residential area 1)

Thus, the board recognized the political character of smart charging, in the sense that absence of smart charging would result in anarchy. However, beyond that, the board manager understood smart charging as a fairly nonpolitical issue. Rather than being interpreted as part of a broader move towards urban development or sustainability transitions, smart charging was understood as a straightforward technical solution to a technical problem. In addition, the social dynamics of the urban residential community were perceived as a barrier to the successful implementation of a smart charging system. The example illustrates that the presence of electric vehicles in themselves does not produce collective engagement with the electricity grid. As pointed out earlier, material participation and resulting articulations are multivalent and cannot be taken for granted. Rather, electricity grid sensitivity is a product of how relations are established between the ecology of actors and things within any given locality.

Promoting smart charging through highlighting values such as fairness and equality

The contemporary material politics of smart EV charging in Norway has appeared in part through the emergence of national regulations such as those discussed, and in part through experiences generated through interaction between individual homeowners, commercial actors, and consulting electricians who work within the field, sometimes through the intermediation of elected board. These encounters have been and continue to be central in shaping the micropolitics of smart charging. In the early phases of EV implementation in Norway, people contacted professional actors such as electricians to have their private chargers installed. However, many of the electricians and professional actors who worked within the field recognized quite early on that the assignments had broader and more systemic implications, and that there was a distinct political quality to the work. Therefore, it was articulated that the electricity flowing through shared garage spaces would need governance and regulation, as increased electricity consumption from EV charging would result in new peak loads that would be problematic for the capacity of many garages if not managed well. Thus, they recognized the fact that immediate individual needs and desires for installing electricity chargers should be suspended somewhat to cater for the needs of future collectives of citizens, through active choices of load management by installing smart charging. One interviewee stated:

> In a shared space it needs to be fair and equal for all. That's what I think. [It does not matter] if everyone does not need [an EV] right now […] Imagine how wrong it would be if only half of the apartments were given proper access to TV and Internet signals, and the rest did not get the same. (Interview 6, electrician)

Thus, for professional actors, such as electricians, both within and associated with the electricity industry, there was an outspoken aim to raise the awareness among elected urban community residents' boards and dwellers related to needs concerning the electricity grid. This illustrates the importance of this actor group in producing processes and outcomes that are understood as just, and perhaps signals that this group is important, but relatively overlooked in crafting what the literature discusses as energy justice (e.g. Jenkins et al., 2016). The actors do this in part by working to produce what we have discussed as grid sensitivity: an awareness that the grid produces not only factual insights into the electricity peaks flowing through copper wires but also reflections on how the resource can be distributed locally. One example of this can be seen in the following quotation:

> [Smart charging] forces itself through in the end because it is so unfair if fifteen out of fifty apartments install EV chargers, and the grid operator says "No! Now [the rest of] you cannot connect any more EV chargers because we do not have any more capacity." This is very unfair. What should the board say to its residents? (Interview 15, electrician)

Thus, electricians operating in what has been defined as the second stage of the Norwegian EV transition (Ryghaug & Skjølsvold, 2019), in which EVs became mainstream, expressed the same sort of care, both concerning the grid and for the communities served by the grid. For them, implementing a planned and structured system of load management through smart charging was seen as a key to realizing equity and fairness, framed as the opposite of "infrastructural anarchy." Consulting electricians who worked either for their consulting firms or the electricity industry saw themselves as promoters of such ideals and worked actively to enroll other actors such as car dealers in the promotion of planned and smart charging technology.

Furthermore, our analysis revealed that the actors (i.e. electricians) had an important relationship with the elected boards of urban residential communities. They actively targeted and tried to enroll the boards by highlighting aspects such as equality and fairness. As one interviewee noted: "Yes, I recommend switching to a locked system, a system of shared loads, because people are so [swearing] concerned with equality" (Interview 11, Electrician,). Here, equality denoted both the rights to EV charging when needed, but also equal rights to electricity in general. Another electrician noted, "you cannot make a system based on the needs of the first five EVs. You need to consider them all" (Interview 6), clearly pointing out that the system should be fair, also to future generations of EV drivers.

Thus, we found that actors who traditionally have been seen as external to the local urban community were seen as a central element of the ecology of actors that constitutes the material politics of smart EV charging. Their role was mainly to translate material constraints and local capacity problems into tangible community concerns such as equity and fairness, which resonates well with the historical roots of the communities in question. This, in turn, was operationalized through smart, ICT-enabled charging, which in different ways served to manage the electricity loads flowing through the

strained grids of shared garages. In doing so, they also contributed to paving the ground for further expansion of the Norwegian EV transition more broadly.

Concluding discussion

In this paper, we have explored a form of localized urban politics rooted in smart energy technologies, which exists beyond glossy imaginaries of what a smart city or a smart grid might be, and is frequently enacted in highly structured pilot and demonstration projects (Ryghaug & Skjølsvold, 2021). Empirically, we have zoomed in on urban residential communities in Norway, the European country with the highest market penetration of electrical vehicles (EV) (Skjølsvold & Ryghaug, 2019). This influx of EVs actualizes the electricity grid in new ways, producing a need to deal with electricity load management in a much more localized way than has commonly been done in the past. Against this backdrop, smart EV charging as a way of operationalizing the smart grid and the smart city has emerged as a central element. On a practical level, one can argue that the dynamics described here represent an understudied aspect of what Lanzeni (2016) calls the smart agenda. Within studies of smart grids and smart cities, there has been a tendency to study the developments through pilot projects or experiments that often have been implemented from the top down. Researchers have also highlighted how the smart agenda, when implemented in demo projects, promotes technologies that primarily stimulate measurement and reflexive practices, and aids a neoliberal or post-political order, where control over critical infrastructure is moved from public and political institutions to private and economic actors, under the pretense of empowering citizens or governments to make more active and better decisions (Evans et al., 2018; Rommetveit et al., 2021).

By contrast, we have shown the emergence of what can be called "a patchwork approach" to smart charging, in which concrete infrastructure constraints, the influx of electric vehicles, new ICT technologies, a distinctive form of urban residential communities, and external professional actors form an ecology of actors that enacts a new form of material politics in which "smart" can be interpreted both as outcome and as a driving force. Within this work, we have emphasized the role of democratically elected neighborhood boards, as well as electricians as intermediary actors. In sum, the process has enabled new forms of discursive and material practices, and has produced what we call collective *electricity grid sensitivity*, which entails the following:

- A collectively increased awareness and increased knowledge of local electricity grids and the effects that increasing the share of electric vehicles might have on the grid
- An increased sense of having a relationship to the electricity grid that transcends being a consumer
- An increased interest in local electricity grids as a set of political issues relating to notions such as justice, fairness, and equality
- A local-political mobilization of citizens to advance certain infrastructural developments on behalf of the grid.

As scholars following the developments within smart cities and smart grids, it is quite easy to become cynical with respect to what sometimes seems to resemble technology

implementation quite detached from attempts at solving tangible and localized issues. As such, we believe our analysis illustrates how "smart" might be implemented differently, not as a programmatic idea about what a future city should look like and how it should function, but rather as a concrete set of social and technical responses to matters that are by-products of the broader work to decarbonize the transport sector. As Evans et al. (2018) have highlighted, such organic developments represent a less glossy and utopian vision for a smart urban future. As we have seen, patchwork is painstaking and sometimes slow. Nevertheless, it produces engagement with a series of issues that will be important over the coming years for making urban communities that are attractive, fair, and more sustainable. As the energy transition advances further, dynamics resembling those discussed here will most likely become actualized in new sites, engaging new forms of actors operating under more or less similar conditions to those discussed in this paper. We hope to have illustrated here that not only should this be seen as a barrier to success, but also that resources of local spaces and ecologies of actors might be mobilized as resources for realized transition goals.

Note

1. Hereafter, we use the term "urban residential communities" in this context as a collective term for co-ownership housing and housing co-operatives. In regulatory terms, the latter two terms are slightly different. The charging Act of 2018 applied to co-ownership, and since 2021 a similar ownership Act for housing co-operatives has been implemented.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This article has benefited by funding from the European Union's Horizon 2020 project ECHOES, H2020-LCE-2016-RES-CCS-RIA, grant no. 727470, the "Research council of Norway", grant no. 296205, Norwegian Centre for Energy Transition Strategies (NTRANS), and the "Research council of Norway", grant no. 257626, Centre for intelligent electricity distribution (CINELDI).

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References

Aas, Øyvind, Devine-Wright, Patrick, Tangeland, Torvald, Batel, Susana, & Ruud, Audun. (2014). Public beliefs about high-voltage powerlines in Norway, Sweden and the United Kingdom: A comparative survey. *Energy Research & Social Science*, *2*, 30–37.

Adams, Sophie, Kuch, Declan, Diamond, Lisa, Fröhlich, Peter, Henriksen, Ida Marie, Katzeff, Cecilia, Ryghuag, Marianne, & Yilmaz, Selin. (2021). Social license to automate: A critical review of emerging approaches to electricity demand management. *Energy Research & Social Science*, *80*, Article 102210.

Anfinsen, Martin, Lagesen, Vivian Anette, & Ryghaug, Marianne. (2019). Green and gendered? Cultural perspectives on the road towards electric vehicles in Norway. *Transportation Research Part D: Transport and Environment*, *71*, 37–46.

Aune, Margrethe. (2007). Energy comes home. *Energy Policy*, *35*(11), 5457–5465.

Aune, Margrethe, Godbolt, Åsne Lund, Sørensen, Knut Holtan, & Ryghaug, Marianne. (2016). Concerned consumption: Global warming changing household domestication of energy. *Energy Policy*, *98*, 290–297.

Ballo, Ingrid Foss. (2015). Imagining energy futures: Sociotechnical imaginaries of the future smart grid in Norway. *Energy Research & Social Science*, *9*, 9–20.

Bjerkan, Kristin Ystmark, Nørbech, Tom, & Nordtømme, Marianne Elvsaas. (2016). Incentives for promoting battery electric vehicle (BEV) adoption in Norway. *Transportation Research Part D: Transport and Environment*, *43*, 169–180.

Bulkeley, Harriet, McGuirk, Pauline McGuirk, & Dowling, Robyn. (2016). Making a smart city for the smart grid? The urban material politics of actualising smart electricity networks. *Environment and Planning A: Economy and Space*, *48*(9), 1709–1726.

Burgess, Jacquelin, & Nye, Michael. (2008). Re-materialising energy use through transparent monitoring systems. *Energy Policy*, *36*(12), 4454–4459.

Burke, Matthew J. (2018). Shared yet contested: Energy democracy counter-narratives. *Frontiers in Communication*, *3*, Article 22.

Canzler, Weert, Engels, Franziska, Rogge, Jan Christoph, Simon, Dagmar, & Wentland, Alexander. (2017). From "living lab" to strategic action field: Bringing together energy, mobility, and information technology in Germany. *Energy Research & Social Science*, *27*, 25–35.

Chilvers, Jason, Pallett, Helen, & Hargreaves, Tom. (2018). Ecologies of participation in socio-technical change: The case of energy system transitions. *Energy Research & Social Science*, *42*, 199–210.

Evans, James, Karvonen, Andrew, & Raven, Rob. (2018). *The experimental city*. Routledge.

Figenbaum, Erik. (2017). Perspectives on Norway's supercharged electric vehicle policy. *Environmental Innovation and Societal Transitions*, *25*, 14–34.

Geels, Frank W., Sovacool, Benjamin K., Schwanen, Tim, & Sorrell, Steve. (2017). Sociotechnical transitions for deep decarbonization. *Science*, *357*(6357), 1242–1244.

Geels, Frank W. (2002). Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Research Policy*, *31*(8-9), 1257–1274.

Hattrem, Hanne. (2019, May 19). *Går mot ny lov for elbileiere i borettslag:skal få rett til å lade.* E24. https://e24.no/teknologi/i/op92k7/gaar-mot-ny-lov-for-elbileiere-i-borettslag-skal-faa-rett-til-aa-lade

Hauge, Åshild Lappegard, Thomsen, Judith, & Löfström, Erica. (2013). How to get residents/owners in housing cooperatives to agree on sustainable renovation. *Energy Efficiency*, *6*(2), 315–328.

Henriksen, Ida Marie, Throndsen, William, Ryghaug, Marianne, & Skjølsvold, Tomas Moe. (2021). Electric vehicle charging and end-user motivation for flexibility: A case study from Norway. *Energy, Sustainability and Society*, *11*(1), Article 44.

Ingeborgrud, Lina, & Ryghaug, Marianne. (2019). The role of practical, cognitive and symbolic factors in the successful implementation of battery electric vehicles in Norway. *Transportation Research Part A: Policy and Practice*, *130*, 507–516.

Jenkins, Kirsten, McCauley, Darren, Heffron, Raphael, Stephan, Hannes, & Rehner, Robert. (2016). Energy justice: A conceptual review. *Energy Research & Social Science*, *11*, 174–182.

Kivimaa, Paula, Bergek, Anna, Matschoss, Kaisa, & van Lente, Harro. (2020). Intermediaries in accelerating transitions: Introduction to the special issue. *Environmental Innovation and Societal Transitions*, *36*, 372–377.

Kivimaa, Paula, Boon, Wouter, Hyysalo, Sampsa, & Klerkx, Laurens. (2019). Towards a typology of intermediaries in sustainability transitions: A systematic review and a research agenda. *Research Policy*, *48*(4), 1062–1075.

Klöckner, Christian. (2014). The dynamics of purchasing an electric vehicle – A prospective longitudinal study of the decision-making process. *Transportation Research Part F: Traffic Psychology and Behaviour*, *24*, 103–116.

Lanzeni, Débora. (2016). Smart global futures: Designing affordable materialities for a better life. In Sarah Pink, Elisenda Ardevol, & Débora Lanzeni (Eds.), *Digital materialities: Design and anthropology* (pp. 45–60). Bloomsbury.
Latour, Bruno. (2005). From realpolitik to dingpolitik, or how to make things public. In Bruno Latour & Peter Weibel (Eds.), *Making things public: Atmospheres of democracy* (pp. 515–539). MIT Press.
Laurent, Brice. (2017). *Democratic experiments. Problematizing nanotechnology and democracy in Europe and the United States*. MIT Press.
Lovdata. (2018, June 22). *Lov om endring i eierseksjonsloven*. https://lovdata.no/dokument/LTI/lov/2018-06-22-74
Marres, Noortje. (2007). The issues deserve more credit: Pragmatist contributions to the study of public involvement in controversy. *Social Studies of Science*, *37*(5), 759–780.
Marres, Noortje. (2010). Frontstaging nonhumans: Publicity as a constraint on the political activity of things. In Bruce Braun & Sarah Whatmore (Eds.), *Political matter: Technoscience, democracy and public life* (pp. 177–210). University of Minnesota Press.
Marres, Noortje. (2011). The costs of public involvement: Everyday devices of carbon accounting and the materialization of participation. *Economy and Society*, *40*(4), 510–533.
Marres, Noortje. (2012). *Material participation: Technology, the environment and everyday publics*. Palgrave MacMillan.
Marres, Noortje. (2013). Why political ontology must be experimentalized: On eco-show homes as devices of participation. *Social Studies of Science*, *43*(3), 417–443.
Marres, Noortje, & Lezaun, Javier. (2011). Materials and devices of the public: An introduction. *Economy and Society*, *40*(4), 489–509.
Martiskainen, Mari. (2017). The role of community leadership in the development of grassroots innovations. *Environmental Innovation and Societal Transitions*, *22*, 78–89.
Martiskainen, Mari, Heiskanen, Eva, & Speciale, Giovanna. (2018). Community energy initiatives to alleviate fuel poverty: The material politics of energy cafés. *Local Environment*, *23*(1), 20–35.
Marvin, Simon, Luque-Ayala, Andrés, & McFarlane, Colin. (2015). *Smart urbanism: Utopian vision or false Dawn?* Routledge.
Mignon, Ingrid, & Kanda, Wisdom. (2018). A typology of intermediary organizations and their impact on sustainability transition policies. *Environmental Innovation and Societal Transitions*, *29*, 100–113.
Ministry of Local Government and Regional Development. (2013). *The Housing Cooperatives Act*. https://www.regjeringen.no/en/dokumenter/the-housing-cooperatives-act/id439595/
Moss, Timothy. (2009). Intermediaries and the governance of sociotechnical networks in transition. *Environment and Planning A*, *41*(6), 1480–1495.
Niesten, Eva, & Alkemade, Floortje. (2016). How is value created and captured in smart grids? A review of the literature and an analysis of pilot projects. *Renewable and Sustainable Energy Reviews*, *53*, 629–638. https://elbil.no/slik-lader-elbileierne/
Norsk elbilforening. (2021, December 31). *Norwegian EV market*. https://elbil.no/english/norwegian-ev-market/
Pallesen, Trine, & Jenle, Rasmus Ploug. (2018). Organizing consumers for a decarbonized electricity system: Calculative agencies and user scripts in a Danish demonstration project. *Energy Research & Social Science*, *38*, 102–109.
Parag, Yael, & Janda, Kathryn B. (2014). More than filler: Middle actors and socio-technical change in the energy system from the "middle-out". *Energy Research & Social Science*, *3*, 102–112.
Rommetveit, Kjetil, Ballo, Ingrid Foss, & Sareen, Sareen. (2021). Extracting users: Regimes of engagement in Norwegian smart electricity transition. *Science, Technology, & Human Values*. Advance online publication.
Ryghaug, Marianne, & Skjølsvold, Tomas Moe. (2019). Nurturing a regime shift toward electromobility in Norway. In Matthias Finger & Maxime Audouin (Eds.), *Governance of smart transportation systems* (pp. 147–168). Springer International Publishing.

Ryghaug, Marianne, & Skjølsvold, Tomas Moe. (2021). *Pilot society and the energy transition: The co-shaping of innovation, participation and politics*. Springer Nature.
Ryghaug, Marianne, Skjølsvold, Tomas Moe, & Heidenreich, Sara. (2018). Creating energy citizenship through material participation. *Social Studies of Science*, *48*(2), 283–303.
Ryghaug, Marianne, & Toftaker, Marit. (2014). A transformative practice? Meaning, competence, and material aspects of driving electric cars in Norway. *Nature and Culture*, *9*(2), 146–163.
Saglie, Inger-Lise, Inderberg, Tor Håkon, & Rognstad, Helga. (2020). What shapes municipalities' perceptions of fairness in windpower developments? *Local Environment*, *25*(2), 147–161.
Sareen, Siddharth, & Haarstad, Håvard. (2021). Digitalization as a driver of transformative environmental innovation. *Environmental Innovation and Societal Transitions*, *41*, 93–95.
Skjølsvold, Tomas Moe, Jørgensen, Susanne, & Ryghaug, Marianne. (2017). Users, design and the role of feedback technologies in the Norwegian energy transition: An empirical study and some radical challenges. *Energy Research & Social Science*, *25*, 1–8.
Skjølsvold, Tomas Moe, & Lindkvist, Carmel Margaret. (2015). Ambivalence, designing users and user imaginaries in the European smart grid: Insights from an interdisciplinary demonstration project. *Energy Research & Social Science*, *9*, 43–50.
Skjølsvold, Tomas Moe, & Ryghaug, Marianne. (2019). Temporal echoes and cross-geography policy effects: Multiple levels of transition governance and the electric vehicle breakthrough. *Environmental Innovation and Societal Transitions*, *35*, 232–240.
Skjølsvold, Tomas Moe, Ryghaug, Marianne, & Throndsen, William. (2020). European island imaginaries: Examining the actors, innovations, and renewable energy transitions of 8 islands. *Energy Research & Social Science*, *65*, Article 101491.
Smale, Robin, van Vliet, Bas, & Spaargaren, Gert. (2017). When social practices meet smart grids: Flexibility, grid management, and domestic consumption in the Netherlands. *Energy Research & Social Science*, *34*, 132–140.
Sovacool, Benjamin K., & Hirsh, Richard F. (2009). Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. *Energy Policy*, *37*(3), 1095–1103.
Sovacool, Benjamin K., Noel, Lance, Axsen, Jonn, & Kemton, Willett. (2018). The neglected social dimensions to a vehicle-to-grid (V2G) transition: A critical and systematic review. *Environmental Research Letters*, *13*(1), Article 013001.
Statistics Norway. (2021, March 23). *Boforhold, registerbasert*. https://www.ssb.no/boforhold
Strengers, Yolande. (2013). *Smart energy technologies in everyday life*. Palgrave Macmillan.
Throndsen, William, & Ryghaug, Marianne. (2015). Material participation and the smart grid: Exploring different modes of articulation. *Energy Research & Social Science*, *9*, 157–165.
Trondheim kommune. (2012). *Krav til parkering – veileder*. Kommuneplanens arealdel 2012-2024. Vedlegg 15. https://www.trondheim.kommune.no/globalassets/10-bilder-og-filer/10-byutvikling/byplankontoret/samferdsel/reisevaner/15_parkeringsveileder_web.pdf
van Lente, Harro, Hekkert, Marko, Smits, Ruud, & van Waveren, Bas. (2003). Roles of systemic intermediaries in transition processes. *International Journal of Innovation Management*, *7* (03), 247–279.
Wallenborn, Grégoire, Orsini, Marco, & Vanhaverbeke, Jeremie. (2011). Household appropriation of electricity monitors. *International Journal of Consumer Studies*, *35*(2), 146–152.
Winther, Tanja, Westskog, Hege, & Sæle, Hanne. (2018). Like having an electric car on the roof: Domesticating PV solar panels in Norway. *Energy for Sustainable Development*, *47*, 84–93.